REVISED SUPPLEMENTAL REMEDIAL PROGRAM/ ALTERNATIVES ANALYSIS

EMERSON POWER TRANSMISSION FACILITY
620 AURORA STREET
ITHACA, NEW YORK
SITE NO. 7-55-010

FINAL

PREPARED

BY

WSP ENGINEERING OF NEW YORK, P.C.

SEPTEMBER 23, 2008

WSP Engineering of New York, P.C.
11190 Sunrise Valley Drive, Suite 300
Reston, VA 20191
Tel: (703) 709-6500
Fax: (703) 709-8505

Contents

Part I – Supplemental Remedial Program

Contents
(continued)

Page

Part II - Alternatives Analysis for AOCs 1, 4, 15, and 24

Contents
(continued)

Page

Contents
(continued)

Contents
(continued)

List of Figures:

List of Tables:

Acronym List

$\mu g/m^3$	micrograms per cubic meter
aMSL	above mean sea level
AS	air sparging
bgs	below ground surface
cis-1,2-DCE	cis-1,2-dichloroethene
COC	constituents of concern
CSIA	compound specific isotope analysis
DOT	Department of Transportation
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
EPT	Emerson Power Transmission
GAC	granular activated carbon
gpm	gallons per minute
HASP	Health and Safety Plan
IC/EC	Institutional Control/Engineering Control
IRM	Interim Remedial Measures
ISCO	*in situ* chemical oxidation
LNAPL	light non-aqueous phase liquid
MNA	monitored natural attenuation
NYCRR	New York Codes, Rules, and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	operation and maintenance
OPTV	optical televiewer
PID	photoionization detector
PRB	permeable reactive barrier
PRI	Paleontological Research Institute
QA/QC	quality assurance/quality control
qPCR	quantitative polymerase chain reaction
RAO	remedial action objective
RI	Remedial Investigation
SCO	Soil Cleanup Objectives
SMP	Site Management Plan
SOP	Standard Operating Procedure
SPDES	state pollutant discharge elimination system
SRI	Supplemental Remedial Investigation
STARS	Spill Technology and Remediation Series
SVE	soil vapor extraction
TCE	trichloroethene
TOGS	Technical and Operational Guidance Series
trans-1,2-DCE	trans-1,2-dichloroethene
VOC	volatile organic compounds

1.0 Introduction

1.1 Preface

On behalf of Emerson Electric Co. and its subsidiary, Emerson Power Transmission Corp. (EPT), WSP Engineering of New York, P.C., has prepared this revised Supplemental Remedial Program/Alternatives Analysis Report for the EPT site in Ithaca, New York (the site). This report was prepared in accordance with an Administrative Order on Consent (Index #A7-0125-87-09) entered into by the New York State Department of Environmental Conservation (NYSDEC) and EPT on July 13, 1987. The overall framework is consistent with that outlined in the NYSDEC letter to Emerson, dated March 19, 2008, and addresses comments by NYSDEC on the April 21, 2008 draft Supplemental Remedial Program/Alternatives Analysis Report for the EPT site.

The report is divided into two parts, Part I: Supplementary Remedial Program and Part II: Alternatives Analysis Evaluation. The supplemental remedial program addresses groundwater and the fire water reservoir at the EPT site and the potential for vapor intrusion into the EPT facility buildings. The supplemental remedial program for the fire water reservoir program will be implemented as an Interim Remedial Measure (IRM) during the 2008 construction season. The IRM will involve designing and constructing an enhancement to the existing groundwater extraction and treatment system to intercept affected groundwater in the highly fractured bedrock (B-zone) and the horizontal bedding plane within the C-zone between 515 and 518 feet above mean sea level (aMSL) in the current remediation area. This IRM also will involve extracting groundwater from the C-zone immediately below the fire water reservoir. Pre-design investigations necessary to fill data gaps and complete the design of this IRM are also detailed. In addition, actions will be taken to address the potential for vapor intrusion within facility buildings.

The second part of the report is an alternatives analysis addressing the four areas of concern (AOCs) identified in the Supplemental Remedial Investigation (SRI) for the site where soil and/or groundwater impacts were identified above NYSDEC soil cleanup objectives or petroleum product was found. The AOCs consist of the following:

- AOC 1 – Former Department 507 Degreaser – Methylene chloride and vinyl chloride were detected in soil at concentrations above the NYSDEC Restricted

Use Soil Cleanup Objectives (SCOs) for protection of groundwater in one sample. Cis-1,2-dichloroethene (DCE), trans-1,2-DCE, and vinyl chloride were detected in groundwater above the ambient water quality standards.

- AOC 4 – Former Open Reservoir (Stone) – A petroleum product was encountered.
- AOC 15 – Former 500-Gallon Gasoline Aboveground Tank – A petroleum product was encountered.
- AOC 24 – Fire Water Reservoir – A petroleum product was encountered.

Pre-design investigations that are required to further define the extent of impacts in each AOC as well as an evaluation of appropriate remedial alternatives are described. In addition to the above, the following pathways have been identified for the migration of vapors associated with historical releases of volatile organic compounds (VOCs) from the sanitary sewer lines servicing the EPT facility (along Turner Place and South Cayuga Street):

- through fractures in the unsaturated bedrock formation
- along the sewer lines themselves
- along laterals connected to the sewer lines

The proposed additional investigations to evaluate these pathways are detailed. The results of the additional investigations in combination with previous work will provide sufficient data to undertake an evaluation of remedial alternatives to address vapor migration along each of these three pathways.

The remainder of Section 1 includes a description and history of the EPT facility, followed by a discussion of the site geology and hydrogeology. The last part of Section 1 provides a conceptual model for groundwater transport beneath the fire water reservoir as well as soil vapor migration along the sanitary sewers on Turner Place and South Cayuga Street. Part I of the document describes the proposed supplementary remedial program for groundwater near the fire water reservoir which will be implemented as an IRM and actions to address soil vapor intrusion in facility buildings. It includes an introduction and purpose in Section 2, information on the groundwater and fire water reservoir area data gaps and proposed additional investigations in Section 3, the scope of the IRM for the groundwater and fire water reservoir area in Section 4, and a description of the measures to address indoor air in select EPT buildings in Section 5. Part

II of the document details the alternatives analysis for AOCs 1, 4, 15, and 24. It includes an introduction and purpose in Section 9, remedial action objectives in Section 10, proposed pre-design investigations for each AOC in Section 11, a description of additional investigations for the sanitary sewers along Turner Place and South Cayuga Street in Section 12, identification and screening of technologies in Section 13, an evaluation of potentially feasible technologies in Section 14, and recommended remedial strategies and selection rationale in Section 15.

1.2 Facility Description and History

The EPT facility is located at 620 South Aurora Street in Ithaca, New York (Figure 1). The site consists of three main buildings along the northeast and southwest portions of South Hill (Figure 1). The facility buildings are located at an elevation of approximately 600 feet aMSL. The majority of the floor space is in the main plant building, which extends approximately 1,600 feet near the northeastern portion of the 110-acre site. The main building is flanked by a number of smaller buildings to the southwest and a series of access roads and parking lots that terrace the hillside above the plant to the east (Figure 2). Further uphill and to the east are South Aurora Street and the campus of Ithaca College. Undeveloped woodland borders the site to the southwest along the steep embankments of the hill. West Spencer Street, which runs parallel to the EPT property, marks the western edge of the wooded area and the base of South Hill. Beyond Spencer Street to the west and in areas along the steep northern approach to South Hill and the EPT property are residential areas. These neighborhoods are bordered by Six Mile Creek, which flows north along the base of South Hill and eventually empties into Cayuga Lake approximately 2 miles northwest of the site. Figure 2 shows the facility layout and the surrounding areas.

The original building at the EPT site was built in 1906 by Morse Industrial Corporation, which manufactured steel roller chain for the automobile industry. From approximately 1928 to 1983, Borg-Warner Corporation owned the property and manufactured automotive components and power transmission equipment using similar processes, but not necessarily the same materials, as those currently conducted by EPT. A more detailed description of the site history and construction dates of the various building at the site is detailed in the report entitled Onsite Assessment of the Former Borg Warner – Morse Chain Facility (ESC 2005). Up until the late 1970s, Borg-Warner Corporation used trichloroethene (TCE), a widely-used solvent at the time for cleaning and degreasing metal parts. In 1983, Morse Industrial Corporation was purchased from Borg-Warner Corporation by Emerson and, in the late 1980's, became known as Emerson Power Transmission. EPT manufactures industrial roller chain, bearings, and clutching for the power transmission industry. Under Emerson's ownership, TCE has not been used at the Ithaca facility. Investigations conducted by Emerson in 1987 revealed onsite groundwater contamination, originating from a fire-water reservoir located on the western portion of the property. Emerson promptly reported these findings to the New York State Department of Environmental Conservation. The remediation of this contamination was the subject of the July 1987 Consent Order (Index # A7-0125-87-09) referenced above.

1.3 Site Geology

The EPT site is located on the northern edge of the Appalachian Plateau Physiographic Province, which is characterized in central New York by deeply dissected hilly uplands and glacially gouged stream valleys. The EPT site lies on the limits of one of the dissected hills and overlooks the Cayuga Lake basin, which is formed in a former stream valley eroded and enlarged by the advance of glaciers. Underlying the site is a thin, discontinuous veneer of glacial till and man-made fill. The soil is classified as the "A-zone" in the site conceptual model and hydrogeologic framework presented below. It is typically a silty or clayey gravel and ranges in depth from 2.5 to 33 feet thick, though most of the EPT site and the western slope of South Hill is covered by less than 15 feet of soil. Soil depths generally increase with decreasing elevation and eventually merge with glacio-lacustrine silt and clay that lines the bottom of the valley floor below South Hill.

Beneath the overburden lies bedrock of the Ithaca Siltstone, a member of the Genesee Formation. The bedrock is typically well-cemented with generally non-fossiliferous beds ranging in thickness from 0.1 inch to 2.5 feet in thickness. Previous interpretations of the site bedrock, based on core logs recovered from boreholes drilled during investigation activities, differentiated the rock into three zones based on the frequency of bedding plane fractures and joints: an upper "stress relief zone" (B-zone), a middle "transitional zone" (C-zone), and a lower "lithologically controlled zone" (D-zone). The uppermost B-zone is characterized as very highly to highly fractured weathered bedrock. Onsite the B-zone extends to a maximum depth of approximately 22 feet below ground surface (bgs) and has an average thickness of approximately 8 to 10 feet on the western portion of the site where the current remediation system is located.

The transitional zone (C-zone) extends from the base of the B-zone to a maximum depth of approximately 55 feet bgs at the EPT site. The lower lithologically controlled zone (D-zone) extends from the bottom of the C-zone to a minimum depth of 145 feet bgs. According to geologic logs, bedding plane fractures are reportedly confined to intervals that are widely spaced, and their occurrence is controlled by lithology.

1.3.1 Joint Measurements

Four regular joint sets are recognized regionally: Two cross-strike joint sets (Ia and Ib) related to separate phases of the Alleghanian Orogeny, a strike-parallel set (II), and an oblique set (III) reflecting the contemporary stress field. Engelder and Geisler (1980) reported measured orientations of the joint sets in Tompkins County and throughout the Appalachian Plateau of New York. The average strike of Ib joints at 11 outcrops of the Genesee Group in Tompkins County was 341° ± 3°. The average strike of Ia joints at 2 outcrops of the Genesee Group in Tompkins County was 007° ± 3°. The average orientation of the strike-parallel joint set (II) was 82°.

Engelder and Geisler (1980) also observed that joints in the siltstone are more likely to have regular spacing, while joints in the shales were less likely to be regularly spaced. Vertically, joints tended to terminate at lithologic boundaries.

As detailed above, the bedrock in the Ithaca area is cut by at least three sets of vertical fractures or joints. Limited geologic mapping performed by Radian at 16 bedrock outcrop locations on and around the EPT facility identified three consistent joint orientations: N13W to N21W (north-northwest); N70E to N89E (east-northeast); and N45E to N55E (northeast). Two of the three strike orientations measured by Radian are in close agreement with regional joint set measurements of N19W and N7E made at outcrops of the Genesee Group in Tompkins County. All of the joints measured by Radian were within 8° of vertical.

In December 2005, WSP measured the orientation of bedrock joint sets at seven bedrock outcrops in the South Hill area northwest of the EPT facility. Two primary joint sets were identified, one oriented north-northwest and another oriented east-northeast. The north-northwest trending joint set was more common and better expressed in the observed bedrock outcrops. A total of 22 measurements were made of the north-northwest trending joint set and 3 measurements of the east-northeast trending joint set. Measurements were made using a Brunton compass adjusted for magnetic declination of Ithaca, New York at the time of the investigation (12° 12’ W). The mean joint orientation of the 22 north-northwest trending joint set measurements was 342/82 (strike/dip using right-hand rule) or N18W/82E. The mean joint orientation of the 3 north-northeast trending joint set measurements was 252/81 or S72W/81N. These orientations are consistent with published regional trends, as well as previous measurements collected by Radian.

1.3.2 Structural Framework

As part of the 2007 SRI, downhole logging and sampling was completed at 17 exploratory borings drilled across the site. The objective of the investigation was to develop a more comprehensive understanding of potential migration pathways within bedrock underlying the area and to build on the data collected from previous investigations. The results of the SRI indicated that two types of well defined fractures are visible in outcrops, geophysical logs, and rock cores collected. The first type is horizontal open fractures that are parallel to bedding (bedding plane fractures). The second type consists of three orientations of nearly vertical joint sets. The bedding plane fractures extend laterally a few inches or feet and intersect to create an interconnecting network of relatively planar, paper-thin, horizontal planes of effective porosity. The individual vertical joint sets extend 10s of feet laterally and vertically to create an intersecting network of permeable vertical conduits that are bounded by blocks of bedrock.

In addition, the results of exploratory boring installed near the fire water reservoir confirmed the presence of bedding plane fractures at an elevation of approximately 515 feet aMSL in each of the six exploratory borings installed. This bedding plane fracture has been identified is a major migration pathway for groundwater beneath the fire water reservoir area.

1.4 Site Hydrogeology

Groundwater flow within the overburden and underlying B-zone generally mimic surface topography, which slopes to the northwest. Groundwater flow within the siltstone bedrock (C and D zones) is significantly affected by vertical and horizontal distribution of vertical joint sets and horizontal bedding plane fractures within the upper sections of bedrock.

Groundwater near the fire water reservoir area is present within the overburden and bedrock. Overburden groundwater appears to be perched and is restricted to limited areas of the site where the discontinuous cover of soil is thickest. In areas where the soil cover is thin (i.e., steep slopes along Turner Place), the overburden or upper portion of fractured bedrock is not saturated. Based on measurements collected during groundwater sampling, the overburden groundwater in the remediation area is in hydraulic communication with the underlying bedrock of the B-zone, and the two units appear to be acting act as a single hydraulic zone. In addition, the results of aquifer testing conducted within the remediation area indicate that because of the highly fractured and jointed nature of the B-zone, the unit responds as porous media. In the less fractured and jointed deeper sections of bedrock, the system responds as a fracture flow network with both primary and secondary porosity.

1.5 Conceptual Site Models

Two conceptual site models (CSMs) were developed for the EPT Ithaca site based on available data to illustrate the relationship between the constituents of concern, transport pathways, potential exposure pathways including point routes, and receptors. The first CSM is for VOC-containing groundwater associated with releases from the fire water reservoir and the second is for historical releases of VOCs (solvents) from the sanitary sewer lines on Turner Place and South Cayuga and the associated transport pathways.

1.5.1 Fire Water Reservoir Area

The fire water reservoir has a capacity of 200,000 gallons and was constructed in 1906. The reservoir is constructed of concrete and extends approximately 19 feet bgs. Unsaturated soil is present to a depth of approximately 12 feet and is underlain by highly fractured bedrock to a depth of approximately 22 feet bgs. Groundwater is encountered at the soil bedrock contact at approximately 12 feet below bgs, which is approximately 7 feet above the base of the reservoir. The results of previous investigations show that the fire water reservoir is the source of solvent releases to the subsurface. Specifically, solvents, which were discharged to the reservoir, migrated through cold joint cracks in the sidewalls and possibly the base into the surrounding fractured bedrock (B-zone). The bedrock surrounding the reservoir consists of a highly jointed and fractured siltstone. Releases from the reservoir discharged directly into surrounding groundwater within the fractured bedrock (B-zone).

Once in the bedrock, dissolved constituents migrated horizontally in groundwater downgradient within the highly fractured material, and vertically downward via open joints sets that intersect a prominent bedding plane fracture at the base of the C-zone (Figure 3). The main transport mechanisms for releases from the reservoir are through the vertical joint (fracture) sets and horizontal bedrock bedding planes. These migration pathways form an interconnected network for groundwater transport. The horizontal bedding planes (fractures) significantly decrease in frequency with depth (Figure 3). The vertical joint sets remain open and do not change with depth, but appear to terminate at lithologic contacts (Engelder and Geisler 1980).

A prominent horizontal bedding plane was identified at an elevation between 515 to 518 feet aMSL (base of C-zone) beneath the fire water reservoir area. This nearly horizontal feature extends, at a minimum, laterally to the west and potentially discharges into the B-zone identified near EXB-7 located on South Cayuga Street (Figure 4).

Figure 4 shows the migration pathways for affected groundwater downgradient of the fire water reservoir within the highly fractured B-zone and within the bedding plane fracture at 515 feet aMSL along cross section lines A-A’ and B-B’. Cross section A-A’ generally shows the fire water reservoir and subsurface areas to the northwest. Cross section B-B’ generally shows a profile of the South Cayuga Street sanitary sewer line that extends to the north. The zones of affected groundwater are shown vertically in Figure 4 along cross section line A-A’.

In the fire water reservoir area, groundwater generally occurs within the upper portion of fractured bedrock (B-zone) and within a bedding plane fracture encountered at 515 feet aMSL (C-zone). The distribution of total VOCs (site-related compounds) in groundwater downgradient of the fire water reservoir is shown in Figures 5 and 6. Groundwater flow within these two zones is presented in Figure 7 (B-zone) and Figure 8 (C-zone).

There are no potential exposure pathways to affected groundwater on the EPT site via drinking water because groundwater is not used for potable purposes. However, downgradient of the EPT site, the bedding plane fracture at 515 aMSL potentially discharges to the B-zone near EXB-7 located on South Cayuga Street or at the elevation where the sanitary sewer line intersects the bedding plane fracture on South Cayuga Street. Potential exposure pathways are associated with vapor intrusion into homes near the location of where the bedding plane fracture may discharge to the B-zone and direct contact by utility workers to groundwater that may discharge to the B-zone along the sanitary sewer.

1.5.2 Sanitary Sewers

Two parallel sewer lines extend from the EPT site to the north down Turner Place where they join at a manhole near the intersection of Columbia Street. A third sewer line extends from the western portion of the EPT property north along South Cayuga Street. In the area of Turner Place, unsaturated soil is present to a depth of approximately 1 to 3 feet and is underlain by unsaturated fractured bedrock. In this area of the site, the highly fractured B-zone is not saturated. Groundwater is encountered in the C-zone at approximately 20 feet bgs. According to City utility drawings, the majority of the sanitary sewer lines along both Turner Place and South Cayuga are trenched directly into the upper section of fractured bedrock and invert elevations range from approximately 5 to 7 feet bgs. In areas where the lines were installed less than 3 feet bgs, flowable fill (concrete) was used to increase the load capacity of the sewer lines.

The sewer lines along Turner Place and South Cayuga Street have been identified as historical sources of releases of VOCs. Based on a review of historical site information, solvent discharges likely occurred over a number of years and likely ceased in the late 1970's. Discharges from these sewers can be conceptualized as leaks from an aging sewer system that have migrated out of the sewers into the surrounding material (Figure 9). Because the Turner Place sewer lines are constructed within unsaturated fractured bedrock, releases from the sewers would have migrated horizontally within the open fractures that are parallel to bedding and vertically within the joint sets. Figure 9 depicts the conceptualized discharge paths from the Turner Place sewer lines through the fractured and jointed bedrock which also extends beneath nearby homes. The figure also shows the horizontal and vertical migration pathways for vapor migration within the bedding plane fractures and joint sets.

Based on the long history of manufacturing and the results of previous soil vapor sampling near the sanitary sewer network in the South Hill area, it is clear that historic solvent releases occurred to the sewers. During Borg Warner's ownership, solvents were discharged along with other wastewaters into the municipal sewers along Turner Place and South Cayuga Street. These sewer lines leaked at joints and where cracks developed. Wastewater containing dissolved VOCs was released through joints and cracks into the bedding of the sewer pipe. Subsequently, wastewater containing dissolved VOCs migrated both along the pipe bedding and into sediment filled fractures (joints and bedding planes) of the surrounding bedrock which is unsaturated. The dissolved VOCs migrated within sediment filled bedrock fractures and remain in the pore spaces of the sediment – held by capillary forces. VOCs in the sediment filled fracture subsequently volatilize into the gaseous phase and are transported by diffusion both vertically (based on a pressure differential) and laterally (Figure 10).

In addition, results of soil vapor sampling show that solvent releases have occurred from the sewer line originating at the former NCR facility. This sewer line extends across the south east portion of the EPT property, then north along South Aurora Street, west along Columbia Street, and connects to the sewer on Turner Place. Municipal sewer lines originating from the Therm facility connect to the South Aurora/Columbia Street sewer line, which in turn, connects with to the Turner Place sewer.

Inhalation has been identified as a potential exposure pathway for affected soil vapor that has migrated from releases from the sewers. Residuals from these releases likely remain within the fracture network and migrate by diffusion both vertically and laterally.

Part I

Supplemental Remedial Program

2.0 Introduction and Purpose

The proposed supplementary remedial program involves implementing an enhancement to the existing groundwater extraction system and extracting from the C-zone immediately below the fire water reservoir as an IRM. In addition, the program involves implementing actions to address the potential for vapor intrusion into the EPT facility. The current groundwater extraction and treatment system is described in Section 3.1. This is followed by Section 3.2 with a summary of the findings of investigations conducted in the area of the fire water reservoir since 2003 and the identified data gaps. Pre-design investigations necessary to fill data gaps and to further evaluate the hydraulic characteristics of the C-zone bedding plane fracture and finalize the design parameters for the IRM are described in Section 3.3. Finally, Section 4.0 describes the preliminary scope of the IRM for enhancing the existing groundwater remedy and also extracting groundwater from the C-zone below the fire water reservoir. Included are descriptions of preparatory activities, the construction activities, and site restoration and associated permitting.

The description of actions to address the potential for vapor intrusion into the EPT facility buildings includes a summary of the results of the indoor air and sub-slab vapor monitoring conducted in the building (Section 5.1), and a description of the proposed measures for the buildings where VOC sampling results indicated the need for further action in Section 5.2.

3.0 Groundwater and Fire Water Reservoir Area

This section presents background information on remedial activities conducted for the groundwater in the fire water reservoir area as well as data gaps and proposed investigations to fill these data gaps to properly design the IRM. The first section describes the existing extraction system. Section 3.2 is a summary identified data gaps based on an evaluation of supplemental investigations conducted in the remediation area and the area around the fire water reservoir since 2003. A scope of work for the pre-design investigations that will be undertaken to fill identified data gaps is presented in Section 3.3.

3.1 Existing Groundwater Extraction System

The remedy selected for the fire water reservoir area, as detailed in the Record of Decision (December 1994) is 2-PHASE™ Extraction, which removes both groundwater and vapors from wells. The existing system consists of five extraction wells (EW-1, EW-3, EW-4, MW-2, and MW-31) installed downgradient of the fire water reservoir (Figure 11). The extraction wells are completed at depths of approximately 50 to 65 feet bgs within the “C” zone. Groundwater is removed by the extraction wells using a high efficiency vacuum blower. Extracted groundwater and vapors are piped to an air/water separator to separate the air and water streams which are subsequently treated using activated carbon to remove the VOCs. The air stream is vented to the atmosphere and the treated water is discharged to a permitted outfall located on the western portion of the facility. The system has been operating since July 1996 in accordance with the Operation, Maintenance, and Monitoring Manual dated April 1997, and addendum pages dated July 11, 1997.

The current groundwater recovery system is evaluated based on the results of quarterly and semi-annual sampling events. The sampling events are conducted according to WSP Engineering’s Standard Operating Procedures and all appropriate quality assurance/quality control measures are taken during the events. The most recent quarterly sampling event occurred in December 2007, and the results were presented in the July through December 2007 Semi-Annual 2-PHASE™ Extraction System Progress Report #23. Figures 11 and 12 show the results of groundwater samples collected (semiannually and quarterly) during the reporting period.

3.2 Findings of Supplemental Investigations

A series of supplemental investigations were conducted in the area of the fire water reservoir (remediation area) in August 2003, June 2006, and the fall of 2007 to further evaluate groundwater within the B-zone and C-zone and ascertain the characteristics of the aquifer in these zones. The B-zone work involved installing and sampling B-zone monitoring wells adjacent to the fire water reservoir and within the current remediation area. This work was followed by a series of short duration B-zone pumping tests. The C-zone work involved packer testing, surface and subsurface geophysics, and installation and sampling of exploratory borings within fire water reservoir area and downgradient. The major findings of these investigations are presented below and are as follows:

- a substantial amount of VOC mass is present within the upper portion of B-zone fractured bedrock (10 to 22 feet bgs)
- a horizontal bedding plane fracture zone at approximately 515 feet aMSL in the C-zone is a significant groundwater transport pathway
- the existing extraction system is capturing affected groundwater in the C-zone within the remediation but it can be enhanced to more effectively remove VOC mass in the bedding plane fracture at 515 feet aMSL and the B-zone
- a petroleum product was encountered in one B-zone well(MW-8B) located to the east of the fire water reservoir
- aquifer testing demonstrated that the B-zone aquifer is generally equivalent to a porous media and that there is little to no hydraulic connection between the B- and C- zones at extraction well EW-3 within the remediation area
- the extent of affected groundwater within the B-zone is laterally defined to the northeast and southwest of the remediation area

The data gaps identified based on these investigations are as follows:

- the extent of affected groundwater within the bedding plane fracture (C-zone) to the north, south, and west of the remediation area is not defined
- the extent to which the existing extraction system is capturing affected groundwater throughout the remediation area is uncertain
- the extent of petroleum within the B-zone to the north of MW-8B is uncertain

- the characteristics of the C-zone aquifer throughout the remediation area are uncertain
- additional data is necessary to draw definitive conclusions regarding groundwater quality in the D-zone

Figure 11 shows the results of groundwater and product samples collected during the 2007 Supplemental Remedial Investigation from the fire water reservoir area.

3.3 Proposed Pre-Design Investigations

This section describes the proposed scope of work to fill the data gaps identified above. The work activities will be conducted in accordance with the NYSDEC Draft DER-10 Technical Guidance for Site Investigation and Remediation, dated December 25, 2002, and WSP Engineering's standard operating procedures (SOPs), which were provided to NYSDEC on July 28, 2004 (2004 Supplemental Groundwater Investigation Work Plan). Additionally, all manufacturer specifications will be adhered to for operation and maintenance of field sampling and monitoring equipment.

3.3.1 Exploratory Borings

Two C-zone exploratory borings (EXB-9 and EXB-10) will be installed to further characterize the C-zone bedding plane fractures in bedrock north, south, and west of the fire water reservoir area (Figure 14). The data collected from these borings will be used to determine the horizontal extent of affected groundwater within the C-zone bedding plane fracture. One D-zone exploratory boring (EXB-11) will be installed in an area of affected groundwater downgradient of the fire water reservoir to confirm (as observed in previous investigations) that the lower sections of bedrock remain unaffected by releases from the fire water reservoir. The C-zone borings will be completed to a depth intersecting an elevation of 515 feet aMSL and the D-zone boring will be installed to a depth 50 feet below the 515 foot elevations (465 feet aMSL). C-zone exploratory borings EXB-9 and EXB-10 will be drilled to a depth of approximately 60 feet bgs. The D-zone (EXB-11) exploratory boring will be drilled to a depth of approximately 70 feet bgs. Borings EXB-9 and EXB-10 will be designed to intersect the bedding plane elevation at 515 feet above MSL. EXB-11 will be designed to intersect and evaluate features below the C-zone bedding plane. Each boring will be drilled using 6.25-inch inside-diameter

(ID) hollow-stem augers through the overburden. Continuous soil samples will be collected from the ground surface to refusal at bedrock using 2-foot-long, split-spoon samplers. The soils recovered from the split spoons will be screened for organic vapors in the field using a photoionization detector.

At each boring location, the bedrock will be cored, and each section of rock core recovered will be logged for lithology, structure, and the presence of water conducting fractures or solutional openings. All cuttings removed from the borehole will be screened with a photoionization detector (PID), and samples collected from intervals that exhibit the highest PID reading will be sent to the laboratory for analysis of VOCs. If no PID readings are noted, no soil samples will be submitted to the laboratory. At EXB-9 and EXB-10, a steel casing will be grouted in place within the borehole at the base of the highly fractured ("B") zone to seal it from the C-zone bedrock. At EXB-11, a steel casing will be grouted in place within the borehole at an elevation below the C-zone bedding plane to seal it from the more competent D-zone bedrock. Coring will then continue until the targeted depths have been reached. The Rock Quality Designation of each bedrock core will be measured and recorded in the field logbook. Once the terminal depth of the boring is reached, the borehole will be expanded (reamed) using a 4.25-inch rotary air hammer. The boring will be installed by a driller licensed in the state of New York in accordance with § 15-1525 of the New York Environmental Conservation Law.

The elevation of the ground surface at the exploratory boring locations will be surveyed to the nearest 0.01 foot. The horizontal location of the boring location will also be determined to the nearest 0.1 foot and referenced to the state plane coordinate system. A surveyor licensed in New York State will survey the locations and elevations. The locations and elevations of the borings will be tied into the existing base map for the site.

3.3.1.1 Borehole Development

Each exploratory boring will be developed to remove sediments and ensure effective communication between the borehole and surrounding saturated zones. Groundwater from the borings will be removed by bailing or pumping. Turbidity, pH, temperature, and specific conductance will be periodically monitored during the development process to ensure that representative groundwater is entering the borehole. Development will continue until the discharge is relatively free of suspended sediments. If water is added to the borehole during the drilling activities, an equal volume of water will be removed during well development. Water generated during the well development will be treated at the onsite treatment building.

All development/redevelopment activities will be conducted with clean equipment to prevent potential cross-contamination between well locations. Equipment will be cleaned between each boring with the decontamination procedure dependent on the development/redevelopment method(s) and equipment used.

3.3.1.2 Geophysical Logging

In order to identify and locate horizontal and vertical fracture features within the open sections of each exploratory boring, downhole geophysical logging will be performed. The geophysical scope of work will include video logging and collecting measurements for fluid temperature, fluid conductivity, and borehole diameter (caliper measurements).

3.3.1.2.1 Optical Televiewer

The borehole optical televiewer (OPTV) is a downhole logging device that has the capability of digitally scanning the interior of the open rock borehole. The OPTV will be used to identify, locate, and geologically characterize the horizontal and vertical fracture features within each borehole.

3.3.1.2.2 Fluid Temperature

Fluid temperature will be collected continuously from the top of bedrock to the termination depth of the borehole. Deflections in fluid temperature will be used to locate water producing features within the borehole.

3.3.1.2.3 Caliper Measurements

A caliper tool will be used to measure the borehole diameter and to identify changes in borehole diameter that indicate a potential fracture interval.

3.3.1.3 Vertical Groundwater Profiling

Based on the results of the geophysical logging, selected intervals within each open borehole will be designated for discrete sampling to vertically evaluate groundwater quality. Vertical profiling will be conducted approximately 1-2 weeks following development activities. Before any groundwater samples are collected, the depth to water will be measured in all exploratory borings. After the water levels have been measured, groundwater samples will be collected in accordance with the low-flow sampling SOP in Appendix A. The low flow sampling technique will be designed to discretely sample designated intervals within each exploratory boring to vertically profile the bedrock aquifer. Measurements of temperature, pH, conductivity, dissolved oxygen, turbidity, and redox potential will be continuously monitored during the purging process at each fracture interval. *In situ* parameters will be allowed to stabilize before sample collection begins. All measurements will be recorded in the field notebook or on groundwater monitoring forms.

Samples will be collected, handled, preserved, and transported in accordance with WSP SOPs. The samples will be placed in pre-cleaned and, if appropriate, pre-preserved sample containers. The samples will be placed in a cooler with ice and delivered to the laboratory with the appropriate chain-of-custody documentation. The groundwater samples will be submitted to the laboratory for analysis of VOCs using U.S. Environmental Protection Agency (EPA) Method 8260. Quality assurance/quality control (QA/QC) samples, including equipment blanks, trip blanks, and duplicates, will be collected in accordance with the SOPs.

3.3.2 Aquifer Testing

Following the delineation of affected groundwater, a series of short duration aquifer tests will be conducted to evaluate the hydraulic properties of the C-zone bedding plane fracture and to demonstrate that affected groundwater will be contained by the upgraded groundwater extraction system. The final number and configuration of the IRM extraction wells will be based on the results of the supplemental groundwater investigation and aquifer testing. In order to evaluate the hydraulic characteristics of the 515-foot bedding plane fracture necessary to design the IRM system upgrades, a constant rate pumping test will be conducted. The pumping test will be focused on exploratory borings that intersect the 515-foot bedding plane fracture within and downgradient of the current remediation area. The proposed field activities will be conducted in accordance with the NYSDEC Draft DER-10 Technical Guidance for Site Investigation and Remediation, dated December 25, 2002.

The aquifer tests will be designed to record the rate and magnitude of drawdown and recovery of hydraulic head in the "C" zone unit under pumping conditions. The aquifer parameters to be measured include aquifer transmissivity, specific yield, hydraulic boundary conditions, and concentrations of chemical constituents. The data will be used to:

- determine the radius of influence at a constant pumping rate ("C" zone)
- determine the hydraulic conductivity and transmissivity ("C" zone)

- determine the extent of hydraulic communication (leakance) between the upper and lower zones of fractured bedrock (“B” and “C” zones)
- determine the extent of hydraulic communication between wells within each groundwater zone
- determine number, location and depth of additional extraction wells (“C” zone) to enhance groundwater capture
- calculate groundwater extraction rate (“C” zone)
- calculate anticipated additional chemical loading to existing treatment system associated with enhanced groundwater recovery system (“C” zone)

All field activities will be performed under the direction of WSP Environment & Energy and WSP Engineering of New York. The site-specific safety requirements in the Health and Safety Plan will be amended to include the pumping test, and this amended plan will be followed during the performance of the test.

3.3.2.1 Extraction Well Installation Methods

Exploratory boring EXB-6, which was drilled, logged, and sampled as part of the 2007 Supplemental Remedial Investigation field activities, will be used for the purpose of conducting the pre-design pumping test. Exploratory boring EXB-6 is located within the southern portion of the current remediation area. Based on observations made during downhole logging, a prominent vertical joint with trace mineralization was observed at EXB-6 from 24 to 32.5 feet bgs. Additional high-angle fractures were observed from approximately 38.5 to 40 feet bgs. A prominent bedding plane parallel fracture and associated borehole diameter increase was identified at 46.25 feet BTOC (516 feet aMSL) that directly correlates to the open bedding plane fracture identified elsewhere in the remediation area and around the fire water reservoir. The water level at the time of the borehole geophysical logging was 30.34 feet BTOC. Because of the wide open nature of the bedding plane fracture and the prominent vertical joint, EXB-6 is the most appropriate boring for aquifer testing. The location of the proposed pumping test extraction well is shown in Figure 14.

3.3.2.2 Water Level Monitoring

Procedures and methods to be used during each phase of the aquifer testing are described below. The aquifer testing will consist of four phases in the following order:

- background water level monitoring (24 hours – "B" and "C" zones)
- step-drawdown test (estimated 3 steps – "C" zone)
- constant-rate pumping test (24 to 72 hours – "C" zone)

Based on the average pumping rate of the existing extraction system (0.4 gallons per minute [gpm]), an electric submersible pump that is capable of pumping at rates between 0.1 gpm to 5 gpm will be used to ensure adequate capability to stress the aquifer system.

3.3.2.3 Background Water Level Monitoring

The extraction system will be shut down for a minimum of 2 weeks prior to aquifer testing to attain static (non-pumping) conditions in the groundwater system. Water level data will be collected from exploratory borings and extraction wells that intersect the C-zone bedding plane fracture. Select B-zone monitoring wells will also be monitored. The wells proposed for monitoring during aquifer testing are shown in Figure 14 and include the following locations:

- existing extraction wells EW-1, EW-2, and EW-3, each of which intersect the C-zone bedding plane fracture
- existing exploratory borings EXB-2, EXB-5, and EXB-7
- existing exploratory boring EXB-6 will be used as the extraction well during both the constant rate test and the drawdown test
- proposed exploratory borings EXB-9, EXB-10, and EXB-11 (D-zone); this assumes the bedding plane fracture is observed at these locations
- existing B-zone monitoring well MW-5B, and MW-32B

Changes in atmospheric pressure can have a detectable effect on water levels in aquifers and monitoring wells. To assess the relationship between atmospheric pressure and water levels, both will be monitored for a 24-hour time period prior to aquifer testing. Static water levels will be measured at 15-minute intervals in the EXB-5, EXB-6, EXB-7, and MW-5B using pressure transducers and recorded in an electronic data logger. The atmospheric pressure will be measured and recorded. The data collected during the background monitoring period will be used to establish a correction curve for each monitoring/extraction well to remove the effect of atmospheric pressure during the aquifer tests. One additional manual round of water level measurements will be collected before starting the aquifer tests.

3.3.2.4 Step-Drawdown Testing

A step-drawdown test will be conducted by applying incremental flow rates on the extraction well (EXB-6) and measuring the corresponding groundwater elevation at each flow rate. The objective of the step testing is to determine the range of sustainable pumping rates, from which an appropriate rate can be selected for the constant-rate pumping test. It is anticipated that three to five incremental steps will be required to determine the maximum sustainable flow rate.

The pumping rate will be regulated by using a variable-speed submersible groundwater pump. The discharge rate from the extraction well will be monitored throughout the test using an in-line flow meter (or equivalent) to ensure there are no erratic fluctuations. Based on these readings, an average extraction rate will be maintained throughout the pumping phase of the test. Groundwater generated during the pumping test will be piped to the onsite treatment system.

3.3.2.5 Constant-Rate Pumping Test

The constant-rate pumping test will begin following the step-drawdown test and will consist of extracting groundwater at the optimum discharge rate, as determined during the step-drawdown test, from extraction well EXB-6. Pumping will occur continuously for a minimum of 24 hours. If practical, the test will be extended for up to 72 hours to collect the maximum amount of pumping test data. The discharge rate from the extraction well will be monitored throughout the drawdown portion of the test using an in-line flow meter to ensure there are no erratic fluctuations in the well discharge. Based on these readings, a constant extraction rate will be maintained throughout the pumping phase of the test.

Existing/proposed extraction wells and monitoring wells (EW-1, EW-2, EW-3, EXB-2, EXB-5, EXB-7, EXB-9, EXB-10, EXB-11, MW-5B, and MW-32B) will be used as observation wells during the constant rate pumping test. Water levels will be recorded at these 11 observation wells and the pumping well EXB-6 using data logging pressure transducers. The pressure transducers will be programmed to collect water levels on a logarithmic scale, which allows for more rapid data collection at the beginning of the test, when testing intervals are critical and less frequent data collection near the end of the test. The maximum time interval between data points will be 30 minutes. Manual groundwater measurements will also be made before, during, and after the test to ensure that the transducer measurements are representative of actual conditions. Barometric pressure data will also be recorded during each pumping step.

Water level data will be measured in the same manner as the step-drawdown test and confirmed with manual water level measurements. Water level recovery data will be measured at the extraction well and observations wells immediately after completion of the drawdown portion of the test. The recovery portion of the test will continue for approximately 12 to 24 hours or until the water level in the extraction well sufficiently recovers to the non-pumping level. Barometric pressure will be recorded throughout the constant-rate pumping and recovery tests.

The 11 observation wells included in the constant-rate and recovery tests include two monitoring wells (MW-5B and MW-32B) screened in the highly fractured “B” zone and nine exploratory boring that are or will be cased through the “A” and “B” zones and open boreholes within the “C” zone bedding plane fracture at 515 feet aMSL.

3.3.2.6 Discharge Sampling and Analysis

At two times during the constant rate pumping test, groundwater samples will be collected from the pumping well discharge. The samples will be analyzed for VOCs using EPA Method 8260, total and dissolved metals using EPA Method 6010/7470, hardness, alkalinity, total dissolved solids, total suspended solids, pH, chemical oxygen demand, and biochemical oxygen demand. The sample results will be used to determine the treatment system design upgrades and sizing.

3.3.2.7 Analysis of Pumping Test Data

The background monitoring data collected before conducting the constant-rate test will be used to evaluate the barometric pressure effects in the observation wells. Water level data collected during the constant-rate pumping test will be analyzed to determine the hydraulic characteristics of the “C” zone bedding plane fracture. The drawdown data from the constant-rate pumping test will be evaluated using a single fracture model (Gringarten 1972) and a double porosity model (Moench 1984). The method used to analyze the drawdown data is based on the following assumptions concerning the aquifer properties and test set-up:

- aquifer has infinite areal extent
- aquifer has uniform thickness
- aquifer potentiometric surface is initially horizontal
- pumping and observation wells are fully penetrating
- pumping rate is constant

- fractured aquifer represented by double porosity system consisting of low-permeability, primary porosity blocks and high-permeability, secondary porosity fissures
- matrix consists of slab-shaped or spherical blocks
- flow is unsteady
- water is released instantaneously from storage with decline of hydraulic head

Estimated values for hydraulic conductivity (K) and transmissivity (T) of the "C" zone bedding plane fracture will be determined. Hydraulic conductivity will be calculated by dividing the transmissivity obtained from the selected solution method by the thickness of the fractured unit at the extraction well or observation well locations. The aquifer parameter estimates and other hydrogeologic data for the site will be used to determine the capture zone for extraction well EXB-6. The capture zone for a pumping well represents the hydraulically upgradient area that provides inflow to the well. The technical approach that will be used to estimate the capture zone involves determining the boundaries of the portion of the aquifer producing inflow at an infinite time (i.e., steady-state groundwater flow condition). This approach assumes a constant pumping rate for the well.

The recovery data will be analyzed using the Theis Recovery Method (Theis 1935). The Theis Recovery Method is widely used for the analysis of recovery data in confined, leaky, and unconfined aquifers. Hydraulic conductivity calculated by the Theis Recovery Method will provide an independent check on analysis of the constant-rate pumping test.

3.4 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements, the application of which ensures that data generated during the fire water reservoir investigation are adequate to support the objectives of the work plan. DQOs are based on the intended use of the data and are specified for each data collection activity. Chemical analyses of groundwater will be performed in accordance with Analytical Level III requirements. Field measurements will be conducted in accordance with Analytical Level I requirements.

4.0 Scope of Interim Remedial Measure for Groundwater and Fire Water Reservoir

This section addresses the proposed IRM for enhancing the existing groundwater extraction system and extracting groundwater from the B-zone and C-zone immediately beneath the fire water reservoir at EPT facility. The IRM for groundwater and the fire water reservoir includes the redesign of selected existing extraction wells and the installation of new extraction wells. Both tasks require appropriate mobilization and site preparation activities before work can commence. Upon completion of the IRM, the site will be restored to pre-existing conditions and equipment will be demobilized from the site. The following sections detail the tasks of the proposed IRM for groundwater and the fire water reservoir.

4.1 Mobilization and Site Preparation

Site preparation work will involve mobilizing resources to the site, establishing proper controls, constructing staging areas, and verifying the locations of underground utilities. The site preparation activities are summarized below.

4.1.1 Site Preparation

Prior to mobilization, the selected contractor will be required to submit any necessary Site Management Plan, Site-Specific Health and Safety Plan (HASP), and an Emergency Preparedness and Contingency Plan, as specified by WSP Engineering. The selected contractor will mobilize all equipment and supplies necessary to complete the activities associated with the IRM. Upon arrival at the site, the contractor will participate in a Pre-Construction meeting with the Project Manager, Projector Director, and any other appropriate field personnel or interested parties. The Pre-Construction meeting will detail the schedule of operations and resolve any issues raised by attending parties.

Support facilities are present onsite and include a groundwater treatment system/building, sanitary facilities, electric power, and water. The staging and decontamination areas, as well as the exclusion zone, will be established once personnel have arrived onsite and prior to beginning construction. Any necessary erosion control measures or temporary water collection areas will be identified. Temporary fencing and warning signs will be installed around all areas to prevent unauthorized access during periods of inactivity. Access will be restricted by EPT facility personnel within the buildings when construction occurs inside. Continuous 24-hour surveillance is not considered necessary because the facility has an active security plan in place.

In accordance with WSP Engineering's SOPs, steps must be taken to address underground utilities. Prior to beginning any work, Dig Safely New York will be contacted to mark all underground utilities entering the site. A private utility locator will be contracted to mark underground utilities on the facility property. Historical plant utility drawings will be consulted to determine the locations of underground utilities when necessary. Identified utilities shall be protected or relocated.

4.1.2 Health and Safety

All work will be conducted in accordance with the project-specific HASP. This plan will apply to WSP Engineering site personnel only. Subcontractors retained to complete the work will be required to adhere to a separate HASP that is substantially consistent with WSP Engineering's HASP and is commensurate with the work and activities that will be completed by the subcontractor. The subcontractor's HASP will be submitted to WSP Engineering for review prior to initiating field work.

The HASP will outline emergency preparedness procedures and identify all hazards associated with the construction activities. WSP Engineering's HASP must be reviewed and signed by all onsite WSP Engineering personnel. Routine health and safety briefings will be held. Prior to beginning work each day, a health and safety tailgate meeting will be conducted by the onsite safety coordinator for the project team and subcontractor personnel. Personnel from Emerson will also be informed of health and safety requirements, as appropriate.

4.1.3 Orientation of Field Personnel

Field personnel will review the HASP before mobilizing to the site. Once onsite, field personnel orientation will consist of an onsite project briefing for each field team member to review health and safety requirements, quality assurance/quality control protocols, and field procedures. A Pre-Construction meeting will be held with retained subcontractors to clarify all project tasks. In addition, field personnel and subcontractors involved in field activities will participate in onsite daily briefings before beginning fieldwork to outline tasks and goals for the day.

4.1.4 Permits and Approvals

Prior to conducting fieldwork, all potentially applicable State and local codes and regulations will be reviewed to determine the permitting requirements for implementation of the IRM Work Plan. Any necessary permits will be obtained accordingly.

The governing bodies that may require permits are the City of Ithaca, New York, Tompkins County, and New York State. Necessary permits could include, but are not limited to, building permits, well installation permits, and modifying existing discharge permits.

4.2 Description of Groundwater and Fire Water Reservoir IRM

Emerson proposes to enhance the existing groundwater extraction system by incorporating additional extraction wells located below the fire water reservoir and within the remediation area downgradient of the fire water reservoir. The final design will be based on the results of the aquifer testing described in section 3.3.2. The proposed extraction well network includes reconfiguring three existing extraction wells (EW-1, EW-2, and EW-3) and constructing three new extraction wells in existing borings EXB-5, EXB-6, and EXB-8 (note that EXB-8 is an angled boring that will be used to extract groundwater from the bedding plane fracture below the reservoir). In addition, three wells (MW-3-31, MW-2, and EW-4) that are part of the existing treatment system will be taken offline. The enhanced system will be designed to intercept contaminated groundwater flow from the highly fractured and interconnected bedrock (B-zone) and from the horizontal bedding plane fractures at the base of the C-zone between 515 and 518 feet aMSL.

The placement of extraction wells will be based on the results of the B-zone pumping tests, bedding plane fracture investigation from the SRI, the proposed pre-design work in Section 3.3, and the ability of the extraction wells to achieve the goals of hydraulic control and enhance/maximize mass removal All groundwater extracted by the B-zone and C-zone extraction wells will be treated by the onsite treatment system, which will be replaced in its entirety to properly treat the additional groundwater.

The proposed treatment system will involve pumping and treating groundwater onsite as well as removing vapors from the extraction wells for subsequent onsite treatment, if required. A dual-phase extraction treatment system will be implemented to remove and treat both aqueous and vapor phase VOC mass loadings. The system utilizes a network of extraction wells; piping for groundwater, vapor, and air conveyance; and vapor and aqueous treatment equipment.

4.2.1 New Extraction Wells

The proposed extraction wells are designed to focus remediation within the highly fractured B-zone and the C-zone horizontal bedding plane fractures between 515 and 518 feet aMSL. Based on the results of previous aquifer testing activities conducted at the facility, a minimum of four additional B-zone extraction wells spaced at 20 foot centers are planned for the current remediation area. These four wells will be installed to a depth of 20 to 25 feet bgs. As for the C-zone, one angled extraction well will be completed within existing directional borehole at EXB-8 to target the zone beneath the fire water reservoir, approximately 80 feet bgs. Exploratory borings EXB-5 and EXB-6 are existing boreholes that extend to approximately 60 feet bgs. EXB-5 and EXB-6 will also have extraction wells installed within the boreholes to target the bedding plane fractures between 515 and 518 feet aMSL. Three extraction wells from the existing treatment system, EW-1, EW-2, and EW-3, will be reconfigured to focus on the bedding plane fractures between 515 and 518 feet aMSL. Three existing extraction wells, EW-4, MW-2, and MW-3-31, will be abandoned because they are not efficient extraction points. Figure 15 shows the planned B-zone and horizontal bedding plane fracture (C-zone) extraction wells. Depending on the pre-design evaluation described in Section 3.3, potentially three additional exploratory borings may be converted to extraction points. In summary, the enhanced system is anticipated to comprise 10 to 12 extraction wells. Based on previous aquifer test results and historic system performance data, an extraction rate of 0.5 gpm per extraction well is anticipated. The extraction rate may be revised following completion of pre-design activities. The total design flow for the system is anticipated to be from 5 to 15 gpm, which allows for the addition of extraction wells following the pre-design evaluation. It is anticipated that the enhanced groundwater extraction system will result in an increased mass removal which will require upgrades to the current groundwater treatment system as detailed in section 4.2.5.

The proposed B-zone and C-zone extraction wells will be constructed of 2-inch or 4-inch diameter Type 304 stainless steel risers and screens, depending on pre-design work. Each extraction well will be installed to the depths described to target either the highly fractured bedrock (B-zone) or the C-zone bedding place fractures between 515 and 518 feet aMSL. The bedrock will be cored so that the quantity of fractures and the physical characteristics of the fractures can be logged. Within the B-zone, the screened interval and final depth of the extraction wells will depend on the quantity of fractures encountered. The boreholes will be terminated as the quantity of fractures begins to diminish with depth or at a maximum depth of 25 feet bgs. Once the terminal depth of the extraction well is determined, the borehole for the well will be expanded (reamed) using a 4.25-inch rotary air hammer. The horizontal bedding plane fracture wells will be installed and screened to focus on the 515 to 518 feet aMSL fractures.

The well screen for each extraction will be wire-wrapped screen with 0.01-inch slot size and 5 to 10 feet in length. A clean sand filter pack will be placed from the bottom of the well borehole to approximately 2 feet above the top of the screen. A 3-foot-thick bentonite seal will then be placed on top of the sand filter pack. The remaining annular space will be backfilled with a cement-bentonite grout mixture (tremie piped from the bottom to the top).

The extraction wells will be completed as 3 foot threaded stick up wells for the construction of wellhead vaults to be installed.

Drill cuttings and water generated during extraction well installation will be contained in Department of Transportation-approved, 55-gallon steel drums. The drums will be labeled and moved to an onsite staging area. Soil cuttings will be characterized for offsite disposal. Water generated during well installation will be added to the onsite groundwater treatment system. All investigative-derived waste (soil) will be sampled and analyzed for disposal characterization, the disposal methods for which will be contingent on analytical data and consistent with state and federal law. Used protective clothing and equipment will be managed in a manner consistent with the EPA Guidance Document, Management of Investigative Derived Waste during Site Inspections (May 1991), OERR 9345.3-02.

All drilling activities will be conducted using clean equipment. Split-spoon samplers will be decontaminated in accordance with WSP Engineering’s SOPs (decontamination procedures). The drilling equipment (augers and rods) will be decontaminated using a portable steam cleaner. All decontamination fluids generated during the drilling activities will be contained in 55-gallon steel drums and will be managed in the same manner as water generated during the well installation.

The elevations of the ground surface at each new extraction well and the top of the well casing will be surveyed to the nearest 0.01-foot. The horizontal locations of the new wells will also be determined to the nearest 0.1 foot and referenced to the state plane coordinate system. A surveyor licensed in New York State will survey the well location and elevations. The locations and elevations of the wells will be tied into the existing base map for the site. A boring log will be prepared for the extraction well borehole after completion of the field activities.

The extraction wells will be developed 24 hours after installation to remove sediments and to ensure effective communication between the well screen and surrounding saturated zone. The well will be developed by surging the screened interval to loosen any fine-grained sediment in the sand filter pack and adjacent aquifer material. Groundwater will then be removed by bailing or pumping. Development will continue until the discharge is relatively free of suspended sediments. If water is added to the well borehole during the drilling and installation activities, an equal volume of water will be removed during development. Water generated during the well development will be collected in drums and added to the onsite groundwater treatment system.

All development activities will be conducted with clean equipment to prevent potential cross-contamination between well locations. Equipment will be cleaned between each well, with the decontamination procedure dependent on the development and redevelopment method(s) and equipment used.

4.2.2 Extraction Well Pumps

Bottom-inlet, controller-less, pneumatic pumps will be installed in each extraction well to recover groundwater. These pumps do not require controllers, timers, or down-well probes to regulate pumping cycles in response to well yield, which will ease operational requirements. The pneumatic pumps would operate only when there is sufficient water in the extraction well to pump. A unique pneumatic pump will be required for the angled extraction well at boring location EXB-8 in order to effectively operate at this angle.

A rotary air compressor will supply pressurized air to the pneumatic pumps. The compressor will be housed in the treatment building and will be capable of supplying air at sufficient pressure to drive all of the operating pneumatic pumps simultaneously. The compressor will be sized to appropriately accommodate the exact number of wells in the system, and will include room for expansion. Both the compressor and the air supply lines will be sized to maximize air conveyance and minimize the total pressure head required to maintain adequate system pressure to actuate the pumps. Therefore, the pipe diameters may vary depending on site-specific factors, such as distance from the treatment building. A refrigerated cooler/dryer, automatic condensate separator, particulate filter, solenoid valve, and pressure and temperature indicators will be plumbed into the air supply system to protect the air supply lines and groundwater extraction pumps.

The air supply connection at each well head will be equipped with a pressure indicator/regulator to regulate the air pressure and prevent over pressurization of the pump and a ball valve for on/off flow control. The water discharge line at each well head will also be equipped with a ball valve for on/off flow control. The specific pumps and components will be specified based on pre-design activities.

4.2.3 Extraction Well Vaults

Each extraction well head will be housed in a pre-fabricated, locking, aboveground well vault. The pipe headers will run through the well head vault and will connect to the well head by tubing or galvanized steel laterals. Each well vault will be sealed watertight.

The water line piping in each well vault will be connected to the water discharge header within each vault. A gate valve will be installed on each water line piping for flow control and isolation. Down well air supply piping will also be connected to the header in the same manner with a ball valve on the piping.

A vacuum will be applied to the extraction well head to draw soil gas vapors from within the encased well. The amount of vacuum necessary will be determined during pre-design activities. Extracted vapors will be conveyed from the extraction well to the vapor header line by a lateral pipe teed off the extraction well head. Flow from the lateral will be regulated with a butterfly valve and a vacuum relief valve. A vacuum gauge will be installed at each extraction well head. Vacuum relief valves will also be installed at the well head to prevent excessive groundwater upwelling.

In order to maintain the water discharge line (rehabilitate clogged piping), pipe cleanouts will be installed on water conveyance headers at selected vaults to allow removal of sediment or debris within the pipes and fittings.

4.2.4 Conveyance Lines

The water discharge, air conveyance, and vapor extraction lines will be sized to maximize in-pipe velocities and minimize the total dynamic head required for conveyance to and from the treatment building. Therefore, the pipe diameters may vary depending on location. All piping will be run aboveground and will be heat traced and insulated to withstand weather conditions.

The down well tubing at each extraction well may consist of a water discharge tube, air supply tube, and air exhaust tube. The air exhaust tube is required to operate the pneumatic pump and will be discharged to the atmosphere within the extraction well vault. The down well tubing, if used instead of hard piping, will be sized to appropriately fit the selected pump's requirements.

4.2.5 Treatment System Upgrades

Based on an estimated extraction rate of 0.5 gpm per well, the total estimated extraction rate is 5 gpm (10 wells). However, the treatment system upgrades will be designed to treat up to 15 gpm. As described, an aqueous phase, and a vapor phase will be conveyed to the treatment building via aboveground piping. The existing onsite treatment building onsite will be utilized to house the new treatment equipment. In addition, the existing discharge outlet will continue to operate under a State Pollutant Discharge Elimination System (SPDES) permit that will be revised, as appropriate. WSP Engineering will contact the NYSDEC to determine if the SPDES permit will need to be modified based on the proposed changes to the remediation system. Groundwater will be conveyed into an equalization tank within the treatment building. The equalization tank will minimize downstream cycling of system components by providing a reservoir of water to be treated. The vessel will be sized to accommodate system flow and allow for potential upgrades to the system.

Groundwater will be pumped from the equalization tank through a series of bag filters to remove particulates and sediments before it is treated. The removal of dissolved VOCs will be facilitated using liquid-phase granular activated carbon (GAC) in vessels that are appropriately sized to accommodate flow and minimize the frequency of change out. It is anticipated that 500 or 1,000-pound carbon vessels will be used. There will be three vessels available within the treatment building. Two GAC vessels will operate in series to minimize the potential for breakthrough. When breakthrough is apparent in effluent samples from the first GAC unit, the second unit will replace the first unit and the third carbon vessel will be brought online for polishing. The change-out of GAC units will be subcontracted appropriately, and spent carbon will be disposed of properly. Treated effluent will leave the treatment building through the existing discharge point.

The treatment building will also house an appropriately sized vacuum blower able to provide adequate vacuum to the extraction wells to remove vapor from the subsurface. The blower will be sized to accommodate the proposed network of extraction wells, as well as expansion of the system.

The vapor phase stream will be conveyed from the well heads to a gas-liquid separator prior to any vapor phase treatment or discharge. Liquids that are removed from the vapor stream will be transferred to the equalization tank for treatment with the aqueous phase treatment train. Separated vapor will be either treated or discharged, based on pre-design activities.

Based on mass loading air permit discharge requirements, the other treatment train within the treatment building may include a vapor phase. The vapor removed from extraction wells will also be conveyed to the treatment building through above ground piping. The vapor will be treated with a vapor-phase GAC unit, if required. Depending on permit requirements, one GAC unit may be kept in the treatment building on reserve to facilitate the ease of changing the units without disrupting system operation. An air permit is not required for the existing groundwater remediation system because this emission source is considered a trivial activity under Title 6, New York Codes, Rules, and Regulations (NYCRR), 201.3.3(c)(29). It is our understanding that the proposed modified system will not need an air permit; however, the air emissions are required to meet applicable air quality standards. Therefore, WSP will calculate the potential air emissions from the modified system to verify that it meets all applicable standards.

4.2.6 Performance Evaluation

Evaluating the performance of the groundwater extraction system will involve scheduled groundwater and vapor sampling events. An initial round of groundwater samples will be collected from the extraction wells to establish baseline conditions followed by annual sampling thereafter. In addition, a network of wells will be sampled semi-annually to monitor site conditions. The network of monitoring wells will be determined based on the locations of the new extraction wells. The sampling program will be conducted according to WSP Engineering’s SOPs, including all quality assurance/quality control protocols. All purge water will be run through the onsite treatment system. All disposable sampling equipment will be disposed of appropriately.

In addition to groundwater sampling, monthly effluent discharge samples of both water and vapor will be collected from discharge points in the treatment building. These samples will be used to ensure all discharges remain within permitted discharge requirements.

Results from the sampling program will be summarized in progress reports and presented to the NYSDEC. An Operation, Maintenance and Monitoring plan will be prepared for the upgraded system.

4.3 Potential Treatment Technologies for Below Fire Water Reservoir

WSP has identified six possible *in situ* treatment technologies to be utilized in conjunction with the expanded groundwater extraction system to enhance VOC mass reduction in area below the fire water reservoir. The following *in situ* treatment alternatives will be evaluated for application at the base of the reservoir:

- air sparging with vapor extraction
- dual phase extraction
- *in situ* bioremediation/bioaugmentation
- *in situ* chemical oxidation (ISCO)
- zero valent iron
- steam injection with vapor recovery

A preliminary screening will be conducted of each technology with respect to feasibility, implementability, and effectiveness in achieving remedial objectives for groundwater to narrow the technology list. Based on this evaluation, one or more alternatives will be selected for bench and/or pilot testing. A work plan for the pilot test will be prepared describing the scope of work for the pilot test and include appropriate sampling procedures. The work plan for the pilot test will be submitted to the NYSDEC following implementation of the groundwater IRM to incorporate initial performance results.

5.0 Actions to Address Vapor Intrusion - EPT Facility

This section describes the actions that will be undertaken to address the potential for vapor intrusion into the EPT facility. First is a description of the construction of the EPT facility and the current use and operations in select buildings. This is followed by a summary of results of the indoor air and sub-slab soil gas sampling previously conducted in the EPT facility. Areas where VOC concentrations were detected above the New York State Department of Health (NYSDOH) Matrix guidance values are identified. The final section describes the proposed actions to address building areas where there is a potential for exposure to VOC vapors as a result of vapor intrusion.

5.1 EPT Buildings and Sampling Activities

The EPT facility consists of three main buildings that encompass approximately 800,000 square feet and are divided into separate structures, all terraced on three levels (basement, main, and upper). The lowest level of each building is constructed on grade (highlighted on Figure 16). Approximately 500,000 square feet are used for manufacturing, 200,000 square feet are vacant or used for storage (generally basement areas), and approximately 100,000 square feet are leased for storage of miscellaneous equipment and office furniture.

The basement or lower level consists of Buildings 1 through 6A, 33, and 34, all of which are constructed on grade. On the main level is the second level of the same buildings and a series of buildings constructed on grade to the east (Buildings 11A, 10A, 9, 8, 6A, 33, and 34). The upper level (buildings 13, 14, and 35) is entirely slab on grade. Building 24 is a free standing building located off the northeast corner of the main buildings (Figure 16).

A description of the current use and operations in the facility buildings of potential concern for vapor intrusion are listed below.

Basement Level

- Building 3 is not in active use. It is accessed on a limited basis by maintenance staff and to access other portions of the lower level.
- Building 4 is accessed on a limited basis by maintenance staff and for accessing other portions of the lower level. Storage tanks and an associated coolant recovery system are housed in this building. Maintenance personnel inspect the

system several times each working day and may be present for periods of 15-30 minutes. There is a quality assurance laboratory in Building 4 which has a separate air handling system from the remainder of Building 4. The laboratory is occupied for an 8-hour shift each working day.

- Building 6A is the location of an assembly area. It is occupied for at least one 8-hour shift per working day.
- Building 33 is used for storage. This building is occasionally accessed by maintenance staff.
- Building 34 houses a machine shop. The building is occupied for at least one 8-hour shift per working day.

Main Level

- Building 8 is used for storing parts. This building is accessed periodically during 8-hour work-shifts typically for 15 - 30 minutes at a time.
- Building 10 houses manufacturing operations. It is occupied for at least one 8-hour shift per working day.

Building 24- Stand Alone Building

- Building 24 is a free-standing building consisting of five levels. The basement and first levels are partial levels terraced into the hillside while the upper three levels (levels 2 through 4) are full floors above the first level. The basement and first levels of Building 24 are used for storage by the Paleontological Research Institute (PRI) under an agreement with EPT. The space is infrequently accessed (less than 1 hour per week) by PRI personnel to retrieve stored materials and by EPT maintenance and security personnel. The second (main) level was used for offices and storage by Cornell University; however, their lease has been terminated and this level is now vacant. The third level is leased to a non-profit organization and is occupied during weekdays. The fourth level is vacant.

An indoor air assessment was conducted in the EPT facility to evaluate whether VOCs were potentially affecting sub-slab soil gas and indoor air quality within the buildings. Two sampling events were conducted; one in December 2005 and the second in February 2006. In December 2005, concurrent indoor air and sub-slab soil gas samples were collected at 21 locations within the EPT facility where the construction is slab on grade (Figure16). In February 2006, indoor air samples were collected in four buildings (Buildings 3, 4, 24, and 33) to verify the initial sampling results. The testing activities were conducted in accordance with a work plan, dated November 8, 2005, which was approved by the NYSDOH.

Results of the testing identified eight areas within the EPT facility where vapor intrusion is a potential concern. These include the lowest levels within the following portions of the facility: Building 3, Building 4, Building 6A, Building 8, Building 10, Building 33, Building 34, and Building 24.

In addition to the above testing, soil borings were installed and soil samples collected in Buildings 3, 8, 24, and 34 as part of the supplemental remedial investigation. No VOCs other than methylene chloride were detected at concentrations above the respective laboratory reporting limits in any of the soil samples. Methylene chloride concentrations were all below the NYSDEC Restricted Use SCOs for protection of public health at industrial facilities.

5.2 Proposed Actions to Address Potential Vapor Intrusion

The actions proposed to address potential concerns related to vapor intrusion in the EPT facility are discussed below. Proposed actions are provided for each building along with the rationale.

5.2.1 Lowest Level

Building 3

Building 3 is not in current use. It is accessed only by maintenance personnel and by a limited number of employees to access other portions of the lower level. Results for two indoor air samples collected in this building showed TCE at 5.84 micrograms per cubic meter ($\mu g/m^3$) and 3.88 $\mu g/m^3$.

Actions to be undertaken in Building 3 consist of conducting an inspection for cracks and penetrations in the concrete slab, walls, sumps, and where pipes and wires extend through the foundations and concrete slab. Cracks and penetrations larger than the approximate width of a quarter (1/16th of an inch) will be sealed using elastomeric joint sealant, compatible caulks, non-shrink mortar, grouts, expanding foam, drain seals, or airtight gaskets. The specific type of material used and the appropriate method for sealing will depend on the size and orientation of the crack/penetration as determined by the engineer performing the inspection. Repairs of cracks/penetrations that cannot be properly sealed may consist of the removal and replacement of a section of the concrete floor encompassing the crack/penetration. This determination will be made under the direction of a licensed professional engineer. After the actions above have been performed, indoor air samples will be collected to assess the effectiveness of these engineering control measures on indoor air quality (see Section 5.3).

Inspections will be conducted on an annual basis to assess the condition of previously repaired cracks and penetrations and to determine if there are any newly formed cracks or penetrations. The nature and scope of repairs to be made to any cracks and penetrations identified will be determined by the engineer performing the inspection.

In addition, a health and safety plan will be prepared for maintenance staff needing to access Building 3 to perform maintenance activities lasting more than 15 minutes. The plan will identify measures that must be undertaken during such events which include engineering controls (use of fans and providing makeup air). Employees will be required to sign the plan and document the access (day, time in and out) and indicate engineering controls utilized.

Building 4

Building 4 is accessed on a limited basis by maintenance staff and for accessing other portions of the lowest level. Concentrations of TCE in indoor air samples collected in this building ranged from 5.35 $\mu g/m^3$ to 12.8 $\mu g/m^3$. There is also a quality assurance laboratory in Building 4 with a separate air handling system.

Actions to be undertaken in Building 4 consist of conducting an inspection for cracks and penetrations in the concrete slab, walls, sumps, and where pipes and wires extend through the foundations and concrete slab. Cracks and penetrations larger than the approximate width of a quarter (1/16th of an inch) will be sealed using elastomeric joint sealant, compatible caulks, non-shrink mortar, grouts, expanding foam, drain seals, or airtight gaskets. The specific type of material used and the appropriate method for sealing will depend on the size and orientation of the crack/penetration as determined by the engineer performing the inspection. Repairs of cracks/penetrations that cannot be properly sealed may consist of the removal and replacement of a section of the concrete floor encompassing the crack/penetration. This determination will be made under the direction of a licensed professional engineer. After the actions above have been performed, indoor air samples will be collected to assess the effectiveness of these engineering control measures on indoor air quality (see Section 5.3).

Inspections will be conducted on an annual basis to assess the condition of previously repaired cracks and penetrations and to determine if there are any newly formed cracks or penetrations. The nature and scope of repairs to be made to any cracks and penetrations identified will be determined by the engineer performing the inspection.

In the quality assurance laboratory, indoor air sampling will be conducted after the engineering controls described above have been implemented to ascertain VOC concentrations. If the sample results indicate a potential concern for exposure to VOCs, the laboratory will be moved to another location in the building or an evaluation of the air handling system will be conducted to determine what enhancements can be made to improve air flow. Also, the floor in the quality assurance laboratory will be assessed for cracks or penetrations and sealed in the same manner as described above.

Building 6A

Building 6A houses an assembly area. One indoor air sample was collected in the lower level of this building in December 2005. TCE was detected at a concentration of 1.26 $\mu g/m^3$ in the indoor air. Actions to be undertaken in Building 6A consist of conducting an inspection for cracks and penetrations in the concrete slab, walls, sumps, and where pipes and wires extend through the foundations and concrete slab. Cracks and penetrations larger than the approximate width of a quarter (1/16th of an inch) will be sealed using elastomeric joint sealant, compatible caulks, non-shrink mortar, grouts, expanding foam, drain seals, or airtight gaskets. The specific type of material used and the appropriate method for sealing will depend on the size and orientation of the crack/penetration as determined by the engineer performing the inspection. Repairs of cracks/penetrations that cannot be properly sealed may consist of the removal and replacement of a section of the concrete floor encompassing the crack/penetration. This determination will be made under the direction of a licensed professional engineer. After the actions above have been performed, indoor air samples will be collected to assess the effectiveness of these engineering control measures on indoor air quality (see Section 5.3).

Inspections will be conducted on an annual basis to assess the condition of previously repaired cracks and penetrations and to determine if there are any newly formed cracks or penetrations. The nature and scope of repairs to be made to any cracks and penetrations identified will be determined by the engineer performing the inspection.

Building 33

Building 33 is used for storage. Two indoor air samples were collected in the lower level of this building; TCE was detected at concentrations of 8.52 $\mu g/m^3$ and 0.819 $\mu g/m^3$. Actions to be undertaken in Building 33 consist of conducting an inspection for cracks and penetrations in the concrete slab, walls, sumps, and where pipes and wires extend through the foundations and concrete slab. Cracks and penetrations larger than the approximate width of a quarter (1/16th of an inch) will be sealed using elastomeric joint sealant, compatible caulks, non-shrink mortar, grouts, expanding foam, drain seals, or airtight gaskets. The specific type of material used and the appropriate method for sealing will depend on the size and orientation of the crack/penetration as determined by the engineer performing the inspection. Repairs of cracks/penetrations that cannot be properly sealed may consist of the removal and replacement of a section of the concrete floor encompassing the crack/penetration. This determination will be made under the direction of a licensed professional engineer. After the actions above have been performed, indoor air samples will be collected to assess the effectiveness of these engineering control measures on indoor air quality (see Section 5.3).

Inspections will be conducted on an annual basis to assess the condition of previously repaired cracks and penetrations and to determine if there are any newly formed cracks or penetrations. The nature and scope of repairs to be made to any cracks and penetrations identified will be determined by the engineer performing the inspection.

Building 34

Building 34 houses manufacturing operations and a machine shop. Two indoor air samples were collected in the lower level of this building; TCE was detected at concentrations of 1.37 $\mu g/m^3$ and 1.47 $\mu g/m^3$. Actions to be undertaken in Building 34 consist of conducting an inspection for cracks and penetrations in the concrete slab, walls, sumps, and where pipes and wires extend through the foundations and concrete slab. Cracks and penetrations larger than the approximate width of a quarter (1/16th of an inch) will be sealed using elastomeric joint sealant, compatible caulks, non-shrink mortar, grouts, expanding foam, drain seals, or airtight gaskets. The specific type of material used and the appropriate method for sealing will depend on the size and orientation of the crack/penetration as determined by the engineer performing the inspection. Repairs of cracks/penetrations that cannot be properly sealed may consist of the removal and replacement of a section of the concrete floor encompassing the crack/penetration. This determination will be made under the direction of a licensed professional engineer. After the actions above have been performed, indoor air samples will be collected to assess the effectiveness of these engineering control measures on indoor air quality (see Section 5.3).

Inspections will be conducted on an annual basis to assess the condition of previously repaired cracks and penetrations and to determine if there are any newly formed cracks or penetrations. The nature and scope of repairs to be made to any cracks and penetrations identified will be determined by the engineer performing the inspection.

5.2.2 Main Level

Buildings 8 and 10

Building 8 is used for storing parts and is accessed periodically during 8-hour work-shifts. One indoor air sample was collected in this building; TCE was detected at 1.37 $\mu g/m^3$. Building 10 houses manufacturing operations. One indoor air sample was collected inside this building; TCE was detected at 0.765 $\mu g/m^3$.

Actions to be undertaken in Buildings 8 and 10 consist of conducting an inspection for cracks and penetrations in the concrete slab, walls, sumps, and where pipes and wires extend through the foundations and concrete slab. Cracks and penetrations larger than the approximate width of a quarter (1/16th of an inch) will be sealed using elastomeric joint sealant, compatible caulks, non-shrink mortar, grouts, expanding foam, drain seals, or airtight gaskets. The specific type of material used and the appropriate method for sealing will depend on the size and orientation of the crack/penetration as determined by the engineer performing the inspection. Repairs of cracks/penetrations that cannot be properly sealed may consist of the removal and replacement of a section of the concrete floor encompassing the crack/penetration. This determination will be made under the direction of a licensed professional engineer. After the actions above have been performed, indoor air samples will be collected to assess the effectiveness of these engineering control measures on indoor air quality (see Section 5.3).

Inspections will be conducted on an annual basis to assess the condition of previously repaired cracks and penetrations and to determine if there are any newly formed cracks or penetrations. The nature and scope of repairs to be made to any cracks and penetrations identified will be determined by the engineer performing the inspection.

5.2.3 Stand Alone Building - Building 24

The basement and first levels of this building are used for storage of materials by PRI. These levels are infrequently accessed by PRI personnel to retrieve stored materials and by EPT maintenance and security personnel. Three indoor air samples were collected in the basement level; TCE was detected at 1.8 $\mu g/m^3$, 5.63 $\mu g/m^3$, and 1.31 $\mu g/m^3$. Two indoor air samples were collected in the first level; TCE was detected at 7.81 $\mu g/m^3$ and 4.1 $\mu g/m^3$. The second (main) level was used for offices and storage by Cornell University and was occupied by up to 2 persons each work day. The third level is leased to a non-profit organization and is occupied during weekdays. The fourth level is vacant and will remain unoccupied.

PRI and the non-profit will vacate the building by the end of December 2008. Thereafter, Building 24 will remain unoccupied. EPT will also restrict access to the building only to maintenance and security personnel staff. Entrances to all floors will remain locked at all times and keys maintained by authorized EPT personnel. A health and safety plan will be prepared for EPT maintenance staff needing to access the building to perform maintenance activities lasting more than 30 minutes. The plan will identify measures that must be undertaken in such events to include engineering controls (use of fans and providing makeup air). Employees will be required to sign the plan and document the access (day, time in and out) and indicate engineering controls utilized. Indoor air samples will be collected in the basement and first level to assess indoor air quality (see Section 5.3).

5.3 Indoor Air Monitoring

Indoor air sampling will be performed in the lower level of Buildings 3, 4, 6A, 33, and 34, in Buildings 8 and 10, and in the basement and first level of Building 24 during the heating season following completion of the improvements described in Section 5.2; first in November 2008 and again in February 2009. This includes the quality assurance laboratory in Building 4. In general, between April and October, windows and doors are routinely open throughout the facility allowing for increased ventilation. Thereafter, indoor air sampling will be conducted annually during the heating season (i.e., each November and the following February).

The results of the sampling will be evaluated to ascertain if additional actions may be appropriate to improve air flow in these buildings (louvers, fans, modifications to the HVAC system, etc.). All sampling activities will be conducted following the approved general work plan for indoor air sampling dated September 23, 2005, and NYSDOH's Guidance for Evaluating Soil Vapor Intrusion in the State of New York, dated October 2006. The samples will be analyzed for the complete list of compounds specified in EPA Method TO-15. The minimum detection limits using EPA Method TO-15 for all sample types will be 0.25 $\mu g/m^3$ for TCE and 1 $\mu g/m^3$ for all other VOCs.

6.0 Interim Remedial Measure Construction Completion Report

The final modifications and upgrades to the fire water reservoir groundwater treatment system, as well as the steps taken to mitigate indoor air in Building 4, will be presented in a Construction Completion Report and submitted to the NYSDEC. The report will also detail any modifications or upgrades that are made to increase the mass removal of the existing groundwater extraction system.

The results of indoor air sampling conducted in Buildings 3, 6, 10, 24, 33, and 34 will be presented in a letter report to the NYSDEC and NYSDOH following the two heating season sampling events. These results will be presented separately from the Construction Completion Report due to the anticipated sampling event scheduling.

7.0 Schedule

The activities to be completed as part of the pre-design work and IRM implementation include the following:

- fire water reservoir pre-design groundwater assessment
- analysis of pre-design results
- design of groundwater treatment system upgrades
- preparation and mobilization for completion of IRM activities
- groundwater treatment system upgrades (including the installation and operation of new extraction wells)
- mitigation of indoor air quality
- construction completion report preparation

The pre-design field activities will commence within approximately 4 weeks of submittal of this document to NYSDEC. Assuming no delays, the pre-design activities will be completed in approximately 6 weeks and the analysis and design of the groundwater treatment system upgrades in 4 weeks. The design document will be submitted to the NYSDEC and NYSDOH for review before construction activities begin. Actual construction work will begin approximately 2 weeks following approval of the design document and is estimated to take 8 to 10 weeks to complete. Following the completion of construction activities, a construction completion report will be submitted.

The results of the indoor air sampling events in November 2008 and February 2009 will be presented within 5 weeks of completion of each event.

8.0 References

Environmental Strategies Consulting LLC. 2005. Onsite Assessment Former Borg Warner – Morse Chain Facility, 620 South Aurora Street, Ithaca, New York.

Environmental Strategies Consulting LLC. 2006. Indoor Air Testing Results for EPT Facility Buildings, 620 South Aurora Street, Ithaca, New York.

ESC Engineering of New York, P.C. 2008. July Through December 2007 Semi-Annual 2-PHASE Extraction System Progress Report #23, Emerson Power Transmission, Ithaca, New York (Morse Industrial Corporation, Site No. 7-55-010).

Hantush, M.S. and Jacob, C.E. 1955. Non-steady radial flow in an infinite leaky aquifer, Am. Geophys. Union Trans., vol. 36, pp. 95-100.

New York State Department of Environmental Conservation. 1994. Record of Decision for the Morse Industrial Site Inactive Hazardous Waste Site, Ithaca, Tompkins County, New York. December.

Radian Corporation. 1990. Final Report; Remedial Investigation Stages 1 and 2; Emerson Power Transmission (EPT), Ithaca, New York. February.

Theis, C.V. 1935. The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage. American Geophysical Union Trans. Vol. 16. pp. 519-524.

WSP Environmental Strategies. 2007. Supplemental Remedial Investigation Report, Emerson Power Transmission, Ithaca, New York). December.

Part II

Alternatives Analysis Report for
AOCs 1, 4, 15, and 24

9.0 Introduction and Purpose

The purpose of this report is to identify and evaluate remedial alternatives that address the light non-aqueous phase liquids (LNAPL) and VOCs present in the soil and/or groundwater at specified AOCs at the site in a manner that is appropriate for site-specific conditions; to be protective of human health and the environment; to be consistent with applicable Federal and State standards, criteria, and guidelines; and that are cost effective. The AOCs addressed in this report include the following:

- AOC 1 – Former Department 507 Degreaser
- AOC 4 – Former Open Reservoir (Stone)
- AOC 15 – Former 500-gallon Aboveground Tank
- AOC 24 – Fire Water Reservoir

The remainder of Section 9.0 contains a brief summary of the SRI and pertinent findings for the designated AOCs. Section 10.0 identifies the remedial action objectives that guided the screening and evaluation of the remedial alternatives and that are protective of human health and the environment, and describes the impacted areas at each AOC. In Section 11.0, the pre-design investigations required to further define the extent of contamination in each AOC are detailed and followed by Section 12.0 which defines the supplemental investigation for the sanitary sewers along Turner Place and South Cayuga Street to fill in data gaps to be used in evaluating potential remedial alternatives for the sewers. Section 13.0 presents the potentially feasible technologies those that meet the remedial action objectives (RAOs) for each AOC. In Section 14.0, a detailed analysis of the retained remedial technologies is presented, and Section 15.0 presents the recommended remedial strategy and selection rationale for each AOC.

9.1 Summary of AOC Investigation Findings

The work conducted as part of the SRI included the investigations of 25 AOCs onsite. This work was conducted between August 20 and September 3, 2007, and involved installing soil borings, excavating test pits, and collecting soil, groundwater, and soil vapor samples for laboratory analysis. All borings installed at AOCs were installed to the top of bedrock.

Based on the AOC investigation results, four AOCs (1, 4, 15, and 24) were identified by the NYSDEC as requiring remedial action to address the VOCs in groundwater (AOC 1) and the light LNAPL encountered in soil or groundwater at the remaining three AOCs. Following is a brief summary of the investigation results.

Solvent odors were noted in three of the borings installed in AOC 1, the Former Department 507 Degreaser Area. Soils collected from this area contained site-related VOCs above the NYSDEC Restricted SCOs for the migration to groundwater. In addition, a water sample collected from one of these borings contained TCE, vinyl chloride, cis-1,2-DCE, and trans-1,2-DCE above the NYSDEC Technical and Operational Guidance Series (TOGS) 1.1.1 ambient water quality criteria.

A petroleum-type product was encountered from 8-10 feet bgs at AOC 4, former open stone reservoir in Building 6A. The analytical results for a product sample collected from this area did not indicate any compounds above the comparative criteria. In AOC 15 (Former 500 gallon Gasoline Aboveground Tank) petroleum staining and an oily product were encountered between 20-26 feet bgs. No Spill Technology and Remediation Series (STARS) VOCs were detected in the soil sample collected from the stained/oily interval. Monitoring well MW-8B, located adjacent to the eastern side of the fire water reservoir (AOC 24), contained an LNAPL. A sample of the LNAPL collected from this well contained methylene chloride at 1,800 µg/kg and TCE at 2,600 µg/kg. The laboratory determined that this sample should be considered a sludge and therefore analyzed as a solid; hence the results are reported in µg/kg.

As part of the SRI completed in 2007, soil vapor sampling was conducted in addition to the soil and groundwater samples discussed above, to evaluate the potential presence of VOCs along sewer lines on South Cayuga Street, Turner Place, and Columbia Street and near a potential groundwater discharge area located along the lower portion of Turner Place and East Spencer Street. The results of the soil vapor sampling demonstrated that the sewer extending from the former NCR facility is a source of VOCs to soil gas. The results also showed that historical releases occurred from two sewer lines along Turner Place and one line along South Cayuga Street that serve the EPT facility during Borg-Warner's ownership. Additionally, sewer lines originating from the Therm facility connect to the South Aurora/Columbia Street sewer line, which in turn, connects with to the Turner Place sewer. This sewer may have carried historical solvent discharges from Therm.

10.0 Remedial Action Objectives

10.1 General

RAOs are medium-specific goals for protecting human health and the environment. Definition of the RAOs under a full feasibility study requires identification and assessment of the constituents of concern (COCs), affected media, potential migration pathways, exposure routes, and potential receptors. Because these RAOs are specific to identified AOCs and human health risk, and habitat-based assessments were not completed for the site, the RAOs were developed by considering standards, criteria, and guidelines identified as potentially applicable to the site.

This section briefly summarizes the information used as the basis for development of the RAOs, identifies the RAOs for each AOC, and describes the impacted areas at each AOC based on the identified remedial goal and RAOs.

10.2 RAOs

The remedial action goal includes restoring each AOC to pre-release conditions, to the extent feasible. Implementation of the selected remedy for each AOC will eliminate or mitigate all significant threats to public health and the environment presented by the site COCs. Identifiable sources of contamination will be removed or eliminated, to the extent feasible.

RAOs were determined by following NYSDEC guidance for soil and groundwater standards. Soil cleanup standards were governed by the NYSDEC Subpart 375-6 Restricted Use SCO for Protection of Groundwater. Groundwater cleanup standards were based on the New York Division of Water TOGS 1.1.1, Table 1, Ambient Water Quality Standards and Guidance Values, which includes the groundwater standards found in 6 NYCRR Part 703.5.

Tables 1 and 2 summarize historic soil and groundwater data including COCs detected in excess of their respective Groundwater Quality Standard and soil SCOs for Protection of Groundwater.

Based on the data obtained during the RI, SRI, and the information presented in this report, the RAOs for AOCs 1, 4, 15, and 24 at the site are as follows:

- Reduce, control, or eliminate the concentrations of COCs present within soil and groundwater onsite at AOC 1 in excess of their respective standards.

- Reduce or eliminate the potential for ingestion/direct contact with COC affected soils at AOC 1.
- Reduce or eliminate the presence of LNAPL (i.e., free product) identified in AOCs 4, 15, and 24 to the extent practicable.

The remedial goals and RAOs identified for groundwater and soil for each AOC that was previously investigated are used as the basis for identifying the impacted areas, as described below. In Sections 13 and 14, the remedial goals and RAOs are used as a basis for identifying remedial technologies and developing remedial alternatives to address the impacted areas of soil and groundwater.

10.3 Impacted Areas

The following sections describe specific goals for groundwater and soil related to the AOCs identified at the site.

10.3.1 AOC 1

Results of the remedial investigations indicate that there are eight site-related VOCs that have been detected in groundwater. These include tetrachloroethene, TCE, cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, 1,1,1-trichloroethane, 1,2-DCE, and methylene chloride.

Soil quality in AOC 1 was compared to protection of groundwater SCOs with respect to the eight site-related compounds. Soil sample results in AOC 1 had detections of methylene chloride and vinyl chloride in excess of the NYSDEC Restricted Use SCOs for protection of groundwater, which are 50 µg/kg for methylene chloride and 20 µg/kg for vinyl chloride. These standards have been established as the remedial goal for soil in AOC 1.

Groundwater collected from AOC 1 also contained site-related VOCs in excess of TOGS criteria, including cis-1,2-DCE, trans-1,2-DCE, TCE, and vinyl chloride. TOGS ambient water quality standards are 5 µg/l for cis-1,2-DCE, 5 µg/l for trans-1,2-DCE, 5 µg/l for TCE, and 2 µg/l for vinyl chloride. These standards have been established as the remedial goal for groundwater in AOC 1.

The extent of soil and groundwater contamination has not been defined both vertically and horizontally in AOC 1. Implementation of the selected soil and groundwater remedies will be based on the pre-design activities (Section 11) that address these data gaps.

10.3.2 AOCs 4, 15, and 24

AOCs 4, 15, and 24 all contained LNAPL (product) that was identified during installation of soil borings or monitoring wells during the SRI. Although the product analyzed in samples collected from AOCs 4 and 24 did not contain VOCs above NYSDEC criteria, not all samples (including from AOC 15) were analyzed for total VOCs. This data gap will be addressed during the pre-design investigation phase. The components of the product recovered from AOCs 4, 15, and 24 can be found in Table 3. According to the NYSDEC DER-10 Technical Guidance for Site Investigation and Remediation, free product is defined as an immiscible or non-aqueous phase liquid (NAPL) existing at the surface or in the subsurface in a potentially mobile state. Such a free product was identified in samples collected in these AOCs.

The Remedy Selection section of DER-10 states that alternatives and a proposed remedy that removes contamination or reduces or eliminates exposure to contaminants should be developed. Specifically, for free product, "…this should include the removal of the source of the contamination, including but not limited to, any free product and any grossly contaminated soils, to the extent technically and practically feasible, as determined by the DER." The Remedial Design/Remedial Action Section states, "Free product determined to be present is to be treated or removed when practicable, or contained when treatment or removal are not practicable." The DER-10 guidance applies to AOCs 4, 15, and 24, and the RAO for these areas is to reduce or eliminate free product to the extent practicable.

11.0 Pre-Design Investigations

To better define the extent of VOCs in the groundwater and LNAPL in the soil and groundwater at AOCs 1, 4, 15, and 24, pre-design investigations shall be implemented. The following sections describe these investigations to be conducted at each AOC before a final remedial action is selected.

11.1 AOC 1 – Former Department 507 Degreaser

Site-related VOCs were detected above state criteria in soil and groundwater collected from former soil boring SB-1d located in the formerly depressed area of the floor along the northern edge of the former Department 507 degreaser. To delineate the horizontal extent of VOCs in groundwater within AOC 1, two direct push soil borings (SB-1e and SB-1f) will be installed, as discussed with NYSDEC (Figure 17). The borings will be installed to approximately 12 feet bgs or refusal. Continuous soil samples will be collected and based on the field screening results one unsaturated soil sample will be submitted for laboratory analysis of total VOCs. Upon completion of the boring, water (if present) will be allowed to seep into the borehole, and a water sample will be collected from each location. The water samples will be analyzed for VOCs. If product or product sludge is encountered, a sample will be collected for laboratory analysis of VOCs and Hydrocarbon Fingerprinting using EPA Method 31013 for characterization purposes.

Two-day turnaround time will be requested for the groundwater analytical results for borings SB-1e and SB-1f. If VOCs are detected at concentrations above NYSDEC criteria, a steel casing will be installed to approximately 1 foot into the top of bedrock at the same boring locations (SB-1e or SB-1f). The casing will be grouted into place and allowed to set for 24 hours followed by leak testing. Once it has been determined that the casing does not leak, drilling will continue through the casing into the fractured bedrock (B-zone) to determine if the bedrock is saturated at these locations. If water is encountered within the B-zone, a sample will be collected and analyzed for VOCs using EPA Method 8260.

11.2 AOC 4 – Former Open Reservoir (Stone)

Two soil borings were installed to the top of bedrock in the vicinity of the former open stone reservoir in Building 6A (Figure 18). A strong weathered petroleum odor was observed from 4 to 8 feet below the top of the concrete slab in boring SB-4b and a petroleum product was encountered from 8 to 10 feet bgs in this same boring. The soil sample collected from SB-4b at 7 to 8 feet below the top of the concrete slab (exhibited the highest PID reading) did not contain any VOCs above the NYSDEC criteria. Additionally, a sample of a petroleum product collected from the top of groundwater also did not contain VOCs above NYSDEC criteria.

To further characterize and delineate the petroleum product identified in former soil boring SB-4b, three additional soil borings will be installed at locations shown in Figure 18. One boring each will be installed east, north, and west of original boring SB-4b to the top of bedrock (approximately 10 feet bgs). Continuous soil samples will be collected and logged for each boring to the termination depth. Based on field screening results, one *unsaturated* soil sample will be collected and analyzed for VOCs using EPA Method 8260. Sufficient time will then be allowed to determine if water and/or product seeps into the boring. If product or product sludge is encountered, a sample will be collected for laboratory analysis of VOCs using EPA Method 8260 and Hydrocarbon Fingerprinting using EPA Method 31013 for characterization purposes. In addition, a 4-inch recovery well will be installed at that location for product recovery or institution of another appropriate remedial technology.

At a minimum, a 4-inch well will be installed in the location of former boring SB-4b to be used for potential product recovery or other treatment technology determined appropriate.

11.3 AOC 15 – Former 500-Gallon Gasoline Aboveground Tank

A former 500-gallon gasoline aboveground storage tank was located northwest of Building 4. During the supplemental RI, one soil boring (SB-15) was installed to the top of bedrock (approximately 25 feet bgs) in the center of the area where the tank was stored. Petroleum staining and an oil product were noted between 20-26 feet bgs during installation of the boring. Although no STARS VOCs were detected in the soil sample collected between 20-24 feet bgs, the petroleum product will be further characterized and delineated as detailed below to determine if product is migrating at depth along the retaining wall in this area (Figure17).

Two soil borings will be installed along the retaining wall to a depth of approximately 30 feet bgs; one 25 feet north and one 25 feet south of former boring SB-15. Continuous soil samples will be collected and logged for each boring to the termination depth. Based on field screening results, one *unsaturated* soil sample will be collected and analyzed for VOCs using EPA Method 8260. If product is encountered during drilling, a 4-inch recovery well will be installed at that location. A sample of the product will be collected and analyzed for VOCs using EPA Method 8260 and Hydrocarbon Fingerprinting using EPA Method 31013 for characterization purposes. An additional boring will then be installed further along the retaining wall an additional 25 feet to delineate the extent.

At a minimum, a 4-inch product recovery well will be installed at the location of former boring SB-15 to a depth of approximately 30 feet. A sample of the product will be collected and analyzed for total VOCs using EPA Method 8260 and for characterization purposes.

11.4 AOC 24 – Fire Water Reservoir

Two, 2-inch groundwater monitoring wells (MW-7B and MW-8B) were installed adjacent to the fire water reservoir (Figure 17) to further evaluate groundwater quality within the upper portion of the fractured bedrock (B-zone). Monitoring well MW-7B was installed south of the fire water reservoir and well MW-8B was installed to the east. The wells were screened in the uppermost fractured bedrock from 10 to 20 feet bgs (1 foot below the reservoir). During rock coring activities for these wells, an oily sheen was observed on the cores and drilling fluids. Following installation, LNAPL was encountered in well MW-8B and found to contain chlorinated VOCs above the NYSDEC criteria.

To delineate the LNAPL in shallow fractured bedrock encountered in well MW-8B, two soil borings (one north and one east) will be installed using hollow stem augers approximately 25 feet from well MW-8B to an interval within the upper section of fractured bedrock (within the B-zone). Continuous soil samples will be collected and logged for each boring to the termination depth. Based on field screening results, one *unsaturated* soil sample will be collected and analyzed for VOCs using EPA Method 8260. If product is encountered, a 4-inch well will be installed for product recovery at that location. A sample of the product will be collected for analysis and analyzed for VOCs using EPA Method 8260 and Hydrocarbon Fingerprinting using EPA Method 31013 for characterization purposes.

11.5 Soil Boring Installation Methods

At all soil boring locations, continuous soil samples will be collected. If the locations inside the building are not accessible for a conventional rig, then a tripod with cathead, slam bar, or similar method will be employed after the floor is cored. On retrieval, the soil, if present, will be logged and classified according to the Unified Soil Classification System. Other pertinent soil observations, such as staining, odors, presence of fill, and moisture content, will be recorded. A PID will be used to screen each sample for organic vapors and visually checked for evidence of staining. The PID screening results and visual observations will be recorded in a field log book. The sample with either the highest PID reading or the heaviest staining (if staining is observed) will be selected for laboratory analysis. If no PID readings are measured and no evidence of staining is observed, then a sample of the soil on top of the bedrock will be collected for laboratory analysis, if feasible. For borings installed inside the buildings, the concrete slab will be cored before initiating sampling with the Geoprobe® unit or hand auger. If bedrock is encountered directly beneath the slab, no soil samples will be collected at that location and a notation will be recorded in the field log book. In addition, if actual groundwater is encountered in soil borings within the buildings, a sample will be collected for laboratory analysis VOCs using EPA Method 8260.

Following sampling activities, if the borings are not used for product recovery, they will be backfilled with bentonite pellets or coarse bentonite chips, the bentonite material will be hydrated with tap water, and the concrete floor will be repaired. All downhole sampling equipment will be decontaminated after each use.

11.6 Well Installation Methods

Boreholes for the product recovery wells will be drilled using 6.25-inch ID hollow-stem augers through the overburden. Continuous soil samples will be collected from the ground surface to refusal at bedrock using 2-foot-long split-spoon samplers. The soils recovered from the split spoons will be screened for organic vapors in the field using a PID. Sample descriptions and PID readings will be recorded in a field notebook.

Monitoring wells will be constructed as shown in Appendix B. The upper B-zone monitoring wells will be constructed using 2-inch-ID threaded, flush jointed, Schedule 40 PVC.

The screens in all wells will be 5 feet in length with 0.010-inch horizontal slots. A clean sand filter pack will be placed in the annular space surrounding the screen from the bottom of the borehole to approximately 2 feet above the top of the screen. A 3-foot-thick bentonite seal will then be placed on top of the sand filter pack. The remaining annular space will be backfilled with a cement-bentonite grout mixture (tremie piped from the bottom to the top). Well construction information will be recorded in a field notebook, and as-built diagrams will be prepared for each monitoring well installed during the investigation.

The wells will be completed as flush-mounts. The flush mount assembly will be 8 inches in diameter and have a lockable watertight cap. This assembly will be set in a hole that is at least 4 to 8 inches larger than the flush mount assembly, and set in concrete.

Drill cuttings and water generated during well installation will be contained in Department of Transportation (DOT)-approved, 55-gallon steel drums. The drums will be labeled and moved to an onsite staging area. The soil cuttings will be characterized for disposal after completion of the field activities. The water generated during the investigation will be treated in the onsite remediation system.

All drilling and sampling activities will be conducted with clean equipment. Split-spoon samplers will be decontaminated in accordance with WSP Engineering SOPs. The drilling equipment (augers and rods) will be decontaminated using a portable steam cleaner. All decontamination fluids generated during the drilling activities will be contained in 55-gallon DOT-approved steel drums and managed in the same manner as water generated during the well installation.

Boring logs will be prepared for each well after completion of the field activities. All wells will be completed and installed by a driller licensed in the state of New York in accordance with the Environmental Conservation Law 15-1525.

The elevations of the ground surface at each new monitoring well and the top of the PVC well casing will be surveyed to the nearest 0.01 foot. The horizontal locations of the new wells will also be determined to the nearest 0.1 foot and referenced to the state plane coordinate system. A surveyor licensed in New York State will survey the well locations and elevations. The locations and elevations of the wells will be tied into the existing base map for the site.

11.6.1 Well Development Methods

The new wells will be developed to remove sediments and ensure effective communication between the well screens and surrounding saturated zones. The wells will be developed by surging the screened interval to loosen any fine-grained sediment in the sand filter pack and adjacent aquifer material. Groundwater from the well will then be removed by bailing or pumping. Turbidity, pH, temperature, and specific conductance will be periodically monitored during the development process to ensure that groundwater representative of the screened portion of the aquifer is entering the well. Development will continue until the discharge is relatively free of suspended sediments. If water is added to the well borehole during the drilling and installation activities for the new monitoring wells, an equal volume of water will be removed during well development. Water generated during the well development will be treated at the onsite treatment building.

All development/redevelopment activities will be conducted with clean equipment to prevent potential cross-contamination between well locations. Equipment will be cleaned between each well, with the decontamination procedure dependent on the development/redevelopment method(s) and equipment use

11.7 Sample Collection and Analysis

Groundwater or product grab samples will be collected using dedicated disposable Teflon or polyethylene bailers or tubing. Bailers or tubing will be lowered slowly into the boring to avoid agitating the water, if encountered. Disposable nitrile gloves will be worn by the sampling personnel and the gloves will be changed before each sample is collected. Samples for VOC analysis will be collected in three precleaned 40-ml vials, labeled with the time and date of sampling, the sample location, the sampler’s initials, and the analyses to be performed. The samples will be preserved with hydrochloric acid to a pH of 2 or less. The vials will be completely filled. Once the samples have been filled and sealed, they will be placed in a cooler with ice. Custody seals will be placed on the outside of the coolers.

The groundwater or product samples will be shipped to a laboratory certified by the NYSDOH Environmental Laboratory Approval Program, and analyzed for the following parameters, as appropriate:

- VOCs by EPA Method 8260
- Hydrocarbon Fingerprinting using EPA Method 31013

Table 4 summarizes the number of groundwater or product samples to be collected from each AOC and the sample parameters designated for analysis.

Photographs of soil and groundwater samples collected from each AOC will be taken and recorded in the field notebook.

11.8 Quality Assurance and Quality Control

QA/QC samples, including equipment blanks, trip blanks, and duplicates, will be collected in accordance with WSP Engineering SOPs (Appendix A). Additional sample volumes will be collected to allow the laboratory to perform matrix spike and matrix spike duplicates of selected samples. Additional volumes will be provided for at least 1 per 20 samples per analyte group. All samples will be sealed, labeled, placed in a cooler with ice, and shipped to STL. Appropriate chain-of-custody procedures will be followed.

12.0 Supplemental Investigation for Sanitary Sewers

The sanitary sewers that serve the EPT facility and continue down Turner Place and South Cayuga Street may be a potential pathway for the migration of VOC vapors in the South Hill neighborhood. These VOC vapors are associated with historic solvent releases into the South Cayuga and Turner Place sewers during Borg Warner's ownership as described in the conceptual site model in Section 1.5.2 of this report. Additional investigations are necessary in order to further evaluate the pathways for migration of vapors associated with historical releases of VOCs to the sewer lines.

The objective of the supplemental sampling activities is to determine if affected soil vapors are migrating along three potential vapor migration pathways (1) the sanitary sewer lines, (2) the residential sanitary sewer laterals, and/or (3) within the vertical and horizontal planes of porosity (fractured bedrock) surrounding the sewer lines.

The information obtained from the additional investigations will be used to confirm and if necessary, revise, the conceptual site model described in Section 1.5.2. Following completion of the additional investigations, an alternatives analysis will be prepared for the offsite sanitary sewers that will include the no action alternative, potentially applicable treatment technologies, and operation of sub-slab ventilation systems and monitoring based on technical impracticability.

12.1 Scope of Work

WSP proposes to collect 15 additional soil vapor samples at the locations designated SV-53 through SV-67 on Figure 19. These locations were selected based on previous soil vapor sample results collected as part of the SRI. Samples locations SV-53, 54, 56, 57, 60, 62, 65, and 67 will be installed directly over the sewer lines along Turner Place, South Cayuga Street, and East Spencer Street. These locations were selected to evaluate the potential presence of site-related VOCs in soil gas along the sewer lines themselves. Proposed soil vapor points SV-56 and SV-57 are located immediately adjacent to manhole 4 (MH-4) where the highest soil gas concentrations have been measured. MH-4 is also the convergence point of the three sewer lines originating from the EPT, NCR and Therm facilities. Sample locations SV-55, 58, 61, and 64 will be installed directly over the sewer laterals for selected mitigated homes to evaluate the potential for migration of soil vapor along the sewer laterals. These sewer laterals were chosen based on TCE results for sub-slab soil gas samples collected beneath the homes on that specific property. In addition, sample locations SV-59, 63, and 66 will be installed over bedrock structural features to evaluate the migration of vapors through fractures in the bedrock. These locations were selected based on previous surface and subsurface geophysical studies conducted in the area.

The sample locations shown in Figure 19 are approximate and will be adjusted in the field based on access or the location of underground and overhead utilities. Sampling and analysis procedures will be conducted in accordance with the NYSDOH soil vapor intrusion guidance (October 2006), and procedures described in the NYSDEC-approved Vadose Zone Work Plan for the EPT site, dated January 16, 2004.

Soil vapor samples will be collected at the 14 locations shown on Figure 19. To install the temporary soil gas sampling devices, direct-push rods equipped with a 1.25-inch OD drive point will be advanced to a depth of approximately 6 feet bgs. A 6-inch-long stainless steel screen will be attached to 0.25-inch ID Teflon® or Teflon®-lined tubing and lowered to the bottom of the open borehole. Approximately 1 foot of quartz sand will be placed in the bottom of the borehole around the screen and tubing to create a 1-foot-thick sample interval. The remainder of the borehole will be sealed with a bentonite slurry. If the subsurface materials are non-cohesive, it may be necessary to lower the stainless steel screen and tubing through the hollow probe rods until it rests on top of the drive point. The base of the wire mesh screen would then be threaded into the top of the drive point by rotating the tubing and screen. The probe rods would then be removed from the hole leaving the drive point, screen, and tubing in place. Alternatively, a macro-core sampler equipped with a single-use acetate liner may be used to advance the boring. If groundwater or bedrock is encountered at depths less than 4.0 feet below ground surface air samples will not be collected from that location.

Before soil vapor samples are collected, a pre-sample purge will be conducted to remove dilution air from the tubing and probe assembly. The flow rate of the purging will not exceed 0.2 liter per minute (L/min). In accordance with the NYSDOH guidance, a non-toxic tracer gas (i.e., helium or sulfur hexafluoride) will be used during purging and sampling of soil vapor probes in unpaved areas to demonstrate that the sample has not been diluted with ambient air. At each location, an approximately 3-foot-by-3-foot piece of polyethylene sheeting will be placed on the ground surface around the sample probe with the sample tubing passing through a small opening near the middle of the sheeting. An enclosure will then be placed over the vapor probe, and it will be sealed to the plastic sheeting with hydrated bentonite (or equivalent). Sand will be placed on top of the sheeting along the edges to fasten/seal it to the ground. The sample tubing will either pass through an opening in the enclosure or will be connected to a hose fitting on the inside of the enclosure (i.e., with a corresponding hose fitting on the exterior of the enclosure to allow for sample collection). Once the enclosure is sealed to the plastic, the atmosphere inside the enclosure will be enriched with the tracer gas, but care will be taken not to pressurize the enclosure. The enrichment of the atmosphere will be documented with a portable gas detector designed to measure for the tracer gas. Next, a pump or syringe will be used to purge one to three well-volumes of soil vapor from the probe and the air will be contained in a Tedlar® bag. Once the purge is complete, the Tedlar® bag will be closed and disconnected from the sample tubing, removed from the structure, and the contents of the bag will be tested with a tracer gas detector. If the purged air contains greater than 10 percent tracer gas, the seal on the soil vapor probe will be reinforced and the test will be repeated.

To collect the soil vapor sample, an Entech flow regulator or equivalent type will be connected directly to the sample tubing, or to a fitting on the enclosure using Teflon® or Teflon®-lined tubing. The flow regulator will be attached to an evacuated 1-liter Entech canister or equivalent type to initiate sample collection. The flow regulator will be pre-set by the laboratory to collect the soil vapor sample over a 1-hour period at a flow rate that will not exceed 0.2 L/min. After 1 hour, the flow regulator will be disconnected from the canister to complete the sample collection. The sample name, location, time and date of sample collection, regulator and canister number, and the analytical method will be recorded on the chain-of-custody form and in the field log book. On completion of the sample collection, a second tracer gas test will be performed to document that short circuiting did not occur during sample collection. Following collection of the soil vapor samples, the tubing will be removed from the ground and the borehole will be capped with soil cuttings to match the surrounding surface.

Site conditions will be documented during the soil vapor sampling activities in accordance with Section 2.7.1 of the NYSDOH guidance.

12.1.1 Sample Analysis

All samples will be shipped, or transported by courier, under ambient conditions to a New York State Department of Health Environmental Laboratory Approval Program-approved laboratory under strict chain-of-custody procedures. The samples will be analyzed for the complete list of VOCs specified in EPA Method TO-15. Analytical results for all VOCs detected by EPA Method TO-15 will be reported to the NYSDEC. The minimum detection limits using EPA Method TO-15 for all sample types will be 0.25 µg/m^3 for trichloroethene and vinyl chloride and the lowest achievable laboratory detection limit (approximately 1.0 µg/m^3) for all other VOCs.

12.1.2 Quality Assurance/Quality Control

Each Entech or similar canister used for the sampling activities will be certified-clean by the selected laboratory. This certification involves analyzing the ambient air inside each clean canister by EPA Method TO-15. If no target compounds are detected at concentrations above the reporting limits, then the canister is evacuated again and the canister is available for sampling. If target compounds are detected at concentrations above the reporting limits, then the canister is not used and will be re-cleaned and re-tested. A duplicate soil vapor sample will be collected from one location using a "T" splitter or "T" connect device. In addition, a laboratory-prepared trip blank will accompany the sample canister for one of the vapor samples from the laboratory to the field and from the field to the laboratory. The trip blank will be used to evaluate the potential for sample cross-contamination during shipment or during sample collection.

In accordance with the NYSDOH Soil Vapor Intrusion Guidance, the reliability and representativeness of the sampling data and associated QA/QC information will be verified by a qualified person to ensure the following:

- the data package is complete
- holding times are met
- the QC data fall within the required limits and specifications
- the data have been generated using established and agreed upon analytical protocols
- the raw data confirm the results provided in data summary tables and QC verification forms
- correct data qualifiers have been used

The data deliverables will comply with the most recent NYSDEC Analytical Services Protocol B (2005).

13.0 Identification and Screening of Potentially Feasible Technologies

The following sections describe remedial technologies that were selected based on the RAOs established for AOCs 1, 4, 15, and 24. This section describes the evaluation matrix presented in Table 5 which screens potentially feasible remedial technologies for groundwater and soil in AOC 1 and for groundwater in AOCs 4, 15, and 24. The remedial technologies that were selected as being potentially feasible following a qualitative analysis of technical benefits, limitations, and cost considerations, are included in a more detailed analysis in Section 14.

13.1 Description of Identified Technologies for Groundwater for AOC 1

13.1.1 No Action

The no-action alternative would not involve the implementation of any remedial activities to address the constituents of interest in groundwater at AOC 1. No effort would be made to change any of the current conditions in AOC 1. The no-action alternative has no technical benefits or limitations because it does not address any treatment technology, and therefore would not achieve RAOs for groundwater. There are no costs associated with implementing this alternative. However, because the no-action alternative does not address the RAOs in groundwater, it was not considered potentially feasible and was not carried through for further analysis.

13.1.2 Monitored Natural Attenuation

Monitored natural attenuation (MNA) is a recognized technology that can effectively reduce VOC concentrations to levels that are protective of human health and the environment. Natural attenuation involves intrinsic processes as stated in the EPA definition of MNA: "the biodegradation, dispersion, dilution, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants to effectively reduce contaminant toxicity, mobility, or volume to levels that are protective of human health and the environment" (EPA 1997). The monitoring portion of this technology is used to evaluate temporal changes in COC concentrations resulting from the attenuation processes. With proper subsurface conditions (i.e. those conducive to reductive dechlorination) and relatively low concentrations of VOCs, MNA can effectively decrease CVOC concentrations to meet the RAOs.

MNA eliminates the need for *ex situ* treatment of groundwater, which in turn reduces technical complexity and overall cost of the implemented technology. There is very little or no maintenance associated with MNA when compared to mechanically based technologies. MNA does not involve using any type of physical treatment technology. However, it can be used as a supplement remedy to other treatment technologies. MNA does not hydraulically contain dissolved VOCs in the subsurface and therefore, the potential for migration remains. Source areas and “hot spots” cannot be effectively addressed using MNA. Because the installation of mechanical treatment equipment is not necessary, costs for this alternative are very low. Establishing a monitoring program involves low capital cost with no associated operation and maintenance (O&M) costs, followed by costs associated with periodic groundwater monitoring and reporting. The MNA treatment alternative was considered potentially feasible because existing data (presence of degradation products for TCE in groundwater) indicate favorable conditions in the groundwater, and it would be possible to integrate with other treatment technologies. MNA was retained for a more detailed analysis.

13.1.3 Air Sparging with Soil Vapor Extraction

Soil vapor extraction (SVE) is a common treatment technology used to remove VOCs from unsaturated soil. Air sparging (AS) is a treatment technology used to remove VOCs from groundwater and saturated soils below the water table. These two technologies can be coupled to enhance VOC reduction in the saturated zone (soil and groundwater) as well as when a source of VOCs remains in the unsaturated zone where the underlying groundwater is affected.

SVE works by removing soil vapor from the subsurface through adequately spaced extraction wells screened only in the vadose (unsaturated) zone. The vacuum side of a blower is connected to the extraction wells to induce the flow of soil vapors by generating a subsurface vacuum. As soil vapors move through the subsurface toward the well screens, VOCs adsorbed to the soil or contained in soil moisture partition into the vapor phase to maintain equilibrium. The extracted vapors are then conveyed to the surface for discharge and/or treatment. Vapor treatment methods include GAC, thermal destruction, or oxidation.

Air sparing involves installing wells within the saturated zone and air is injected into the saturated zone. This creates channels of air that rise within the saturated zone. VOCs partition from the aqueous-phase to the vapor-phase and flow with the injected air into the unsaturated zone to maintain equilibrium. The vacuum extraction wells installed for the SVE system then capture the vapor-phase VOCs and remove them from the subsurface for subsequent treatment. AS/SVE is generally suitable for compounds with a K-Henry value greater than about 0.1 (vapor pressure greater than 1 mm Hg) and subsurface conditions having a hydraulic conductivity greater than about 10^{-5} cm/sec (silty sand or better) and at least five feet of saturated thickness. Air sparging can be modified to include other gases (such as ozone) or heat (hot air and/or steam).

AS with SVE eliminates the need for ex-situ treatment of groundwater, which reduces the cost and complexity over traditional mechanically-based systems. This treatment technology can also hydraulically contain groundwater if an AS curtain configuration is used.

Existing conditions at AOC 1 place technical limitations on AS with SVE. Access to AOC 1 is limited by an existing building and structures that prevent the direct application to affected groundwater that underlies the buildings and structures. Soil borings from AOC 1 and historic pumping tests demonstrate that subsurface conditions are not ideal for this technology. Low permeability soil (A-zone) on the order of 10^{-5} cm/s, as well as heterogeneity of soil materials, will limit the effectiveness by preventing uniform distribution of AS and transfer of stripped VOCs. Additionally, treatment of groundwater in bedrock (B-zone) would not be feasible with this technology. The capital and O&M costs of AS with SVE can be high if large-scale vapor treatment equipment is necessary to control vapor emissions. If large numbers of injection points are necessary to treat the plume, costs can also be significant. If successful, AS with SVE can provide a relatively short remediation time frame. However, because of the low permeability of the soil in the A-zone, the potential for COC affected groundwater in bedrock in the B-zone, and the presence of existing buildings, AS with SVE was considered not feasible to address groundwater at AOC 1. This treatment technology was not retained for further analysis.

13.1.4 *In Situ* Bioremediation

In situ bioremediation is a technology that promotes or augments the biodegradation of chlorinated VOCs by introducing select materials into the subsurface. These materials may include specially-formulated solutions containing microbial cultures capable of biodegradation of chlorinated VOCs (bioaugmentation), or solutions containing specific nutrients (nitrogen and phosphorus) to help stimulate growth of native bacteria capable of biodegradation of chlorinated VOCs (biostimulation). When targeting chlorinated VOCs, these materials are typically formulated to promote anaerobic conditions conducive to reductive dechlorination. Application of these materials is typically through temporary injection points, permanent injection points, or passive-diffusive socks installed in monitoring points. This technology often involves multiple injection events and comprehensive monitoring to assess performance and confirm conditions are favorable for biodegradation. As it is necessary to address both the A-zone and upper B-zone at AOC 1 which have extreme variations in characteristics, consideration must be taken for uniform distribution of the injected solution throughout both substrates.

In situ bioremediation eliminates the need for ex-situ groundwater treatment, which reduces technical complexity and costs. This technology may require much less maintenance when compared to mechanically based treatment technologies. However, the success of *in situ* bioremediation may be limited because of existing buildings and structures that may inhibit the direct application of the treatment solutions to affected groundwater. As described, low permeability and heterogeneity of soils in AOC 1 may also limit the successful delivery of materials to the subsurface. Successful delivery may require straddle packers to effectively target bedrock. In addition, because this technology does not involve any mechanically based technologies, it does not hydraulically contain dissolved VOCs in groundwater. If a large number of injection points are necessary, it may be costly to implement this technology because of the need to install permanent injection points into fractured bedrock. There are no associated O&M costs, per se, only the recurring cost of periodic groundwater monitoring necessary to demonstrate effectiveness. Existing data (presence of degradation products for TCE in groundwater) demonstrate that reductive dechlorination is naturally occurring in the subsurface. Therefore, *in situ* bioremediation was considered technically feasible and was retained for further analysis.

13.1.5 *In Situ* Chemical Oxidation

ISCO involves introducing a strong oxidant into the subsurface, typically via an injection well. There are many types of commercially-available oxidants used to address chlorinated solvents, including hydrogen peroxide, persulfate and potassium permanganate. Oxidants address contaminants by mineralizing the contaminant on contact, producing carbon dioxide, water, dissolved hydrogen, or other innocuous compounds. These oxidants also react with soil materials (matrix demand) and therefore chemical dosages must include both matrix demand and stoichiometric requirements for the chemicals being oxidized. Potassium permanganate also produces manganese dioxide and can increase manganese levels in groundwater. For chlorinated compounds with double bonds, such as TCE, chemical oxidation breaks the double bonds at the beginning of the process. Thus, the formation of potentially toxic byproducts does not occur. Unreacted oxidants naturally decompose in groundwater, and there are no long-term adverse effects to the groundwater.

With successful delivery and uniform distribution, the process results in a nearly instantaneous reduction in VOCs in the treated area. This technology is well-suited for addressing contamination "hot spots" in a relatively short time because of the ability to target an area. In favorable subsurface conditions, *in situ* chemical oxidation can successfully reduce the concentrations of both dissolved-phase VOCs and free product. This treatment technology eliminates the need for ex-situ treatment of groundwater, which reduces technical complexity and associated costs. It requires very little or no maintenance when compared with mechanically based technologies.

The introduction of oxidants into the subsurface requires extensive pre-design work, which can often be conducted at laboratories specializing in oxidant selection. These tests, referred to as treatability studies and optimization tests, determine parameters that may affect the success of certain oxidants. For all applications, it may be necessary to determine:

- VOCs present in the subsurface
- approximate contaminant mass
- natural organic matter (total organic carbon or f_{oc})
- matrix demand
- chemical oxygen demand
- pH
- hydraulic conductivity
- soil characterization
- groundwater gradient
- vadose zone permeability
- oxidation reduction potential
- dissolved oxygen
- conductivity/resistivity

Specific oxidants require information on mineral concentrations, lower explosive limits, carbon dioxide, iron concentrations, alkalinity, and moisture content. When injecting into fractured bedrock, it is also necessary to analyze the aquifer matrix and bedrock to ensure the selected oxidant does not react adversely with aquifer qualities. Once an appropriate oxidant is selected, pilot testing in the field is necessary to determine aquifer demand and radius of influence.

In situ chemical oxidation is limited by heterogeneous or low permeability soil materials, which can prevent the uniform distribution of oxidant solution. Low permeability soil in the subsurface often requires dense spacing of injection points or diffusive applications. As previously stated, it is also necessary to address the upper portion of the B-zone, which complicates typical injection approaches. It could be necessary to install permanent injection points, which further increases costs. This technology does not hydraulically contain dissolved VOCs, and spreading of subsurface contaminants is possible if the plume is not properly delineated. Effectiveness is limited by existing buildings and structures that prevent the direct application of the oxidant to areas of affected groundwater underlying the buildings and structures. In addition, certain oxidants produce exothermic reactions with organic materials that can create heat or steam pressure that may damage subsurface utilities and structures. There are no associated annual O&M costs with this technology. The only periodic cost is that associated with groundwater monitoring necessary to demonstrate effectiveness. Rebound of contaminant levels may occur, and further oxidant applications may be necessary. This technology was considered potentially feasible for AOC 1 and has been retained for further analysis.

13.1.6 Permeable Reactive Barrier

A permeable reactive barrier (PRB) is a linear zone of reactive materials that either transects or intersects a plume of affected groundwater. Reactive materials placed within the barrier remove contaminants in the groundwater as it passes through the barrier through either chemical destruction or transformation. A PRB provides an effective linear barrier against contaminant migration and is often implemented to protect downgradient areas. PRBs are often constructed by filling a subsurface trench with granular or mineral-based materials that react with COCs.

PRBs can be an effective technology because they hydraulically contain dissolved VOCs and prevent impact to offsite properties. PRBs eliminate the need for ex-situ treatment of groundwater, which reduces cost and technical complexity. PRBs require little or no maintenance when compared to mechanically based technologies. There are no associated annual O&M costs. The only recurring cost is from periodic groundwater monitoring to demonstrate effectiveness. However, applying a PRB to AOC 1 is limited by the presence of existing buildings and structures. It would not be possible to install a PRB that intersects the VOC plume. PRBs do not address contamination "hot spots", and are a passive technology that would serve only as an effective containment strategy in AOC 1. However, because of the need to treat groundwater in the B-zone, installing a PRB into bedrock would be cost prohibitive. In typical installations, it is often difficult to intercept a full vertical profile of VOCs. As a PRB would not be feasible to implement in AOC 1, it was not retained for further analysis.

13.1.7 Pumping and Treating

Groundwater extraction and treatment, or pumping and treating, is a common technology used to contain and remove groundwater contaminants. The technology consists of pumping groundwater from the subsurface for treatment at the surface using a network of extraction wells. Several methods exist to remove VOCs from extracted groundwater, including air stripping, filtering with GAC, or a combination of these technologies. Treated groundwater can either be discharged to a local publicly-owned treatment works, discharged to surface water through a SPDES permit, or re-injected through an underground injection permit.

Pumping and treating has the benefits of hydraulic containment of dissolved VOCs and can prevent the potential impact to offsite properties. This technology can be implemented in combination with other technologies to effectively contain and control dissolved VOC migration. The overall remediation time of pump and treat systems can be relatively long because of the dissolution-limited rate of dissolved VOC extraction. This type of system can require a large network of extraction wells to ensure adequate capture in low-permeability formations. In the instance of AOC 1, the groundwater yield of the aquifer is expected to be low. The relatively long remediation time of pump and treat systems can increase operating costs significantly over the life of the system. Having a large network of extraction wells and potentially treating large volumes of water will require relatively expensive treatment equipment due to size and power consumption. As a result of these complications, pumping and treating groundwater was not considered a feasible technology and was not retained for further analysis.

13.2 Description of Identified Technologies for Soil at AOC 1

13.2.1 No Action

Similarly to groundwater treatment alternatives, the no-action alternative would not involve the implementation of any remedial activities to address the constituents of interest in soil at AOC 1. AOC 1 would be allowed to remain in its current condition, and no effort would be made to change any of the current conditions. The no-action alternative has no technical benefits or limitations because it does not address any treatment technology, and therefore would not achieve the RAOs for soil. There are no costs associated with implementing this alternative. Again, the no-action alternative was not considered a feasible technology for soil and was not retained for further analysis.

13.2.2 Containment/Institutional Control

Containment of affected soil would involve installing engineering controls in AOC 1 to prevent disruption of *in situ* materials. An example of containment controls are capping the area and instituting deed restrictions. The engineered cap could be constructed of a low-permeability asphalt concrete cap (or modification of the existing concrete floor inside the facility building) across AOC 1 that would mitigate potential exposure to impacted soils, minimize any infiltration of surface water (outside the building), and reduce the overland transport of affected materials. Prior to installation of a cap outside the building, the existing asphalt concrete layer and gravel base would be removed and disposed of offsite to facilitate the installation of a new, low-permeability cap. Low-lying areas would be graded and filled as necessary to promote drainage downgradient. Construction of a cap would not require the removal of above-ground structures and/or disturb subsurface utilities because it would not be as intrusive as excavation. Following installation, a maintenance and monitoring program would be necessary to monitor the integrity of the cap and implementation of a site management plan that includes institutional controls (deed controls) and engineering controls.

Institutional controls associated with AOC 1 would include deed restrictions placed on the property deed to prevent future interaction with affected soils. These would be carried on through deed transfers to maintain control over the area.

One limitation of this technology is that there would be no active treatment of affected soil and the RAOs for the soil would not be achieved. The associated cost is low, and long-term costs would include cap maintenance and repair. This technology may be used in conjunction with other treatment technologies or remedial alternatives implemented in AOC 1. Therefore, containment was considered potentially feasible and was retained for further analysis.

13.2.3 Soil Vapor Extraction

As described in Section 13.1.3, SVE is a technology that is often implemented in conjunction with AS of groundwater to remove VOCs from the soil with the ultimate goal of protecting groundwater quality. As described, SVE was not considered a feasible treatment technology because of low permeability soils and existing structures onsite that would prevent effective application. SVE was not retained for further analysis.

13.2.4 Excavation

Excavation is a method of source removal in which affected soils are mechanically removed and transported off-site to an appropriately permitted treatment or disposal facility. Soil in excess of the NYSDEC Restricted Use SCOs for protection of groundwater would be removed to the extent necessary to achieve the RAOs for AOC 1. Excavation of soil would be conducted using conventional construction equipment such as backhoes, excavators, front-end loaders, dump trucks, etc. Underground piping and utilities are marked and protected, or replaced, as necessary. AOC 1 would likely require excavation depths of 10 feet or greater, which would mandate proper sloping or shoring of sidewalls. Areas beneath building walls would be inaccessible.

Excavation would not be easily implemented in AOC 1 because source removal inside an active manufacturing facility at a depth greater than 10 feet would be very difficult. In addition, the AOC is located adjacent to the main wall of the building where excavation of affected soils at depth could compromise the integrity of the structure. The cost of excavating to these depths and in this environment would be expensive due to limited access. Therefore, excavation was not considered a feasible technology and was not retained for further analysis.

13.3 Description of Identified Technologies for Groundwater at AOCs 4, 15, and 24

13.3.1 No Action

As with soil and groundwater in AOC 1, the no-action alternative was considered for AOCs 4, 15, and 24. With no implemented action, the constituents of interest in groundwater would not be addressed for these AOCs and the RAOs would not be achieved for groundwater. The no-action alternative was not considered feasible and was not retained for further analysis.

13.3.2 Monitored Natural Attenuation

MNA was another potential alternative for addressing free product in AOCs 4, 15, and 24. However, there is no evidence of natural processes currently active that are degrading the free product in these AOCs. As MNA would not achieve the RAOs for groundwater, this alternative was not considered feasible and was not retained for further analysis.

13.3.3 *In situ* Oxidation

In situ chemical oxidation was also evaluated for AOCs 4, 15, and 24. Pre-design work, similar to that described in Section 13.1.5, would be necessary to determine a compatible oxidant that effectively destroys free product. This would again eliminate the need for costly and complex ex-situ groundwater treatment with little maintenance. However, this technology would not hydraulically contain free product, and buildings present at AOC 4 would limit the accessibility and effectiveness of direct application. Oxidation is not effective in treating large thicknesses of free product, and vertical delineation during pre-design investigations would be necessary to determine suitability. Thus, if it is determined that there is only a thin veneer of product (i.e., sheen) in the groundwater at these AOCs, *in situ* oxidation could be effective. Oxidation is also effective when used as a polisher following implementation of another technology. The effectiveness may be limited, however, by low permeability soils, and injection would be limited to a network of wells that had measurable free product. Oxidant would be delivered directly into wells containing a sheen on the groundwater as opposed to temporary injection points. If a large number of injection points were necessary, the cost of implementing this technology could be high. Additionally, injection may spread free product while the oxidation process occurs. Exothermic reactions could again damage subsurface utilities and structures. Despite the complexities associated with this technology, *in situ* chemical oxidation is considered a potentially feasible technology for addressing only sheens of petroleum on the groundwater and was retained for further analysis as a polishing technology.

13.3.4 *In Situ* Bioremediation

In situ bioremediation has been used to treat thin layers of free product. It again has the benefits of eliminating the need for costly and complex *ex-situ* groundwater treatment systems that rely heavily on mechanics. There is little cost associated with maintenance of bioremediation. Limitations of bioremediation for eliminating free product are that it does not hydraulically contain free product. Biostimulation injections are difficult in low permeability and heterogeneous soil, and injecting can spread free product. The technology is complicated in AOC 4 by the presence of existing buildings and structures that would limit direct application. While there are no O&M costs and low costs associated with groundwater monitoring events, the treatment may be costly because of the possibility for a large number of injection points and complex subsurface matrix. Unlike with the presence of degradation products for VOCs, there is no evidence of natural processes degrading free product in the subsurface. For these reasons, *in situ* bioremediation was not considered potentially feasible for AOCs 4, 15, and 24 and was not retained for further analysis.

13.3.5 Free Product Removal and Off-Site Treatment/Disposal

Free product removal and off-site treatment/disposal was another treatment technology considered for AOCs 4, 15, and 24. Removal techniques include product-only pumps installed in wells, absorbent socks placed in wells to retain free product, or extraction using a vacuum truck or manual bailing. The removed product is containerized for disposal or treatment at an appropriately permitted facility. This technology effectively achieves the RAOs because free product is removed. This treatment technology has limitations involving product-only pumps. These pumps are not always effective at removing thin layers of free product. It would be necessary to vertically and horizontally delineate free product to determine the placement of extraction wells and select the appropriate removal method. Vacuum extraction or manual removal would require frequent O&M activities to facilitate product removal, and it would be necessary to monitor wells for migration of additional free product that may be present in the subsurface.

The cost associated with this technology is relatively low and would be directly related to the number of extraction wells containing free product. O&M costs associated with removal of free product would be low compared to mechanically based treatment technologies. It would also be necessary to maintain groundwater monitoring following completion of the free product removal program to ensure free product does not enter the wells at a later date. This treatment technology was considered potentially feasible for AOCs 4, 15, and 24 and was retained for further analysis.

14.0 Detailed Evaluation of Potentially Feasible Technologies

Potentially feasible technologies were identified following screening of the treatment technologies for groundwater and soil in AOCs 1, 4, 15, and 24, (summarized in Table 5). Potentially feasible technologies were further screened in Table 6 to determine appropriateness and suitability for achieving the RAOs at each AOC. The following sections describe the effectiveness and implementability of potentially feasible remedies, as well as the cost and estimated time frame for achieving the RAOs. When applicable, a remedy was recommended for each AOC.

14.1 Potentially Feasible Technologies for Groundwater - AOC 1

Three technologies passed the initial technology screening for achieving the groundwater RAOs in AOC 1. These include MNA, *in situ* bioremediation, and *in situ* oxidation. These technologies are described in more detail below.

14.1.1 Monitored Natural Attenuation

14.1.1.1 Technical Description

As previously described, MNA is a potentially feasible technology to address groundwater at AOC 1. Under this alternative, no remedial activities would be implemented. Instead, periodic groundwater monitoring would be conducted to document potential natural attenuation of constituents in the groundwater. Monitoring events would initially need to be conducted more frequently to gather enough data to establish a long-term monitoring plan. Monitoring activities would include collecting groundwater samples for laboratory analysis from a network of groundwater monitoring wells in the vicinity of AOC 1. As there are currently no permanent monitoring wells in AOC 1, these would need to be installed, which would impact the cost slightly and modify this alternative over traditional MNA approaches with existing wells. The results of the groundwater monitoring events would be presented in a report and would determine long-term frequency of future monitoring events. In the event that natural attenuation was not demonstrated in these results, the report would include recommendations for additional remedial alternatives. If degradation is actively occurring, the MNA results could be used to predict the time until the groundwater RAOs were achieved for this area.

The important attributes of subsurface conditions for the promotion of MNA are the availability of a source of organic carbon and anaerobic conditions. The presence of VOC degradation products of TCE in groundwater at AOC 1, including cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride, imply that existing subsurface conditions may be ideal for MNA.

14.1.1.2 Effectiveness

MNA can be protective of human health and the environment if natural degradation is actively occurring. However, as there would be no actual remedy to address the source area, there are potential risks to current and future on-site workers that would not be addressed by this alternative alone. There would be no contact with groundwater with the exception of monitoring events because it is not a potable source. There is the potential for contact with vapors or soil if the soil or building floor is disturbed. It may be necessary to consider institutional controls, such as deed restrictions, in addition to MNA.

Under this alternative, constituents in AOC 1 would be addressed only by natural processes. This alternative would not be effective in the short-term because biodegradation rates are slow. In addition, hydraulic containment would not be achieved by this alternative. In the long-term, MNA can achieve the groundwater RAOs if VOCs are actively degrading to non-toxic compounds. The long-term effectiveness of this alternative is dependent on maintaining anaerobic aquifer conditions that are conducive to reductive dechlorination.

14.1.1.3 Implementability

The presence of TCE degradation compounds indicates that aquifer conditions are conducive to natural attenuation, and this technology should be feasible for AOC 1. The implementability of this option requires plume stability to be effective. This alternative may need to be implemented in conjunction with downgradient groundwater source removal or control tactics.

14.1.1.4 Cost and Time Frame

If used in conjunction with control technologies, MNA could achieve the groundwater RAOs in approximately 7 to 10 years. MNA would be a low cost alternative, with the only capital cost being the installation of permanent groundwater wells for monitoring events. The only recurring cost would be groundwater monitoring events, which would include costs for labor, disposable sampling equipment, rental equipment, and laboratory analysis.

However, because MNA will not achieve the groundwater RAOs as a stand-alone technology and does not protect from the migration of affected groundwater, it is not a recommended alternative for addressing groundwater at AOC 1.

14.1.2 *In Situ* Bioremediation

14.1.2.1 Technical Description

Enhanced *in situ* bioremediation involves supplying an electron donor to the subsurface to provide a substrate for naturally occurring or augmented microorganisms. Naturally-occurring bacteria are known to degrade chlorinated compounds in the subsurface. This can sometimes be enhanced by introducing microbial cultures to the subsurface. The important attributes of subsurface conditions for the promotion of reductive dechlorination are the availability of a source of organic carbon and reducing conditions. The presence of VOC degradation products of TCE in groundwater at AOC 1, including cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride, suggest that existing subsurface conditions would support *in situ* bioremediation. Unlike with MNA, the degradation process is facilitated by the addition of substrate as a carbon and energy source to promote biological growth. Examples of electron donors include cheese whey, vegetable oil, sodium lactate, molasses, glycerol, or hydrogen releasing compounds.

Electron donors can be introduced through temporary injection points or permanent injection points. Given the subsurface conditions in AOC 1, low or no pressure application driven by diffusion and gravity would be most appropriate. This would allow the material to "flood" the thin overburden horizon and upper portion of the fractured bedrock affected by COCs in groundwater.

14.1.2.2 Effectiveness

The effectiveness of this alternative requires successful delivery of the carbon source. Without success, effectiveness is reduced. Reductive dechlorination can stall at DCE, requiring intervention with special organisms introduced to the subsurface through bioaugmentation. The success of bioaugmentation is expensive and uncertain. Pre-design testing can predict the success of enhanced bioremediation and determine the ability of the process to overcome degradation of DCE.

Enhanced bioremediation is slow in the short-term. Rates are governed by the growth of bacteria, which cannot be increased even with the introduction of substrate. The long-term effectiveness is dependent on maintaining anaerobic aquifer conditions that are conducive to reductive dechlorination. Substrates can be effective in the subsurface for many months and can promote anaerobic conditions for a significant period of time after application.

Pre-design work and pilot testing would be necessary to determine the appropriate substrate, application levels to the subsurface to promote biodegradation, and whether the native bacterial population can achieve the remedial goals without additional bioaugmentation. Furthermore, advanced diagnostic microbial monitoring might be required to prove that the indigenous microbial populations present at the site are sufficient to complete degradation of the site COCs in groundwater utilizing anaerobic biostimulation. In addition, it would be necessary to properly delineate affected groundwater so permanent injection points could be appropriately installed.

14.1.2.3 Implementability

As described, the presence of TCE degradation products indicates natural reductive dechlorination. This implies that enhanced bioremediation could effectively achieve the RAOs in groundwater. Biostimulants and substrates are commercially-available and could be introduced to the subsurface through permanent injection points. This alternative would require long-term monitoring of VOCs to ensure degradation was effectively occurring and determine if reapplication of substrates was necessary.

14.1.2.4 Cost and Time Frame

The cost of enhanced *in situ* bioremediation is moderate to high. It can be expensive to implement if a large number of permanent application points are necessary to treat the plume. There are no associated O&M costs. Periodic groundwater monitoring would be required. Costs involved with groundwater monitoring include labor, disposable sampling equipment, rental equipment, and laboratory analysis. The time frame associated with this alternative is 5 to 10 years.

In situ bioremediation is further retained for evaluation following a review of the data collected during the pre-design activities described previously for AOC 1.

14.1.3 *In situ* Oxidation

14.1.3.1 Technical Description

ISCO involves the delivery of oxidants to the subsurface to address impacted groundwater. This alternative would also address soil source areas located at or near the same elevation of impacted groundwater in the overburden. COCs are chemically transformed to innocuous compounds. Traditional oxidants used to address VOCs include hydrogen peroxide, iron-catalyzed hydrogen peroxide or Fenton's reagent, Modified Fenton's, potassium permanganate, sodium persulfate, and ozone. Based on the COCs and concentrations identified in AOC 1, permanganate-based oxidants would not be applicable because they do not alter methylene chloride (detected in a soil sample collected from a soil boring installed in AOC 1). Another consideration in oxidant selection is the naturally occurring reductive dechlorination, likely resulting from natural bioremediation. Some oxidants will alter the anaerobic environment in the subsurface that is conducive to reductive dechlorination. Modified Fenton's reaction using hydrogen peroxide may be a suitable oxidant because it is not as detrimental to natural anaerobic biodegradation. Aerobic environments created through Fenton's reaction are reversible, such that oxidation could be followed by an MNA program. In addition, COC concentrations in groundwater were less than typical concentrations by more than an order of magnitude *in situ*ations where oxidants are used. Thus, in applying oxidation to AOC 1, it may be appropriate to modify the amount or concentration of oxidant applied.

As described, oxidants are typically applied through injection. However, with low permeability soils overlying bedrock, injections are likely not an effective approach. It is necessary to treat both the A-zone and upper B-zone groundwater. Applying oxidant to this area could be achieved by installing permanent diffusive application points that are screened across the entire area of interest, or screened above the fractured bedrock. Oxidant would be added to the application points and allowed to diffuse through soil and bedrock, likely following similar channels that COCs have taken. Pre-design work would involve surveying the subsurface to determine locations of fractures and anomalies that could potentially be pathways for COC transport. These fractures would then be the focus of application. With such low concentrations of COCs, one approach to oxidant application would be using lower than usual oxidant concentrations and applying these at set intervals over a period of time. For example, reapplying the oxidant every three months until COCs in groundwater reach groundwater standards.

As previously described, the suitability of a particular oxidant is dependent on many characteristics in the subsurface soil and bedrock. It would be necessary to perform laboratory testing and pre-design work to determine the proper oxidant, application procedure, and optimize the rate of application. This can be achieved through a combination of laboratory analyses to determine a suitable oxidant and pilot testing in the field to determine success of delivery.

Through laboratory testing, oxidant demand, the potential for rebound and ongoing control of rebound, and the potential for microbial inhibition can be determined. It would also be necessary to delineate the affected groundwater plume more precisely to ensure proper spacing of application points.

14.1.3.2 Effectiveness

Effectiveness of *in situ* oxidation would rely on proper oxidant selection and characterization of the subsurface through pre-design work and pilot testing. In the short-term, levels of contaminant removal are limited by reaction time. Removal rates can more accurately be determined in bench scale testing as part of pre-design work. Long-term effectiveness is related to successful application. Oxidants are only active in the subsurface for a certain length of time and reapplication may be necessary in the long-term because the RAOs are unlikely to be achieved through a single application. VOC concentrations may also rebound, necessitating future oxidant applications. With proper oxidant selection, VOCs can effectively oxidize into non-toxic compounds and achieve the RAOs for groundwater in AOC 1.

14.1.3.3 Implementability

As described, pre-design work and testing would be necessary to determine plume characteristics and select the proper oxidant that is compatible with the soil and bedrock matrix of AOC 1. Improper oxidant selection could negatively impact reductive dechlorination, bedrock characteristics, or fail at reducing the concentrations of COCs. This approach would require the installation of permanent application points and a long-term monitoring program, which are easily established.

14.1.3.4 Cost and Time Frame

The cost associated with *in situ* oxidation is moderate to high. Commercially-available oxidants can be costly, and if multiple applications are necessary, the cost could be significant. In addition, pre-design work, laboratory bench scale testing, and pilot tests will impact cost. Long-term O&M costs will be minor when compared to mechanically-based systems. Associated recurring costs will include labor, disposable sampling equipment, rental equipment, and laboratory analysis. The time frame associated with this alternative is estimated to be up to 2 years.

In situ chemical oxidation is further retained for evaluation following a review of the data collected during the pre-design activities described previously for AOC 1.

14.2 Potentially Feasible Technologies for Soil for AOC 1

Only one alternative for addressing soil in AOC 1 was retained as a feasible option following initial analysis. Containment/institutional control is described in more detail in the following section.

14.2.1 Containment/Institutional Control

14.2.1.1 Technical Description

As described, containment of impacted soil at AOC 1 would involve the installation of a low-permeability cap across the area to mitigate potential exposure and minimize surface water infiltration (outside the building). The existing asphalt outside the building would be saw cut and removed before installing a new cap. This would include the removal of asphalt and the gravel base below. Based on soil boring results, the existing concrete slab inside the building is approximately 3 inches thick and is underlain by 3 inches of base material. The existing concrete slab would be inspected and modified if necessary to maintain an appropriate cap over the area encompassing AOC 1. Removed materials would be disposed of offsite at a properly permitted treatment or disposal facility.

The construction of a new exterior cap could include a vapor barrier, a layer of graded fill, and a layer of low-permeability asphalt or concrete. The surface would be finished in kind to match the surrounding asphalt driveway of the facility. This alternative would not actively remove or treat source areas, but would contain and prevent contact with affected soils. Therefore, this option would be protective of human health and the environment because site workers would not come in contact with affected soils. This alternative would meet the site-specific RAO of minimizing the potential for exposure to surface and subsurface soils. However, the migration of affected materials resulting from infiltration and water movement is still possible if the areas outside the building surrounding the source area are not properly addressed. It is unlikely that water will infiltrate inside the building, but outside water would affect the source and it would be necessary to extend the cap to prevent this occurrence.

Because this remedy results in contamination above RAOs remaining onsite, it would be necessary to implement institutional controls, such as deed restrictions, to prevent disruption of the cap and eliminate the direct contact exposure pathway. A site management plan (SMP) would be developed and implemented, and would include institutional controls and engineering controls intended to:

- address residual contaminated soils that may be excavated from the site during future redevelopment, including provisions for proper soil characterization and disposal in accordance with state and federal regulations
- evaluate the potential for vapor intrusion for any future buildings developed onsite, including provisions for mitigation of any impacts identified
- provide for the operation and maintenance of the components of the remedy
- monitor groundwater
- identify any use restrictions on site development or groundwater use
- provide a groundwater monitoring program, including installing monitoring wells and sampling them on a regular basis

This monitoring program and the effectiveness of the remedy would be periodically reevaluated. The SMP would require the responsible party or property owner to provide an Institutional Control/Engineering Control (IC/EC) certification, prepared and submitted by a professional engineer or environmental professional, which will certify the institutional controls and engineering controls put in place onsite. The document would require periodic review to certify that site conditions are unchanged from the previous certification and that nothing has occurred that would impair the ability of the implemented control to protect public human health and the environment. This remedy would require imposition of an institutional control in the form of an environmental easement that would require compliance with the approved SMP. The future use and development of the property at this area would be limited to industrial or commercial use only. Groundwater use would be restricted as a source of potable or process water without proper water quality treatment. The property owner would be required to submit an updated IC/EC as necessary.

14.2.1.2 Effectiveness

The short-term effectiveness of containment would be immediate upon installation of the necessary cap. In the long-term, containment would mitigate the potential for exposure to affected soils by providing a physical barrier. Future subsurface excavation activities, such as utility installation or new building foundation, would require personal protective equipment in accordance with site-specific health and safety plans because disruption of soil could pose a physical risk. It would be necessary to monitor the integrity of the cap and maintain it as necessary.

14.2.1.3 Implementability

Construction of a cap outside the building modifications to the floor inside the building is technically feasible and easily implemented. Most of the area is already under asphalt, but may require replacement with an appropriately engineered containment cap. Modification of the building floor would be completed using readily available construction techniques and it would not be difficult to establish a maintenance plan.

14.2.1.4 Cost and Time Frame

The cost associated with this alternative, including capital costs and future maintenance, would be relatively low. While there is no time frame for treatment because this is not an active technology, it is estimated that this alternative would be effective for 30 years.

Containment/Institutional control is further retained for evaluation following a review of the data collected during the pre-design activities described previously for AOC 1.

14.3 Potentially Feasible Technologies for Groundwater for AOCs 4, 15, and 24

After the initial screening provided in Section 14.0 of this report, *in situ* oxidation and free product removal with offsite treatment/disposal were retained for further analysis. It should be noted that for AOC 24, the alternatives discussed below are designed to address the LNAPL within the fire water reservoir area only.

14.3.1 *In situ* Chemical Oxidation

14.3.1.1 Technical Description

In situ chemical oxidation can be used to treat thin layers of free product when applied directly to the source area. As described, there are many commercially available oxidants that can be tested and selected on a laboratory scale to determine suitability.

As described, oxidants are typically applied through injection. However, with low permeability soils overlying bedrock, injections are likely not an effective approach. Applying oxidant to this area could be achieved by installing permanent monitoring wells that are screened across the entire area of interest, or screened above the fractured bedrock. Another typical approach when addressing free product is to add oxidant directly to the monitoring wells where product is present. Again, it may be necessary to reapply oxidant if free product enters the wells after initial treatment, and a suitable reapplication schedule would be developed as required by observed data.

As previously described, the suitability of a particular oxidant is dependent on many characteristics in the subsurface soil and bedrock (if free product is determined to be present in shallow bedrock based on pre-design activities). It would be necessary to perform laboratory testing and pre-design work to determine the proper oxidant, application procedure, and optimize rate of application. This can be achieved through a combination of laboratory analyses to determine a suitable oxidant and pilot testing in the field to determine success of delivery. Delineation of free product both horizontally and vertically would be necessary for proper application.

14.3.1.2 Effectiveness

Effectiveness of *in situ* oxidation would depend on proper oxidant selection and characterization of the subsurface through pre-design work and pilot testing. In the short term, levels of contaminant removal are limited by reaction time. Removal rates can more accurately be determined in bench scale and/or pilot testing as part of pre-design work. Long-term effectiveness is related to successful application. Oxidants are only active in the subsurface for a certain length of time and reapplication may be necessary in the long-term because RAOs may not be achieved through a single application. Free product may re-enter wells and require further oxidant applications.

14.3.1.3 Implementability

As described, pre-design work and testing would be necessary to delineate free product plume characteristics and select the proper oxidant that is compatible with the soil and bedrock matrix (if free product is present in bedrock) of the AOCs. Improper oxidant selection could fail to destroy free product or could adversely impact the subsurface matrix. This approach would require the installation of permanent monitoring wells and a long-term monitoring program, which are easily established.

14.3.1.4 Cost and Time Frame

The cost associated with *in situ* oxidation is moderate to high. Commercially-available oxidants can be costly, and if multiple applications are necessary, the cost could be significant. In addition, pre-design work, laboratory bench scale testing, and pilot tests will impact cost. Long-term O&M costs are minor when compared to mechanically-based systems. Associated costs will include labor, disposable sampling equipment, rental equipment, and laboratory analysis. The time frame associated with this alternative is estimated to be up to two years.

In situ chemical oxidation would not achieve the groundwater RAOs as a stand-alone technology and does not protect from the migration of affected groundwater; however, it could be used as a polishing technology coupled with the free product removal technology described in the next section. Therefore, it will be further evaluated as a polishing technology following completion of the pre-design activities.

14.3.2 Free Product Removal and Offsite Treatment/Disposal

14.3.2.1 Technical Description

Another method of achieving the RAO for free product in AOCs 4, 15, and 24 is by physical removal. As described, physical removal can involve a variety of methods, including vacuum trucks, manual bailing, product-only pumps, or absorbent socks. The physically-removed product would be containerized and disposed of at an appropriately permitted facility. Free product can be removed directly from a groundwater monitoring well, or it can be removed from a designated collection sump that is installed for the purpose of collecting free product. The frequency of removal would be dependent upon the thickness of the product and how quickly, if at all, the product would re-enter monitoring wells or sumps.

The method is dependent on the vertical and horizontal extent of product present in each AOC. If only a thin layer of product is present, product-only pumps would not be the most effective method for removal. All methods are proven effective for removing product in the appropriate setting. After delineation, monitoring wells or sumps would be installed in and around the plume area in a manner that would effectively capture free product. One approach would be initially vacuuming or bailing out the floating layer of free product, and then installing absorbent socks to capture product that re-enters. If absorbent socks spoil quickly because of large amounts of free product, relying only on vacuuming or bailing may be the most effective method. Some removal methods such as vacuuming using a vacuum truck may not be implementable at AOC 4 due to the location of this area inside the facility building. Any approach will require monitoring the wells for free product using a product-level delineation meter.

14.3.2.2 Effectiveness

The method effectiveness is dependent on the vertical and horizontal extent of product present in each AOC. All methods are proven effective for removing product in the appropriate setting. In the short-term, this alternative would be effective immediately upon removal of free product. In the long-term, this method would be effective with continued monitoring. If any free product re-entered the wells, it would be necessary to remove it. Even if there are successive monitoring events where no free product was measured, monitoring would still be necessary because it is possible that product could diffuse slowly into monitoring wells.

14.3.2.3 Implementability

Free product removal through physical methods is easily implemented. Equipment is readily available for removal and can be mobilized to the site. It would be necessary to categorize the free product for acceptance at an appropriately permitted treatment or disposal facility. In addition, a long-term monitoring program is easily implemented.

14.3.2.4 Cost and Time Frame

The cost associated with this alternative is low to moderate. Overall cost would be based on the quantity of product that is removed, and the frequency at which it is removed. Contracting a vacuum truck would likely have a higher cost than using absorbent socks or manual bailing, but the selection of the appropriate method would be based on delineation of the free product layer. The costs associated with monitoring would include labor, rental equipment, disposable sampling equipment, and any necessary laboratory costs. The time frame associated with this alternative is up to 2 years, but may vary depending upon the results of the pre-design activities.

Free product removal and offsite treatment and disposal will achieve the RAO for these AOCs and is retained as an acceptable technology.

15.0 Recommended Remedial Strategy and Selection Rationale

Based on the results of the RI and SRI, there are four AOCs at EPT that require the implementation of remedial technologies to address affected areas of soil and groundwater. The following sections describe the selected remedy for each AOC.

15.1 AOC 1

Groundwater

Additional investigation is necessary to further delineate the extent of VOCs in groundwater before recommending an appropriate remedial alternative. The potentially recommended alternatives are *in situ* chemical oxidation, *in situ* bioaugmentation, or a treatment train involving the sequential use of both. Both alternatives, used independently or together as necessary, can effectively address VOCs in the correct setting, and would be appropriate for addressing the site-related compounds found in AOC 1. However, with limited knowledge on the subsurface and before pre-design work is conducted, it is not possible to recommend a specific technology. Both chemical oxidation and bioremediation require pre-design work to determine characteristics about the subsurface that are critical to the remedial success of these technologies. The pre-design treatability testing required for chemical oxidation may include 1) reaction kinetics to determine oxidant demand, 2) desorption kinetics to determine the potential for rebound of COC concentrations and ongoing control of that rebound, 3) oxidation intermediates-mediated chemical oxidation demand analysis, and 4) bioremediation inhibition to determine if the oxidant may inhibit ongoing reductive dechlorination either temporarily or indefinitely. The purposes of these diagnostic tests are to insure the proper choice of chemical oxidant, avoid pitfalls in their deployment, and optimize rates of application.

Similar to chemical oxidation, pre-design treatability testing is required to implement bioremediation. These tests may include a suite of analysis including quantitative polymerase chain reaction (qPCR) measurements, phospholipid fatty acid analyses, surrogate tracer degradation analyses, and/or stable isotope analyses used in conjunction with a unique passive sample collection matrix called a Bio-Trap®. Some forms of useful stable isotope analyses (compound specific isotope analysis or CSIA) can also be done directly on water samples such as C13/C12 ratio analysis which gives valuable information on natural attenuation rates and enhanced natural attenuation rates after chemical oxidation or bioremediation.

Bio-Trap® samplers are a passive sampling tool designed to collect actively colonizing bacteria for the purpose of understanding the bioremediation potential at a given site. The Bio-Trap® consists of a sampling medium with high surface area (Bio-Sep® beads, a composite of Nomex®, and powdered activated carbon) contained in a small tube of porous (1-10 micron pore size) Teflon, and capped on either end with a nylon cap. The samplers are suspended in wells for periods of 30 to 60 days to allow microbes to colonize and grow on the Bio-Sep® beads and to compensate for the inherent variability in groundwater quality and flow. Bio-Trap® samplers may be used in AOC 1 to evaluate the microbial response to different amendments and to demonstrate that bioremediation is occurring. After the Bio-Trap® samplers are removed from a well, DNA can be extracted from the beads and analyzed by qPCR to determine if the microbes that are critical to the bioremediation of chlorinated solvent compounds are present and if so, at what concentration. Similar useful analyses at the whole class level (e.g., dechlorinators, methanogens) can be made through the PFLA method. As stated, non-incubated water samples can be used for CSIA. The purpose of these bioremediation diagnostics is to establish rates of remediation before and after treatment to assist in selecting the most appropriate substrate.

Both chemical oxidation and bioremediation could also serve as the final remedy with both technologies being combined to meet the remediation goals. As stated, implementation of chemical oxidation could be followed by bioremediation to effectively meet these goals. However, proper diagnostic and treatability studies are required to demonstrate the effectiveness and implementability of this treatment train.

A subsurface investigation (included in Section 11.1) to determine the extent of affected groundwater within the B-zone is necessary to determine the appropriate application method for both technologies. Without knowledge on the extent of affected groundwater in the overburden and shallow bedrock (B-zone), it cannot be determined whether diffusive application and/or overburden and bedrock injections are most appropriate. Depending on the delineated extent of affected groundwater, surveying the subsurface may be necessary to determine preferential flow pathways in the shallow bedrock that could be part of the targeted application plan. After pre-design work has been conducted, an appropriate technology can be recommended.

Soil

The recommended alternative for addressing soil in AOC 1 is containment and institutional controls. Containment and institutional controls was the only technology that survived the screening process as a feasible and appropriate technology. When used in conjunction with an appropriate groundwater remediation technology, containment will successfully achieve the RAO of preventing exposure to affected soil and limiting future contact. Appropriate institutional controls will also prevent future contact if the property is transferred and serve to warn of hazards associated with disturbing the subsurface. The SMP will outline the procedures necessary for maintaining a containment cap and limiting exposure.

Depending upon the results of the pre-design investigation activities, if the impacted overburden soil is isolated to a thin layer at and/or just above the groundwater table, implementation of the groundwater remedy may have positive effects on the reduction of COC concentrations in soil. This will be further evaluated during the pre-design phase and incorporated, if applicable, into the final remedy to address impacted soil at this AOC.

15.2 AOCs 4, 15, and 24

The recommended alternative for addressing the product layers in AOCs 4, 15, and 24 is removal and offsite disposal. The rationale for selecting this remedy is that this technology will achieve the RAO for these AOCs in both the short-term and long-term without altering subsurface conditions. This technology is also cost effective. Effective NAPL removal will require delineation of the product layer, including its horizontal and vertical extents, in order to select the appropriate removal technique and properly locate product collection sumps or wells.

The recommended removal technologies are manual bailing, product-only pumps, and/or vacuuming out product. Baseline measurements of the product thickness in each well will be recorded in a field log book. Initially, manual bailing of the product layers will be performed at least weekly. Following bailing, the product thickness in each well will be measured daily during the work week and recorded in the field log book. Product bailing will be conducted a minimum of once a week or when the measured product thickness approaches the original baseline measurement. This approach will be followed for approximately one month. At this point, product thickness measurements will be reviewed to determine if continuation of manual bailing is appropriate or whether an alternative technology would be more effective.

Alternatives that would be considered are product only pumps or vacuuming. The selection of the approach for continued product removal will be documented.

After the first month, product removal activities will continue. Thickness measurements will be recorded weekly. Once the product thickness approaches a sheen, active removal will be discontinued and absorbent socks will be placed in the wells. The adsorbent socks will be checked monthly for visible product. Use of adsorbent socks will continue until the product layer has been successfully eliminated, as determine by the lack of observed sheen or product in the well.