UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF: SR-6J

October 5, 2017

Ms. Madelyn Adams
Site Coordinator
Division of Environmental Response and Revitalization
Ohio EPA, Southwest District Office
401 East Fifth Street
Dayton, Ohio 45402

Re: EPA Approval of Final Focused Feasibility Study Report
East Troy Contaminated Aquifer Site, Troy, Ohio

Dear Ms. Adams:

This letter notifies you that the United States Environmental Protection Agency (EPA) approves the Final Focused Feasibility Study Report dated August 31, 2017 for the East Troy Contaminated Aquifer site in Troy, Miami County, Ohio. EPA received Ohio EPA's concurrence letter on the above document on September 28, 2017.

If you have any questions, please contact me at (312) 886-6151 or at kolak.shari@epa.gov.

Sincerely,

Shari Kolak
Remedial Project Manager
Superfund Division

cc: Guy Montfort (SulTRAC)

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Ohio Environmental Protection Agency

John R. Kasich, Governor
Mary Taylor, Lt. Governor
Craig W. Butler, Director

September 28, 2017

Ms. Shari Kolak
Remedial Project Manager
U.S. EPA, Region 5
SR-6J
77 West Jackson Boulevard
Chicago, Illinois 60604

Re: Troy Well Field Unknown Source
Remediation Response
Approval
Remedial Response
Miami County
555001353004

Subject: Ohio EPA Review and Concurrence
Final Focused Feasibility Study, August 31, 2017 for East Troy Contaminated Aquifer Site, Troy, Miami County, Ohio

Dear Ms. Kolak:

On August 31, 2017, the Ohio Environmental Protection Agency (Ohio EPA) Division of Environmental Response and Revitalization (DERR) received the Final Focused Feasibility Study, submitted by SulTRAC on behalf of U.S. EPA, for the East Troy Contaminated Aquifer Site located in Troy, Miami County, Ohio.

Upon Ohio EPA review and in consultation with Mike Proffitt, DERR Chief, we hereby concur with the document. Our concurrence is with the understanding that the frequency of sampling of the sub-slab depressurization systems under Ohio EPA-funded operation and maintenance (O&M) will be determined by Ohio EPA. O&M of the sub-slab depressurization systems will be determined in the O&M Plan and will be conducted in accordance with relevant guidance and as necessary for the protection of human health.

If you have any questions, please contact me at (937) 285-6456 or Madelyn.Adams@epa.ohio.gov.

Sincerely,

Madelyn Adams

Madelyn Adams
Site Coordinator
Division of Environmental Response and Revitalization

ec: Allison Reed, SWDO-DDAGW
Sarah Beal, CO-DERR
Jeff Martin, CO-DERR
Mike Starkey, SWDO-DERR
Mark Rickrich, CO-DERR
Mike Proffitt, CO-DERR

MA/bp

August 31, 2017

Ms. Shari Kolak
Work Assignment Manager
U.S. Environmental Protection Agency (EPA)
77 W. Jackson Blvd.
Chicago, Illinois 60604

Subject: **Final Focused Feasibility Study (FFS) Report**
East Troy Contaminated Aquifer (ETCA) Site
Troy, Miami County, Ohio
Remedial Action Contract (RAC) 2 No. EP-S5-06-02
Work Assignment No. 145-RICO-B5EN

Dear Ms. Kolak:

SulTRAC is enclosing the above-referenced draft FFS report for your review. One CD containing a full electronic copy of the draft FS report is provided with this submittal. A duplicate copy (CD) is being sent directly to Madelyn Adams, Ohio Environmental Protection Agency (Ohio EPA) Site Coordinator. Hard copies of the report will be provided to both agencies under separate cover.

The FFS report was developed at the request of EPA to support a proposed interim action (IA) at the ETCA site. The FFS is based on Remedial Action Objectives (RAOs) that were developed through direction from EPA and Ohio EPA in 2016 and 2017. The FFS report was originally submitted in draft form in January 2017. SulTRAC revised the draft FFS to address comments received from Ohio EPA in March 2017, and to address additional issues identified in subsequent discussions with EPA and Ohio EPA. The final FFS report has been revised in accordance with SulTRAC's responses to Ohio EPA comments and proposed revisions to the FFS in correspondence dated June 8, 2017.

If you have any questions regarding this report, please call me at (513) 333-3669.

Sincerely,

Guy Montfort
SulTRAC Project Manager

Enclosure

cc: Daniel Olsson, EPA Project Officer (letter only)
Melinda Gould, SulTRAC Contract Manager (letter only)
Madelyn Adams, Ohio EPA Site Coordinator (Southwest District Office)
File

FINAL
FOCUSED FEASIBILITY STUDY

EAST TROY CONTAMINATED AQUIFER SITE
TROY, MIAMI COUNTY, OHIO

Prepared for
U.S. Environmental Protection Agency
Region 5
77 West Jackson
Chicago, Illinois 60604

Work Assignment No.	:	145-RICO-B5EN
Contract No.	:	EP-S5-06-02
Date Prepared	:	August 31, 2017
Prepared by	:	SulTRAC
SulTRAC Project Manager	:	Guy Montfort
Telephone No.	:	(513) 333-3669
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Appendix C Remedial Alternative Cost Estimates

C1 – Soil Alternative Cost Estimates

C2 – Groundwater Alternative Cost Estimates

C3 – Vapor Intrusion Alternative Cost Estimates

Appendix D Preliminary Identification of Applicable or Relevant and Appropriate Requirements

ACRONYMS

APC	Air pollution control
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	Below ground surface
CAA	Clean Air Act
CD	Consent decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cDCE	Cis-1,2-dichloroethene
cm/sec	Centimeters per second
COC	Chemical of concern
COPC	Chemical of potential concern
CTE	Central tendency exposure
CWA	Clean Water Act
DAF	Dilution attenuation factor
DNAP	Dense nonaqueous-phase liquid
EA	Exposure area
EPA	U.S. Environmental Protection Agency
EPDM	Ethylene propylene diene monomer
ERD	Enhanced Reductive Dechlorination
ESI	Expanded site inspection
ESV	Ecological screening value
ETCA	East Troy Contaminated Aquifer (site)
FFA	Federal Facility Agreement
FFS	Focused feasibility study
foc	Fraction organic carbon
ft/day	Feet per day
ft^2/day	Square feet per day
ft/year	Feet per year
GAC	Granular activated carbon
GMR	Great Miami River
GRA	General response action
HDPE	High-density polyethylene
HHRA	Human health risk assessment
HI	Hazard index
Hobart	Hobart Cabinet Company
HQ	Hazard quotient
HRSC	High resolution site characterization
HVAC	Heating, ventilation, and air conditioning
IA	Interim action
IC	Institutional control

ISCO	In situ chemical oxidation
ISCR	In situ chemical reduction
KC	Kimberly Clark
LDR	Land disposal restriction
MCD	Miami Conservatory District
MCL	Maximum contaminant level
MGD	Million gallons per day
mg/kg	Milligram per kilogram
mg/L	Milligram per liter
MIP	Membrane interface probe
MNA	Monitored natural attenuation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOD	Natural oxidant demand
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
O&M	Operations and maintenance
OMZA	Outside Mixing Zone Average
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
POTW	Publicly owned treatment works
ppbv	Part per billion by volume
ppm	Part per million
PRG	Preliminary remediation goal
PVC	Polyvinyl chloride
RA	Remedial Action
RAC	Remedial Action Contract
RAO	Remedial action objective
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial design/remedial action
RI	Remedial investigation
RME	Reasonable maximum exposure
ROD	Record of Decision
ROI	Radius of influence
RSL	Regional screening level
SAP	Sampling and analysis plan
SDWA	Safe Drinking Water Act
SL	EPA Screening Level
SLERA	Screening level ecological risk assessment
Spinnaker	Spinnaker Coatings, LLC
SPLP	Synthetic precipitation leaching procedure
SSD	Sub-slab depressurization

SSDS	Sub-slab depressurization system
SSL	Site Screening Level
SSP	Sub-slab pressurization
SSV	Sub-slab ventilation
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
TBC	To be considered
TCA	Trichloroethane
TCE	Trichloroethene
TCRA	Time critical removal action
TOT	Time of travel
TSCA	Toxic Substances Control Act
TCVOC	Total chlorinated volatile organic compound
UECA	Uniform Environmental Covenants Act
UIC	Underground Injection Control
USDA	U. S. Department of Agriculture
UV	Ultraviolet
VAP	Voluntary Action Program
VAS	Vertical aquifer sampling
VCP	Vitrified clay pipe
VI	Vapor intrusion
VISL	Vapor intrusion screening level
VOC	Volatile organic compound
VC	Vinyl chloride
Waterloo APS	Waterloo Advanced Profiling System
ZVI	Zero-valent iron
µg/kg	Microgram per kilogram
µg/L	Microgram per liter
$\mu g/m^3$	Microgram per cubic meter
ºC	Degrees Celsius

1.0 INTRODUCTION

SulTRAC prepared this focused feasibility study (FFS) report for the U.S. Environmental Protection Agency (EPA) under EPA Remedial Action Contract No. EP-S5-06-02 (RAC), Work Assignment No. 145-RICO-B5EN. Under this work assignment, EPA tasked SulTRAC to conduct an FFS to evaluate potential remedial alternatives to support an interim action (IA) at the East Troy Contaminated Aquifer (ETCA) site. Specifically, EPA and SulTRAC, with input from the Ohio Environmental Protection Agency (Ohio EPA), developed a list of potential remedial alternatives to address chemicals of concern (COC) associated with soil, groundwater, and indoor air at specific areas of the ETCA site. SulTRAC prepared this FFS report in accordance with the EPA Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (EPA 1988).

A remedial investigation (RI) was completed for this site in January 2015. The RI determined that the ETCA site involves multiple contaminant sources, two groundwater contaminant plumes (referred to herein as the “Residential Area” plume” and “East Water Street” plume), and multiple exposure pathways, in a complex hydrogeologic setting. The site is located in a semi-urban residential and commercial area and contains contaminated groundwater beneath numerous private properties, which constrains the selection of remedial approaches that may be effectively implemented for this site. In 2015, an initial set of remedial action objectives (RAOs) and potential remedial alternatives were developed by EPA and SulTRAC, with input from Ohio EPA. The nature and extent of contamination, site complexity, and constraints caused by the site setting have significant influence on the estimated timeframes that will be required for remediation of this site to achieve the full list of potential RAOs for all areas and exposure pathways. For this reason, EPA elected to conduct an FFS to address a focused group of RAOs and to evaluate remedial alternatives that are directly related to meeting the focused RAOs. The interim RAOs prioritize reduction of exposure risk and reduction of contaminant mass in the source areas of groundwater contamination. Specifically, RAOs for this IA have been established for:

- Groundwater and indoor air/vapor intrusion (VI) in the Residential Area plume, which is - contaminated by tetrachloroethene (PCE)
- Soil in portions of the East Water Street plume area

EPA considers it important to implement an IA as soon as practicable for several reasons. The IA will reduce contaminant mass in, and thus reduce continuing migration of VOCs from, the Residential Area plume contaminant source area and known high-concentration areas of the groundwater contaminant

plume. Reduction of the contaminant mass in these areas will also reduce the potential for VI. Implementing an IA in select areas of soil contamination will reduce potential exposure above human-health risk standards, and reduce the amount of contamination remaining in soil that is an ongoing source of groundwater contamination to the East Water Street plume area.

This FFS and the associated IA will not supplant an FS and final, site-wide remedy ultimately required for this site. The scope of the IA also does not include complete restoration of the aquifer to "beneficial use" (removal of all manmade contaminants to below EPA Maximum Contaminant Levels [MCL]). Aquifer restoration is not within the scope of the IA due to the estimated timeframes that would be required, and also because some approaches, such as monitored natural attenuation (MNA) commonly used to achieve complete aquifer restoration, are generally not appropriate for sites where the groundwater contaminant sources have not yet been addressed or when dense nonaqueous-phase liquid (DNAPL) may still be present (EPA 1999). For this FFS, EPA has decided to specifically address areas of soil contamination that exceed human health risk standards, and that coincide with apparent groundwater contaminant source areas. Additional areas of soil contamination may be considered for future action in the final remedy depending on the effectiveness of the IA in reducing contaminant concentrations in site groundwater. The final FS, proposed plan, record of decision (ROD), and remedial action (RA) will be completed following implementation of the IA. The effectiveness of the IA in meeting the interim RAOs will be monitored and the final FS/ROD/RA may be implemented at any future time. Nominally, this may occur once the RAOs for the IA have been fully achieved, or conversely if it is determined that the IA is not effective in achieving the RAOs.

The primary goals of this FFS are to (1) establish a focused set of site-specific interim RAOs for the ETCA site emphasizing contaminant source reduction and addressing soil exposure risk/hazard greater than 1E-06 or a hazard index (HI) of 1; (2) propose interim general response actions (GRA) for the ETCA site by defining actions to satisfy RAOs; (3) screen remedial technologies and process options to ensure that only applicable technologies are retained; (4) develop a range of interim remedial alternatives in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and screen each alternative for effectiveness, implementability, and cost; (5) conduct a detailed analysis of each interim remedial alternative; and (6) conduct a comparative analysis of each interim remedial alternative.

This FFS report presents and evaluates alternatives to address (1) soil in portions of the East Water Street plume area, (2) groundwater in the Residential Area plume, and (3) vapor intrusion in the vicinity of the

Residential Area plume. Choosing, and possibly combining, remedial alternatives to effectively concentrate on each of the three areas will help to establish the IA.

The report is organized into seven major sections. Section 1.0 provides a general introduction that presents a summary of historical activities and summarizes the nature and extent of contamination at the ETCA site. Section 2.0 identifies RAOs specific to the IA, applicable or relevant and appropriate requirements (ARAR), and estimated areas and volumes requiring remediation. Section 3.0 provides general response actions (GRAs) and identifies remedial technologies and process options. Section 4.0 provides a screening of remedial technology types and process options. Section 5.0 describes the remedial alternatives assembled for the ETCA site. Section 6.0 presents a detailed evaluation of each remedial alternative. Section 7.0 presents a comparative analysis of the remedial alternatives. References are located in Section 8.0. Figures are located after Section 8.0. Four appendices are also included. Appendix A presents input parameters and calculations of site-specific leach-based remediation goals applicable to the soil alternatives. Appendix B presents estimates of dissolved phase contaminant mass in the area of the proposed groundwater IA for the Residential Area PCE plume. Appendix C presents detailed cost estimates for each of the remedial alternatives. Appendix D presents a preliminary identification of ARARs.

1.1 EAST TROY CONTAMINATED AQUIFER SITE BACKGROUND AND HISTORY

The following sections provide a description of the ETCA site and a brief summary of historical activities that have been conducted at the ETCA site. More detailed information can be found in the remedial investigation (RI) report for the site (SulTRAC 2015). Unless otherwise cited, all information presented in Sections 1.1.1 and 1.1.2 was previously summarized in the RI report (SulTRAC 2015).

1.1.1 Site Description

The ETCA site is in the City of Troy, Miami County, Ohio (see Figure 1-1). The site contains contaminated groundwater, which has impaired water quality in the local sand and gravel aquifer. The contamination is present in two separate plumes that likely have originated from different sources. The aquifer is the sole source of drinking water in the area. The groundwater contamination has also impaired indoor air quality in structures above the groundwater contaminant plumes, through vapor intrusion (VI). Investigations completed to date have indicated that the contamination originated from multiple sources. Contaminated soils are present in and adjacent to the suspected source areas of the East Water Street plume. The original sources of the Residential Area plume no longer exist and the source area has been extensively reworked and is covered by more recent construction. It is unknown if contaminated soil

remains in the vadose zone at that location. Groundwater in the saturated zone in the vicinity or the Residential Plume source area contains part per million (ppm) level concentrations of PCE, with the highest concentrations approximately 20 to 40 feet below the water table, suggesting that DNAPL and/or sorbed PCE may be present in the saturated zone and is acting as a secondary, ongoing source of contamination.

The ETCA site includes an area west of the Great Miami River (GMR) that extends from approximately South Walnut Street on the northwest to Floral Avenue on the southeast, where volatile organic compounds (VOCs) have been identified in groundwater, soil, or indoor air of residential, public, and commercial properties (see Figure 1-2). This area is generally bounded by Canal and Scott Streets on the southwest and the GMR on the northeast.

The site overlies a prolific sand and gravel aquifer that is considered a sole source aquifer system. The term "sole-source aquifer" is a federal designation used to protect drinking water supplies in areas with few or no alternative sources of drinking water. The City of Troy obtains its public water supply, which serves approximately 25,000 residents, from two wellfields that draw from this aquifer, located on the east side of the GMR. (The West wellfield is located about 0.75 mile north of the ETCA site and was not part of the ETCA site RI.) The East wellfield is located at the southeastern boundary of the ETCA site and includes five production wells. The chlorinated VOC, cis-1,2-dichoroethene (cDCE), has been detected at low concentrations (below the EPA MCL) in water samples collected from several wells in the East wellfield, most frequently in Well P-18. The origin of the cDCE is suspected to be from the breakdown of low concentrations of tetrachloroethene (PCE) and trichloroethene (TCE) from an area west of the river, which are then being drawn beneath the GMR through deeper portions of the aquifer near the East wellfield. The overall direction of groundwater flow is to the southeast (generally parallel to the GMR) but is locally affected by pumping in the East wellfield. The entire ETCA site lies within the 5-year time of travel (TOT) for the East wellfield production wells. Some local residents in Troy and on the ETCA site also use non-potable water from private wells installed in the aquifer; however, a City of Troy ordinance restricts use of private potable water supply wells within the city.

The ETCA site includes multiple groundwater contaminant plumes that originate from two or more primary sources and co-mingle in some areas (see Figure 1-2). A groundwater contaminant plume, referred to as the Residential Area plume, is located within a predominantly residential area southwest of East Main Street. This plume primarily contains PCE at concentrations greater than 1,000 micrograms per liter (µg/L) in the source area, with TCE and cDCE occasionally detected at lower concentrations.

This plume appears to originate immediately northwest of South Walnut Street, roughly mid-block between East Main and East Franklin Streets (Figure 1-3). This area was the former location of a dry cleaning operation identified as "Troy One-Hour Cleaners" that operated at 10 East Main Street, and possibly in portions of adjacent structures behind it that fronted on South Walnut Street, from 1958 to 1979 (EDR 2013; Troy-Miami County Public Library 2016). The former locations of the dry cleaner and attached structures in the source area are shown on Figures 1-3A and 1-3B. The dry cleaner and adjacent structures were demolished after a fire that occurred in September 1979. The original source of the release is unknown. One common mechanism of release at former dry cleaners of this era was gradual release of PCE-contaminated process wastewater via discharge into sewer laterals, which were likely to leak. Several current and historic sewer laterals connect to the Walnut Street sanitary sewer adjacent to the Residential Area plume. However, the footprint of the former dry cleaner and adjacent alleys and courtyards in the immediate vicinity are now completely covered by more recent construction.

The Residential Area plume flows beneath an area of mainly older, single-family residences mixed with a few businesses, churches, and schools. Groundwater data collected to date have indicated that this plume extends downgradient (southeastward) from the source area to the vicinity of Floral Avenue. A subarea of the Residential Area plume is located along South Union Street between East Main and East Franklin Streets and may have originated from a different source than the main Residential Area plume. However, it may also simply represent a small pocket of contamination that was pulled away from the main plume by groundwater pumping. This second area is still considered to be part of the Residential Area plume for discussion in this report because of its location and similarity of contaminants.

The second primary area of contamination, referred to as the East Water Street plume, extends from the rear of the area containing the former Hobart Cabinet Company (Hobart) property at 301 East Water Street, extends beneath the Hobart building (which remains), and then continues to the southeast beneath and parallel to East Water Street. The area above the plume is a mixed industrial, residential, and institutional use area. PCE, TCE, and cDCE are present in this plume. Total VOC concentrations in this plume are generally lower than those detected in the Residential Area plume. The specific compounds and concentrations vary spatially and, in some cases, temporally at individual locations within the East Water Street plume. Soil and groundwater contamination have been detected on the Hobart property, with the highest VOC concentrations in soil detected in an apparent source area in the rear of the property. Adjacent to and downgradient of the Hobart facility is a second industrial facility, formerly Brown-Bridge Industries (now owned and operated by Spinnaker Coatings LLC [Spinnaker]), where

chlorinated VOCs, including the same VOCs present on the Hobart property, have also been detected in both soil and groundwater.

Near the eastern terminus of East Water Street, the East Water Street plume may co-mingle with contamination migrating from the Residential Area plume because of the influence of pumping in the East wellfield. Data collected during the RI indicate that groundwater contamination has migrated along East Water Street beyond the street's eastern terminus, and through adjacent properties on either side of the street, eventually reaching the GMR. Data further indicate that PCE contamination from the vicinity of South Union Street is also migrating toward the area between the eastern end of East Water Street and the levee of the GMR, where it mixes with contamination from the East Water Street plume.

Surface water and sediment samples from the GMR did not indicate the presence of detectable concentrations of site-related chemicals of potential concern (COPC). Horizontal and vertical distribution of groundwater contaminants, near the levee between Frank and Williams Streets, indicate that low concentrations of chlorinated VOCs are migrating at depths below 50 feet below ground surface (bgs) toward the East wellfield and are currently being captured by pumping in the East wellfield. By the time the chlorinated VOCs reach the East wellfield, only cDCE is detected.

1.1.2 Site History

The ETCA study area encompasses a relatively old residential, industrial, and commercial portion of the City of Troy, Ohio. This area includes a long history of residential use with interspersed commercial, institutional, and industrial areas.

Residential Area Plume

The source of the Residential Area plume is believed to have been release of PCE from a dry cleaner that operated out of 10 East Main Street and possibly one or more attached structures at 8 and 10 South Walnut Street between 1958 and 1979. The plume originates in an area between the former footprints of these structures and the Walnut Street sanitary sewer (Figures 1-3A and 1-3B). Most of this area is now covered by a more recent (2002) addition to the Troy First Presbyterian Church, at the northwest corner of East Main and South Walnut Streets. As shown on Figures 1-3, 1-3A and 1-3B, the highest concentrations of PCE detected in groundwater during the RI were found in samples from several vertical profile borings completed in Walnut Street between the northwest curb and the Walnut Street sanitary sewer in 2014, directly downgradient/southeast of the church addition. (Due to access constraints, the roadway of South Walnut Street was the closest point to the church structure at which sampling was

feasible during the RI.) The plume migrated downgradient/southeastward over time and extends to the vicinity of Floral Avenue.

The 2002 church addition structure completely covers the former footprints of several late 1800s/early 1900s structures that were destroyed in a fire in 1979, including the former location of the dry cleaner that is believed to have been the original source (Figures 1-3A and 1-3B). The former buildings in this area included two buildings that fronted on East Main Street (one building contained a single address of 8 East Main Street and the second building, closer to the corner, was divided into two areas with separate addresses (10 and 12 East Main Street). The rear of the 10/12 East Main Street structure was connected to two additional structures that fronted on South Walnut Street (8 and 10 South Walnut Street) that were also destroyed in the 1979 fire. At the time of the fire, a narrow gap/alley separated the 10 South Walnut Street structure from the exterior wall of an earlier (1950s) church addition.

This entire complex (10/12 East Main Street, and the attached structures behind at 8 and 10 South Walnut Street) were originally part of a harness manufacturing shop in the late 1800s and early 1900s. After the 1920s, the buildings were all listed as "stores" according to Sanborn Fire Insurance maps until 1955, the last date for which Sanborn maps are available. A dry cleaner began operating from the 10 East Main Street address in 1958. Historic Troy City Directories, telephone books, and newspaper ads confirm that "Troy One Hour Cleaners" - a "One-Hour Martinizing" dry cleaning facility operated at the 10 East Main Street address from 1958 until 1979 (see Figures 1-3, 1-3A and 1-3B). A shoe store operated in the other half of the same three story building, at the 12 East Main Street address in this era. No other businesses are known to have operated in the attached structures at 8 and 10 South Walnut Street from 1958-79; and therefore they were most likely associated with the dry cleaner and/or shoe store located in the attached 10/12 East Main Street structure (EDR 2013; Troy-Miami County Public Library 2016).

Unlike earlier dry cleaning processes the One-Hour Martinizing process used non-flammable solvents (typically PCE) and thus allowed cleaning to occur on-site at the drop-off locations, within central business districts in proximity to other buildings, eliminating the need for an off-site facility and allowing same-day turnaround for customers. This process was invented in the late 1940s and was in widespread use by the mid-1950s. Operations typically consisted of a storefront/drop-off counter and clothes storage area, with the main cleaning machines and processes to the rear of the buildings. The structure at the Troy One Hour Cleaners primary business address (10 East Main Street) was relatively small and not likely large enough to have housed all of the actual cleaning processes as well as the customer service counter and clothes racks (see Figure 1-3A). Due to the limited available space at 10 East Main Street

and the apparent absence of other business listings for 8 and 10 South Walnut Street during the 1958-79 era, Troy One Hour Cleaners may have used portions of one or both of the adjacent/connected structures (shown in Figures 1-3, 1-3A and 1-3B) for dry cleaning operations. The highest concentrations of PCE detected in site groundwater during the RI were encountered directly downgradient from and adjacent to the former location of 8 South Walnut Street and the reported locations of two sewer laterals that align with the former locations of these structures.

The mechanism(s) by which the contamination was released into the subsurface at this source area is unknown but likely included discharge of PCE in process water to, and subsequent leakage from, drains and/or the sanitary sewer over time. The Troy sanitary sewer line, constructed of 8-inch diameter butted-collar joint vitrified clay pipe (VCP) sections, was built by the early 1920s and historic Sanborn maps do not indicate the presence of wells, drywells, storm drains or other such wastewater management features on the properties at 10 East Main Street or 8 and 10 South Walnut Street. For this reason the former buildings were most likely connected to the sewer from the 1920s forward. City of Troy sewer maps indicate the presence of sewer laterals in the area between the former locations of 8 and 10 South Walnut Street and the Walnut Street sanitary sewer, and also from the former 8, 10 and 12 East Main Street locations to the East Main Street sanitary sewer. These laterals would presumably have connected the former structures to the sewer mains. Generalized estimates of PCE consumption in typical dry cleaning processes during the era are reportedly in the range of about to 150-200 pounds of PCE per ton of clothing cleaned (State Coalition for Remediation of Dry Cleaners 2010). Although this amount would also include loss through volatilization, wastewater - typically discharged to the sanitary sewer – reportedly typically contained significant amounts of PCE even at locations where solvent separation/recovery was employed. For this reason, PCE originating in the dry cleaning operation and released via discharge of wastewater to, and subsequent leakage from, the laterals or main sewer during routine day-to-day operations between 1958 and 1979, may have caused the contamination.

The complex of buildings at 10/12 East Main Street and 8 and 10 South Walnut Street, as well as the adjacent structure to the northwest at 8 East Main Street (which was not associated with the dry cleaner operations), were heavily damaged by a fire in September 1979 and subsequently demolished. News articles from the time of the fire refer to the most heavily damaged areas being “in the back” of the dry cleaning business and “across the courtyard” from nearby apartments at 6 East Main Street;and, that the main building counter/clothes storage area in the front was not heavily damaged; further indicating that the connected 8 and/or 10 South Walnut Street structures were where the heaviest damage occurred and likely housed some or most of the cleaning operations (Troy Daily News 1979).

After the buildings were demolished, the area remained a vacant lot until approximately 2002. The Troy First Presbyterian Church, located at the corner of East Franklin and South Walnut streets, has gradually expanded to the northeast over its history (parallel to Walnut Street) first in the 1920s, then 1950s, and finally in the early 2000s, eventually acquiring the properties where the 8 and10/12 East Main Street and the connected 8 and 10 South Walnut Street structures were formerly located. In 2002, the church constructed a multi-story addition with a sub-grade ground level that completely covered the area where these former structures were located. Based on architectural plans for the addition and the known dimensions of the present structure, the soil in the area was removed to at least 7 feet below grade to facilitate construction of the addition's ground level and underlying slab (Moody-Nolan Inc. 2002). The exact depth of excavation may have been greater; an EPA report from 2009 indicated that the building contractor stated that the excavation extended to 16 feet below ground surface, which is typically within 1 to 3 feet of the water table in this area. Because the former dry cleaning facility and adjacent buildings were demolished and the underlying soil and prior existing foundations removed(Moody-Nolan Inc. 2002), the exact location and process layout of the former dry cleaning operations, equipment, drains and other ancillary features cannot be ascertained. However, based on the narrow width of the groundwater plume along Walnut Street on the downgradient side of the First Presbyterian Church addition, the apparent groundwater flow direction, and the results of sub-slab vapor samples from within the church addition collected by Ohio EPA in 2016, the distribution of contaminants suggests the main original source(s) to have been most likely in one or more of the following locations (see Figure 3a):

- The far rear (southwest) wall area of the former 10/12 East Main Street Structure,
- The attached structure at 8 South Walnut Street
- The area between these former buildings and the sanitary sewer along Walnut Street, in the vicinity of the two sewer laterals that would have connected structures at 8 and 10 South Walnut Street (or possibly the back of 10 East Main Street) to the Walnut Street sewer .

EPA and the City of Troy completed a camera inspection of the sanitary sewer on South Walnut Street in 2011 and observed sewer laterals, both active and inactive/capped, exiting the area beneath the church addition. As shown in Figure 1-3, 1-3A and 1-3B, the highest concentrations of PCE in groundwater found during the RI were in the vicinity of two sewer laterals that are indicated on City of Troy sewer maps that appear to have connected structures at 8 and 10 South Walnut Street to the Walnut Street sanitary sewer (see Figure 1-3A). These two laterals are located near the eastern (upstream/origin) end of the Walnut Street sewer. During the survey, the robotic camera could not reach the area of these two laterals due to the small sewer diameter and the presence of debris. For this reason the condition of these laterals (active vs. capped) could not be confirmed during the RI; however, based inspection of the

plumbing system of the present structure, at least one active lateral serving the present church addition is located in this area. The Walnut Street sewer, which is approximately 12 feet below street level, sits about 5 to 8 feet above the water table. VCP sewers are not watertight; leaks from joints, manhole bottoms, and lateral connections are commonplace. During the camera survey, root intrusion was noted at many of the joints and many of the lateral connections were observed to be rough with gaps. These observations further support that wastewater containing PCE may have leaked out via the laterals or from the main sanitary sewer beneath Walnut Street.

In addition, as shown on Figure 1-3, little to no PCE was detected near the intersection of East Main and South Walnut Streets. PCE was detected at 330 µg/L in a Geoprobe groundwater sample collected along the south side of East Main Street, approximately 75 feet further downgradient/southeast of the intersection (see Figure 1-10); suggesting that lesser amounts of PCE may have also migrated from the 10 East Main Street portion of the building via the East Main Street sewer. However, additional groundwater samples collected further downgradient and across East Main Street confirm that the groundwater contamination on East Main Street is limited in extent and more likely due to changes in flow direction/plume migration pathways over time as industrial pumping in the area gradually declined.

As previously discussed, the current First Presbyterian Church addition covers the entire area of the former dry cleaner and was inaccessible for soil or groundwater sampling during the RI. Based on the known, and reported possible maximum depths of excavation prior to construction (7 feet and 16 feet, respectively), and the relative shallow depth to groundwater in the area (about 18 to 20 feet) approximately 40 to 90 percent of the vadose zone soil beneath the footprint of the current building was removed prior to construction of the addition. Ohio EPA performed post-RI sub-slab vapor sampling at the church addition in 2016 (Ohio EPA 2016a), which detected VOC vapor concentrations similar to those in areas overlying the plume at locations outside of the suspected source area. Therefore, available data suggest that residual contamination beneath the former suspected source may be primarily associated with the saturated zone; however, confirmatory vadose zone soil sampling was not performed beneath the current structure due to access limitations.

Another dry cleaner (Waltz Cleaners) operated within the Residential Area plume from the 1950s to the 2000s in a group of structures with the combined address of 432 East Main Street (see Figure 1-2). These structures front on both Main Street and Union Street. PCE contamination has been detected in groundwater on the east side of this group of structures, near the location where a sanitary sewer lateral from the buildings joins the main sanitary sewer line. It is unknown whether this PCE contamination is

residual PCE that "split" from the main Residential Area plume, or if it originated from a second source, such as Waltz Cleaners. The area is near the 1-year time of travel of the East wellfield. In addition, a neighboring residence reportedly used a private well for non-potable purposes for many years, and thus it is possible that pumping by the private well could have pulled the contamination away from the main residential plume.

East Water Street Plume

The East Water Street plume originates near the loading dock, behind the northwest corner of the former Hobart Cabinet building (now owned by Hobart Property Management), at 301 East Water Street (see Figure 1-2). Hobart operated in this building from the 1930s to 2000s as a manufacturer of specialty metal cabinetry and used a vapor degreaser and a paint line in its processes. Ohio EPA recorded reports of dumping of used solvents on the property. At the time of completion of the RI (January 2015) Hobart was using the building only for rental storage space and limited manufacturing of lock-out/tag out boxes for industry use. This operation included cutting and forming sheet metal; however, the vapor degreaser, formerly located near the front of the building on East Water Street, was removed in 2009. Data collected in the East Water Street plume area on the Hobart Cabinet property during the RI (surface and subsurface soil samples, HRSC/vertical profile groundwater samples, and membrane interface probe [MIP] vertical contaminant profiles) suggest that the groundwater plume may have originated from surface spills or dumping of solvents in the area near the Hobart loading dock.

The former Brown-Bridge facility (now owned by Spinnaker Coatings LLC) at 504 East Water Street is located predominantly downgradient from the Hobart facility with regard to groundwater flow (Figure 1-2). In 1928, Brown-Bridge Industries, Inc., began manufacturing adhesive products at the property. Kimberly-Clark, Inc. (KC) acquired Brown-Bridge Industries in 1971 and continued operation of the facility until 1994, when the property was sold to Spinnaker. Spinnaker is a manufacturer of adhesive-coated papers and related products. Various investigations by KC, Ohio EPA, and EPA have detected chlorinated VOCs in soils and groundwater at this property. Soil contaminants, including some of the same VOCs present in soil and groundwater at the Hobart property, have been detected at various locations throughout the western parking lot area and areas adjacent to the northwest corner of the Spinnaker plant building. Groundwater contamination has been detected at locations around the northwest and southeast ends of the facility, as well as between the building and the GMR. Prior to the 1960s, the western parking area hosted several small businesses, including a machine shop and another Waltz Cleaners facility. Whether dry cleaning operations ever occurred here is unknown. In the 1960s,

the Brown-Bridge plant was expanded with an addition to the west, and the western parking area was also enlarged, covering the area where these businesses had been present.

Previous Investigations and Significant Findings

Since 1988, low concentrations of chlorinated VOCs have been detected in raw water samples (samples taken directly from the production well before treatment or blending) from several production wells in the East wellfield. In previous investigations, the compound cDCE was detected in the East wellfield, typically in Well P-18. cDCE has been sporadically detected in Well P-14, and after 2010, it was detected only once in Well P-13 and twice in Well P-4E. Concentrations detected have been predominantly trace level, ranging from less than 1 to 2.9 µg/L, and have consistently been below the MCL of 70 µg/L established under the Safe Drinking Water Act (SDWA).

The detections of chlorinated VOCs in the East wellfield prompted a series of investigations by Ohio EPA, private entities, and EPA, which were completed between the late 1990s and 2008. These investigations are summarized below. The RI report (SulTRAC 2015) includes additional information regarding the scope and results of pre-RI studies at the ETCA.

From 1999 to 2007, Ohio EPA investigated the chlorinated VOC plumes, advancing more than 60 Geoprobe borings to collect and analyze groundwater and soil samples for VOCs. Ohio EPA also installed and sampled 13 groundwater monitoring wells (wells OEPA-1 through OEPA-13), and conducted a limited pumping test to evaluate responses in the aquifer west of the GMR to changes in pumping in the East wellfield. Ohio EPA also completed soil gas sampling and vapor intrusion monitoring, compiled the data from the investigations, and completed an Expanded Site Inspection (ESI) Report. The ESI was used to support EPA's decision to list the ETCA site on the National Priorities List (NPL), which occurred in September 2008.

Since the 1990s, KC and Ohio EPA have conducted extensive investigations on the Spinnaker property to identify sources of contamination in soils and groundwater and delineate the extent of the contamination. In addition, KC has conducted various remedial activities at the property and continues quarterly groundwater monitoring at the site. Data indicate that groundwater contamination at Spinnaker varies in composition with location. Shallow monitoring well KMW-10, located at the northwest (upgradient) boundary of the Spinnaker property, historically has exhibited the highest concentrations of chlorinated VOCs of any of the monitoring wells at the Spinnaker property, with cDCE typically detected at concentrations of 35 to 139 µg/L during quarterly events. However, as part of the investigations

supporting the sale of the Spinnaker property in 1994, soil and groundwater contaminated by fuel oil, toluene, and chlorinated VOCs were identified in several areas at the west end of the property. PCE, TCE, and cDCE were detected in site soils at some locations on the Spinnaker property at depths above the water table. KC subsequently excavated soils from two areas shown on Figure 1-4. Based on the reported dimensions of the excavation, the total volume of soil excavated was approximately 3,600 cubic yards. The excavation reportedly extended to the water table at 13 feet bgs. Soil samples were analyzed for VOCs, and approximately 1,528 cubic yards of soil were disposed of off site; the remaining soil was reportedly returned to the excavation based on analytical data and field screening results. In 2005, KC conducted an investigation to evaluate risk from VOCs left in place in the western parking area, including the excavation/backfill areas. PCE, TCE, and cDCE were detected in soil samples from the property,. Maximum detected concentrations of each of these three compounds detected in soil at the Spinnaker facility in 2005 are as follows:

Sampling Location	Depth (ft bgs)	Date	Hazardous Substance	Maximum Concentration (µg/kg)
PSB-20 (near northwest corner of building)	2-4	4/1/2005	TCE	133,000
SSB-17 (west of northwest corner of building)	8-9	5/5/2005	PCE	931
PSB-22 (adjacent to western exterior wall of building)	13-14.5	3/30/2005	cDCE	14,900

Notes:

ft bgs	Feet below ground surface
VOC	Volatile Organic Compound
PCE	Tetrachloroethene
TCE	Trichloroethene
cDCE	*cis*-1,2-Dichloroethene
µg/kg	Microgram per kilogram

Elevated concentrations of VOCs have been detected in sub-slab soil gas and indoor air from structures within the area corresponding to the vicinity of groundwater contamination in the ETCA site. Sampling performed by the City of Troy and Ohio EPA in 2005 and 2006 detected PCE and other VOCs in indoor air samples. Ohio EPA requested that EPA conduct a time-critical removal action assessment to determine the extent of VI to indoor air and assess the need to mitigate concentrations of VOCs in indoor air that exceeded screening levels established by the Agency for Toxic Substances Disease Registry (ATSDR) and the Ohio Department of Health (ODH). From 2006 to 2007, EPA conducted sub-slab and indoor air sampling at 85 locations: 78 residences, 2 churches, 4 schools, and the Troy Police Station.

VOC concentrations at 17 residences exceeded the screening criteria of 1.2 parts per billion by volume (ppbv) for PCE and 0.4 ppbv for TCE in indoor air. EPA initiated a removal action on May 31, 2007. Vapor abatement mitigation systems were installed in 16 residences and also at St. Patrick Elementary School, which is located across East Water Street from the Spinnaker and Hobart facilities. The EPA removal action was completed on April 17, 2008. Several of the 2006-2007 sampling locations, including the First Presbyterian Church addition overlying the Residential Area plume PCE source, were retested during the RI or after the RI to obtain updated information. RI activities are discussed below.

1.2 ETCA REMEDIAL INVESTIGATION SUMMARY

EPA initiated the RI/FS in 2009. The final RI report was issued in January 2015 (SulTRAC 2015). The following sections summarize activities at the ETCA site during RI sampling events and additional VI testing completed by Ohio EPA in 2016.

The RI was completed in two phases: Phase I began in 2009 and Phase II began in 2012. The overall approach to the RI was an iterative process involving continual, ongoing review of data as data became available. For this reason, some activities discussed, such as "screening" level sampling and analysis, primarily served to help focus subsequent activities such as selection of locations for monitoring well installation or VI monitoring.

From December 2009 through May 2012, SulTRAC performed Phase I RI activities at the site, as listed below.

- Review of KC quarterly groundwater data from the Spinnaker property and collection of split groundwater samples at the Spinnaker property during KC's routine sampling in December 2009.
- A baseline groundwater sampling event that included sampling all Ohio EPA and Troy monitoring wells in the ETCA site that existed in August 2010.
- Collection of surface water and sediment samples from the GMR in September 2010.
- A sewer camera survey in October and November 2011.
- Collection of shallow groundwater samples using a direct-push (Geoprobe) rig in the area near East Franklin Street between South Union and Counts Streets to confirm preferred monitoring well locations (December 2011).
- Phase I VI monitoring of businesses and residences (January 2012).
- Drilling, vertical aquifer sampling (VAS), and monitoring well installation (February to March 2012).
- Additional sampling of shallow groundwater, including soil boring and sampling using a direct-push rig (May 2012).

- Comprehensive groundwater sampling of all pre-RI Ohio EPA and Troy monitoring wells and newly installed Phase I RI monitoring wells, and several wells on the Spinnaker property and Miami Conservatory District (MCD) piezometers adjacent to the GMR (April-May 2012).

Phase II of the RI consisted of the following activities:

- Review of KC quarterly monitoring data.
- A second round (summer season – August 2012) of VI sampling at locations initially sampled in January 2012 during Phase I.
- Preliminary Geoprobe boring and groundwater sampling in December 2012 to further refine estimates of plume boundaries, and guide selection of locations for additional monitoring wells, similar to Phase I.
- Deep groundwater level measurements in January 2013 to further support decisions regarding selection of Phase II monitoring well and VAS locations.
- Rotosonic drilling, VAS, and monitoring well installation in January 2013.
- Soil borings and sampling in February 2013, which also included additional groundwater sampling.
- A Phase II groundwater sampling event in March 2013 that included all Ohio EPA, Troy, and newly installed Phase I and Phase II RI monitoring wells, as well as several wells on the Spinnaker property and MCD piezometers adjacent to the GMR.
- VI monitoring of additional locations, selected based on ongoing review of data from Phase II activities, in May 2013.
- A site visit with inspections of each of the contaminant source areas identified during Phase I and Phase II in July 2013.

Supplemental Phase II activities were continued in 2013 and 2014 to further characterize source areas and the extent of contamination. Further Phase II activities, completed by May 2014, are listed below.

- Development of work plans/sampling and analysis plans (SAP) for additional investigations, including (1) a membrane interface probe (MIP) investigation sampling plan, (2) an additional Phase II SAP for high-resolution site characterization (HRSC) activities using the Waterloo Advanced Profiling System (APS) groundwater profiling system), (3) installation of additional borings and monitoring wells, and (4) additional sampling and analysis of soil, groundwater, surface water, and sediment.
- Addition of a series of investigative borings using a MIP between October and November 2013.
- Additional sampling of soil at Hobart and Spinnaker properties, and collection of two grab groundwater samples at Hobart.
- Installation of a groundwater monitoring well (EPA Well MW-124S) to evaluate groundwater contaminant concentrations near the downgradient limit of the Residential Area plume (December 2013).
- Collection of groundwater samples from eight groundwater monitoring wells, which were analyzed for VOCs and various parameters to support preliminary screening of viable remedial options for the site (December 2013 to January 2014).

- Completion of three borings (one on the Spinnaker property near Well KMW-10, one at South Clay Street and East Franklin Street near Monitoring Well OEPA-7, and one adjacent to EPA Well MW-107I), with collection of soil samples that were analyzed for grain size distribution, permeability, and other parameters to support screening of remedial options (January 2014).
- Completion of a survey of the residential area to evaluate potential presence and use of private wells in the study area (April and May 2014).
- Additional rounds of water level measurements in October 2013 and April-May 2014 to evaluate groundwater flow under various pumping conditions at the East wellfield.
- Use of a Waterloo profiler to perform an intensive HRSC boring program, and use of an on-site mobile laboratory to investigate the nature and extent of contamination in source areas and to supplement the monitoring well data regarding the general extent and migration of contamination (April to May 2014).
- Additional sampling of surface water and sediment from the GMR (May 2014).

The findings of the RI and risk assessment are presented in the RI report for the ETCA, which was finalized in January 2015 (SulTRAC 2015). During development of RAOs for this site in February 2016, Ohio EPA completed additional VI monitoring at the First Presbyterian Church addition that overlies the location of the former Troy One-Hour Cleaners, believed to be the source of the Residential Area PCE plume. The following sections summarize key findings of the RI and risk assessment for the ETCA site.

1.2.1 Regional Geology

Miami County is generally covered by various kinds of glacial drift left behind by continental glaciers during the Pleistocene epoch. These glacial drift deposits covered the bedrock and filled pre-glacial stream valleys. Two dominant types of glacial deposits are present in Miami County: outwash deposits consisting of sand and gravel deposited by running melt water from the glacial ice, and glacial till consisting largely of clay mixed with boulders, gravel, sand, and silt deposited directly by glacial ice. The most significant of the sand and gravel outwash deposits are those that fill a deep bedrock valley — a tributary of the ancient Teays drainage system — oriented from north to south down the center of the county, through which the present-day GMR flows. This valley underlies the ETCA site. Tills and lacustrine clays and silts are often found interbedded within the outwash deposits resulting from multiple stages of glacial advance and retreat, deposited over outwash, and later outwash eroding into and being deposited above till. The result is an extremely complex, heterogeneous subsurface with high variability in content and physical characteristics, such as porosity and permeability, over very short distances.

The glacial deposits overlie Paleozoic era sedimentary bedrock. In areas where the glacial and post-glacial streams have carved deep valleys (primarily the valley running down the central portion of the

county), the Ordovician-aged rocks of the Cincinnatian series are the uppermost remaining bedrock units. The Ordovician-aged bedrock is composed primarily of shales with thin interbedded limestone layers.

The GMR and its underlying bedrock valley are the most significant geomorphic features in the site area. This bedrock valley extends to depths of 200 feet or more, but has been filled with glacial and post-glacial sediments, so that present-day surface topography is relatively flat to gently rolling with gradual relief. Elevations in the site vicinity range from about 810 to 850 feet above sea level. Surficial soils in the site area are predominantly Eldean loam. U.S. Department of Agriculture (USDA) soil maps indicate that reworking of local soils in Troy was extensive during construction of the MCD levee system.

1.2.2 ETCA Site Geology

The geology of the ETCA site has been extensively characterized. Information regarding the site geology has been drawn from on-site data gathered during RI Phases I and II, as well as during previous studies. During the ETCA RI, 31 borings were installed and logged for characterizing site geology and installing groundwater monitoring wells. Information gathered from these locations was supplemented by observations and physical data acquired during the MIP (38 borings) and Waterloo (36 borings) sampling programs and by logs of more than 60 shallow borings completed during the soil boring programs. Additional information is available from logs of borings installed by Ohio EPA, Troy, and KC prior to the RI that were reviewed during development of the RI work plan.

The ETCA site is above the deep buried bedrock valley that trends north to south down the approximate center of the southern half of Miami County and within which the present-day GMR flows. The subsurface at the site consists of a thick sequence of sand, gravel, silt, and clay overlying Ordovician-age interbedded shale and limestone bedrock. The unconsolidated materials are of primary interest for the RI/FS because these contain groundwater, and control the flow of groundwater and contaminants within the site and surrounding area. For this reason, geologic investigations during the RI were limited to the unconsolidated materials; bedrock was not encountered in any of the borings completed for the RI. Based on information reported by others, the thickness of unconsolidated materials at the ETCA site is approximately 200 feet.

The unconsolidated materials are often discussed in terms of three zones, loosely based on differentiations among (1) the zone used for the municipal water supply (“lower” aquifer), (2) the shallow sand and gravel deposits (“upper” aquifer), and (3) less permeable fine-grained materials, limited in extent, that occur at all depths but in some areas form a localized zone encountered between the “upper” and “lower” sand and

gravel deposits. However, geologic and contaminant data gathered during the RI indicate no continuous, distinct separation between the "upper" and "lower" sand and gravel zones. Observations made during completion of RI borings generally indicated that although clays and silts of significant thickness are present in some areas, they are absent in other areas, and no distinct horizon fully separates the sand and gravel units into upper and lower zones consistently at the site.

Fill of varying thicknesses and composition (sand, gravel, silt, clay and brick fragments) was encountered at most boring locations. In general, the underlying native subsurface materials encountered in the RI borings consisted primarily of fine to coarse sand and fine to coarse gravel and cobbles with sporadic interbedded, laterally discontinuous zones of variable silt and clay content. When encountered, fine-grained materials (silts or clays) were typically mixed with sand and gravel (for example, silty sand and gravels or clayey gravels), and were not present as distinct layers. However, silty or clayey zones were present at some locations in irregularly shaped masses and lenses at varying elevations, interspaced with the coarser deposits. Fill materials and underlying materials encountered in the Spinnaker parking lot area included some dense silty clays. The maximum amount of clay observed at any location was found at Well MW-EPA-106D, located near East Main Street and New Street, where three distinct layers were encountered at depths of approximately 20 to 25 feet bgs, 35 to 50 feet bgs, and another extending from approximately 65 to 120 feet bgs.

Residential Plume Source Area Geology

The Residential Plume source area appears to lie between the rear (southwest) portion of the former location of 10 East Main Street and the Walnut Street sanitary sewer, including the former locations of attached structures at 8 and 10 South Walnut Street, as shown on Figure 1-3A. Due to access limitations, collection of geologic data directly in the areas of the former building footprints was not feasible during the RI. However, RI data collected from the Walnut Street, Main Street and Market Street areas around the source area included data from seven Waterloo profile borings, seven MIP vertical profile borings, 13 Geoprobe borings, and a hollow-stem auger geotechnical boring. Three new rotosonic borings/monitoring wells were also installed and sampled, as well as existing wells installed by Ohio EPA during previous investigations. At each boring location, multiple lines of data were collected. Data collected included lithologic characteristics, VOC concentrations, relative hydraulic conductivity, specific conductance, grain size, and other properties of the subsurface materials.

Based on the extensive data collected to date, the geology of the Residential Plume source area is predominantly sand and gravel with varying amounts of silt, although several relatively thin clay layers

were observed at the borings for monitoring wells MW-EPA-107I and -107D, located on the east side of Walnut Street directly across/downgradient from the source area (see Figure 1-3). Core recovery was more complete at MW-EPA-107I than at adjacent boring MW-EPA-107D. The following vertical sequence was observed for materials in the saturated zone at the MW-EPA -107 location:

- Fine to coarse sand and gravel from ground surface to 35 feet bgs
- Clayey sand from 35 to 38 feet bgs
- Dense gray clay from 38 to 40 feet bgs
- Silty gravel and sand from 40 to 44.5 feet bgs (56 percent sand and gravel; 44 percent fines, minor amount clayey sand)
- Dense clay from 44.5 to 45 feet bgs
- Orange-brown-stained sand and gravel from 45 to 50 feet bgs (92 percent sand and gravel, less than 8 percent fines)
- Sand and gravel with some clayey/silty sand below 50 feet bgs

The location of well MW-EPA-107I (east side of Walnut Street) is shown on Figure 1-3 Figures 1-3A and 1-3B depict the locations of, and vertical PCE concentration profile data from the line of Waterloo/VAS borings completed on the west side of Walnut Street, on the downgradient side of suspected source area. The highest PCE concentrations detected during the RI were found in Waterloo/VAS boring WL-5, near the west curb of Walnut Street, about 75 feet northwest/upgradient from MW-107I, at depths between 40 and 45 feet bgs. MW-EPA-107I (see Figure 1-3 for location) is screened from 47 to 52 feet bgs, primarily in the orange-brown stained sand and gravel. The maximum PCE concentration detected in samples from this well during the RI was 2,200 µg/L. The MW-EPA-107 well cluster is approximately 75 feet further downgradient/southeast.

Overall, the data from both sides of Walnut Street strongly indicate that the contamination is primarily concentrated in the zone between about 40 and 55 feet bgs. Based on observation of geologic cores from the east side of Walnut Street at well MW-EPA-107I, this zone may be a mixed zone of sand and gravel layers interbedded with silty zones and some thin clay layers. However, continuous hydraulic conductivity (IK) logs for each of the Waterloo borings on Walnut Street indicated no significant variations in hydraulic conductivity over their entire depths to a maximum depth of 85 feet bgs. Thus the observation of fine grained materials interbedded with the sand and gravel in the zone below 35 feet bgs at the location of well MW-EPA-107I suggests that geologic conditions closer to the source area could vary from those observed at the location of well MW-EPA-107I.

Due to the potential for lateral and vertical variability with regard to fines content, additional data will be gathered during the predesign studies supporting the RD to further define geologic conditions in the immediate vicinity of the primary suspected source area of the Residential Plume. Specifically additional data will be gathered at the actual locations where groundwater remediation technologies may be deployed to support the RD. The exact data needs and methods to be used to gather that data will be determined during the pre-design studies.

1.2.3 Site Hydrogeology

The thick sequences of sand and gravel in the valley of the GMR and its major tributaries comprise the highly productive GMR sole source aquifer system. Troy supplies the entire city water system from wells that draw water from the sand and gravel deposits. Based on the 2011 census, the Troy system serves a population of at least 25,374 people.

Piezometric elevation data were obtained from the site-wide monitoring well network and at the Troy production wells over the course of the RI. Depth to uppermost groundwater at the site is relatively shallow, typically ranging from approximately 12 to 20 feet bgs, but varies depending on location and season. The total estimated saturated thickness of unconsolidated materials in the site vicinity likely ranges from about 100 to 175 feet, exclusive of unsaturated clay layers that may be present in the area.

Based on the piezometric data gathered during the RI, the flow direction in the uppermost zone is generally southeast, parallel to the GMR, with localized and seasonal variations, particularly in the area immediately adjacent to the GMR and also in the area near the East wellfield. Based on the observed groundwater elevations and studies undertaken by the City of Troy, pumping in the wellfield has localized influence on the shallow zone.

The flow in the deeper portions of the aquifer also generally follows this same direction (southeast) in the upgradient/northwest part of the site. However, flow in the deep zone is more heavily influenced by pumping at the East wellfield, east and southeast of Union Street. In particular, groundwater flow between East Main Street and the GMR (southeast of Union Street) appears to be heavily influenced by pumping from the East wellfield in both the shallow and deep zones. This area is within the modeled 1-year TOT of the East wellfield production wells.

Based on data acquired during the RI, the calculated horizontal gradient in the shallow zone ranges from about 0.001 to 0.005, depending on its location within the site and seasonal variations. Generally, the gradient is greater in the area north of East Main Street and east of Crawford Street. The horizontal

gradient measured among monitoring wells screened in the deep zone also ranged from approximately 0.001 to 0.005, exclusive of the area within the direct cone of influence of the pumping wells.

The five Troy production wells in the East wellfield draw water from the deeper aquifer zone at depths ranging from approximately 64 to 115 feet bgs. Average production from the East wellfield is approximately 2.3 million gallons per day (MGD). The reported transmissivity in the East wellfield ranges from approximately 9,800 to 18,900 square feet per day (ft^2/day). The wells in the East wellfield are capable of yielding in excess of 1,000 gpm with 10 to 20 feet of drawdown. Troy has developed and updated flow models for the East wellfield to support its wellhead protection and wellfield sustainability programs. The entire ETCA site lies within the modeled 5-year TOT of the East wellfield, and a portion of the site (to the north and east of the intersection of Crawford and East Main Streets) is within the 1-year TOT.

Piezometric head differences measured between the shallow, intermediate, and deep zones west of the GMR indicate potential vertical gradients that vary in both direction and magnitude across the site, ranging from upward, to neutral, to downward. These variations are consistent with geologic data gathered during the RI, which indicate that clays and silts within the sand and gravel aquifer are discontinuous and have not prevented migration of contaminants into the “lower” sand and gravel, particularly in the vicinity of the Residential Area plume source.

The GMR is hydraulically connected to the upper sand and gravel aquifer. The aquifer system extends to depths much lower than the current river channel. Leakage studies conducted by the City of Troy indicated that the GMR recharges the aquifer and is a losing stream in the channelized area that lies adjacent to the groundwater contaminant plumes and the East wellfield.

Literature values for hydraulic conductivities differ from one source to another and vary over a large range. Estimates of advective groundwater velocity range from 0.25 to 2.5 feet per day (ft/day) in the shallow zone and from 0.2 to 1.75 ft/day in the deeper zone. Assuming average velocities, the advective groundwater flow rate in the shallow zone is 343 feet per year (ft/year), and in the deeper zone is an estimated 246 ft/year. However, it is important to note that actual velocities vary significantly depending on materials present in specific areas, which are highly variable in glacial depositional settings.

Residential Plume Source Area Hydrogeology

The apparent groundwater flow direction in the Residential Plume source area is southeast, generally parallel to the trend of the buried bedrock valley and the present GMR, as shown on Figure 1-3. This apparent flow direction, when viewed in comparison to the observed VOC distribution in the most concentrated part of the plume (Figures 1-3A and 1-3B), is consistent with the original source area being in the rear of the former locations of 10 East Main Street or the attached structures at 8 and 10 South Walnut Street, or the sewer laterals that would have connected these structures to the Walnut Street sewer.

As discussed in Section 1.2.2, data from both sides of Walnut Street near the source area indicate that the highest contaminant concentrations were found between about 34 and 55 feet bgs. The boring log for monitoring well MW-EPA-107I indicates the presence of some finer grained materials interbedded and mixed with the sand and gravel in this horizon.

Continuous hydraulic conductivity (IK) logs for each of the Waterloo borings on Walnut Street indicated no significant variations in hydraulic conductivity over their entire depths, which were logged to a maximum depth of 85 feet bgs. Thus the observation of finegrained materials at the well MW-EPA-107I location does not correlate with the IK data from the west side of Walnut Street. Therefore, it is unclear if the finer grained materials observed mixed and interbedded with the sand and gravel at MW-EPA-107I extend to the west side of Walnut Street, and if so, whether they would significantly impact hydraulic conductivity in the source area.

Additional data regarding source area hydrogeology, including hydraulic conductivity data, will be gathered as part of the pre-design studies to support the RD for this site. Data will be gathered at proposed sites for deployment of groundwater remediation technologies. If found, the presence of zones of limited hydraulic conductivity will be considered in the RD.

1.2.4 Nature and Extent of Contamination

This section presents information on the nature and extent of contamination at the ETCA site. The information used to delineate the nature and extent of contamination is based on analysis of soil, groundwater, sub-slab and indoor air, surface water, and sediment samples collected during the RI. The RI approach included screening level sampling during both phases of the investigation; however, screening level sampling results were used primarily to guide subsequent sampling, and these results were used to supplement the information obtained from the formal site characterization. The site is, by definition, chlorinated VOC contamination in soil and groundwater. As specified in the EPA-approved

SAP, the presence of other chemicals — even if not likely related to the sources of the chlorinated VOCs — was evaluated on a limited basis during Phase I of the RI for the sole purpose of determining if they were present at concentrations high enough to affect calculation of human health or ecological risk at the site and thus be considered COCs. For this reason, samples collected at 10 percent of sampling locations were tested for additional analytes, including semivolatile organic compounds (SVOC), pesticides, polychlorinated biphenyls (PCB), and metals during Phase I of the RI. As the RI progressed, the data from each event were evaluated. This continuing evaluation did not indicate the presence of additional analytes at concentrations high enough to alter the risk assessment of the site, and therefore those analytes were not designated as COCs. For this reason, the following discussions focus on the extent of VOC contamination in site groundwater, soil, vapor (sub-slab and indoor air), surface water, and sediment. The RI report presents a complete discussion of the results of all chemicals analyzed (SulTRAC 2015).

Analytical results for VOCs were compared with screening levels (SL) to assess whether a chemical exceeded a given SL, and if so, the extent of its distribution. These comparisons were not meant to evaluate site risks, but rather to provide a preliminary indication of the potential for risk, with a focus on contamination present at the site. SLs for the site were established in collaboration with EPA and Ohio EPA. Sample results were compared with the following SLs:

Soil results were compared with EPA residential and industrial regional screening levels (RSL) for target hazard quotient of 1.0 and target risk of 1E-06 as well as protection of groundwater risk-based RSLs using a dilution attenuation factor of 1.

- Groundwater results were compared with the EPA tap water RSLs, EPA MCLs, and EPA vapor intrusion screening levels (VISL) using the EPA VISL calculator based on default values.
- Sub-slab, indoor air, and ambient air results were compared with EPA residential and commercial VISLs for target hazard quotient of 1.0 and target risk of 1E-06.
- Surface water results were compared to the Ohio Water Quality Criteria for the Protection of Human Health and Ohio River Basin Aquatic Life Criteria outside mixing zone average (OMZA).
- Sediment results were compared to EPA Residential Soil Screening Levels and EPA Region 5 Ecological Screening Levels.

Discussions on the nature and extent of contamination in soil, groundwater, soil vapor (sub-slab and indoor air), surface water, and sediment appear below.

1.2.4.1 Soil

Soil samples were collected during Phases I and II of the RI. Surface soil samples (0 to 6 inches bgs), subsurface soil samples (deeper than 6 inches bgs), or both were collected at each location from the vadose zone or at the capillary fringe for chemical analysis. Soil samples were collected at four general areas, including the Residential Area plume, the Hobart property, the Spinnaker property, and residential properties between Hobart and Spinnaker, referred to here as the East Water Street Residential Area.

The objective of the soil sampling completed within the Residential Area plume was to determine whether additional or secondary sources of groundwater contamination existed in the area, rather than to evaluate risk to receptors via the soil pathway. This objective was set because (1) soil in the main suspected source area (the former dry cleaning facility at 10 East Main Street) was inaccessible for sampling because of the present structure, and (2) the mechanism by which VOC contamination has migrated outside of the original source area is groundwater transport and therefore the soil exposure pathway (which involves surficial or vadose-zone subsurface soils) is not applicable to most of the Residential Area plume.

The objective of the Phase I soil samples collected at the Hobart and Spinnaker properties was to evaluate the potential source areas of VOCs. The sampling objective was modified in the Phase II RI to focus on further evaluating the extent of contamination and potential risk to current and future receptors.

Soil sampling completed in the residential areas between the Hobart and Spinnaker properties focused on evaluating risk to current and future receptors.

Results from soil samples collected within the four investigation areas during both phases of the RI are discussed below.

Residential Area Plume

Due to access restrictions to the First Presbyterian Church addition that now covers the location of the former dry cleaner at 10 East Main Street, and the electronics store at 432 East Main Street, collecting soil samples from directly beneath the original suspected source areas was not feasible during the RI, resulting in a degree of uncertainty on the presence and extent of soil contamination at these locations. However, as previously discussed, based on the known and reported aspects of the construction of the church addition, at least 40 percent to as much as 90 percent of the vadose zone soil beneath the footprint of the church addition was excavated and removed prior to construction. Any residual contaminated soil, if

present, is covered by the present structure. Sub-slab soil vapor samples collected by Ohio EPA from the church addition basement in 2016 did indicate the presence of PCE in sub-slab vapor, but the concentrations were consistent with those detected in sub-slab samples collected during the RI at downgradient locations well outside of the source area. For this reason the data were inconclusive as to whether any vadose zone soil contamination remains or if the vapor is originating solely from the saturated zone beneath or adjacent to the structure. (Ohio EPA 2016a).

Soil samples collected at various accessible locations throughout the Residential Area plume are shown on Figure 1-5. Samples were collected as close as possible to potential source areas, and along potential preferential pathways, such as sewer laterals, to evaluate whether soil had been contaminated at these locations.

Fourteen VOCs were detected in the soil samples; however, none exceeded residential or industrial SLs. Four chemicals (PCE, TCE, toluene, and benzene) exceeded the SL for protection of groundwater. PCE exceeded the SL in 19 samples, TCE in four samples, and benzene and toluene in one sample each.

As shown on Figure 1-5, low levels of PCE, TCE, toluene, and benzene (the compounds exceeding the protection of groundwater SL) are present within an area roughly bounded by East Main Street, Crawford Street, Franklin Street, and Walnut Street. Given the depths of the samples collected, the sample results were divided into three general groups (0 to 6 feet bgs, 6 to 12 feet bgs, and deeper than 12 feet bgs) to evaluate the vertical distribution of contamination. Concentrations of these VOCs were lower from 0 to 6 feet bgs and 6 to 12 feet bgs than concentrations recorded from samples taken deeper than 12 feet bgs. The approximate depth to groundwater in this area varied during each RI sampling event but typically ranged from about 15 to 18 feet bgs. The correlation of depth to groundwater and the higher detections of contaminants (such as PCE at 140 µg/kg in the 12- to 14-foot bgs sample at Location CRA-1) may signal the presence of a “smear zone” from contaminated groundwater as the water table elevation fluctuates. Alternatively, PCE at this location could have resulted from wastewater transport through the sewer, either as discharge directly into the sewer or as contaminated groundwater infiltrating the sewer and migrating laterally through the sewer.

Hobart Property

Soil samples were collected at various accessible locations throughout the Hobart property to evaluate whether soil had been contaminated on the Hobart property. These samples included exterior locations

around the Hobart building and two locations within the basement and garage area that underlies the loading dock.Figure 1-6 shows the soil sample locations and presents the VOC analytical results..

While 23 VOCs were detected, only 13 VOCs exceeded one or more site SLs. Four of these VOCs (PCE, TCE, 1,1,2-trichloroethane [1,1,2-TCA], and benzene) exceeded the residential or industrial SLs in addition to the protection of groundwater SL. PCE, benzene, and 1,1,2-TCA exceeded the residential and industrial SLs in one sample (HOB3), while TCE exceeded the residential SL in 26 samples and the industrial SL in 19 samples. Maximum concentrations were 72,000 micrograms per kilogram (µg/kg) PCE, 10,000J µg/kg benzene, 2,700J µg/kg 1,1,2-TCA, and 89,000 µg/kg TCE ("J" denotes an estimated value).

As shown on Figure 1-6, the highest concentrations of VOCs were detected at the northwest part of the property near the loading dock area (soil borings HOB3, SB315, SB316, SB317, SB318, SB319, SB320, and SB321). The highest concentrations of TCE (89,000; 40,000; and, 20,000 µg/kg) and the highest concentrations of PCE (72,000 and 28,000 µg/kg) were all detected in samples collected from approximately 4 feet bgs.

In addition, lead was detected in surface soil above site SLs at a single location (HOB7 – located between the north side of the Hobart building and the GMR levee in EA-2) at 927 milligrams per kilogram (mg/kg), exceeding the industrial RSL. As previously discussed, only a minimal number of soil samples were analyzed for metals or parameters other than VOCs as the site is, by definition, a chlorinated VOC groundwater plume and thus insufficient data were available to evaluate lead in the risk assessment. For this reason, and because the IA's primary objectives focus on the source areas of chlorinated VOCs in groundwater, lead was not carried forward as a COC for this site.

Spinnaker Property

Soil samples were collected at various accessible locations throughout the western portion of the Spinnaker area to evaluate whether soil had been contaminated on the Spinnaker property. The nature and extent of soil contamination at Spinnaker is discussed below based on results from the RI. However, as noted in Section 1.1.2, the presence of VOC contamination in soil in other areas in the western parking lot was documented through previous sampling by other entities (Shaw 2006). When the results from those previous investigations are also included in the analysis, the extent of soil contamination at Spinnaker exceeds that delineated by the RI alone (see Figure 1-7).

Twenty VOCs were detected, and concentrations of 10 chemicals exceeded one or more site SLs. Concentrations of TCE exceeded the residential and industrial SLs and the protection of groundwater SL. TCE exceeded the residential SL in 15 samples and exceeded the industrial SL in four samples, with a maximum concentration of 22,000 µg/kg.

As shown on Figure 1-7, the highest concentrations of VOCs detected during the RI were reported in samples near the west end of the main Spinnaker parking lot. This parking lot area has been paved with asphalt or concrete, depending on location, since the late 1960s when the plant was expanded westward. In this area, samples from borings SPN1, SB014, SB300, SB301, SB303, and SB304 contained TCE at concentrations above the residential SL. In addition, TCE was also detected above the industrial SL in samples from borings SPN1 and SB301, with maximum concentrations of 22,000 and 12,000 µg/kg detected at depths of 2 to 4 feet bgs at these locations. TCE was also detected above the residential SL in samples collected from borings near the west and north walls of the Spinnaker building (borings SB309, SB310, SB311, SB312, SB313, and SB314). Soil samples from two of these borings (SB311 and SB313) also exceeded the industrial SL for cancer risk, although they were below the non-cancer hazard index based RSL of 6,000 ug/kg. In addition, TCE was reported at a concentration of 133,000 µg/kg in a previous sample from 2 to 4 feet bgs. This sample was collected by Shaw in 2005 near the northwest corner of the building, within the footprint of one of the areas excavated by KC in 2005. VOCs were detected at various other locations within and near the reported former excavation areas. The area with the highest concentrations of VOCs, detected during the Shaw investigation in 2005 is located between the two areas of soil contamination defined by the RI described above. The area where soil contamination was generally highest during the 2005 sampling events is also shown on Figure 1-7.

East Water Street Residential Area

Soil samples were collected at four locations in the East Water Street Residential Area. Surface soil samples were collected at Locations SB016 through SB018. Surface soil (1 foot bgs) and subsurface soil (4 feet bgs) samples were collected at Location SB005. These samples were collected at accessible locations to evaluate whether soil had been contaminated as a result of operations on the Hobart or Spinnaker properties. All samples were analyzed for VOCs only.

The only VOCs detected in soil were acetone and methyl acetate. Neither of the detected VOCs exceeded any of the site SLs. Figure 1-8 shows locations of soil samples in this area and indicates that no VOCs were detected above site SLs in any of the samples collected.

1.2.4.2 Groundwater

Groundwater investigations completed for the RI included:

- Baseline groundwater sampling of the existing (pre-RI) Ohio EPA wells and Troy wells (Troy-L through Troy-Q) to establish baseline groundwater conditions at the onset of the RI (Figure 1-9)
- Phase I screening level sampling, involving collection of grab samples from soil borings and VAS to supplement baseline data to guide placement of RI monitoring wells
- Phase I comprehensive sampling of the existing Ohio EPA wells, the Troy wells, and the newly installed Phase I RI wells to evaluate groundwater conditions at completion of the Phase I investigation (Figure 1-10)
- Phase II screening level sampling, involving collection of grab samples from soil borings and VAS to address data gaps identified at the completion of Phase I, and to guide placement of additional Phase II monitoring wells
- Phase II comprehensive sampling of the existing Ohio EPA wells, the Troy wells, and the newly installed Phase I and II RI wells to evaluate groundwater conditions with addition of the Phase II wells (Figures 1-11, 1-11A, 1-11B, 1-11C, 1-12)
- Additional Phase II sampling activities including HRSC, installation of monitoring well MW-EPA-124, and sampling of select monitoring wells for VOCs and general remediation parameters. The purpose of these activities was to conduct high-resolution sampling at specific areas to investigate potential source areas, further define the vertical distribution of contamination in specific areas, add another monitoring well at the downgradient end of the Residential Area plume, and assess general groundwater chemistry to support development of potential remedial alternatives in the FS (Figure 1-13).

Results of all Phase I and II RI groundwater samples indicate that six VOCs (PCE, TCE, cDCE, chloroform, bromodichloromethane, and dibromochloromethane) were detected at concentrations above one or more of the site SLs, which are listed below for reference.

Compound	MCL	Tapwater RSL	VISL
Tetrachloroethene (PCE)	5	4.10	15
Trichloroethene (TCE)	5	0.280	1.20
cis-1,2-Dichloroethene (cDCE)	70	3.60	NE
Chloroform	80	0.22	0.81
Bromodichloromethane	80	0.13	0.88
Dibromochloromethane	80	0.17	3.20

Notes:

All concentrations are in units of micrograms per liter (µg/L).
cDCE– *cis*-1,2-Dichloroethene
MCL – EPA Safe Drinking Water Act maximum contaminant level
NE – A screening level has not been established for this compound
PCE - Tetrachloroethene
RSL – EPA tapwater regional screening level
TCE – Trichloroethene
VISL – EPA vapor intrusion screening level based on a target hazard quotient of 1 and target risk of 1E-06

The SLs exceeded by each VOC are summarized as follows:

Compound	MCL	Tapwater RSL	VISL
Tetrachloroethene (PCE)	■	■	■
Trichloroethene (TCE)	■	■	■
cis-1,2-Dichloroethene (cDCE)		■	NE
Chloroform		■	■
Bromodichloromethane		■	■
Dibromochloromethane		■	■

Notes:

cDCE –*cis*-1,2-Dichloroethene
MCL – EPA Safe Drinking Water Act maximum contaminant level
NE – Not established
PCE – Tetrachloroethene
RSL – EPA tapwater regional screening level
TCE – Trichloroethene
VISL – EPA vapor intrusion screening level

As shown in the summary table above, PCE and TCE were the two VOCs present at concentrations exceeding MCLs. All six VOCs exceeded tapwater RSLs and VISLs. The exception is cDCE, which exceeded only the tapwater RSL because a VISL has not been established for this compound.

Additional discussion of the nature and extent of groundwater contamination has been divided into three overall areas. These areas include the Residential Area plume, the East Water Street plume, and site-wide groundwater. Each of these areas is discussed below.

Note that within this document, all conclusions and discussions regarding groundwater contamination in the context of human health risk thresholds are based on analytical data collected from permanent groundwater monitoring wells. However, general discussions regarding horizontal and vertical extent and distribution of contamination within the plume are based on a combination of data from groundwater samples collected from monitoring wells, shallow direct push borings, and HRSC vertical profile borings sampled with the Waterloo sampling system. (All three types of groundwater samples were analyzed by either a fixed off-site or on-site mobile laboratory using standard EPA Methods.) MIP results are considered qualitative data and were not used for developing conclusions regarding the extent or volume of contamination, or risk.

Residential Area Plume Observations and Conclusions

Due to access restrictions to the basement of the First Presbyterian Church addition that now covers the former dry cleaner location at 10 East Main Street, collection of groundwater, soil, or sub-slab vapor

samples directly beneath the original suspected source area was not feasible during the RI. The inability to collect samples in this area resulted in a degree of uncertainty regarding the extent of soil or groundwater contamination beneath the present structure. However, sub-slab soil vapor samples collected by EPA in 2007 and post-RI sub-slab vapor samples collected by Ohio EPA in 2016 from the church addition basement indicated that PCE was present in sub-slab vapor. Therefore, some groundwater contamination likely exists beneath at least a portion of the structure. Vadose zone soil contamination may also be present at that location; however, the sub-slab vapor data collected by Ohio EPA were generally consistent with data collected farther downgradient, outside of the source area, and therefore the presence of vadose zone soil contamination has not been confirmed (Ohio EPA 2016a).

The results of the groundwater investigations indicated that the highest concentrations of VOCs (primarily PCE, with lesser amounts of TCE and cDCE) detected during the RI were found in samples collected along Walnut Street directly downgradient from the former locations of the far rear (southwest) end of 10 East Main Street and the attached structure at 8 South Walnut Street, adjacent to two sewer laterals that connect (or formerly connected) structures in this area to the Walnut Street sewer. Groundwater profiling data indicate that contamination extends to depths greater than 80 feet in this area and immediately downgradient. Based on Waterloo APS groundwater profiling results, the highest concentrations of PCE were detected in borings drilled along the west side of Walnut Street; which during the RI was the closest to the former dry cleaner where sampling could feasibly be completed. The highest concentrations detected were 2,740 µg/L (34 feet bgs), 2,400 µg/L (39 feet bgs), and 3,560 µg/L (44 feet bgs), as shown in Figure 1-3. The relatively narrow width of the most concentrated and deepest part of the plume suggests an original source that was relatively small in lateral extent – such as a point discharge/release – with subsequent rapid migration primarily downward and horizontally downgradient (SulTRAC 2015).

Dense, nonaqueous-phase liquid (DNAPL) was not observed in any groundwater samples or purge water from monitoring wells in the Residential Plume source area. Immiscible phases were not detected in any of the monitoring wells when checked with a multiphase-probe during the RI. The maximum detected PCE concentrations were substantially lower than the solubility of PCE in water. However, studies and guidance published by EPA and various other sources indicate a conservative “rule of thumb” that assumes dissolved-phase VOC concentrations greater than 1 to 10 percent of the solubility of a particular compound suggest a possibility that some DNAPL may be present at the site (EPA 1992). It is important to note that this rule of thumb is based on the observation that DNAPL has been encountered at many sites where dissolved-phase concentrations in those ranges were found in groundwater, rather than any

empirical relationship between DNAPL presence and dissolved phase concentrations at any given location. However, for purposes of this FFS, it is conservatively assumed that DNAPL could be present in the Residential Plume source area because the maximum concentration of PCE observed in dissolved-phase groundwater samples collected in the Walnut Street area (3,560 µg/L) is greater than 1 percent of the solubility of PCE in water (the solubility of PCE in water is 150,000 µg/L resulting in 1 percent of the solubility being 1,500 µg/L). Additional data will be gathered during the RD and zones of significantly higher contaminant concentrations or DNAPL will be addressed in the RD.

The dissolved-phase plume migrates southeast, roughly parallel to the course of the GMR (Figure 1-11). Samples from monitoring wells and HRSC activities (Waterloo APS) at the origin of the plume near Walnut Street indicated that PCE is present at concentrations of thousands of micrograms per liter, TCE is present at tens to hundreds of micrograms per liter, and cDCE is present at single-digit levels of micrograms per liter. Downgradient, as the plume moves from the vicinity of Mulberry Street to Frank Street, concentrations gradually decrease, with PCE present at concentrations of hundreds of micrograms per liter, TCE at tens of micrograms per liter, and cDCE present at single-digit to trace levels of micrograms per liter. Based on these observations, the most highly contaminated area lies between Walnut Street and Oak Street. The area of highest concentrations, the "axis" of the plume, is relatively narrow, and lies between East Main Street and East Franklin Street between the source area and Clay Street. The axis then trends along and across Franklin Street as it moves downgradient to the vicinity of Oak Street. Southeast of Oak Street, the plume axis likely trends closer to East Canal Street as it dissipates to lower concentrations.

Concentrations gradually decrease with distance downgradient; between Frank and Morehead Streets, total VOCs are present at tens of micrograms per liter. Vinyl chloride (VC) was not detected in any of the monitoring wells or in Waterloo APS profiling samples collected in the Residential Area plume during the RI. VOCs in the plume decrease to below screening levels as the plume migrates southeastward to the vicinity of Floral Avenue.

The lateral extent of the Residential Area plume is bounded by Floral Avenue to the east, Scott Street to the south, and Walnut Street (the inaccessible area just west of Walnut Street) to the west. Between Walnut and Union Streets, the plume is bounded on the north by East Main Street. As previously discussed, a section of the plume near Union Street appears to partially split off from the main plume, possibly as a result of pumping from nearby wells and subsurface geologic features, crossing East Main Street as it moves eastward (see Figure 1-11). It is also possible that a second potential source of

contamination may be present near the intersection of Union and East Main Streets. The possibility of a second source was indicated solely by the spatial distribution of PCE in groundwater samples collected in the area surrounding the 432 East Main Street property, which is the location of a former dry cleaning facility (Waltz Cleaners). Concentrations of PCE detected below Union Street were highest between Canal and Franklin Streets, decreased progressing northward from Franklin Street, and then increased again in the area adjacent to 432 East Main Street (see Figures 1-11, and 1-11A). Additional discussions regarding the distribution of PCE in this area are presented in the RI report (SulTRAC 2015).

The vertical extent of contamination is deepest at the plume's axis in the area near Walnut Street, with VOCs detected to depths exceeding 80 feet bgs. Overall, throughout much of the downgradient portions of the Residential Area plume, the highest concentrations of VOCs were encountered in the zone between approximately 30 and 60 feet bgs, roughly 10 to 40 feet below the water table. The vertical extent of contamination is not as deep at the lateral edges of the plume. Generally, the vertical extent of contamination decreases at the lateral edges of the plume and in the downgradient direction, based on Waterloo APS results and results from deep monitoring well samples.

East Water Street Plume Observations and Conclusions

The origin of the East Water Street plume is near the northwest corner of the Hobart property in close proximity to the loading dock. Overall, the data gathered during the RI indicate that the East Water Street plume is generally narrower and shallower and contains lower concentrations of PCE than the Residential Area plume. Concentrations of VOCs observed in this plume are orders of magnitude lower than those observed in the Residential Area plume, and substantially less than the 1 percent solubility "rule of thumb" range, referred to previously, that is cited in various reports and guidance as being potentially indicative of proximity to DNAPL. Additionally, no visual evidence of DNAPL was observed in groundwater samples collected in East Water Street plume. The plume also generally contains a higher ratio of TCE to PCE than the Residential Area plume, and cDCE is also more prevalent in groundwater samples, especially in the downgradient portion of this plume. In addition, VC was detected in only one sample collected (at Spinnaker) during the RI at 9.9 µg/L.

The plume is bounded laterally by the GMR to the north and east, Water Street to the south, and Clay Street to the west. The plume extends downgradient at least to the GMR. The plume initially migrates southeast, roughly parallel to the GMR, passing beneath the Hobart building. The higher concentrations of PCE and TCE are generally detected in the area between Clay and Union Streets, and the higher concentrations of cDCE are generally detected between Union Street and the GMR. However, well KMW-10 on the Spinnaker property is an exception. KC collects quarterly monitoring data from this well

(located at the upgradient end of the Spinnaker property) and numerous other wells on the Spinnaker property. Reported VOC concentrations from KMW-10 are often elevated relative to other nearby locations on the Spinnaker property, possibly indicating the presence of a second localized source of contamination. KC's reported data from the quarterly monitoring events indicates that KMW-10 typically exhibits the highest cDCE concentrations in the East Water Street plume area, ranging from 35 to 139 ug/L (SulTRAC 2015).. EPA sampled KMW-10 twice, during the Phase II comprehensive and supplemental groundwater sampling events, with varying results. cDCE was not detected during the comprehensive sampling event, but was detected at 52 ug/L during the supplemental sampling event, Figures 1-11C and 1-13).

The vertical extent of contamination in the East Water Street plume is relatively shallower than in the Residential Area plume. The highest concentrations of VOCs detected were in wells and Waterloo APS samples collected at or near the water table. VOC concentrations within this plume generally decreased with depth and were not detected above SLs in the majority of the Waterloo APS borings and deep monitoring well samples.

TCE was detected in screening groundwater samples collected from Geoprobe borings behind the Spinnaker building. During Phase II of the RI, TCE was detected at 39 µg/L in a screening sample from a soil boring advanced between the north side of the Spinnaker western plant building and the levee of the GMR. It was also detected at locations between the Spinnaker building and the levee sampled by Ohio EPA in 2007. The concentration of TCE detected in the Phase II RI sample was higher than typically reported in any of the adjacent shallow monitoring wells during Spinnaker's quarterly monitoring events and higher than TCE concentrations detected in Phase I or Phase II groundwater samples collected at nearby well OEPA-3.

Site-Wide Groundwater Observations and Conclusions

Wells EPA-108S (for the Residential Area plume) and EPA-122S and OEPA-13 (for the East Water Street plume), along with upgradient Waterloo APS groundwater profiling results, are outside of the plume areas and upgradient relative to the plumes.

In addition, sample results from upgradient wells on the east side of the GMR (Troy L, Troy M, Troy N, EPA-105S, EPA-105D, EPA-123D) and in samples from VAS location VAS-208 did not show detections of VOCs above site SLs (see Figures 1-2, 1-10, and 1-12 for these well locations). These sample results indicated no sources east of the GMR that may be contributing to the VOCs detected in the East wellfield production wells.

In general, the types of contaminants detected in groundwater at the site and their concentrations have been relatively consistent in samples collected over time (prior to the RI and throughout the multiple phases of the RI).

Throughout most of the site, the Residential Area and East Water Street plumes are separate. This separation is evident in the data from the many monitoring well and grab groundwater samples collected along Main Street between Union and Mulberry Streets. However, in the area encompassing wells EPA-103S, EPA-106S, EPA-114S, GZA-2, and MCD-T-14S the Residential Area and East Water Street plumes may co-mingle. This co-mingling is indicated by the presence of PCE in these wells with little to no TCE present.

The area along the levee, roughly located between monitoring wells KMW-4 and MCD-T-14S appears to be where the contamination from the (possibly combined) plumes migrates below the GMR to the Troy production wells. This determination is supported by detections of low levels of cDCE in samples from various Waterloo APS borings and at VAS boring VAS-209 (as well as detections of cDCE in Troy production wells P-18 and P-14). This area is also where the City of Troy wellhead protection plan, Wellfield Sustainability Report, and multiple rounds of water level measurements taken during the RI indicated that pumping from the wellfield significantly influenced localized groundwater flow. VOCs were not detected in groundwater screening samples collected at the 25- and 50-foot horizons at VAS boring VAS-209, between Troy production well P-18 and the GMR. cDCE was detected at 1.69 and 3.19 µg/L in samples from 75 and 105 feet bgs. These sample depths correlate with the upper and lower portions of the screened horizon at P-18, where cDCE is frequently detected at similar or lower concentrations. Because cDCE was not found at upgradient locations east of the GMR, it is likely that cDCE (or potentially TCE or PCE) is migrating beneath the GMR at a depth below 50 feet in the area.

1.2.4.3 Soil Vapor

The VI pathway was evaluated by collecting soil vapor and air samples (sub-slab, indoor air, and ambient air) during Phase I. Some Phase I locations were resampled during Phase II, along with additional locations. Therefore, some locations were sampled during both phases, and some were sampled during only one phase. Several property owners declined access, so the sample locations partially depended on access, as well as overall relationship to the groundwater plumes.

Phase I VI monitoring of businesses and residences was performed in January 2012. Phase II VI monitoring began in August 2012 and included a second round (summer season) of VI sampling at

locations initially sampled during Phase I. In the spring of 2013, Phase II VI monitoring was performed at additional locations not sampled during Phase I or not accessible for the summer sampling event. These additional locations were chosen based on ongoing review of data from Phase I and initial Phase II activities.

Results from locations sampled during both Phase I and Phase II were generally consistent in regard to compounds detected and locations where elevated results were obtained. Although concentrations varied between the two events, Phase II summer sample results exceeded applicable SLs only at the same locations where results had exceeded applicable SLs during the Phase I winter samples, collected in January 2012. Several property owners at locations sampled during Phase I declined access for Phase II sampling, and therefore, no Phase II and summer data are available for these locations.

Results from additional Phase II locations sampled in spring 2013 were used to supplement previous Phase I and II results and indicated that the areas of most significant potential concern regarding VI are generally aligned along or close to the axis of the groundwater contaminant plumes.

In general, the extent of VI contamination appears consistent with the alignment of groundwater contaminant plumes, with the highest VOC concentrations detected in areas close to the axes of the groundwater plumes (see Figures 1-14 and 1-15). For this reason, the upgradient boundary of the area impaired by contaminants in soil vapor is near South Walnut Street, and the lateral boundaries of the area are approximated by East Main Street and East Canal Street. The farthest downgradient location in the area of the Residential Area plume where access for sampling was granted was on East Canal Street between Counts and Frank Streets. The Residential Area PCE groundwater plume is located beneath this structure and extends approximately four to five blocks farther downgradient from this location.

Only PCE, TCE, chloroform, bromodichloromethane, and dibromochloromethane exceeded SLs in sub-slab or indoor air samples, and were also detected in groundwater at concentrations above their VI SLs. These results indicate a possible correlation between these VOCs in groundwater and in VI samples. It should be noted that of these compounds, chloroform, bromodichloromethane, and dibromochloromethane are commonly associated with dechlorination of municipal potable water and thus are typically found in both potable water supplies and wastewater in sanitary sewers. They are not believed to be associated with the sources of the groundwater contamination at the ETCA site.

Soil vapor and air samples were not collected in the East Water Street plume area during the RI. EPA documented VI concerns during previous sampling conducted in the East Water Street plume area in 2006 and 2007. All four residences located between the Hobart and Spinnaker properties were sampled at that time. Additional sampling was completed at St. Patrick's school and the parish hall located on East Water Street. Based on comparison of the results of the past VI sampling to groundwater data collected during the RI, the area affected by VI of soil gas into buildings in the East Water Street area corresponds to the footprint of the groundwater VOC plume.

In addition to evaluating a link between VOCs in groundwater and VOCs in vapor and air samples, analytical results were also evaluated to identify VOCs that exceeded SLs in both sub-slab and indoor air samples collected at a given location.

Detections of chemicals above the VISL in groundwater, sub-slab samples, and indoor air samples indicate that the VI pathway may be complete. Given the presence of PCE in these three media (as well as frequent detections of TCE in groundwater and sub-slab samples), the VI pathway may be complete at locations that directly overlie the groundwater plumes. (Chloroform is also present but as previously discussed is most likely due to leakage from water and sewer lines in the area.) Other VOCs detected in soil vapor and air include benzene, 1,2-dichloroethane, and 1,4-dichlorobenzene; however, the connection between these chemicals in groundwater, sub-slab, and indoor air samples is not completely demonstrated. These other VOCs were further evaluated in the human health risk assessment and were not retained as COPCs.

RI results suggest that the area with the highest potential for VI was the area overlying the Residential Area plume, generally bounded by East Main Street to the north, potentially beyond Williams Street to the east, East Canal Street to the south, and Walnut Street to the west. In addition, the RI indicated a potential for VI (although lower than in the Residential Plume Area) in the following areas:

- The area overlying the East Water Street plume, generally bounded by the GMR to the north, Frank Street to the east, East Water Street to the south, and Clay Street to the west. This area includes the residences between the Hobart and Spinnaker properties.
- The area where the plumes appear to comingle, generally bounded by East Water Street to the north, Frank Street to the east, East Main Street to the south, and Union Street to the west.

1.2.4.4 Surface Water and Sediments

Surface water and sediment samples were collected from the GMR during Phase I and Phase II of the RI. VOCs detected in surface water samples included acetone, chloroform, and toluene. None of these VOCs

was detected above the surface water SLs, including Ohio Water Quality Criteria for Protection of Human Health and Ohio River Basin Aquatic Life Criteria. VOCs detected in sediment samples included methylene chloride and toluene. Neither VOC was detected above its residential soil or ecological SL. In summary, VOCs were not detected in surface water or sediment samples at concentrations exceeding the applicable SLs.

1.2.5 Risk Assessments

The human health risk assessment (HHRA) and the screening level ecological risk assessment (SLERA) are presented as Appendix M to the ETCA RI report (SulTRAC 2015). The risk assessments were prepared consistent with EPA and Ohio EPA guidance.

Summaries and conclusions of the HHRA and SLERA are presented below in Sections 1.2.5.1 and 1.2.5.2. Appendix M of the RI report contains details regarding methodologies, assumptions, and results of the risk assessments (SulTRAC 2015).

1.2.5.1 HHRA Summary and Conclusions

The ETCA study area was subdivided into four areas in the RI, primarily according to the location and composition of groundwater contamination:

- East Water Street Plume
- Residential Area Plume
- City of Troy East Wellfield
- GMR

These four areas were further divided into a series of exposure areas as follows:

- Each plume was divided into upgradient and downgradient exposure areas for evaluating potential groundwater exposure and characterizing associated risks and hazards (see Figure 1-16)

- COPCs in soil were only identified for the upgradient portion of the East Water Street plume. Based primarily on current land use conditions and the nature and extent of soil contamination, the upgradient portion of the East Water Street plume was divided into six soil exposure areas (EA-1 through EA-6 - see Figure 1-17).

Four human receptors were evaluated: current and future residents, current and future industrial/ commercial workers, current and future construction workers, and current and future utility workers. An increased incidence of cancer less than 1 in one million (1E-06) and a noncancer hazard index (HI) of less than or equal to1 are considered protective for long-term exposure to contaminants. These values are also

considered the point-of-departure for evaluating the need for corrective action, and are the bases for United States Environmental Protection Agency (EPA) Regional Screening Levels (RSL).

Cancer risks and noncancer hazards determined for the ETCA exposure areas are summarized in Table 1-1. It should be noted that Table 1-1 presents only exposure area-, medium-, exposure pathway-, and chemical-specific risks greater than or equal to 1E-06, noncancer hazards greater than 1 (and noncancer hazards less than 1 that are associated with a chemical with a risk greater than or equal to 1E-06), or both. Therefore, the results in Table 1-1 are similar to, but not directly comparable to the bulleted risk assessment summaries presented at the end of this section.

Table 1-1: Summary of Human Health Risks Greater than EPA Threshold Levels East Troy Contaminated Aquifer Site – Troy, Ohio

Receptor	Media	Pathway	Chemical(s) of Concern	Cancer Risk	Non-cancer Hazard
EA 1 – East Water Street Plume, Upgradient **					
Current Resident	Indoor Air	Inhalation of Vapors (Vapor Intrusion)	Chloroform	**1E-06**	0.001
Future Resident	Surface Soil	Inhalation	Trichloroethene	**2E-06**	0.5
	Subsurface Soil	Ingestion	Trichloroethene	**3E-06**	0.6
		Inhalation	1,1,2-Trichloroethane	**1E-06**	0.9
			Tetrachloroethene	**1E-06**	0.4
			Trichloroethene	**2E-05**	**5**
	Groundwater	Ingestion	Bromodichloromethane	**3E-06**	0.01
			Chloroform	**4E-06**	0.05
			Dibromochloromethane	**4E-06**	0.008
			Trichloroethene	**1E-05**	**2**
		Dermal	Trichloroethene	**2E-06**	0.05
		Inhalation of Vapors (Household Use)	Bromodichloromethane	**3E-05**	--
			Chloroform	**5E-05**	0.05
			Dibromochloromethane	**2E-05**	--
			Trichloroethene	**2E-05**	**4**
	Indoor Air	Inhalation of Vapors (Vapor Intrusion)	Chloroform	**1E-06**	0.001
Future Industrial/ Commercial Worker	Subsurface Soil	Inhalation	Trichloroethene	**4E-06**	1
	Groundwater	Ingestion	Bromodichloromethane	**1E-06**	0.002
			Chloroform	**1E-06**	0.01
			Dibromochloromethane	**1E-06**	0.002
			Trichloroethene	**3E-06**	0.4
		Inhalation of Vapors (Domestic Use)	Bromodichloromethane	**7E-06**	--
			Chloroform	**1E-05**	0.01
			Dibromochloromethane	**4E-06**	--
			Trichloroethene	**3E-06**	1
Current and Future Construction Worker	Outdoor Air	Inhalation of Vapors (Trench Air)	Bromodichloromethane	**2E-06**	--
			Chloroform	**2E-06**	0.2
			Dibromochloromethane	**3E-06**	--
			Trichloroethene	4E-07	**14**
Current and Future Utility Worker	Outdoor Air	Inhalation of Vapors (Trench Air)	Bromodichloromethane	**3E-06**	--
			Chloroform	**6E-06**	0.007
			Dibromochloromethane	**1E-05**	--
			Trichloroethene	**2E-06**	0.5
EA 2 – East Water Street Plume, Upgradient *					
Future Resident	Subsurface Soil	Inhalation	Trichloroethene	**1E-06**	0.3
EA 3 – East Water Street Plume, Upgradient *					
Soil not evaluated for any receptor					
EA 4 – East Water Street Plume, Upgradient *					
No unacceptable cancer risk or non-cancer hazard from soil for any receptor					
EA 5 – East Water Street Plume, Upgradient *					
Future Resident	Surface Soil	Inhalation	Trichloroethene	**2E-06**	0.4
	Subsurface Soil	Inhalation	Trichloroethene	**2E-06**	0.4
EA 6 – East Water Street Plume, Upgradient *					
Future Resident	Subsurface Soil	Inhalation	Trichloroethene	**8E-06**	**2**
Future Industrial/ Commercial Worker	Subsurface Soil	Inhalation	Trichloroethene	**1E-06**	0.5
EA 7 – East Water Street Plume, Downgradient **					
Future Resident	Groundwater Indoor Air	Ingestion	Trichloroethene	**2E-06**	0.3
		Inhalation of Vapors (Household Use)	Bromodichloromethane	**3E-06**	--
			Tetrachloroethene	**1E-06**	0.3
			Trichloroethene	**3E-06**	0.6
Current and Future Construction Worker	Outdoor Air	Inhalation of Vapors (Trench Air)	Trichloroethene	6E-08	**2**

Table 1-1: Summary of Human Health Risks Greater than EPA Threshold Levels
East Troy Contaminated Aquifer Site – Troy, Ohio
(Continued)

Receptor	Media	Pathway	Chemical(s) of Concern	Cancer Risk	Non-cancer Hazard
EA 8 – Residential Area Plume, Upgradient **					
Current and Future Child Resident	Groundwater	Dermal (Pool)	Trichloroethene	**1E-06**	0.1
Current Resident	Indoor Air	Inhalation of Vapors (Vapor Intrusion)	Chloroform	**3E-06**	0.004
			Tetrachloroethene	**2E-05**	**6**
Future Resident	Groundwater	Ingestion	Tetrachloroethene	**2E-05**	**6**
			Trichloroethene	**4E-05**	**5**
		Dermal	Tetrachloroethene	**1E-05**	0.5
			Trichloroethene	**7E-06**	0.1
	Indoor Air	Inhalation of Vapors (Household Use)	Chloroform	**5E-06**	0.005
			Tetrachloroethene	**3E-05**	**9**
			Trichloroethene	**5E-05**	**12**
		Inhalation of Vapors (Vapor Intrusion)	Chloroform	**3E-06**	0.004
			Tetrachloroethene	**2E-05**	**6**
Current Industrial/ Commercial Worker	Indoor Air	Inhalation of Vapors (Vapor Intrusion)	Tetrachloroethene	**5E-06**	1
Future Industrial/ Commercial Worker	Groundwater	Ingestion	Tetrachloroethene	**6E-06**	1
			Trichloroethene	**9E-06**	1
	Indoor Air	Inhalation of Vapors (Household Use)	Chloroform	**1E-06**	0.001
			Tetrachloroethene	**8E-06**	**2**
			Trichloroethene	**9E-06**	**3**
		Inhalation of Vapors (Vapor Intrusion)	Tetrachloroethene	**5E-06**	1
Current and Future Construction Worker	Outdoor Air	Inhalation of Vapors (Trench Air)	Tetrachloroethene	8E-07	**20**
			Trichloroethene	5E-07	**18**
Current and Future Utility Worker	Outdoor Air	Inhalation of Vapors (Trench Air)	Tetrachloroethene	**3E-06**	0.8
			Trichloroethene	**2E-06**	0.7
EA 9 – Residential Area Plume, Downgradient **					
Future Resident	Groundwater	Ingestion	Tetrachloroethene	**2E-06**	0.5
		Dermal	Tetrachloroethene	**1E-06**	0.05
	Indoor Air	Inhalation (Household Use)	Chloroform	**6E-06**	0.007
			Tetrachloroethene	**3E-06**	0.8
Future Industrial/ Commercial Worker	Indoor Air	Inhalation (Domestic Use)	Chloroform	**1E-06**	0.002
Current and Future Construction Worker	Outdoor Air	Inhalation of Vapors (Trench Air)	Tetrachloroethene	9E-08	**2**

Notes: Only those receptor/media/pathway/chemical combinations that have a cancer risk greater than or equal to 1E-06 or a non-cancer hazard greater than 1 at one significant figure are included. For complete results see the Human Health Risk Assessment (Appendix M) (SulTRAC 2015).
Bold and yellow indicates exceedance of threshold value.

* The calculated groundwater cancer risks and non-cancer hazards for future receptors are the same as shown for EA1.

** The vapor intrusion pathway was evaluated using U.S. Environmental Protection Agency's (EPA) Vapor Intrusion Screening Level (VISL) calculator as a second line of evidence for this area; see Appendix M (SulTRAC 2015).

EA Exposure Area
RME Reasonable Maximum Exposure

References:

SulTRAC. 2015. Final Remedial Investigation Report for East Troy Contaminated Aquifer Site, Troy, Miami County, Ohio. Prepared for U.S. Environmental Protection Agency Region 5. January.

Based on results of the HHRA, conclusions were drawn and are discussed below. However, regarding interpretation of risks and hazards from contaminants in soil, the following points should be recognized. First, collection of soil samples from the former dry cleaner source area at 10 East Main Street (beneath the present-day First Presbyterian Church addition) was not feasible because of access restrictions. Therefore, risks and hazards were not confirmed or quantified for soil at this location, but were conservatively assumed to exist. This area, however, was at least partially excavated and reworked during the construction of the present structure and therefore the presence of residual soil contamination in this area has not been confirmed. Second, soil-related risks and hazards discussed below are based on direct-contact exposure pathways only. Third, the risk and hazard results below were extracted from the human health risk assessment. These results include all medium-specific COPCs and, therefore, are similar to, but not directly comparable to the exposure area-, medium-, exposure pathway-, and chemical-specific results presented in Table 1-1.

- At Soil Exposure Areas (EA) 1 through 6 within the East Water Street plume – Upgradient area, all receptor-specific cumulative soil cancer risks (based on surface and subsurface soil) are less than or within EPA's risk range of 1E-06 to 1E-04.
- Soil Exposure Area 1 (future residents and industrial/commercial workers) and Area 6 (future residents) are the only exposure areas with noncancer hazard indices (HI) greater than 1 — all based on potential future exposure to TCE in subsurface soil via inhalation
- Cumulative soil cancer risks exceed or equal 1E-06 in surface soil only at Soil Exposure Area 1 (2.4E-06) and Exposure Area 5 (2.0E-06), assuming future residential exposure. TCE is the only COC in surface soil at both locations.
- Cumulative soil cancer risks exceed or equal 1E-06 in subsurface soil at Soil Exposure Areas 1, 2, 5, and 6. TCE is the only COC in subsurface soil, except at Soil Exposure Area 1 (see below).
- Soil Exposure Area 1 is the only exposure area with (1) cumulative soil cancer risks greater than 1E-05 (cumulative cancer risk of 2.9E-05, assuming residential exposure to subsurface soil), and (2) COCs other than TCE (including PCE and 1,1,2-trichloroethane) in subsurface soil.
- Soil Exposure Areas 3 and 4 have no soil COCs (no soil COPCs [Area 3] or all receptor-specific cumulative soil cancer risks less than 1E-06 [Area 4]).
- Cumulative groundwater receptor-specific cancer risks are similar to and slightly exceed EPA's risk range of 1E-06 to 1E-04 at both upgradient plume areas, assuming future residential potable groundwater use: East Water Street plume – Upgradient (1.4E-04) and Residential Area plume – Upgradient (2.0E-04). However, COCs in groundwater differ at the two plumes:
    - East Water Street plume – Upgradient: PCE, TCE, chloroform, bromodichloromethane, and dibromochloromethane.
    - Residential Area plume – Upgradient: PCE, TCE, and chloroform
    - Key differences:
        - Significantly higher trihalomethane (chloroform, bromodichloromethane, and dibromochloromethane) contribution for East Water Street plume – Upgradient (As previously discussed, these compounds are typically associated with dechlorination

of municipal water and are not believed to be associated with the sources of the primary COCs - PCE and TCE - at the ETCA site.)

  - Significantly higher PCE contribution for Residential Area plume – Upgradient
  - Slightly higher TCE contribution for Residential Area plume – Upgradient.

- Cumulative receptor-specific noncancer HIs are 2 to 5 times higher at Residential Area plume – Upgradient than at East Water Street plume – Upgradient (future residential (39 versus 6.9), future industrial/commercial worker (8.8 versus 1.5), current and future construction worker (39 versus 15), and current and future utility worker (1.5 versus below 1). Differences are primarily related to higher PCE concentrations at Residential Area plume – Upgradient. Plume-specific COCs are as follows:
  - East Water Street plume – Upgradient: TCE only
  - Residential Area plume – Upgradient: PCE and TCE
- Cumulative groundwater receptor-specific cancer risks are similar to and less than or within EPA's risk range of 1E-06 to 1E-04 at both downgradient plume areas. Maximum cumulative groundwater cancer risks assuming future residential potable groundwater use are as follows: East Water Street plume– Downgradient (1.1E-05) and Residential Area plume – Downgradient (1.3E-05). However, groundwater COCs differ at the two plumes:
  - East Water Street plume – Downgradient: TCE, bromodichloromethane, and PCE
  - Residential Area plume – Downgradient: chloroform and PCE
- Cumulative groundwater receptor-specific noncancer HIs are similar for the downgradient plume areas and exceed 1 only for residents (HI = 1.4 for both plumes) and construction workers (3.1 for East Water Street plume – Downgradient and 2.5 for Residential Area plume – Downgradient).
- Receptor-specific cumulative cancer risks and noncancer HIs are about 10 times higher in upgradient plume areas than in downgradient plume areas for both plumes. It should be noted that the upgradient COPC concentrations in groundwater are expected to migrate from the upgradient to the downgradient areas of each plume. Therefore, the ratio of upgradient and downgradient concentrations (and related risks and hazards) may change in the future.
- The risk evaluation indicated that the upgradient area of the Residential Area plume was the only area at the ETCA site where residential VI exposure scenarios resulted in a HI>1.
- Based on available indoor air analytical data from the RI, cumulative cancer risks and noncancer HIs associated with the VI pathway (current residents and industrial/commercial workers) are higher in the area of the Residential Area plume – Upgradient (cumulative cancer risk of 2.7E-05 and HI of 6.1) than in the area of the East Water Street plume – Upgradient (cumulative cancer risk of 1.2E-06 and HI below 1). Differences are the result of relative PCE concentrations in groundwater.

  Because of limited number and locations of available indoor air sampling results (for example, indoor air samples were not collected at the Hobart and Spinnaker buildings above the East Water Street plume – Upgradient or at the First Presbyterian Church at the head of the Residential Area plume – Upgradient), VI cancer risks and noncancer HIs were also calculated using EPA's VISL calculator. A comparison of the two sets of calculations indicates that results from VISL may overestimate risks and HIs from the East Water Street Plume – Upgradient, but may reasonably estimate vapor intrusion risks and HIs from the Residential Area Plume – Upgradient.

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- Individual child and adult groundwater non-potable use scenarios are associated with insignificant cancer risks and HIs, except for the cumulative cancer risk in the area of Residential Area plume – Upgradient which is driven by potential dermal exposure to TCE.
- Total risks and hazards calculated under central tendency exposure (CTE) conditions are about 1 to 10 times lower than those calculated under reasonable maximum exposure (RME) conditions, depending on the receptor considered.
- Based on the maximum concentration of cDCE detected in Troy production well P-18 at the Troy East wellfield, none of the receptors considered in the HHRA (residents, industrial/ commercial workers, construction workers, and utility workers) would face significant risks from potential exposure to untreated groundwater from the Troy East wellfield.

1.2.5.2 SLERA Summary and Conclusions

As discussed in more detail in Appendix M of the RI report, no viable terrestrial ecological habitat was found within the ETCA study area. Therefore, the SLERA focused on potential exposures and associated risks to ecological receptors in the GMR (SulTRAC 2015).

Two approaches were followed to evaluate potential impacts of the contaminated groundwater discharges on the aquatic community in the GMR. First, analytical results from surface water and sediment samples from the GMR were compared with surface water and sediment ecological screening values (ESV). No detected concentration of a VOC in the surface water and sediment exceeded an ESV. In the second step, concentrations of constituents in groundwater obtained via monitoring well samples or from direct-push wells closest to the GMR were compared with surface water ESVs. The purpose was to identify any constituents present at concentrations that could affect aquatic receptors in the GMR. Ten constituents were detected in the analysis; however, none were found at a maximum detected concentration (total) that resulted in an HQ that exceeded the EPA threshold value of 1.

The next step in the evaluation of the groundwater was to evaluate potential additive impacts of these detected chemicals in the groundwater on potential aquatic receptors. This evaluation used the same toxic mechanism for all chemicals identified. SulTRAC followed EPA guidance on evaluation of chemical mixtures involving organic contaminants and used necrosis as the common toxicity endpoint. This approach was also applied to the maximum concentrations from the wells adjacent to the GMR, and the HI was also less than 1, indicating that using the necrosis endpoint did not lead to identification of significant additional risk.

Based on results of the SLERA, the following general conclusion was drawn:

- Aquatic receptors exposed to GMR surface water are not at risk for adverse effects from groundwater discharges at the current time. The groundwater data were also evaluated for potential additive impacts from maximum concentrations in the wells adjacent to the GMR, and no significant risk was identified.

2.0 INTERIM REMEDIAL ACTION OBJECTIVES, ARARs, AND AREAS/VOLUMES REQUIRING REMEDIATION

This section identifies the RAOs, preliminary ARARs, and estimated areas and volumes of media (where applicable) pertinent to the IA for the ETCA site.

As discussed in Section 1.2, the RI evaluated the nature and extent of contamination, and assessed the risk for all identified sources, pathways, and receptors at the ETCA site. The nature and extent of contamination, site complexity, and constraints caused by the site setting have significant influence on the estimated timeframes that will be required for remediation of this site. Furthermore, potential remedial processes, such as MNA for groundwater, which may be applicable as part of a final remedy for this site, are not yet viable given (1) the presence of contaminated media (soil and groundwater) that appear to be acting as ongoing secondary sources of dissolved phase groundwater contamination, and (2) the potential presence of residual DNAPL in the Residential Area plume source area (EPA 1999). For these reasons, EPA determined to evaluate a streamlined group of RAOs that focus on the groundwater plume source areas and allow expedited implementation of an IA involving alternatives that will potentially achieve those RAOs. The interim RAOs are also anticipated to reduce human health risk in those areas where action will be taken; although the IA will not eliminate all risks at the site. Specifically RAOs for this IA have been established for:

- Groundwater and indoor air/vapor intrusion (VI) in the “Residential Area” PCE source and plume area
- Soil in Exposure Areas 1 and 6 (EA-1 and EA-6) in the “East Water Street” plume source areas

The IA will reduce contaminant mass in the groundwater in the Residential Plume source area and thus reduce migration of VOCs from the source area and known high-concentration areas of the groundwater contaminant plume. Reduction of the contaminant mass in these areas will also reduce the potential for VI. Implementing an IA in select areas of soil contamination will reduce potential unacceptable exposure risk as well as reduce the likelihood of contaminated soil in those areas acting as an ongoing source of groundwater contamination.

Ongoing monitoring will be a component of the IA. Institutional controls (IC) would be limited to those necessary to ensure the integrity and performance of specific alternatives, and existing City of Troy ordinances governing use of private potable water supply wells. The objectives of monitoring will be to (1) monitor progress of the IA as it relates to overall objectives; and, (2) ensure that assumptions based on the current understanding of risk remain valid as implementing the IA progresses. .

As previously discussed, the IA's primary objective is to address the groundwater plume source areas; however, this objective does not supplant an ultimate final remedy for this site. As the IA is implemented, remedial progress will be monitored and additional actions needed to achieve final remedial objectives will be evaluated as necessary. The final remedy, which would be evaluated and implemented at a future date, may include RAOs and alternatives for groundwater, soil, or soil vapor that may be more effectively evaluated or adopted once the sources of contamination are confirmed to be controlled.

The following sections present the interim RAOs; related applicable, relevant, and appropriate regulations (ARARs); and the areas and volumes of contaminated media requiring remediation to address those RAOs.

2.1 INTERIM REMEDIAL ACTION OBJECTIVES

As specified in the NCP, RAOs should specify (1) COCs, (2) exposure routes and receptors, and (3) numeric standards (preliminary remediation goals [PRG]). Interim RAOs for the ETCA site were developed through discussions with EPA and Ohio EPA for three media – soil, groundwater, and soil vapor. Results of the HHRA are summarized in Table 1-1 and presented in Section 1.2.5.1. The summary table presents COCs, exposure routes, and receptors for these three media. In addition, Table 1-1 also presents the cancer risk and noncancer hazards posed by the COCs.

Two soil areas exceeded EPA's risk threshold for a noncancer HI of 1: EA-1 (Hobart property) and EA-6 (Spinnaker property). Data gathered during the RI indicate that these areas coincide with the apparent source areas of the East Water Street groundwater plume, which contains primarily PCE, TCE, and a related degradation product (cDCE). For these reasons, RAOs have been established for EA-1 and EA-6 for soil. Potential PRGs for soil in these areas were identified by back calculating site-specific risk-based values for soil, and site-specific values based on protection of groundwater for both TCE and PCE. The lower of the values were selected as the PRGs.

Groundwater and VI risks were significantly higher in the Residential Area PCE plume than in the East Water Street plume. The source area of the Residential Area plume contains PCE at concentrations suggestive of the presence of residual DNAPL, and this area appears to be an ongoing source of dissolved-phase contamination. This source area, and the area of highest dissolved-phase VOC concentrations, also contains a significant number of occupied residences and commercial structures and the risk assessment indicated that individual residential exposure scenarios resulted in HI>1 based on groundwater and VI exposure in this area. For this reason, EPA is also recommending an IA, and has

established RAOs, based on a goal of contaminant mass reduction for groundwater in the residential area plume.

Due to the high groundwater VOC concentrations and in the Residential Area plume, EPA is proposing a presumptive IA of installing VI mitigation systems over the source area and over areas with the highest identified PCE concentrations in groundwater. These mitigation systems will also provide protection from VI to structures throughout the area of the proposed groundwater IA. Because the RAO will preemptively address a pre-determined area and will not involve evaluating new vapor data to determine the area of the action, the PRGs for VI are proposed solely to document the performance of the selected alternative following implementation and to make adjustments if necessary. Due to the lower groundwater concentrations, the exceedances of risk thresholds for VI in the East Water Street plume area are limited to future workers conducting excavation or trenching activities. Therefore, the IA does not include RAOs specific to VI in the East Water Street Plume area. However, reduction of contaminant mass in soil in EA-1 and EA-6 may reduce the potential for ongoing release of COCs to groundwater and thus reduce VI risk over time.

RAOs for soil, groundwater, and vapor intrusion are discussed below.

2.1.1 RAOs for Soil

As discussed in Section 1.2.4, the extent of soil contamination exceeding residential or industrial RSLs was identified in the RI. Concentrations in soil exceeded the SLs in the northwest part of the Hobart property, the western part of the Spinnaker parking lot, and the area adjacent to the northwest part of the Spinnaker building (see Figures 1-6 and 1-7). Investigations conducted at the Spinnaker property prior to the RI also indicated that soil was contaminated by VOCs beneath the west parking lot area (Shaw 2006); however, this information was not used in the RI to evaluate the extent of soil contamination.

Exposure areas (EA) were used in the HHRA to evaluate risk associated with soil. Elevated results for soil in the northwest part of the Hobart property were assigned to EA-1, with some results that exceeded SLs present in the westernmost part of EA-2 (Figure 1-17). Elevated results in the western part of the Spinnaker parking lot were assigned to EA-6. Elevated results for soil in the area adjacent to the northwest part of the Spinnaker building were assigned to EA-5 with some elevated results present in the northeast part of EA-4 (see Figure 1-17).

The risk assessment indicated that COC concentrations in soil resulted in a cancer risk below or within the range of 1E- 04 to 1E-06 for all EAs. Noncancer hazards were less than 1 for all areas, with the exceptions of EA-1 on the Hobart property, and EA-6 on the Spinnaker property. The noncancer HI for TCE in EA-1 was greater than 1 based on future resident (inhalation and ingestion pathways) and future industrial/commercial worker (inhalation pathway) receptors. It should be noted that, although both properties are currently industrial, the risk assessment conservatively assumed that future uses of the Hobart and Spinnaker properties could potentially include residential scenarios.

As previously discussed, lead was detected above site SLs in surface soil only at a single location (HOB7 – located between the north side of the Hobart building and the GMR levee in EA-2) at 927 mg/kg, exceeding the industrial RSL. Ten percent of the RI soil samples were analyzed for lead and other parameters, in order to evaluate if there was a significant potential for non-VOC substances to contribute to the overall site risk. This result is believed to be relatively isolated as the data collected did not indicate widespread exceedances of the lead SLs, although a sufficient number of samples were not available to quantify site-specific risk for the individual exposure area EA-2. However, the IA will focus on chlorinated VOCs as these are the COCs associated with the groundwater plumes; for this reason, lead is not carried forward as a COC in this FFS and PRGs for lead are not established. TCE concentrations at the Spinnaker property pose a noncancer hazard to future residents (inhalation pathway) future industrial/commercial workers (inhalation pathway) in EA-6.

The RI and HHRA also identified VI from soil to indoor air as an uncertain exposure pathway. Soil and soil gas samples could not be collected at some locations because of physical constraints and limited access. In addition, EPA guidance does not recommend modeling from soil directly to indoor air; therefore, the VI pathway was evaluated by (1) collecting sub-slab and indoor air samples, and (2) comparing groundwater concentrations with VISLs. The relationship of groundwater COCs to indoor air is discussed under groundwater RAOs in Section 2.1.2.

The overall goals of the IA are to reduce future exposure to COCs in excess of human health risk standards (>1E-04 risk or hazard index of 1) and reduce the contaminant mass that is acting, or available to act, as an ongoing source of groundwater contamination at the ETCA site. For this reason, soil EAs having COC concentrations exceeding acceptable human health risk and that also appear to be acting as source areas for groundwater contamination exceeding MCLs were determined to be the focus of the RAOs for soil in this FFS. In addition to the human health exposure exceedances for soil, during the RI, groundwater concentrations of PCE and TCE (EA-1 and portion of EA-2) exceeded MCLs in monitoring wells located

in or downgradient from these EAs. Quarterly monitoring conducted by KC during the same period detected cDCE at concentrations up to 139 ug/L in monitoring well KMW-10, which is located in EA-6.

PCE and TCE are the primary COCs present in soil that were also detected in groundwater at concentrations above MCLs in EA-1 and EA-6. (The trihalomethanes chloroform, bromodichloromethane, and dibromochloromethane were detected in groundwater above tapwater RSLs – not MCLs – but these VOCs were likely the result of chlorination of public water supplies and not site-related COCs). cDCE was detected at Monitoring Well KMW-10, located within EA-6, but only sporadically at concentrations exceeding MCLs. cDCE did not exceed human health direct contact risk in soil in EA-6, but is a VOC typically encountered as an intermediate breakdown/ daughter product of PCE and TCE and therefore its presence in groundwater in EA-6 may be related to releases of PCE or TCE from soils in this area.

No risks or hazards are posed by soil to ecological receptors at the ETCA site.

Based on these considerations, RAOs for the IA have been established for PCE and TCE in soils in EA-1 (Hobart) and EA-6 (western side of Spinnaker Parking lot). As previously discussed, the targeting of these areas in the FFS does not mean that future action will not be considered for other soil EAs at this site when the permanent ROD and remedy are implemented. The RAOs for soil are:

- Prevent exposure to TCE in soil that poses unacceptable cancer risks or noncancer hazards to future residents and industrial/commercial workers in EA-1, and to future residents in EA-6.
- Minimize leaching of PCE and TCE from soil to groundwater in the EAs where unacceptable cancer risks or noncancer hazards exist (EA-1 and EA-6).

Soil contaminated with PCE and/or TCE exists under two types of conditions: exposed soil (vegetation or gravel at the surface, as in EA-1) and covered soil (asphalt or concrete at the surface, as in EA-6). In both locations, however, shallow groundwater is contaminated with the same VOCs detected in the soil, suggesting that leaching of contaminants from vadose zone soil to groundwater may be an ongoing source of contamination.

The HHRA indicated the future resident and future industrial/commercial worker had estimated risks from soil exposure to TCE in EA-1 that would exceed the EPA thresholds of cancer risk greater than or equal to 1E-06 and a non-cancer HI greater than 1. Risk from TCE in EA-6 exceeded the HI threshold for future residents. Risk-based soil remediation goals were calculated for TCE using the equations for the RSLs (EPA 2014) and the exposure parameters listed in Table 4s of the HHRA (SulTRAC 2015) for the resident

and industrial/commercial worker. Risk-based soil remediation goals apply to both surface and subsurface soil. Risk-based concentrations were developed for TCE concentrations that correspond to cancer risks of 1E-06 and 1E-05 and a noncancer hazard of 1.0.

Protection of groundwater PRGs were also developed for both PCE and TCE (as described below) and are significantly lower than the human health risk-based PRGs. Although PCE did not exceed EPA risk thresholds in EA-1 or EA-6, it was detected at significant concentrations in EA-1 this leaching of PCE is a potential concern,

The risk-based concentrations were compared with the protection of groundwater SL. The proposed risk-based PRG was identified as the most conservative value of the risk-based and SL concentrations. The following table summarizes potential PRGs that were evaluated to achieve the soil RAOs, the proposed PRGs for soil and the basis for selecting them.

Chemical of Concern	**Human Health Risk Levels**		**Protection of Groundwater[3]**	**Proposed PRG**	**Basis**
	Target cancer risk 1E-06[1]	**Target Hazard Quotient=1.0[2]**			
Tetrachloroethene	NA	NA	44	44	Protection of groundwater
Trichloroethene	940	4,100	34	34	Protection of groundwater

Notes:
PRG – Preliminary remediation goal
RSL –Regional screening level
NA – Not applicable; soil risk for PCE did not exceed HI of 1.
[1] The 1E-06 back-calculated risk level is based on the future resident (most conservative) receptor (see Appendix A).
[2] The HQ = 1 back-calculated hazard level is based on future resident (most conservative) receptor (see Appendix A).
[3] The protection of groundwater PRGs were derived using leaching equations presented in EPA Soil Screening Guidance (EPA 1996b;) with a combination of site-specific input parameters and default values specified by Ohio EPA.

All concentrations are in units of micrograms per kilogram (µg/kg).

As shown in the table above, the proposed PRGs provide site-specific cleanup levels that address the noncancer hazards that exceed the HI of 1, and are also protective of groundwater.

The protection of groundwater PRGs were determined using the leaching model equations found in EPA's "Soil Screening Guidance" (including the 1996 guidance and 2002 updates) (EPA 1996b; 2002). Varying input parameters used to account for actual site-specific conditions, such as infiltration rate, hydraulic gradient, and mixing zone depth significantly affects the final values. The input parameters to be used and the estimated PRG values were specified by Ohio EPA (Ohio EPA 2016b) and were based on a combination of site-specific data collected during the RI, literature on local soil/geologic material types

and conditions in the site area, and default values consistent with the Ohio Voluntary Action Program (VAP). Separate PRGs were calculated for PCE and TCE in each area (EA-1 and EA-6) based on site-specific factors; however, the resulting calculated PRG values for each compound were the same for both sites.

Site-specific mixing zone lengths and depths were determined for EA-1 and EA-6 based on actual sample data. An average hydraulic gradient of 0.003 was used, based on the range of 0.001 to 0.005 observed during the RI. The value selected for fraction of organic carbon (foc) of the soil was specified by Ohio EPA as the Ohio VAP default value of 0.002 based on the reported site soil type in the "Soil Survey for Miami County." Ohio EPA's January 2014 guidance, VA30007.14.001, Sampling and Analysis of Fraction Organic Carbon (foc) in Soils, recommended a modified Walkley-Black procedure to determine foc. However, foc data determined by this method were not available for the ETCA site and for this reason, Ohio EPA specified that a default value of 0.2 percent (0.002) be used. Ohio EPA also specified that an infiltration rate of 0.21 meter (m) be used, based on the "Ground Water Pollution Potential of Miami County Ohio" which determined that net recharge rates for the ETCA area range from 7 to 10 inches per year (0.17-0.25 m/year). (Ohio EPA 2016b),

Ongoing groundwater monitoring will be a component of the IA, as well as institutional controls (ICs). Monitoring of the plume in the East Water Street areas is necessary to evaluate the effects of the soil source reduction on groundwater concentrations and ensure that assumptions based on the current understanding of risk remain valid as the IA progresses. ICs limiting the use of groundwater will help limit the potential for exposure to groundwater contaminants during and after completion of the IA. The groundwater plumes at this site appear to eventually co-mingle. For this reason, all site-wide groundwater monitoring and ICs are included in the discussions and costs associated with the groundwater RAOs and alternatives.

The input values, sources and references and derivation of the protection of groundwater PRGs are presented in detail in Appendix A

2.1.2 RAOs For Groundwater

COCs detected in groundwater at the ETCA site that pertain to the FFS are VOCs. The specific VOCs driving risks and hazards in groundwater primarily include PCE and TCE. As previously stated, the trihalomethanes chloroform, bromodichloromethane, and dibromochloromethane were also detected in

groundwater below MCLs but above tapwater RSLs; however, these VOCs are considered to be the result of the chlorination of public water supplies and not site-related COCs.

Groundwater contamination is present in two separate VOC plumes (see Figure 1-11). The Residential Area plume originates near the location of the former dry cleaning facility that was located at Walnut and Main Streets. The East Water Street plume originates on or near the Hobart property. The two plumes appear to co-mingle in the general area around East Main Street between Oak and Counts Streets.

EAs were used in the HHRA to evaluate risk associated with groundwater (see Figure 1-16). As shown in Figure 1-16, the Residential Area plume and the East Water Street plume were both assigned upgradient and downgradient EAs for risk assessment. EAs with COCs posing unacceptable cancer risks or noncancer hazards are summarized in Table 1-1.

No unacceptable risks are posed by groundwater to ecological receptors at the ETCA site. Cumulative groundwater receptor-specific cancer risks slightly exceed EPA's risk range of 1E-06 to 1E-04 at both upgradient plume areas (EA-7 and EA-8), assuming future residential potable groundwater use. For the East Water Street plume, (EA-7) no current individual groundwater exposure scenarios resulted in a HI greater than 1. Noncancer HI was greater than 1 for a future resident based on ingestion, or inhalation of vapors from household use. Trench air exposure to current and future construction workers (related to VOCs in groundwater) is also greater than 1.

In the Residential Area Plume EAs no current groundwater exposure scenarios resulted in a HI greater than 1, as groundwater from private wells is not used for potable purposes in the plume area. Exposure scenarios with noncancer HI exceeding 1 included future residents through potable groundwater use, and future commercial/industrial and construction workers (inhalation of vapor). The HI for trench air exposure to current and future construction workers is also greater than 1.

VOC concentrations in the Residential Area plume are significantly higher, by one to two orders of magnitude, than those in the East Water Street plume, and are high enough to suggest the possible presence of DNAPL in the plume source area.

Groundwater in both plumes areas is not currently used for potable water supplies because the entire area is served by the Troy municipal water system. Concentrations of VOCs detected in the Troy municipal wells were below MCLs. Due to City of Troy ordinances limiting use of private wells for potable

supplies; and, based on available sample data, no residences within the plume boundaries are known to rely on private wells for potable water, Therefore, the potential for direct contact, ingestion, or inhalation of groundwater in the plume areas is limited. However, VI risk in the Residential Area plume includes risk to current and future residents, with HI exceeding 1 for PCE.

Based on the above considerations, EPA is proposing an interim action based on reducing the dissolved-phase contaminant mass at the source of the Residential Area plume, and also in the part of the plume where the highest chlorinated VOC concentrations were detected during the RI, which lies between South Walnut Street and South Union Street (see Figure 1-16). For purposes of the IA, the area has been further divided into 4 "zones" (see Figure 5-4) as follows:

- Zone A includes area between the Residential Area plume source area (currently covered by the church addition) and South Mulberry Street
- Zone B includes the area between South Mulberry and South Clay Streets
- Zone C includes the area between South Clay and South Crawford Streets
- Zone D includes the area between South Crawford and South Union Streets

The area of the IA is centered along the axis of the plume and thus lies between East Main Street on the northeast and East Canal Street on the southwest.

A reduction in contaminant mass, in turn, will result in reduced groundwater contaminant concentrations. Reducing the contaminant mass will reduce the amount of dissolved-phase contamination migrating downgradient from the source area in Zone A and will reduce concentrations of chlorinated VOCs throughout Zones A through D.

The following RAOs have been developed to address groundwater under the IA: Achieve a 70 to 90 percent reduction in dissolved VOC mass in groundwater in the area designated as Zone A

- Achieve a 70 to 90 percent reduction in dissolved VOC mass in groundwater throughout the entire IA targeted treatment areas (Zone A through Zone D).

The following discussions of the individual zones and ranges of concentrations are based on a data collected from groundwater monitoring wells, direct push borings, and HRSC/Waterloo borings. Figure 5-3 summarizes the maximum VOC concentrations detected at the site. Zone A includes the source area and immediate downgradient area, extending from the area just northwest of South Walnut Street to South Mulberry Street. The maximum PCE concentration detected in groundwater in a monitoring well in Zone

A during the RI was 2,200 µg/L in well MW-107I. Additional data collected from Waterloo/HRSC borings indicated results as high as are 3,560 µg/L.

Zones B, C, and D, where contamination has migrated from Zone A, lie downgradient between Mulberry and Clay, Clay and Crawford, and Crawford and Union Streets, respectively. Maximum VOC concentrations in Zones B, C, and D gradually decrease from upgradient to downgradient, from approximately 800 µg/L at Clay Street to 400 µg/L at Union Street. Residual dissolved-phase contamination at such concentrations may continue to feed PCE to the plume. Zones A, B, C, and D comprise most of the "upgradient" exposure area of the Residential Area plume (EA-8), where the calculated VI risk is the highest, and also cover a predominantly residential area. For these reasons the IA will actively treat groundwater in zones B, C, and D as well as in the source area/Zone A.

Because the RAOs focus on dissolved phase contaminant mass removal, preliminary estimates of the dissolved mass of chlorinated VOCs for Zone A, and for the entire interim action treatment area (Zones A through D) have been completed. A summary of the estimated dissolved phase mass and the residual dissolved mass after treatment (assuming 90 percent mass removal) is presented in Appendix B.

Achieving at least 70 percent reduction in dissolved phase mass (based on confirmatory sampling of performance monitoring wells) would be indicative that VOCs in the source area are reduced to less than 1,500 µg/L, or less than 1 percent of the solubility limit of PCE. As described in various EPA and other guidance documents, past studies have indicated that DNAPL is often present at sites exhibiting dissolved-phase concentrations greater than this value. Thus, reduction of PCE concentrations by 70 percent will provide confidence that no DNAPL remains in the source area after treatment. (As previously discussed, however, DNAPL has not been observed in groundwater samples collected at the site to date.) Removing 70 to 90 percent of the contaminant mass will also substantially deplete the amount of PCE available in Zone A to feed the downgradient portions of the plume. A reduction of 70 to 90 percent of the mass is also anticipated to reduce groundwater VOC concentrations throughout Zones B, C, and D to a range of less than 100 µg/L, to 150 ug/L.which will in turn reduce the potential for VI at this site. Reduction of VOC mass may also facilitate an expanded range of alternatives that may be available in the future for consideration for the final remedy for this site. Overall, achieving the upper end of the goal range (90 percent reduction in PCE) would result in post-IA PCE concentrations ranging from approximately 10 to 400 µg/L in the treated areas (A, B,, C and D.

As previously discussed, the timeframe for full restoration of the aquifer to potential beneficial use is estimated to be significantly longer than the timeframe in which VI risk in the residential area PCE plume could be significantly reduced. Achieving final site cleanup levels is not a goal of the interim remedial action and will be addressed as part of the final site remedy. However, controlling potential exposure through use of institutional controls and monitoring is proposed as a component of the IA. Ongoing monitoring will be necessary to evaluate progress of the IA as it relates to overall objectives, and to ensure that assumptions based on the current understanding of risk remain valid as the IA progresses. For this reason, monitoring will apply to both the Residential Area plume and East Water Street plume areas

2.1.3 RAOs for Vapor Intrusion

Sub-slab and indoor air samples were collected within residential and commercial buildings throughout the ETCA site. While EPA was unable to gain access to all structures located above the plumes, the RI and HHRA determined unacceptable cancer risks and noncancer hazards are posed by the VI pathway under certain scenarios. In addition, VOCs in sub-slab soil gas and indoor air samples have been detected at concentrations exceeding residential and commercial RSLs and the site-specific SLs used in EPA's 2006 TCRA.

During the RI, VI sampling was attempted at all previously untested locations that appeared to be over or near the portions of the groundwater plume where the highest VOC concentrations were recorded. However, there were many locations where EPA was not granted access for sampling. Also, treatment of groundwater within treatment Zones A, B, C, and D is anticipated to reduce the future risk of VI; however, in the short term, it is possible that some groundwater remediation technologies can generate minor amounts of degradation products from PCE, such as TCE, cDCE, or VC. For these reasons EPA has determined to preemptively address potential vapor intrusion above the targeted treatment area (Zones A - D) plus an additional "buffer" area extending approximately three blocks downgradient of the treatment area to Frank Street. Buildings on the lateral edges of the treatment area will also be considered for vapor mitigation systems. Buildings not addressed as part of the interim remedial action may still be assessed to evaluate the potential for VI under a separate initiative by EPA, but building assessment is not included in the IA. As such, the following RAO has been developed to address potential VI under the interim remedial action:

- Mitigate potential vapor intrusion in buildings overlying the targeted groundwater treatment area as well as an additional buffer area extending beyond the downgradient end of the targeted treatment area.

As the RAO is to preemptively address potential VI within a predetermined area, PRGs were calculated only for the purpose of confirmatory sampling to demonstrate that the IA is effective at structures where it is implemented. Indoor air risk-based remediation goals were calculated using the inhalation equations for the RSLs (EPA 2014) and the exposure parameters listed in Table 4s of the HHRA (SulTRAC 2015). The following PRGs will be used to confirm the effectiveness of the IA:

Residential Buildings[1]	**Residential Indoor Air PRG**
Tetrachloroethene	11
Trichloroethene	0.48
Industrial/Commercial Buildings[2]	**Industrial/Commercial Indoor Air PRG**
Tetrachloroethene	47
Trichloroethene	3

Notes:

PRG – Preliminary remediation goals

[1] Residential indoor air and sub-slab PRGs are based on selecting the lower of the PRGs based on a target risk (TR) of 1.0E-06 and a target hazard quotient (THQ) of 1.

[2] Industrial/commercial indoor air and sub-slab PRGs are based on selecting the lower of the PRGs based a TR of 1.0E-06 and a THQ of 1.

Concentrations are presented in units of micrograms per cubic meter (µg/m^3).

2.2 ARARS

The following sections present an overview of ARARs and identify potential ARARs and other chemical-, action-, and location-specific criteria, advisories, guidance, and proposed standards to be considered (TBC).

2.2.1 Overview of ARARs

Under Section 121(d)(2)(a) of CERCLA, on-site remedial actions must attain a level or standard of control that achieves any standard, requirement, criterion, or limitation under any federal environmental law determined to be legally applicable or relevant and appropriate, including, but not limited to, the RCRA; the Toxic Substances Control Act (TSCA); the SDWA; the Clean Air Act (CAA); the Clean Water Act (CWA); the Marine Protection, Research, and Sanctuaries Act; and the Solid Waste Disposal Act.

CERCLA also requires remedial actions to achieve a level or standard of control that attains any promulgated standard, requirement, criterion, or limitation under a state environmental or facility citing

law that is more stringent than any federal standard, requirement, criterion, or limitation and is legally applicable or relevant and appropriate.

Section 121(d)(4) of CERCLA provides for waivers of ARARs under the following six types of circumstances:

- When the remedial action is an interim measure
- When the final remedy will attain the ARAR when it is completed
- When compliance with an ARAR will result in a greater risk to human health and the environment than other options
- When compliance with an ARAR is technically impractical from an engineering perspective
- When an alternative remedial action will attain the equivalent standard of performance of the ARAR
- When the ARAR is a state requirement that the state has not consistently applied (or when the state has demonstrated the intent to apply consistently in similar circumstances). For CERCLA Section 104 Superfund-financed remedial actions, when compliance with the ARAR will not provide a balance between protecting human health and the environment and Superfund money that is available for response actions at other sites.

CERCLA Section 121(e) states that no federal, state, or local permit will be required for any portion of any remedial action conducted entirely on site. "On site" is defined as the areal extent of contamination and all suitable areas in close proximity to the contamination necessary for implementation of the response action. This exemption applies only to the administrative requirements of the permit. On-site actions must still comply with the substantive requirements that permits enforce. Substantive requirements pertain directly to actions or conditions in the environment. Health- or risk-based restrictions such as MCLs, technology-based requirements such as incinerator standards, and location restrictions such as those that apply to wetlands are examples of substantive requirements.

Administrative requirements are mechanisms that facilitate implementation of the substantive requirements of a statute or regulation. Examples of these requirements include approving and issuing permits as well as reporting and recordkeeping.

The NCP identifies two categories of remedial action requirements: ARARs and TBCs (EPA 1990). An ARAR can be either applicable or relevant and appropriate to a remedial action. Applicable requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law. These requirements specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site.

Relevant and appropriate requirements consist of cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that are not applicable to circumstances at a site but that do address problems or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site.

TBCs consist of other federal and state criteria, advisories, guidance, and proposed standards that are not legally binding but that may provide useful information or recommended procedures. For example, a TBC can be used to set cleanup levels when no ARAR exists for a specific situation or when an existing ARAR does not ensure protectiveness. TBCs generally fall within the following four categories:

- Health effects information
- Technical information
- Policy requirements
- Proposed rules and regulations.

Federal and state ARARs for the ETCA site are listed in Appendix D. This list has been developed and refined based on input from EPA and Ohio EPA in 2014. Table D-1 summarizes the federal ARARs for the ETCA site. Table D-2 provides the State of Ohio ARARs.

The ARARs are divided into the following three categories, as defined in EPA's RI/FS guidance (EPA 1988):

- Chemical-specific requirements
- Action-specific requirements
- Location-specific requirements.

Chemical-specific ARARs are usually health- or risk-based requirements, often expressed as numerical values that, when applied to site-specific conditions, establish the acceptable amount of a chemical that can be detected in or discharged to the ambient environment. Action-specific ARARs are usually technology- or activity-based requirements triggered by the remedial activities selected to accomplish a remedy, such as capping, air stripping, or other remedies. Location-specific ARARs are requirements that place restrictions on either the concentrations of hazardous substances or on the conduct of activities solely because activities are in specific locations (such as wetlands, floodplains, historic places, and other locations).

Chemical-, action-, and location-specific ARARs and TBCs are discussed individually below.

2.2.2 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs include federal and state requirements that regulate contaminant levels in various media. TBCs include proposed regulations and policy or guidance documents. ARARs and TBCs are important in developing remedial objectives that comply with regulatory requirements or guidance (as appropriate). Summaries of potential chemical-specific ARARs for soil, groundwater, and vapor intrusion are presented in Appendix D.

2.2.3 Action-Specific ARARs

Action-specific ARARs consist of regulatory requirements that define acceptable treatment and disposal procedures. The potential action-specific ARARs for soil, groundwater, and vapor intrusion are summarized in Appendix D.

2.2.4 Location-Specific ARARs

Location-specific ARARs consist of requirements for contaminant concentrations or remedial activities resulting from a site's physical location. For example, federal and state ARARs exist for sites where remedial activities would affect wetlands, flood plains, critical habitats, wilderness areas, fault zones, or areas of historic or significant artifacts. These ARARs are summarized in Appendix D.

2.3 AREAS AND VOLUMES THAT REQUIRE REMEDIATION

This section discusses the areas and volumes of soil and groundwater that will be addressed by the IA. Areas and volumes for soil and the VOC plumes in groundwater are based on data collected during the RI and the results of the risk assessment. Soil volumes include vadose zone soils in EA-1 (and possibly a part of EA-2) and EA-6. Groundwater volumes that will be addressed by the IA include Zones A through D of the Residential Area PCE plume. The area of the RAO for VI includes structures above Zones A through D plus those above the "buffer zone" extending from Union to Frank Street. Buildings in some areas adjacent to the lateral edges of the treatment zones will also be included in the IA based on detections of PCE in groundwater during the RI and/or VI sampling completed by EPA in 2006-2007. These include several structures on the north side of East Main Street between South Walnut and South Mulberry Streets and between Counts and Frank Streets. A general discussion regarding VI is provided in Section 2.1.3 however, specific area and volume estimates are not applicable as the RAO is based on preemptive abatement at the point of potential exposure (within structures), rather than remediation of all of the contaminated medium (soil vapor) in the targeted area.

If future monitoring indicates that other areas of soil, groundwater, or vapor contamination not included in this FFS warrant remediation, those areas will be addressed in the final remedy for the site.

2.3.1 Soil

The surface area of the soil to be remediated was estimated based on information presented in the RI (SulTRAC 2015). During the RI, soil borings were advanced and soil samples were collected at multiple depths at each location. Analytical results were used in the RI and risk assessment to evaluate the extent of soil contamination and site-related risks. This information was used to develop RAOs and PRGs discussed in Section 2.1.1.

The EAs and depth assumptions for soil exceeding the PRGs for the Hobart and Spinnaker properties are illustrated in Figure 2-1. RI results indicated that the Hobart area of contaminated soil (HI>1) is approximately 12,150 square feet. Only soils in EA-1 exceeded a HI of 1. The noncancer HI for TCE in Area 2 was less than 1 and soils were below the threshold warranting action. However, a soil sample from a portion of EA-2 adjoining EA-1 contained TCE at concentrations that exceed the proposed PRG for protection of groundwater (see Figure 1-6). For this reason, the area and volume estimates for the soil IA include a portion of the EA-2 soil. It should be noted that during the RI, soil samples were analyzed from multiple depths, and the soil samples contained concentrations of contaminants exceeding the RAOs to the base of the borings. Thus, based on the assumption that groundwater is present at a depth of approximately 15 feet bgs, the volume of unsaturated soil that exceeded RAOs at the Hobart site was 9,111 cubic yards.

Based on the findings from the RI, some borings at the Spinnaker site indicated the total depth of soil contamination was variable on the Spinnaker property. EA-6 was therefore further subdivided to estimate the total volume of soil exceeding RAOs. The total depth of contaminants exceeding RAOs was assumed to extend 2 feet below the depth interval where a SL was exceeded, when data were not available for an interval below.

The following table summarizes the areas and volumes of soil at Spinnaker EA-6 that are identified as exceeding RAOs:

Exposure Area	Subarea	Area (square feet)	Depth (feet)	Volume (cubic yards)
Area 6	SB-301	170	10	64
	SB-303	305	8	90
	SB300/302/304	2,700	6	600
TOTAL		3,175	varies	754

Based on the estimated volumes of soil that exceed PRGs at the Hobart and Spinnaker properties, a total of 9,865 cubic yards of soil would require remediation to meet the RAOs for this IA. (Note – this volume value does not include bulking or compaction factors that would influence disposal or backfill volumes; however, such factors are assumed where applicable in the volume and cost estimates disucssed in Sections 4-7 and presented in Appendix C).

2.3.1 Groundwater

The horizontal extent of groundwater contamination is shown on Figure 1-11. The approximate area subject to the groundwater IA is shown on Figure 1-16 and Figure 5-4. The information presented on these figures is derived from the RI (SulTRAC 2015).

The "Residential Area plume" refers to groundwater in the Residential Area containing VOCs exceeding EPA RSLs. This area extends from just west of South Walnut Street, southeastward to the vicinity of Floral Avenue. The water table in this area is 12 to 19 feet bgs (RI Figure 3-2 [SulTRAC 2015]). The plume is approximately 4,000 feet long and 250 to 800 feet wide. Near the source area at Walnut Street, the plume extends to approximately 80 to 100 feet bgs, with the highest concentrations of VOCs present in a zone that lies between approximately 40 and 60 feet bgs.

As the plume moves downgradient it recedes to a shallower maximum depth of approximately 50 feet bgs at Clay Street, approximately 700 feet downgradient. Downgradient of Clay Street, the bottom of the plume lies between 40 and 50 feet bgs (RI Appendix K [SulTRAC 2015]). As such, the plume is generally approximately 30 feet thick, except in the vicinity of the source area where it is approximately 60 feet thick. The plume occupies an area of approximately 54 acres and a pore volume of approximately169 million gallons (assuming soil porosity is 0.3). The bulk volume of saturated soil within the plume boundary is estimated as approximately 2.8 million cubic yards.

For purposes of the IA, RAOs based on 70 to 90 percent dissolved phase mass reduction have been established for four "Treatment" Zones (A to D). Zone A includes the source area and immediate downgradient area (extending to Mulberry Street). PCE concentrations within the range of approximately 1,000 to 3,560 µg/L were detected in Zone A. Zones B, C, and D where contamination has migrated, lie downgradient between Mulberry and Union Streets. Maximum VOC concentrations in Zones B, C, and D gradually decrease from upgradient to downgradient, from a maximum of approximately 800 µg /L at Clay Street to approximately 400 µg /L at Union Street. The IA will treat groundwater in these zones. Because the RAO focuses on dissolved-phase contaminant mass removal, preliminary estimates of the dissolved mass of chlorinated VOCs for Zone A, and for the entire interim action treatment area (Zones A through D) have been completed. A summary of the estimated dissolved mass and the residual dissolved mass after treatment (assuming 70 to 90 percent removal) is presented below and the calculations are presented in Appendix B. The estimates in Appendix B are based on volumetric estimates of the amount of total chlorinated VOCs in the targeted treatment areas and consider (1) the general geometry and dimensions of the plume (which vary along its length and vary with depth within each "zone"); (2) the RI data regarding VOC concentrations in each area and horizon; and, (3) hydrogeologic factors (saturated thickness, total porosity, and effective porosity). Additional details regarding the specific assumptions and values used to estimate the dissolved phase VOC mass are presented in Appendix B.

Zone A:

- Estimated to contain approximately 58 pounds of total chlorinated VOCs in dissolved phase
- A goal of 70-90 percent reduction leaves approximately 5.8 pounds (minimum) to 17.5 pounds (maximum) of total chlorinated VOCs

Zones A through D total:

- Estimated to contain approximately 109 pounds of total chlorinated VOCs in dissolved phase
- A goal of 70 to 90 percent reduction leaves approximately 10.9 pounds (minimum) to a maximum of 32.8 pounds of total chlorinated VOCs.

2.3.2 Vapor Intrusion

As previously discussed, the IA for VI will preemptively address potential VI exposure within a predetermined area. For this reason, no estimates of the area or volume of contaminated media are necessary. The area of potential concern for VI to be addressed by the IA includes the proposed groundwater treatment area (see Figure 1-16) and a buffer zone extending from Union to Frank Street (See Figure 5-8) that also includes some areas adjacent to the lateral edges of the treatment zones. The area includes most of the area in which the risk assessment indicated that VI hazard indices exceeded 1 for current or future residents or workers.

The areas potentially affected by VI at the ETCA site have been identified based on historical information and information defined during the RI (SulTRAC 2015). Sub-slab and indoor air samples were collected at numerous locations during the RI. The locations sampled were intended to provide overall spatial coverage across the plumes and were also influenced by residents or property owners who granted or denied access. Based on the results, it appeared that VI may be an issue for current or future residents in buildings overlying the upgradient portion of the Residential Area plume. Uncertainty exists with respect to estimating the number of buildings that may require VI mitigation systems for the following reasons:

- Every building overlying the plumes was not sampled
- Temporal changes in groundwater and soil vapor concentrations may result in VI at certain times and not at others
- Preferential migration pathways (either as a result of soil conditions or cracks and openings to the structures themselves) may contribute to VI at some locations and not at others
- Differences exist in building construction details (size, slab vs. basement, and ventilation design)

The RAO for VI addresses those locations overlying the proposed groundwater treatment zones (A through D) and an additional "buffer" zone extending downgradient to Frank Street. The total estimated number of occupied buildings (either residential or commercial) encompassed in this area is approximately 156, including a contingency allowing for currently unidentified locations such as multi-tenant/multi-structure properties, permanently occupied guest houses, or garages. EPA is proposing VI mitigation at all occupied structures above the groundwater treatment areas and downgradient buffer zone. Therefore, this FFS assumes that 156 buildings (128 residential and 28 commercial) will be addressed by the vapor intrusion mitigation component of the IA.

3.0 GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES, AND PROCESS OPTIONS

General response actions (GRAs) are broad categories of actions to be taken at a site, such as containment, institutional actions, collection, treatment, discharge, or a combination of these actions. Several technology types and specific process options exist under each GRA. GRAs satisfy the RAOs discussed in Sections 2.1.1, 2.1.2, and 2.1.3. Separate GRAs for the ETCA site have been developed for soil, groundwater, and VI issues associated with the contaminant plume in groundwater. The GRAs are intended to achieve the interim action RAOs for soil, groundwater, and VI that are specified in Section 2.1. GRAs, remedial technologies, and process options identified for soil, groundwater, and VI are summarized in Figures 3-1 through 3-3 and are discussed below.

3.1 GRAS, TECHNOLOGY TYPES, AND PROCESS OPTIONS FOR SOIL

GRAs have been developed for soil at the ETCA site. According to EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (EPA 1988), the categories of GRAs for soil include no action, land use controls, containment, source removal, in situ treatment, ex situ treatment, and disposal. Remedial technologies and process options for soil are described in Figure 3-1. Each GRA and the associated process options that apply to the ETCA site are discussed below.

Under the IA, two separate areas of soil contamination are to be addressed. These areas are identified as (1) soil near the loading dock area of the Hobart Brothers property, and (2) soil at the west end of the Spinnaker industrial facility.

3.1.1 No Action

The no action GRA will be carried forward in the screening evaluation to provide a baseline that represents current site conditions, as required by the NCP.

3.1.2 Land Use Controls

Land use controls include institutional controls and engineering controls (EPA 2012). Institutional controls are non-engineered instruments, such as administrative and legal controls, that help minimize the potential for exposure to contamination or protect the integrity of a response action. For the ETCA, institutional controls could include administrative constraints on potential land use to limit direct contact of potential receptors with soil over the long term. Engineering controls include actions such as adding a fence to restrict access and posting signs to deter trespassing.

3.1.3 Containment

Containment of soil may include installation of a soil cover or engineered cap to prevent direct contact of potential receptors with contaminated soil and also reduce infiltration of precipitation and leaching of contaminants to the groundwater. This cap could be installed over contaminated soil that exceeds the PRGs for the project.

3.1.4 Source Removal

The remedial technology selected for source removal would be excavation. Under excavation, contaminated soil would be removed to eliminate potential exposure of receptors through: (1) direct contact with and ingestion of soil, and (2) contaminants leaching to the groundwater and groundwater ingestion. Soil excavated from the ETCA site could be treated on site or disposed of off site at appropriate disposal facilities once land disposal requirements are met.

3.1.5 In Situ Treatment

Remedial technologies for in situ treatment of soil include biological and physical/chemical remediation technologies. Biological process options include enhanced bioremediation, natural attenuation, phytoremediation, and bioventing. Physical/chemical process options include soil flushing, chemical oxidation or reduction, solidification/stabilization, hot air injection, and soil vapor extraction (SVE).

3.1.6 Ex Situ Treatment

Remedial technologies for ex situ treatment of soil include biological, physical/chemical, and thermal remediation. Process options for biological remediation include biocells and landfarming. Physical/chemical process options include chemical oxidation or reduction and solidification/stabilization. Thermal remediation process options include rotary kiln incineration and low-temperature thermal desorption.

3.1.7 Disposal

Soil can be disposed of on or off site. On-site disposal would consist of creating an on-site landfill. Off-site disposal would occur at a licensed, regulated disposal facility.

3.2 GRAS, TECHNOLOGY TYPES, AND PROCESS OPTIONS FOR GROUNDWATER

This section presents potential groundwater GRAs at the ETCA site. Remedial technologies and process options under each of these GRAs are presented in Figure 3-2.

3.2.1 No Action

No action means that nothing would be done to address the existing groundwater contamination. The NCP requires evaluation of a no action alternative to provide a baseline that can be used to compare other remedial alternatives.

3.2.2 Land Use Controls

Land use controls include institutional controls and engineering controls (EPA 2012). Institutional controls (ICs) are primarily administrative and legal controls that minimize the potential for exposure to contamination by prohibiting (where possible) or discouraging certain actions. IC's for groundwater at the ETCA site would employ a legal or administrative action to prohibit installation of water wells at certain locations and depths to prevent exposure to contaminated groundwater. (As previously discussed, the City of Troy has existing ordinances that limit use of private potable supply wells in the city limits.) Engineering controls include actions such as fencing to restrict access and posting signs to deter trespassing. Engineering controls are typically not applicable to groundwater.

3.2.3 Monitoring

Monitoring is a GRA that simply provides information. The remedial alternatives herein include this GRA because every remedy must be monitored to gauge its performance and decide when the remedy has met its goals. Monitoring typically includes monitoring well installation, measurement of water levels, measurement of field parameters such as pH, groundwater sampling, and chemical analysis of water samples.

3.2.4 Containment

Containment is a GRA that isolates contamination to control its migration into the environment and limit exposure to receptors. Containment for groundwater might take the form of a physical barrier such as a wall or a hydraulic barrier that manipulates hydraulic gradients to control flow. For example, a slurry wall around a contaminant source might prevent ongoing pollution of groundwater, or strategically placed groundwater extraction wells could hydraulically contain a targeted portion of the plume.

3.2.5 In Situ Treatment

In situ treatment refers to actions that remove groundwater contaminants or destroy them in place without extracting groundwater from the formation. In situ treatment may employ technologies that treat groundwater using physical, chemical, or biological processes. Technologies under this GRA include sparging, bioremediation, and chemical oxidation, and chemical reduction.

3.2.6 Removal

Removal refers to bulk removal of contaminated groundwater so that it can be processed aboveground. This GRA may employ technologies such as pumping to extract groundwater from vertical wells or from horizontal pipes laid in trenches. Removal is typically combined with ex situ treatment and disposal.

3.2.7 Ex Situ Treatment

Ex situ treatment refers to actions that remove or destroy contaminants in groundwater that has been extracted from the formation. This GRA includes technologies such as air stripping, carbon adsorption, and advanced oxidation.

3.2.8 Disposal

Disposal refers to actions that manage process water. For instance, extracted groundwater, once treated, could be managed by discharging it to surface water, groundwater, or to a publicly owned treatment works (POTW).

3.3 GRAS, TECHNOLOGY TYPES, AND PROCESS OPTIONS FOR VAPOR INTRUSION

GRAs have been developed for vapors in buildings at or near the ETCA site. Based on information presented in the RI report and HHRA, unacceptable risks associated with the VI pathway may exist. Therefore, remedial technologies are considered to meet the RAOs established in Section 2.1.3. Remedial technologies and process options identified for VI are shown in Figure 3-3. Each GRA and the associated process options that apply to the ETCA site are discussed below.

3.3.1 No Action

The no action GRA will be carried forward in the screening evaluation as a baseline that represents current site conditions, as required by the NCP.

3.3.2 Land Use Controls

Land use controls include institutional controls and engineering controls (EPA 2012). Institutional controls are site access restrictions, administrative constraints, or zoning requirements on potential land use to limit direct contact of potential receptors over the long term. Institutional controls would most likely apply to future construction, if deemed necessary. Engineering controls include actions such as adding a fence to restrict access and posting signs to deter trespassing or entering basements or crawl spaces.

3.3.3 Monitoring

VI monitoring would include creating a site-specific sampling plan, installing soil vapor probes (exterior soil gas probes or sub-slab soil vapor probes), and performing periodic sampling. Sampling would likely consist of soil gas, sub-slab vapor, and indoor air sample collection. VI monitoring would be conducted for two primary reasons. First, it may be used to evaluate VOC concentrations over an extended time period and to assess where vapor mitigation actions may be necessary. Second, it may also be used to evaluate whether vapor concentrations were decreasing as a result of other remediation actions at the site or whether additional action is needed to address the VI pathway.

3.3.4 Containment

Containment of vapors may include implementation of passive barriers (such as sheet barriers, poured and cured-in-place barriers, and general sealing of structures), passive venting, active building depressurization systems (such as sub-slab depressurization [SSD], crawlspace depressurization, block-wall depressurization, or sub-slab ventilation systems), or active building pressurization systems (such as heating, ventilation, and air conditioning [HVAC] and sub-slab pressurization systems). These various options are specific to either new construction or existing structures. If applied to new construction, barriers would be incorporated during building construction. Alternatively, existing structures would be retrofitted to prevent or reroute vapors from entering the building. Containment options would be used at locations where VOC concentrations were consistently elevated within the sub-slab or indoor air of an existing building and posed a clear threat to indoor inhabitants or workers. They would also be used if new construction was to occur over the footprint or in close proximity to the plume of VOCs in groundwater. In each of these remedial options, soil vapor would be diverted from entering the building.

3.3.5 Treatment

A SVE system would be used to extract soil vapors from the vadose zone. SVE could be conducted adjacent to existing building to collect and remove soil vapors before they could migrate inside the structure. The number of SVE points would be selected based on the assumed or demonstrated radius of influence (ROI) of the SVE system. The vapors collected would be released directly to the atmosphere or treated, depending on analytical results for the vapor and air emission requirements. Granular activated carbon is typically used to treat SVE emissions, when necessary.

Treatment of contaminated vapors may also be effective to address vapors within a building (carbon sorption and photocatalytic oxidation). Vapors within the building may be treated using carbon adsorption and photocatalytic oxidation (ultraviolet light) on a room-by-room basis. In each of these remedial options, soil vapor would be extracted and treated to eliminate the threat to human health.

4.0 SCREENING OF REMEDIAL TECHNOLOGY TYPES AND PROCESS OPTIONS

This section identifies remedial technology types and specific process options that are potentially implementable for the IA at the ETCA site. These process options are evaluated for overall effectiveness, implementability, and cost.

The effectiveness of each process option was evaluated against other options within the same technology type in accordance with Title 40 Code of Federal Regulations (CFR) Part 300.430(e)(7)(i). The evaluation focused on the following factors:

- Potential effectiveness of a process option for soil, contaminated groundwater, and VI in meeting the RAOs
- Potential impact on human health and the environment during implementation of a process option
- Reliability and performance of a process option over time, considering conditions at the ETCA site

The implementability evaluation considered both the technical and the institutional feasibility of implementing each remedial technology type and process option at the ETCA site. Institutional aspects considered in the detailed evaluation included permit requirements, available treatment capacity at off-site facilities, available equipment, available on-site space, and skilled labor requirements. Some remedial technology types are proven and readily available, but others are in the research and development stages. Insufficiently developed remedial technology types are generally screened out in accordance with 40 CFR 300.430 (e)(7)(ii).

Each process option was evaluated to assess whether its cost was high, low, or comparable with other process options for the same remedial technology type, in accordance with 40 CFR 300.430 (e)(7)(iii). At this stage of the evaluation, cost was considered one of the least important criteria, when compared to the technical and institutional aspects of the process options. The screening evaluated relative capital and operation and maintenance (O&M) costs instead of detailed estimates.

The factors that primarily influenced the initial screening included (1) areas and volumes of impacted soil; (2) the types of contaminants present in soil and groundwater; (3) the extensive nature of the groundwater plume; and (4) the representative process options chosen for each technology for evaluation and the use of similar process options, if deemed necessary. Finally, potential future land uses and selection of process options compatible with these land uses were considered as well as the degree in which the IA is expected to be consistent with any final long-term remedial actions taken. The screening process options for soil, groundwater, and VI are discussed below, followed by a summary of process

options retained for alternative development. Remedial technology types and process options that are not considered suitable for implementation of the IA at the ETCA site were eliminated from further consideration based on information obtained during the RI.

4.1 TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL

The GRAs, remedial technologies, and process options for soil are identified in Figure 3-1. Figure 4-1 summarizes the screening of each process option for effectiveness, implementability, and cost. The process options retained for further consideration are identified in Figure 4-1. Process options associated with each GRA for soil are discussed below.

4.1.1 No Action

Under the no action GRA, no remedial action would be carried out at the site; therefore, a process option is not applicable for this GRA. Initial conditions would be the same as those described in the RI report (SulTRAC 2015). Only natural processes would act to reduce contaminant concentrations; however, this potential reduction would not be monitored or documented.

Under the current and future land-use scenario, contaminants in soil pose an unacceptable risk in certain EAs. Therefore, this option would not be effective in achieving the RAOs for soil. Nothing would be implemented under this option; therefore, no capital or O&M costs are associated with it.

This option is retained for further consideration because the NCP requires that the no action GRA be used as a reference for evaluating the performance of other remedial action alternatives developed for a CERCLA site such as the ETCA site.

4.1.2 Land Use Controls

Land use controls include ICs and engineering controls.

Restricting the disturbance of the contaminated soil (including its excavation or removal) through ICs can reduce the risks associated with direct contact with or ingestion of contaminated soils. Temporary or permanent ICs may alsobe implemented to ensure the effectiveness of other process options, such as capping. ICs are low-cost and easy to implement. ICs are discussed below; they would be applicable if an alternative is selected that does not include removing the contaminated soil. ICs may include:

- ***Proprietary controls*** - generally created pursuant to state and tribal law to prohibit activities that may compromise the effectiveness of the response action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment. The most common examples of proprietary controls are easements and covenants. Many states, including Ohio, have enacted statutes addressing the implementation and long-term effectiveness of proprietary controls. One model that has been developed is the Uniform Environmental Covenants Act (UECA), which can be adopted as-is or in modified form by states to provide advantages over traditional common law proprietary controls (EPA 2012).

- ***Governmental controls*** that impose restrictions on land use or resource use, using the authority of a government entity (EPA 2012). Typical examples of governmental controls that could apply to the ETCA site include zoning and building codes; state or local regulations; and other land-use limits posed by federal, state, or local resources or public health agencies.

- ***Enforcement and permit tools*** - legal tools, such as administrative orders, permits, Federal Facility Agreements (FFAs) and Consent Decrees (CDs), that limit certain site activities or require the performance of specific activities (for example, to monitor and report on the effectiveness of an IC). They may be issued unilaterally or negotiated (EPA 2012).

- ***Informational devices*** that provide notification to local communities that residual (or contained) contamination remains on site. Typical informational devices include state registries of contaminated sites, notices in deeds, tracking systems, and special advisories (EPA 2012).

Temporary or permanent engineering controls ensure the effectiveness of other process options, such as capping or SVE. Engineering controls typically consist of erecting fencing to prohibit or restrict access and posting warning signs to deter trespassing. Engineering controls are low-cost and easy to implement. However, it is anticipated that ICs will sufficiently control future land use considerations associated with the soil IA and thus engineering controls are not applicable for this site; for this reason engineering controls are not retained for further consideration.

4.1.3 Containment

Containment would consist of capping soil in place. Two capping options are discussed below.

4.1.3.1 Clay or Soil Cap

A low-permeability, compacted layer of clay with a layer of clean soil may be effective in reducing infiltration, and a soil cap would be effective at preventing direct contact with or ingestion of soils. This process option has moderate capital and O&M costs. Installation of a clay or soil cap would be easy to implement. However, this type of cap would not be suitable due to the vehicle parking or traffic on the Hobart property in EA-1, and in EA-6 on the Spinnaker property and would leave contaminated soil and a cap in place that could interfere with future land use scenarios. Although infiltration would be reduced, residual soil contamination would remain in place that could contact the water table as it fluctuates and

possibly continue to leach contaminants to groundwater. If capping were to be implemented in EA-1 or EA-6 during the IA, asphalt or concrete caps could be equally effective at meeting RAOs and be more suitable given the current and most likely anticipated future land use scenarios. For these reasons, clay or soil caps are not retained for further consideration.

4.1.3.2 Asphalt or Concrete Cap

An asphalt or concrete cap consists of a barrier layer to eliminate direct contact with soil at the site. The asphalt or concrete cap would minimize infiltration of precipitation into the contaminated soil and would be constructed to promote drainage away from the site. An asphalt or concrete cap would be easily implementable and effective in eliminating the potential for direct contact of contaminated soil and would also reduce the potential leaching of contaminants present in the soil to the groundwater. If an asphalt cap were deemed appropriate, it would be required to comply with the requirements in "Asphalt Covers to Prevent Leaching at Industrial Sites, August 18, 2003," and will include liners and drainage layer materials (Ohio EPA 2003). The asphalt or concrete cap would also require ICs to maintain its integrity. Capping would leave contaminated soil, as well as a permanent cap in place that would impact future land use scenarios. However, asphalt or concrete caps can be incorporated into the design of hard-surfaced features such as parking lots, garage areas or access driveways that would potentially support a wide range of land uses on areas adjacent to the cap. Water table fluctuations beneath a capped area could potentially continue to leach vadose zone contaminants to groundwater. Based on these considerations, asphalt or concrete caps are retained for further evaluation for soil area EA-6, but not for EA-1 where existing soil contamination was found to extend to the water table.

4.1.4 Source Removal (Excavation)

Excavation is a common remedial activity. Typical excavation equipment, such as excavators, bulldozers, trucks, and backhoes would be used; this equipment is readily available. Excavated material would either be loaded onto trucks and hauled off site to an approved landfill or treated and disposed of off site. A consideration associated with the source removal option, however, includes health risks to the remediation crew and surrounding population. Excavation would disturb soil, and dust suppressants or wind barriers may be necessary if soil is dry and soil particles or contaminant vapors become airborne. Excavation is highly implementable and effective. Cost depends on the volume and depth of soil to be removed. New backfill would be imported from off-site sources, and would be placed in the excavated area. In general, excavation has high capital and no O&M costs. It is a permanent remedy; and would minimize or eliminate the need for institutional controls with regard to the soil in the excavation areas and thus ensure flexibility for a variety of potential future land use scenarios. It would eliminate soil

contamination that could potentially remain as an ongoing source of groundwater contamination under containment scenarios. Excavation of contaminated soil is retained for further consideration.

4.1.5 In Situ Treatment

The in situ process options associated with soil treatment are divided into the following categories: (1) biological treatment, including enhanced bioremediation, phytoremediation and bioventing; (2) natural attenuation and (3) physical and chemical remediation, including soil flushing, chemical oxidation or reduction, solidification/ stabilization, hot air injection, and soil vapor extraction. Each of these process options is discussed below.

4.1.5.1 Enhanced Bioremediation or Bioventing

Enhanced bioremediation or bioventing stimulates the natural in situ biodegradation of organic contaminants or the immobilization of inorganic contaminants in soil by providing nutrients such as nitrogen and phosphorous, oxygen, or other amendments to existing microorganisms. Enhanced bioremediation typically involves percolation or injection of uncontaminated water that is mixed with nutrients and saturated with dissolved oxygen. In some applications, acclimated microorganisms or an alternative oxygen source such as hydrogen peroxide are also added. Bioventing uses low air flow rates to provide oxygen to sustain microbial activity. Oxygen is typically supplied through direct air injection into the contaminated soil. An infiltration gallery or spray irrigation system is normally used to deliver the nutrients and oxygen to shallow contaminated soil; injection wells are used for deeper contaminated soil.

Enhanced bioremediation and bioventing have each been used successfully to remediate soil contaminated with a variety of VOCs and SVOCs. Bioremediation has also been experimentally used to change the oxidation state of inorganic contaminants such as metals and cause them to adsorb, immobilize, or precipitate onto soil particles. Anaerobic bioremediation has been used on soil contaminated with chlorinated solvents.

Factors present at the ETCA site that limit the applicability and effectiveness of enhanced bioremediation or bioventing include a high water table, saturated lenses, low-permeability soil, and low ambient air temperatures. In addition, the circulation of water-based solutions through soil can increase contaminant mobility and leaching of contaminants into groundwater. Treatability studies would be necessary to evaluate whether enhanced bioremediation is feasible. According to the EPA's presumptive remedy guidance, in situ bioremediation or bioventing can require several years to achieve remediation goals. In

addition, in situ bioremediation or bioventing may not be effective for the treatment of high levels of chlorinated hydrocarbons in soil or for treatment of lead in soil. Enhanced bioremediation or bioventing of soil has moderate capital and low O&M costs. It is not retained for further consideration because enhanced bioremediation or bioventing would likely require performance or treatability studies, may contaminate groundwater, and is not as effective as other potential options at treating chlorinated hydrocarbons found at the ETCA site.

4.1.5.2 Natural Attenuation

Natural attenuation is effective in treating soil that contains organic contaminants. Natural attenuation (1) is nonintrusive, thereby allowing continued use of the site; (2) has less potential for releasing contaminants during remediation; and (3) does not involve concerns related to site accessibility or equipment limitations. The applicability of natural attenuation for addressing contamination in soil at the ETCA site would depend on the concentrations, mass, and toxicities of contaminants present and on factors that affect the mobility and degradation of contaminants. Evaluation of the applicability of natural attenuation involves assessment of contaminant characteristics (such as concentration, degradability, mobility, and toxicity) as well as site-specific characteristics (such as geology, soil, and microbiology factors). Natural attenuation would not involve installation of any equipment; therefore, it is extremely easy to implement.

No capital and low O&M costs are associated with natural attenuation; therefore, the costs for implementing natural attenuation are negligible compared with other process options. The only cost is associated with monitoring, which would be necessary to evaluate the effectiveness of natural attenuation. Natural attenuation is not retained for further analysis because the concentrations of chlorinated VOCs in soil are such that they would continue to contaminate groundwater if not removed, contained, or treated.

4.1.5.3 Soil Flushing

Soil flushing uses water or other aqueous solutions to extract contaminants from soil. Soil flushing is accomplished by passing the extraction liquid through in-place soil using an injection process. The extraction liquid must be recovered from the underlying aquifer and, when possible, recycled. Soil flushing is effective for removal of inorganics, such as lead, and VOCs. The aboveground treatment cost for the recovered fluids can be very high, resulting in high capital and moderate O&M costs. It is also difficult to contain the flushed contaminants and the soil flushing fluids. Therefore, this process option is not retained for further consideration.

4.1.5.4 Chemical Oxidation or Reduction

Oxidating, or reducing compounds, degrades organic compounds in soil. Reducing compounds also can be used to immobilize metal compounds in soil. Reactive oxidation or reduction compounds can be mixed with contaminated soil using injection wells or mixing augers to break down the contaminants. Variables to consider regarding the successful application of this alternative include depth of contamination, soil porosity and permeability, reaction time, surface area, natural soil oxidant demand, and oxidant or reductant dosage. In addition, the chemical oxidants or reductants may have a negative effect on underground utilities. Because the treatment chemicals would be injected into unsaturated soil, the radius of influence is very small, requiring large amounts of injection points in close proximity to each other. This process option has moderate capital and low O&M costs. Because of the need for a large amount of injections at close spacing, chemical oxidation or reduction is not retained for further consideration for soil treatment.

4.1.5.5 Solidification/Stabilization

In situ solidification/stabilization (immobilization) involves mixing a solidifying agent with contaminated soil to produce a monolithic, solidified matrix or a stabilizing agent to reduce leaching and mobility of contaminants. Contaminated soil would be left in place and mixed with treatment reagents to decrease the mobility of the contaminants. The structural integrity of the solidified soil is higher than that of the original soil. Some solidification/stabilization processes double the volume of contaminated soil, which may lead to off-site disposal of the excess soil volume. Solidification/stabilization is typically most effective on metals contamination and less effective on chlorinated hydrocarbons, which are present in the ETCA site soil. Solidification/stabilization has high capital and low O&M costs. This process option is not retained for further consideration.

4.1.5.6 Hot Air Injection

Hot air injection enhances the volatilization of VOCs from subsurface soil by injecting hot air below the contaminated zone using injection wells or mixing augers. The volatilized contaminants are typically removed by SVE extraction wells. Factors that limit the applicability and effectiveness of hot air injection include high water table, low-permeability and high-organic content soil, low heat capacity of air, and high energy losses in the air delivery piping system. Hot air injection has moderate capital and O&M costs. Because hot air injection merely enhances VOC volatilization from soil, it must be coupled with SVE to capture the contaminant vapor stream. Hot air injection is not effective for metals in soil. Because of the potential migration of the vapor stream in residential areas, it is not retained for further consideration.

4.1.5.7 Soil Vapor Extraction

SVE involves installation of extraction wells and connection to a vacuum blower to extract the soil vapors from the unsaturated zone. The extracted soil vapor would be captured and vented to the atmosphere. The vented off-gas may require treatment prior to discharge to the atmosphere. SVE has moderate capital and O&M costs. Factors that limit the applicability and effectiveness of SVE include high water table, low-permeability and high-organic content soil. It is not anticipated that SVE alone will successfully achieve the leach-based site-specific PRGs required to meet the RAOs for soil. Also, the soils in the vadose zones at Hobart and Spinnaker contain clayey zones mixed with sand and gravel within the fill, which may further limit the effectiveness of SVE. For these reasons, SVE is not retained for further consideration.

4.1.6 Ex Situ Treatment

The ex situ process options associated with soil treatment are divided into three categories: biological treatment (including biocells and landfarming); physical and chemical remediation (including chemical oxidation or reduction, solidification/stabilization); and thermal remediation (including incineration and low-temperature thermal desorption). Each of these process options is discussed below.

4.1.6.1 Biocells or Landfarming

Biocell treatment of contaminated soil involves mixing excavated soil with soil amendments and placing the mixture on a treatment area that includes a leachate collection system and some form of aeration, such as a blower. Landfarming is a full-scale bioremediation technology that places excavated contaminated soil on liners to control leaching of contaminants while the soil is turned over or tilled for aeration.

In biocell or landfarming treatment, the temperature of the treatment area increases as indigenous microorganisms within the amended soil mixture degrade the contaminants. The biocell's moisture, heat, oxygen, and pH levels can be adjusted, and nutrients such as ammonia-nitrogen and phosphorus can be added to enhance biodegradation. Leachate can be recirculated through a pile to maintain suitable moisture. The treatment areas can also be covered with plastic to control runoff, evaporation, and contaminant volatilization, and to promote solar heating. Oxygen levels in a biocell can be increased by blowing air through the biocell or through manual or mechanical mixing. Biocell or landfarming treatment typically requires a few weeks to a few months to achieve cleanup goals. Biocell or landfarming may create air pollution; dust control, vapor migration, and storm water control must be addressed.

The following factors limit the applicability and effectiveness of biocell or landfarming treatment; (1) treatment is less uniform in static areas than in periodically mixed areas, (2) treatability studies are required to identify contaminant biodegradability rates and appropriate oxygen and nutrient loading rates, and (3) the ability to treat chlorinated compounds in solid media is questionable.

Biocell or landfarming treatment has moderate capital and low to moderate O&M costs. Biocell or landfarming treatment is not retained for further consideration because (1) it would be difficult to implement given the site setting because a large area is needed for construction, (2) treatability studies are required to evaluate the technology's effectiveness, and (3) its low effectiveness for chlorinated VOCs.

4.1.6.2 Chemical Oxidation or Reduction

Ex situ chemical oxidation or reduction is similar to in situ chemical oxidation or reduction, except that the process would be conducted in a treatment cell rather than in situ. Contaminated soil would be excavated and transported to a treatment and disposal facility or to a treatment cell on site, where it would be mixed with oxidants or reductants in a large mixing area. After it has been mixed, treated soil would be tested to ensure the treated soil meets RAOs or federal land disposal restriction (LDR) requirements, to determine if the treated waste can be disposed of in a solid waste (Subtitle D) landfill in accordance with EPA requirements. Chemical oxidation is effective for treatment of chlorinated VOCs, and chemical reduction is effective for treatment of chlorinated VOCs and metals. If soil is treated ex situ on site, and the treated material meets RAOs, it can be backfilled into the excavation. If the soil is transported and treated off site, backfill material would be required for the excavation area. Ex situ chemical oxidation or reduction have high capital and low O&M costs. This treatment involves double handling of soil, as it must be excavated, treated, staged on site, and tested before it can be placed back in the excavated area. For these reasons, and also due to the limited space available at the ETCA sites, this alternative is not retained for further consideration.

4.1.6.3 Solidification/Stabilization

Ex situ stabilization/solidification (immobilization) is similar to in situ solidification/stabilization, except the process is conducted off site rather than on site. Contaminated soil would be excavated and transported to a treatment and disposal facility, where it would be mixed with fixation agents. After it has been mixed, treated soil would be transported to a secure curing area and segregated by waste code. When curing is complete and treated soil meets federal LDR requirements, the treated waste can be disposed of in a solid waste (Subtitle D) landfill in accordance with EPA requirements. This process may increase the original volume of contaminated soil up to two times. New backfill would be required to fill

the excavated area. Solidification/stabilization is most effective on metals. Off-site solidification/stabilization has high capital and no O&M costs. Therefore, this alternative is not retained for further consideration.

4.1.6.4 Thermal Treatment Processes

Two potential thermal treatment processes include: (1) incineration and (2) low-temperature thermal desorption. Each of these options is discussed below.

Incineration occurs in a stationary facility that can handle a larger throughput capacity and feed size, accept a greater range of wastes, and requires less time for remediation than a mobile system. Incineration is effective in treating soil contaminated with VOCs, but not for metals. This process option would require excavating and dewatering soil. The incinerator off gas requires treatment by an air pollution control (APC) system to remove particulates and to neutralize and remove acid gases. The technology may also produce three residual waste streams: solids from the incinerator and APC system, water from the APC system and air emissions from the APC system. This process option also has high capital and low O&M costs. Therefore, incineration is not retained for further consideration.

Low-temperature thermal desorption is a separation process used to remove VOCs, SVOCs, pesticides, and PCBs from a solid matrix. This technology is not effective for metals in soil. Contaminated soil would be heated in an indirectly-fired rotary kiln or dryer to temperatures of 572 to 932°F to volatilize organic compounds. The vapors would be routed to a gas handling system, where they would be scrubbed to remove particulate solids. The vapors would then be either cooled to condense the organic constituents or destroyed in a high-temperature afterburner. Thermal desorption creates off gases that would require capture and treatment. Thermal desorption has moderate capital and low O&M costs. Thermal desorption is not retained for further consideration.

4.1.7 Disposal

The two process options associated with soil disposal are discussed below.

4.1.7.1 On-site Landfill

Disposal of soil in an on-site landfill, while effective, would be difficult to implement because little land is available in the area for the landfill. In addition, the need for a large disposal area and long-term monitoring make this process option difficult to implement. On-site disposal has high capital and moderate O&M costs. On-site landfill disposal is not retained for further consideration.

4.1.7.2 Off-Site Licensed Disposal Facility

Soil disposal at an off-site licensed disposal facility, including a nonhazardous sanitary landfill or RCRA hazardous waste (Subtitle C) landfill, would require transport of contaminated soil excavated from the ETCA site to the disposal facility. The implementability of this process option depends on the permitting capabilities of the disposal facilities and on LDR requirements that limit certain hazardous wastes to be landfilled. The capital cost associated with this process option is high, depending on the amount of waste. No O&M cost is associated with this process option. Off-site disposal of contaminated soil at a licensed disposal facility is retained for further consideration.

4.1.8 Summary of Retained Options for Soil

The process options retained for soil are listed below.

Retained Soil Process Options
No action
Land Use Controls (ICs)
Asphalt or Concrete Caps
Excavation
Off-Site Disposal

Excavation and off-site disposal of soil would eliminate the contaminated soils in EA-1 and EA-6 and thus are anticipated to also eliminate the need for future restrictions on land use in those areas. However, if a capping scenario is employed for Area EA-6 in lieu of excavation, ICs would be necessary to ensure the integrity of the cap and the performance of the cap with regard to ensuring that RAOs are achieved. Therefore, ICs are retained for further evaluation.

Monitoring will be required for groundwater in the East Water Street plume area during implementation of the IA to monitor the impact of the soil/source area IA on site groundwater. However, monitoring of site groundwater is discussed in Section 4.2.3 below and not included as a retained process option for soil.

4.2 TECHNOLOGIES AND PROCESS OPTIONS FOR RESIDENTIAL AREA PCE PLUME GROUNDWATER

GRAs for groundwater include no action, institutional controls, monitoring, containment, removal, in situ treatment, ex situ treatment, and disposal. Technologies and process options for groundwater are identified in Figure 3-2. Applicable technologies and process options under each GRA are discussed below and evaluated for effectiveness, implementability and cost. This evaluation is summarized on Figure 4-2 which also shows which process options will be retained for further consideration during implementation of the IA.

4.2.1 No Action

As indicated previously, the no action GRA is carried forward as a baseline for comparison. There would be no activities or monitoring under this GRA. Furthermore, there are no technologies or process options under this GRA.

Contaminated groundwater at the ETCA site poses unacceptable risk to human health. No action would be taken to mitigate this risk. Although natural processes can reduce contamination over time, no action implies that this natural attenuation would not be monitored. With no way to gauge progress, no action would not ensure the protection of human health. Further, data from monitoring wells OEPA-6, OEPA-7 and OEPA-11 indicate that dissolved-phase concentrations of COCs in the proposed groundwater treatment area have remained relatively consistent over time since monitoring was initiated by Ohio EPA in the early 2000s. Therefore, no action would not be effective at the ETCA site. Nothing would be implemented under this option; therefore, no capital or O&M costs are associated with it.

The no action GRA is retained for comparison to other alternatives, as required by the NCP.

4.2.2 Institutional Controls

Land use controls would limit activities that could compromise a remedy or pose unacceptable risk to human health. IC, which are one type of LUC, would be appropriate at this site, and are discussed below. Engineering controls are not applicable to groundwater.

ICs include (1) proprietary controls, (2) governmental controls, (3) enforcement and permit tools, and (4) informational devices (EPA 2012). Remedies can take a long time to implement, and institutional controls help limit exposure to contaminated media until remediation goals are achieved. The different types of ICs were discussed in Section 4.1.2. All of these ICs are low cost, can be layered with other

institutional controls, and are easy to implement; therefore, they are retained for further consideration. Further, the City of Troy presently restricts potable use of groundwater so some ICs with regard to groundwater use currently exist at the site.

ICs for groundwater would primarily involve governmental controls prohibiting the use of groundwater within the proposed treatment area. However, the City of Troy already has existing ordinances that essentially achieve this. =The entire area containing both plumes at the ETCA site lies within the Troy city limits, and all existing homes within the plume boundaries are served by the Troy municipal water system, based on available information. Future use of private potable supply wells in the plume areas appears unlikely as the City of Troy has existing ordinances that (1) prohibit installation or use of potable wells for new construction in the service area and (2) prohibit connecting a potable supply well to a house that is served by system. The City only allows connection of non-potable "agricultural" supply wells with appropriate backflow control devices to houses that are connected to the system. Although some limited use of these wells for occasional non-potable use (watering lawns or gardens, washing cars, etc.) may occur, risk from such use was evaluated in the RI/HHRA and found to be negligible (SulTRAC 2015a).

The City of Troy does not restrict ongoing use of existing potable wells at locations that were never connected to the City system; however, the City is only aware of one home in the general vicinity that is not connected and still uses a potable supply well. This home is reportedly located in the 1200 block of East Main Street and is located outside of the plume areas based on available information. The City sampled this well in April 2017 and no VOCs were detected at a reporting limit of 0.5 µg/L (City of Troy 2017a; 2017b). This home is located outside of the proposed treatment zones. Because the existing Troy municipal ordinances restricting groundwater use in the area appear to sufficiently address reasonable assumptions regarding current and future use, ICs for groundwater are not retained for further evaluation as part of the groundwater IA. The need for IC's as part of the final groundwater remedy at this site will be considered at that future time.

4.2.3 Monitoring

Monitoring would provide information that could be used to evaluate risk, plan remedial action, and observe and evaluate progress.

Groundwater monitoring is a technology under the monitoring GRA. Groundwater monitoring would provide information on the state of the plume. Historical monitoring data may be used to gauge remedial progress, plan future actions, and assess potential threats to human health or the environment. Monitoring

would be necessary to establish a refined baseline estimate of the dissolved-phase contaminant mass in the plume and evaluate to the progress of the IA toward meeting the RAO of 70 to 90 percent dissolved-phase contaminant mass reduction. Groundwater monitoring would consist of periodic sampling and analyses of groundwater from existing monitoring wells at the ETCA site. In addition, new monitoring wells may be installed if necessary.

Groundwater monitoring by itself does not speed progress toward remediation goals, but is essential to evaluate the progress of the IA. Monitoring would be readily implementable at low capital costs and low to moderate O&M costs. It is therefore retained for further consideration.

Monitoring would apply not only to the Residential Area plume, but to site-wide groundwater (including the East Water Street plume). This is because (1) it will be essential to continue to monitor groundwater in both plume areas to evaluate the effectiveness of the IA, (2) the exact area of potential influence of the groundwater treatment is unknown at this time, and (3) the two plumes appear to comingle.

An extensive monitoring well network, that monitors multiple vertical horizons as well as the lateral boundaries of the groundwater contaminant plumes, exists at the site. This network will be supplemented with additional monitoring wells that would be installed to support the RD and support effective monitoring of the performance of the IA, as well as allow rapid detection of and response to generation of VOC daughter products or mobilization of metals to site groundwater as a result of treatment. The exact numbers, locations and depths of additional monitoring wells will be determined as part of the RD.

Monitoring is retained for further evaluation.

4.2.4 Containment

Containment technologies isolate contaminants from the environment. At the ETCA site, the Residential Area PCE plume appears to have resulted from subsurface releases that occurred prior to 1979. A source of contaminants that appears to be primarily located in the saturated portion of the aquifer remains and may include DNAPL and PCE sorbed to fine-grained aquifer materials. Isolation of a source may reduce leaching of these contaminants to dissolved-phase in groundwater. Containment technologies that may be applicable to this site are evaluated below.

4.2.4.1 Pumping

Pumping can be used to hydraulically contain contaminated groundwater in a target area. Hydraulic containment via pumping typically requires a network of extraction wells, a treatment system, and the means to dispose of treated water. Treated water may be re-injected, discharged to surface water, or discharged to a POTW. Strategically placed extraction wells would create a hydraulic capture zone, thereby precluding the migration of contaminants from that zone. Maintaining the capture zone would require continuous pumping.

The highly transmissive soils at this site are conducive to groundwater extraction. Therefore, pumping may be able to isolate the source but would also require extraction of large quantities to achieve hydraulic control of the plume and would have to continue indefinitely, which would make this technology energy intensive. Pumping may slowly deplete contaminants from the source area, but it is unlikely that it would completely eliminate every source of contamination or achieve the RAO of 70 to 90 percent dissolved-phase mass reduction in Zones A, B, C, and D. Consequently, significant potential for contaminant rebound exists if pumping stops. For these reasons, pumping is considered only moderately effective. This technology (as would all of the proposed technologies and process options that involve injection or extraction) would require work in roadways and access to private property. The work would require temporary lane closures, and possibly road closures. It would also necessitate extracting large quantities of groundwater from areas near or possibly within the 1-year TOT zone of the East wellfield. The technology would have moderate capital costs and moderate to high O&M costs. Containment is also not consistent with the RAOs of reducing contaminant mass. Pumping is not retained for further consideration as a plume containment technology; however, pumping as a cleanup technology or ancillary feature supporting other technologies is discussed in Section 4.2.6.

4.2.4.2 Vertical Barriers

Vertical barriers are low-permeability barriers meant to obstruct groundwater flow. Some process options under this technology include sheet pile barriers and slurry walls. At the ETCA site, a vertical barrier would have to be installed around the source area to isolate the source from the environment. Vertical barriers typically extend to the top of a low-permeability confining layer such as bedrock or a clay aquitard with sufficient lateral extent to allow construction of an effective barrier across the targeted area. Such layers were not encountered in the Residential Plume source area during the RI. Therefore, additional controls (such as groundwater extraction) would be required.

Data collected during the RI confirmed the presence of PCE and TCE at depths exceeding 80 feet in the source area. The subsurface is comprised of heterogeneous, unconsolidated material without a continuous confining layer present that vertical barriers could be linked to. Vertical barriers also would be difficult to install because of existing structures and underground utilities in the area, and they generally have high capital costs and low O&M costs. Furthermore, the area to which the overall IA will apply is laterally extensive, approximately 2 city blocks wide and 4 blocks long, making application of barriers impractical. Containment is also not consistent with the RAOs of reducing contaminant mass. This technology is not retained, because of the incompatible aquifer characteristics, presence of structures and utilities, high capital cost, and construction hurdles.

4.2.5 In Situ Groundwater Treatment

Groundwater would be treated in situ using chemical, biological, or physical processes. These processes may remove contaminants, destroy them, transform them to less toxic forms, or make them less mobile. In situ groundwater treatment technologies may require ancillary process options to be effective.

4.2.5.1 Monitored Natural Attenuation

Monitored natural attenuation (MNA) involves observing the state of the plume and monitoring the influence of natural processes to reduce concentrations of contaminants in groundwater. The information is used to determine whether natural attenuation is occurring and if it can be relied on to attain the remediation goals. For the organic COCs at this site, the MNA analytical suite would include parameters such as dissolved gases and chloride; these parameters that are often omitted in standard groundwater monitoring programs. As specified in EPA guidance, MNA would also involve more robust data analysis and reporting (EPA 1998). However, as previously discussed, due to the age of the release (pre-1979), and according to data gathered during the RI and a review of past site investigations, MNA is not currently significantly impacting VOC concentrations in the Residential Area plume as VOC concentrations have remained relatively consistent, at least since the early 2000s. Data collected during the RI indicate groundwater concentrations in the Residential Area plume source area are consistent with the potential presence of residual DNAPL and indicate that contamination in the saturated zone is acting as an ongoing secondary source of dissolved phase contamination that is migrating downgradient. EPA's MNA guidance states that MNA is not appropriate for situations involving uncontrolled sources and/or sites where DNAPL is present (EPA 1999). For these reasons, MNA is not anticipated to meet RAOs and is not retained as a viable alternative for the IA.

4.2.5.2 Enhanced Reductive Dechlorination (ERD)

Reductive dechlorination is the process that transforms chlorinated organic molecules by removing their chlorine atoms and usually replacing them with hydrogen. This term is often used in reference to chlorinated ethenes (such as PCE and TCE) and ethanes, which are common environmental contaminants. Complete dechlorination of these contaminants produces ethene or ethane.

ERD uses an organic carbon substrate such as vegetable oil, molasses, or sodium lactate delivered into the subsurface to stimulate native microorganisms and create reducing conditions. In addition to serving as a source of food for microorganisms, substrates produce the hydrogen necessary for dechlorination reactions. Anaerobic bacteria proliferate under these conditions, and some of these bacteria degrade chlorinated ethenes and ethanes, primarily through halorespiration and cometabolism. Abiotic dechlorination may also occur. In some cases, ERD also includes bioaugmentation, where laboratory-grown bacterial cultures acclimated to specific contaminants are introduced into the subsurface. These introduced cultures often speed up degradation and ensure complete dechlorination to ethene or ethane. Substrates and microorganisms are commonly injected into the subsurface using direct-push injection technology or permanent wells.

The degradation product, cDCE, has been detected in groundwater at very low levels in the Residential Area PCE plume, and vinyl chloride has not been detected. Discrete sampling conducted during the RI (RI Appendix K [SulTRAC 2015]) revealed reducing conditions at approximately 45 percent of the investigated locations. The data therefore suggest that biodegradation at the site is not pervasive, but could be stimulated.

ERD may require recirculation to be effective. In recirculation, groundwater is extracted downgradient of the targeted treatment zone, most of it amended with remediation chemicals and then re-injected upgradient of the targeted treatment zone. When upgradient injections are performed in clean groundwater (for example, injections on the closest available point to the former dry cleaner location in the source area) a clean water source would be required to prepare the injectant. That is, contaminated groundwater would not be injected into clean groundwater. The groundwater extraction rate may slightly exceed the injection rate, requiring some groundwater treatment ex situ and discharged to a sewer. The purpose of recirculation is to speed up groundwater flow so that injected amendments can reach distal portions of the remediation zone before the amendments are consumed.

The clean water source for injectant preparation may be tap/municipal water or clean groundwater extracted outside the contaminant plume. However, clean groundwater is preferred because it is less oxygenated than tap water and is not chlorinated. For this reason, water supply wells would be needed.

In the Residential Plume source area, the present structures prevent access to portions of the plume that are targeted for remediation. Those inaccessible portions may be targeted through injections into groundwater upgradient of those structures. Groundwater flow would then be relied upon to carry injected amendments into the treatment zone. Groundwater seepage velocity at ETCA is estimated to range from 0.5 to 2.1 feet per day (SulTRAC 2015). At the low end of this range, groundwater seepage velocity would result in excessive travel times and poor amendment distribution. Recirculation would speed up groundwater flow, thereby decreasing travel time, and ensuring adequate amendment distribution and contact with contaminants in the treatment zone. ERD is one of a limited range of potential technologies that would likely be effective at this site; however, ERD would be challenging to implement because of the urban setting, underground utilities and limited access to the source area. The need to recirculate groundwater would present technical and logistical challenges.

Groundwater containing the concentrations of VOCs known to be present immediately downgradient of the source area would not be suitable for reinjection at the viable upgradient injection points due to the potential to contaminate areas that are currently upgradient from the plume. This would increase logistical considerations and costs for management of extracted groundwater. ERD may also create a short-term potential for dechlorination byproducts. ERD generally has moderate capital costs and O&M costs; however costs may be significantly affected by recirculation requirements. ERD is retained for further consideration.

4.2.5.3 In Situ Chemical Oxidation

Chemical oxidation uses oxidants to transform harmful contaminants into less toxic ones. The oxidant is typically injected into groundwater using direct-push technology, or permanent wells. After injection, the oxidant spreads into the surrounding soil and groundwater, where it reacts with contaminants.

Permanganate, persulfate, ozone, and hydrogen peroxide are commonly used oxides that could treat chlorinated VOCs on site. Hydrogen peroxide is commonly combined with a catalyst to produce the highly reactive hydroxyl free radical; technologies that employ these free radicals to degrade contaminants are better known as advanced oxidation processes.

In situ chemical oxidation (ISCO) is one of a limited range of technologies that would likely be effective at this site. It would require a source of water to mix with the remediation chemical prior to injection into the targeted treatment area. As previously discussed, clean groundwater is preferable due to its similar characteristics to the water in the treatment zone. A water supply well would therefore be needed to provide a source of makeup water. ISCO can temporarily mobilize naturally occurring heavy metals and would require careful consideration if used in the vicinity of water supply wells. ISCO would be also challenging to implement given the urban setting and limited access to the source area. ISCO generally has moderate to high capital costs and moderate O&M costs. However, high natural oxidant demand (NOD) can make ISCO cost-prohibitive. It is difficult to accurately estimate the effectiveness (and associated cost) of ISCO without an estimate of the NOD of the site soils. ISCO is retained for further consideration.

4.2.5.4 In Situ Chemical Reduction

In situ chemical reduction (ISCR) refers to treatment of contaminants through chemical reduction. It involves placing reducing agents in groundwater to destroy or immobilize contaminants. Zero-valent iron (ZVI) is a commonly used reducing agent used to treat chlorinated VOCs, such as those present at the ETCA site. ZVI may be used in its pure form, in combination with an organic carbon substrate, or impregnated in activated carbon. ZVI corrosion reactions result in abiotic dechlorination of chlorinated aliphatics, producing nontoxic ethene or ethane. Activated carbon-impregnated ZVI causes dechlorination through the same mechanism as pure ZVI, but may work faster because of greater surface area and possible catalysis through sorption.

ISCR products may be introduced into the subsurface through injection, soil mixing, or excavation and backfilling. ISCR products at the ETCA site would likely be introduced via direct-push injection.

ISCR is one of a limited range of technologies that may be effective and is retained for further consideration. It may be difficult to implement given the urban setting and limited access to the source area. As with ERD, recirculation is likely required for this technology to be effective. ISCR generally has high capital and low O&M costs; however both capital and O&M costs may be significantly affected by recirculation considerations. Specifically, , at the Residential Plume source area, groundwater containing known VOCs, present on the immediate downgradient side of Zone A, would not be suitable for reinjection at the viable upgradient injection points due to the potential to contaminate areas that are currently upgradient from the plume. This would in turn add logistical considerations and costs due to the need for management of extracted groundwater.

4.2.5.5 Sparging

Air sparging is a physical process used to strip dissolved volatile organics from liquids. It transfers liquid-phase contaminants to the vapor phase. The vapor phase is simultaneously collected via SVE, then discharged to the atmosphere with or without treatment. The need for treatment is usually based on the estimated mass of contaminants discharged and where that mass lies in relation to discharge limits established by the state.

Air sparging involves the injection of air into groundwater through permanent wells. The air is supplied by an oil-free air compressor. Dissolved contaminants migrate into the injected air and are carried into the vadose zone where they are captured by an SVE system. The SVE system would consist a network of vapor extraction wells connected to a blower and off-gas processing equipment. Off-gas processing equipment usually includes a moisture separator, and sometimes include treatment systems that sorb or destroy contaminants.

Air sparging is inadvisable in situations where vapors produced by sparging cannot be captured. This is especially relevant when VI into indoor air is a concern. Therefore, air sparging could be implemented only where the vadose zone is permeable. Conversely, air sparging could not be implemented where the vadose zone is clayey. The RI confirmed the presence of clayey layers in various areas of the subsurface (RI Figures 3-2 through 3-6 [SulTRAC 2015]). Consequently, developing an air sparging remedy would require further characterization of vadose zone soils in targeted treatment areas, including those underlying buildings. As previously discussed, accessibility to the area in the immediate vicinity of the original plume source is extremely limited by the present structure and surrounding underground utilities, which include electrical power, natural gas, water, sewer, and communications. Air sparging has moderate capital and O&M costs.

Ozone sparging is similar to air sparging with several significant exceptions; primarily that ozone is injected rather than air, resulting in an in-situ chemical oxidation (ISCO) reaction with the VOCs rather than simply physically stripping VOCs. Ozone is a potentially hazardous substance requiring extreme caution when used in the vicinity of occupied structures. Ozone sparging is discussed in this section as it is potentially applicable to similar contaminants and site conditions, and accomplished in a manner similar to, air sparging, although it is essentially a hybrid of physical and chemical treatment processes.

Current uncertainties regarding the exact location of the primary source area beneath the present church addition structure necessitate an assumption that some treatment beneath the structure will be required.

However, the source area potentially includes physically inaccessible areas, as shown in Figure 1-3A: the former location at 10 East Main Street as well as other now-landlocked former locations of structures covered by the church addition. Much of this area lies at a distance beyond the typical effective radius of sparging wells (which is about 15 feet) from the nearest potential available locations for drilling around the present building exterior. For this reason, vertical sparging wells would not likely be capable of effectively treating the area. Horizontal drilling/wells would be technically and administratively challenging, possibly infeasible, due to the presence of utilities and numerous private properties that would have to be crossed. In addition, the vertical thickness of the zone requiring treatment (assumed to be at least 75 to 80 feet) also renders horizontal wells impractical.

Due to the limited radius of influence for sparging wells, the difficulties associated with horizontal drilling in the source area, the saturated thickness of the zone requiring treatment, and potential hazards associated with ozone, air and ozone sparging are not retained for further consideration.

4.2.6 Removal

Groundwater would be cleaned up by extracting contaminated groundwater from the subsurface. This section focuses on extraction. Treatment of extracted groundwater is discussed separately.

4.2.6.1 Pumping

Pumping technology was previously discussed in Section 4.2.3.1; however, the objective of this pumping would be to clean up rather than contain contaminated groundwater. Extraction wells and interceptor trenches are process options for pumping. Interceptor trenches are not practical given the depth to which contamination extends (greater than 80 feet bgs in the source area) and the urban setting. Extraction wells would have significant yields because of the transmissive soils at this site. Cleaning up groundwater would take multiple pore volume exchanges, and contaminant concentrations could still rebound if source areas or areas with high dissolved-phase concentrations persist. Based on the age of the plume and groundwater flow velocity, and relatively consistent VOC concentrations since monitoring began at this site, the number of pore volumes may be high. This approach would require extraction, treatment, and disposal of large volumes of contaminated groundwater and it is not anticipated that it would be possible to clean up the source using pumping alone. This technology would be difficult to implement and has moderate capital costs and moderate to high O&M costs. Pumping is not retained for further consideration as a remediation option. Pumping, is retained only as an ancillary component supporting recirculation of water for the ERD and ISCR technologies.

4.2.7 Ex Situ Treatment

This option refers to treatment of extracted groundwater. The organic COCs at this site are conducive to treatment via air stripping, carbon adsorption, and chemical oxidation. These technologies and process options are employed in conjunction with groundwater extraction. As discussed in Sections 4.2.4.1 and 4.2.6.1, pumping and/or extraction, either as a containment or removal strategy, is not considered capable of achieving the RAOs established for the IA within reasonable timeframes due to the extent of contamination. Also the high volume of contaminated water that would be required to be managed would render the logistics of a pump and treat remedy for this site problematic. However, ex-situ treatment may be required as an ancillary component associated with ERD and ISCR to manage groundwater extracted to support recirculation and therefore is retained as a process option.

4.2.8 Disposal

This refers to disposal of treated water when removal and ex situ treatment GRAs are used. Treated water may either be discharged to injection wells, discharged to surface water, or discharged to a POTW. These technologies and process options are employed in conjunction with groundwater extraction. As discussed in Sections 4.2.4.1 and 4.2.6.1, pumping/extraction – either as a containment or removal strategy, is not considered capable of achieving the RAOs established for the IA within reasonable timeframes due to the extent of contamination. Also the high volume of contaminated water that would be required to be managed would render the logistics of a pump and disposal remedy for this site problematic. Disposal may, however be required as an ancillary component associated with ERD and ISCR in the event that extracted groundwater exceeds the volume that can be recirculated, and is therefore retained. Disposal may require additional ancillary processes, such as treatment to remove VOCs prior to disposal. All three of the discharge options will require some regulatory review or approval: Underground Injection Control (UIC) program approval, a National Pollutant Discharge Elimination System (NPDES) permit, or pretreatment approval through the local POTW system.

4.2.9 Summary of Retained Process Options for Groundwater

The process options retained for groundwater are listed below.

Retained Groundwater Process Options
No action
Groundwater monitoring (Sitewide)
Enhanced reductive dechlorination (ERD)
In situ chemical oxidation (ISCO)
In situ chemical reduction (ISCR)
Extraction
Air stripping
Carbon adsorption
Advanced oxidation
Discharge to surface water
Discharge to POTW
Discharge to Injection Wells

4.3 TECHNOLOGIES AND PROCESS OPTIONS FOR VAPOR INTRUSION

The GRAs, remedial technologies, and process options for VI are identified in Figure 3-3. Figure 4-3 summarizes the screening of each process option for effectiveness, implementability, and cost. Process options associated with each GRA for vapor intrusion are discussed below.

4.3.1 No Action

The no action GRA will be carried forward in the screening evaluation as a baseline that represents current site conditions, as required by the NCP.

4.3.2 Land Use Controls

Risks associated with vapor intrusion may exist in a future residential or commercial scenario if a structure was built on or near a property overlying the groundwater contaminant plumes. ICs may be put in place on an interim or permanent basis to protect human health while longer-term remedies are being implemented. The different types of ICs were discussed in Section 4.1.2. Restricting land use by prohibiting construction of residential or commercial buildings at specific locations or requiring vapor mitigation systems or building control technologies for new construction near the groundwater plumes, would prevent future potential vapor intrusion issues. However, any ICs could require legal actions or significant local ordinance changes to limit the use of certain properties or to require the installation of vapor mitigation technologies. The area of the proposed IA is an older neighborhood that is already

densely built; for this reason, new construction in the area during the timeframe of the IA is not anticipated to be significant. Further, the IA is anticipated to significantly reduce the VI risk at existing structures by reducing the ongoing source of VI (VOCs in groundwater). For these reasons, IC's with regard to VI are not retained for further consideration as part of the IA. The need for any IC's as part of the final remedy may be evaluated at a future time.

4.3.3 Vapor Intrusion Monitoring

VI monitoring may be conducted to evaluate vapor phase contamination to nearby buildings or evaluate the performance of technologies deployed to abate VI within a structure. Air monitoring would consist of one or more of the following, depending on the location: (1) soil gas monitoring at locations adjacent to existing buildings, (2) installing and sampling permanent sub-slab probes in affected buildings, and (3) conducting indoor air monitoring and background ambient air monitoring. The vapor intrusion monitoring network would be sampled on a periodic basis (quarterly, semi-annually, or annually) to measure contaminant concentrations seasonally over time. Additional actions may be necessary if monitoring indicates that contaminant concentrations are increasing.

Depending on the amount of soil vapor probes to be installed and sampled and the number of buildings requiring indoor air sampling, the capital costs are low and the O&M costs are low to moderate, depending on the frequency of sampling. However, comparative costs for containment (see Section 4.3.4 below) indicate that presumptive installation of sub-slab-depressurization systems in areas most likely to be impacted by VI is more protective and comparable in cost. For this reason, vapor monitoring is retained for further consideration only in conjunction with monitoring the effectiveness of containment. It is easily implemented and it could be used in conjunction with other process options to evaluate the effectiveness of other mitigation measures.

4.3.4 Containment

Containment options for vapor intrusion at the ETCA site include the installation of passive barriers, passive venting, active depressurization systems (and similar alternatives), and active pressurization systems. Containment options for vapor intrusion follow similar methods as those used in radon mitigation. The containment options discussed below are evaluated for actions that could be taken to mitigate vapor intrusion in existing structures. Containment process options are also evaluated for current site conditions (existing structures). Some process options that are not retained may be effectively implemented during future construction in conjunction with institutional controls discussed in

Section 4.3.2. Passive barriers, passive venting systems, active depressurization systems, and active pressurization systems are discussed below.

4.3.4.1 Passive Barrier

The passive barrier option includes installation of sheet geomembrane; sprayed, poured, or cured-in-place barriers; and general sealing to provide a physical barrier to vapor intrusion. Sheet membranes are usually 40 to 60 mil high-density polyethylene (HDPE) but can also be constructed of polyethylene, polyvinylchloride, or ethylene propylene diene monomer (EPDM) rubber (EPA 2008). Sheet membranes are installed as an impermeable layer between the subsurface and the concrete slab and can only be feasibly installed during new construction. Their effectiveness depends on the quality of their seals at utility penetrations and the ability of the barrier to remain puncture-free. This option would have a high capital cost and negligible O&M costs. A sheet membrane barrier is not retained for further consideration because it would be applicable only for new construction.

Poured or cured-in-place barriers are poured or spray applied to a specific thickness over the existing basement slab (EPA 2008). The barrier may be a rubberized asphalt emulsion or an epoxy. Using this option would require an unfinished subgrade (or grade if no basement exists) to apply the barrier sealant. Most of the properties at the ETCA site contain existing buildings that are inhabited; therefore, implementing this option would require occupants to remove everything from their basements prior to applying the barrier. This option would have a high capital cost and low O&M cost and is not retained for further consideration.

Under the general sealing option, flexible sealant or epoxy would be applied to cracks within the foundation and utility conduits to create a barrier. Effective sealants should have good adherence to building materials, be flexible and resistant to shrinking, be durable and water resistant, and be compatible with site COCs (ITRC 2007). Issues related to this option include difficulties in finding all cracks and utility conduits and removing floor coverings to visually inspect the entire floor. If the foundation is severely cracked, a spray- or roller-applied vapor barrier paint may be used. According to EPA, only about one third of the states allow sealing of the building as a control measure to be used alone (EPA 2008). General sealing has a low capital cost and low O&M costs but is most effective when used in conjunction with other technologies, such as sub-slab depressurization, and therefore is not retained for further consideration as a stand-alone process option. However, because of the age and unknown construction features of structures in the proposed area of the IA, sealing procedures may be required at some locations to ensure that the remedy achieves PRGs, and would be evaluated on a case by case basis.

4.3.4.2 Passive Venting

Passive venting produces a reduced pressure zone below the building, intended to prevent VOC-bearing soil gas from entering the building (EPA 2008). Passive venting relies on natural diffusion or pressure gradients to cause soil gas to migrate to collection pipes and exhaust to the atmosphere.

Installing a passive venting piping system outside an existing building has a moderate capital and low O&M cost and the system can be converted to an active sub-slab depressurization system if passive venting is not effective. This process is not retained for further consideration because, when maintained properly, active depressurization systems are significantly more effective for existing structures at only slightly increased costs.

4.3.4.3 Active Building Depressurization Systems (Sub-Slab, Crawlspace, Block Wall)

Methods of active building depressurization under this option include sub-slab depressurization (SSD), crawlspace depressurization, block wall depressurization, and sub-slab ventilation. All of these depressurization options include creating a passive venting system outside the existing building (as described above) and then adding a fan-powered vent to remove vapors and decrease pressure within the area to mitigate further vapor intrusion. The difference in each option is the location of the depressurization system; sub-slab (as the name implies), crawlspace (as the name implies), and block wall (the void network within a block wall foundation). Depressurization systems are the most common and usually the most reliable vapor intrusion mitigation methods (EPA 2008).

A variation of the sub-slab depressurization system (SSDS) is a sub-slab ventilation system (SSV), which uses adequate air flow induced in the sub-slab to dilute VOCs diffusing from soil or groundwater. The same infrastructure used in the SSDS is also used in the SSV system, but in reverse, to keep vapors from entering the building by blowing the vapors out the side of the building. The active alternatives to the SSD will depend on the aggregate used beneath the building slab.

SSDS have been proven to function effectively at other sites and are widely available. The active building depressurization systems have moderate capital costs and low O&M costs. SSDSs are the most widely used of the building remediation methods discussed above. SSDS consume small amounts of electrical power, and may cause the HVAC system to operate more frequently to maintain the desired temperature in a structure (although this is more common with sub-slab pressurization), resulting in slight increases to the property owner's utility costs. Other options (such as sealing) may be applicable, depending on where the VOC vapors have accumulated, the construction of a particular structure, or the

material used below the slab. The need for such options would be considered on a case-by-case basis in the individual system design. Based on current building knowledge, sub-slab depressurization was chosen as the representative active building depressurization process option to address potential vapor intrusion. SSDS are commonly used for radon mitigation. SSDS have also have been successfully employed in the region for mitigation of VI resulting from chlorinated VOC groundwater plumes (including at locations within the ETCA site) are thus available. In addition, experienced contractors capable of installing SSDSs are also widely available. Therefore, SSDS are retained for further considerations.

4.3.4.4 Active Building Pressurization

Two methods of active building pressurization are considered. One option involves using the current HVAC system to create positive pressure within the building. The other option involves using sub-slab pressurization (SSP) to create pressure beneath the building. The positive pressure induced by both options would force the vapors beneath the slab to stay in place instead of being released into the building. The HVAC system would need to be maintained, and could not be shut off to maintain positive pressure. According to EPA, building pressurization using an HVAC system is more common in large structures and less common for residential buildings (EPA 2008). The capital cost may be minimal to none if the existing HVAC system is capable of continuously supplying the necessary pressure. This option has a low capital and moderate O&M cost caused by continuously operating the HVAC system. In addition, the homeowner would need to agree to operate that system for an undetermined amount of time. This option is not retained for further consideration due to homeowner considerations.

The SSP system would work by using a SSDS in reverse. Instead of removing vapors from the sub-slab, air would be forced into the sub-slab. SSP is normally used when the permeability of the soil is too high to allow a sufficient vacuum to be generated for SSD and the fan does not pull enough flow for effective SSV (EPA 2008). SSP has been shown to lead to improved performance of SSDSs in certain cases, such as where homes are built on well-drained gravel soils or on highly fractured rock. This option has a moderate capital and moderate O&M cost. As indicated in Section 4.3.4.3, SSD is more commonly employed, and therefore SSP is not retained for further consideration.

4.3.5 Treatment

Treatment options consist of an exterior soil-gas treatment system such as SVE or an indoor air treatment system (carbon sorption and photocatalytic oxidation). An exterior SVE system may be used to mitigate vapors from entering the area near the building. Indoor air treatment can remove VOC air contaminants

within the building in a specific room. Indoor air treatment is generally used for existing buildings because other types of more cost-effective systems can typically be installed during new building construction (ITRC 2007).

4.3.5.1 SVE System

SVE is an in situ technology that uses vacuum blowers and extraction wells to strip VOCs from unsaturated soils (EPA 1996a). SVE systems typically consist of vertical extraction points screened above the water table. A vacuum is applied to the extraction points to remove the vapors. The design of an effective SVE system should be based on the site-specific geology and the depth to groundwater. The extracted vapors are often treated (if vapors are above screening criteria) at the surface and released to the atmosphere. Emissions from the SVE process are filtered by activated carbon, or treated either by thermal destruction or condensation refrigeration, before they are released into the air. This option would be used to mitigate vapor intrusion issues before vapors reach the building.

For the ETCA site, the groundwater plumes underlie numerous privately owned properties. Therefore, effective SVE systems would be difficult to implement. This would require installation and operation of multiple exterior systems and make SVE impractical or cost prohibitive. SVE wells located in the right of way may not provide effective protection within structures located away from the street. In addition, the proposed groundwater alternatives will present logistical challenges with regard to available space for working around area utilities and private property; thus the additional construction activities required for exterior SVE systems would significantly exacerbate the challenges to implementing the long-term solution to the VI issue (addressing the groundwater plume). SVE systems have a moderate capital costs and moderate to high O&M costs. The SVE option is not retained for further consideration.

4.3.5.2 Carbon Adsorption

Carbon adsorption operates by filtering ambient air within the building through a carbon filter to eliminate VOCs. Sorption filtration is the most effective off-the-shelf commercial technology, at least for the initial period, for removal of indoor VOCs (EPA 2008). This option is best applied to reduce VOC concentrations on a room-by-room basis. Disadvantages of indoor air treatment and carbon sorption include the facts that vapors are allowed to build in a room prior to treatment, the treatment system must remain on, and it requires large amounts of energy (ITRC 2007). Costs associated with carbon sorption include the continual replacement and disposal of spent carbon and the purchase of the system. This option has a low capital and a moderate O&M cost and is not retained for further consideration based on the discussion above.

4.3.5.3 Photocatalytic Oxidation

Photocatalytic oxidation operates by bringing a catalyst (such as titanium dioxide) in contact with the VOCs in the presence of ultraviolet (UV) light to reduce VOC concentrations (Zentox 1998). Oxidized radicals are produced in this environment, which reduce VOCs to carbon dioxide and water. However, treating chlorinated VOCs also produces hydrochloric acid, which would require additional treatment. Chlorinated VOCs are the chemicals of concern at the ETCA site. A photocatalytic oxidation system can be installed as a room filter or within an HVAC system. Installing a photocatalytic oxidation system has a low capital and moderate O&M cost. Based on the production of hydrochloric acid caused by the treatment of chlorinated VOCs, this process is not retained for further consideration.

4.3.6 Summary of Retained Process Options for Vapor Intrusion

The process options retained for vapor intrusion are listed below.

Retained Vapor Intrusion Process Options
No action
Vapor intrusion monitoring (System Performance Monitoring)
Sub-slab depressurization

5.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

This section describes the development and screening of remedial alternatives for the ETCA site. The alternatives include only the remedial process options that merited further evaluation after the initial process option screening discussed in Section 4.0. Each alternative was developed to achieve the IA RAOs identified in Section 2.0.

Alternatives have been developed to address soil, groundwater, and soil vapor, and are presented as three separate sets of alternatives. Following this approach, this section presents and evaluates three separate sets of alternatives to address (1) soil in EA-1 and EA-6, (2) Residential Area PCE plume groundwater, and (3) Residential Area PCE plume vapor intrusion. Although separate sets of alternatives are presented, the interaction of alternatives for each medium and the degree to which these alternatives will work together must be considered to provide an effective interim remedy.

According to Section 4.1.2.1 of EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," (EPA 1988) the screening effort may be minimized or eliminated if the number of viable or appropriate alternatives for addressing site problems is limited. The scope of the screening effort can vary substantially, depending on the number and type of alternative developed, and the extent of information necessary for conducting the detailed analysis.

This section also provides screening information corresponding to the alternatives developed. The purpose of the alternative screening evaluation is to potentially reduce the number of alternatives that will undergo a more thorough and extensive analysis. Based on EPA guidance (EPA 1988), the criteria used during initial alternative screening include:

- Effectiveness – the degree to which each alternative is protective of human health and the environment
- Implementability – the technical and administrative feasibility of constructing, operating, and maintaining each remedial alternative
- Cost – comparative estimates of capital and O&M costs

Each alternative is described below and was assembled to accommodate different scenarios and to allow EPA a range of alternatives to choose from.

5.1 DESCRIPTION OF ALTERNATIVES FOR SOIL

Three remedial alternatives have been developed by combining the process options retained and described in Section 4.1.8 and shown in Figure 4-1. Each of these alternatives is described below and screened against the effectiveness, implementability, and cost criteria.

5.1.1 Soil Alternative S-1: No Action

The no action alternative provides a baseline for evaluating the other alternatives. Under Alternative S-1, no action would be taken to remediate soil at EA-1 or EA-6. Under the no action alternative, no material would be excavated, treated, or capped.

5.1.1.1 Effectiveness

Contamination in soil at the ETCA site poses an unacceptable risk to human health, including soil in EA-1 an EA-6. The no action alternative would not mitigate that risk or reduce the toxicity, mobility, or volume of contamination at the ETCA site. Therefore, Alternative S-1 would not be protective of human health or the environment.

5.1.1.2 Implementability

Although this alternative would be easily implemented, the administrative feasibility of selecting this alternative is very low. It is unlikely that EPA or Ohio EPA would approve of this alternative because it would not provide adequate protection of human health and the environment.

5.1.1.3 Cost

No capital or O&M costs are associated with this alternative.

5.1.1.4 Decision

The no action alternative will be retained for detailed analysis because the NCP requires that it be used as a standard for evaluating the performance of other remedial alternatives.

5.1.2 Soil Alternative S-2: Excavation in Combination with Offsite Disposal for EA-1 (Hobart) and EA-6 (Spinnaker)

This alternative would require excavation of contaminated soil at specific parts of the Hobart and Spinnaker properties, followed by off-site disposal. Figure 5-1 shows the areas to be excavated under this alternative. This alternative assumes that the majority of the contaminated soil excavated would require disposal as non-hazardous waste and a percentage would be characterized as hazardous waste. Thus, the

assumption is that excavated soil would be disposed of off site in both a licensed hazardous waste landfill and a licensed non-hazardous waste landfill.

Soil excavation would be conducted in EA-1 (and possibly a portion of EA-2) of the Hobart property and EA-6 at the Spinnaker property (see Figure 5-1 for excavation locations). The volume of soil to be excavated from the Hobart property is estimated at 9,111 cubic yards. The volume of soil to be excavated from the Spinnaker property is estimated at 753 cubic yards. Soils in EA-1 at Hobart were found to be predominantly sand and gravel; whereas soils at Spinnaker EA-6 contained a higher proportion of clay; based on these considerations a factor of 20 percent was used for EA-1 and 30 percent for EA-6 to account for bulking/expansion of excavated soil and potential settling and compaction of clean backfill. Based on these factors, the total volumes of soil to be disposed of and replaced is estimated to be 11,913 cubic yards.

Because vadose zone soils with concentrations exceeding both human health and groundwater-based PRGs will be removed, no additional ICs directly related to soil are assumed to be required. Groundwater monitoring, to evaluate the effectiveness of the soil IA, is included as part of groundwater Alternatives RGW-2A, 2B, and 2C.

5.1.2.1 Effectiveness

This alternative would be effective at protecting human health and the environment. Contaminated soil would be excavated at specific parts of the Hobart and Spinnaker properties and be disposed of off site. This would prevent exposure of human receptors to contamination in soil, and would also be effective in preventing contaminant migration from soil to groundwater in these areas.

5.1.2.2 Implementability

Excavation of the soil at the Hobart and Spinnaker properties would be moderately difficult to implement technically. The EA-1 excavation will require soil excavation adjacent to the Hobart building which in part has a stone foundation dating to the 1800s. Excavation along the building footers could undermine the structures and, if soil contamination exists below or behind the building footers, it will not be removed by this alternative. Access from the property owners for Hobart and Spinnaker would be required. In addition, excavation would be performed near the levee and the MCD property. The proposed area of excavation will not extend onto the MCD levee; however the MCD property adjoins EA-1 and EA-2. access and permits from the MCD will be required to perform the excavation work if any of the proposed excavation staging activities require access to or take place on MCD property. The remedial

implementation may also disrupt Hobart or Spinnaker operations by prohibiting or limiting operational access to the excavation areas.

Off-site disposal of excavated material would be easily implemented.

5.1.2.3 Cost

The excavation of soil alternative would have moderately high capital with no O&M costs. (Costs for groundwater monitoring are included with the groundwater alternatives in Section 5.2). The capital costs would depend on the volume of soil to be disposed of off site, and its waste characterization.

Decision

Because this alternative effectively prevents exposure to and reduces migration of contaminants from soil to groundwater soil through excavation and off-site disposal, it is retained for further analysis.

5.1.3 Soil Alternative S-3: Excavation in Combination with Offsite Disposal for EA-1; Capping in Place with Institutional Controls for EA-6 (Asphalt Cap)

This alternative would require excavation of contaminated soil at specific parts of the Hobart property, followed by off-site disposal; and, capping of specific areas on the Spinnaker property with an asphalt cap. Figure 5-2 shows the areas to be excavated or capped under this alternative.

Soil excavation would be conducted in EA-1 (and possibly a portion of EA-2) of the Hobart property in the same manner described for Alternative S-2 in Section 5.1.2. The volume of soil to be excavated from the Hobart property is estimated at 9,111 cubic yards, with a total estimated disposal and backfill volume of 10,933 cubic yards assuming a 20 percent bulking and settling/compaction factor. This alternative assumes that the majority of the contaminated soil excavated would require disposal as non-hazardous waste and a percentage would be characterized as hazardous waste. Thus, the assumption is that excavated soil would be disposed of off site in both a licensed hazardous waste landfill and a licensed non-hazardous waste landfill.

The area to be capped at EA-6 of the Spinnaker property is estimated at approximately 3,175 square feet. The ARAR-compliant asphalt or concrete cap would be designed and constructed in accordance with Ohio EPA guidance and regulations.

Because vadose zone soils with concentrations exceeding both human health and groundwater-based PRGs will be removed from EA-1, no ICs directly related to soil are assumed to be required for EA-1. However, under this alternative, ICs would be required for the capped area of EA-6 to control future land use and ensure proper maintenance and continued performance of the cap. ICs would be required to restrict future land use by preventing specific areas (EA-6) from being zoned for residential use, maintaining the cap into perpetuity, and preventing excavation of soil from the capped area. These controls would be put in place to prevent the potential for direct contact with or ingestion of any contaminated soils. Groundwater monitoring, which is included as part of the groundwater remedy in Alternatives RGW-2A, 2B, and 2C, will be used to monitor the reduction of groundwater VOC concentrations over time.

5.1.3.1 Effectiveness

This alternative would be effective at protecting human health and the environment. Contaminated soil would be excavated from EA-1 at Hobart and would be disposed of off site. The contaminated soil at EA-6 would be covered with a permanent cap, rendering the underlying soil inaccessible to receptors at the surface and minimizing infiltration of surface drainage through the vadose zone soil. This would prevent exposure of human receptors to contamination in soil, and would reduce the potential for contaminant migration from soil to groundwater in these areas. However, this alternative does not reduce the toxicity and volume of soil contamination. Ongoing effectiveness would be ensured through ICs requiring appropriate maintenance of the cap and groundwater monitoring in areas downgradient from the cap and excavated areas

5.1.3.2 Implementability

Alternative S-3 would be moderately difficult to implement. Excavation of the soil at the Hobart property in conjunction with capping soil at the Spinnaker property would be moderately difficult to implement technically. Access from the property owners for Hobart and Spinnaker would be required.

The EA-1 excavation will require soil excavation adjacent to the Hobart building which in part has a stone foundation dating to the 1800s. Excavation along the building footers could undermine the structures and, if soil contamination exists below or behind the building footers, it will not be removed by this alternative. In addition, excavation would be performed near the levee and the MCD property. The proposed area of excavation will not extend onto the MCD levee; however the MCD property adjoins EA-1 and EA-2. Access and permits from the MCD will be required to perform the excavation work if any of

the proposed excavation staging activities require access to or take place on MCD property. Off-site disposal of excavated material would be easily implemented.

Capping EA-6 would require access permission from Spinnaker and possibly neighboring property owners due to EA-6's position along the western Spinnaker property line. Capping of EA-6 would require removal of the existing pavement and construction of an ARAR-compliant cap thus remedial implementation may disrupt day to day site operations by prohibiting or limiting access to or traffic through the capping area as well as staging areas for equipment and materials. ICs associated with capping EA-6 would be relatively simple to implement; however they would affect future land use scenarios at the site and would require negotiation with the owners of any affected property.

Because this alternative effectively reduces exposure to and migration of contamination through removal and containment, it is retained for further analysis.

5.1.3.3 Cost

The combined excavation/capping soil alternative would have moderately high capital and low O&M costs. O&M would be limited to ongoing maintenance of the cap at EA-6 to ensure continued performance. (Costs for groundwater monitoring are included with the groundwater alternatives in Section 5.2). The capital costs would depend on the waste characterization of soils excavated from EA-1, and the type of cap (asphalt or concrete) constructed for EA-6. This FFS and costs presented herein are based on an asphalt cap.

Decision

Because this alternative effectively prevents exposure to and reduces migration of contaminants from soil to groundwater soil through excavation and off-site disposal, it is retained for further analysis.

5.2 DESCRIPTION OF ALTERNATIVES FOR GROUNDWATER

Retained technologies presented in Section 4.2.9 and on Figure 4-2 have been developed into two general remedial alternatives for groundwater. The first alternative, RGW-1,is the "No Action" alternative. Alternative RGW-2 encompasses in-situ source treatment to address contaminant mass reduction in the Residential Area plume; and, sitewide groundwater monitoring. As previously discussed, the IA will address the source and most contaminated areas of the Residential Area plume; however monitoring will address both plumes. Alternative RGW-2 is divided and evaluated in subsequent sections of this FFS as

three potential treatment options: ERD (Alternative RGW-2A); ISCR (Alternative RGW-2B); and, ISCO (Alternative RGW-2C).

In situ treatment of all contaminated groundwater at this site would likely be cost-prohibitive and may not be technically feasible. Therefore, alternatives employing in situ treatment target specific areas (Zones A, B, C, and D) of the plume (see Figure 5-4), where the bulk of the contaminant of mass is expected to reside. Reducing the source mass through treatment would potentially allow for a wider range of alternatives to be employed in the final long-term site remedy.

Areas targeted for treatment were based on the known source areas of releases of contaminants; concentrations of COCs in groundwater indicated by data from the site groundwater monitoring well network; and vertical profiling data collected using HRSC (MIP and Waterloo) techniques. Section 1.2.4 and Figures 1-9 through 1-13 summarize the nature and extent of groundwater contamination based on the results of the RI. To identify the most contaminated areas within the Residential Area plume and East Water Street plume, data from the Phase II screening level sampling, the Phase II comprehensive sampling, and the additional Phase II HRSC groundwater profiling sampling events were used to create total chlorinated VOC (TCVOC) plume maps for the Residential Area and the East Water Street area. These TCVOC plumes are shown on Figure 5-3. TCVOC concentrations include the sums of PCE, TCE, cDCE, and VC concentrations. The highest detected concentration was used at locations where more than one sample was collected (including duplicates).

The results shown represent varying depths. Both shallow and deep monitoring well results are presented on the figures without any distinction between the two. Similarly, HRSC results from multiple depths at a specific location were used to calculate a maximum TCVOC concentration for that location; HRSC concentrations shown on the figures are maximum values. It should be noted that contaminants were detected in some wells at higher concentrations during other RI sampling events than during the Phase II events. For example, TCVOCs were detected at concentrations as high as 2,283 µg/L at Well EPA-107I in the Residential Area plume. In the East Water Street plume, Well EPA-110S contained TCVOCs at concentrations as high as 31 µg/L, and Well KMW-10 contained TVOCs at concentrations as high as 52 µg/L (Note – although data provided by KC indicates TVOC concentrations as high as 139 µg/L in KMW-10 during their quarterly monitoring events, the contours in Figure 5-3 are based on data collected by EPA during the RI.)

All alternatives (except the no action alternative) would require ongoing inspections, monitoring, and 5-year reviews. An extensive monitoring well network, that monitors multiple vertical horizons as well as the lateral boundaries of the groundwater contaminant plumes, exists at the site. This network will be supplemented with additional monitoring wells that would be installed to support the RD and support effective monitoring of the performance of the IA and allow rapid detection of and response to generation of VOC daughter products or mobilization of metals to site groundwater as a result of treatment. The numbers and locations of additional performance monitoring wells indicated on Figure 5-4 and 5-8 are conceptual. The exact numbers, locations and depths of additional monitoring wells will be determined as part of the RD and during the IA should ongoing monitoring indicate the need for additional wells.

As previously discussed, the entire plume area falls within the Troy city limits and municipal water service area. For all residences in this area, Troy municipal ordinances currently in place (1) restrict connection of a potable supply well to any household system that is connected to the Troy municipal system, and (2) require all new construction to be connected to the municipal system and not use private potable supply wells. The Troy ordinances would continue to prevent exposure to contaminated groundwater while the IA is being implemented; for this reason no additional ICs are included under the proposed groundwater alternatives.

Each alternative is described below and evaluated for effectiveness, implementability, and cost.

5.2.1 Residential Area Groundwater Alternative RGW-1: No Action

Alternative RGW-1 would take no action to address groundwater at the ETCA site.

5.2.1.1 Effectiveness

Alternative RGW-1 is not effective. It would do nothing to reduce existing risk at the ETCA site and would therefore not protect human health or the environment.

5.2.1.2 Implementability

Alternative RGW-1 rates low for implementability. Although implementable in the physical sense, it would not gain acceptance from EPA or Ohio EPA. The alternative would therefore be impossible to implement.

5.2.1.3 Cost

Alternative RGW-1 has no associated capital or O&M costs.

5.2.1.4 Decision

The no action alternative will be retained for detailed analysis because the NCP requires that it be used as a standard for evaluating the performance of other remedial alternatives.

5.2.2 Residential Area Groundwater Alternative RGW-2A: Source Treatment usingERD; and, Groundwater Monitoring

Alternative "RGW-2" will treat the most contaminated portions of the Residential Area plume via in-situ treatment. Alternative RGW-2 encompasses three potential remedial approaches described in this and subsequent sections of this FFS as RGW-2A, RGW-2B and RGW-2C. This section discusses Alternative RGW-2A, which includes in-situ source treatment using ERD.

The areas targeted for treatment are shown on Figure 5-5. It includes those areas of the plume with TCVOC concentrations greater than 500 µg/L and extends from the source area (just northwest of Walnut Street) to Union Street. The treatment area is outside the 1-year travel time capture zone around the City of Troy's East wellfield. The treatment area is assumed to include the footprint of the former Troy One-Hour dry cleaning facility (currently First Presbyterian Church addition) as well as adjacent areas of Walnut Street as the groundwater plume appears to originate in the intervening area. The treatment area between Walnut Street and Clay Street would target a vertical interval of approximately 15 feet to 100 feet bgs, and the treatment area east of Clay Street would target a vertical interval of approximately 15 feet to 50 feet bgs. The actual treatment locations and horizons will be confirmed during predesign studies to support the RD.

ERD would involve biostimulation and bioaugmentation. Bioaugmentation would speed complete dechlorination to ethene and reduce the production of vinyl chloride, which is more toxic than PCE and TCE. Depending on the method of injection, biostimulation may employ generic substrates such as sodium lactate, or proprietary timed-release substrates such as emulsified vegetable oils. Bioaugmentation would require proprietary Dehalococcoides microorganism cultures. Additional monitoring wells would need to be installed to monitor progress of the source area remedy.

ERD may potentially generate methane as the treatment of VOCs progresses. Methane generation is typically not sufficient to significantly impact the vadose zone and can be monitored and controlled through the use of inhibitors if necessary.

Injection locations would be determined to some degree by the physical constraints of the site – structures, underground and overhead utilities, and other features that may limit drilling activity. The locations would be determined during the RD but may include injections both upgradient from the source area (on East Main Street or Market Street) and directly into the area on the Walnut Street side of the church addition where part per million (ppm) level PCE concentrations have been detected and DNAPL may be present, as shown on Figure 5-5.

The method of injection would depend on the accessibility of properties in targeted treatment areas. Both injection wells and direct-push injection techniques would require access to public and private property. However, direct-push injection would require larger swaths of private property. Permanent injection wells would be used if access to private property proves difficult.

Direct-push injection would involve the advancement of hundreds of boreholes within targeted treatment areas. In some cases, directional drilling may be used to access target areas under buildings.

If permanent injection wells are used, they would be located in public right-of-ways to the extent possible. Transfer pipelines supplying injection wells would be installed in public roadways, which would require trenching through streets and easement areas. Process equipment could be located in the municipal parking lot near the intersection of North Walnut Street and East Main Street or the intersection of Mulberry Street and East Main Street.

Recirculation is assumed as part of this alternative, as described in Section 4.2.5. A source of water to mix with the amendment material prior to injection into the targeted treatment area would be required and for Zones B, C, and D this water would be supplied by extraction and recirculation water from the downgradient ends of the zones. In Zone A, a water supply well would need to be added to provide a source of clean water for injections at the upgradient end. Extraction of contaminated groundwater that cannot be reinjected is assumed herein to require additional ancillary process options, such as ex situ treatment and disposal. For cost estimating purposes, it is assumed that extracted water that could not be recirculated would be treated via air stripping to remove VOCs and discharged to the POTW. The final treatment and disposal options would be determined in the RD. The IA would continue at least until the dissolved-phase contaminant mass has been reduced by 70 to 90 percent or the IA is supplanted by another alternative or permanent remedy.

Groundwater monitoring would be conducted in both plume areas (site-wide) during the IA to evaluate remedial progress. Specifically, groundwater monitoring would be conducted in the Residential Area PCE plume to evaluate the effectiveness of the groundwater IA and monitor the plume for potential daughter products of PCE, and methane. Monitoring would be conducted in the East Water Street plume area to evaluate whether the soil IA was effective in reducing groundwater contaminant concentrations. It is likely that groundwater monitoring would be extended beyond the IA (as part of the final long-term remedy) until remediation goals are attained.

Designing the remedy would require performing a pilot test and possibly pre-design investigations to refine design parameters. In addition, construction of additional monitoring wells to refine the "baseline" plume volume estimates and monitor the reduction in dissolved phase mass will be required.

5.2.2.1 Effectiveness

Alternative RGW-2A rates high for effectiveness. Although data from the RI suggested that the aquifer may possess inadequate conditions for biodegradation, its present state and some geochemical parameters such as nitrate and sulfate may compete with the reductive pathway, this is expected in aquifers with low organic carbon content. However, none of the geochemical data collected during the RI suggest that the aquifer would resist ERD. Although the aquifer is currently inhospitable to dechlorinators, those microorganisms are present in the aquifer (as evinced by cDCE detection in some wells), and can be stimulated. ERD would require that electron donors (organic carbon food source) be injected to stimulate microbial growth. In addition, the aquifer would be inoculated with acclimated dechlorinating microorganisms. In essence, the remedy would produce the conditions necessary for microbial degradation of PCE and its daughter products, even if they do not exist at present.

This alternative would be protective of human health and the environment because the sources and concentrations of VOCs in groundwater would be significantly reduced.. Structures within and adjacent to the proposed treatment zones will be offered SSDS to ensure that potential generation of dechlorination byproducts in the short term would not result in VI concerns. A potential for temporary generation of methane exists, and would be monitored during the duration of the IA and controlled as needed.

This technology would require recirculation of treated groundwater. Capture zones for extraction would be determined during the RD. Conceptually, it is possible to maintain capture through design of well locations and injection and extraction rates and thus it is highly unlikely that recirculation would affect the City of Troy wellfield's source water protection area, which lies to the east of Union Street and

northeast of East Main Street. Ongoing groundwater monitoring (including supplemental wells to be installed as part of the IA) would detect any potential changes in flow direction or concentrations of VOCs in the vicinity of the source water protection area. Vapor intrusion controls that are planned for individual properties would mitigate concerns regarding vapor intrusion of daughter products.

5.2.2.2 Implementability

Alternative RGW-2A rates moderate for implementability, with the primary challenges being access to public and private property, and physical limitations such as structures and utilities in the primary source area. Because this process requires recirculation of groundwater Ohio EPA approval would be required for underground injections. Logistical needs include management of groundwater that cannot be reinjected into areas that are currently outside of the plume. For this reason, extracted water from Zone A would require treatment and disposal. Costs herein assume this water will be treated to remove VOCs and disposed of via the sanitary sewer/POTW. Also, a source of "clean" make-up water would be needed for mixing with the ERD compound for the injections on the upgradient side of Zone A. If direct-push injection is used, the ability to target areas below buildings may be limited by the availability of specialized injection contractors.

5.2.2.3 Cost

Alternative RGW-2A rates moderate for capital cost and O&M costs because of the logistical challenges involved in implementation and management of extracted groundwater.

5.2.2.4 Decision

This alternative is retained for further consideration.

5.2.3 Residential Area Groundwater Alternative RGW-2B: Source Treatment using ISCR; and, Groundwater Monitoring

Alternative "RGW-2" encompasses three potential alternatives for Residential Area plume in-situ treatment; RGW-2A, -2B and -2C. This section discusses Alternative RGW-2B, which includes in-situ source treatment using ERD.

Alternative RGW-2B is similar to Alternative RGW-2A, except that the chemical used for biostimulation would also cause direct chemical dechlorination. The area targeted for treatment is assumed to encompass the area between Market Street and Union Street and is shown on Figures 5-4 and 5-6 and will be confirmed during pre-design studies. The chemical used may be one of many proprietary products that

combine ZVI or ferrous iron with organic carbon. As with RGW-2A, construction of additional monitoring wells to refine the "baseline" plume volume estimates and monitor the reduction in dissolved phase mass may be required. The use of groundwater monitoring would be similar to what was described under Alternative RGW-2A. As with RGW-2A, recirculation would be required, necessitating the same logistical and ancillary treatment and disposal considerations in Zone A that were described for RGW-2A. Also, as with RGW-2A, bioaugmentation would be employed to facilitate complete dechlorination to ethene and reduce the production of vinyl chloride, which is more toxic than PCE and TCE. Depending on the method of injection, biostimulation may employ generic substrates such as sodium lactate, or proprietary timed-release substrates such as emulsified vegetable oils. Bioaugmentation would require proprietary Dehalococcoides microorganism cultures. Additional monitoring wells would need to be installed to monitor progress of the source area remedy.

5.2.3.1 Effectiveness

Alternative RGW-2B rates moderate for effectiveness. The potential effectiveness of this alternative may be inhibited by the limited direct access to the source area and thus the time required for injected ISCR agents to reach the targeted treatment area under natural groundwater transport time, and would depend on recirculation. Groundwater monitoring would be conducted to assess whether this alternative would achieve IA mass reduction objectives.

ISCR may potentially generate methane as the treatment of VOCs progresses. Methane generation is typically not sufficient to significantly impact the vadose zone and can be monitored and controlled through the use of inhibitors if necessary.

ISCR may solubilize naturally occurring arsenic and manganese in treatment areas and cause them to migrate downgradient. However, dissolved arsenic and manganese would once again return to their insoluble forms when they migrate beyond artificially induced reducing zones. The RD would have to consider factors such as proximity to the City of Troy's East wellfield 1-year TOT. As with Alternative RGW-2A, the remedial design will determine the capture zones for any pumping/recirculation systems employed. The existing monitoring well network will be supplemented with additional wells at appropriate locations and depths to monitor performance of the remedy relative to RAOs, potential displacement of contaminants, or migration of heavy metals. Ongoing monitoring will allow for changes in operating parameters if needed to ensure protection of the City of Troy wellfield.

5.2.3.2 Implementability

Alternative RGW-2B rates moderate for implementability, with the primary challenges being access to public and private property, and physical limitations such as structures and utilities in the primary source area. Because this process requires recirculation of groundwater Ohio EPA approval will be required for underground injection. Logistical needs include management of groundwater that cannot be reinjected into areas that are currently outside of the plume,. For this reason some extracted water from zone A would require treatment and disposal. Costs herein assume this water will be treated with an air stripper to remove VOCs and disposed of via the sanitary sewer/POTW. Also, a source of "clean" make-up water would be needed for mixing with the ISCR compound for the injections on the upgradient side of Zone A.

5.2.3.3 Cost

Alternative RGW-2B would have moderate capital and O&M costs because of the logistical concerns with implementation and need to manage extracted groundwater from Zone A.

5.2.3.4 Decision

This alternative is retained for further consideration.

5.2.4 Residential Area Groundwater Alternative RGW-2C: Source Treatment using ISCO; and, Groundwater Monitoring

As previously discussed, Alternative "RGW-2" encompasses three potential alternatives for Residential Area plume in-situ treatment; RGW-2A, -2B, and -2C. This section discusses Alternative RGW-2C, which includes in-situ source treatment using ERD.

Alternative RGW-2C is similar to Alternatives RGW-2A and RGW-2B, except that the source area would be remediated using ISCO instead of ERD or ISCR. Figures 5-4 and 5-7 depict the proposed treatment areas and conceptual layout of the ISCO injection locations. Unlike ERD and ISCR, ISCO does not require extraction/recirculation of contaminated water although it does require a source of groundwater to be used for mixing and injection of the ISCO compounds. This water would be obtained from a clean area rather than extracted at the downgradient end of the treatment area. The use of site-wide groundwater monitoring would be similar to what was described under Alternatives RGW-2A and RGW-2B.

As presented in Section 3.4.4.3 of the RI report (SulTRAC 2015), groundwater seepage velocity is estimated to range from 0.25 to 2.5 feet per day. At velocities as high as 2.5 feet per day, oxidants can wash out, making direct-push injection infeasible. Therefore, unless pre-design investigations determine otherwise, the source area would be treated using permanent injection wells.

The oxidant would be either permanganate or persulfate, depending on the results of pre-design NOD tests. To the extent possible, the injection wells would be located in public right-of-ways. Transfer pipelines supplying injection wells would be installed in the right-of-way of public roadways and other municipal property (such as parking lots), which would require trenching through streets and easement areas. Process equipment could be located in the municipal parking lot near the intersection of North Walnut Street and East Main Street or Mulberry Street and East Main Street.

Rebound of VOC concentrations can occur when treatment terminates before significant depletion of non-aqueous contaminant mass (sorbed mass and NAPL). To prevent rebound, remedies must focus on the area or areas containing most of the contaminant mass, and ensure adequate contact between contaminants and the remediation chemical. If ISCO is selected, adequate contact would achieve be achieved through ongoing, gradual (continuous) injection of oxidant such that relatively constant oxidant concentrations are maintained within targeted treatment zones for several years. Injection wells would be designed to avoid preferential flow and facilitate vertical distribution of the oxidant. Contaminant concentrations will invariably increase when treatment stops, and if the rebound concentrations exceed treatment objectives, injection would resume. Active remediation would continue until the RAO of at least 70 percent reduction without evidence of rebound is attained or the IA is supplanted by an alternative or permanent remedy.

ISCO would temporarily render the formation inhospitable to anaerobic microorganisms, which would limit the natural biodegradation of the groundwater contaminants. However, the use of ISCO during the IA is not anticipated to adversely impact the potential for MNA at this site as ISCO only temporarily decreases the microbial population (Sahl et. al. 2007). Also, there is little evidence that naturally occurring reductive dechlorination is currently impacting VOCs in this area of the aquifer and therefore biotic processes may not be a significant MNA mechanism even after the IA. If MNA were ever to be selected as a component of a final ROD and site-wide groundwater remedy, it would primarily be accomplished through source depletion abiotically in some areas; that is, contaminant concentrations would attenuate because clean groundwater upgradient of the source area would flush through, gradually depleting residual contamination.

Designing the remedy would require a pilot test and pre-design investigations to refine design parameters. Soil NOD tests would be essential. In addition, construction of additional monitoring wells to refine the "baseline" plume volume estimates and monitor the reduction in dissolved phase mass will be required.

5.2.4.1 Effectiveness

Alternative RGW-2C rates high for effectiveness. This alternative would be protective of human health and the environment because dissolved-phase groundwater contaminant mass would be reduced. ISCO may solubilize naturally occurring heavy metals in treatment areas and cause them to migrate downgradient. However, these dissolved metals would once again return to their insoluble forms when they migrate beyond artificially induced oxidation zones. Also, the injection and monitoring programs will be designed to detect and address potential concerns with regard to use of ISCO, such as spreading of the plume or potentially solubilizing and mobilizing metals. Treatment will commence in Zone A and proceed to areas further downgradient gradually after data from Zone A indicates that the technology is beginning to be effective and operating parameters can be optimized. This will allow adjustment of any operating parameters as needed to minimize risks of spreading high concentrations of VOCs to areas that are currently clean or have significantly lower VOC concentrations. The existing site monitoring well network will be supplemented with additional wells at appropriate locations and depths to monitor the performance of the technology to meet RAOs and to detect lateral or vertical displacement of VOCs, or mobilizing metals at levels of concern. The locations and depths of these wells will be determined during the RD. In addition, the oxidant would be injected at low flow rates. There would not be discrete injection events displacing large pore volumes of groundwater. The network of performance monitoring wells would detect plume spreading if it occurs.

Treatability studies that will be conducted as part of the pre-design will also consider and evaluate the applicable safety considerations for ISCO (or any selected technology) with regard to mobilizing chromium or other metals, allowing the RD to appropriately address any concerns. The conceptual treatment approach (commencing in Zone A) - the zone farthest upgradient from the source water protection area, and gradually proceed to areas further downgradient - will allow adjustment of any operating parameters as needed to ensure protection of the City of Troy's wellfield.

As previously discussed, rebound of VOC concentrations occurs when treatment terminates before significant depletion of non-aqueous contaminant mass (sorbed mass and NAPL). To prevent rebound, the ISCO delivery method would be designed to maintain relatively constant oxidant concentrations within targeted treatment zones for several years using gradual, continuous injections via fixed wells (as

opposed to temporary borings). Injection wells would be designed to avoid preferential flow and facilitate vertical distribution of the oxidant. Contaminant concentrations will invariably increase when treatment stops;, if the rebound concentrations exceed treatment objectives, injection would resume through the existing wells or possibly additional supplemental injection locations and depths if found necessary.

Manganese dioxide is an end product of permanganate redox reactions. Therefore, manganese dioxide precipitation within the treatment areas will occur, and can result in pore space occlusion. However, DNAPL, although conservatively presumed to potentially be present in the source area, has not been observed in samples collected to date and the maximum concentrations of VOCs detected in groundwater were two orders of magnitude below solubility limits. Based on available site hydrogeologic and geochemical information, manganese dioxide precipitation is not anticipated to be a critical factor with regard the effectiveness of the technology at this site.

5.2.4.2 Implementability

Alternative RGW-2C rates moderate for implementability, with the primary challenge being access to public and private property and physical limitations such as structures and utilities. Ohio EPA approval for underground injection would be required.

5.2.4.3 Cost

Alternative RGW-2C would have moderate capital cost. It would have moderate to high O&M costs because of the uncertainty in oxidant demand. NOD is typically low for sand, but even sandy soil can have NODs that vary by factors of 2 to 5. Therefore, a high NOD could more than double oxidant cost. Pre-design studies would include an NOD evaluation to refine the design parameters should this alternative be selected for the IA.

5.2.4.4 Decision

This alternative is retained for further consideration.

5.3 DESCRIPTION OF ALTERNATIVES FOR VAPOR INTRUSION

The vapor intrusion remedial alternatives evaluated for the ETCA site include: (1) no action and (2) installing SSD systems. Alternative VI-2 would require ongoing inspections, indoor air monitoring, and 5-year reviews.

5.3.1 Soil Vapor Alternative VI-1: No Action

The no action alternative provides a reference to evaluate other alternatives. Under Alternative VI-1, no action would be taken to remediate vapor intrusion at the ETCA site under a remedial action. Under the no action alternative, no mitigation or removal systems would be installed.

5.3.1.1 Effectiveness

The no action alternative would not reduce the toxicity, mobility, or volume of contamination at the ETCA site and therefore would not be protective of human health or the environment.

5.3.1.2 Implementability

Although this alternative would be easily implemented, the administrative feasibility of selecting this alternative is very low. It is unlikely that EPA or Ohio EPA would approve of this alternative because it would not provide a mechanism for ensuring adequate protection of human health and the environment.

5.3.1.3 Cost

No capital or O&M costs are associated with this alternative.

5.3.1.4 Decision

The no action alternative will be retained for detailed analysis because the NCP requires that it be used as a standard for evaluating the performance of other remedial alternatives.

5.3.2 Soil Vapor Alternative VI-2: Sub-Slab Depressurization System and Monitoring

This alternative would be used to actively remove soil vapors from beneath the building's slab, find and seal vapor intrusion pathways within the existing building as needed to ensure performance of the SSDS, limit future habitable property development to buildings that include vapor mitigation as part of the new construction design or demonstrate that such features are not needed, and use monitoring to assess the effectiveness of the IA. These technologies may be used in combination or singularly depending on site-specific factors, including the building type and property access. This alternative would be used to mitigate potential VI issues during the IA and may continue until remediation of the source of the vapor intrusion (groundwater contamination) is permanently addressed.

SSDSs employ creation of an extraction point or points in a basement floor that is connected to a high-static pressure extraction fan (EPA 2010). The extraction points typically consist of 3-inch-diameter schedule 40 PVC that is cored in the sub-slab and sealed. The PVC piping is routed outside the building

from the extraction point, where the extraction fan is located. The extraction fan is typically attached to the side of the building and vented through PVC piping above the roof line where no windows or vents for the building are located. SSDSs have been extensively installed for use in radon mitigation. SSDs are commonly used in the region to mitigate VI as well as radon, and installation procedures for installing SSDSs are well documented. Where necessary, sealing may be included on a case by case basis to enhance the performance of the SSDS. If needed, sealing will focus on finding the main entry routes of vapor intrusions. Examples include main seams between construction materials (including expansion and other joints), utility penetrations and sumps, and cracks (EPA 2008). These main entry routes would be sealed with a concrete filler or hydraulic cement (EPA 2010). The use of "Drylock" or epoxy paints may be considered if a large surface area needs to be covered or to cover previously caulked materials in the concrete wall or floor.

The proposed area for VI mitigation (Figure 5-8) is based on reasonably conservative assumptions regarding the exposure areas where groundwater contaminant concentrations appear most likely to result in potential VI concerns; the proposed groundwater treatment sites; and, buffer areas on the lateral and downgradient edges of the plumes. SSDSs are not considered a permanent solution for VI concerns at the site. A permanent solution can only be achieved by addressing the high groundwater concentrations of VOCs. EPA will offer an SSDS to property owners of all structures within the proposed VI mitigation area who will accept it to reduce VI risk in the interim until groundwater contaminant concentrations are reduced to safe levels. Public outreach will be conducted in advance and multiple attempts will be made to encourage participation and ensure that all property owners are contacted and made aware of why the systems are being offered, the potential health risks associated with the plume and groundwater treatment, and the estimated timeframes for which operation of the systems will be required. The property owners will also be informed of the details regarding how the system would be installed and maintained. Outreach support from state and local resources is anticipated to enhance public participation. Based on these considerations, individual property owners may make an informed decision as to whether to accept a system.

Air monitoring would consist of indoor air monitoring and background ambient air monitoring to confirm SSDS performance. Indoor air would be sampled following completion of the SSDS installation to measure contaminant concentrations seasonally over time. Existing and newly constructed SSDSs would also be inspected and maintained to ensure that they function effectively until overall remediation of the VI source is achieved.

5.3.2.1 Effectiveness

This alternative would be effective in protecting human health because the soil vapors beneath the building would be extracted by SSDSs before they can enter the building. Monitoring would be effective in determining if the selected remedy is performing as expected and whether site conditions have changed over time.

The proposed mitigation area encompasses the entire proposed groundwater treatment area as well as buffer zones on the lateral edges and a three-block (approximately 200 yard) buffer zone on the downgradient end. Based on these considerations, the proposed groundwater treatment activity is not anticipated to exacerbate VI concerns in areas beyond the proposed VI mitigation zone. In addition, the potential to form degradation products will somewhat depend on which technology is implemented; for example using ISCO, daughter product formation is less likely. Overall, regardless of the technology implemented, commencing treatment in Zone A and evaluating performance, as well as monitoring for daughter products and potential changes in VOC concentrations in the treatment zones and key lateral downgradient locations as treatment progresses, would provide ample warning should the treatment temporarily exacerbate conditions in areas currently outside the proposed VI mitigation area.

Two of the groundwater alternatives presented herein (RGW-2A and RGW-2B) would involve recirculation of treated groundwater and potentially could generate minor amounts of VOC daughter products through dechlorination of PCE. However, vapor intrusion controls that are planned for individual properties would mitigate concerns regarding vapor intrusion of daughter products throughout the proposed treatment area and beyond in buffer zones extending downgradient/southeastward to Frank Street and along the lateral edges of the plume area.

5.3.2.2 Implementability

This alternative would be moderately difficult to implement. There is a relatively high density of privately owned residential structures over the groundwater treatment areas, and installation of SSDSs would require access from a large number of property owners. Installation would require coordination with owners as well as tenants. The basic mechanics for SSDS design are well known; however, building owners or occupants may not agree to installation of extraction points in a finished basement or may oppose SSDS installation altogether. In addition, due to the varying ages of the structures in the area, a variety of conditions may be encountered that could require specialized design considerations on a case by case basis. For example, older structures may have dirt basement floors requiring installation of a plastic membrane to ensure that the system can function. The number of structures without a slab can be

reasonably estimated based on the locations where such conditions were encountered during the RI and the 2006-2007 time critical removal action (TCRA). (Locations where only indoor air samples were collected and not supplemented with sub-slab samples provide a conservative estimate of structures with dirt basement floors or crawlspaces only. Based on these considerations, 9 out of 110 total locations tested, or roughly 8 percent of the locations, had no slabs. For this reason, 8 percent of the proposed SSDS locations are assumed to have basements with dirt floors.

If other sealing is needed it would involve locating vapor intrusion pathways, accessing those areas, and sealing them. If sub-slab floors and walls are finished (carpet or tile on the floor and drywall on the walls), it may be difficult to find the main entry routes. An owner's consent to remove flooring or walls may be difficult to obtain or may not be an option. Monitoring is readily feasible and would require permission of home owners and tenants and an approved sampling plan.

5.3.2.3 Cost

This alternative would have moderate capital costs and moderate O&M costs. The majority of the capital costs are associated with installation of the SSDS. Although some homes in the area may not have slabs, previous experience has indicated that the number is likely to relatively small and the additional measures required to install effective systems at such locations would not significantly impact the overall cost of the alternative.

The majority of the O&M costs are associated with long-term indoor air monitoring. The number of monitoring points and the frequency of indoor air monitoring would impact the overall O&M costs. Costs associated with power consumption for SSDSs would be the responsibility of the property owner.

Costs associated with institutional controls pertain to administrative costs only. The actual vapor mitigation technologies used for new construction would be based on the type of future construction planned. A contingency would be included with ICs allowing for a waiver of the permit requirement if a demonstration can be made that the new building will not require a mitigation system. Mitigation system and permitting costs for new construction be incurred by the builder or developer and actions and costs associated with mitigation or control systems for future construction are not included in the evaluation of this alternative.

5.3.2.4 Decision

This alternative would be effective in reducing vapor intrusion in the sub-slab (and subsequently indoor air) of each building. Installation of the SSDSs and sealing vapor migration pathways (if required) would require consent from the building owners and tenants and contracting with an experienced SSDS installer. This option would be effective at protecting the human health of the building occupants. It would also be effective in protecting occupants of future buildings through the use of institutional controls requiring vapor mitigation systems. Monitoring would be performed to evaluate the effectiveness of the remedy and whether site conditions have changed over time. Therefore, this alternative is retained for further analysis.

5.4 SUMMARY OF RETAINED ALTERNATIVES

The following alternatives for soil, groundwater, and VI have been identified and retained for detailed analysis in the next section.

Alternative No.	Alternative Description
Soil	
S-1	No Action
S-2	Excavation in Combination with Offsite Disposal for EA-1 (Hobart) and EA-6 (Spinnaker)
S-3	Excavation of Soil at Hobart EA-1 Combined with Off-site Disposal; Asphalt Cap and ICs at Spinnaker EA-6.
Groundwater	
RGW-1	No Action
RGW-2:	In-Situ Source Treatment:
RGW-2A	Source Treatment Using ERD and, Monitoring
RGW-2B	Source Treatment Using ISCR; and, Monitoring
RGW-2C	Source Treatment Using ISCO; and, Monitoring
Vapor Intrusion	
VI-1	No Action
VI-2	Sub-Slab Depressurization System; and, Monitoring

6.0 DETAILED ANALYSIS OF ALTERNATIVES

This section presents a detailed analysis of the soil, groundwater, and VI remedial alternatives. This analysis evaluates the alternatives and supports development of designs for the alternatives retained. The evaluation criteria, which are specified in Subsection 300.430(e)(9)(iii) of the NCP, address the statutory requirements in Section 121 of CERCLA. Although separate sets of alternatives are presented, the interaction of alternatives for each medium and the degree that these alternatives will work together must be considered to provide an effective remedy. In this manner, an IA remedy can then be established by choosing an alternative from each of these three groups, considering the impact of remediation on other media. IA progress will be monitored to evaluate if any additional actions are necessary for a final overall site remedy.

The ETCA site encompasses groundwater contamination that lies beneath hundreds of individually-owned properties. Remedial activities would occur, to the greatest extent possible, on publicly owned areas, such as road right of ways, parking lots, or vacant land. However, to achieve the RAOs specified in this FFS report, various components of the proposed alternatives (such as installation of SSDS) that would occur on, or affect portions of the plumes lying beneath private properties will require consent from private property owners.

The alternative descriptions presented in this section provide a conceptual understanding of each alternative with a level of detail appropriate to evaluate each alternative and support cost assumptions presented in the FFS. A description of the evaluation criteria and detailed evaluations of the alternatives based on these criteria are presented below.

6.1 DESCRIPTION OF EVALUATION CRITERIA

The nine evaluation criteria specified in the NCP are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of the toxicity, mobility, or volume of contaminants through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

Remedial alternatives for soil, groundwater, and vapor intrusion are analyzed in Sections 6.2, 6.3, and 6.4, based on these criteria (with the exceptions discussed below). State and community acceptance will be evaluated after the public comment period. The results of the analysis are used to provide a comparative evaluation of the alternatives in Section 7.0.

Remedial alternatives are evaluated according to the first seven of nine NCP evaluation criteria. The nine criteria can be subdivided into three categories: threshold criteria, primary balancing criteria, and modifying criteria. The threshold criteria (overall protection of human health and the environment; compliance with ARARs) relate to statutory requirements that each alternative must satisfy to be eligible for selection. The primary balancing criteria (long-term effectiveness; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are the technical criteria used as the basis for the detailed analysis. The modifying criteria (state and community acceptance) are assessed formally after the public comment period, although, to the extent they are known, they are factored into the identification of the preferred alternative. The nine NCP evaluation criteria are numbered and defined in the following paragraphs as they pertain to this FFS (EPA 1988, 1990).

In addition, a sustainability criterion has been added for further evaluation of alternatives in this FFS report. Although sustainability is not one of the nine CERCLA-prescribed criteria, it has been included in accordance with EPA Region 5's Greener Cleanup Interim Policy (EPA 2009). Sustainability criteria may be taken into consideration, yet are not required for remedial alternative selection.

6.1.1 Overall Protection of Human Health and the Environment

Alternatives were assessed to evaluate whether they can adequately protect human health and the environment in both the short and long term from unacceptable risks posed by hazardous substances, pollutants, or contaminants through their elimination, reduction, or control so as to achieve levels established during development of remedial goals in accordance with 40 CFR 300.430(e)(2)(i).The overall assessment of protection included other criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

6.1.2 Compliance with ARARs

Each alternative was assessed to evaluate whether it would meet ARARs under federal environmental laws and state environmental or facility citing laws or would provide grounds for invoking one of the waivers under 40 CFR 300.430(f)(1)(ii)(C).

A decision would be made whether a waiver would be appropriate under Section 121 of CERCLA if a specific ARAR cannot be met by an alternative. All chemical-specific, location-specific, and action-specific ARARs identified would be considered in making this decision. Potential federal and state ARARs for the ETCA site are listed in Appendix D.

6.1.3 Long-Term Effectiveness and Permanence

Alternatives were assessed in terms of the long-term effectiveness and permanence they would provide and the degree of certainty that the alternatives would prove successful. Factors that were considered, as appropriate, include the following: (1) the magnitude of residual risk associated with treated and untreated soil, groundwater, and soil vapor that would remain after the conclusion of remedial activities, and (2) the adequacy and reliability of in situ and ex situ treatment systems and access controls needed to manage treated and untreated media.

6.1.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The degree that the alternatives would employ recycling or treatment that reduces the toxicity, mobility, or volume of contaminants in soil, groundwater, and soil vapor was assessed, as was the approach that would be used to reduce the threats posed by the site. Factors considered, as appropriate, include the following: (1) the treatment or recycling process that an alternative would employ and the materials that would be treated; (2) the amounts of hazardous substances, pollutants, or contaminants that would be destroyed, treated, or recycled; (3) the degree of the expected reduction in contaminant toxicity, mobility, or volume that would result from treatment or recycling and the identification of the reduction that would occur; (4) the degree to which treatment would be irreversible; (5) the types and quantities of soil and groundwater contaminants that would remain after treatment, and their persistence, toxicity, mobility, and propensity to bioaccumulate; and (6) the degree to which treatment would reduce the inherent threats posed by contamination at the site.

6.1.5 Short-Term Effectiveness

The short-term effectiveness of alternatives were assessed by considering the following factors, as appropriate: (1) short-term risks that might be posed to the community during implementation of an alternative, (2) potential environmental impacts on workers during remedial activities and the effectiveness and reliability of protective measures, (3) potential environmental impacts of the remedial alternative and the effectiveness and reliability of mitigating measures that would be taken during implementation, and (4) the time required to implement the remedial alternative.

6.1.6 Implementability

The ease or difficulty of implementing the alternative was assessed by considering the following factors, as appropriate, for each alternative: (1) its technical feasibility, including technical difficulties and factors associated with construction and operation of the technology, the ease of undertaking additional remedial activities, and the ability to monitor the effectiveness of the remedy; (2) its administrative feasibility, including the need to coordinate with government offices and agencies and the ability and time required to obtain necessary approvals and permits from government agencies for off-site actions; (3) the availability of required services and materials, including the availability of adequate off-site treatment, storage, and disposal capacity and services; (4) the availability of necessary equipment, appropriate specialists, and any necessary additional resources; and (5) the availability of prospective technologies used in the alternative.

6.1.7 Cost

Cost estimates for the retained alternatives are presented in Appendix C. The types of costs assessed include the following: (1) capital costs, including both direct and indirect costs; (2) annual O&M costs; and (3) the net present value of capital and O&M costs.

Capital costs are divided into direct and indirect costs. Direct capital costs include construction, equipment, and disposal costs. Indirect capital costs include engineering expenses, legal fees, license or permit costs, startup costs, and contingency allowances.

O&M costs include all post-construction costs necessary to ensure the continued effectiveness of an alternative. These costs include labor and materials related to O&M, auxiliary materials and energy, disposal of residues, administration, insurance and licensing, contingency funds related to maintenance, rehabilitation, and periodic site review, if required.

The cost estimates presented in this report were developed using unit costs from Micro-computer Aided Cost Estimating System (MCASES), Second Generation (MII), Version 4.2, 2012 Cost Book, 2013 National Construction Estimator via Get-a-Quote.net, quotations from various vendors, and SulTRAC's experience with similar projects. The accuracy of the cost estimates is expected to lie between +50 and -30 percent, which conforms to EPA guidelines for feasibility studies (EPA 1988). The net present value of each alternative was calculated by summing the present values of capital and O&M costs. The present value is the estimated value of a future expense in current year dollars. Present values were calculated by

discounting future costs using a 7 percent discount rate prescribed for a 30-year period in Office of Management and Budget (OMB) circular A-94 Appendix C revised in December 2014. Therefore, the estimated cost of every alternative is in 2017 dollars and projected over the anticipated duration of each IA alternative.

The cost estimates in this FFS for groundwater alternatives 2A, 2B, and 2C assume treatment of groundwater to depths of up to 100 feet below ground surface (bgs) in the Walnut Street area, and also assumed that treatment/ injections will occur at multiple horizons. For estimating purposes, three horizons were selected because the Waterloo profile data from the west side of Walnut Street suggested relatively consistent hydraulic conductivity at least to depths of 85 feet. However, visual geologic characterization of soil cores from the boring for MW-EPA-107I and nearby borings on the east side of Walnut Street noted some finer grained zones (mostly silty sand and gravel mixtures rather than clay), primarily between 35 and 60 feet bgs, interbedded with coarse sand and gravel, and thus lithology may vary laterally and vertically in the source area. Based on comparison with the nearby Waterloo data, these variations may or may not impact hydraulic conductivity in the areas that will ultimately be treated. Estimates of the exact numbers, locations, and depths of injection wells will be refined through additional data to be collected in pre-design studies to support the RD. If found at the proposed injection sites, the presence of zones of limited hydraulic conductivity or DNAPL will be considered in the RD and may require additional injection depths or other design considerations.

In addition, the estimated remedial timeframes and costs for groundwater alternatives RGW-2A, -2B, and 2C are conservatively based on achieving the upper end of the targeted treatment range of 70 to 90 percent VOC mass removal. These estimates were based on typical performance characteristics of the proposed treatment agents, known and assumed hydrogeolgic and geochemical factors, conceptual level assumptions regarding presumed injection sites and depths, and professional experience employing these technologies at other sites with similar aquifer and contaminant characteristics. For this reason, costs and remedial timeframes for the groundwater alternatives were estimated under a conservative goal of achieving the upper end of the RAO range discussed in Section 2.1.2 (90 percent removal). A 30 percent contingency is factored into the estimated capital cost for each alternative. The current cost estimates reflect the -30% to +50 range specified in EPA guidance for feasibility studies. As described above, various data to be gathered during the RD will reduce the number of assumptions and further refine the cost estimates.

An extensive monitoring well network, that monitors multiple vertical horizons as well as the lateral boundaries of the groundwater contaminant plumes, exists at the site. This network will be supplemented with additional monitoring wells that would be installed to support the RD and support effective monitoring of the performance of the remedy, as well as allow rapid detection of and response to generation of VOC daughter products or mobilization of metals to site groundwater as a result of treatment. The general cost assumptions regarding additional performance monitoring wells that will be installed as part of the IA are presented in Appendix C; however, it should be noted that the exact numbers, locations and depths of additional monitoring wells will be determined as part of the RD.

6.1.8 Sustainability

As previously mentioned, a sustainability criterion has been added for further evaluation of alternatives in this FFS Report. Although sustainability is not one of the nine CERCLA-prescribed criteria, it has been included in accordance with EPA Region 5's Greener Cleanup Interim Policy (EPA, 2009). Sustainability criteria may be taken into consideration, yet they are not required for remedial alternative selection. Sustainability criteria specified in Region 5's Interim Policy factor in an alternatives ability to reduce air pollutant emissions and greenhouse gas production, minimize impacts to water quality and water resources, support sustainable human and ecological use and reuse of remediated land, minimize material use and waste production, and conserve natural resources and energy.

6.2 DETAILED ANALYSIS OF SOIL ALTERNATIVES

Two remedial alternatives for soil contamination are described in Section 5.1. Detailed analyses of the two soil alternatives are presented below.

6.2.1 Detailed Analysis of Soil Alternative S-1: No Action

Alternative S-1 consists of one retained process option: no action. The no action alternative provides a reference to evaluate other alternatives. Under Alternative S-1, no action would be taken to remediate soil under a remedial action. If no action occurred at the site, the soil would be left "as is" without implementation of access controls, containment, removal, treatment, or other mitigating actions. The analysis of the no action alternative is included to provide a comparative baseline used to evaluate other alternatives as required by the NCP.

6.2.1.1 Overall Protection of Human Health and the Environment

Alternative S-1 would not eliminate, reduce, or control risks to human health or the environment posed by contaminated soil. Soil would be left "as is" because no action would occur. Hazardous substances in the

soil may continue to naturally volatilize, biodegrade, dilute, and attenuate over time; however, no monitoring or sampling would be conducted to demonstrate that Alternative S-1 is effective.

6.2.1.2 Compliance with ARARs

Alternative S-1 would not comply with chemical-specific ARARs. Under this alternative, soil would not be monitored to evaluate whether it is being naturally restored to its unrestricted use.

6.2.1.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative S-1.

Magnitude of Residual Risks

Based on the COC concentrations detected during the RI and apparent length of time since the initial releases likely occurred, it appears that natural processes would be too slow to produce a significant change in the magnitude or extent of contamination in the foreseeable future. Therefore, existing risks would remain without any significant reduction in magnitude.

Adequacy and Reliability of Controls

There would be no controls to rely on. The alternative would be inadequate and could not be relied on to protect human health or the environment.

6.2.1.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The toxicity, mobility, and volume of hazardous substances in soil would not be reduced by Alternative S-1 because the soil would not be treated. Contaminant concentrations in the soil might decrease over time as a result of degradation and attenuation; however, the degree of degradation and attenuation would not be monitored.

6.2.1.5 Short-Term Effectiveness

The four short-term effectiveness factors described in Section 6.1.5 are assessed below for Alternative S-1.

The alternative would not pose new health risks to the community, current site occupants, workers, or the environment because Alternative S-1 involves no remedial activities or construction. This alternative would require no time to implement.

6.2.1.6 Implementability

The implementability of Alternative S-1 would depend on its technical and administrative feasibility and the availability of resources required to implement the alternative. No construction or other activities would be required to implement this alternative; therefore, the alternative is technically feasible. This alternative would involve no administrative activities. Alternative S-1 would not require resources or specialized labor and would therefore be easy to implement, but it would not achieve RAOs.

6.2.1.7 Cost

No capital or O&M costs are associated with Alternative S-1.

6.2.1.8 Sustainability

This alternative would be implemented without any heavy construction equipment, which minimizes the material use, waste production, use of natural resources and energy, air pollutants and greenhouse gas production, and impacts to water quality and water resources. Therefore, the lack of use of heavy construction equipment enhances the sustainability of this alternative. However, due to the lack of remedial activity, impacts to water quality and water resources are not minimized, and sustainable reuse of the land is not supported, thereby reducing the sustainability of this alternative.

6.2.2 Detailed Analysis of Soil Alternative S-2: Excavation with Off-site Disposal

This alternative would require excavation of contaminated soil at Hobart and Spinnaker properties (EA-1 and EA-6), and off-site disposal (see Figure 5-1). This alternative assumes that the majority of the contaminated soil excavated would require disposal as nonhazardous waste and a low percentage of the soil would need to be characterized as hazardous waste (assumes that 10 percent of the waste would be characterized as hazardous). Thus, excavated soil would be disposed of off site in both a licensed hazardous waste landfill and a licensed nonhazardous waste landfill.

Soil would be excavated in designated (EA-1 and EA-6) areas of the Hobart) and Spinnaker properties (see Figure 5-1); soil samples would be collected during excavation to ensure all soil exceeding the RAOs was removed to the extent possible given utilities and structures on the properties. As previously discussed, on the Hobart property the action would be taken to address the risk-related RAO associated with EA-1 but may extend into the adjacent portion of EA-2 to achieve the PRGs for protection of groundwater. Groundwater monitoring would be necessary to document that that leaching to groundwater has been reduced and that contaminant concentrations in groundwater show a continued decrease over time – this monitoring is discussed under Alternatives RGW-2A, RGW-2B, and RGW-2C.

Because contaminant concentrations in the vadose zone soils exceed human-health risk and exceed the protection of groundwater goals, these soils would be permanently removed and ICs specifically associated with the soil would not be required. Contaminated material would remain at depths below the water table and in the groundwater and therefore ICs restricting the use of groundwater would be required for the properties, as discussed under Alternatives RGW-2, RGW-2B, and RGW-2C.

6.2.2.1 Overall Protection of Human Health and the Environment

Soil Alternative S-2 would be effective in protecting human health and the environment because contaminated soil at the Hobart and Spinnaker properties that may be a continuing source of contamination to groundwater would be excavated and disposed of off site. The soil cleanup levels that protect groundwater used as drinking water also would protect potential users from all other exposures, such as direct contact and ingestion.

6.2.2.2 Compliance with ARARs

Soil Alternative S-2 would comply with federal and state ARARs. The soil would be remediated to achieve the PRGs. Under this alternative, it is assumed that the majority of the contaminated soil would be disposed of as nonhazardous waste and a portion would be disposed of as hazardous waste. ARARs involving excavation, transportation, and disposal would therefore apply.

6.2.2.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative S-2.

Magnitude of Residual Risks

Under Alternative S-2, the residual risks associated with contaminated soil in EA-1 and EA-6 would be fully mitigated. Soil verification samples would be collected to ensure that target cleanup levels are met after soil is excavated.

Adequacy and Reliability of Controls

Soil Alternative S-2 uses a reliable and proven technology that can achieve the cleanup levels for PCE and TCE in soil. Soil excavation is a reliable and proven technology that can achieve the cleanup goals for the Hobart and Spinnaker properties.

6.2.2.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The ability of Alternative S-2 to satisfy the evaluation criterion of contaminant toxicity, mobility, or volume through treatment, described in Section 6.1.4, is discussed below.

Destruction of Toxic Hazardous Substances

The toxicity of hazardous substances at the site is expected to be reduced. Excavation of soil and disposal off site in a landfill would not destroy any contaminants.

Reduction of Total Mass of Toxic Hazardous Substances

The total mass of VOCs present in soil at the Hobart and Spinnaker properties would remain in the excavated soil that would be transported to a protective landfill for disposal. Excavation and disposal off site in a landfill would not reduce the mass of contaminated soil. However, the total mass of VOC-contaminated soil at the ETCA site would be reduced by removal of soil from EA-1 and EA-6 and disposal at a landfill.

Irreversible Reduction of Hazardous Substance Mobility

The removal of soils with VOC contamination from EA-1 and EA-6 at the Hobart and Spinnaker properties would be irreversible; however, the mass of contaminants would remain in the excavated soil that would be transported to a protective landfill for disposal. Excavation and disposal off site in a landfill would minimize future impacts to groundwater at the site since the VOCs would be removed with the soil.

Reduction of Total Volume of Contaminated Media

The volume of contaminated soil at the Hobart and Spinnaker properties EA-1 and EA-6 would be transported to a protective landfill for disposal. Excavation and disposal off site in a landfill would reduce contaminated soil volume at the site, however, it would be transported and placed in an engineered (landfill) containment cell.

6.2.2.5 Short-Term Effectiveness

The four short-term effectiveness factors described in Section 6.1.5 are assessed below for Alternative S-2.

Protection of Community

The community would be exposed to minimal risks if Alternative S-2 is implemented. There would be an increased risk of contaminant transport via air or surface runoff during excavation at the Hobart and Spinnaker properties. Risks during construction may include spilling contaminated wastes, spilling

hazardous materials, damaging utilities or structures, environmental releases through wind and stormwater erosion, dust generation, physical hazards from heavy equipment, traffic disturbance resulting from road or lane closures, and noise. Fuel for equipment would most likely be stored on site. These risks would be minimized by employing dust-suppression methods during excavation and loading the dump trucks, and the dump trucks would be covered with tarps during transport. A storm water pollution prevention plan would be developed to minimize risks of transport of contaminated soil with storm water surface runoff. Engineering controls and safe work practices would minimize these risks.

Protection of Workers

Workers would be protected from direct contact with and inhalation of hazardous substances in soil through use of proper health and safety measures. Air monitoring and engineering controls would be used to minimize worker exposure, and workers would be equipped with proper protective clothing and respiratory equipment, as necessary. It is assumed that workers would perform all construction work wearing Level D personal protective equipment (PPE). Construction would include excavation of contaminated soils at the Hobart and Spinnaker properties and placement of backfill. In addition, physical hazards associated with excavation would be minimized through use of standard construction safety practices. Earth moving and drilling near gas, water, sewer and electric utilities would add to worker risks.

Environmental Impacts

No significant, adverse, short-term environmental impacts are anticipated from excavation of contaminated soil for off-site disposal. Minimal risks would be posed to the environment from off-site transportation of contaminated material by dump truck. There would, however, be an increased risk of contaminant transport via air or surface runoff. These risks would be minimized by employing dust suppression during excavation and loading of the dump trucks, and the dump trucks would be covered with tarps during transport. A storm water pollution prevention plan would be developed to minimize risks of transport of contaminated soil with storm water surface runoff.

Time Required to Implement the Remedial Action and Achieve RAOs

It is anticipated that about 3 months would be needed to obtain required access permits from MCD, mobilize, clear utilities, excavate the soil for off-site disposal, and restore the sites. The timeframe to achieve RAOs would therefore be 3 months for the Spinnaker and Hobart properties, because the contaminated soil would be removed from the properties.

6.2.2.6 Implementability

The technical and administrative feasibility of implementing Alternative S-2 and the availability of required resources are discussed below.

Technical Feasibility

Excavation of soil at the Hobart and Spinnaker properties would be moderately easy to implement; however, soil would be excavated from areas adjacent to the active industrial buildings, which would require care to avoid damaging the buildings. Excavation would require coordination with property owners. Excavation and transportation and off-site disposal are standard technologies.

Confirmation sampling of soil during excavation of the Hobart and Spinnaker properties would verify that all soil with contamination concentrations above RAOs was removed. The excavations would be filled with clean fill soil and the surface restored as prior to the excavation (gravel at Hobart EA-1 and EA-2 and asphalt pavement at Spinnaker EA-6). This approach would leave the areas readily accessible if additional remedial actions are necessary in the future. .

Administrative Feasibility

Alternative S-2 would require coordination with city and local officials and private utility companies since various utilities run through the sites. The soil excavation at the Hobart and Spinnaker properties would also require coordination with transportation providers and disposal facilities as well as the property owners and other entities for purposes of accessibility (MCD). Although the excavation will not extend onto MCD property, the limited space behind the Hobart building will likely necessitate some locations to be accessed via the MCD property adjacent to the levee.

Availability of Required Resources

The services and materials needed to implement Alternative S-2 would be readily available. All services and materials are common and available from several sources.

6.2.2.7 Cost

The estimated capital and O&M costs for Alternative S-2 are detailed in Appendix C, Table C-1-1. The estimated capital cost is $1,762,724. There are no O&M costs. Costs associated with monitoring the site groundwater and ICs restricting site groundwater use are included in groundwater Alternatives RGW-2A, 2B and 2C. The total present worth cost of Alternative S-2, including a 30 percent contingency, is $$2,290,000.

6.2.2.8 Sustainability

Factors that enhance the sustainability for this alternative would include reuse of the land and involve measures to reduce impacts to water quality. Factors that reduce the sustainability of this alternative include use of natural resources and energy (transportation to landfill, import of backfill materials, and fuel for equipment and vehicles) and air pollutant and greenhouse gas emissions (product of vehicle fuel combustion), during the soil excavation, transport, and disposal.

6.2.3 Detailed Analysis of Soil Alternative S-3: Excavation of Soil at Hobart EA-1 Combined with Off-site Disposal; Asphalt Cap and ICs at Spinnaker EA-6.

This alternative would require excavation and off-site disposal of contaminated soil from Hobart (EA-1) and capping of contaminated soil at Spinnaker (EA-6) (see Figure 5-2).

Soil would be excavated in Hobart EA-1 (see Figure 5-2); soil samples would be collected during excavation to ensure all soil exceeding the RAOs was removed to the extent possible given utilities and structures on the properties. As previously discussed, on the Hobart property the action would be taken to address the risk-related RAO associated with EA-1 but may extend into the adjacent portion of EA-2 to achieve the PRGs for protection of groundwater. Groundwater monitoring would be necessary to document that that leaching to groundwater has been reduced and that contaminant concentrations in groundwater show a continued decrease over time – this monitoring is discussed under Alternatives RGW-2A, RGW-2B, and RGW-2C.

This alternative assumes that the majority of the contaminated soil excavated at EA-1 would require disposal as nonhazardous waste and a small percentage of the soil would need to be characterized as hazardous waste (for FFS purposes, it is assumed that 10 percent of the waste would be characterized as hazardous). Thus, excavated soil would be disposed of off site in both a licensed hazardous waste landfill and a licensed nonhazardous waste landfill.

At EA-6 (Spinnaker) the existing asphalt pavement would be removed and an engineered cap would be installed. Cost estimates herein assume an asphalt cap. The actual cap components and construction sequence will be determined during the remedial design. If an asphalt cap is deemed appropriate, it will be designed to comply with the requirements in “Asphalt Covers to Prevent Leaching at Industrial Sites, August 18, 2003,” and will include liners and drainage layer materials (Ohio EPA 2003). It is assumed that the existing asphalt at Spinnaker will require replacement to meet the Ohio EPA requirements.

Because contaminant concentrations in the vadose zone soils at EA-1 exceed human-health risk and exceed the protection of groundwater goals, these soils would be permanently removed and therefore ICs specifically associated with the soil in EA-1would not be required. The risk of contact and leaching would be eliminated, and current Troy ordinances limit use of private potable supply wells. However, soils in the vadose zone at EA-6 that exceed human-health risk and protection of groundwater goals will be left in place but capped to prevent direct contact with potential receptors and to prevent surface infiltration and leaching. For this reason, ICs that restrict future use of the capped area and ensuring O&M in perpetuity would be required.

6.2.3.1 Overall Protection of Human Health and the Environment

Soil Alternative S-3 would be effective in protecting human health and the environment because contaminated soil at the Hobart and Spinnaker properties that may be a continuing source of contamination to groundwater would be excavated and disposed of off site from EA-1, and capped in EA-6. Removal of vadose zone soil at EA-1 and capping at EA-6 will be equally effective in preventing direct contact with contaminated soil.

6.2.3.2 Compliance with ARARs

Soil Alternative S-3 would comply with federal and state ARARs. The soil would be remediated or capped to achieve the PRGs. Under this alternative, it is assumed that the majority of the excavated contaminated soil would be disposed of as nonhazardous waste and a portion would be disposed of as hazardous waste. ARARs involving excavation, transportation, and disposal would therefore apply for excavation. The cap for EA-6 would be designed in accordance with State of Ohio ARARs for asphalt caps.

6.2.3.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative S-3.

Magnitude of Residual Risks

Under Alternative S-3, the residual risks associated with contaminated soil in EA-1 would be fully mitigated. Soil verification samples would be collected to ensure that target cleanup levels are met after soil is excavated. Residual risk would be fully mitigated in EA-6; although such mitigation would rely on ICs governing use and maintenance of the capped area.

Adequacy and Reliability of Controls

Soil Alternative S-3 uses reliable and proven technologies that can either achieve the cleanup levels for PCE and TCE in soil at EA-1 or achieve the containment objectives at EA-6. Soil excavation is a reliable and proven technology that can achieve the cleanup goals for the Hobart property. Asphalt caps and associated ICs such as zoning controls, covenants or deed restrictions are also reliable and proven approaches that would be effective in meeting the RAOs of preventing contact with contaminated soil and preventing infiltration and leaching through the contaminated zone.

6.2.3.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The ability of Alternative S-3 to satisfy the evaluation criterion of reducing contaminant toxicity, mobility, or volume through treatment, described in Section 6.1.4, is discussed below.

Destruction of Toxic Hazardous Substances

The pathway for direct contact with toxic hazardous substances would be eliminated by the combination of removing some, and capping the remainder, of the contaminated soil. However, this alternative would not actually reduce or eliminate the chemical toxicity of the substances as the substances would either be transferred to a disposal landfill or left in place.

Reduction of Total Mass of Toxic Hazardous Substances

The total mass of VOCs present in soil at the Hobart and Spinnaker properties would remain in the excavated soil from EA-1 that would be transported to a protective landfill for disposal and the soil that will remain in place under the cap at EA-6. Thus Alternative S-3 will not reduce the net mass of contaminated soil. However, the total mass of VOC-contaminated soil at the ETCA site would be reduced by removal of soil from EA-1 that is disposed of off-site at a landfill.

Irreversible Reduction of Hazardous Substance Mobility

The removal of soils with VOC contamination from EA-1 would be irreversible; however, the mass of contaminants would remain in the excavated soil that would be transported to a protective landfill for disposal. Excavation and disposal off site in a landfill would minimize future impacts to groundwater at the site since the VOCs would be removed with the soil. A reduction of the mobility of substances in EA-6 would be contingent on ongoing maintenance of the cap; should the cap be disturbed, cracked or otherwise breeched, surface infiltration could remobilize contaminants from the covered area into groundwater.

Reduction of Total Volume of Contaminated Media

The volume of contaminated soil at the Hobart property (EA-1) would be transported to a protective landfill for disposal. Excavation and disposal off site in a landfill would reduce contaminated soil volume at the site, however, it would be transported and placed in an engineered (landfill) containment cell. Construction of an asphalt cap at the Spinnaker property (EA-6) would not reduce the total volume of contaminated soil in that area.

6.2.3.5 Short-Term Effectiveness

The four short-term effectiveness factors described in Section 6.1.5 are assessed below for Alternative S-3.

Protection of Community

The community would be exposed to minimal risks if Alternative S-3 is implemented. There would be an increased risk of contaminant transport via air or surface runoff during excavation and capping at the Hobart and Spinnaker properties. Risks during construction may include spilling contaminated wastes, spilling hazardous materials, damaging utilities or structures, environmental releases through wind and stormwater erosion, dust generation, physical hazards from heavy equipment, traffic disturbance resulting from road or lane closures, and noise. Fuel for equipment may be temporarily stored on site. These risks would be minimized by establishing an exclusion zone for the work and staging areas, employing dust-suppression methods during excavation and loading the dump trucks, and the dump trucks would be covered with tarps during transport. A storm water pollution prevention plan would be developed to minimize risks of transport of contaminated soil with storm water surface runoff. Engineering controls and safe work practices would minimize these risks.

Protection of Workers

Workers would be protected from direct contact with and inhalation of hazardous substances in soil through use of proper health and safety measures. Air monitoring and engineering controls would be used to minimize worker exposure, and workers would be equipped with proper protective clothing and respiratory equipment, as necessary. It is assumed that workers would perform all construction work wearing Level D personal protective equipment (PPE). Construction would include excavation of contaminated soils at the Hobart property with placement of backfill; removal of existing asphalt pavement in EA-6 at the Spinnaker property, and construction of an ARAR-compliant asphalt cap in the same area. In addition, physical hazards associated with excavation would be minimized through use of standard construction safety practices. Earth moving and drilling near gas, water, sewer and electric utilities would add to worker risks.

Environmental Impacts

No significant, adverse, short-term environmental impacts are anticipated from excavation of contaminated soil for off-site disposal. Minimal risks would be posed to the environment from off-site transportation of contaminated material by dump truck. There would, however, be an increased risk of contaminant transport via air or surface runoff. These risks would be minimized by employing dust suppression during excavation and loading of the dump trucks, and the dump trucks would be covered with tarps during transport. A storm water pollution prevention plan would be developed to minimize risks of transport of contaminated soil with storm water surface runoff.

Time Required to Implement the Remedial Action and Achieve RAOs

It is anticipated that about 6 months would be needed to obtain required access permits from MCD, complete the design and obtain approval from Ohio EPA for the cap, and coordinate access with the neighboring property owners. Another 3 months would be required to mobilize, clear utilities, excavate the soil from EA-1 and existing asphalt from EA-6 for off-site disposal, construct the cap, and restore the sites. ICs could be developed and enacted as the cap construction progressed. The timeframe to achieve RAOs would therefore be 9 months, because the pathway for contact and potential for leaching VOCs to groundwater would be eliminated. Ongoing O&M for the cap would continue in perpetuity.

6.2.3.6 Implementability

The technical and administrative feasibility of implementing Alternative S-3 and the availability of required resources are discussed below.

Technical Feasibility

Excavation of soil at the Hobart property would be moderately easy to implement; however, soil would be excavated from areas adjacent to the active industrial buildings and possibly near the MCD levee property, which would require care to avoid damage. Excavation would require coordination with property owners. Excavation and transportation and off-site disposal are standard technologies.

Confirmation sampling of soil during excavation would verify that all soil with contamination concentrations above RAOs was removed. The excavation would be filled with clean fill soil and the surface restored as prior to the excavation (currently gravel at Hobart EA-1 and EA-2). This approach would leave the area readily accessible if additional remedial actions are necessary in the future.

Capping of soil at EA-6 and measures to ensure performance with regard to RAOs into the future would be moderately difficult to implement. At EA-6 (Spinnaker) the existing asphalt pavement would have to first be removed. This would be followed by construction of an asphalt cap, capable of meeting performance requirements sufficient to eliminate the direct contact pathway and inhibit surface infiltration. The cap will include liners and drainage layers. The actual cap components and construction sequence will be determined during the remedial design but would require coordination with Spinnaker operations as it would use of the capped area during, and limit use following construction, and require staging areas and clear access for heavy equipment. Due to EA-6's position on the western Spinnaker property line, it is likely that coordination and access permission from the neighboring property owner would also be required. Some site restoration may be required due to the possible need to drive heavy equipment on adjacent properties. A cap would require periodic inspections – patching, resurfacing and documentation - to ensure performance.

Administrative Feasibility

Alternative S-3 would require coordination with city and local officials and private utility companies since various utilities run through the sites. The soil excavation at the Hobart property would also require coordination with transportation providers and disposal facilities as well as the property owners and other entities for purposes of accessibility (MCD). Although the excavation will not extend onto MCD property, the limited space behind the Hobart building will likely necessitate some locations to be accessed via the MCD property adjacent to the levee.

An asphalt cap for EA-6 would be required to be designed and constructed to comply with the requirements in Ohio EPA's "Asphalt Covers to Prevent Leaching at Industrial Sites, August 18, 2003" and Ohio Department of Transportation (ODOT) specifications (ODOT 2015) for pavement as the area is assumed to be traffic-bearing. Construction would require coordination with Spinnaker operations as it would limit use of EA-6 and adjacent areas during construction and would also affect future land use on the capped area. Due to EA-6's position on the western Spinnaker property line, it is likely that coordination and access permission from the neighboring property owner would also be required. ICs would be required to prevent future disturbance of and ensure maintenance of the cap in perpetuity and thus may involve deed restrictions, covenants and easements. Documentation of O&M and ongoing administrative activities would be required.

Availability of Required Resources

The services and materials needed to implement Alternative S-3 would be readily available. All services and materials are common and available from several sources.

6.2.3.7 Cost

The estimated capital and O&M costs for Alternative S-3 are detailed in Appendix C, Table C-1-2. The estimated capital cost is $1,642,949. Institutional controls are estimated to cost approximately $21,000 to prepare and implement. Annual inspection and O&M and associated reporting costs are estimated to be $14,500. Costs associated with monitoring the site groundwater are included in groundwater Alternatives RGW-2A, -2B and -2C. The total present worth cost of Alternative S-3, including a 30 percent contingency, is $2,470,000.

6.2.3.8 Sustainability

Factors that enhance the sustainability for this alternative would include reuse of the land (although for limited purposes in EA-6) and involve measures to reduce impacts to water quality. Factors that reduce the sustainability of this alternative include use of natural resources and energy (transportation to landfill, import of backfill materials, and fuel for equipment and vehicles) and air pollutant and greenhouse gas emissions (product of vehicle fuel combustion), during the soil excavation, transport, and disposal and construction of the cap.

6.3 DETAILED ANALYSIS OF GROUNDWATER ALTERNATIVES

Four remedial alternatives for groundwater are described in Section 5.2. Detailed analyses of these groundwater alternatives are presented below.

6.3.1 Detailed Analysis of Groundwater Alternative RGW-1: No Action

Alternative RGW-1 would take no action to address groundwater at the ETCA site. In accordance with the NCP, this alternative is evaluated only to provide a benchmark for comparison to other alternatives.

6.3.1.1 Overall Protection of Human Health and the Environment

Alternative RGW-1 would not protect human health or the environment because nothing would be done to control existing risks. Contaminants in groundwater would continue to degrade the environment as well as endanger human health through uncontrolled potential exposure pathways, including ingestion, inhalation, and dermal contact.

6.3.1.2 Compliance with ARARs

Alternative RGW-1 would not comply with chemical-specific ARARs.

6.3.1.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative RGW-1.

Magnitude of Residual Risks

Natural processes would be too slow to produce a significant change in the magnitude or extent of contamination in the foreseeable future. Therefore, existing risks would remain without any significant reduction in magnitude.

Adequacy and Reliability of Controls

There would be no controls. The alternative would be inadequate and could not be relied on to protect human health or the environment.

6.3.1.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

This alternative does not involve treatment and would therefore not reduce toxicity, mobility, or volume of contaminants through treatment.

6.3.1.5 Short-Term Effectiveness

The alternative would not pose new health risks to the community, current site occupants, workers, or the environment because Alternative RGW-1 involves no remedial activities or construction. This alternative would require no time to implement.

6.3.1.6 Implementability

The implementability of Alternative RGW-1 would depend on its technical and administrative feasibility and the availability of resources required to implement the alternative. No construction or other activities would be required to implement this alternative; therefore, the alternative is technically feasible. This alternative would involve no administrative activities. Alternative RGW-1 would not require resources or specialized labor and would therefore be easy to implement, but it would not achieve RAOs.

6.3.1.7 Cost

No capital or O&M costs are associated with Alternative RGW-1.

6.3.1.8 Sustainability

This alternative would not consume any energy and would thus conserve energy sources. On the other hand, it may allow continued degradation of a sole-source aquifer resource that provides water to over 25,000 residents in Troy and also would not provide progress toward restoring this resource. Therefore, overall, this alternative would rate low for sustainability.

6.3.2 Detailed Analysis of Groundwater Alternative RGW-2A: Source Treatment using ERD; and, Groundwater Monitoring

Alternative RGW-2A would treat the most contaminated portions of the plume via biostimulation and bioaugmentation. The area targeted for treatment is shown on Figure 5-4 and a detail of the conceptual layout of the Zone A treatment area is shown in Figure 5-5. Additional monitoring wells (locations to be determined) would be installed to refine baseline estimates of dissolved phase contaminant mass and monitor progress of the source area remedy. Active remediation would continue until the average dissolved-phase contaminant mass, as determined through collection of groundwater samples over time, in treatment Zone A, and the total amount in Zones A through D, has been reduced by 70 to 90 percent without any evidence of rebound.

The entire plume area falls within the Troy city limits and municipal water service area. For all residences in this area, Troy municipal ordinances currently in place (1) restrict connection of a potable supply well to any household system that is connected to the Troy municipal system, and (2) require all new construction to be connected to the municipal system and not use private potable supply wells. The Troy ordinances would continue to prevent exposure to contaminated groundwater while the IA is being implemented and therefore ICs are not included as part of this alternative. Groundwater monitoring would be conducted during the IA to evaluate remedial progress. Specifically, groundwater monitoring would be conducted in the Residential Area PCE plume area to evaluate the effectiveness of the groundwater IA and conducted in the East Water Street plume area to evaluate whether the soil IA was effective in reducing groundwater contaminant concentrations. It is likely that groundwater monitoring would be extended beyond the IA (as part of the final long-term remedy) until remediation goals are attained.

6.3.2.1 Overall Protection of Human Health and the Environment

Alternative RGW-2A would destroy more than 70 percent of the dissolved phase contaminant source mass through treatment. Current City of Troy ordinances that are currently in place would prevent human exposure to contaminated groundwater until the final remediation goals have been attained. Risk of

impact to the city's East wellfield would be minimized by sequencing applications of the remedy gradationally to evaluate the aquifer's response beginning in treatment in Zone A, which is located farthest from the East wellfield. Treatment parameters could then be adjusted if needed, as treatment is initiated in Zones B, C, and D. Ongoing monitoring will be conducted as the IA progresses gradually and the RD will include potential appropriate corrective measures that could be further evaluated and implemented in the event that formation of daughter products appears to present a significant concern. Examples of various types of corrective measures that could be implemented include PRB, abiotic dechlorination, air sparging, chemical oxidation, etc. If necessary, corrective measures could be employed to remove or reduce daughter product concentrations and the specific corrective measure chosen would depend on the alternative selected, design parameters and types, locations and concentrations of daughter products present; therefore, specific measures cannot be identified in the FFS at this time. However, this approach will allow ample time for corrective measures should the remedy not progress as predicted. For instance, groundwater from the farthest upgradient treatment area west of Mulberry Street would take at least 2 years to arrive at the East wellfield. If this area discharged daughter products at problematic concentrations, the daughter product plume would take 1 to 5 years to reach Union Street, where it could be intercepted and contained. Lessons learned from the first treatment area could then be applied as the remediation applications continued to advance downgradient. The risk of discharging elevated concentrations of daughter products would decrease with distance from the source because the concentration of PCE being treated would decrease. Based on these considerations, it is unlikely that daughter products from treatment would affect the East wellfield. Naturally occurring metals solubilized by treatment are not expected to migrate more than a few hundred feet beyond the treatment area, which would be at least 1,000 feet upgradient of the East wellfield. Workers and the community would be protected during remediation through safe work practices and engineering controls. Therefore, this alternative would protect human health and the environment in both the short and long term.

6.3.2.2 Compliance with ARARs

Due to the need for recirculation, this alternative would require Ohio EPA approval for reinjection of extracted groundwater. However, it is anticipated that Alternative RGW-2A would comply with federal and state ARARs.

6.3.2.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative RGW-2A.

Magnitude of Residual Risks

After the remediation goals for the IA are attained, residual risk would be reduced, but not eliminated. However, the IA is expected to reduce concentrations to the point that a wider range of remedies focused on final cleanup goals, could be considered and implemented at a future date.

Adequacy and Reliability of Controls

City of Troy ordinances currently in place would continue to prevent inadvertent exposure to contaminated groundwater. Sentinel wells would provide advance warning of conditions requiring correction. The sequence of the injections would provide an added level of control to minimize the risk of affecting the East wellfield. Long-term groundwater monitoring would track remedial progress as well as provide information that could be used to optimize the remedy.

6.3.2.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The ability of Alternative RGW-2A to satisfy the evaluation criterion of contaminant toxicity, mobility, or volume through treatment, described in Section 6.1.4, is discussed below.

Destruction of Toxic Hazardous Substances

Alternative RGW-2A would destroy COCs in targeted treatment areas producing harmless ethene and ethane. Treatment would be irreversible.

Reduction of Total Mass of Toxic Hazardous Substances

Alternative RGW-2A would reduce the total dissolved phase mass of COCs in targeted treatment areas by 70 to 90 percent.

Irreversible Reduction of Hazardous Substance Mobility

Alternative RGW-2A would not reduce the mobility of COCs.

Reduction of Total Volume of Contaminated Media

Treatment to 70 to 90 percent reduction in dissolved phase mass in Zones A-D is anticipated to reduce the downgradient extent of the plume over time, and thus reduce the volume of contaminated media.

6.3.2.5 Short-Term Effectiveness

The four short-term effectiveness factors described in Section 6.1.5 are assessed below for Alternative RGW-2A.

Protection of Community

Risks during construction may include spilling contaminated wastes (from well construction), spilling hazardous materials, damage to utilities, environmental releases through wind and stormwater erosion, dust generation, physical hazards from heavy equipment, traffic disturbance resulting from road or lane closures, and noise. The vast majority of materials used for remediation would be nonhazardous, and fuel for construction equipment would comprise the bulk of hazardous materials stored on site. Engineering controls and safe work practices would minimize these risks. The recirculation process will require management (treatment and disposal) of extracted groundwater that is likely to be contaminated with VOCs; this water will be treated to remove VOCs before it is discharged for disposal (herein assumed to be via the sanitary sewer/POTW). Costs herein assume that treatment will be accomplished using air stripping, necessitating sampling of influent and effluent water to ensure effectiveness. SSDSs, to be installed in structures overlying the proposed treatment area as part of Alternative VI-2 will provide protection from VI during and after implementation of the groundwater IA.

In addition, of the retained alternatives, ERD has the potential to generate minor amounts of intermediate byproducts of dechlorination of PCE and TCE, including TCE, cDCE, and VC, that could in turn continue to present a VI risk. This risk would be minimized at locations where SSDSs are installed within and downgradient from the proposed treatment areas, as discussed later in Section 6.4.2, under Alternative VI-2. ERD may also generate methane; as previously discussed, the amount of methane is not anticipated to significantly affect the vadose zone; however methane will be a required groundwater monitoring parameter and can be adjusted through the addition of methane inhibitors if needed.

Protection of Workers

Physical hazards from heavy equipment would pose the majority of risk to workers. Workers may also be exposed to contaminated or hazardous materials. Work in public rights-of-way may also expose workers to risk of collision with public vehicles. Earthmoving and drilling near gas and electric utilities would add to worker risks. These risks would be minimized by following safe work practices and using PPE. Engineering controls, such as dust suppression and utility clearance, would further reduce risk to workers.

Environmental Impacts

Generation of greenhouse gases by construction equipment and personnel vehicles would be the only certain environmental impact. If air stripping is used as an ancillary process to treat groundwater generated by recirculation in Zone A, some VOCs may be emitted by the process. Accidental releases of

contaminated or hazardous material could also affect the environment, but could be mitigated through good housekeeping and spill prevention and countermeasures

Time Required to Implement Remedial Action and Achieve RAOs

It is estimated that it will take 6 months to complete pre-design tests and 6 months to complete the design. Once injections commence, it is estimated that it will take approximately one year for the ERD compound to distribute through the targeted treatment zone. The estimated timeframe assumed for the IA to achieve the PRGs herein is assumed to be 15 years, based on the achieving the upper end of the 70 to 90 percent mass reduction objective across all areas (A-D). This is based on a schedule of phased injection and the apparent half-life for PCE and potential degradation products (TCE, cDCE and VC) to be reduced to 10 percent or less of the average initial concentrations. The estimated timeframe for the technology to achieve 90 percent reduction in a single zone is estimated to be within 8 years of commencing treatment in that zone. Timeframes to achieve the lower end of the goal (70 percent reduction) would be anticipated to be shorter. Additional details regarding the assumed treatment sequence and timeframes are provided in Appendix C. Note that the estimated timeframe assumes that a period of time following cessation of injections will be required for VOC concentrations throughout Zones A-D to be reduced to the goals. Groundwater monitoring will be continued during this period to evaluate progress toward the remedial goals.

6.3.2.6 Implementability

The technical and administrative feasibility of implementing Alternative RGW-2A and the availability of required resources are discussed below.

Technical Feasibility

Alternative RGW-2A would be difficult to implement. Ensuring proper distribution of bioremediation amendments within targeted treatment areas may prove challenging because of space constraints. For this reason, targeting the potential source area underneath the former Troy One-Hour dry cleaning facility may be difficult. Recirculation may be the only viable process option to inject amendments into the area beneath the interior portion of the present structure. This alternative would require injection wells, extraction wells, and associated piping connecting these wells to central process equipment. Targeting contamination over extended vertical intervals within treatment areas would require nested injection wells screened at multiple depths. The urban landscape, abundance of utilities, and property ownership and control would make it difficult to install remediation wells and conveyance pipelines. Injection and/or extraction locations would possibly be needed upgradient from the source area (on the Market and East

Main Street sides of Zone A) as well as on the Walnut Street side of the source area, where dissolved phase groundwater PCE concentrations up to 3,560 µg/L were detected,). Predesign studies would be required to determine injection locations and horizons as well as evaluate aquifer hydrogeological and geochemical characteristics in those locations. Management of extracted water may be problematic if the extracted volume exceeds what can be reinjected. Costs herein assume that groundwater in Zone A will be treated to remove VOCs and disposed of via the sanitary sewer/ POTW.

Administrative Feasibility

In general, Alternative RGW-2A is anticipated to meet the requirements of all regulatory agencies. However, developing the details of implementation to the satisfaction of all parties involved would require significant effort. These details may including work in public rights-of-way, access to private property, traffic control, obtaining UIC permits for underground injection, location of infrastructure, groundwater monitoring, and contingency measures.

Availability of Required Resources

All resources except for horizontal drilling services would be readily available. Longer lead times would be needed to procure specialized horizontal drilling services. All materials necessary to construct and implement the remedy would also be readily available.

6.3.2.7 Cost

The estimated capital and O&M costs for Alternative RGW-2A are detailed in Appendix C, Table C-2-1. The estimated capital cost (construction plus pre-design studies) without contingency is $ 10,943,795and the present worth O&M cost without contingency is $3,493,592. The total present worth cost for Alternative RGW-2A, with 30 percent contingency, is $18,769,000.

6.3.2.8 Sustainability

Alternative RGW-2A would reduce contaminant mass and thus be a significant step toward restoring a sole-source aquifer, removing a threat to the city's water supply and reducing VI potential over the plume. However, full restoration of the aquifer to beneficial use is not an objective of the IA and should be addressed when deciding on the final remedy for the site. This alternative would be energy intensive and would consume significant quantities of natural resources to attain remediation goals. However, if the remedy were not implemented, future consumption of natural resources to decontaminate the city's water supply and operate SSDSs above the plume area could be equally significant. With the benefit of remediation outweighing the expense, Alternative RGW-2 appears sustainable.

6.3.3 Detailed Analysis of Groundwater Alternative RGW-2B: Source Treatment using ISCR; and, Groundwater Monitoring

Alternative RGW-2B is similar to Alternative RGW-2A, except that the chemical used for biostimulation would also cause direct chemical dechlorination. The area targeted for treatment is shown on Figure 5-4 and a detail of the conceptual layout of the Zone A treatment area is shown in Figure 5-6. The chemical used may be one of many proprietary products that combine ZVI or ferrous iron with organic carbon.

6.3.3.1 Overall Protection of Human Health and the Environment

Alternative RGW-2B would destroy more than 70 percent of the dissolved-phase contaminant source mass through treatment and would protect human health and the environment in the same manner as RGW-2. If naturally occurring metals are solubilized by treatment, they are not expected to migrate more than a few hundred feet beyond the treatment area, which would be at least 1,000 feet short of the East wellfield. Workers and the community would be protected during remediation through safe work practices and engineering controls. Therefore, this alternative would protect human health and the environment in both the short and long term.

6.3.3.2 Compliance with ARARs

Alternative RGW-2B would comply with ARARs.

6.3.3.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative RGW-2B.

Magnitude of Residual Risks

After attainment of remediation goals, residual risk would be eliminated.

Adequacy and Reliability of Controls

The entire plume area falls within the Troy city limits and municipal water service area. For all residences in this area, Troy municipal ordinances currently in place (1) restrict connection of a potable supply wells to any household system that is connected to the Troy municipal system, and (2) require all new construction to be connected to the municipal system and not use private potable supply wells. These ordinances would continue to prevent inadvertent exposure to contaminated groundwater. Sentinel wells would provide advance warning of conditions requiring correction. Sequencing the remedy would provide an added level of control to minimize the risk of affecting the East wellfield. Groundwater

monitoring would track the progress of remediation as well as provide information that could be used to optimize the remedy.

6.3.3.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The ability of Alternative RGW-2B to satisfy the evaluation criterion of contaminant toxicity, mobility, or volume through treatment, described in Section 6.1.4, is discussed below.

Destruction of Toxic Hazardous Substances

Alternative RGW-2B would destroy COCs in targeted treatment areas (occupying approximately 20 percent of the total plume area), producing harmless ethene and ethane. COC destruction would be irreversible.

Reduction of Total Mass of Toxic Hazardous Substances

Alternative RGW-2B would reduce the total mass of dissolved phase COCs in targeted treatment areas by 70 to 90 percent.

Irreversible Reduction of Hazardous Substance Mobility

Alternative RGW-2B would not reduce the mobility of COCs.

Reduction of Total Volume of Contaminated Media

As treatment progresses, the plume is anticipated to shrink, thereby reducing the volume of contaminated groundwater.

6.3.3.5 Short-Term Effectiveness

The four short-term effectiveness factors described in Section 6.1.5 are assessed below for Alternative RGW-2B.

Protection of Community

Risks during construction may include spilling contaminated wastes (from well construction), spilling hazardous materials, damage to utilities, environmental releases through wind and stormwater erosion, dust generation, physical hazards from heavy equipment, traffic disturbance resulting from road or lane closures, and noise. The vast majority of materials used for remediation would be nonhazardous, and fuel for construction equipment would comprise the bulk of hazardous materials stored on site. Engineering controls and safe work practices would minimize these risks. The recirculation process will require management (treatment and disposal) of extracted groundwater that is likely to be contaminated with

VOCs; this water will be treated to remove VOCs before it is discharged for disposal (herein assumed to be via the sanitary sewer/POTW). Costs herein assume that treatment will be accomplished using air stripping, necessitating sampling of influent and effluent water to ensure effectiveness. SSDSs, to be installed in structures overlying the proposed treatment area as part of Alternative VI-2 will provide protection from VI during and after implementation of the groundwater IA. ISCR may also generate methane; as previously discussed, the amount of methane is not anticipated to significantly affect the vadose zone; however methane will be a required groundwater monitoring parameter and can be adjusted through the addition of methane inhibitors if needed.

Protection of Workers

Physical hazards from heavy equipment would pose the majority of risk to workers. Workers may also be exposed to contaminated or hazardous materials. Work in public rights-of-way may also expose workers to risk of collision with public vehicles. Earthmoving and drilling near gas and electric utilities would add to worker risks. These risks would be minimized by following safe work practices and using PPE. Engineering controls, such as dust suppression and utility clearance, would further reduce risk to workers.

Environmental Impacts

Generation of greenhouse gases by construction equipment and personnel vehicles would be the only certain environmental impact. If air stripping is used as an ancillary process to treat groundwater generated by recirculation in Zone A (as assumed in the groundwater cost estimates) some VOCs could be emitted by the process. Accidental releases of contaminated or hazardous material could also affect the environment, but could be mitigated through good housekeeping and spill prevention and countermeasures.

Time Required for Implementation of the Remedial Action and to Achieve RAOs

It would take 6 months to complete pre-design tests and 6 months to complete the design. Once injections begin it would take an estimated timeframe of 1 year for the ISCR chemicals to distribute through a treatment zone. The estimated timeframe assumed for the IA to achieve the PRGs herein across all zones (A-D) is assumed to be 10 years, based on the upper end (90 percent reduction) of the RAO goal. . This is based on a schedule of phased injection and the apparent half-life for PCE and potential degradation products (TCE, cDCE and VC) to be reduced to 10 percent of the average initial concentrations. The estimated timeframe for the technology to achieve 90 percentVOC reduction in a single zone is estimated to be within 6 years of commencing treatment in that zone. The estimated timeframe to achieve the lower end of the RAO goal (70 percent reduction) would thus be shorter. Additional details regarding the

assumed treatment sequence and timeframes are provided in Appendix C. Note that the estimated timeframe assumes that a period of time following cessation of injections will be required for VOC concentrations throughout Zones A-D to be reduced to the goals. Groundwater monitoring will be continued during this period to evaluate progress toward the remedial goals.

6.3.3.6 Implementability

The technical and administrative feasibility of implementing Alternative RGW-2B and the availability of required resources are discussed below.

Technical Feasibility

Assuring proper distribution of ISCR chemicals within targeted treatment areas may prove challenging because of space constraints. This factor is exacerbated by the limited access to the source area which is at least partially covered by the present overlying church addition structure. Targeting potential source areas underneath interior portions of the present church addition structure, where the former Troy One-Hour dry cleaning operation was located - may be difficult. Recirculation may be the only viable process option to inject amendments. This alternative would require injection wells, extraction wells, and associated piping connecting these wells to central process equipment. Injection and/or extraction locations would be needed upgradient from the source area (on the Market and East Main Street sides of Zone A) as well as on the Walnut Street side of the source area, where dissolved groundwater concentrations as high as 3,560 µg/L were detected. Targeting contamination over extended vertical intervals within treatment areas would require nested injection wells screened at multiple depths. Predesign studies would be required to determine injection locations and horizons as well as evaluate aquifer hydrogeological and geochemical characteristics in those locations. The urban landscape, abundance of utilities, and property ownership and control would make it difficult to install remediation wells and conveyance pipelines. Recirculation in Zone A would necessitate management of contaminated groundwater, herein assumed to be by air-striping to remove VOCs followed by disposal via the sanitary sewer and POTW. Overall, this alternative would be difficult to implement.

Administrative Feasibility

In general, Alternative RGW-2B is anticipated to meet the requirements of all regulatory agencies. However, developing the details of implementation to the satisfaction of all parties involved would require significant effort. These details may including work in public right-of-ways, traffic control, obtaining UIC permits for underground injection, location of infrastructure, groundwater monitoring, and contingency measures.

Availability of Required Resources

All resources except for horizontal drilling services would be readily available. Longer lead times would be needed to procure specialized horizontal drilling services. All materials necessary to construct and implement the remedy would also be readily available.

6.3.3.7 Cost

The estimated costs for Alternative RGW-2B are detailed in Appendix C, Table C-2-2. The estimated capital cost (construction plus pre-design studies) without contingency is $ 16,179,797and the present worth O&M cost without contingency is $3,097,418. The total present worth cost for Alternative RGW-2B, with 30 percent contingency is $25,061,000.

6.3.3.8 Sustainability

Alternative RGW-2B would reduce contaminant mass and thus be a significant step toward restoring a sole-source aquifer and removing a threat to the city's water supply. However, full restoration of the aquifer to beneficial use is not an objective of the IA and should be addressed when determining the final remedy for the site. This alternative would be energy intensive and would consume significant quantities of natural resources to attain remediation goals. However, if the remedy were not implemented, future consumption of natural resources to decontaminate the city's water supply and ongoing operation of SSDSs above the plume to mitigate VI could be equally significant. With the benefit of remediation outweighing the expense, Alternative RGW-2B appears sustainable.

6.3.4 Detailed Analysis of Groundwater Alternative RGW-2C: Source Treatment using ISCO; and, Groundwater Monitoring

Alternative RGW-2C is similar to Alternative RGW-2A and RGW-2B, except that the source area would be remediated using ISCO instead of ERD or ISCR and would not rely on recirculation, thus eliminating the need for treatment and disposal requirements associated with recirculation. The area targeted for treatment is shown on Figure 5-4. A detail of the conceptual system layout for Zone A is shown in Figure 5-7.

The oxidant would be either permanganate or persulfate. The goal of the IA is to decrease dissolved phase COC concentrations in the targeted treatment area by at least 90 percent without any evidence of rebound. Institutional controls would be implemented to limit human exposure to contaminated groundwater as well as protect the remedy until remediation goals are attained.

6.3.4.1 Overall Protection of Human Health and the Environment

Alternative RGW-2C would destroy more than 70 percent of the source mass through treatment and facilitate natural attenuation to remediation goals and thus would protect human health and the environment as described for RGW-2 and RGW-2B. ISCO would not produce PCE daughter products or methane, but could solubilize naturally occurring chromium.

ISCO would produce oxidizing conditions within the treatment zone, and can cause chromium to transition from insoluble trivalent chromium (Cr-III) to soluble hexavalent chromium (Cr-VI). However, site groundwater conditions do not appear conducive for Cr-VI to persist once groundwater exits the targeted treatment area. Table 3-1 in Appendix C of the RI (SulTRAC 2015) presents a summary of field parameters. The pH of groundwater at the site ranged from 5.39 to 8.52, and the oxidation-reduction potential (ORP or Eh) ranged from -222 millivolts (mV) to 211 mV. At these ranges of Eh and pH, chromium exists as a solid (Cr2O3) in its trivalent oxidation state. This is consistent with groundwater data collected during the RI. Chromium was not detected at significant concentrations in the limited number of groundwater samples analyzed for metals during the RI. Within the pH-range of site groundwater, the Eh would have to be at least 300 mV (approximate) before chromium transforms to its soluble hexavalent oxidation state. Chemical oxidation may increase Eh above 300 mV within targeted treatment areas, oxidizing naturally occurring Cr-III to Cr-VI. However, as Cr-VI would return to its insoluble trivalent oxidation state when it exits the treatment zone. Therefore, as groundwater exits the treatment zone, Cr-VI (if generated) will be expected to readily return to Cr-III. For these reasons, chromium is not expected to migrate more than a few hundred feet from the treatment zone, which is at least 1,000 feet short of the East wellfield. Initializing treatment in Zone A and progressing eastward/downgradient would allow ample time for corrective measures should the remedy not progress as predicted. For instance, groundwater from the farthest upgradient treatment area west of Mulberry Street would take at least 2 years to arrive at the East wellfield. If this area discharged chromium at very high concentrations, the chromium plume would take 1 to 5 years to reach Union Street, where it could be intercepted and contained. Lessons learned from the first treatment area could then be applied to the next treatment area between Mulberry Street and Clay Street, and so on. As such, it is unlikely that the IA would result in increased chromium reaching the East wellfield. Therefore, this alternative would protect human health and the environment in both the short and long term.

6.3.4.2 Compliance with ARARs

Alternative RGW-2C would comply with ARARs.

6.3.4.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative RGW-2C.

Magnitude of Residual Risks

After remediation goals are attained, residual risk would be eliminated.

Adequacy and Reliability of Controls

The entire plume area falls within the Troy city limits and municipal water service area. Troy municipal ordinances currently in place that govern new construction in this area and connection to the Troy municipal water system would continue to prevent inadvertent exposure to contaminated groundwater. Sentinel wells would provide advance warning of conditions requiring correction. Sequencing the remedy would provide an added level of control to minimize the risk of affecting the East wellfield. Long-term groundwater monitoring would be needed track remedial progress as well as provide information that could be used to optimize the remedy.

6.3.4.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The ability of Alternative RGW-2C to satisfy the evaluation criterion of contaminant toxicity, mobility, or volume through treatment, described in Section 6.1.4, is discussed below.

Destruction of Toxic Hazardous Substances

Alternative RGW-2C would mineralize COCs in targeted treatment areas producing carbon dioxide and water. Destruction of COCs would be irreversible.

Reduction of Total Mass of Toxic Hazardous Substances

Alternative RGW-2C would reduce the total mass of COCs in targeted treatment areas by 70 to 90 percent.

Irreversible Reduction of Hazardous Substance Mobility

Alternative RGW-2C would not reduce the mobility of COCs.

Reduction of Total Volume of Contaminated Media

As treatment progresses, the plume would shrink, thereby reducing the volume of contaminated groundwater.

6.3.4.5 Short-Term Effectiveness

The four short-term effectiveness factors described in Section 6.1.5 are assessed below for Alternative RGW-2C.

Protection of Community

Risks during construction may include spilling contaminated wastes (from well construction), spilling hazardous materials, damage to utilities, environmental releases through wind and storm water erosion, dust generation, physical hazards from heavy equipment, traffic disturbance resulting from road or lane closures, and noise. Oxidants and fuel for construction equipment would comprise the bulk of hazardous materials stored on site. Engineering controls and safe work practices would minimize these risks. As previously discussed, ISCO may solubilize chromium (if present in the aquifer materials) and temporarily generate Cr-VI; however, Cr-VI is anticipated to rapidly precipitate as Cr-III as groundwater exits the treatment zone. Cr would be monitored as part of the groundwater monitoring program and adjustments to the treatment process could be made in ample time to ensure protection of the city wellfield.

Protection of Workers

Physical hazards from heavy equipment would pose the majority of risk to workers. Workers may also be exposed to contaminated or hazardous materials. Work in public rights-of-way may also expose workers to risk of collision with public vehicles. Earthmoving and drilling near gas and electric utilities would add to worker risks. These risks would be minimized by following safe work practices and using PPE. Engineering controls, such as dust suppression and utility clearance, would further reduce risk to workers.

Environmental Impacts

Generation of greenhouse gases by construction equipment and personnel vehicles would be the only certain environmental impact. Accidental releases of contaminated or hazardous material could also affect the environment.

Time Required to Implement Remedial Action and Achieve RAOs

It would take 6 months to complete pre-design tests and 6 months to complete the design. Once injections begin, it is estimated that it will take approximately 1 year for ISCO compound to distribute through the targeted treatment zone. The estimated timeframe assumed for the IA to achieve the upper end of the RAO (90 percent reduction in VOC mass) across all zones (A-D) is 10 years. This is based on a schedule of phased injection and the apparent half-life for PCE to be reduced to 10 percent of the average initial concentrations. The estimated timeframe for the technology to achieve 90 percent VOC

reduction in a single zone is estimated to be within 4 years of commencing treatment in that zone. Timeframes to achieve the lower end of the RAO goal (70 percent reduction) are anticipated to be shorter. Additional details regarding the assumed treatment sequence and timeframes are provided in Appendix C. Note that the estimated timeframe assumes that a period of time following cessation of injections will be required for VOC concentrations throughout Zones A-D to be reduced to the goals. Groundwater monitoring will be continued during this period to evaluate progress toward the remedial goals.

6.3.4.6 Implementability

The technical and administrative feasibility of implementing Alternative RGW-2C and the availability of required resources are discussed below.

Technical Feasibility

Ensuring proper distribution of oxidants within targeted treatment areas may prove challenging because of space constraints. Oxidants would be injected into targeted treatment areas via injection wells. This alternative would require injection wells, and associated piping connecting these wells to central process equipment. Targeting contamination over extended vertical intervals within treatment areas would require nested injection wells screened at multiple depths. Targeting a potential source underneath the interior areas of the present church addition structure – where the former Troy One-Hour dry cleaning operation was formerly located - may also prove challenging because the addition and neighboring structures prevent direct access to the original location. This would necessitate injections at the closest available upgradient area (most likely near the current town square in the vicinity of monitoring well MW-108) and also possibly on the Main Street sidesof the current church addition and on the Walnut Street side of the building where dissolved phase PCE concentrations as high as 3,560 ug/L were detected in groundwater (See Figure 5-7). Predesign studies would be required to determine injection locations and horizons as well as evaluate aquifer hydrogeological and geochemical characteristics in those locations. The urban landscape and abundance of utilities would make it difficult to install injection wells and conveyance pipelines. Overall, this alternative would be moderately difficult to implement.

Administrative Feasibility

In general, Alternative RGW-2C is anticipated to meet the requirements of all regulatory agencies. However, developing the details of implementation to the satisfaction of all parties involved would require significant effort. These details may including work in public rights-of-way and private property, traffic control, obtaining Underground Injection Control (UIC) permits for underground injection, location of infrastructure, groundwater monitoring, and contingency measures.

Availability of Required Resources

All resources except for horizontal drilling services would be readily available. Longer lead times would be needed to procure specialized horizontal drilling services. All materials necessary to construct and implement the remedy would also be readily available.

6.3.4.7 Cost

The estimated costs for Alternative RGW-2C are detailed in Appendix C, Table C-2-3. The estimated capital cost (predesign studies plus construction) without contingency is $ 6,911,454and the present worth O&M cost without contingency is $2,293,409. The total present worth cost for Alternative RGW-2C, with 30 percent contingency, is $11,966,000. The estimated cost depends on soil NOD, which has not been tested. If soil NOD is higher than assumed, the cost of this alternative may increase significantly.

6.3.4.8 Sustainability

Alternative RGW-2C would restore a natural resource that is a sole-source aquifer and remove a threat to the city's water supply. This alternative would be energy intensive and would consume significant quantities of natural resources to attain remediation goals. However, if the remedy were not implemented, future consumption of natural resources to decontaminate the city's water supply and continue operation of SSDSs over the plume area could be equally significant. With the benefit of remediation outweighing the expense, Alternative RGW-2C appears sustainable.

6.4 DETAILED ANALYSIS OF SOIL VAPOR ALTERNATIVES

Soil vapor alternatives are intended to address vapors that could enter buildings overlying the groundwater plume. As such, the objective is to address the vapor intrusion pathway as opposed to "remediation" of soil vapor itself. Therefore, the soil vapor alternatives presented in this section will be integrated with soil and groundwater remedies. Although soil vapor alternatives are evaluated separately from soil and groundwater alternatives, the overall effectiveness of the IA will depend on the cumulative effectiveness of the soil, groundwater, and soil vapor remedies selected for the site. Detailed analyses of the two soil vapor alternatives are presented below.

6.4.1 Detailed Analysis of Soil Vapor Alternative VI-1: No Action

Alternative VI-1 consists of no action. The no action alternative provides a reference to evaluate other alternatives. Under Alternative VI-1, no action would be taken to mitigate vapor intrusion under a remedial action. If no action occurred at the site, the soil vapor would be left "as is" without implementation of access controls, containment, removal, treatment, or other mitigating actions. The

analysis of the no action alternative is included to provide a comparative baseline used to evaluate other alternatives as required by the NCP.

6.4.1.1 Overall Protection of Human Health and the Environment

Alternative VI-1 would not eliminate, reduce, or control current or future risks to human health or the environment posed by soil vapor. In addition, this alternative would provide no measure of protection from dechlorination byproducts potentially generated by the groundwater IA. Soil vapor concentrations would be left "as is" because no action would occur. Hazardous substances in the soil vapor may continue to enter buildings or they may naturally volatilize, biodegrade, dilute, and attenuate over time. No monitoring or sampling would be conducted to demonstrate that Alternative V-1 is effective.

6.4.1.2 Compliance with ARARs

Alternative VI-1 would not comply with chemical-specific ARARs. Under this alternative, soil vapor concentrations would not be monitored to evaluate whether they have naturally been restored to acceptable levels or whether soil or groundwater remedial actions have been effective in reducing soil vapor concentrations.

6.4.1.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative VI-1.

Magnitude of Residual Risks

Natural processes would be too slow to produce a significant change in the magnitude or extent of contamination in the foreseeable future. Therefore, existing risks would remain without any significant reduction in magnitude.

Adequacy and Reliability of Controls

There would be no controls. The alternative would be inadequate and could not be relied on to protect human health or the environment.

6.4.1.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The toxicity, mobility, and volume of hazardous substances in soil vapor would not be reduced by Alternative VI-1 because the soil vapor would not be treated. Contaminant concentrations in the soil vapor might decrease over time as a result of degradation and attenuation; however, the degree of degradation and attenuation would not be monitored.

6.4.1.5 Short-Term Effectiveness

The alternative would not pose new health risks to the community, current site occupants, workers, or the environment because Alternative VI-1 involves no remedial activities or construction. This alternative would require no time to implement.

6.4.1.6 Implementability

The implementability of Alternative VI-1 would depend on its technical and administrative feasibility and the availability of resources required to implement the alternative. No construction or other activities would be required to implement this alternative; therefore, the alternative is technically feasible. This alternative would involve no administrative activities. Alternative VI-1 would not require resources or specialized labor and would therefore be easy to implement, but it would not achieve RAOs.

6.4.1.7 Cost

No capital or O&M costs are associated with Alternative VI-1.

6.4.1.8 Sustainability

Implementation of this alternative does not require any construction equipment or material use. Under this alternative, there is no waste production, use of natural resources and energy, air pollutants and greenhouse gas production. As such, these factors enhance the sustainability of this alternative. However, based on the lack of remedial activity associated with this alternative, impacts to natural resources are not minimized, and sustainable reuse of the land is not supported, thereby reducing the overall sustainability of this alternative.

6.4.2 Detailed Analysis of Soil Vapor Alternative VI-2: Residential Area PCE Plume Sub-Slab Depressurization System and Monitoring

This alternative would be used to actively remove soil vapors from beneath the building's slab, limit future habitable property development to buildings that include vapor mitigation as part of the new construction design, and use monitoring to assess the effectiveness of the IA. These technologies may be used in combination or alone depending on site-specific factors, including the building type and property access.

SSDSs would be offered to property owners and installed within the area shown on Figure 5-8. This area would encompass the locations where the highest concentrations of PCE and TCE were detected in indoor air and/or sub-slab samples during the TCRA and the RI. The proximity of structures to the apparent lateral edges of the plume was also considered in determining the lateral boundaries of the proposed VI

treatment area. The proposed area also encompasses all of the proposed groundwater treatment Zones A, B, C, and D as well as a "buffer" zone that extends an additional 2 blocks downgradient to Frank Street, where groundwater PCE concentrations decrease significantly. Thus the proposed area of VI mitigation encompasses the known boundaries of the Residential Area PCE plume between the source area and Frank Street. The total estimated number of structures in the area is 156, assumed for cost-estimating purposes. This assumes 128 residential and 28 commercial structures, based on an actual count of addresses and including a contingency allowance for residences (such as occupied garage structures) that may be discovered in the future but are currently unknown. Alternative VI-2 consists of the components described in Section 5.3. The extracted vapors may be treated at the surface (if vapor emissions exceed applicable criteria) or released directly to the atmosphere. Pre-design information would be required to tailor the vapor mitigation systems to the specifics of each individual building. Incidental sealing may be necessary on a case by case basis to ensure the effectiveness of the SSDS. Due to the age of the structures in the Residential Plume area, it is possible that some may have dirt basement floors. Such situations would require special design considerations, such as installation of a plastic membrane liner, to ensure proper function of the SSDS. Based on limited inspections performed to date, approximately 8 percent of the buildings had dirt floors; therefore, it is assumed that 12 of the 156 buildings will have dirt floors.

Indoor air monitoring would be required, as described in Section 5.3. Post-installation follow-up testing would be done to ensure that the systems are functioning properly. The vapor intrusion monitoring network would be sampled on a periodic basis (costs herein assume annually) to document that the systems are functioning as designed and measure changes in contaminant concentrations and over time.

6.4.2.1 Overall Protection of Human Health and the Environment

Alternative VI-2 would be protective of human health and the environment. Alternative VI-2 would protect residents and occupants of buildings from VOCs in soil vapor while other IA components (groundwater actions) are implemented. SSDSs would protect occupants of existing residential and commercial buildings while the groundwater IA is actively reducing VOCs in groundwater.

6.4.2.2 Compliance with ARARs

Alternative VI-2 would comply with federal and state ARARs. If treatment is necessary before extracted vapors could be emitted to the atmosphere, treatment system components would be designed to comply with air emission standards.

6.4.2.3 Long-Term Effectiveness and Permanence

The factors evaluated under long-term effectiveness and permanence, described in Section 6.1.3, are assessed below for Alternative VI-2.

Magnitude of Residual Risks

Under Alternative VI-2, residual risks would remain as long as contaminant concentrations in groundwater are at levels that would result in VI issues and routes of entry exist for soil vapors. If the VI mitigation systems are installed properly and operate as expected, residual risks to occupants would be minimal.

Adequacy and Reliability of Controls

SSDSs have proven track records at many sites and can be expected to continue to perform properly until the fan requires replacement. The expected life span of fans is typically 5 to 15 years, with a 5-year warranty. Concentrations should be expected to fluctuate over time as a result of seasonal effects and varying occupant activities. Concentrations of potential degradation byproducts of groundwater remediation may vary over time as well and would be mitigated by the systems. Mitigation systems are considered reliable, as long as they function properly. Occupants of buildings or homes can readily detect problems with the fan by silence (the fan stops operating), noise (bearing failure in fan), or lack of differential pressure in the manometer. As a result, inoperative fans can be replaced relatively quickly, ensuring no significant impact on long-term mean concentrations or system reliability. Most other factors that could affect the long-term reliability of mitigation systems are the result of homeowner actions, including deliberately turning off the fan or ignoring an inoperative fan, and knocking the suction pipes down. All of these events are readily mitigated as long as the homeowners contact the party responsible for system operation and arrange for repairs.

6.4.2.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

The ability of Alternative VI-2 to satisfy the evaluation criterion of contaminant toxicity, mobility, or volume through treatment, described in Section 6.1.4, is discussed below.

Destruction of Toxic Hazardous Substances

Under Alternative VI-2 hazardous substances would not be destroyed unless vapors require treatment before they are emitted to the atmosphere.

Reduction of Total Mass of Toxic Hazardous Substances

Alternative VI-2 would not reduce the total mass of toxic hazardous substances.

Irreversible Reduction of Hazardous Substance Mobility

Alternative VI-2 would prevent contaminated soil vapors from entering structures but would not reduce the mobility of toxic hazardous substances.

Reduction of Total Volume of Contaminated Media

Alternative VI-2 would not reduce the total volume of toxic hazardous substances.

6.4.2.5 Short-Term Effectiveness

The four short-term effectiveness factors described in Section 6.1.5 are assessed below for Alternative VI-2.

Protection of Community

Impacts to the community during implementation would be relatively minor. Impacts would primarily result in minor inconveniences to property owners while the SSDSs are being installed. Access to buildings would be required during pre-design studies and again during system installation. Building inspections and installation of SSDSs would be closely coordinated with property owners and tenants to minimize the degree of inconvenience. In addition, the work areas may also experience increased vehicle traffic while the systems are installed.

Protection of Workers

Workers would experience minimal environmental impacts during remedial activities. Potential exposure associated with soil vapor or contact with other media during installation is easily addressed through the use of properly trained employees and protective measures specified in the site health and safety plans.

Environmental Impacts

Environmental impacts from Alternative VI-2 would be minimal. This alternative does not generate much waste, and the potential for spills or other types of environmental problems is negligible.

Time Required for Remedial Action

The time required to implement Alternative VI-2 depends on the availability of property owners to grant access for SSDS installation. Uncertainty also exists when coordinating activities with property owners and tenants since the SSDSs are installed inside buildings. Once access is granted, the time required to

install a typical SSDS at a residence is about 6 days. This timeframe includes pre-installation testing, installation, and post-installation testing. Installation of SSDSs would likely proceed at multiple locations simultaneously. Based on the estimated number of buildings to be addressed (156) and assuming an installation rate of 7 per week, it is estimated that it would require a total of about 23 weeks (or about 5 to 6 months) to fully implement this alternative. This timeframe estimate assumes that access would be granted to all 156 buildings and there would be no breaks in the construction schedule. A 15-year operational period is assumed, consistent with the estimated timeframes for the groundwater IA to achieve RAOs.

6.4.2.6 Implementability

The technical and administrative feasibility of implementing Alternative VI-2 and the availability of required resources are discussed below.

Technical Feasibility

SSDSs have proven track records at many sites and are technically easy to implement.

Administrative Feasibility

No permits would be necessary to implement Alternative VI-2. Administratively, EPA would need to obtain access to the properties to install the systems. This may be challenging based on the partial number of responses or denial of access from some property owners when access has been requested by EPA in the past for sampling during the TCRA and the RI.

Availability of Required Resources

SSDS have been widely used in the region for both mitigation of VOC vapors and radon. The services and materials needed to implement Alternative VI-2 would be readily available. This alternative would use easily obtainable materials and installation technicians. .

6.4.2.7 Cost

The estimated capital and O&M costs for Alternative V-2 are detailed in Appendix C, Table C-3-1. Costs assume that systems will be installed at all structures within the area indicated on Figure 5-8 and that these structures would include 128 residences and 28 commercial or institutional locations. The major capital cost items include installation, construction oversight, and testing of SSD systems. Although some homes in the area may not have slabs, previous experience has indicated that the likely number of these

(assumed at 8 percent of all structures) would not result in costs that significantly impact the overall estimated cost for the alternative, as the costs assume a 30 percent contingency.

The estimated capital cost is $1,281,946. O&M costs assumed for Alternative VI-2 include routine system maintenance and annual monitoring events for 15 years as this is the median of the timeframe estimates for the various groundwater alternatives to operate under the IA. The estimated annual O&M cost is $233,877 and the present worth O&M cost without contingency is $2,846,654. The overall present worth costs for Alternative VI-2 with a 30 percent contingency is $5,367,180.

6.4.2.8 Sustainability

Factors that reduce the sustainability of this alternative include use of natural resources and energy (fuel for equipment and vehicles) and air pollutant and greenhouse gas emissions (product of vehicle fuel combustion and SSD system emissions). SSDSs operate continually using electrical power and in some instances can increase airflow in a structure, which in turn may make the HVAC system operate more frequently. For these reasons, natural resources will be consumed both during the initial SSDS installation and during operation. Operation of the SSDSs could be discontinued at a future time when groundwater contaminant concentrations are reduced to levels that no longer present a VI risk. The targeted IA treatment goals for groundwater (90 percent dissolved-phase mass reduction in Zones A through D) is anticipated to decrease VOC concentrations to the point where the risk of VI will be greatly reduced. However, full restoration of the aquifer and elimination of all VI risk may not occur until a final groundwater remedy is completed.

7.0 COMPARATIVE EVALUATION OF REMEDIAL ALTERNATIVES

The final element of the FFS is to conduct a comparative analysis of alternatives in accordance with CERCLA guidance (EPA 1988). As previously noted, there are two CERCLA threshold criteria and five primary balancing criteria. In total, seven CERCLA criteria were considered in the comparative analysis. The two CERCLA modifying criteria of state acceptance and community acceptance are reserved for consideration after the public comment period. An eighth criterion for sustainability of the alternatives was also considered. The evaluation criteria are described in Section 6.1 but are listed below for reference.

Threshold criteria (CERCLA criteria):

- Overall protectiveness of human health and the environment
- Compliance with ARARs

Primary balancing criteria (CERCLA criteria):

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying criteria (CERCLA criteria – reserved for use after the public comment period):

- State acceptance
- Community acceptance

Additional criterion:

- Sustainability

Threshold and primary balancing criteria are evaluated in this section. The two modifying criteria (state acceptance and community acceptance) will be evaluated after comment on this FS report and the proposed plan and will be addressed in the Record of Decision (ROD). Thus, a comparative analysis of modifying criteria is not presented herein.

The sustainability criterion is also compared in this section. While sustainability is an important consideration in selecting the correct alternative, the sustainability comparison is not part of the CERCLA-mandated evaluation process. Instead, the intent is to simply consider the sustainability of an alternative when assessing equally favorable alternatives.

7.1 COMPARATIVE ANALYSIS OF SOIL ALTERNATIVES

Two soil alternatives have been developed for the IA.

S-1 No Action

S-2 Excavation with Offsite Disposal at Hobart EA-1 and Spinnaker EA-6

S-3 Excavation with Offsite Disposal at Hobart EA-1; Asphalt or Concrete Cap and ICs at Spinnaker EA-6

7.1.1 Overall Protection of Human Health and the Environment

Alternative S-1 would not be protective because it would take no action.

Alternative S-2 would be the most protective because it would permanently remove the contaminated soil in both EA-1 and EA-6, eliminating the potential risk from contact with contaminants and eliminating sources that may be leaching contaminants to groundwater.

Alternative S-3 would be slightly less protective as it would leave contaminated soil in place in EA-6. The soil would be covered with a low-permeability cap that would prevent contact with contaminated soil and also limit the potential for infiltration of surface drainage and leaching of contaminants from soil to groundwater. However, contaminated soil remaining at this location could potentially contact groundwater during periods of high water levels and thus an ongoing potential for leaching would remain. Alternative S-3 would also rely on ICs to ensure continued maintenance, integrity and performance of the cap with regard to meeting the RAOs of reducing risk to future residents and limiting infiltration.

7.1.2 Compliance with ARARs

Alternative S-1 would not comply with ARARs because it would take no action. All other alternatives would comply with ARARs.

Achieving compliance with ARARs would be more complex for Alternative S-3 than S-2 because State of Ohio ARARs governing the design and construction of asphalt caps would apply for this alternative, in addition to the ARARs for excavation which would apply to both Alternatives S-2 and S-3.

7.1.3 Long-Term Effectiveness and Permanence

Alternative S-1 would be the least effective because it would take no action.

Alternative S-2 would be the most permanent and effective in the long-term because it would permanently remove the contaminated soil in both EA-1 and EA-6, eliminating the potential risk from contact with contaminants and eliminating sources that may be leaching contaminants to groundwater. It would require no ICs to ensure effectiveness in the future. Alternative S-3 would potentially be less permanent and less effective in the long-term. Although a cap in EA-6 would eliminate the potential for contact with contaminated soil and reduce surface infiltration, Alternative S-3 would leave a potential source of groundwater contamination (contaminated soil near the zone of water table fluctuation) in place in EA-6 and would also rely on ICs to limit uses of the capped area and ensure continued maintenance, integrity and performance of the cap.

7.1.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

None of the soil alternatives are anticipated to involve treatment.

Alternative S-1 would rate the lowest because it would take no action and would therefore not reduce toxicity, mobility, or volume through treatment.

Alternatives S-2 and S-3 would reduce the availability of VOCs to mobilize to groundwater from soil on site by removing and/or limiting infiltration through the contaminated soil. Alternative S-3 would remove a greater volume of contamination from the site than S-3, as S-3 would leave contaminated soil in place in EA-6 and thus S-2 would provide greater reduction of contaminant mass from the site. However, both alternatives include disposal of the excavated material in landfills, and therefore the overall toxicity, mobility or net volume of contamination would not actually be impacted unless pre-treatment or fixation were conducted at the disposal facility to meet disposal requirements.

7.1.5 Short-Term Effectiveness

Alternative S-1 would not be effective in the short term because it would not address existing risk posed by COCs and it would not reduce the potential for leaching of contaminants to groundwater, which data suggest may be currently occurring.

Both alternatives S-2 and S-3 would pose similar risks until IA goals are attained. However, Alternative S-2 would be slightly more effective than Alternative S-3 in the short term for several reasons. Excavation would not require a formal engineering design or the legal processes necessary to identify, draft, enter and implement ICs that would be required for capping scenarios. Excavation would potentially require a smaller number of subcontractors to complete. For these reasons mobilization could occur more quickly for Alternative S-2. Once mobilized, excavation and backfill of EA-1 and EA-6

could be completed more rapidly than a combination of excavation at EA-1 and capping at EA-6 and thus the goal of meeting the RAOs would be achieved in a slightly shorter timeframe for Alternative S-2, although the estimated time difference is relatively minor. However, the shorter construction duration would result in less disruption to use of the properties; and, shorter timeframes for exposure to noise, dust, traffic and vehicle emissions for neighboring residents.

7.1.6 Implementability

Alternative S-1 would be easy to physically implement because it would require no action. However, S-1 is not likely to receive agency approval because it would not protect human health or the environment, making it impossible to implement.

Alternatives S-2 and S-3 are both moderately difficult to implement, although S-2 would be easier to implement than S-3 for several reasons. The technical challenges associated with excavation are primarily associated with proximity to the Hobart building and the MCD levee in EA-1 and thus would impact Alternatives S-2 and S-3 equally. Both S-2 and S-3 would require preparation of sealed bid packages for potential subcontractors. However, the engineering design for S-3 would be more complex as it involves design of a cap that would have to consider, and incorporate to the degree possible, anticipated future use scenarios for EA-6. Thus, even if the site remains a parking lot or driveway, it will have to be designed to support such use and thus require more complex long term planning and coordination with the property owners. S-3 would also be more complex to implement as it would involve all of the same types of technical considerations and subcontracting needs as S-2, plus the additional resources for construction of a cap and thus would likely require more subcontractors to procure and manage. The shorter duration involved in excavation would require less time during which construction in EA-6 would have to be coordinated with routine traffic and operational activities at adjacent businesses. Finally, S-3 would rely on developing and enacting ICs regarding future property use and to ensure maintenance of the cap in perpetuity, whereas S-2 would require no ICs and would not restrict future land use.

7.1.7 Cost

The present worth costs for the three soil alternatives, from highest to lowest, are as follows: (1) Soil Alternative S-3–$2,470,000; (2) Soil Alternative S-2–$2,290,000; and (3) Soil Alternative S-1 $ 0.

7.1.8 Sustainability

Alternative S-1 would not be sustainable because it would not reduce the ongoing degradation of a natural resource. S-1 would allow continued degradation of a sole-source aquifer that provides drinking water to

over 25,000 people in the City of Troy. In addition, commercial and industrial activity at the Hobart site has gradually decreased over the years and access to EA-1 is unrestricted, increasing the potential for trespassing, and thus S-1 would do nothing to reduce the ongoing potential for exposure to soils in this area. Of the two remaining soil alternatives S2 and S3, Alternative S-2 would be more sustainable in that it would permanently remove the sources of potential ongoing groundwater contamination and sources of potential exposure to future workers or residents, and would not require future O&M or ICs.

7.2 COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

One site-wide remedial alternative (no action) and three remedial alternatives for the Residential Area plume are compared below under seven evaluation criteria.

RGW-1	No Action
RGW-2	Source Treatment Using ERD; and, Groundwater Monitoring
RGW-2B	Source Treatment Using ISCR; ; and, Groundwater Monitoring
RGW-2C	Source Treatment Using ISCO; and, Groundwater Monitoring

7.2.1 Overall Protection of Human Health and the Environment

Alternative RGW-1 would not be protective because it would take no action.

Alternative RGW-2C would be the most protective for the Residential Area plume, and Alternatives RGW-2A, and RGW-2B would be slightly less protective. Alternatives RGW-2A, RGW-2B, and RGW-2C rely to some extent on monitoring and contingency measures to protect the East wellfield from unforeseen effects of source area treatment; however RGW-2C is anticipated to present the least likely possibility of generating significant levels of dechlorination byproducts (TCE, cDCE, VC) as PCE and TCE are reduced. In all alternatives, existing City of Troy ordinances governing use of private wells within the municipal water service area would continue to minimize the risk of human exposure to contaminated groundwater.

7.2.2 Compliance with ARARs

Alternative RGW-1 would not comply with ARARs because it would take no action. All other alternatives would comply with ARARs.

Alternatives RGW-2A, RGW-2B and RGW-2C are anticipated to comply with ARARs; however, RGW-2A and RGW-2B are likely to necessitate recirculation to be effective and thus would require reinjection of groundwater extracted within the treatment areas. For this reason, compliance with ARARs would be most easily achieved by alternative RGW-2C.

7.2.3 Long-Term Effectiveness and Permanence

Alternative RGW-1 would be the least effective because it would take no action.

Alternatives RGW-2A, RGW-2B, and RGW-2C would have similar effectiveness for the Residential Area plume because they would each attain IA goals, result in the same magnitude of residual risk, and rely on the same type of institutional controls to limit human exposure to contaminated groundwater. However, the effectiveness of Alternative RGW-2C would be contingent on NOD testing to confirm that conditions are favorable. Long-term groundwater monitoring would also be necessary to evaluate the effectiveness of each alternative.

7.2.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

Alternative RGW-1 would rate the lowest because it would take no action and would therefore not reduce toxicity, mobility, or volume through treatment.

Alternatives RGW-2A, RGW-2B, and RGW-2C would all destroy approximately the same mass of source area and plume contaminants through treatment (at least 70 to 90 percent).

7.2.5 Short-Term Effectiveness

Alternative RGW-1 would not be effective in the short term because it would not address existing risk posed by COCs. Although the City of Troy currently has ICs in place limiting use of private wells for potable supplies there currently are no restrictions on other uses. Alternatives RGW-2A,RGW-2B, and would have similar construction requirements; Alternative RGW-2C (which does not require recirculation) would be slightly easier to construct and operate, and therefore more effective in the short term. All alternatives would pose similar risks until IA goals are attained. Alternative RGW-2A would take 15 years or less to attain remediation goals, Alternative RGW-2B and Alternative RGW-2C are estimated to each take 10 years or less to achieve the goals. Therefore, Alternatives RGW-2B and RGW-2C would have similar short-term effectiveness with regard to duration and risk of exposure to contaminated groundwater until RAOs are achieved, and Alternative RGW-2A would be slightly less

effective. With regard to complexity of construction and risk of exposure during the remediation Alternative RGW-2C would be more effective.

7.2.6 Implementability

Alternative RGW-1 would be easy to physically implement because it would require no action. However, RGW-1 is not likely to receive agency approval because it would not protect human health or the environment, making it impossible to implement.

Alternatives RGW-2A andRGW-2B, for the Residential Area plume would require similar skill and effort to construct and would therefore have similar implementability. Because Alternative RGW-2C does not rely on recirculation, extraction wells and ex-situ treatment would not be required, reducing the amount of construction required, and therefore would be more easily implementable.

7.2.7 Cost

The present worth costs for the three groundwater alternatives, from highest to lowest, are as follows: (1) Groundwater Alternative RGW-2B–$25,061,000; (2) Groundwater Alternative RGW-2A–$18,769,000; (3) Groundwater Alternative RGW-2C–$11,966,000, and (4) Groundwater Alternative RGW-1 $ 0.

7.2.8 Sustainability

Alternative RGW-1 would not be sustainable because it would not restore a degraded natural resource. RGW-1 would allow continued degradation of a sole-source aquifer that provides drinking water to over 25,000 people in the City of Troy.

Alternatives RGW-2 and RGW-2B would have similar sustainability because they would each consume similar amounts of resources to attain remediation goals. Alternative RGW-2C may be slightly more sustainable because it would consume less resources, both in terms of extracting groundwater and use of consumables and power to operate the extraction and treatment system. This alternative would also eliminate the need for treatment and disposal of extracted groundwater. For Alternatives RGW-2, RGW-2B, and RGW-2C, best engineering practices can be employed to minimize the use of resources and reduce energy consumption to the extent practicable.

7.3 COMPARATIVE ANALYSIS OF SOIL VAPOR ALTERNATIVES

The two soil vapor alternatives were retained for evaluation.

VI-1 No Action

VI-2 Sub-Slab Depressurization System and Monitoring

Only one active alternative exists (Alternative VI-2) because one of the alternatives is the "No Action" alternative. As such, a comparative analysis of soil vapor alternatives is not necessary and was not performed as part of the FFS.

8.0 REFERENCES

City of Troy, Ohio. (Troy). 2009. Map of Troy Sanitary Sewer System and Laterals.

Troy. 2011. Video - Camera Survey of Walnut Street Sanitary Sewer. Provided by Troy to SulTRAC. November.

Troy. 2017. E-mail correspondence regarding Troy ordinances addressing private wells in the City and VOC sampling results for private well. April.

Get-a-Quote.net. (Get-a-Quote). Undated. "Online Construction Costs for Contractors." Accessed in June 2015. Worldwide web address: http://www.get-a-quote.net/

Environmental Data Resources (EDR). 2013. Certified Sanborn Map Reports for the ETCA Residential Area Plume Source Area 1892-1955. June.

Interstate Technology & Regulatory Council (ITRC). 2007. Technical and Regulatory Guidance, Vapor Intrusion Pathway: A Practical Guideline. ITRC Vapor Intrusion Team. January. On-line Address: http://www.itrcweb.org/documents/VI-1.pd

MCASES. 2012. Micro-computer Aided Cost Estimating System (MCASES), Second Generation (MII), Version 4.2, 2012 Cost Book.

Moody-Nolan, Inc. 2002. Architectural Plans for Addition – First Presbyterian Church. Provided by First Presbyterian Church to EPA (February 2016).

Ohio Department of Transportation (ODOT). 2015. Pavement Design Manual. Office of Pavement Engineering. July.

Ohio Environmental Protection Agency (Ohio EPA). 2003. Technical Decision Compendium, Asphalt Covers to Prevent Leaching at Industrial Sites, August 18.

Ohio EPA. 2016a. Sub-Slab Sample Analytical Data – 20 South Walnut Street. March.

Ohio EPA2016b. Ohio EPA Review - Input Values of Site-Specific Soil Leaching Calculations for Focused Feasibility Study, East Troy Contaminated Aquifer Site, Troy, Miami County July 11.

Shaw Group (Shaw). 2006. Supplemental Soil and Groundwater Investigation Report. Spinnaker Coatings LLC Facility. 518 East Water Street, Troy, Ohio. October.

State Coalition for Remediation of Dry Cleaners. 2010. Conducting Contamination Assessment Work at Drycleaning Sites. https://drycleancoalition.org/publications.cfm

SulTRAC. 2015. Remedial Investigation Report for East Troy Contaminated Aquifer Site, Troy, Miami County, Ohio. January.

Troy-Miami County Public Library. Communication (e-mail) from Patrick Kennedy to Guy Montfort, SulTRAC, regarding business listings for 10 East Main and neighboring buildings. February 11.

U.S. Environmental Protection Agency (EPA). 1988. Guidance for Conducting Remedial Investigation Site Characterization and Treatability Studies. Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01. October.

EPA. 1990. National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule (40 *Code of Federal Regulations* [CFR] Part 300). *Federal Register*, 55(46):8666-8865. April 9.

EPA. 1992. Estimating Potential for Occurrence of DNAPL at Superfund Sites. OSWER Publication 9355.4-07FS. National Technical Information Service (NTIS) Order Number PB92-963338CDH. http://www.epa.gov/superfund/resources/gw docs/non_aqu.htm

EPA. 1996a. Engineering Forum Issue Paper: Soil Vapor Extraction Implementation Experiences. Office of Emergency and Remedial Response. April. On-line Address: http://www.clu-in.org/download/remed/sveissue.pdf

EPA 1996b. Superfund Soil Screening Guidance. (Quick Reference Fact Sheet, User's Guide, Technical Background Document, and 2002 Supplemental Guidance. On-line at Address: https://www.epa.gov/superfund/superfund-soil-screening-guidance.

EPA. 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water. Office of Research and Development. EPA/600/R-98/128. September. On-Line Address: http://www.epa.gov/osw/hazard/correctiveaction/resources/guidance/rem_eval/protocol.pdf

EPA. 1999. Use of Monitored Natural Attenuation at Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action and Underground Storage Tank Sites. OSWER Directive 9200 4-1 17P. April 21.

EPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER Directive 9355.4-24. December.

EPA. 2008. Engineering Issue, Indoor Air Vapor Intrusion Mitigation Approaches, Office of Research and Development. Cincinnati, OH. EPA/600/R-08-115. October. On-line Address: http://www.clu-in.org/download/char/600r08115.pdf

EPA. 2009. *U.S. Environmental Protection Agency Region 5 Greener Cleanup Interim Policy.* On-line Address:

http://www.epa.gov/R5Brownfields/pdfs/gcinterimpolicyr05signedcopy1109.pdf

EPA. 2010. Vapor Intrusion Guidebook, Region 5 Superfund Division. October. On-line Address: http://www.epaosc.org/sites/3806/files/VI%20Guidebook%20-%20%2010-1-10%20-%20final%20version.pdf

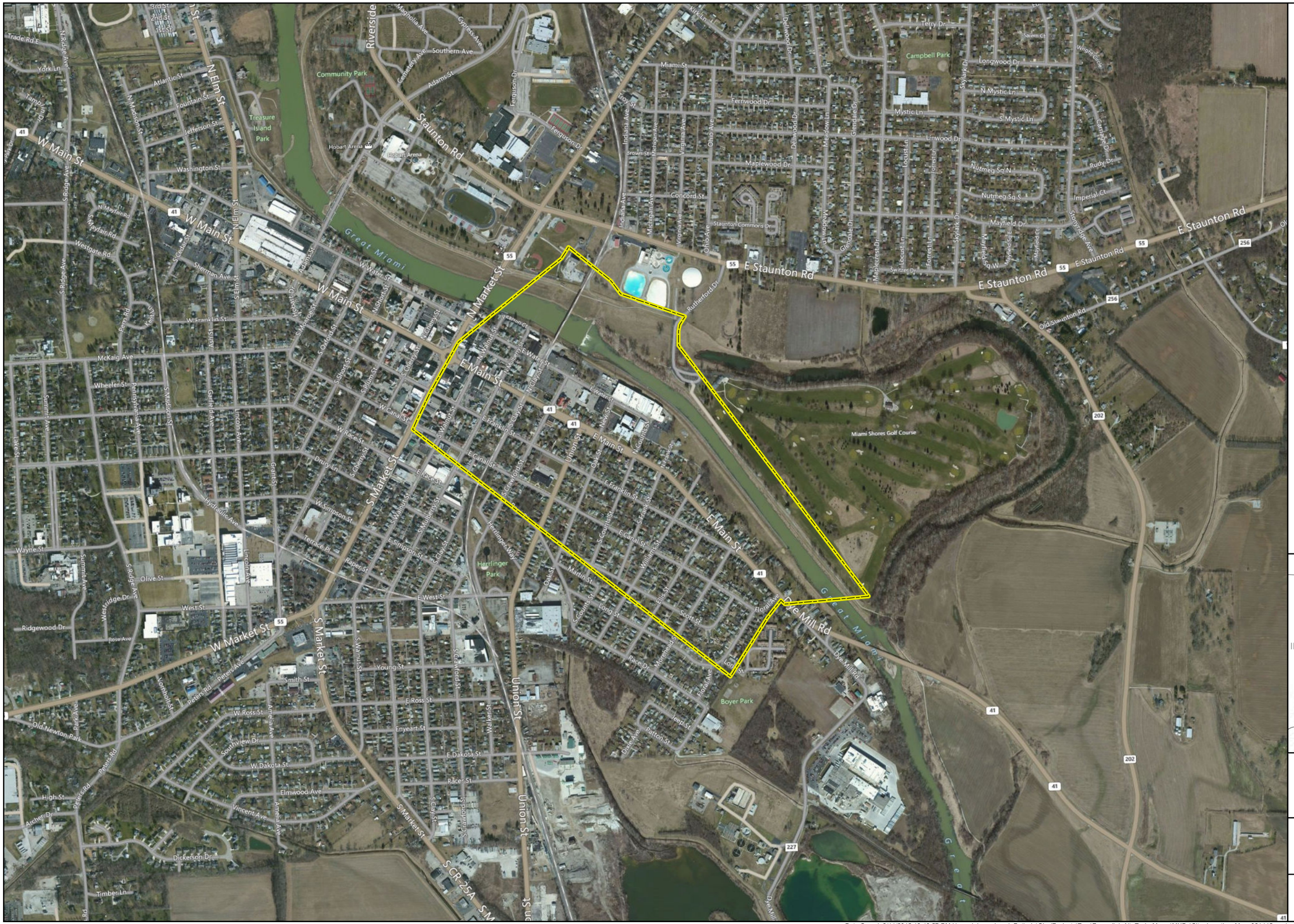
EPA. 2012. "Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites." Office of Solid Waste and Emergency Response (OSWER). EPA 540-R-09-001. December.

EPA. 2013. OSWER Vapor Intrusion Assessment, Vapor Intrusion Screening Level (VISL) Calculator, Version 3.1, June 2013 RSLs. June. On-line Address: http://www.epa.gov/oswer/vaporintrusion/guidance.html

EPA. 2015. "Regional Screening Level (RSL) Summary Table, January 2015." On-line Address: http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/docs/master_sl_table_run_JAN2015.pdf

Troy Daily News. 1979. News article regarding fire at 10/12 East Main Street. September.

Zentox Corporation. 1998. Zetox's PCO Treats VOC Air. Waste Treatment Technology News, v14, n1, Oct 1. On-line Address: http://www.clu-in.org/products/tins/tinsone.cfm?id=5915256



Legend

Remedial Investigation Study Area

N

0 500 1,000

Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-1

SITE LOCATION

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EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-2
SITE FEATURES

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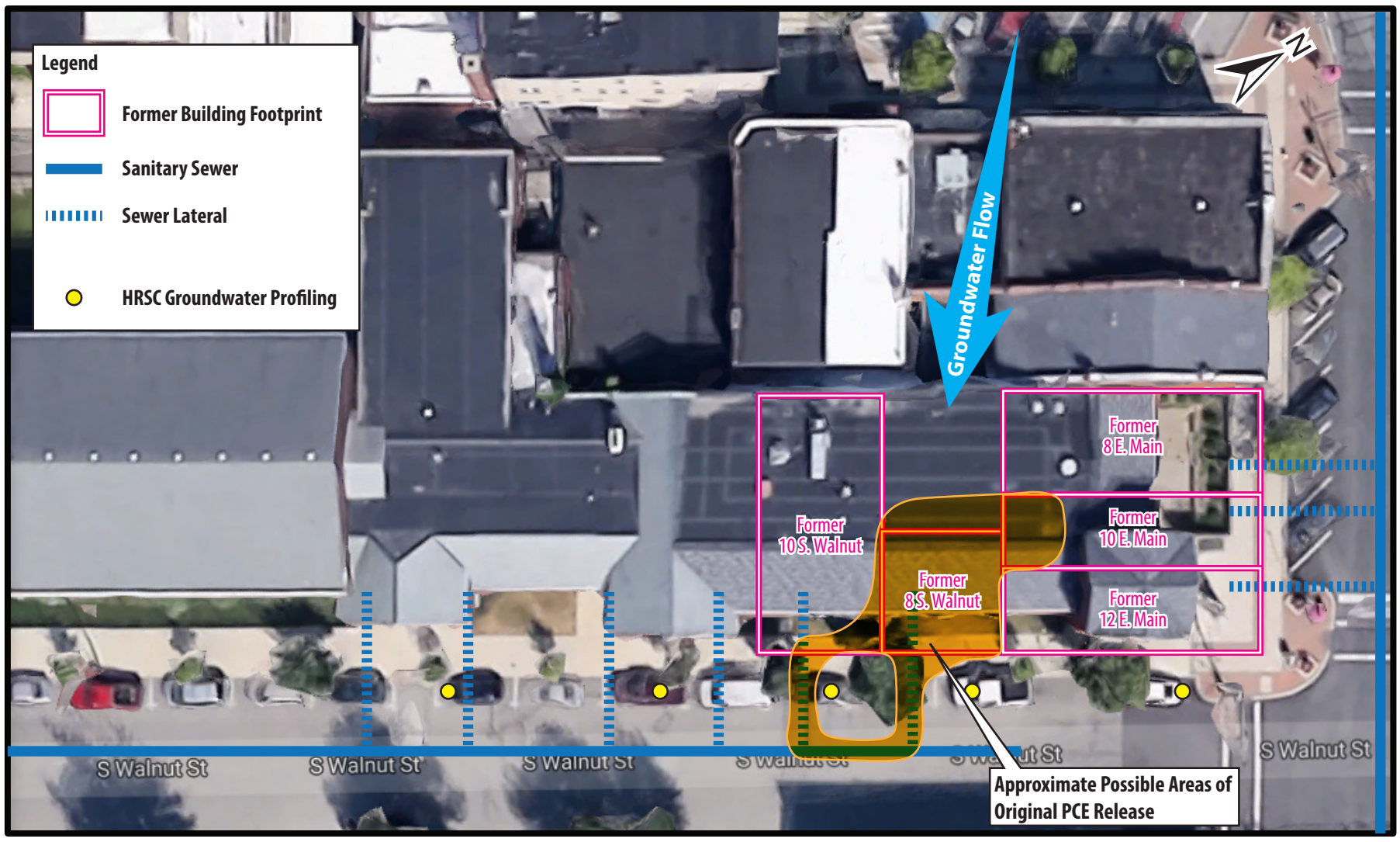
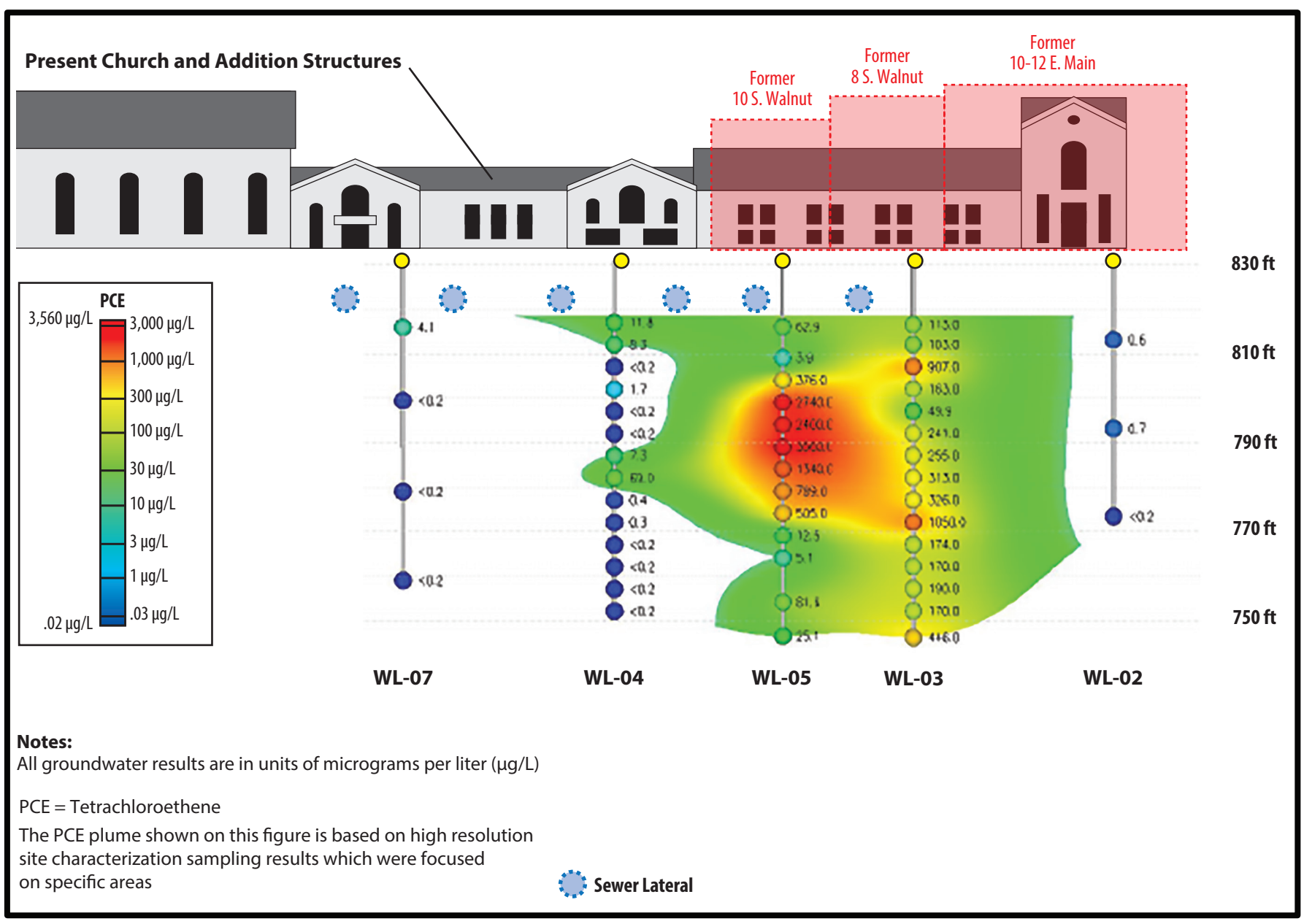


Figure 1-3A. Plan view of Residential Plume Source Area



Notes:
All groundwater results are in units of micrograms per liter (µg/L)

PCE = Tetrachloroethene

The PCE plume shown on this figure is based on high resolution site characterization sampling results which were focused on specific areas

Figure 1-3B . Waterloo Groundwater PCE Profile Along Walnut Street Adjacent to Source Area

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-3A AND 1-3B
RESIDENTIAL AREA PLUME SOURCE AREA - PLAN AND PROFILE VIEWS

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- Ohio EPA Well
- Phase I RI Well
- Geoprobe Location
- HRSC Groundwater Profiling
- Former Building Footprint
- Direction of Groundwater Flow

Total Chlorinated VOCs

- 1,000 (ppb)
- 500 (ppb)
- 100 (ppb)
- 5 (ppb)

Notes:
Total concentration is the sum of PCE, TCE, cis-1,2-DCE, and VC.
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
D - Deep
EPA - US Environmental Protection Agency
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
ETCA - East Troy Contaminated Aquifer
KC - Kimberly Clark
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
MOR - Morehead Street
ND - Not detected
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
S - Shallow
T - Miami Conservancy District Monitoring Well
TCE - Trichloroethene
VAS - Vertical Aquifer Sample
VC - Vinyl Chloride
VOC - Volatile Organic Compound
WAL - Walnut Stree

0 50 100
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-3
RESIDENTIAL AREA PCE PLUME SOURCE AREA LAYOUT

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Approximate Excavation Area Based on Shaw 2006 Report

N

0 25 50

Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-4

SOIL EXCAVATION AREAS
SPINNAKER PROPERTY WEST END

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- Phase I Soil Sample (May-June 2012)
- Phase II Soil Sample (February 2013)

Soil sample concentrations in micrograms per kilogram (µg/kg).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

N

0 200 400
Feet

Notes:
CHE - Cherry Street
CLY - Clay Street
CRA - Crawford Street
FRA - Franklin Street
HER - Herrlinger Way
J - Estimated value
MAI - Main Street
MUL - Mulberry Street
PCE - Tetrachloroethene
RAC - Race Street
SB - Soil Boring
TCE - Trichloroethene
TPD - Troy Police Department

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-5

RESIDENTIAL AREA
SOIL SAMPLING RESULTS

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- Phase I Soil Sample (May-June 2012)
- Phase II Soil Sample (February 2013)
- Additional Phase II Soil Sample (December 2013 and January 2014)
- Approximate Extent of Soil Exceeding Industrial Screening Levels
- Approximate Extent of Soil Exceeding Residential Screening Levels

Soil sample concentrations in micrograms per kilogram (µg/kg).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

N

0 30 60

Feet

Notes:
1,1,2-TCA - 1,1,2-Trichloroethane
cis-1,2-DCE - cis-1,2-Dichloroethene
HOB - Hobart
J - Estimated value
PCE - Tetrachloroethene
SB - Soil Boring
STP - St. Patrick Parking Lot
TCE - Trichloroethene

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-6

HOBART AREA
SOIL SAMPLING RESULTS

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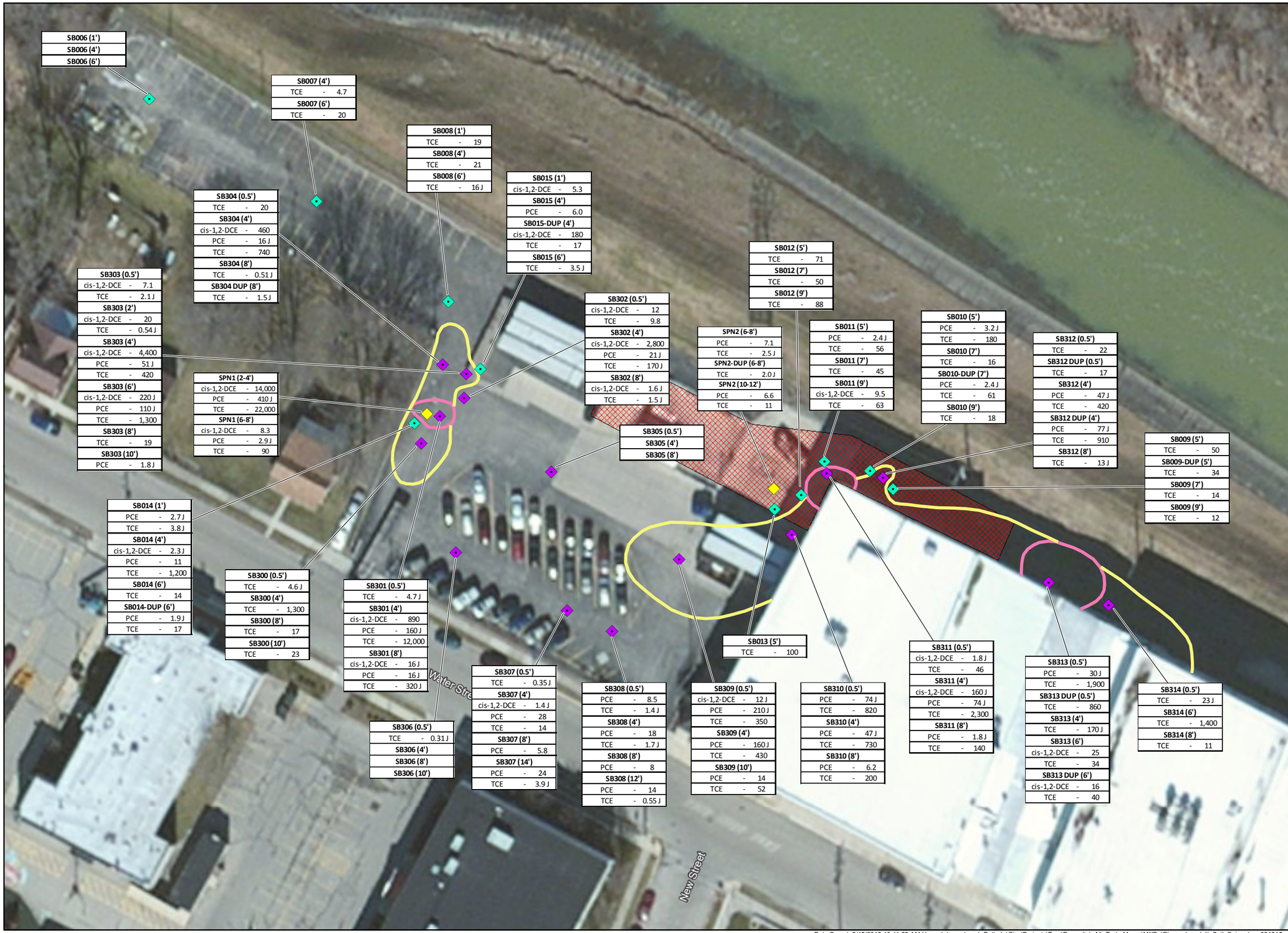

Legend

- Phase I Soil Sample (May-June 2012)
- Phase II Soil Sample (February 2013)
- Additional Phase II Soil Sample (December 2013 and January 2014)
- Approximate Extent of Soil Exceeding Industrial Screening Levels
- Approximate Extent of Soil Exceeding Residential Screening Levels
- Approximate Area with Highest VOC Detections Based on Shaw 2006 Report

Soil sample concentrations in micrograms per kilogram (µg/kg).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

N

0 25 50
Feet

Notes:
cis-1,2-DCE - cis-1,2-Dichloroethene
DUP - Duplicate
J - Estimated value
PCE - Tetrachloroethene
SB - Soil Boring
SPN - Spinnaker
TCE - Trichloroethene

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-7

SPINNAKER AREA
SOIL SAMPLING RESULTS

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Legend

Phase II Soil Sample (February 2013)

Soil sample concentrations in micrograms per kilogram (µg/kg).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

N

0 20 40
Feet

Notes:
SB - Soil Boring
SS - Surface Soil Sample

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-8

EAST WATER STREET RESIDENTIAL AREA SOIL SAMPLING RESULTS

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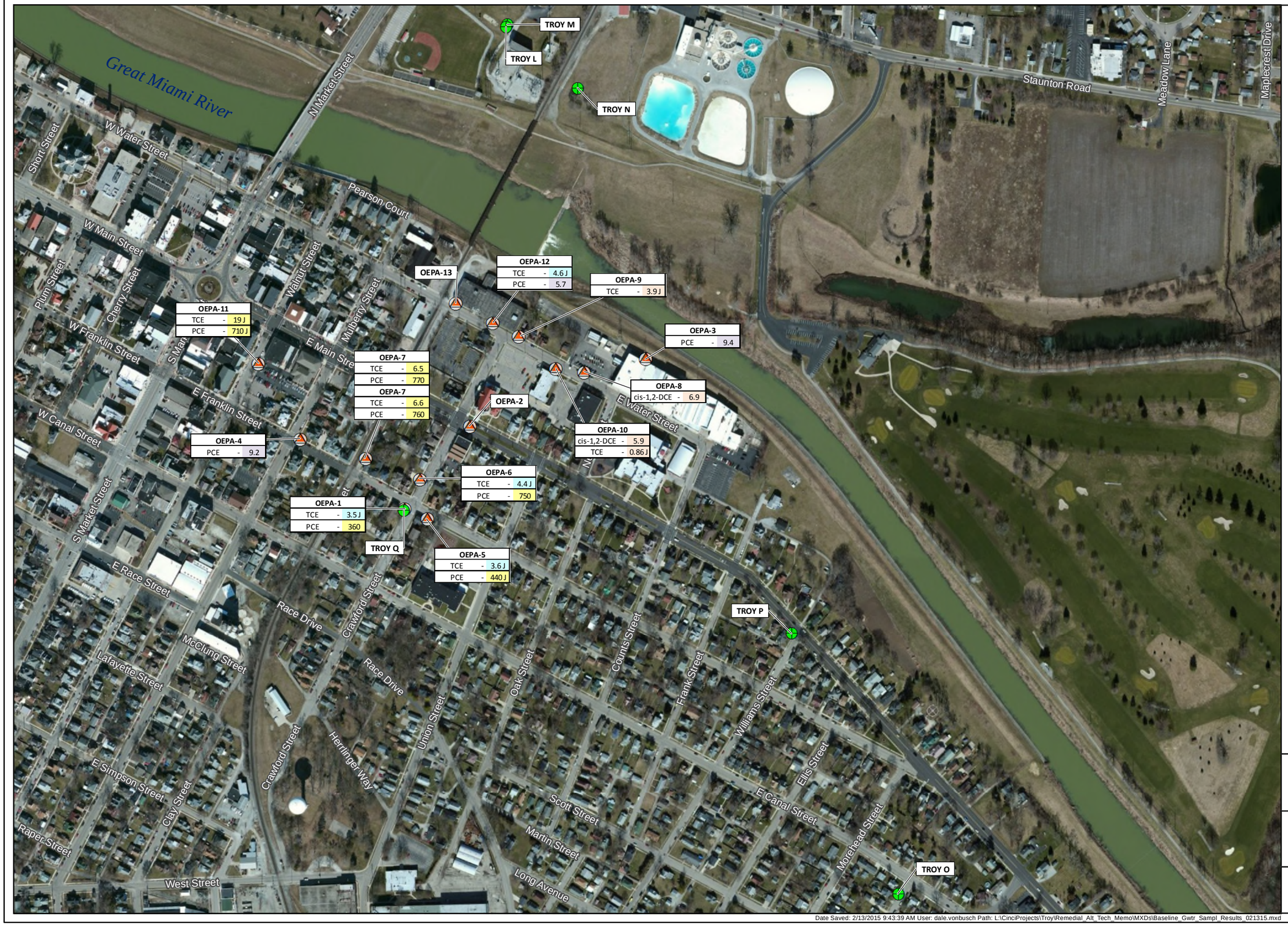

Legend

- Ohio EPA Well
- Troy Monitoring Well

Groundwater sample concentrations in µg/L (Micrograms per liter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

N

0 200 400
Feet

Exceeds MCL, tap water EPA RSL, and EPA VISL
Exceeds tap water EPA RSL
Exceeds EPA VISL and tap water EPA RSL
Exceeds MCL and tap water EPA RSL

Notes:
cis-1,2-DCE - cis-1,2-Dichloroethene
J - Estimated value
MCL - Maximum Contaminant Level
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
RSL - Regional Screening Level
TCE - Trichloroethene
VISL - Vapor Intrusion Screening Level

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-9

BASELINE GROUNDWATER SAMPLING RESULTS- AUGUST 2010

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Groundwater sample concentrations in µg/L (Micrograms per liter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

Legend

- Ohio EPA Well
- Phase I RI Well
- Troy Monitoring Well
- KC Monitoring Well
- MCD Well
- Screening Sample From Direct Push Boring
- Geoprobe Groundwater Sampling (December 2011)

N

0 150 300
Feet

- Exceeds MCL, tap water EPA RSL, and EPA VISL
- Exceeds tap water EPA RSL
- Exceeds EPA VISL and tap water EPA RSL
- Exceeds MCL and tap water EPA RSL

Notes:
Bromo - Bromodichloromethane
cis-1,2-DCE - cis-1,2-Dichloroethene
Chlor - Chloroform
CLY - Clay Street
D - Deep
Dibromo - Dibromochloromethane
DUP - Duplicate
EPA - US Environmental Protection Agency
ETCA - East Troy Contaminated Aquifer
FRA - Franklin Street
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
HOB - Hobart Area Boring
I - Intermediate
J - Estimated value
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MAI - Main Street
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
RSL - Regional Screening Level
S - Shallow
SB - Soil Boring
STP - Saint Patrick Parking Lot
T - Miami Conservancy District Monitoring Well
TCE - Trichloroethene
VISL - Vapor Intrusion Screening Level
WAL- Walnut Street

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-10

PHASE I COMPREHENSIVE GROUNDWATER SAMPLING RESULTS - APRIL/MAY 2012

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Groundwater sample concentrations in µg/L (Micrograms per liter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

Legend

- Ohio EPA Well
- Phase I RI Well
- Phase II RI Well
- Troy Monitoring Well
- KC Monitoring Well
- MCD Well
- Geoprobe Location
- VAS Location
- Total Chlorinated VOCs >100 µg/L (ppb) Plume Area
- Total Chlorinated VOCs <100 µg/L (ppb) Plume Area

N

0 200 400
Feet

Exceeds MCL, tap water EPA RSL, and EPA VISL
Exceeds tap water EPA RSL
Exceeds EPA VISL and tap water EPA RSL
Exceeds MCL and tap water EPA RSL

Notes:
Bromo - Bromodichloromethane
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
Chlor - Chloroform
Dibromo - Dibromochloromethane
DUP - Duplicate
EPA - US Environmental Protection Agency
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
ETCA - East Troy Contaminated Aquifer
J - Estimated value
KC - Kimberly Clark
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
MOR - Morehead Street
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
RSL - Regional Screening Level
S - Shallow
T - Miami Conservancy District Monitoring Well
TCE - Trichloroethene
VAS - Vertical Aquifer Sample
VISL - Vapor Intrusion Screening Level
VOC - Volatile Organic Compound
WAL - Walnut Street

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-11

PHASE II COMPREHENSIVE GROUNDWATER SAMPLING RESULTS - FEBRUARY/MARCH 2013 (SHALLOW ZONE)

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Groundwater sample concentrations in µg/L (Micrograms per liter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

Legend

- Ohio EPA Well
- Phase I RI Well
- Phase II RI Well
- Troy Monitoring Well
- KC Monitoring Well
- MCD Well
- Geoprobe Location
- VAS Location
- Total Chlorinated VOCs >100 µg/L (ppb) Plume Area
- Total Chlorinated VOCs <100 µg/L (ppb) Plume Area

Exceeds MCL, tap water EPA RSL, and EPA VISL
Exceeds tap water EPA RSL
Exceeds EPA VISL and tap water EPA RSL
Exceeds MCL and tap water EPA RSL

Notes:
BW - Soil Boring - Groundwater
DUP - Duplicate
EPA - US Environmental Protection Agency
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
ETCA - East Troy Contaminated Aquifer
KC - Kimberly Clark
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
MOR - Morehead Street
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
RSL - Regional Screening Level
S - Shallow
T - Miami Conservancy District Monitoring Well
VAS - Vertical Aquifer Sample
VISL - Vapor Intrusion Screening Level
VOC - Volatile Organic Compound
WAL - Walnut Street

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-11A

PHASE II COMPREHENSIVE GROUNDWATER SAMPLING - PCE RESULTS - FEBRUARY/MARCH 2013 (SHALLOW ZONE)

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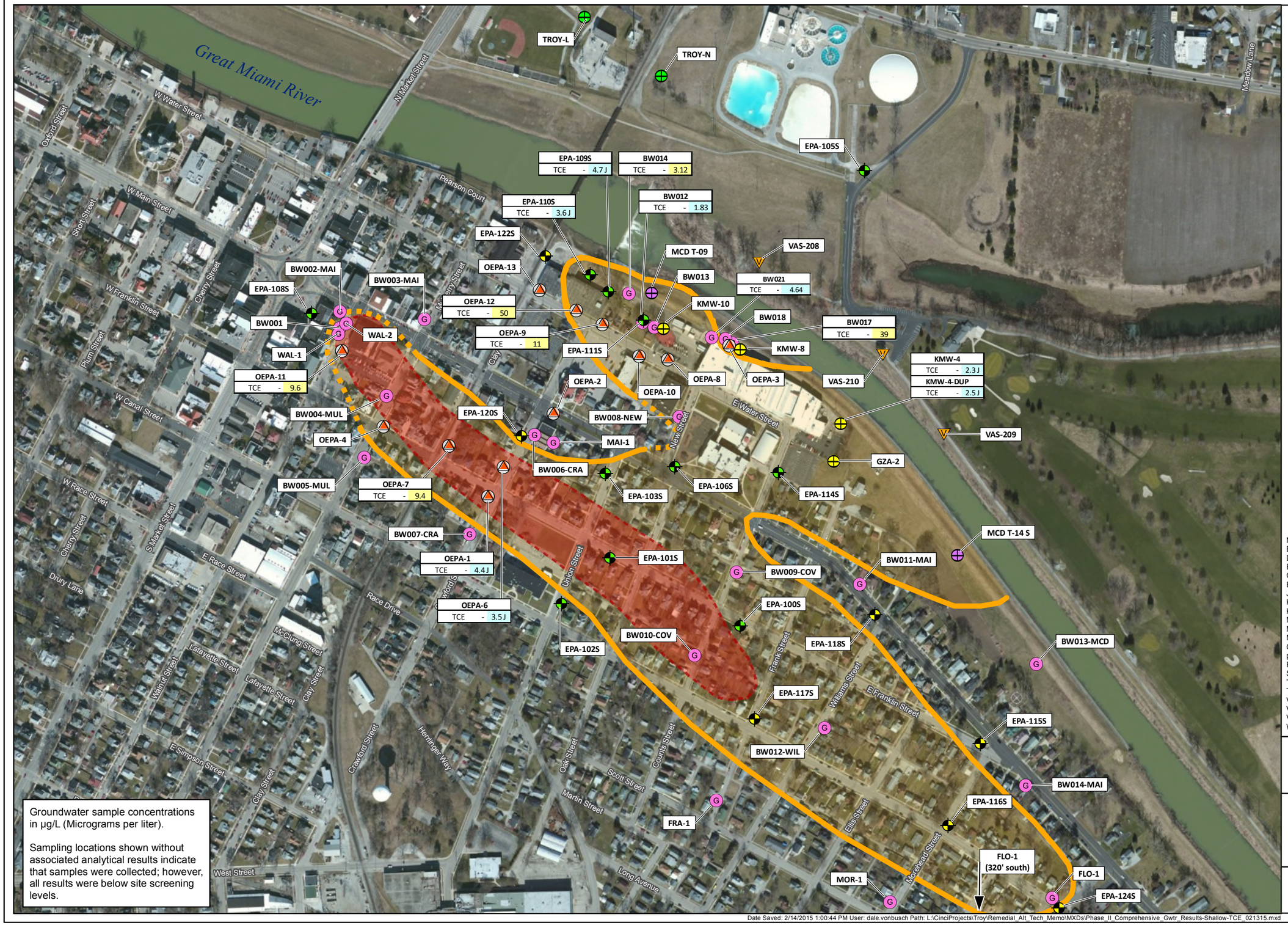

Groundwater sample concentrations in µg/L (Micrograms per liter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

Legend

- Ohio EPA Well
- Phase I RI Well
- Phase II RI Well
- Troy Monitoring Well
- KC Monitoring Well
- MCD Well
- Geoprobe Location
- VAS Location
- Total Chlorinated VOCs >100 µg/L (ppb) Plume Area
- Total Chlorinated VOCs <100 µg/L (ppb) Plume Area

N

0 200 400
Feet

Exceeds MCL, tap water EPA RSL, and EPA VISL
Exceeds tap water EPA RSL
Exceeds EPA VISL and tap water EPA RSL
Exceeds MCL and tap water EPA RSL

Notes:
BW - Soil Boring - Groundwater
DUP - Duplicate
EPA - US Environmental Protection Agency
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
ETCA - East Troy Contaminated Aquifer
J - Estimated value
KC - Kimberly Clark
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
MOR - Morehead Street
OEPA - Ohio Environmental Protection Agency
ppb - Parts per billion
RSL - Regional Screening Level
S - Shallow
T - Miami Conservancy District Monitoring Well
TCE - Trichloroethene
VAS - Vertical Aquifer Sample
VISL - Vapor Intrusion Screening Level
VOC - Volatile Organic Compound
WAL - Walnut Street

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-11B

PHASE II COMPREHENSIVE GROUNDWATER SAMPLING - TCE RESULTS - FEBRUARY/MARCH 2013 (SHALLOW ZONE)

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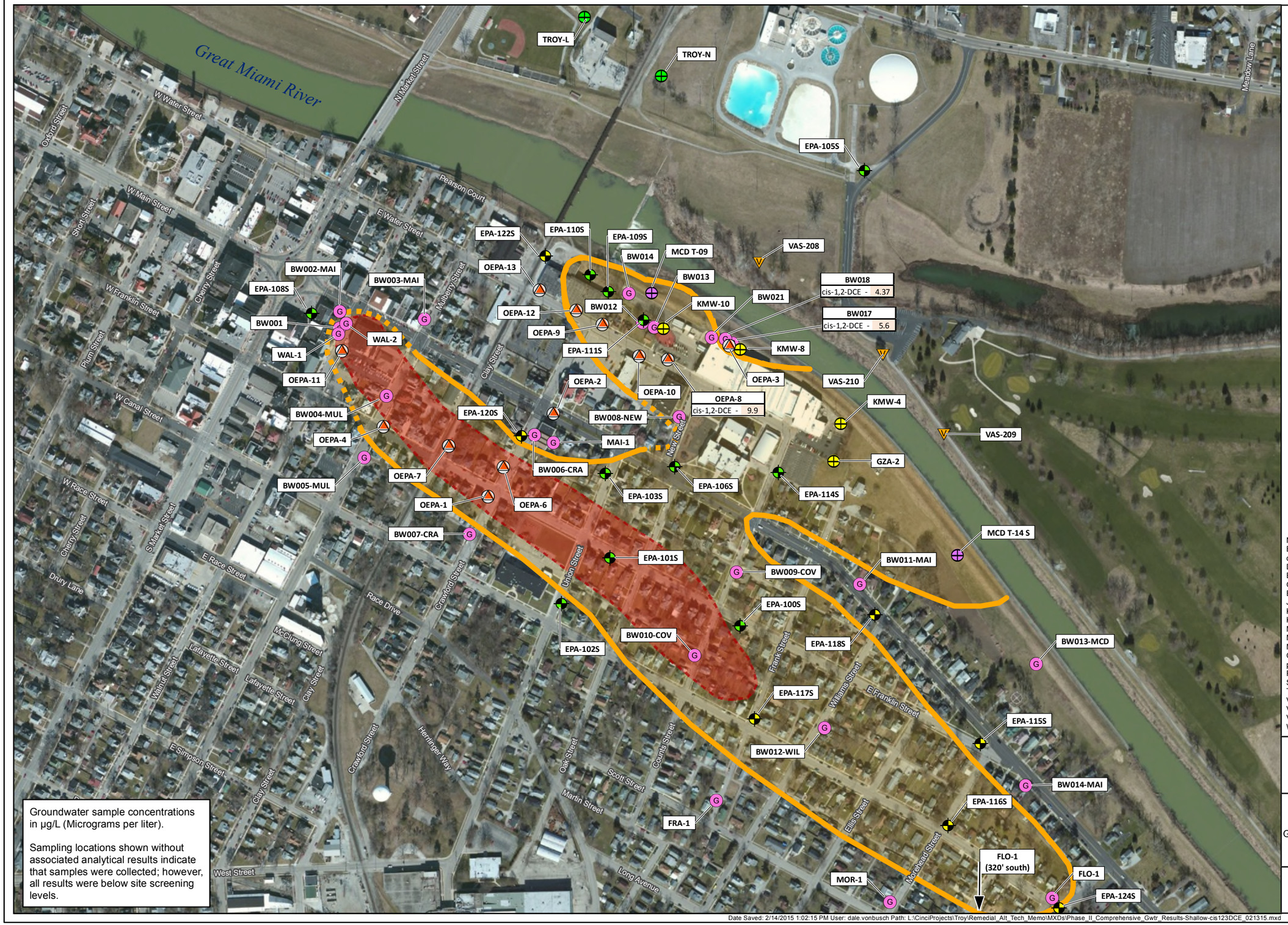

Legend

- Ohio EPA Well
- Phase I RI Well
- Phase II RI Well
- Troy Monitoring Well
- KC Monitoring Well
- MCD Well
- Geoprobe Location
- VAS Location
- Total Chlorinated VOCs >100 µg/L (ppb) Plume Area
- Total Chlorinated VOCs <100 µg/L (ppb) Plume Area

N

0 200 400
Feet

Exceeds MCL, tap water EPA RSL, and EPA VISL
Exceeds tap water EPA RSL
Exceeds EPA VISL and tap water EPA RSL
Exceeds MCL and tap water EPA RSL

Notes:
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
DUP - Duplicate
EPA - US Environmental Protection Agency
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
ETCA - East Troy Contaminated Aquifer
J - Estimated value
KC - Kimberly Clark
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
MOR - Morehead Street
OEPA - Ohio Environmental Protection Agency
ppb - Parts per billion
RSL - Regional Screening Level
S - Shallow
T - Miami Conservancy District Monitoring Well
VAS - Vertical Aquifer Sample
VISL - Vapor Intrusion Screening Level
VOC - Volatile Organic Compound
WAL - Walnut Street

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-11C

PHASE II COMPREHENSIVE GROUNDWATER SAMPLING - cis-1,2 DCE RESULTS - FEBRUARY/MARCH 2013 (SHALLOW ZONE)

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Groundwater sample concentraions in µg/L (Micrograms per liter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

Legend

- Phase I RI Well
- Phase II RI Well
- Troy Monitoring Well
- Vertical Aquifer Sampling Location (VAS)

N

0 200 400
Feet

Exceeds MCL, tap water EPA RSL, and EPA VISL
Exceeds tap water EPA RSL
Exceeds EPA VISL and tap water EPA RSL
Exceeds MCL and tap water EPA RSL

Notes:
D - Deep
EPA - US Environmental Protection Agency
I - Intermediate
MCL - Maximum Contaminant Level
PCE - Tetrachloroethene
RSL - Regional Screening Level
TCE - Trichloroethene
VAS - Vertical Aquifer Sample
VISL - Vapor Intrusion Screening Level

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-12
PHASE II COMPREHENSIVE GROUNDWATER SAMPLING RESULTS - FEBRUARY/MARCH 2013 (INTERMEDIATE AND DEEP ZONES)

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Groundwater sample concentraions in µg/L (Micrograms per liter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

Legend

- Ohio EPA Well
- Phase I RI Well
- Phase II RI Well
- KC Monitoring Well
- Phase II Soil Boring Grab Groundwater Sample (December 2013/ January 2014)

N

0 200 400
Feet

Exceeds MCL, tap water EPA RSL, and EPA VISL
Exceeds tap water EPA RSL
Exceeds EPA VISL and tap water EPA RSL
Exceeds MCL and tap water EPA RSL

Notes:
Chlor - Chloroform
cis-1,2-DCE - cis-1,2-Dichloroethene
DUP - Duplicate
EPA - US Environmental Protection Agency
I - Intermediate
J - Estimated value
MCL - Maximum Contaminant Level
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
RSL - Regional Screening Level
S - Shallow
SB - Soil Boring
TCE - Trichloroethene
VISL - Vapor Intrusion Screening Level

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-13
ADDITIONAL PHASE II GROUNDWATER SAMPLING RESULTS – DECEMBER 2013 AND JANUARY 2014

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Sample concentrations in µg/m^3 (Micrograms per cubic meter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

Legend

Vapor Intrusion Monitoring Locations (January 2012)

N

0 150 300
Feet

Exceeds residential indoor air VISL for target hazard quotient of 1 and target risk of 1E-06

Exceeds commercial indoor air VISL for target hazard quotient of 1 and target risk of 1E-06

Exceeds residential sub-slab soil gas VISL for target hazard quotient of 1 and target risk of 1E-06

Exceeds commercial sub-slab soil gas VISL for target hazard quotient of 1 and target risk of 1E-06

Notes:
1,2-DCA - 1,2-Dichloroethane
1,2,4-TCB - 1,2,4-Trichlorobenzene
1,3-B - 1,3-Butadiene
1,4-DCB - 1,4-Dichlorobenzene
a-C - alpha-Chlorotoluene
Bromo - Bromodichloromethane
cis-1,2-DCE - cis-1,2-Dichloroethene
Chlor - Chloroform
CT - Carbon Tetrachloride
Dibromo - Dibromochloromethane
EB - Ethyl Benzene
IA - Indoor Air Sample
J - Estimated value
J+ - Results estimated, but may be biased high
MCL - Maximum Contaminant Level
PCE - Tetrachloroethene
RSL - Regional Screening Level
SS - Sub-Slab Sample
TCE - Trichloroethene
VISL - Vapor Intrusion Screening Level

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-14

PHASE I VAPOR INTRUSION MONITORING RESULTS

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Sample concentrations in µg/m^3 (Micrograms per cubic meter).

Sampling locations shown without associated analytical results indicate that samples were collected; however, all results were below site screening levels.

Legend

Vapor Intrusion Monitoring Locations (August 2012 and April 2013)

N

0 150 300
Feet

Exceeds residential indoor air VISL for target hazard quotient of 1 and target risk of 1E-06

Exceeds commercial indoor air VISL for target hazard quotient of 1 and target risk of 1E-06

Exceeds residential sub-slab soil gas VISL for target hazard quotient of 1 and target risk of 1E-06

Exceeds commercial sub-slab soil gas VISL for target hazard quotient of 1 and target risk of 1E-06

Notes:
1,2-DCA - 1,2-Dichloroethane
1,2,4-TCB - 1,2,4-Trichlorobenzene
1,3-B - 1,3-Butadiene
1,4-DCB - 1,4-Dichlorobenzene
a-C - alpha-Chlorotoluene
Bromo - Bromodichloromethane
cis-1,2-DCE - cis-1,2-Dichloroethene
Chlor - Chloroform
CT - Carbon Tetrachloride
Dibromo - Dibromochloromethane
EB - Ethyl Benzene
IA - Indoor Air Sample
J - Estimated value
J+ - Results estimated, but may be biased high
MCL - Maximum Contaminant Level
PCE - Tetrachloroethene
RSL - Regional Screening Level
SS - Sub-Slab Sample
TCE - Trichloroethene
VISL - Vapor Intrusion Screening Level

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-15

PHASE II VAPOR INTRUSION MONITORING RESULTS

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Notes:
D - Deep
EPA - US Environmental Protection Agency
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
I - Intermediate
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
OEPA - Ohio Environmental Protection Agency
S - Shallow
T - Miami Conservancy District Monitoring Well
TROY - City of Troy Monitoring Well
VOCs - Volatile Organic Compounds
µg/L - Micrograms per liter

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-16

GROUNDWATER SAMPLE LOCATIONS AND GROUNDWATER EXPOSURE AREAS – BOTH PLUMES

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Legend

- Phase I Soil Sample (May-June 2012)
- Phase II Soil Sample (February 2013)
- Phase II Soil Sample (December 2013 and January 2014)
- Exposure Areas

N

0 40 80
Feet

Notes:
CHE - Cherry Street
CLY - Clay Street
CRA - Crawford Street
FRA - Franklin Street
HER - Herrlinger Way
HOB - Hobart
MAI - Main Street
MUL - Mulberry Street
RAC - Race Street
SB - Soil Boring
SPN - Spinnaker
SS - Soil Sample
STP - St. Patrick Parking Lot
TPD - Troy Police Department

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 1-17

SOIL SAMPLE LOCATIONS AND SOIL EXPOSURE AREAS - EAST WATER STREET PLUME

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Legend

- Phase I Soil Sample (May-June 2012)
- Phase II Soil Sample (February 2013)
- Phase II Soil Sample (December 2013 and January 2014)
- Exposure Areas
- Estimated area of soil exceeding PRGs to 15 feet deep
- Estimated area of soil exceeding PRGs to 10 feet deep
- Estimated area of soil exceeding PRGs to 8 feet deep
- Estimated area of soil exceeding PRGs to 6 feet deep

Notes:
CHE - Cherry Street
CLY - Clay Street
COC - Contaminant of concern
CRA - Crawford Street
FRA - Franklin Street
HER - Herrlinger Way
HOB - Hobart
MAI - Main Street
MUL - Mulberry Street
PRG - Preliminary Remediation Goal based on RAOs for the interim action
RAC - Race Street
RAO - Regional Action Objectives
SB - Soil Boring
SPN - Spinnaker
SS - Soil Sample
STP - St. Patrick Parking Lot
TPD - Troy Police Department

0 50 100
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 2-1
AREAS AND DEPTHS OF SOILS SUBJECT TO RAOs

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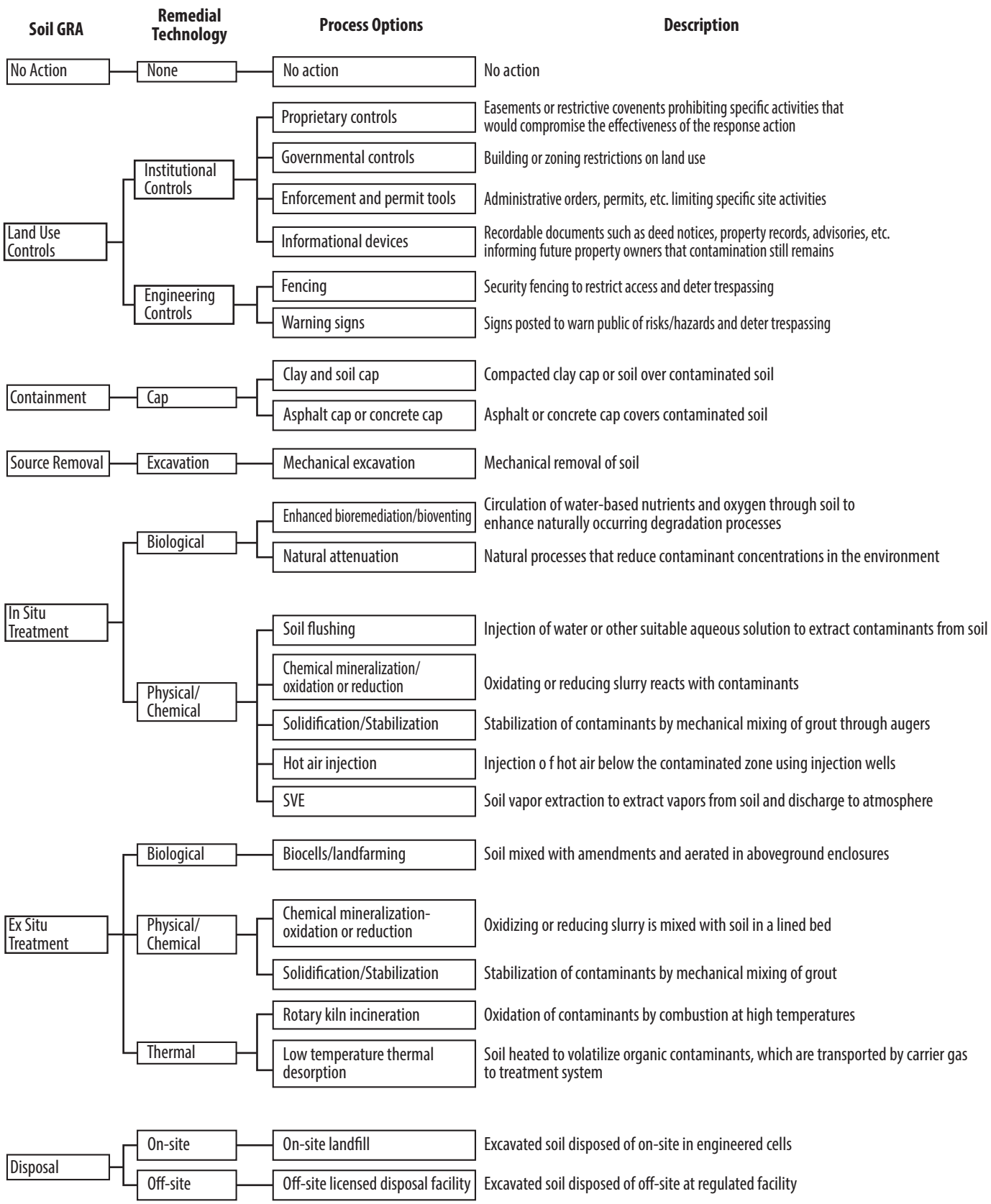

FIGURE 3-1
GRAs, TECHNOLOGIES, AND PROCESS OPTIONS FOR SOIL

Notes:

GRA = General response action
SVE = Soil vapor extraction

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Groundwater GRA	Remedial Technology	Process Options	Description
No action	No action	No action	No action
Land Use Controls	Institutional Controls	Proprietary controls	Easements or restrictive covenents prohibiting specific activities that would compromise the effectiveness of the response action
		Governmental controls	Building or zoning restrictions on land use
		Enforcement and permit tools	Administrative orders, permits, etc. limiting specific site activities
		Informational devices	Recordable documents such as deed notices, property records, advisories, etc. informing that future property owners contamination still remains
Monitoring	Monitoring	Groundwater monitoring	Periodic sampling and analyses of groundwater in existing monitoring wells at the ETCA site
Containment	Pumping/ barriers	Extraction wells	Installation of several wells at a site and pumping these wells at specified rates to manipulate the natural hydraulic gradient
		Slurry wall	A vertical barrier constructed of a cement-bentonite mixture sometimes mixed with native soil
		Sheet piling	A vertical barrier constructed by driving interlocking sections of steel into the ground to create an impervious wall
In Situ Treatment	Natural Attenuation	Monitored Natural attenuation	Attenuation through natural physical, chemical, and biological processes
	Biological treatment	Enhanced reductive dechlorinization	Anaerobic biodegradation using organic carbon substrate such as vegetable oil, molasses, or sodium lactate delivered into the subsurface to stimulate native microogranisms
	Chemical treatment	In-situ chemical oxidation	Uses chemicals called "oxidants" to help change harmful contaminants into less toxic ones
		In-situ chemical reduction	Placement of reducing agents in groundwater to destroy or immobilize contaminants
	Physical treatment	Air sparging	A system of injection wells injects air into groundwater, where dissolved and adsorbed VOCs would be removed by air stripping
Removal	Pumping	Extraction wells	Installation of several wells at a site and pumping these wells at specified rates to manipulate the natural hydraulic gradient
		Interceptor trenches	A trench with a perforated pipe layed horizontally along the bottom
Ex Situ Treatment	Physical/ Chemical	Air stripping	Contaminated water in an air stripping unit is exposed to large volumes of air where VOCs are transferred from a water phase to an air phase
		Adsorption	Various techniques which concentrate contaminated solids or remove nonaqueous liquids from groundwater or other aqueous streams via physical and chemical means
		Advanced oxidation	Technology that generates the hydroxyl free radical to destroy organic contaminants
Disposal	Discharge	Injection	Treated groundwater is injected back in the formation
		Discharge to surface water	Collecting contaminated groundwater, treating groundwater to meet NPDES discharge requirements, and discharging the treated groundwater to nearby water body
		Discharge to POTW	Collecting contaminated groundwater, treating groundwater to meet POTW standards, and discharging the treated groundwater to the POTW for final treatment and disposal

Notes:

GRA = General response action
NPDES = National Pollution Discharge Elimination System
POTW = Publicaly owned treatment works
VOC = Volatile organic compound

FIGURE 3-2
GRAs, TECHNOLOGIES, AND PROCESS OPTIONS FOR GROUNDWATER

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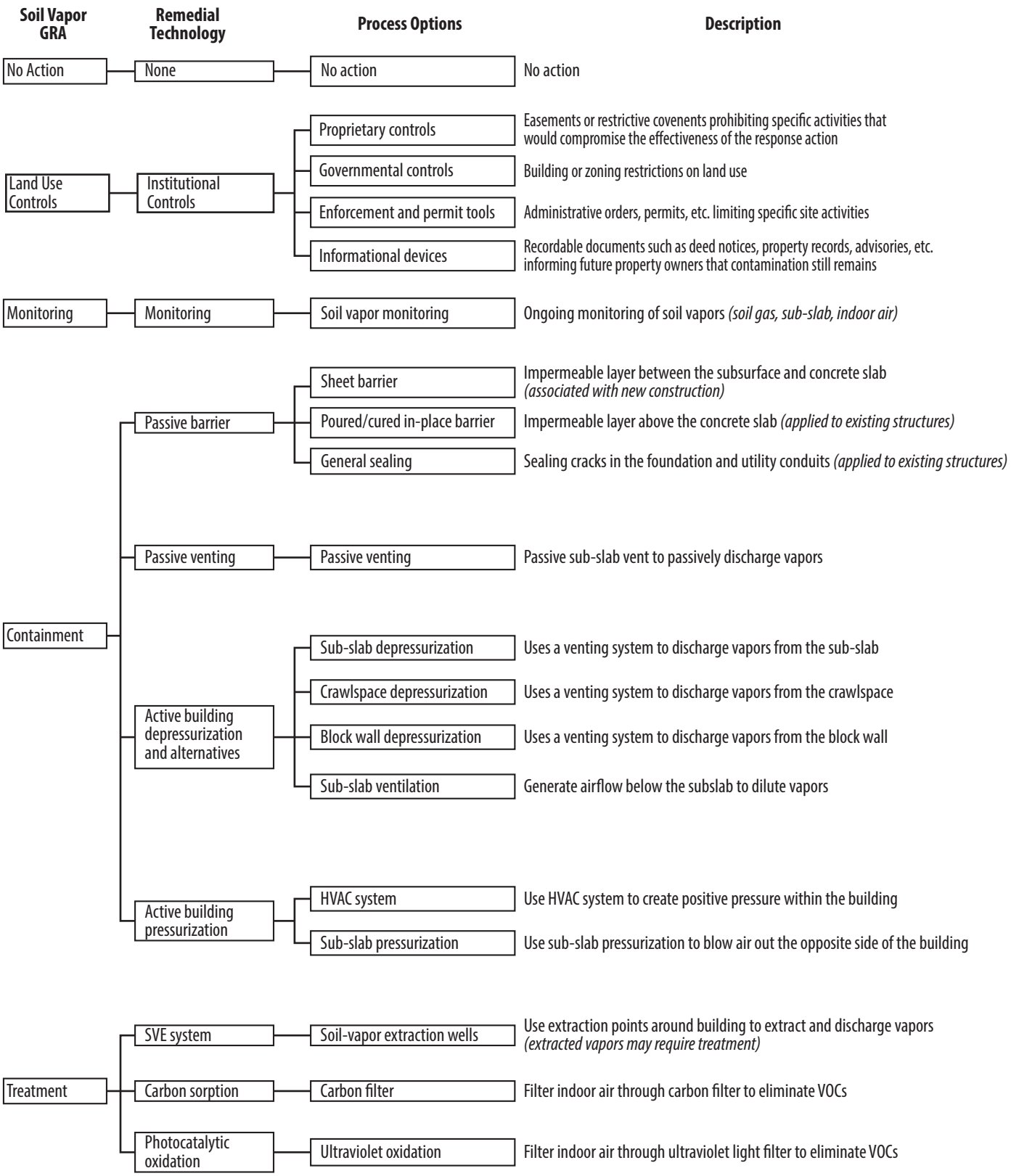

Notes:

GRA = General response action
HVAC = Heating ventilation and air conditioning
SVE = Soil vapor extraction
VOC = Volatile organic compound

FIGURE 3-3
GRAs, TECHNOLOGIES, AND PROCESS OPTIONS FOR VAPOR INTRUSION

ST SulTRAC

Process Options	Effectiveness	Implementability	Cost
No action	Does not achieve RAOs	Not acceptable to state and federal agencies	None
Institutional controls	Effective for limiting potential exposure to contaminants by restricting access and land use	Readily implementable	Negligible capital and low O&M costs
Engineering Controls	Effective for limiting potential exposure to contamination by prohibiting or restricting access and deterring trespassing	Readily implementable	Low capital and O&M costs
Capping	Effective for limiting potential exposure by preventing direct contact, reduces infiltration, minimizes leaching of contamination from soil to groundwater	Readily implementable, requires institutional controls to maintain integrity	Moderate capital and moderate to low O&M costs
Excavation	Effective for limiting potential exposure by preventing direct contact, prevents leaching of contamination from soil to groundwater; workers and community may be exposed to contaminated soil during implementation	Readily implementable	High capital and no O&M costs
Enhanced Bioremediation/ Bioventing	Effective for reducing the concentrations of contaminants in soil; thus reducing the potential exposure to and leaching of contaminants	Readily implementable	Moderate capital and low O&M costs
Natural Attenuation	Effective for reducing potential exposure to contaminants	Readily implementable, would be required for long term	No capital and low O&M costs
Soil Flushing	Effective for reducing the concentrations of contaminants in soil; thus reducing the potential exposure to and leaching of contaminants	Readily implementable	High capital and moderate O&M costs
In-Situ Chemical Oxidation/ Reduction	Effective for reducing the concentrations of contaminants in soil; thus reducing the potential exposure to and leaching of contaminants	Readily implementable	Moderate capital and low O&M costs
Solidification/ Stabilization	Effective for imobilizing or stabilizing contaminated soil; thus reducing the potential exposure to and leaching of contamination	Readily implementable	High capital and low O&M costs
Hot Air Injection	Effective for reducing the concentrations of contaminants in soil; thus reducing the potential exposure to and leaching of contaminants	Readily implementable; requires power for blowers; may require treatment of air discharge	Moderate capital and O&M costs
SVE	Effective for reducing the concentrations of contaminants in soil; thus reducing the potential exposure to and leaching of contaminants may not achieve preliminary remediation goals	Readily implementable; may require treatment of air discharge and power for blowers	Moderate capital and O&M costs
Biocells/Landfarming	Effective for reducing potential exposure to contaminants, reduces leaching of contaminents from soil to groundwater	Readily implementable; would require large land area and long time frame	Moderate capital and low to moderate O&M costs
Ex-situ Treatment (Bio/Phys/Chem/Thermal)	Effective for reducing potential exposure to contaminants, reduces leaching of contaminents from soil to groundwater	Readily implementable; requires pilot test and large area for treatment process	Moderate to high capital and low to no O&M costs
On-site Disposal	Effective for reducing potential exposure to contaminants, reduces leaching of contaminents from soil to groundwater	Readily implementable; requires large land area for constructing disposal facility and long term O&M	High capital and moderate O&M costs
Off-site Disposal	Effective for reducing potential exposure to contaminants, reduces leaching of contaminents from soil to groundwater	Readily implementable	High capital and no O&M costs

Notes:

O&M = Operation and maintenance
SVE = Soil vapor extraction
RAO = Remedial action objective

Retained process option (*see text in Section 4.1 for screening discussion details*)

FIGURE 4-1
SCREENING OF PROCESS OPTIONS FOR SOIL

SulTRAC

Process Options	Effectiveness	Implementability	Cost
No action	Does not achieve RAOs	Not acceptable to state and federal agencies	None
Proprietary controls	Effective for limiting potential exposure to contaminants	Readily implementable	Negligible
Governmental controls	Effective for limiting potential exposure to contaminants	Readily implementable	Negligible
Enforcement and permit tools	Effective for limiting potential exposure to contaminants	Readily implementable	Negligible
Informational devices	Effective for informing on-site or nearby populations of remaining contamination	Readily implementable	Negligible
Groundwater monitoring	Effective for tracking contaminants	Readily implementable	Low capital and low to moderate O&M costs
Extraction wells (containment)	Effective for plume control	Readily implementable	Moderate capital and moderate to high O&M costs
Sheet piling/slurry wall	Effective in controlling off-site groundwater migration if keyed into a lower confining layer or coupled with hydraulic control	Difficult to implement because of urban landscape and buried utilities	High capital and low O&M costs
Monitored Natural attenuation	Effective for low level contamination	Readily implementable	Low capital and moderate O&M costs
Enhanced reductive dechlorination	Effective for high level contamination	Moderately difficult to implement; requires significant treatability studies	Moderate capital and O&M costs
In-situ Chemical oxidation	Effective for high level contamination	Readily implementable	Moderate to high capital and moderate O&M costs
In-situ chemical reduction	Effective for high level contamination	Moderately easy to implement	High capital and low O&M costs
Extraction wells (removal)	Effective for groundwater cleanup	Readily implementable	Moderate capital and moderate to high O&M costs
Sparging	Effective for high level contamination	Readily implementable; requires soil vapor extraction to remove vapor-phase contaminants	Moderate capital and O&M costs
Interceptor trenches	Effective for plume control	Difficult to implement because of urban landscape and buried utilities	High to moderate capital and low to moderate O&M costs
Air stripping	Effective for removing volatile COCs in extracted groundwater	Readily implementable	Low capital and O&M costs
Adsorption	Effective for removing organic COCs in extracted groundwater	Readily implementable; separate-phase contamination is not expected at the site	Moderate capital and high O&M costs
Advanced oxidation	Effective for organic COCs in extracted groundwater	Readily implementable; explosives are not contaminants of concern at the site; pre- and post-treatment of contaminated groundwater will be required	High capital and low O&M costs
Discharge to Injection Wells	Effective for managing extracted and treated groundwater	Technically implementable; will require approval by state agencies	Moderate capital and O&M costs
Discharge to surface water	Effective for managing extracted and treated groundwater	Technically implementable; will require approval by state agencies	Moderate capital and O&M costs
Discharge to POTW	Effective for managing extracted and treated groundwater	Depends on POTW capacity. Pre-treatment standards easily attainable	Moderate capital and O&M costs

Notes:

O&M = Operation and maintenance
POTW = Publicly owned treatment works
RAO = Remedial action objective
COC = Chemical of concern

Retained process option (*see text in Section 4.2 for screening discussion details*)

FIGURE 4-2
SCREENING OF
PROCESS OPTIONS FOR GROUNDWATER

SulTRAC

Process Options	Effectiveness	Implementability	Cost
No action	Does not achieve RAOs	Not acceptable to state and federal agencies	None
Institutional controls	Effective for reducing potential exposure to contaminants	Readily implementable	Negligible capital and low O&M costs
Vapor intrusion monitoring	Effective for tracking contaminants and evaluating effectiveness of vapor intrusion mitigation systems	Readily implementable; would require installation of soil-gas and sub-slab probes	Low capital and low to moderate O&M costs
Sheet barrier	Effective for preventing vapor intrusion through the sub-slab	Difficult to implement for existing structures; requires removing and replacing existing slab	High capital and negligible O&M costs
Poured or cured in-place barrier	Effective for preventing vapor intrusion through the sub-slab	Difficult to implement; requires removing all existing features in basement until existing slab is exposed	High capital and low O&M costs
General sealing	Effective for preventing vapor intrusion through cracks and openings the sub-slab or walls	Moderately difficult to implement; requires finding and sealing conduits and cracks in basement	Low capital and low O&M costs
Passive venting	Effective for rerouting vapors from the sub-slab through vents	Difficult to implement; requires new construction to take advantage of convection currents associated with piping through the house	Moderate capital and low O&M costs
Sub-slab depressurization	Effective for actively removing vapors from the sub-slab	Moderately difficult to implement; requires installation of soil-vapor system to remove vapors from the sub-slab	Moderate capital and low O&M costs
Crawlspace depressurization	Effective for actively removing vapors from the crawlspace	Moderately difficult to implement; requires installation of soil-vapor system to remove vapors from the crawlspace	Moderate capital and low O&M costs
Block wall depressurization	Effective for actively removing vapors from the block wall	Moderately difficult to implement; requires installation of soil-vapor system to remove vapors from the block wall	Moderate capital and low O&M costs
Sub-slab ventilation	Effective for diluting VOCs within the sub-slab	Moderately difficult to implement; requires installation of soil-vapor system to blow air beneath the sub-slab	Moderate capital and low O&M costs
HVAC system	Effective for creating positive pressure within the building to prevent vapors from entering the building	Readily implementable; uses existing HVAC system	Low capital and moderate O&M costs
Sub-slab pressurization	Effective for blowing vapors out of the sub-slab to the other side of building	Moderately difficult to implement; requires installation of soil-vapor system to blow air out from underneath the sub-slab	Moderate capital and moderate O&M costs
Soil vapor extraction wells	Effective for removing soil vapors around the building	Moderately difficult to implement; requires the installation of an SVE system and delineation of soil-gas plume	Moderate capital and moderate to high O&M costs
Carbon filter	Effective for removing specific VOCs from a single room	Readily implementable; requires purchase of room filters	Low capital and moderate O&M costs
Ultraviolet oxidation	Effective for removing specific VOCs from a single room or entire house	Readily implementable; requires purchase of room filter or HVAC filter	Low capital and moderate O&M costs

Notes:

HVAC = Heating ventilation and air conditioning
O&M = Operation and maintenance
RAO = Remedial action objective
VOC = Volatile organic compound

Retained process option (*see text in Section 4.3 for screening discussion details*)

FIGURE 4-3
SCREENING OF
PROCESS OPTIONS FOR VAPOR INTRUSION

SulTRAC

Legend

- Phase I Soil Sample (May-June 2012)
- Phase II Soil Sample (February 2013)
- Phase II Soil Sample (December 2013 and January 2014)
- Exposure Areas
- Estimated area of soil exceeding PRGs to 15 feet deep
- Estimated area of soil exceeding PRGs to 10 feet deep
- Estimated area of soil exceeding PRGs to 8 feet deep
- Estimated area of soil exceeding PRGs to 6 feet deep

Notes:
CHE - Cherry Street
CLY - Clay Street
COC - Contaminant of concern
CRA - Crawford Street
FRA - Franklin Street
HER - Herrlinger Way
HOB - Hobart
MAI - Main Street
MUL - Mulberry Street
PRG - Preliminary Remediation Goal based on RAOs for the interim action
RAC - Race Street
RAO - Regional Action Objectives
SB - Soil Boring
SPN - Spinnaker
SS - Soil Sample
STP - St. Patrick Parking Lot
TPD - Troy Police Department

0 50 100
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 5-1
SOIL ALTERNATIVE S-2
PROPOSED EXCAVATION AREAS

SulTRAC

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Legend

- Phase I Soil Sample (May-June 2012)
- Phase II Soil Sample (February 2013)
- Phase II Soil Sample (December 2013 and January 2014)
- Exposure Areas
- Proposed Area of Asphalt Cap
- Assumed Area of Excavation (area exceeding PRGs)

Notes:
CHE - Cherry Street
CLY - Clay Street
COC - Contaminant of concern
CRA - Crawford Street
FRA - Franklin Street
HER - Herrlinger Way
HOB - Hobart
MAI - Main Street
MUL - Mulberry Street
PRG - Preliminary Remediation Goal based on RAOs for the interim action
RAC - Race Street
RAO - Regional Action Objectives
SB - Soil Boring
SPN - Spinnaker
SS - Soil Sample
STP - St. Patrick Parking Lot
TPD - Troy Police Department

0 50 100
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 5-2
SOIL ALTERNATIVE S-3
PROPOSED SOIL EXCAVATION AND ASPHALT CAP AREAS

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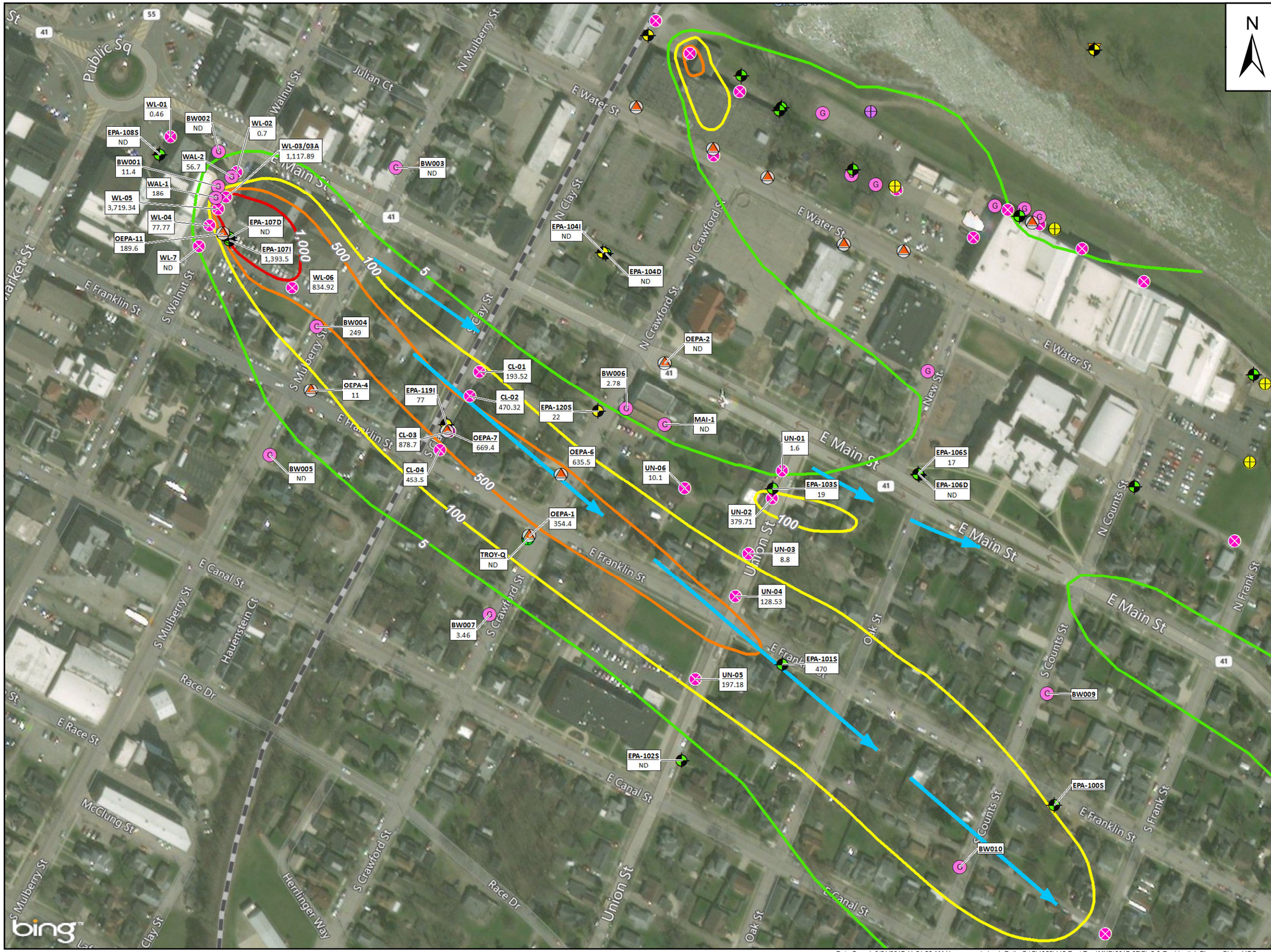

Legend

- Ohio EPA Well
- Phase I RI Well
- Phase II RI Well
- Troy Monitoring Well
- KC Monitoring Well
- MCD Well
- Geoprobe Location
- HRSC Waterloo Groundwater Profiling (April-May 2013)
- VAS Location
- Direction of Groundwater Flow

Total Chlorinated VOCs

- 5 (ppb)
- 1,000 (ppb)
- 500 (ppb)
- 100 (ppb)

Notes:
Total concentration is the sum of PCE, TCE, cis-1,2-DCE, and VC.
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
D - Deep
EPA - US Environmental Protection Agency
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
ETCA - East Troy Contaminated Aquifer
KC - Kimberly Clark
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
MOR - Morehead Street
ND - Not detected
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
S - Shallow
T - Miami Conservancy District Monitoring Well
TCE - Trichloroethene
VAS - Vertical Aquifer Sample
VC - Vinyl Chloride
VOC - Volatile Organic Compound
WAL - Walnut Street

0 100 200
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 5-3
PHASE II TOTAL CHLORINATED VOCs NEAR THE SOURCE AREA - RESIDENTIAL AREA PLUME

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Legend

- Conceptual Performance Monitoring Well
- Ohio EPA Well
- Phase I RI Well
- Phase II RI Well
- Troy Monitoring Well
- KC Monitoring Well
- MCD Well
- Geoprobe Location
- HRSC Groundwater Profiling
- VAS Location
- Conceptual Injection and/or Extraction Well Locations

Total Chlorinated VOCs

- 5 (ppb)
- 1,000 (ppb)
- 500 (ppb)
- 100 (ppb)

Notes:
Injection, extraction and performance monitoring wells depicted are conceptual; actual locations and numbers will be determined during the remedial design.

Total concentration is the sum of PCE, TCE.

cis-1,2-DCE, and VC.
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
D - Deep
EPA - US Environmental Protection Agency
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
ETCA - East Troy Contaminated Aquifer
KC - Kimberly Clark
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
MOR - Morehead Street
ND - Not detected
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
S - Shallow
T - Miami Conservancy District Monitoring Well
TCE - Trichloroethene
VAS - Vertical Aquifer Sample
VC - Vinyl Chloride
VOC - Volatile Organic Compound
WAL - Walnut Street

0 100 200
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 5-4
ALTERNATIVES RGW-2A, RGW-2B AND RGW-2C CONCEPTUAL LAYOUT

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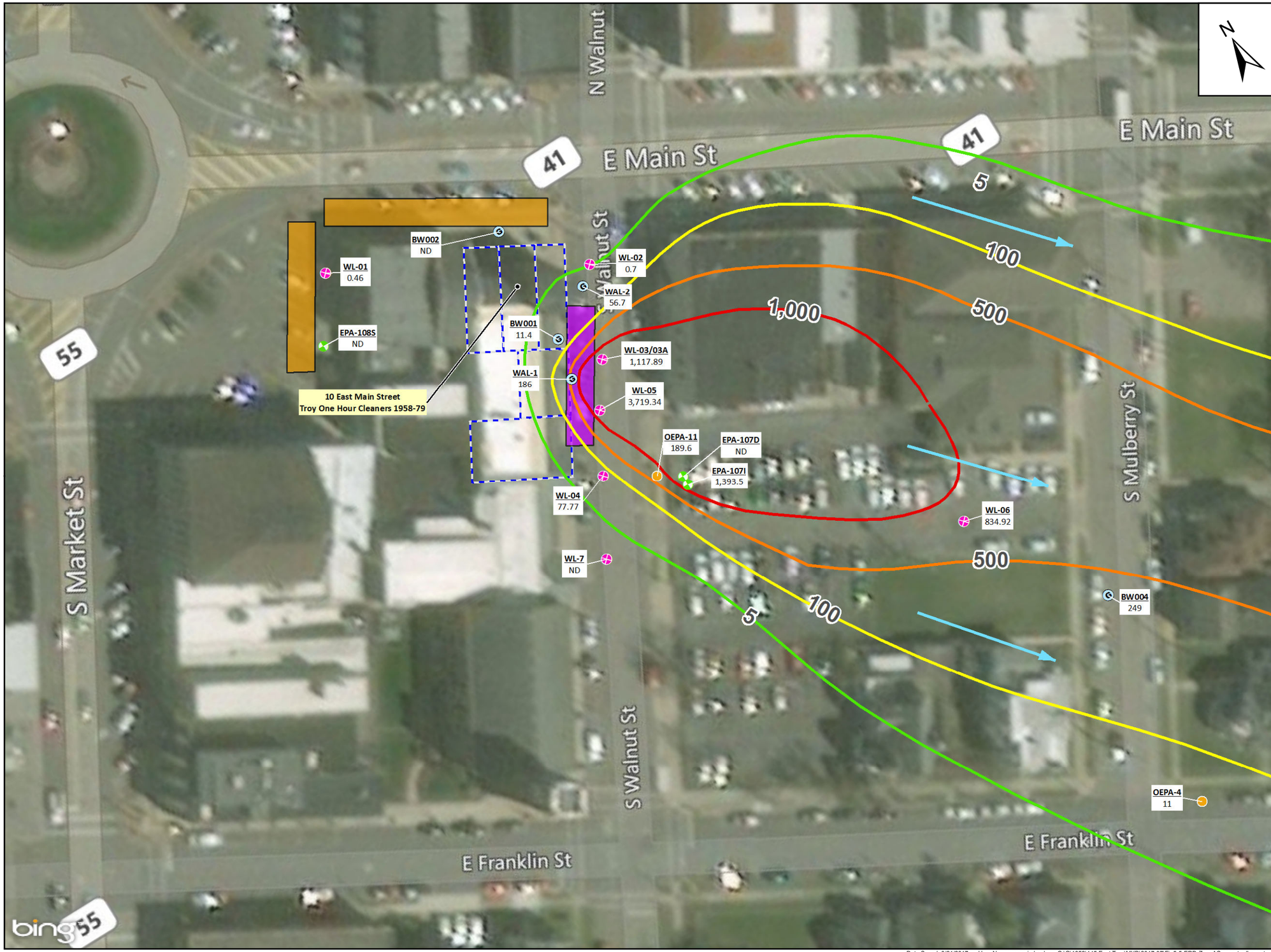

Legend

- Ohio EPA Well
- Phase I RI Well
- Geoprobe Location
- HRSC Groundwater Profiling
- Direction of Groundwater Flow
- Former Building Footprint - Prior structures located in PCE plume source area, now covered by church addition
- Conceptual area for amendment injection and groundwater extraction wells
- Conceptual area for amendment injection with clean water

Total Chlorinated VOCs

- 5 (ppb)
- 1,000 (ppb)
- 500 (ppb)
- 100 (ppb)

Notes:

1. Enhanced reductive dechlorination assumed to deliver amendments to targeted treatment zones via recirculation, with injection and extraction wells used to recirculate groundwater.
2. Clean water supply well would be located ~200 feet from the process equipment.

Total concentration is the sum of PCE, TCE, cis-1,2-DCE, and VC.
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
D - Deep
EPA - US Environmental Protection Agency
ERD - Enhanced Reductive Dechlorination
ND - Not detected
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
S - Shallow
VAS - Vertical Aquifer Sample
VOC - Volatile Organic Compound
WAL - Walnut Stree

0 50 100
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 5-5
ALTERNATIVE RGW-2A: ERD ZONE A CONCEPTUAL LAYOUT

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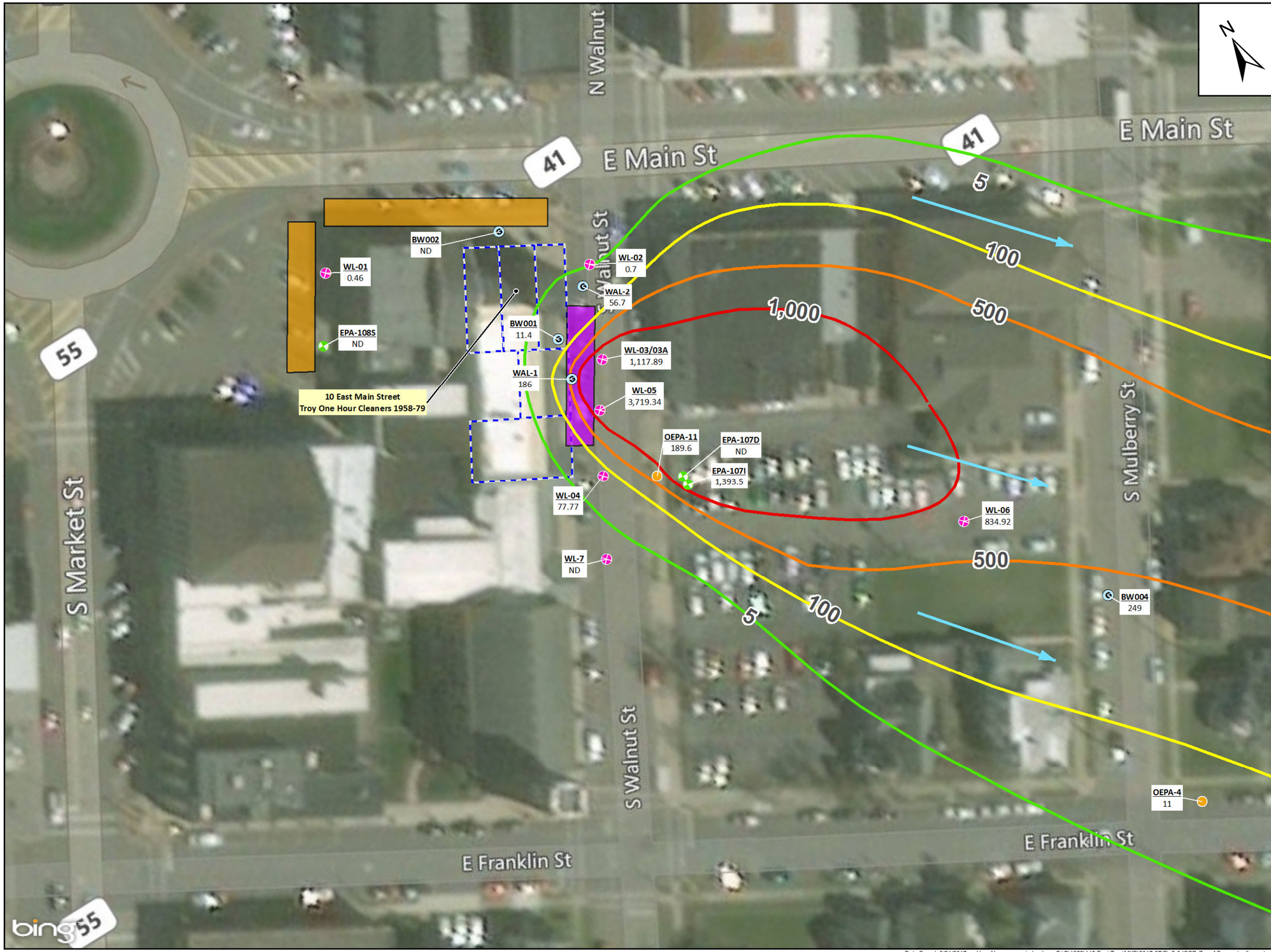

Legend

- Ohio EPA Well
- Phase I RI Well
- Geoprobe Location
- HRSC Groundwater Profiling
- Direction of Groundwater Flow
- Former Building Footprint - Prior structures located in PCE plume source area, now covered by church addition
- Conceptual area for amendment injection and groundwater extraction wells
- Conceptual area for amendment injection with clean water

Total Chlorinated VOCs

- 5 (ppb)
- 1,000 (ppb)
- 500 (ppb)
- 100 (ppb)

Notes:

1. In-situ chemical reduction assumed to deliver amendments to targeted treatment zones via recirculation, with injection and extraction wells used to recirculate groundwater.
2. Clean water supply well would be located ~200 feet from the process equipment.

Total concentration is the sum of PCE, TCE, cis-1,2-DCE, and VC.
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
D - Deep
EPA - US Environmental Protection Agency
ISCR - In Situ Chemical Reduction
ND - Not detected
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
S - Shallow
VAS - Vertical Aquifer Sample
VOC - Volatile Organic Compound
WAL - Walnut Stree

0 50 100
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 5-6
ALTERNATIVE RGW-2B: ISCR ZONE A CONCEPTUAL LAYOUT

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Legend

- Ohio EPA Well
- Phase I RI Well
- Geoprobe Location
- HRSC Groundwater Profiling
- Direction of Groundwater Flow
- Former Building Footprint - Prior structures located in PCE plume source area, now covered by church addition
- Conceptual area for amendment injection with clean water

Total Chlorinated VOCs

- 5 (ppb)
- 1,000 (ppb)
- 500 (ppb)
- 100 (ppb)

Notes:

1. In-situ chemical oxidation assumed to deliver amendments to targeted treatment zones via injection only.
2. Clean water supply well would be located ~200 feet from the process equipment.

Total concentration is the sum of PCE, TCE, cis-1,2-DCE, and VC.
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
D - Deep
EPA - US Environmental Protection Agency
ISCO - In Situ Chemical Oxidation
ND - Not detected
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
S - Shallow
VAS - Vertical Aquifer Sample
VOC - Volatile Organic Compound
WAL - Walnut Stree

0 50 100
Feet

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 5-7
ALTERNIATIVE RGW-2C: ISCO ZONE A CONCEPTUAL LAYOUT

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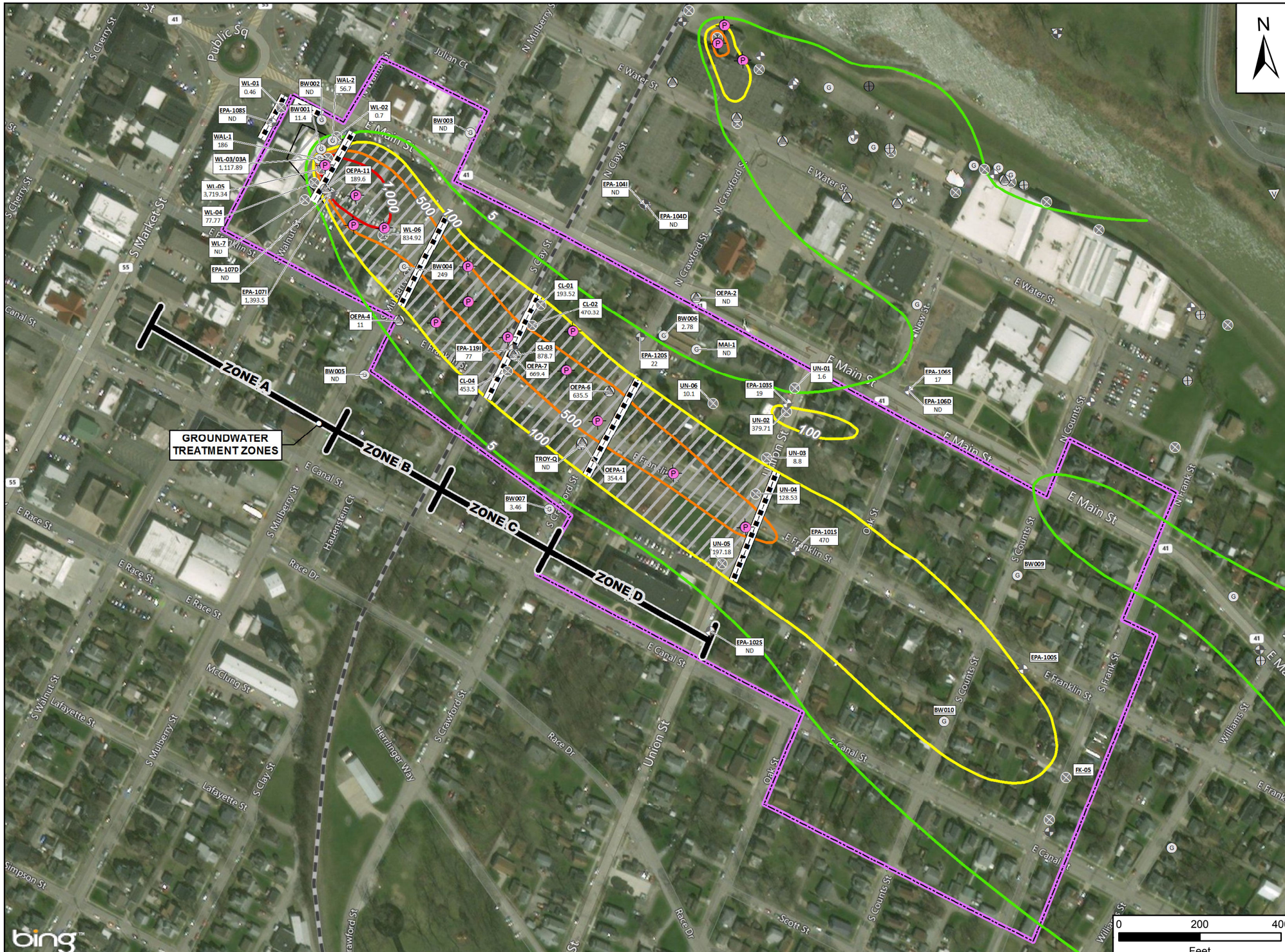

Legend

- Proposed Performance Monitoring Well
- Ohio EPA Well
- Phase I RI Well
- Phase II RI Well
- Troy Monitoring Well
- KC Monitoring Well
- MCD Well
- Geoprobe Location
- HRSC Groundwater Profiling
- VAS Location
- Conceptual Injection and/or Extraction Well Locations
- Targeted Treatment Area
- Estimated Area for Sub-slab Depressurization Systems

Total Chlorinated VOCs

- 5 (ppb)
- 1,000 (ppb)
- 500 (ppb)
- 100 (ppb)

Notes:
Injection, extraction and performance monitoring well locations are conceptual - actual numbers and locations will be determined during the remedial design.

Total concentration is the sum of PCE, TCE.

cis-1,2-DCE, and VC.
BW - Soil Boring - Groundwater
cis-1,2-DCE - cis-1,2-Dichloroethene
D - Deep
EPA - US Environmental Protection Agency
ETCA - East Troy Contaminated Aquifer
GZA - Spinnaker Site/ Kimberly Clark Monitoring Well
KC - Kimberly Clark
KMW - Spinnaker Site/ Kimberly Clark Monitoring Well
MCD - Miami Conservation District
MCL - Maximum Contaminant Level
MOR - Morehead Street
ND - Not detected
OEPA - Ohio Environmental Protection Agency
PCE - Tetrachloroethene
ppb - Parts per billion
S - Shallow
T - Miami Conservancy District Monitoring Well
TCE - Trichloroethene
VAS - Vertical Aquifer Sample
VC - Vinyl Chloride
VI - Vapor Intrusion
VOC - Volatile Organic Compound
WAL - Walnut Street

EAST TROY CONTAMINATED AQUIFER SITE
TROY, OHIO

FIGURE 5-8
ALTERNATIVE VI-2
CONCEPTUAL LAYOUT

SulTRAC

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APPENDIX A

CALCULATIONS FOR LEACHING-BASED REMEDIATION GOALS

Estimation of Mixing zone depth (Equation 12 in Soil Screening Guidance [EPA 1996; 2002])

Symbol	Value	Unit	Parameter	Basis/Source:
L	**40**	m	Source length parallel to groundwater flow	Length of Area 1 (Hobart) measured parallel to groundwater flow, FS Figure 5.3
L	**7**	m	Source length parallel to groundwater flow	Length of Area 6 (Spinnaker) measured parallel to groundwater flow, FS Figure 5.3
d_a	12	m	Aquifer thickness	Average value for the shallow unconfined aquifer, RI Figure 3-5 (Cross Section D-D')
I	**0.21**	m/yr	Infiltration rate	Specified by Ohio EPA in July 2016; Source "Groundwater Pollution Potential of Miami County, Ohio". 1991.
K	11125	m/yr	Hydraulic conductivity	Low end of range presented in RI report (reported range: 100 to 200 ft/d, see RI Section 3.4.3.3)
i	**0.003**	m/m	Horizontal hydraulic gradient	Average horizontal gradient presented in RI report (reported range: 0.001 to 0.005, see RI Section 3.4.3.3)
d	3	m	Mixing zone depth	OEPA request to Shaw to use a mixing zone of about 10 feet
d	**4.41**	m	Mixing zone depth	Calculated for Area 1 (Hobart) using site-specific parameter values
d	**0.77**	m	Mixing zone depth	Calculated for Area 6 (Spinnaker) using site-specific parameter values

Derivation of Dilution Attenuation Factor (Equation 11 in Soil Screening Guidance [EPA 1996; 2002])

K	11125	m/yr	Hydraulic conductivity	Low end of range presented in RI report for the upper zone of the aquifer (reported range: 100 to 200 ft/d - see RI Section 3.4.3.3) The low-end value of the range was reported in the WHPA update for the City of Troy. The upper end of the range was reported by Mill Creek Consultants based on a pump test conducted in the western Spinnaker parking lot. The overall range of site-specific values is also consistent with expected values reported by the USGS for similar aquifer materials.
i	**0.003**	m/m	Horizontal hydraulic gradient	Average horizontal gradient presented in RI report (range: 0.001 to 0.005 depending on where measured on Hobart and Spinnaker properties and depending on event; see RI Section 3.4.3.3 and Figures 3-8, 3-10, 3-12 and 3-14.
I	**0.21**	m/yr	Infiltration rate	Specified by Ohio EPA in July 2016; Source "Groundwater Pollution Potential of Miami County, Ohio". 1991.
L	40	m	Source length parallel to groundwater flow	Length of Area 1 (Hobart) measured parallel to groundwater flow, RI Figure 5.3
L	7	m	Source length parallel to groundwater flow	Length of Area 6 (Spinnaker) measured parallel to groundwater flow, RI Figure 5.3
d	4.41	m	Mixing zone depth	Calculated for Area 1 (Hobart) using site-specific parameter values
d	0.77	m	Mixing zone depth	Calculated for Area 6 (Spinnaker) using site-specific parameter values
DAF	**18.81**	unitless	Dilution Attenuation Factor	Calculated for Area 1 (Hobart) using site-specific parameter values (equals **18** if default mixing zone depth of 3 m is used)
DAF	**18.82**	unitless	Dilution Attenuation Factor	Calculated for Area 6 (Spinnaker) using site-specific parameter values (equals **96** if default mixing zone depth of 3 m is used)

Soil Leach-Based Concentration Calculation (Partitioning Equation for Migration to Groundwater, Equation 10 in Soil Screening Guidance [EPA 1996; 2002])

C_w	0.005	mg/L	Target soil leachate concentration	U.S. EPA maximum contaminant level (MCL) both for PCE and TCE
K_{oc}	94.9	L/kg	Soil Organic Carbon/Water Partitioning Coefficient for PCE	U.S. EPA 2009. Estimation Programs Interface Suite™ for Microsoft Windows®, v. 4.00. Washington, DC.
K_{oc}	60.7	L/kg	Soil Organic Carbon/Water Partitioning Coefficient for TCE	U.S. EPA 2009. Estimation Programs Interface Suite™ for Microsoft Windows®, v. 4.00. Washington, DC.
f_{oc}	0.002	unitless	Fraction organic carbon	Ohio VAP Default value; specified by Ohio EPA in July 2016, based on USDA "Soil Survey of Miami County, Ohio."
θ_w	0.30	L/L	Water filled porosity	Default value from Soil Screening Guidance (EPA 1996; 2002)
θ_a	0.14	L/L	Air filled porosity	Average value of two samples (see RI Appendix F, Table F-1)
H'	0.724	unitless	Henry's law constant for PCE	Syracuse Research Corporation (SRC). 2005. PHYSPROP Database. SRC, Syracuse, NY.
H'	0.403	unitless	Henry's law constant for TCE	Syracuse Research Corporation (SRC). 2005. PHYSPROP Database. SRC, Syracuse, NY.
ρ_b	1.5	kg/L	Dry soil bulk density (typical for silty sand, silty clay, silt mixture)	Default value from Soil Screening Guidance (EPA 1996; 2002)

Notes:

Default value
Site-specific value
Chemical-specific value

References referring to "OEPA requests" refer to: Ohio EPA comments on the "Supplemental Soil and Groundwater Delineation Report" prepared by Shaw on behalf of Kimberly Clark. These comments were transmitted by Ohio EPA to Kimberly Clark in a letter dated October 17, 2007.

CALCULATED SOIL LEACH BASED PROTECTION OF GROUNDWATER CONCENTRATIONS (Cs):

C_s	**0.043**	mg/kg	Soil Leach-based Concentration for PCE	Calculated for Area 1 (Hobart) using bolded values for d and DAF
C_s	**0.034**	mg/kg	Soil Leach-based Concentration for TCE	Calculated for Area 1 (Hobart) using bolded values for d and DAF
C_s	**0.043**	mg/kg	Soil Leach-based Concentration for PCE	Calculated for Area 6 (Spinnaker) using bolded values for d and DAF
C_s	**0.034**	mg/kg	Soil Leach-based Concentration for TCE	Calculated for Area 6 (Spinnaker) using bolded values for d and DAF

Notes:

Default value
Site-specific value
Chemical-specific value

References referring to "OEPA requests" refer to: Ohio EPA comments on the "Supplemental Soil and Groundwater Delineation Report" prepared by Shaw on behalf of Kimberly Clark. These comments were transmitted by Ohio EPA to Kimberly Clark in a letter dated October 17, 2007.

Ohio EPA July 2016 refers to July 11, 2016 correspondence

SUMMARY OF SSL CALCULATION FOR PCE - EXPOSURE AREA 1/ HOBART PROPERTY

Chemical-specific parameters are per Soil Screening Guidance (EPA 1996) and later updates

C_w	0.005	mg/L	Groundwater Concentration
K_{oc}	94.9	L/kg	Soil Organic Carbon/Water Partitioning Coefficient (chemical specific)
f_{oc}	0.002	unitless	fraction organic carbon
θ_w	0.30	L/L	water filled porosity
θ_a	0.14	L/L	air filled porosity [Per RI TABLE F1]
H'	0.724	unitless	henry's law constant (chemical specific)
P_b	1.5	kg/L	dry soil bulk density (typical for silty sand, silty clay, silt mixture)
DAF	18.80901	unitless	dilution attenuation factor (defalt value for 0.5-acre source [EPA 1996] - 20)
SSL	**0.043**	**mg/kg**	Soil Concentration

1 12.73497 1

$$SSL(mg/kg) = C_w\left(\frac{mg}{L}\right) \times DAF \times \left[K_d\left(\frac{L}{kg}\right) + \left(\frac{\left(\theta_w\left(\frac{L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'\right)}{\rho_b\left(\frac{1.5\ kg}{L}\right)}\right)\right]$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{water}}{L_{soil}}\right) - \theta_w\left(\frac{0.3\ L_{water}}{L_{soil}}\right);$$

$$n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\frac{\rho_b\left(\frac{1.5\ kg}{L}\right)}{\rho_s\left(\frac{2.65\ kg}{L}\right)}\right) \text{ and}$$

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\ (0.002\ \text{unitless})$$

SUMMARY OF SSL CALCULATION FOR TCE - EXPOSURE AREA 1/ HOBART PROPERTY

Chemical-specific parameters are per Soil Screening Guidance (EPA 1996) and later updates

C_w	0.005	mg/L	Groundwater Concentration
K_{oc}	60.7	L/kg	Soil Organic Carbon/Water Partitioning Coefficient (chemical specific)
f_{oc}	0.002	unitless	fraction organic carbon
θ_w	0.30	L/L	water filled porosity
θ_a	0.14	L/L	air filled porosity
H'	0.403	unitless	henry's law constant (chemical specific)
P_b	1.5	kg/L	dry soil bulk density (typical for silty sand, silty clay, silt mixture)
DAF	18.80901	unitless	dilution attenuation factor (defalt value for 0.5-acre source [EPA 1996] - 20)
SSL	**0.034**	**mg/kg**	Soil Concentration

$$SSL(mg/kg) = C_w\left(\frac{mg}{L}\right) \times DAF \times \left[K_d\left(\frac{L}{kg}\right) + \left(\frac{\left(\theta_w\left(\frac{L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'\right)}{\rho_b\left(\frac{1.5\ kg}{L}\right)}\right)\right]$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{water}}{L_{soil}}\right) - \theta_w\left(\frac{0.3\ L_{water}}{L_{soil}}\right);$$

$$n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\frac{\rho_b\left(\frac{1.5\ kg}{L}\right)}{\rho_s\left(\frac{2.65\ kg}{L}\right)}\right) \text{ and}$$

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\ (0.002\ \text{unitless})$$

SUMMARY OF SSL CALCULATION FOR PCE - EXPOSURE AREA 6/ SPINNAKER PROPERTY

Chemical-specific parameters are per Soil Screening Guidance (EPA 1996) and later updates

C_w	0.005	mg/L	Groundwater Concentration
K_{oc}	94.9	L/kg	Soil Organic Carbon/Water Partitioning Coefficient (chemical specific)
f_{oc}	0.002	unitless	fraction organic carbon
θ_w	0.30	L/L	water filled porosity
θ_a	0.14	L/L	air filled porosity
H'	0.724	unitless	henry's law constant (chemical specific)
P_b	1.5	kg/L	dry soil bulk density (typical for silty sand, silty clay, silt mixture)
DAF	18.8176	unitless	dilution attenuation factor (defalt value for 0.5-acre source [EPA 1996] - 20)
SSL	**0.043**	**mg/kg**	Soil Concentration

1

$$SSL(mg/kg) = C_w\left(\frac{mg}{L}\right) \times DAF \times \left[K_d\left(\frac{L}{kg}\right) + \left(\frac{\left(\theta_w\left(\frac{L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'\right)}{\rho_b\left(\frac{1.5\ kg}{L}\right)}\right)\right]$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{water}}{L_{soil}}\right) - \theta_w\left(\frac{0.3\ L_{water}}{L_{soil}}\right);$$

$$n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\frac{\rho_b\left(\frac{1.5\ kg}{L}\right)}{\rho_s\left(\frac{2.65\ kg}{L}\right)}\right) \text{ and}$$

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\ (0.002\ \text{unitless})$$

SUMMARY OF SSL CALCULATION FOR TCE - EXPOSURE AREA 6/ SPINNAKER PROPERTY

Chemical-specific parameters are per Soil Screening Guidance (EPA 1996) and later updates

C_w	0.005	mg/L	Groundwater Concentration
K_{oc}	60.7	L/kg	Soil Organic Carbon/Water Partitioning Coefficient (chemical specific)
f_{oc}	0.002	unitless	fraction organic carbon
θ_w	0.30	L/L	water filled porosity
θ_a	0.14	L/L	air filled porosity
H'	0.403	unitless	henry's law constant (chemical specific)
P_b	1.5	kg/L	dry soil bulk density (typical for silty sand, silty clay, silt mixture)
DAF	18.8176	unitless	dilution attenuation factor (defalt value for 0.5-acre source [EPA 1996] - 20)
SSL	**0.034**	**mg/kg**	Soil Concentration

$$SSL(mg/kg) = C_w\left(\frac{mg}{L}\right) \times DAF \times \left[K_d\left(\frac{L}{kg}\right) + \left(\frac{\left(\theta_w\left(\frac{L_{water}}{L_{soil}}\right) + \theta_a\left(\frac{L_{air}}{L_{soil}}\right) \times H'\right)}{\rho_b\left(\frac{1.5\ kg}{L}\right)}\right)\right]$$

where:

$$\theta_a\left(\frac{L_{air}}{L_{soil}}\right) = n\left(\frac{L_{water}}{L_{soil}}\right) - \theta_w\left(\frac{0.3\ L_{water}}{L_{soil}}\right);$$

$$n\left(\frac{L_{pore}}{L_{soil}}\right) = 1 - \left(\frac{\rho_b\left(\frac{1.5\ kg}{L}\right)}{\rho_s\left(\frac{2.65\ kg}{L}\right)}\right) \text{ and}$$

$$K_d\left(\frac{L}{kg}\right) = K_{oc}\left(\frac{L}{kg}\right) \times f_{oc}\ (0.002\ \text{unitless})$$

SUMMARY OF DILUTION ATTENUATION FACTOR CALCULATIONS FOR EA-1 AND EA-6

Equation 4-11
Derivation of Dilution Attenuation Factor

$$\text{Dilution Attenuation Factor (DAF)} \quad 1 + \frac{K \times i \times d}{I \times L}$$

Parameter/Definition (units)	Default
DAF/dilution attenuation factor (unitless)	20 or 1 (0.5-acre source)
K/aquifer hydraulic conductivity (m/yr)	Site-specific
i/hydraulic gradient (m/m)	Site-specific
I/infiltration rate (m/yr)	Site-specific
d/mixing zone depth (m)	Site-specific
L/source length parallel to ground water flow (m)	Site-specific

Hobart (Area 1)			**Spinnaker (Area 6)**		
d =	4.48	m	d =	0.78	m
K=	11125	m/yr	K=	11125	m/yr
i=	0.003		i=	0.003	
I=	0.21	m/yr	I=	0.21	m/yr
L=	40	m	L=	7	m
DAF =	**18.81**		**DAF =**	**18.82**	

SUMMARY OF MIXING ZONE DEPTH CALCULATIONS FOR EA-1 AND EA-6

Equation 4-12
Estimation of Mixing Zone Depth

$$d = (0.0112L^2)^{0.5} + d_a(1 - \exp[(-L \times I)/(K \times i \times d_a)])$$

Parameter/Definition (units)	Default
d/mixing zone depth (m)	Site-specific
L/source length parallel to ground water flow (m)	Site-specific
I/infiltration rate (m/yr)	Site-specific
K/aquifer hydraulic conductivity (m/yr)	Site-specific
i/hydraulic gradient (m/m)	Site-specific
d_a/aquifer thickness (m)	Site-specific

Hobart (Area 1)			**Spinnaker (Area 6)**		
L=	40	m	L=	7	m
d_a=	12	m	d_a=	12	m
I=	0.21	m/yr	I=	0.21	m/yr
K=	11125	m/yr	K=	11125	m/yr
i=	0.003		i=	0.003	
d =	**4.48**	**m**	**d =**	**0.78**	**m**

APPENDIX B

SUMMARY OF ESTIMATED AVERAGE DISSOLVED-PHASE PCE MASS AND PROPOSED REDUCTION BY ZONE - 70 PERCENT REDUCTION

(ETCA - RESIDENTIAL AREA PCE PLUME)

SUMMARY OF PLUME THICKNESS ASSUMPTIONS:

	Depth to Groundwater	Plume Bottom depth			Assumed Plume Thickness	
		Minimum	Maximum	Average		
	ft	ft	ft	ft	ft	
Walnut to Clay St (Zones A and B)	16.5	50	100	75	58.5	(Round to 60)
Clay St to Union St (Zones C and D)	16.5	40	50	45	28.5	(Round to 30)

ESTIMATED DISSOLVED PHASE PCE MASS - CURRENT AND POST TREATMENT

Treatment Zone	Contour Interval		Area within Contour Interval (see "Plume Geometry" Sheet)	Assumed Average Concentration within Contour	Thickness of Contaminated Horizon Within Contour	n effective	Pore Volume (cf)	Current Estimated Mass:		Future Estimated:			
										Reduction	Mass	Avg Conc	Max Conc
	ppb	*ppb*	*sf*	*ug/L*	*ft*			*Kg*	*lb*		*lb*	*ug/L*	
Zone A	1,000	3,719	20,665	2,360	60	0.2	247,980	16.5	36.4	70%	10.92	310	1116
	500	1,000	27,737	750	60	0.2	332,844	7.1	15.6	70%	4.68		
	100	500	27,029	300	60	0.2	324,348	2.8	6.2	70%	1.86		
Zone B	500	500	31203	500	60	0.2	374,436	5.3	11.7	70%	3.51	115	150
	100	500	46908	300	60	0.2	562,896	4.8	10.6	70%	3.18		
Zone C	500	500	38241	500	30	0.2	229,446	3.2	7.1	70%	2.13	115	150
	100	500	48129	300	30	0.2	288,774	2.4	5.3	70%	1.59		
Zone D	500	500	42549	500	30	0.2	255,294	3.6	7.9	70%	2.37	111	150
	100	500	75536	300	30	0.2	453,216	3.8	8.4	70%	2.52		
								49.5	109.2		32.76		

70% total mass reduction

Estimates of dissolved mass for each area were deteremined by estimating the total plume areas within each zone for the following concentration ranges: 100 to 500 ppb; 500 to 1,000 ppb; and >1,000 ppb.

The areas are depicted on the final sheet in this Appendix.

The areas were multiplied by the average thickness of the contaminant plume within that contour interval, and the effective porosity of the aquifer, to determine the volume of contaminated groundwater in each interval.

The mass of PCE and total amount removed were then calculated from the volume of contaminated groundwater and assumed average concentration within that interval.

Residual PCE concnetrations were then back-calculated from the residual mass and pore volume estimates.

Note that these are preliminary estimates and will not be the actual values used to measure performance of the remedial action. The estimates will be refined in the RD/RA.

Progress will be measured relative to that baseline by periodic collection and analysis of groundwater samples from the performance monitoring wells, and using these data to recalculate the estimates of dissolved mass in Zone A; and, in Zones A through D in total. These values will in turn be used to estimate the percentage of the original dissolved mass that has been removed.

APPENDIX B
SUMMARY OF ESTIMATED AVERAGE DISSOLVED-PHASE PCE MASS AND PROPOSED REDUCTION BY ZONE - 70 PERCENT REDUCTION
(ETCA - RESIDENTIAL AREA PCE PLUME)

SUMMARY OF PLUME THICKNESS ASSUMPTIONS:

	Depth to Groundwater	Plume Bottom depth			Assumed Plume Thickness	
		Minimum	Maximum	Average		
	ft	ft	ft	ft	ft	
Walnut to Clay St (Zones A and B)	16.5	50	100	75	58.5	(Round to 60)
Clay St to Union St (Zones C and D)	16.5	40	50	45	28.5	(Round to 30)

ESTIMATED DISSOLVED PHASE PCE MASS - CURRENT AND POST TREATMENT

Treatment Zone	Contour Interval		Area within Contour Interval (see "Plume Geometry" Sheet)	Assumed Average Concentration within Contour	Thickness of Contaminated Horizon Within	n effective	Pore Volume (cf)	Current Estimated Mass:		Future Estimated:			
										Reduction	Mass	Avg Conc	Max Conc
	ppb	*ppb*	*sf*	*ug/L*	*ft*			*Kg*	*lb*		*lb*	*ug/L*	
Zone A	1,000	3,719	20,665	2,360	60	0.2	247,980	16.5	36.4	90%	3.64	103	372
	500	1,000	27,737	750	60	0.2	332,844	7.1	15.6	90%	1.56		
	100	500	27,029	300	60	0.2	324,348	2.8	6.2	90%	0.62		
Zone B	500	500	31203	500	60	0.2	374,436	5.3	11.7	90%	1.17	38	50
	100	500	46908	300	60	0.2	562,896	4.8	10.6	90%	1.06		
Zone C	500	500	38241	500	30	0.2	229,446	3.2	7.1	90%	0.71	38	50
	100	500	48129	300	30	0.2	288,774	2.4	5.3	90%	0.53		
Zone D	500	500	42549	500	30	0.2	255,294	3.6	7.9	90%	0.79	37	50
	100	500	75536	300	30	0.2	453,216	3.8	8.4	90%	0.84		
								49.5	109.2		10.92		

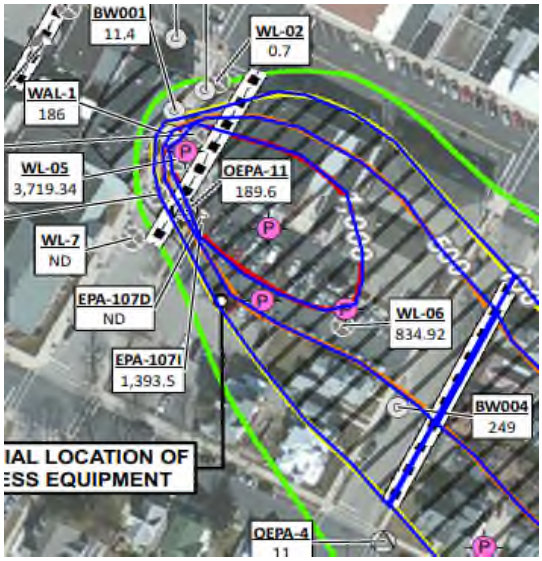
90% total mass reduction

Estimates of dissolved mass for each area were deteremined by estimating the total plume areas within each zone for the following concentration ranges: 100 to 500 ppb; 500 to 1,000 ppb; and >1,000 ppb.
The areas are depicted on the final sheet in this Appendix.
The areas were multiplied by the average thickness of the contaminant plume within that contour interval, and the effective porosity of the aquifer, to determine the volume of contaminated groundwater in each interval.
The mass of PCE and total amount removed were then calculated from the volume of contaminated groundwater and assumed average concentration within that interval.
Residual PCE concnetrations were then back-calculated from the residual mass and pore volume estimates.
Note that these are preliminary estimates and will not be the actual values used to measure performance of the remedial action. The estimates will be refined in the RD/RA.
Progress will be measured relative to that baseline by periodic collection and analysis of groundwater samples from the performance monitoring wells, and using these data to recalculate the estimates of dissolved mass in Zone A; and, in Zones A through D in total. These values will in turn be used to estimate the percentage of the original dissolved mass that has been removed.

GEOMETRY OF TREATMENT ZONES USED TO ESTIMATE DISSOLVED-PHASE CONTAMINANT (PCE) MASS IN PROPOSED TREATMENT AREA ETCA ALTERNATIVES RGW-2A, RGW-2B AND RGW-2C

Zone A

(Walnut Street to Mulberry Street)



TOTAL AREA >100 ppb = 75,431 Square Feet

Zone B

(Mulberry Street to Clay Street)

TOTAL AREA >100 ppb = 78,111 Square Feet

Zone C

(Clay Street to Crawford Street)

Zone D

(Crawford Street to Union Street)

APPENDIX C-1

SOIL ALTERNATIVE COST ESTIMATES

APPENDIX C-1

COST ESTIMATE ASSUMPTIONS FOR SOIL REMEDIATION ALTERNATIVES

Assumptions pertaining to cost estimates for each of the soil remediation alternatives are presented below.

Soil Alternative S-1: No Action

No costs are associated with the No Action alternative.

Soil Alternative S-2: Excavation Combined With Off-site Disposal

This alternative would require excavation of contaminated soil at Hobart Exposure Area (EA)-1 and Spinnaker EA-6, and off-site disposal. Figure 5-1 shows the conceptual layout of the areas to be excavated under this alternative. Note that because soil sample data from EA-2, which is on the Hobart property adjacent to EA-1, exceeded the proposed protection of groundwater preliminary remediation goal (PRG) for trichloroethene (TCE), a portion of Area 2 was included in the area, volume and cost estimates that were assumed for the Hobart property soil excavation.

For cost estimating purposes, this alternative assumes that 90 percent of the contaminated soil excavated would require disposal as non-hazardous waste and 10 percent would be characterized as hazardous waste. Thus, excavated soil would be disposed of off site in both a licensed hazardous waste landfill and a licensed non-hazardous waste landfill.

Costs associated with groundwater monitoring to ensure that soil contamination leaching to groundwater has been reduced and that groundwater contaminant concentrations show a continued decrease over time are not included in this alternative cost analysis. The costs for groundwater remediation and monitoring are provided in the groundwater alternatives (see Appendix C-2).

Soil excavation would be conducted in designated areas of the Hobart and Spinnaker properties (see Figure 5-1 for excavation locations). The area to be excavated from the Hobart property is estimated to be 16,400 square feet, including soils in EA-1 and a portion of EA-2. Assuming the Hobart site is excavated to a depth of 15 feet below ground surface (bgs), the estimated volume is 9,110 cubic yards. The soil to be excavated is mostly sand and gravel fill to include cinders and concrete rubble. Sloping or shoring would be necessary to achieve the prescribed depth of 15 feet. If sloping is performed it will increase the footprint of the excavation by approximately 45 feet on all sides. Because structures and property boundaries and are present on most sides of the excavation, shoring would be the preferred approach to excavation at Hobart. Costs for shoring are included in the cost estimate.

Based on the types of materials observed in the Hobart soil, a bulking factor of 20 percent is added to the volume of material, therefore the total volume would be 10,933 cubic yards of soil to be excavated at the Hobart site.

The area to be excavated from the Spinnaker property is 3,175 square feet. The majority of the area would be excavated to a depth of 6 feet below ground surface (2,700 square feet). A small portion (305 square feet) would be excavated to a depth of 8 feet bgs, and another small area (170 square feet) would be excavated to a depth of 10 feet bgs. Some benching or shoring would be required to get to the prescribed depth. Because of the presence of an adjacent landowner and structures on the north, shoring is included as an assumption to this cost estimate. Based on these measurements, a total of 753 cubic yards of material would be removed.

The soil at the Spinnaker site is fill containing sand and gravel, clayey sand or gravel and brick material. More clay is present with depth. Thus, due to the higher clay contact at the site, a bulking factor of 30 percent is used for the Spinnaker site. Therefore the total volume would be 980 cubic yards of soil to be excavated at the Spinnaker site.

The soil would be excavated and directly loaded into dump trucks for transportation and disposal at a nonhazardous (90% of the soil) and a hazardous (10% of the soil) landfill. Access permits would be obtained from the property owners as well as the adjacent landowner – the Miami Conservatory District.

Confirmation soil samples would be collected from the base of the excavation at a rate of one sample per 20- by 20- foot area and one soil sample from every 20-feet of sidewall, to be submitted for laboratory analysis for VOCs. For Hobart, 41 soil samples would be collected from the base, and 45 would be collected from the sidewalls, for a total of 86 soil samples. For Spinnaker, 8 soil samples would be collected from the base and 10 would be collected from the sidewalls for a total of 18 soil samples.

The excavations would be backfilled with gravel or soil. If soil is used, the material would require compaction and confirmation testing. The cost estimate assumes that gravel backfill would be used to backfill the excavation area. Spinnaker would be backfilled to 14-inches below grade to allow reinstallation of the base course and asphalt.

Because excavation will remove the contaminated soil from the targeted areas on the Hobart and Spinnaker properties, no operations and maintenance will be needed for the excavated areas. Institutional

controls would not be needed for the excavated areas of the Hobart and Spinnaker properties. However, institutional controls may be needed for areas not targeted in the interim action to maintain nonresidential zoning of these properties.

The cost estimates assume engineering design and construction oversight. In addition, construction contractor bonds, permits, plans, mobilization/demobilization, and site restoration and cleanup costs are included.

Soil Alternative S-3: Excavation with Offsite Disposal at EA-1 (Hobart) and Asphalt Cap with ICs at EA-6 (Spinnaker)

This alternative would require excavation and off-site disposal of contaminated soil at Hobart Exposure Area (EA)-1 (and possibly a portion of EA-2) and installing an asphalt cap at Spinnaker EA-6. Figure 5-2 shows the conceptual layout of the areas to be excavated and asphalt capped under this alternative. Note that because soil sample data from EA-2, which is on the Hobart property adjacent to EA-1, exceeded the proposed protection of groundwater PRG for TCE, a portion of Area 2 was included in the area, volume and cost estimates that were assumed for the Hobart property soil excavation.

The assumptions for soil excavation at Hobart are discussed in Soil Alternative S-2 above. The same assumptions in S-2 were used for S-3 for the Hobart site.

The Spinnaker area EA-6 would be asphalt capped. The area to be capped is 3,175 square feet. The asphalt cap would include 1 foot of soil excavation and off-site disposal. Then installation of 8-inches of base course and 6-inches of asphalt. The asphalt would be installed to slope towards the existing storm sewers at the Spinnaker site. No new storm sewers are included in this cost estimate.

The area of material to be removed at the Spinnaker site to include the existing asphalt pavement, base course and soil is estimated at 3,175 square feet. Assuming that 14 inches of material is removed to allow installation of an 8-inch layer of base course and 6-inches of asphalt, the total volume to be removed is 137 cubic yards of material. Because the material to be removed would be largely granular and asphalt grindings and shallow soil, a bulking factor of 20 percent was assumed. Thus, a total of 165 cubic yards of material would require excavation and off-site disposal.

Following removal of the top 14-inch later at the Spinnaker site, a new base course layer would be installed to 8-inches depth. A 6-inch thick layer of asphalt would be installed over the base course and would be sloped to the east and north so that rain runoff drains to the Spinnaker site. Because the

Spinnaker site soil is not being removed for remediation, no confirmation soil samples are required. The final design will comply with the Ohio EPA Division of Environmental Response and Revitalization, Technical Decision Compendium, "Asphalt Covers to Prevent Leaching at Industrial Sites," August 18, 2003. The surface area to be covered is shown on Figure 5-2.

Prior to mobilization and implementation of the caps, agency approvals would be obtained, as well as any necessary access agreements to include private property owners and the Miami Conservatory District.

The cost estimates assume engineering design and construction oversight. In addition, construction contractor bonds, permits, plans, mobilization/demobilization, and site restoration and cleanup costs are included.

Institutional controls will be required to maintain the Spinnaker site as non-residential use and to ensure the asphalt cap remains in place. Operations and maintenance include annual inspection of the asphalt for cracks and potholes. It is assumed that cracks will be filled and sealed once per year over a length of 50 linear feet. It is also assumed that the asphalt cap will have potholes repaired and the entire surface will be chipsealed once every 10 years.

Costs for capping were evaluated for a 30-year timeframe. Thus, present value calculations for the O&M aspect are included in the cost estimate.

Soil Cost Estimate Notes and Abbreviations

bgs	Below ground surface
cy	Cubic yard
ea	Each
hr	Hour
LS	Lump Sum
O&M	Operation and maintenance
O&P	Overhead and profit
sf	Square foot
VOC	Volatile organic compound
wk	Week

TABLE C-1-1
SOIL ALTERNATIVE S-2
SOIL EXCAVATION AND OFF-SITE DISPOSAL

CAPITAL COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
Preparation					
1	Engineering Design/Agency approvals/Access Agreements/Permits	1	LS	$ 80,000.00	$ 80,000
2	Construction Contractor Mobilization/Demobilization, Site Preparation, Permits and Submittals	1	LS	$ 50,000.00	$ 50,000
	Preparation Subtotal				**$ 130,000**
Implementation					
3	Soil Excavation, Transportation and Disposal - Hobart - non-hazardous waste	9,839.70	CY	$ 60.00	$ 590,382
4	Soil Excavation, Transportation and Disposal - Hobart - hazardous waste	1,093.30	CY	$ 175.00	$ 191,328
5	Soil Excavation, Transportation and Disposal - Spinnaker - non-hazardous waste	882	CY	$ 60.00	$ 52,920
6	Soil Excavation, Transportation and Disposal - Spinnaker -hazardous waste	98	CY	$ 175.00	$ 17,150
7	Shoring at Hobart (wood sheeting with wales and braces - drive, extract and salvage - 16 feet)	9,456	SF	$ 15.84	$ 149,783
8	Shoring at Hobart (wood sheeting with wales and braces - drive, extract and salvage- 10 feet)	1,670	SF	$ 12.90	$ 21,543
9	Backfilling at Hobart (stone)	9,110	CY	$ 35.00	$ 318,850
10	Backfilling at Spinnaker (stone)	815	CY	$ 35.00	$ 28,525
11	Replace asphalt surface at Spinnaker - 8-inches base course and 6-inch asphalt	3,175	SF	$ 35.00	$ 111,125
12	Surveyor	1	LS	$ 5,000.00	$ 5,000
	Implementation Subtotal				**$ 1,486,606**
Confirmation Sampling					
13	Confirmation Soil Sampling at Hobart (includes labor, sampling equipment, shipping and laboratory costs)	86	ea	$ 200.00	$ 17,200
14	Confirmation Soil Sampling at Spinnaker (includes labor, sampling equipment, shipping and laboratory costs)	18	ea	$ 200.00	$ 3,600
	Confirmation Sampling Subtotal				**$ 20,800**
Site Restoration					
15	Site Restoration and Cleanup at Hobart	1	LS	$ 5,000.00	$ 5,000
16	Site Restoration and Cleanup at Spinnaker	1	LS	$ 5,000.00	$ 5,000
	Site Restoration Subtotal				**$ 10,000**

Construction Subtotal		**$ 1,647,406**
Construction Contractor Bonds	2%	$ 32,948
Project management and construction oversight	5%	$ 82,370
Construction Subtotal Plus Contractor Bonds, Project Management, and Oversight		**$ 1,762,724**
CAPITAL COST SUBTOTAL		**$ 1,762,724**

INSTITUTIONAL CONTROLS COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
Institutional Controls					
1	None	0	hr	$ -	$ -
Institutional Controls Subtotal					**$ -**

O&M COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
Annual Maintenance					
1	None	0.0	EA	$ -	$ -
	Maintenance Subtotal				**$ -**
Annual Monitoring					
2	None	0.0	EA	$ -	$ -
	Monitoring Subtotal				**$ -**
Annual Operation and Maintenance Subtotal					**$ -**

ALTERNATIVE S-2 SOIL EXCAVATION AND OFF-SITE DISPOSAL COST SUMMARY	
Description	**Subtotal**
Construction	$ 1,762,724
Institutional Controls	$ -
Operation and Maintenance	$ -
Contingency 30%	$ 528,817
Total (Rounded)	**$ 2,290,000**

TABLE C-1-2
SOIL ALTERNATIVE S-3
EXCAVATION AND CAPPING

CAPITAL COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
Preparation					
1	Engineering Design/Agency approvals/Access Agreements/Permits	1	LS	$ 80,000.00	$ 80,000
2	Construction Contractor Mobilization/Demobilization, Site Preparation, Permits and Submittals	1	LS	$ 50,000.00	$ 50,000
	Preparation Subtotal				**$ 130,000**
Implementation					
3	Soil Excavation, Transportation and Disposal - Hobart - non-hazardous waste	9,840	CY	$ 60.00	$ 590,382
4	Soil Excavation, Transportation and Disposal - Hobart - hazardous waste	1,093	CY	$ 175.00	$ 191,328
5	Soil Excavation, Transportation and Disposal - Spinnaker - non-hazardous waste	149	CY	$ 60.00	$ 8,910
6	Soil Excavation, Transportation and Disposal - Spinnaker -hazardous waste	17	CY	$ 175.00	$ 2,888
7	Shoring at Hobart (wood sheeting with wales and braces - drive, extract and salvage - 16 feet)	9,456	SF	$ 15.84	$ 149,783
8	Backfilling at Hobart (stone)	9,110	CY	$ 35.00	$ 318,850
9	Backfilling at Spinnaker (stone)	0	CY	$ 35.00	$ -
10	Install asphalt cap at Spinnaker - 8-inches base course and 6-inch asphalt	3,175	SF	$ 35.00	$ 111,125
11	Surveyor	1	LS	$ 5,000.00	$ 5,000
	Implementation Subtotal				**$ 1,378,266**
Confirmation Sampling					
12	Confirmation Soil Sampling at Hobart (includes labor, sampling equipment, shipping and laboratory costs)	86	ea	$ 200.00	$ 17,200
13	Confirmation Soil Sampling at Spinnaker (includes labor, sampling equipment, shipping and laboratory costs)	0	ea	$ 200.00	$ -
	Confirmation Sampling Subtotal				**$ 17,200**
Site Restoration					
14	Site Restoration and Cleanup at Hobart	1	LS	$ 5,000.00	$ 5,000
15	Site Restoration and Cleanup at Spinnaker	1	LS	$ 5,000.00	$ 5,000
	Site Restoration Subtotal				**$ 10,000**

Construction Subtotal		**$ 1,535,466**
Construction Contractor Bonds	2%	$ 30,709
Project management and construction oversight	5%	$ 76,773
Construction Subtotal Plus Contractor Bonds, Project Management, and Oversight		**$ 1,642,949**
CAPITAL COST SUBTOTAL		**$ 1,642,949**

INSTITUTIONAL CONTROLS COSTS					
Item	**Description**	**Quantity**	**Unit**	**(Incl. O&P)**	**Total Cost**
Institutional Controls					
1	Prepare LUC Implementation Plan (mid-level staff with senior review)	100	hr	$ 110.00	$ 11,000
2	Meetings with agencies (senior staff and attorneys)	40	hr	$ 250.00	$ 10,000
Institutional Controls Subtotal					**$ 21,000**

O&M COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
Annual Maintenance					
1	Asphalt repair, crack filling and sealing	50.0	LF	$ 15.00	$ 750
2	Asphalt repair - fill potholes and chipseal entire surface (once every ten years-total cost adjusted for 3 repairs)	3,175.0	SF	$ 6.00	$ 6,350
	Maintenance Subtotal				**$ 7,100**
Annual Inspections					
3	Annual cap inspections (includes labor - 2 hours - and travel)	8.0	hr	$ 200.00	$ 1,600
4	Annual inspection report	1.0	LS	$ 5,000.00	$ 5,000
5	Project Management	4.0	hr	$ 200.00	$ 800
	Inspections Subtotal				**$ 7,400**
Annual Operation and Maintenance Subtotal					**$ 14,500**

ALTERNATIVE S-3 EXCAVATION AND OFF-SITE DISPOSAL AND ASPHALT CAPPING COST SUMMARY	
Description	**Subtotal**
Construction	$ 1,642,949
Institutional Controls	$ 21,000
Operation and Maintenance (30-Year Present Value Analysis Costs--see Table C-1-1A)	$ 233,877

Contingency	30%	$ 569,348
Total (Rounded)		**$ 2,470,000**

TABLE C-1-2A
SOIL ALTERNATIVE S-2 - EXCAVATION AND CAPPING

Annual Discount Rate [1]:

30-Yr 7.00%

Present Value Analysis						
	Annual Discount Factor [2]	Operation and Maintenance Costs				
Year	**30-Yr**	**Description**	**Future Cost [3]**	**Description**	**Future Cost [3]**	**Present Value (2015)**
0	1.000					$0
1	0.935	Cap O&M	$14,500			$13,551
2	0.873	Cap O&M	$14,500			$12,665
3	0.816	Cap O&M	$14,500			$11,836
4	0.763	Cap O&M	$14,500			$11,062
5	0.713	Cap O&M	$14,500	Five-Year Review	$25,000	$28,163
6	0.666	Cap O&M	$14,500			$9,662
7	0.623	Cap O&M	$14,500			$9,030
8	0.582	Cap O&M	$14,500			$8,439
9	0.544	Cap O&M	$14,500			$7,887
10	0.508	Cap O&M	$14,500	Five-Year Review	$25,000	$20,080
11	0.475	Cap O&M	$14,500			$6,889
12	0.444	Cap O&M	$14,500			$6,438
13	0.415	Cap O&M	$14,500			$6,017
14	0.388	Cap O&M	$14,500			$5,623
15	0.362	Cap O&M	$14,500	Five-Year Review	$25,000	$14,317
16	0.339	Cap O&M	$14,500			$4,912
17	0.317	Cap O&M	$14,500			$4,590
18	0.296	Cap O&M	$14,500			$4,290
19	0.277	Cap O&M	$14,500			$4,009
20	0.258	Cap O&M	$14,500	Five-Year Review	$25,000	$10,208
21	0.242	Cap O&M	$14,500			$3,502
22	0.226	Cap O&M	$14,500			$3,273
23	0.211	Cap O&M	$14,500			$3,059
24	0.197	Cap O&M	$14,500			$2,859
25	0.184	Cap O&M	$14,500	Five-Year Review	$25,000	$7,278
26	0.172	Cap O&M	$14,500			$2,497
27	0.161	Cap O&M	$14,500			$2,333
28	0.150	Cap O&M	$14,500			$2,181
29	0.141	Cap O&M	$14,500			$2,038
30	0.131	Cap O&M	$14,500	Five-Year Review	$25,000	$5,189
Total Present Value of Periodic Cost						**$233,877**

Notes:

1 Annual discount rate = 7% (EPA 540-R-00-002)

2 Annual discount factor = $1/(1+i)^t$, where i = discount rate (includes inflation and interest) and t = year

3 Current dollar cost of future event

O&M Operations and maintenance

APPENDIX C-2

GROUNDWATER ALTERNATIVE COST ESTIMATES

APPENDIX C-2

COST ESTIMATE ASSUMPTIONS FOR GROUNDWATER REMEDIATION ALTERNATIVES

General assumptions for all groundwater alternatives are as follows:

- All design elements described herein are assumptions based on available information and are considered conceptual at the FFS stage; actual design and operating parameters such as numbers; locations; and depths of injection, extraction or monitoring wells will be determined as part of the RD.
- All work would be performed in Level D personal protective equipment.
- The remedial goals for all alternatives are to achieve a 70 to 90 percent reduction in total dissolved VOC mass in Treatment Zone A, and also in Zones A – D (in total).
- Estimates herein are based on targeting the upper end of the remedial goal range (90 percent reduction) and thus the minimum goal of 70 percent reduction would be achieved within the timeframes and costs presented herein.
- The remedial duration estimates are based on reasonable estimated degradation half-lives. A 90 percent decrease in mass corresponds to a reduction by a factor of 10. If treatment decreases concentrations by 50 percent each year, a 90 percent decrease in any given zone could feasibly be achieved in less than 4 years. That is, an apparent degradation half-life (inclusive of desorption) of 1 year would achieve 90 percent reduction in less than 4 years. In general, this is reasonable for active remediation of PCE and daughter products. This is consistent with experience at other sites with similar contaminants and aquifer characteristics. However, remediation at the ETCA site is conservatively assumed to proceed more slowly because of access limitations and the assumption that it will not be possible to inject directly into some of the contaminated zones.
- Treatment would commence in Zone A, allowing monitoring of factors such as reduction of VOCs, formation of daughter products, or mobilization of metals and adjustment of operating parameters as needed.
- The cost estimates assume treatment of up to 80 feet of saturated thickness and to depths up to 100 feet (depending on area) and are based on treating three discrete transmissive intervals in each zone on average. However, the alternatives are conceptual at the FFS stage. The exact numbers, locations and depths of treatment or injection wells will be determined as part of the RD and the depths may vary from location to location, given the nature of the geology and contaminants.
- The assumed aquifer total porosity is 0.3; effective porosity is 0.2.
- Average seepage velocity is 1 foot per day (ft/day) based on average hydraulic conductivity values determined in on-site pumping tests completed in previous studies by other entities and average hydraulic gradient data collected during the RI.
- Anions are present in groundwater at moderate concentrations (based on anion analysis of a limited number of groundwater samples).
- A pre-engineered metal building would house all process and control equipment.
- A new meter and electrical distribution panel would be installed.
- A motor control center would provide manual shutoffs for injection and extraction wells.

- Pressure transducers would be used to measure water levels in injection and extraction wells.
- Gate valves would be used to manually regulate flow rates from extraction wells.
- Flow-sustaining valves would be used to regulate flow rates to injection wells.
- A supervisory control and data acquisition (SCADA) system would provide system automation; the recirculation system would therefore need minimal operator oversight.
- Remediation chemical injection wells would have a 10-foot radius of influence and would be located at 20 feet on centers. This radius of influence would be achieved through pulsed injection.
- Where extraction wells are used, they would have a single screen and a submersible pump.
- Where recirculation is used, groundwater would be pumped out from downgradient extraction wells, conveyed to process equipment where remediation chemicals would be added, then returned to the aquifer via upgradient injection wells.
- Groundwater conveyance pipelines and electrical conduit would be buried underground in 4-foot deep trenches.
- Trenching would be performed in paved areas and would require asphalt cutting, excavation, backfilling, compaction, and paving.
- Pipelines used to convey extracted groundwater and injectant would be 6 inches in diameter and constructed of high-density polyethylene.
- Electrical conduits would be constructed of 1.5-inch diameter PVC.
- ICs are not required as EPA is considering this an interim remedial action
- A discount rate of 7% was used in net present value (NPV) estimates based on EPA guidance document (EPA 540-R-00-002) recommendation for non-federal facilities.

Assumptions pertaining to each of the groundwater remediation alternatives are presented below.

Groundwater Alternative RGW-1: No Action

There are no costs associated with the No Action alternative.

Groundwater Alternative RGW-2A: Source Treatment using ERD and Groundwater Monitoring

Alternative RGW-2A assumes the following:

- The residential source area would be treated via enhanced reductive dechlorination (ERD).
- ERD would be performed within the 100 microgram per liter (µg/L) total chlorinated volatile organic compounds (TVOC) plume extending from the former Troy One Hour dry cleaning facility (currently, First Presbyterian Church extension) to Union Street.
- From the former Troy One Hour dry cleaning facility to Clay Street, ERD would target groundwater from 17 feet below ground surface (bgs) to 100 feet bgs.
- East of Clay Street, ERD would target groundwater from 17 feet bgs to 60 feet bgs.
- The targeted treatment area would be divided into four zones (Zones A, B, C, and D).

- ERD chemicals would be distributed within the targeted treatment area via recirculation employing injection and extraction wells.
- For treatment of Zones B, C, and D, groundwater would be extracted downgradient of the targeted treatment area and most of it would be injected upgradient of the targeted treatment area. Groundwater that is not re-injected would be treated and discharged to the local Troy sanitary sewer system and POTW via the closest suitable access point to the system, which runs throughout the proposed treatment areas.
- For treatment of Zone A, ERD chemicals would be mixed with clean water and injected upgradient of the targeted treatment area. Groundwater would be extracted downgradient of the targeted treatment area, treated, then discharged to the local Troy sanitary sewer system and POTW via the closest suitable access point to the system, which runs throughout the conceptual treatment areas.
- A methane inhibitor would be used to reduce methane generation.
- Clean water for Zone A injections would be sourced from a new water supply well located outside the contaminant plume.
- Extracted groundwater would be treated via air stripping. Influent to the treatment system would be chlorinated to reduce biofouling.
- For estimating purposes, injection wells would conceptually be nested and screened at three different depths spanning the entire targeted vertical interval. However, the actual injection depths/horizons and well design, as well as specifications for performance monitoring wells, will be determined as part of the RD.
- It would take approximately 1 year to distribute ERD chemicals within each treatment zone.
- The recirculation system would operate for 1 year in each zone to distribute ERD chemicals, then shut down for 2 years to allow ERD to continue.
- ERD would be performed twice in each zone.
- The treatment schedule by zone would be as follows:

ERD TREATMENT SCHEDULE		
Year	Zone Targeted for First Injection	Zone Targeted for Second Injection
1	A	-
2	-	-
3	B	-
4	-	A
5	C	-
6	-	B
7	D	-
8	-	C
9	-	-
10	-	D

- Costs assume groundwater monitoring for VOCs and any other key parameters to evaluate performance and effects of treatment on the aquifer for the duration of the IA (15 years).
- ERD chemicals would include emulsified vegetable oil, pH buffer, and Dehalococcoides microorganism culture.
- The emulsified vegetable oil would slowly release dissolved organic carbon for 3 years after it is injected.
- Emulsified vegetable oil dose is strongly influenced by sulfate concentration which has been conservatively assumed at 100 milligrams per liter (mg/L), higher than sulfate concentrations measured in groundwater at the site.
- Remediation goals for Zones A-D would be achieved within 15 years of commencement of groundwater remediation.
- Pre-design investigations would include water quality testing to measure electron acceptor concentrations, baseline groundwater sampling (with installation of additional monitoring wells as necessary) to estimate initial dissolved mass of contaminants; additional source area hydrogeologic and contaminant, and aquifer hydraulic properties testing, , water supply well siting, microcosm studies aimed at electron donor selection, and a pilot test to determine various parameters such as well spacing.

Groundwater Alternative RGW-2B: Source Treatment using ISCR and Groundwater Monitoring

Alternative RGW-2B assumes the following:

- The residential source area would be treated via in situ chemical reduction (ISCR).
- ISCR would be performed within the 100 µg/L TVOC plume extending from the former Troy One Hour dry cleaning facility to Union Street.
- From the former Troy One Hour dry cleaning facility to Clay Street, ISCR would target groundwater from 17 feet bgs to 100 feet bgs.
- East of Clay Street, ISCR would target groundwater from 17 feet bgs to 60 feet bgs.
- The targeted treatment area would be divided into four zones (Zones A, B, C, and D).
- ISCR chemicals would be distributed within the targeted treatment area via recirculation system employing injection and extraction wells.
- For treatment of Zones B, C, and D, groundwater would be extracted downgradient of the targeted treatment area and most of it would be injected upgradient of the targeted treatment area. Groundwater that is not re-injected would be treated and discharged to local Troy sanitary sewer system and POTW via the closest suitable access point to the system, which runs throughout the conceptual treatment areas.
- For treatment of Zone A, ISCR chemicals would be mixed with clean water and injected upgradient of the targeted treatment area. Groundwater would be extracted downgradient of the targeted treatment area, treated, then discharged into a sanitary local Troy sanitary sewer system and POTW via the closest suitable access point to the system, which runs throughout the conceptual treatment areas.
- A methane inhibitor would be used to reduce methane generation.
- Clean water for Zone A injections would be sourced from a new water supply well located outside the contaminant plume.

- Extracted groundwater would be treated via air stripping. Influent to the treatment system would be chlorinated to reduce biofouling.
- Groundwater would be pumped out from downgradient extraction wells, conveyed to process equipment where ISCR chemicals would be added, then returned to groundwater via upgradient injection wells. For estimating purposes, injection wells would conceptually be nested and screened at three different depths spanning the entire targeted vertical interval. However, the actual injection depths/horizons and well design, as well as locations and specifications for performance monitoring wells, will be determined as part of the RD.
- It would take approximately 1 year to distribute ISCR chemicals within each treatment zone.
- ISCR would be performed twice in each zone.
- The treatment schedule by zone would be as follows:

ISCR TREATMENT SCHEDULE		
Year	Zone Targeted for First Injection	Zone Targeted for Second Injection
1	A	-
2	B	-
3	C	-
4	D	A
5	-	B
6	-	C
7	-	D

- Costs assume groundwater monitoring for VOCs and any other key parameters to evaluate performance and effects of treatment on the aquifer for the duration of the IA (10 years).
- ISCR chemicals would include a carbon-zero valent iron substrate, a pH buffer, and Dehalococcoides microorganism culture.
- The carbon-zero valent iron substrate would slowly release dissolved organic carbon for 3 years after it is injected.
- pH buffer dose is based on emulsified vegetable oil dose and would maintain pH of groundwater above 6.5 for the duration of treatment.
- Remediation goals would be achieved in 10 years from commencement of groundwater remediation.
- Pre-design investigations would include water quality testing to measure electron acceptor concentrations, baseline groundwater sampling (with installation of additional monitoring wells as necessary) to estimate initial dissolved mass of contaminants, source area investigation (including sonic angle drilling, and aquifer hydraulic properties testing), East Main Street area investigation, water supply well siting, microcosm studies aimed at electron donor selection, and a pilot test to determine various parameters such as well spacing.

Groundwater Alternative RGW-2C: Source Treatment using ISCO and Groundwater Monitoring

Alternative RGW-2C assumes the following:

- The residential source area would be treated via in situ chemical oxidation (ISCO).
- ISCO would be performed within the 100 µg/L TVOC plume extending from the former Troy One Hour dry cleaning facility to Union Street.
- From the former Troy One Hour dry cleaning facility to Clay Street, ISCO would target groundwater from 17 feet bgs to 100 feet bgs.
- East of Clay Street, ISCO would target groundwater from 17 feet bgs to 60 feet bgs.
- The targeted treatment area would be divided into four zones (Zones A, B, C and D).
- ISCO chemicals would be distributed within the targeted treatment area via injection.
- For estimating purposes, injection wells would conceptually be nested and screened at three different depths spanning the entire targeted vertical interval. However, the actual injection depths/horizons and well design, as well as specifications for performance monitoring wells, will be determined as part of the RD.
- Clean groundwater would be pumped out from a new water supply well located outside the contaminant plume, conveyed to process equipment where ISCO chemicals would be added, then injected into the aquifer via injection wells.
- ISCO injections would be performed continuously via permanent wells. At the assumed seepage rate of 1 ft/day, it is anticipated that the injectant would reach the downgradient end of each treatment zone within approximately 6 to 12 months from the start of injection at the upgradient end of that particular zone.
- The treatment schedule by zone would be as follows:

ISCO TREATMENT SCHEDULE	
Year	Zone Targeted for Continuous Injection
1	A
2	A, B
3	A, B, C
4	A, B, C, D
5	B, C, D
6	C, D
7	D

- Costs assume groundwater monitoring for VOCs and any other key parameters to evaluate performance and effects of treatment on the aquifer for the duration of the IA (10 years).
- The ISCO chemical would be sodium permanganate delivered to the site as a 40 percent solution by weight.

- The sodium permanganate dose is based on a nominal natural oxidant demand (NOD) of 1 gram per kilogram of soil. The actual NOD may be higher or lower.
- Remediation goals for Zones A-D would be achieved in 10 years from commencement of groundwater remediation.
- Pre-design investigations would include water quality testing to measure electron acceptor concentrations, baseline groundwater sampling (with installation of additional groundwater monitoring wells as necessary) to estimate initial dissolved mass of contaminants, additional source area investigations of source geometry and aquifer hydraulic properties, East Main Street area investigation, water supply well siting, NOD testing, and a pilot test to determine various parameters such as well spacing.

Groundwater Cost Estimate Notes and Abbreviations

AWG	American wire gauge
DHC	Dehalococcoides
ea	Each
ERD	Enhanced reductive dechlorination
FFS	Focused feasibility study
ft	Foot
gal	Gallon
gpm	Gallons per minute
HMA	Hot mix asphalt
hr	Hour
IA	Interim action
ISCR	In situ chemical reduction
ISCO	In situ chemical oxidation
KHCO3	Potassium bicarbonate
KWH	Kilowatt hour
lbs	Pound
ls	Lump Sum
LUC	Land use control
MNA	Monitored natural attenuation
mo	Month
NA	Not applicable
NOD	Natural oxidant demand
O&M	Operation and maintenance
O&P	Overhead and profit
POTW	Publicly owned treatment works
RD	Remedial design
ROI	Radius of influence
SCADA	Supervisory control and data acquisition
sf	Square foot
TD	Total depth
VOC	Volatile organic compound
wk	Week
WWTP	Waste water treatment plant

TABLE C-2-1
GROUNDWATER ALTERNATIVE RGW-2A

CAPITAL COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	Wells				
1	Injection wells (includes well box, up to 100' TD, nested, 3x) and wellhead	20.0	ea	$ 20,397.53	$ 407,951
2	Injection wells (includes well box, up to 60' TD, nested, 3x) and wellhead	27.0	ea	$ 12,508.69	$ 337,735
3	Extraction wells (includes well box, up to 100' TD), wellhead, pumps and motors	7.0	ea	$ 23,909.69	$ 167,368
4	Extraction wells (includes well box, up to 60' TD), wellhead, pumps and motors	12.0	ea	$ 14,886.15	$ 178,634
5	Monitoring wells (includes manhole, up to 100' deep)	18.0	ea	$ 9,185.64	$ 165,342
6	Monitoring wells (includes manhole, up to 60' deep)	12.0	ea	$ 5,511.39	$ 66,137
	Wells subtotal				**$ 1,323,167**
	Piping and Fittings				
7	Injection/extraction piping	5,510.0	ft	$ 39.17	$ 215,827
8	Gate valves, flow sustaining valves, solenoid valves	65.0	ea	$ 1,395.39	$ 90,700
	Piping and Fittings subtotal				**$ 306,527**
	Earthwork and Paving				
9	Trenching, bedding, backfilling, compacting (2' wide x 4' deep)	5,310.0	ft	$ 12.33	$ 65,472
10	Asphalt cutting	10,620.0	ft	$ 2.01	$ 21,346
11	Install asphalt pavement (HMA, 6" thick)	10,620.0	sf	$ 5.44	$ 57,773
	Earthwork and Paving subtotal				**$ 144,591**
	Electrical				
12	Electrical service and meter installation	1.0	ea	$ 5,443.84	$ 5,444
13	Building wiring and fixtures	600.0	sf	$ 6.98	$ 4,188
14	Electrical conduit (1.5", power + control)	10,620.0	ft	$ 4.04	$ 42,905
15	Power wiring (14 AWG, 3 wire)	5,310.0	ft	$ 0.50	$ 2,655
16	Control wiring (18 AWG, 2 wire)	15,930.0	ft	$ 0.50	$ 7,965
17	Motor control center	1.0	ea	$ 27,016.60	$ 27,017
18	SCADA system (large)	1.0	ea	$ 135,083.00	$ 135,083
	Electrical subtotal				**$ 225,257**
	Process Equipment				
19	Control building (20' x 30')	600.0	sf	$ 17.80	$ 10,680
20	Chemical holding tank (10,000 gal)	1.0	ea	$ 11,379.38	$ 11,379
21	Metering pump (1 gpm)	1.0	ea	$ 1,730.41	$ 1,730
22	Bag filter	2.0	ea	$ 1,833.08	$ 3,666
23	In-line chlorinator (installed; 1 per treatment zone)	4.0	ea	$ 6,754.15	$ 27,017
24	Treatment system (air stripper; 200 gpm)	1.0	ea	$ 202,624.50	$ 202,625
	Process Equipment subtotal				**$ 257,097**
	Remediation Products				
25	Bioremediation substrate (emulsified oil)	1,365,082.0	lbs	$ 1.82	$ 2,484,449
26	DHC culture (KB-1)	7,399.0	liter	$ 337.71	$ 2,498,716
27	Methane inhibitor	49,459.5	lbs	$ 20.26	$ 1,002,049
	Remediation Products subtotal				**$ 5,985,214**
	Construction Support				
28	Utility surveying	4.0	day	$ 3,377.08	$ 13,508
29	Land survey (progress)	50.0	day	$ 1,702.05	$ 85,103
30	Land survey (as-built)	5.0	day	$ 1,702.05	$ 8,510
	Construction Support subtotal				**$ 107,121**
	Construction Subtotal				**$ 8,348,974**
	Construction Subtotal				**$ 8,348,974**
31	Construction Contractor Mobilization/Demobilization, Site Preparation and Submittals	10%			$ 834,897
32	Project management	2%			$ 166,979
33	Construction oversight	7%			$ 584,428
34	Fate and transport modeling	0.5%			$ 41,745
35	Engineering design	4%			$ 333,959
	Construction Subtotal plus additional above costs				**$ 10,310,983**

INSTITUTIONAL CONTROLS COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
36	Prepare LUC Implementation Plan (mid-level staff with senior review)	0	hr	$ 114.30	$ -
37	Meetings with agencies (senior staff and attorneys)	0	hr	$ 259.78	$ -
	Institutional Controls Subtotal				**$ -**

TABLE C-2-1
GROUNDWATER ALTERNATIVE RGW-2A

PRE-DESIGN ACTIVITIES					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
38	Baseline groundwater monitoring	1.0	ea	$ 51,955.00	$ 51,955
39	Source area investigation	1.0	ea	$ 283,674.30	$ 283,674
40	E Main area investigation	1.0	ea	$ 101,312.25	$ 101,312
41	Water supply well siting	1.0	ea	$ 33,770.75	$ 33,771
42	Bench-scale microcosm testing	1.0	ea	$ 27,016.60	$ 27,017
43	Pilot test (ROI, flow rate, pressure)	1.0	ea	$ 135,083.00	$ 135,083
	Pre-Design Activities Subtotal				**$ 632,812**

GROUNDWATER MONITORING COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	Groundwater Monitoring Event				
44	Sampling	50.0	wells	$ 1,215.75	$ 60,788
45	Field parameters	50.0	ea	$ 33.77	$ 1,689
46	VOCs	58.0	ea	$ 94.56	$ 5,484
47	Dissolved metals	58.0	ea	$ 81.05	$ 4,701
48	Ferrous	58.0	ea	$ 27.02	$ 1,567
49	Dissolved gases	58.0	ea	$ 71.59	$ 4,152
50	Dissolved organic carbon	58.0	ea	$ 67.54	$ 3,917
51	Monitoring report	1.0	ea	$ 13,508.30	$ 13,508
	Groundwater Monitoring Event subtotal				**$ 95,806**

OPERATION AND MAINTENANCE COSTS									
Item	**Description**					**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	O&M and Reporting								
52	System operation					12.0	mo	$ 2,161.33	$ 25,936
53	System maintenance					12	mo	$ 6,754.15	$ 81,050
54	Shock chlorination					12	mo	$ 1,350.83	$ 16,210
55	Well rehabilitation					10	wells	$ 2,000.00	$ 20,000
56	Energy cost					630,571	KWH	$ 0.11	$ 69,363
57	Annual monitoring report					1	ea	$ 20,262.45	$ 20,262
58	Proj. Mgmt.	2 hrs/wk	on proj for	52	weeks	104	hr	$ 129.89	$ 13,509
	O&M and Reporting subtotal								**$ 246,330**

ALTERNATIVE COST SUMMARY	
Description	**Subtotal**
Construction	**$ 10,310,983**
Pre-design activities	**$ 632,812**
Institutional Controls	**$ -**
Operation, Maintenance and Monitoring (Present Value Analysis Costs--see Table C-2-1A)	**$ 3,493,592**

Contingency	30%	**$ 4,331,216**

Total (Rounded)	**$ 18,769,000**

TABLE C-2-1A
GROUNDWATER ALTERNATIVE RGW-2A

Annual Discount Rate [1]:

20-Yr 7.00%

Present Value Analysis						
	Annual Discount Factor [2]	**Operation and Maintenance Costs**				
Year	**30-Yr**	**Description**	**Future Cost [3]**	**Description**	**Future Cost [3]**	**Present Value (2017)**
0	1.000	Baseline monitoring	$95,806			$95,806
1	0.935	Quarterly monitoring and system O&M	$629,554			$588,368
2	0.873	Quarterly monitoring	$383,224			$334,723
3	0.816	Semi-annual monitoring and system O&M	$437,942			$357,491
4	0.763	Semi-annual monitoring and system O&M	$437,942			$334,104
5	0.713	Semi-annual monitoring and system O&M	$437,942	Five-Year Review	$25,000	$330,071
6	0.666	Semi-annual monitoring and system O&M	$437,942			$291,819
7	0.623	Semi-annual monitoring and system O&M	$437,942			$272,728
8	0.582	Semi-annual monitoring and system O&M	$437,942			$254,886
9	0.544	Semi-annual monitoring	$437,942			$238,211
10	0.508	Annual monitoring and system O&M	$342,136	Five-Year Review	$25,000	$186,633
11	0.475	Annual monitoring	$95,806			$45,517
12	0.444	Annual monitoring	$95,806			$42,539
13	0.415	Annual monitoring	$95,806			$39,756
14	0.388	Annual monitoring	$95,806			$37,155
15	0.362	Annual monitoring	$95,806	Five-Year Review	$25,000	$43,786
16	0.339					$0
17	0.317					$0
18	0.296					$0
19	0.277					$0
20	0.258					$0
21	0.242					$0
22	0.226					$0
23	0.211					$0
24	0.197					$0
25	0.184					$0
26	0.172					$0
27	0.161					$0
28	0.150					$0
29	0.141					$0
30	0.131					$0
Total Present Value of Periodic Cost						**$3,493,592**

Notes:

1 Annual discount rate = 7% (EPA 540-R-00-002)

2 Annual discount factor = $1/(1+i)^t$, where i = discount rate (includes inflation and interest) and t = year

3 Current dollar cost of future event

O&M Operations and maintenance

TABLE C-2-2
GROUNDWATER ALTERNATIVE RGW-2B

CAPITAL COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	Wells				
1	Injection wells (includes well box, up to 100' TD, nested, 3x) and wellhead	20.0	ea	$ 20,397.53	$ 407,951
2	Injection wells (includes well box, up to 60' TD, nested, 3x) and wellhead	27.0	ea	$ 12,508.69	$ 337,735
3	Extraction wells (includes well box, up to 100' TD), wellhead, pumps and motors	7.0	ea	$ 23,909.69	$ 167,368
4	Extraction wells (includes well box, up to 60' TD), wellhead, pumps and motors	12.0	ea	$ 14,886.15	$ 178,634
5	Monitoring wells (includes manhole, up to 100' deep)	18.0	ea	$ 9,185.64	$ 165,342
6	Monitoring wells (includes manhole, up to 60' deep)	12.0	ea	$ 5,511.39	$ 66,137
	Wells subtotal				**$ 1,323,167**
	Piping and Fittings				
7	Injection/extraction piping	5,510.0	ft	$ 39.17	$ 215,827
8	Gate valves, flow sustaining valves, solenoid valves	65.0	ea	$ 1,395.39	$ 90,700
	Piping and Fittings subtotal				**$ 306,527**
	Earthwork and Paving				
9	Trenching, bedding, backfilling, compacting (2' wide x 4' deep)	5,310.0	ft	$ 12.33	$ 65,472
10	Asphalt cutting	10,620.0	ft	$ 2.01	$ 21,346
11	Install asphalt pavement (HMA, 6" thick)	10,620.0	sf	$ 5.44	$ 57,773
	Earthwork and Paving subtotal				**$ 144,591**
	Electrical				
12	Electrical service and meter installation	1.0	ea	$ 5,443.84	$ 5,444
13	Building wiring and fixtures	600.0	sf	$ 6.98	$ 4,188
14	Electrical conduit (1.5", power + control)	10,620.0	ft	$ 4.04	$ 42,905
15	Power wiring (14 AWG, 3 wire)	5,310.0	ft	$ 0.50	$ 2,655
16	Control wiring (18 AWG, 2 wire)	15,930.0	ft	$ 0.50	$ 7,965
17	Motor control center	1.0	ea	$ 27,016.60	$ 27,017
18	SCADA system (large)	1.0	ea	$ 135,083.00	$ 135,083
	Electrical subtotal				**$ 225,257**
	Process Equipment				
19	Control building (20' x 30')	600.0	sf	$ 17.80	$ 10,680
20	Chemical holding tank (10,000 gal)	1.0	ea	$ 11,379.38	$ 11,379
21	Metering pump (1 gpm)	1.0	ea	$ 1,730.41	$ 1,730
22	Bag filter	2.0	ea	$ 1,833.08	$ 3,666
23	In-line chlorinator (installed; 1 per treatment zone)	4.0	ea	$ 6,754.15	$ 27,017
24	Treatment system (air stripper; 200 gpm)	1.0	ea	$ 202,624.50	$ 202,625
	Process Equipment subtotal				**$ 257,097**
	Remediation Products				
25	ISCR chemical (EHC-L)	1,095,305.1	lbs	$ 6.28	$ 6,878,516
26	KHCO3 buffer	273,826.3	lbs	$ 3.65	$ 999,466
27	DHC culture (KB-1)	7,399.0	liter	$ 337.71	$ 2,498,716
28	Methane inhibitor	16,000.0	lbs	$ 20.26	$ 324,160
	Remediation Products subtotal				**$ 10,700,858**
	Construction Support				
28	Utility surveying	4.0	day	$ 3,377.08	$ 13,508
29	Land survey (progress)	50.0	day	$ 1,702.05	$ 85,103
30	Land survey (as-built)	5.0	day	$ 1,702.05	$ 8,510
	Construction Support subtotal				**$ 107,121**
	Construction Subtotal				**$ 13,064,618**

	Construction Subtotal		**$ 13,064,618**
31	Construction Contractor Mobilization/Demobilization, Site Preparation and Submittals	10%	$ 1,306,462
32	Project management	1.0%	$ 130,646
33	Construction oversight	5%	$ 653,231
34	Fate and transport modeling	0.5%	$ 65,323
34	Engineering design	2.5%	$ 326,615
	Construction Subtotal plus additional above costs		**$ 15,546,895**

INSTITUTIONAL CONTROLS COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
35	Prepare LUC Implementation Plan (mid-level staff with senior review)	0	hr	$ 114.30	$ -
36	Meetings with agencies (senior staff and attorneys)	0	hr	$ 259.78	$ -
	Institutional Controls Subtotal				**$ -**

TABLE C-2-2
GROUNDWATER ALTERNATIVE RGW-2B

PRE-DESIGN ACTIVITIES					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
37	Baseline groundwater monitoring	1.0	ea	$ 51,955.00	$ 51,955
38	Source area investigation	1.0	ea	$ 283,674.30	$ 283,674
39	E Main area investigation	1.0	ea	$ 101,312.25	$ 101,312
40	Water supply well siting	1.0	ea	$ 33,770.75	$ 33,771
41	Bench-scale microcosm testing	1.0	ea	$ 27,016.60	$ 27,017
42	Pilot test (ROI, flow rate, pressure)	1.0	ea	$ 135,083.00	$ 135,083
	Pre-Design Activities Subtotal				**$ 632,812**

GROUNDWATER MONITORING COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	Groundwater Monitoring Event				
43	Sampling	50.0	wells	$ 1,215.75	$ 60,788
44	Field parameters	50.0	ea	$ 33.77	$ 1,689
45	VOCs	58.0	ea	$ 94.56	$ 5,484
46	Dissolved metals	58.0	ea	$ 81.05	$ 4,701
47	Ferrous	58.0	ea	$ 27.02	$ 1,567
48	Dissolved gases	58.0	ea	$ 71.59	$ 4,152
49	Dissolved organic carbon	58.0	ea	$ 67.54	$ 3,917
50	Monitoring report	1.0	ea	$ 13,508.30	$ 13,508
	Groundwater Monitoring Event subtotal				**$ 95,806**

OPERATION AND MAINTENANCE COSTS									
Item	**Description**					**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	O&M and Reporting								
51	System operation					12	mo	$ 2,161.33	$ 25,936
52	System maintenance					12	mo	$ 6,754.15	$ 81,050
53	Shock chlorination					12	mo	$ 1,350.83	$ 16,210
54	Well rehabilitation					10	wells	$ 2,000.00	$ 20,000
55	Energy cost					630,571	KWH	$ 0.11	$ 69,363
56	Annual monitoring report					1	ea	$ 20,262.45	$ 20,262
57	Proj. Mgmt.	2 hrs/wk	on proj for	52	weeks	104	hr	$ 129.89	$ 13,509
	O&M and Reporting subtotal								**$ 246,330**

ALTERNATIVE COST SUMMARY		
Description		**Subtotal**
Construction		**$ 15,546,895**
Pre-design activities		**$ 632,812**
Institutional Controls		**$ -**
Operation, Maintenance and Monitoring (Present Value Analysis Costs--see Table C-2-2A)		**$ 3,097,418**
Contingency	30%	**$ 5,783,138**
Total (Rounded)		**$ 25,061,000**

TABLE C-2-2A
GROUNDWATER ALTERNATIVE RGW-2B

Annual Discount Rate [1]:

10-Yr 7.00%

Present Value Analysis						
	Annual Discount Factor [2]	Operation and Maintenance Costs				
Year	30-Yr	Description	Future Cost [3]	Description	Future Cost [3]	Present Value (2017)
0	1.000	Baseline monitoring	$95,806			$95,806
1	0.935	Quarterly monitoring and system O&M	$629,554			$588,368
2	0.873	Quarterly monitoring and system O&M	$629,554			$549,876
3	0.816	Semi-annual monitoring and system O&M	$437,942			$357,491
4	0.763	Semi-annual monitoring and system O&M	$437,942			$334,104
5	0.713	Semi-annual monitoring and system O&M	$437,942	Five-Year Review	$25,000	$330,071
6	0.666	Semi-annual monitoring and system O&M	$437,942			$291,819
7	0.623	Semi-annual monitoring and system O&M	$437,942			$272,728
8	0.582	Semi-annual monitoring	$191,612			$111,520
9	0.544	Semi-annual monitoring	$191,612			$104,224
10	0.508	Annual monitoring	$95,806	Five-Year Review	$25,000	$61,412
11	0.475					$0
12	0.444					$0
13	0.415					$0
14	0.388					$0
15	0.362					$0
16	0.339					$0
17	0.317					$0
18	0.296					$0
19	0.277					$0
20	0.258					$0
21	0.242					$0
22	0.226					$0
23	0.211					$0
24	0.197					$0
25	0.184					$0
26	0.172					$0
27	0.161					$0
28	0.150					$0
29	0.141					$0
30	0.131					$0
Total Present Value of Periodic Cost						**$3,097,418**

Notes:

1 Annual discount rate = 7% (EPA 540-R-00-002)

2 Annual discount factor = $1/(1+i)^t$, where i = discount rate (includes inflation and interest) and t = year

3 Current dollar cost of future event

O&M Operations and maintenance

TABLE C-2-3
GROUNDWATER ALTERNATIVE RGW-2C

CAPITAL COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	Wells				
1	Injection wells (includes well box, up to 100' TD, nested, 3x) and wellhead	18.0	ea	$ 20,397.53	$ 367,156
2	Injection wells (includes well box, up to 60' TD, nested, 3x) and wellhead	27.0	ea	$ 12,508.69	$ 337,735
3	Extraction wells (includes well box, up to 100' TD), wellhead, pumps and motors	1.0	ea	$ 23,909.69	$ 23,910
4	Extraction wells (includes well box, up to 60' TD), wellhead, pumps and motors	1.0	ea	$ 14,886.15	$ 14,886
5	Monitoring wells (includes manhole, up to 100' deep)	18.0	ea	$ 9,185.64	$ 165,342
6	Monitoring wells (includes manhole, up to 60' deep)	12.0	ea	$ 5,511.39	$ 66,137
	Wells subtotal				**$ 975,166**
	Piping and Fittings				
7	Injection/extraction piping	2,600.0	ft	$ 39.17	$ 101,842
8	Gate valves, flow sustaining valves, solenoid valves	46.0	ea	$ 1,395.39	$ 64,188
	Piping and Fittings subtotal				**$ 166,030**
	Earthwork and Paving				
9	Trenching, bedding, backfilling, compacting (2' wide x 4' deep)	2,600.0	ft	$ 12.33	$ 32,058
10	Asphalt cutting	5,200.0	ft	$ 2.01	$ 10,452
11	Install asphalt pavement (HMA, 6" thick)	5,200.0	sf	$ 5.44	$ 28,288
	Earthwork and Paving subtotal				**$ 70,798**
	Electrical				
12	Electrical service and meter installation	1.0	ea	$ 5,443.84	$ 5,444
13	Building wiring and fixtures	600.0	sf	$ 6.98	$ 4,188
14	Electrical conduit (1.5", power + control)	5,200.0	ft	$ 4.04	$ 21,008
15	Power wiring (14 AWG, 3 wire)	2,600.0	ft	$ 0.50	$ 1,300
16	Control wiring (18 AWG, 2 wire)	7,800.0	ft	$ 0.50	$ 3,900
17	Motor control center	1.0	ea	$ 27,016.60	$ 27,017
18	SCADA system (large)	1.0	ea	$ 135,083.00	$ 135,083
	Electrical subtotal				**$ 197,940**
	Process Equipment				
19	Control building (20' x 30')	600.0	sf	$ 17.80	$ 10,680
20	Chemical holding tank (10,000 gal)	1.0	ea	$ 11,379.38	$ 11,379
21	Metering pump (1 gpm)	1.0	ea	$ 1,730.41	$ 1,730
22	Bag filter	2.0	ea	$ 1,833.08	$ 3,666
	Process Equipment subtotal				**$ 27,455**
	Remediation Products				
23	Sodium permanganate	573.0	ton	$ 5,241.22	$ 3,003,219
24	NA	0.0	-	$ -	$ -
25	NA	0.0	-	$ -	$ -
	Remediation Products subtotal				**$ 3,003,219**
	Construction Support				
26	Utility surveying	4.0	day	$ 3,377.08	$ 13,508
27	Land survey (progress)	50.0	day	$ 1,702.05	$ 85,103
28	Land survey (as-built)	5.0	day	$ 1,702.05	$ 8,510
	Construction Support subtotal				**$ 107,121**
	Construction Subtotal				**$ 4,547,729**
	Construction Subtotal				**$ 4,547,729**
29	Construction Contractor Mobilization/Demobilization, Site Preparation and Submittals	10%			$ 454,773
30	Project management	3.5%			$ 159,171
31	Construction oversight	15%			$ 682,159
32	Fate and transport modeling	1%			$ 45,477
32	Engineering design	9%			$ 409,296
	Construction Subtotal plus additional above costs				**$ 6,298,605**

INSTITUTIONAL CONTROLS COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
33	Prepare LUC Implementation Plan (mid-level staff with senior review)	0	hr	$ 114.30	$ -
34	Meetings with agencies (senior staff and attorneys)	0	hr	$ 259.78	$ -
	Institutional Controls Subtotal				**$ -**

TABLE C-2-3
GROUNDWATER ALTERNATIVE RGW-2C

PRE-DESIGN ACTIVITIES					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
35	Baseline groundwater monitoring	1.0	ea	$ 51,955.00	$ 51,955
36	Source area investigation	1.0	ea	$ 283,674.30	$ 283,674
37	E Main area investigation	1.0	ea	$ 101,312.25	$ 101,312
38	Water supply well siting	1.0	ea	$ 33,770.75	$ 33,771
39	NOD testing	1.0	ea	$ 6,754.15	$ 6,754
40	Pilot test (ROI, flow rate, pressure)	1.0	ea	$ 135,083.00	$ 135,083
	Pre-Design Activities Subtotal				**$ 612,549**

GROUNDWATER MONITORING COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	Groundwater Monitoring Event				
41	Sampling	50.0	wells	$ 1,215.75	$ 60,788
42	Field parameters	50.0	ea	$ 33.77	$ 1,689
43	VOCs	58.0	ea	$ 94.56	$ 5,484
44	Dissolved metals	58.0	ea	$ 81.05	$ 4,701
45	Ferrous	58.0	ea	$ 27.02	$ 1,567
46	Dissolved gases	58.0	ea	$ 71.59	$ 4,152
47	Dissolved organic carbon	58.0	ea	$ 67.54	$ 3,917
48	Monitoring report	1.0	ea	$ 13,508.30	$ 13,508
	Groundwater Monitoring Event subtotal				**$ 95,806**

OPERATION AND MAINTENANCE COSTS								
Item	**Description**					**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	O&M and Reporting								
49	System operation					12	mo	$ 2,161.33	$ 25,936
50	System maintenance					12	mo	$ 5,403.32	$ 64,840
51	Energy cost					33,188	KWH	$ 0.11	$ 3,651
52	Annual monitoring report					1	ea	$ 20,262.45	$ 20,262
53	Proj. Mgmt.	2 hrs/wk	on proj for	52	weeks	104	hr	$ 129.89	$ 13,509
	O&M and Reporting subtotal								**$ 128,198**

ALTERNATIVE COST SUMMARY	
Description	**Subtotal**
Construction	**$ 6,298,605**
Pre-design activities	**$ 612,549**
Institutional Controls	**$ -**
Operation, Maintenance and Monitoring (Present Value Analysis Costs--see Table C-2-3A)	**$ 2,293,409**

Contingency	30%	**$ 2,761,369**

Total (Rounded)	**$ 11,966,000**

TABLE C-2-3A
GROUNDWATER ALTERNATIVE RGW-2C

Annual Discount Rate [1]:

10-Yr 7.00%

Present Value Analysis						
	Annual Discount Factor [2]	Operation and Maintenance Costs				
Year	30-Yr	Description	Future Cost [3]	Description	Future Cost [3]	Present Value (2017)
0	1.000	Baseline monitoring	$95,806			$95,806
1	0.935	Quarterly monitoring and system O&M	$511,422			$477,964
2	0.873	Semi-annual monitoring and system O&M	$319,810			$279,334
3	0.816	Semi-annual monitoring and system O&M	$319,810			$261,060
4	0.763	Semi-annual monitoring and system O&M	$319,810			$243,981
5	0.713	Semi-annual monitoring and system O&M	$319,810	Five-Year Review	$25,000	$245,844
6	0.666	Semi-annual monitoring and system O&M	$319,810			$213,103
7	0.623	Semi-annual monitoring and system O&M	$319,810			$199,161
8	0.582	Semi-annual monitoring	$191,612			$111,520
9	0.544	Semi-annual monitoring	$191,612			$104,224
10	0.508	Annual monitoring	$95,806	Five-Year Review	$25,000	$61,412
11	0.475					$0
12	0.444					$0
13	0.415					$0
14	0.388					$0
15	0.362					$0
16	0.339					$0
17	0.317					$0
18	0.296					$0
19	0.277					$0
20	0.258					$0
21	0.242					$0
22	0.226					$0
23	0.211					$0
24	0.197					$0
25	0.184					$0
26	0.172					$0
27	0.161					$0
28	0.150					$0
29	0.141					$0
30	0.131					$0
Total Present Value of Periodic Cost						**$2,293,409**

Notes:

1 Annual discount rate = 7% (EPA 540-R-00-002)

2 Annual discount factor = $1/(1+i)^t$, where i = discount rate (includes inflation and interest) and t = year

3 Current dollar cost of future event

O&M Operations and maintenance

APPENDIX C-3

VAPOR INTRUSION ALTERNATIVE COST ESTIMATES

APPENDIX C-3

COST ESTIMATE ASSUMPTIONS FOR VAPOR INTRUSION ALTERNATIVES

Assumptions pertaining to cost estimates for each of the vapor intrusion alternatives are presented below.

Vapor intrusion alternative VI-1: No Action

No costs are associated with the No Action alternative.

Vapor intrusion alternative VI-2: Sub-Slab Depressurization Systems and Monitoring

Alternative VI-2 assumes that SSD systems will be installed at 156 properties, of which 28 are commercial properties and 128 are single-family homes. It is assumed that the SSD systems will consist of suction point(s), suction pipe(s), a fan, and an exhaust stack. It is also assumed that installation of SSD systems will include drilling through ceiling and foundation slabs, installing system components, conducting pre-installation communication tests, conducting pre- and post- installation radon and volatile organic compounds (VOC) tests, and cleaning up and restoring the site.

A basic exterior SSD system for residential application costs approximately $800. This cost includes installation of one suction point, one fan, a condensate bypass fitting, piping, a U-tube manometer, and post-installation pressure field testing at up to two test points. Additional costs that may be incurred include the following:

- $100 for an interior system
- $100 for each extra suction point
- $75 to connect each additional suction point to main header
- $90 for more powerful fan if low-permeability subgrade is encountered
- $150 for alarm system triggered by differential pressure
- $75 for pre- and post-installation communication test for up to eight test holes
- $750 to install and connect each extra fan
- $1 per square foot of crawl space needing membrane and sub-membrane suction point.

Based on system components presented above, SSD systems previously installed in Troy during EPA's removal action in 2007, and costs incurred for similar construction at other sites, it is assumed that installation costs for SSD systems are about $1,500 for single-family structures and about $4,000 for commercial structures.

During the remedial design, additional information would be necessary during pre-design activities to design each individual SSD system. For example, attempts would be made to acquire footprints or plans

of structures requiring SSD systems. SulTRAC assumed a cost of $50,000 for pre-design investigation activities consisting of predesign visual inspections of properties that consent to access.

For FS purposes, SulTRAC developed a unit cost for residential installations and a separate unit cost for commercial installations. SulTRAC used the following assumptions in developing the cost estimate:

- All structures have full basements (none of them have crawl spaces).
- Based on limited inspections performed to date, approximately 8 percent of the buildings had dirt floors; therefore, it is assumed that 12 of the 156 buildings will have dirt floors.
- Each of the estimated 128 residential buildings will receive one SSD system and each of the estimated 28 commercial buildings will receive two SSD systems (total of 184 systems).
- Pre-installation test and foundation inspections will be performed in each property prior to construction.
- In house basements, one suction point will be provided for every 1,200 square feet of area to be depressurized.
- In house basements, one fan will be provided for every 2,000 square feet of area to be depressurized.
- The owner is to clear the basement as necessary to provide access to the contractor.
- Basement ceilings are assumed unfinished, and pipe can be mounted to structural elements without having to remove finished ceilings.
- All properties will receive exterior systems.
- Exhaust gas can be discharged directly to the atmosphere without treatment.
- Project management during construction is assumed to be 5 hours per week for 23 weeks.
- Contractor oversight is assumed to be 12 hours per system.
- Oversight travel and per diem for two people per week is assumed to be $4,000 per week for 23 weeks.
- Post-sampling for VOCs and radon will be conducted at each property. Radon will be used as a surrogate for the contaminants of concern (COC) to test system performance. Testing will occur after SSD system installation to demonstrate that vapors are below remedial levels.
- Mobilization and demobilization is assumed at 10 percent of the construction cost.
- Engineering design is assumed at 12 percent of the construction cost.

The SSD systems will require operation and maintenance (O&M) and monitoring to demonstrate effectiveness in achieving remedial action goals. SulTRAC used the following assumptions in developing the O&M cost estimate:

- Because the anticipated duration of the groundwater interim action is assumed to range from about 10 to 15 years, it was assumed that the SSD systems would be operated for 15 years.
- A discount rate of 7 percent was used to calculate present worth cost.
- Maintenance cost is estimated at $100 per year per system.

- Annual inspections will be performed by a consultant on each system – assuming 2 hours to inspect each system.
- An annual inspection report will be prepared.
- Indoor air monitoring will be performed annually on 128 residential properties – assuming 1 sample per building.
- Indoor air monitoring will be performed annually on 28 commercial properties – assuming 2 samples per building.
- An annual monitoring report will be prepared.

Vapor Intrusion Cost Estimate Notes and Abbreviations

ea	Each
hr	Hour
ls	Lump Sum
LUC	Land use control
O&M	Operation and maintenance
O&P	Overhead and profit
SSD	Sub-slab depressurization
wk	Week

TABLE C-3-1
SOIL VAPOR ALTERNATIVE VI-2

CAPITAL COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
Pre-design					
1	Pre-design investigation (inspection of up to 156 locations)	1.0	ls	$ 50,000.00	$ 50,000
	Pre-design subtotal				**$ 50,000**
Management and Oversight					
2	Project management (5 hr/wk for 23 weeks)	115.0	hr	$ 125.00	$ 14,375
3	Construction oversight (12 hr/system x 184 systems)	2,208.0	hr	$ 100.00	$ 220,800
4	Construction oversight travel (4,000/wk x 23 weeks)	23.0	wk	$ 4,000.00	$ 92,000
	Management and Oversight subtotal				**$ 327,175**
Testing					
5	Post-installation testing (labor for set-up & collection and sample analysis)	184.0	ea	$ 1,200.00	$ 220,800
	Testing subtotal				**$ 220,800**
System Installation					
6	Single-family home installation (128 properties x 1 system each)	128.0	ea	$ 1,500.00	$ 192,000
7	Commercial property installation (28 properties x 2 systems each)	56.0	ea	$ 4,000.00	$ 224,000
	System Installation subtotal				**$ 416,000**
Site Restoration					
8	Site cleanup (184 systems)	184.0	ea	$ 200.00	$ 36,800
	Site Restoration subtotal				**$ 36,800**
Construction Subtotal					**$ 1,050,775**
	Contractor Mobilization/Demobilization, Site Preparation and Submittals	10%			$ 105,078
	Engineering design	12%			$ 126,093
Construction Subtotal plus additional above costs					**$ 1,281,946**
CAPITAL COST SUBTOTAL					**$ 1,281,946**

O&M COSTS					
Item	**Description**	**Quantity**	**Unit**	**Unit Price (Incl. O&P)**	**Total Cost**
	Maintenance				
1	Routine SSD system maintenance	184.0	ea	$ 100.00	$ 18,400
	Maintenance subtotal				**$ 18,400**
	Monitoring				
2	Indoor air monitoring (labor and sample analysis-1 sample per residential structure and 2 samples per commercial structure)	184.0	ea	$ 1,200.00	$ 220,800
3	Annual monitoring report	1.0	ls	$ 5,000.00	$ 5,000
	Monitoring subtotal				**$ 225,800**
	Inspections				
4	Annual system inspections (includes labor - 2 hours per system - and travel)	368.0	hr	$ 125.00	$ 46,000
5	Annual inspection report	1.0	ls	$ 5,000.00	$ 5,000
6	Project Management 2 hrs/wk on project for 52 weeks	104.0	hr	$ 125.00	$ 13,000
	Inspections subtotal				**$ 64,000**
	Annual Operation and Maintenance Subtotal				**$ 308,200**

ALTERNATIVE COST SUMMARY	
Description	**Subtotal**
Construction	**$ 1,281,946**
Operation and Maintenance (15-Year Present Value Analysis Costs--see Table C-3-1A)	**$ 2,846,654**
Contingency 30%	**$ 1,238,580**
Total (Rounded)	**$ 5,370,000**

TABLE C-3-1A
SOIL VAPOR ALTERNATIVE VI-2

Annual Discount Rate [1]:

15-Yr 7.00%

Present Value Analysis						
	Annual Discount Factor [2]	Operation and Maintenance Costs				
Year	**30-Yr**	**Description**	**Future Cost [3]**	**Description**	**Future Cost [3]**	**Present Value (2017)**
0	1.000					$0
1	0.935	SSD SYSTEM O&M	$308,200			$288,037
2	0.873	SSD SYSTEM O&M	$308,200			$269,194
3	0.816	SSD SYSTEM O&M	$308,200			$251,583
4	0.763	SSD SYSTEM O&M	$308,200			$235,124
5	0.713	SSD SYSTEM O&M	$308,200	Five-Year Review	$25,000	$237,567
6	0.666	SSD SYSTEM O&M	$308,200			$205,367
7	0.623	SSD SYSTEM O&M	$308,200			$191,931
8	0.582	SSD SYSTEM O&M	$308,200			$179,375
9	0.544	SSD SYSTEM O&M	$308,200			$167,640
10	0.508	SSD SYSTEM O&M	$308,200	Five-Year Review	$25,000	$169,382
11	0.475	SSD SYSTEM O&M	$308,200			$146,424
12	0.444	SSD SYSTEM O&M	$308,200			$136,844
13	0.415	SSD SYSTEM O&M	$308,200			$127,892
14	0.388	SSD SYSTEM O&M	$308,200			$119,525
15	0.362	SSD SYSTEM O&M	$308,200	Five-Year Review	$25,000	$120,767
Total Present Value of Periodic Cost						**$2,846,654**

Notes:

1 Annual discount rate = 7% (EPA 540-R-00-002)

2 Annual discount factor = $1/(1+i)^t$, where i = discount rate (includes inflation and interest) and t = year

3 Current dollar cost of future event

O&M Operations and maintenance

APPENDIX D

PRELIMINARY IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

TABLE D-1
SUMMARY OF POTENTIAL FEDERAL ARARS FOR ETCA SITE

Requirement	Prerequisite	Citation	Comment
CHEMICAL-SPECIFIC			
Effluent limitations on point source pollutant discharges to waters of U.S.	Groundwater Discharge to Surface Water	CWA of 1977 33 U.S.C. Subsection 1251, et seq.	RI results show groundwater does not discharge to surface water
Establishes MCLs, which are health risk-based standards for public water systems.	Surface water is current or potential source of drinking water	SDWA of 1974 40 CFR 141 and 142	All residents supplied by municipal system; Troy prohibits private wells for potable uses, allows wells agricultural irrigation
Establishes welfare-based secondary standards for public water systems.	Surface water is current or potential source of drinking water	SDWA of 1974 40 CFR 143	All residents supplied by municipal system; Troy prohibits private wells for potable uses, allows wells agricultural irrigation
LOCATION-SPECIFIC			
No adverse impact to a wetland	Remedial action within an on-site wetland or disturbance to off-site wetland	CWA of 1977 40 CFR 6.302(a) Appendix A	No wetlands are on-site or within the footprint of the plume (reference: National Wetlands Inventory, 2014)
Facility must be designed, constructed, operated, and maintained to avoid washout.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste within a 100-year floodplain	40 CFR. 264.18(b)	ETCA is not located within the 100-year flood plain
Preservation of historic or prehistoric resources (including structures) in National Historic Register sites.	Site (or structures) listed in National Register of Historic Places	NHPA of 1966 16 U.S.C. Subsection 470 et seq.	Site (or on-site structures) not listed in Register
ACTION-SPECIFIC			
Minimum design and operation criteria for land disposal of solid wastes	Regulated solid waste disposal unit	40 CFR 257 Subpart A	No regulated units currently on site; substantive requirements may be relative and appropriate for certain alternatives
Site closure, operation and maintenance, monitoring and record-keeping at regulated waste units	RCRA Regulated Hazardous Waste Unit	40 CFR 264.18	The ETCA site is not a RCRA hazardous waste regulated unit; no hazardous waste has been identified on site
Requirements for Corrective Action Management Unit (CAMU) at RCRA-permitted transportation, storage, and disposal facilities undergoing corrective action.	Creation of a Corrective Action Management Unit (CAMU)	40 CFR Part 264.552	No hazardous waste has been identified on site
Land disposal restrictions (LDRs) prohibit disposal of hazardous waste unless treatment standards are met.	Disposal of hazardous waste on site	40 CFR 268.1	May be relevant and appropriate if RCRA - characteristic waste is generated as part of alternative

TABLE D-1
SUMMARY OF POTENTIAL FEDERAL ARARS FOR ETCA SITE

Notes:

ARAR	=	Applicable or relevant and appropriate requirement
CFR	=	Code of Federal Regulations
CWA	=	Clean Water Act
ETCA	=	East Troy Contaminated Aquifer Site
MCL	=	Maximum Contaminant Level
NHPA	=	National Historic Preservation Act
RCRA	=	Resource Conservation and Recovery Act
SDWA	=	Safe Drinking Water Act
U.S.C.	=	United States Code

TABLE D-2
SUMMARY OF POTENTIAL STATE (OHIO) ARARS FOR THE ETCA SITE

CATEGORY	ORC	OAC	PARAGRAPH	CAPTION	TYPE (Location/ Chemical/ Action-Specific)	TEXT	POTENTIAL APPLICATION
ODNR	1517.16			Channel modifications must be approved	LOCATION	No governmental body may modify the channel of any watercourse within a wild, scenic or recreational river area outside the limits of a municipal corporation without approval from the director of ODNR	Consider for any action that includes dredging or altering of riverbanks.
ODNR	1518.02			Endangered plant species	LOCATION	Prohibits removal or destruction of endangered plant species (some private property exceptions).	Applies to remediation sites where chemicals may harm endangered species. Clearly establishes that receptor plant species must be considered in risk assessments. This act may require consideration of endangered species in remediations that involve movement or displacement of large volumes of surface soil.
ODNR	1521.06			Construction permits for dams, dikes and levees	LOCATION	No dam may be constructed for the purpose of storing, conserving or retarding water, or for any other purpose, nor shall any dike or levee be constructed for the purpose diverting or retaining flood water without a permit.	The substantive requirements of this section pertain to remedies that will create or alter a dam, dike or levee. Consider for sites with on-site surface water and for sites within a floodplain.
ODNR	1521.062		A-G	Monitoring, maintenance & operation (dams, dikes, levees)	LOCATION	Dams, dikes and levees (and all appurtenances) shall monitored, maintained and operated safely in accordance with state rules, terms and conditions of the permit and other requirements issued pursuant to this section or section 1521.06 of the ORC.	The substantive requirements of this section pertain to remedies that will create or alter a dam, dike or levee. Consider for sites with on-site surface water and for sites within a floodplain.
ODNR	1531.25			Endangered animal species	LOCATION	Prohibits removal or destruction of endangered animal species	Applies to remediation sites where chemicals may harm endangered species. Clearly establishes that receptor animal species must be considered in risk assessments. This act may require consideration of endangered species in remediations that involve movement or displacement of large volumes of surface soil.
APC	3704.05		A-I	Prohibits violation of air pollution control rules	ACTION	Prohibits emission of an air contaminant in violation sec. 3704 or any rules, permit, order or variance issued pursuant to that section of the ORC.	May pertain to any site where emissions of an air contaminant occurs either as a pre-existing condition of the site or as a result of remedial activities. Should be considered for virtually all sites that require the management of solid/hazardous wastes.
HW	3734.02		(H)	"digging" where hazardous or solid waste facility was located	LOCATION	Filling, grading, excavating, building, drilling or mining on land where hazardous waste or solid waste facility was operated is prohibited without prior authorization from the director of the Ohio EPA.	Pertains to any site at which hazardous or solid waste has come to be located. Certain alternatives include excavation activities which may uncover solid and/or hazardous waste. Should those activities require the management of solid/hazardous wastes on-site, an exemption to permitting and other requirements may be warranted.
HW APC	3734.02		(I)	Air emissions from hazardous waste facilities	ACTION	No hazardous waste facility shall emit any particulate matter, dust, fumes, gas, mist, smoke, vapor or odorous substance that interferes with the comfortable enjoyment of life or property or is injurious to public health.	Pertains to any site at which hazardous waste will be managed such that air emissions may occur. Consider for sites that will undergo movement of earth or incineration.
DSIWM	3734.03			Prohibits open dumping or burning	ACTION	Prohibits open burning or open dumping of solid waste or treated or untreated infectious waste.	Pertains to any site at which solid waste has come to be located or will be generated during a remedial action.
APC DSW	3767.13			Prohibition of nuisances	ACTION	Prohibits noxious exhalations or smells and the obstruction of waterways.	Pertains to any site that may have noxious smells or may obstruct waterways.
DSW	3767.14			Prohibition of nuisances	ACTION	Prohibition against throwing refuse, oil, or filth into lakes, streams, or drains.	Pertains to all sites located adjacent to lakes, streams, or drains.
DERR	5301.00		.80 TO .92	Uniform environmental covenants act	LOCATION	Standards for environmental covenants	Consider for sites with institutional controls or use restrictions
DSW	6101.19			Conservancy districts	LOCATION	Board of directors of a conservancy district may make and enforce rules and regulations pertaining to channels, ditches, pipes, sewers, etc.	This statute pertains to any site that may affect a construction within a conservancy district.
DSW	6111.04			Acts of pollution prohibited	ACTION	Pollution of waters of the state is prohibited.	Pertains to any site which has contaminated on-site ground or surface water or will have a discharge to on-site surface or ground water.
DSW	6111.07		A,C	Water pollution control requirements - duty to comply	ACTION	Prohibits failure to comply with requirements of sections 6111.01 to 6111.08 or any rules, permit or order issued under those sections.	Pertains to any site which has contaminated ground water or surface water or will have a discharge to on-site surface or ground water.
DSW	6111.04.2			Rules requiring compliance with national effluent standards	ACTION	Establishes regulations requiring compliance with national effluent standards.	Pertains to any site which will have a point source discharge.

TABLE D-2
SUMMARY OF POTENTIAL STATE (OHIO) ARARS FOR THE ETCA SITE

CATEGORY	ORC	OAC	PARAGRAPH	CAPTION	TYPE (Location/ Chemical/ Action-Specific)	TEXT	POTENTIAL APPLICATION
ODNR		1501:21-11	03-05	Predesign investigations (dams, dikes, levees)	LOCATION	Presents predesign requirements for dams, dikes and levees. Includes on-site construction material data, surveys and hydrologic and hydraulic investigations.	Pertains to remedies that create or alter a dam, dike or levee. Consider for sites with on-site surface water and for sites within a floodplain.
ODNR		1501:21-13	02-08	Additional design requirements for dams	LOCATION	Presents design requirements specific to dams. Includes such criteria as design storm and flood, spillway design, freeboard requirements, etc.	Pertains to remedies that create or alter a dam. Consider for sites with on-site surface water.
ODNR		1501:21-13	10-14	Additional design requirements for dikes and levees	LOCATION	Presents design requirements specific to dikes and levees. Includes criteria such as design storm and flood and freeboard requirements.	Pertains to remedies that create or alter a dike or levee. Consider for sites within a floodplain.
ODNR		1501:21-15	06	Operation, maintenance and inspections	LOCATION	Presents the minimum information required in a plan addressing the operation, maintenance and inspection of dams, dikes and levees.	Pertains to remedies that create or alter a dam, dike or levee. Consider for sites with on-site surface water and for sites within a floodplain.
ODNR		1501:21-21	03-04	Deficiency and o&m of dams, dikes and levees	LOCATION	Dams, dikes and levees must be operated safely. Repairs or other remedial measures shall be performed on dams, dikes and levees as necessary to safeguard life, health or property.	Pertains to remedies that create or alter a dam, dike or levee. Consider for sites with on-site surface water and for sites within a floodplain.
ODNR		1501:21-5	02-06	Design requirements for dams, dikes and levees	LOCATION	Specifies minimum information required during design for Ohio DNR to determine adequacy of proposed dam, dike or levee. Includes design reports, plans and specifications.	Pertains to remedies that create or alter a dam, dike or levee. Consider for sites with on-site surface water and for sites within a floodplain.
ODNR		1501:31-23	01, A-B	List of endangered animal species	LOCATION	List of Ohio animal species considered endangered.	May apply to remediation sites where listed species are threatened by chemical releases. May also apply at sites where remedial activities could disturb existing habitats.
ODNR		1501-18-1	03, A	List of endangered plant species	LOCATION	Plant species considered endangered in Ohio	May apply at remediation sites where chemical release threatens listed species. Should also be considered where remedial activities may disrupt habitats.
DSW		3745-1-03		Analytical and collection procedures	ACTION	Specifies analytical methods and collection procedures for surface water discharges.	Pertains to both discharges to surface waters as a result of remediation and any on-site surface waters affected by site conditions.
DSW		3745-1-04	A,,B,C,D,E	The "five freedoms" for surface water	ACTION	All surface waters of the state shall be free from: a) objectionable suspended solids. B) floating debris, oil and scum. C) materials that create a nuisance. D) toxic, harmful or lethal substances. E) nutrients that create nuisance growth	Pertains to both discharges to surface waters as a result of remediation and any on-site surface waters affected by site conditions.
DSW		3745-1-05	A-C	Antidegradation policy for surface water	ACTION	Prevents degradation of surface water quality below designated use or existing water quality. Existing in stream uses shall be maintained and protected. The most stringent controls for treatment shall be required by the director to be employed for all new and existing point source discharges. Prevents any degradation of state resource waters	Requires that best available technology (bat) be used to treat surface water discharges. DWQPA uses this rule to set standards when existing water quality is better than the designated use.
DSW		3745-1-06	A,B	Mixing zones for surface water	ACTION	(a) presents the criteria for establishing non-thermal mixing zones for point source discharges (b) presents the criteria for establishing thermal mixing zones for point source discharges	Applied as a term of discharge permit to install (pti). Would pertain to an alternative which resulted in a point source discharge.
DSW		3745-1-21		Water use DES for Great Miami River	LOCATION	Establishes water use designations for stream segments within the Great Miami River basin	Pertinent if stream or stream segment is on-site and is either affected by site conditions of if remedy includes direct discharge. Used by DSW to establish waste load allocations
DSW		3745-1-34		Water quality criteria for Ohio river drainage basin	LOCATION	Establishes criteria for surface water in Ohio river drainage basin.	Pertinent if stream or stream segment is on-site and is either affected by site conditions of if remedy includes direct discharge. Used by DSW to establish waste load allocations
APC		3745-15-05	A-D	De minimis air contaminant source exemption	ACTION	Establishes limits below which air discharge permits are not needed	Pertains to any site which utilizes or will utilize air pollution control equipment on-site.
APC		3745-15-06	A1,A2	Malfunction & maintenance of air poll control equipment	ACTION	Establishes scheduled maintenance and specifies when pollution source must be shut down during maintenance	Pertains to any site which utilizes or will utilize air pollution control equipment on-site.

TABLE D-2
SUMMARY OF POTENTIAL STATE (OHIO) ARARS FOR THE ETCA SITE

CATEGORY	ORC	OAC	PARAGRAPH	CAPTION	TYPE (Location/ Chemical/ Action-Specific)	TEXT	POTENTIAL APPLICATION
APC		3745-15-07	A	Air pollution nuisances prohibited	ACTION	Defines air pollution nuisance as the emission or escape into the air from any sources(s)) of smoke, ashes, dust, dirt, grime, acids, fumes, gases, vapors, odors and combinations of the above that endanger health, safety or welfare of the public or cause personal injury or property damage. Such nuisances are prohibited.	Pertains to any site which causes, or may reasonably cause, air pollution nuisances. Consider for sites that will undergo excavation, demolition, cap installation, methane production, clearing and grubbing, water treatment, incineration and waste fuel recovery.
APC		3745-17-08	A1,A2,B,D	Emission restrictions for fugitive dust	ACTION	All emissions of fugitive dust shall be controlled.	Pertains to sites which may have fugitive emissions (non-stack) of dust. Consider for sites that will undergo grading, loading operations, demolition, clearing and grubbing and construction utilize incineration or fuel recovery (waste fuel recovery)
APC		3745-19-03	A,B,C,D	Open burning standards in restricted areas	ACTION	Open burning without prior authorization from Ohio EPA is prohibited.	Pertains to sites within a restricted area (within the boundary of a municipality and a zone extending beyond such municipality).
APC		3745-21-09		VOC emissions control: stationary sources	ACTION	Establishes limitations for emissions of volatile organic compounds from stationary sources.	Pertains to any site with treatment systems that emit volatile organic compounds, including those with thermal desorption and air stripping.
HW		3745-270-03	A-D	Dilution prohibited as a substitute for treatment.	ACTION	Forbids dilution as a means of achieving land disposal restriction levels	Consider for remedial options including land disposal or leaving wastes in-place
HW		3745-270-07	A-E	Testing, tracking, and recordkeeping requirements	ACTION	Testing, tracking, and recordkeeping requirements for generators, treaters, and disposal facilities.	Consider for sites at which wastes are generated, stored, disposed, or treated
HW		3745-270-09	A-D	Special rules regarding characteristic wastes	ACTION	Rules applicable to land disposal of characteristic wastes	Consider for sties that generate characteristic wastes
HW		3745-270-40	A-J	Applicability of treatment standards	CHEMICAL	Detailed listing of chemical specific land treatment standards or required treatment technologies.	Consider for sites that generate wastes or with wastes disposed on-site
HW		3745-270-42	A-D	Treatment standards expressed as specified technologies	CHEMICAL	Lists specific treatment technologies required for specific wastes	Consider at all sites generating wastes or with on-site disposal
HW		3745-270-45	A-D	Treatment standards for hazardous debris	CHEMICAL	Specifies treatment technologies and performance standards for various debris.	Consider for sites with contamination by debris.
HW		3745-270-48	A	Universal treatment standards	CHEMICAL	Gives contaminant chemical specific standards for land disposal	Consider for sites with waste generation or on-site disposal
HW		3745-270-49	A-E	Land disposal restriction for contaminated soils	CHEMICAL	Specifies standards for soil treatment	Consider at sites where contaminated soils are generated
DSW		3745-3-04	A-D	Prohibited discharges	ACTION	Places restrictions on discharges to POTW's that may harm treatment functions or pass through to receiving stream.	Consider for sites with discharges to POTW
APC		3745-31-02	A,C,D	Permit to install, general requirements	ACTION	General requirements for permit to install air pollution sources	Consider for sites with potential for air emissions, including sites with soil vapor extraction, thermal desorption, incineration or other treatment technologies with air emissions
DSW		3745-32-05		Water quality criteria for decision by the director	ACTION	Specifies substantive criteria for Section 401 water quality criteria for dredging, filling, obstructing or altering waters of the state.	Pertains to any site that has or will affect waters of the state.
UIC		3745-34-06		Prohibition of unauthorized injection	ACTION	Underground injection is prohibited without authorization from the director.	Pertains to sites at which materials are to be injected underground. Consider for technologies such as bioremediation and soil flushing.
UIC		3745-34-07		No movement of fluid into underground drinking water	ACTION	The underground injection of fluid containing any contaminant into an underground source of drinking water is prohibited if the presence of that contaminant may cause a violation of the primary drinking water standards or otherwise adversely affect the health of persons.	Pertains to sites at which materials are to be injected underground. Consider for technologies such as bioremediation and soil flushing.
UIC		3745-34-09		Requirements for wells injecting hazardous waste	ACTION	Specifies requirements for the injection of hazardous wastes underground. See 3745-34-08 for limitations.6 of the ORC.	Pertains to sites at which materials are to be injected underground. Consider for technologies such as bioremediation and soil flushing.
UIC		3745-34-26		Conditions applicable to all permits	ACTION	Specifies minimum conditions to be applied to all underground injections.	Pertains to sites at which materials are to be injected underground. Consider for technologies such as bioremediation and soil flushing.
UIC		3745-34-34		Mechanical integrity	ACTION	Specifies requirements to be met to ensure mechanical integrity of wells.	Pertains to sites at which materials are to be injected underground. Consider for technologies such as bioremediation and soil flushing.

TABLE D-2
SUMMARY OF POTENTIAL STATE (OHIO) ARARS FOR THE ETCA SITE

CATEGORY	ORC	OAC	PARAGRAPH	CAPTION	TYPE (Location/ Chemical/ Action-Specific)	TEXT	POTENTIAL APPLICATION
HW		3745-50-44	A	Permit info required for all hazardous waste facilities	ACTION	Establishes the substantive hazardous waste permit requirements necessary for Ohio EPA to determine facility compliance. Includes information such as facility description, waste characteristics, equipment descriptions, contingency plan, facility location, topographic map, etc.	Pertains to any site which will have treatment, storage or disposal of hazardous waste occurring on-site or has existing areas of hazardous waste contamination on-site that will be capped in-place. This, along with other paragraphs of this rule, establishes the minimum information required during the remedial design stage. Corrective action for waste management units
HW		3745-50-44		Permit info req for all hazardous waste land disp facilities	ACTION	Establishes the substantive hazardous waste land disposal permit requirements necessary for Ohio EPA to determine adequate protection of the ground water. Includes information such as ground water monitoring data, information on interconnected aquifers, plume(s) of contamination, plans and reports on ground water monitoring program, etc. Management of solid/hazardous was	Pertains to any facility/site which will have hazardous waste disposed of on-site or has existing areas of hazardous waste contamination on-site that will be capped in-place. This, along with other paragraphs of this rule, establishes the minimum information required during the remedial design stage.
HW		3745-50-58	E,I,J	Conditions applicable to all permits	ACTION	Establishes general permit conditions applied to all hazardous waste facilities in Ohio. Includes conditions such as operation and maintenance, site access, monitoring, etc.	Pertains to all alternatives that will incorporate treatment, storage or disposal of hazardous waste.
HW		3745-52-11	A-D	Evaluation of wastes	ACTION	Any person generating a waste must determine if that waste is a hazardous waste (either through listing or by characteristic).	Pertains to sites at which wastes of any type (both solid and hazardous) are located.
HW		3745-52-12	A-C	Generator identification number	ACTION	A generator must not store, treat dispose or transport hazardous wastes without a generator number	Pertains to sites where hazardous waste will be transported off-site for treatment, storage or disposal
HW		3745-52-20		Hazardous waste manifest - general requirements	ACTION	Requires a generator who transports or offers for transportation hazardous waste for off-site treatment, storage or disposal to prepare a uniform hazardous waste manifest	Pertains to sites where hazardous waste will be transported off-site for treatment, storage or disposal
HW		3745-52-22		Hazardous waste manifest - number of copies	ACTION	Specifies the number of manifest copies to be prepared	Pertains to sites where hazardous waste will be transported off-site for treatment, storage or disposal
HW		3745-52-23		Hazardous waste manifest - use	ACTION	Specifies procedures for the use of hazardous waste manifests including a requirement that they be hand signed by the generator	Pertains to sites where hazardous waste will be transported off-site for treatment, storage or disposal
HW		3745-52-30		Hazardous waste packaging	ACTION	Requires a generator to package hazardous waste in accordance with U.S. DOT regulations for transportation off-site.	Pertains to any site where hazardous waste will be generated by on-site activities and shipped off-site for treatment and/or disposal.
HW		3745-52-31		Hazardous waste labeling	ACTION	Requires packages of hazardous waste to be labeled in accordance with u.s.dot regulations for off-site transportation.	Pertains to any site where hazardous waste will be generated by on-site activities and shipped off-site for treatment and/or disposal.
HW		3745-52-32		Hazardous waste marking	ACTION	Specifies language for marking packages of hazardous waste prior to off-site transportation	Pertains to any site where hazardous waste will be generated by on-site activities and shipped off-site for treatment and/or disposal.
HW		3745-52-33		Hazardous waste placarding	ACTION	Generator shall placard hazardous waste prior to off-site transportation.	Pertains to any site where hazardous waste will be generated by on-site activities and shipped off-site for treatment and/or disposal.
HW		3745-52-34		Accumulation time of hazardous waste	ACTION	Identifies maximum time periods that a generator may accumulate a hazardous waste without being considered an operator of a storage facility. Also establishes standards for management of hazardous wastes by generators.	Pertains to a site where hazardous waste will be generated as a result of the remedial activities.
HW		3745-52-40	A-D	Recordkeeping requirements, three year retention	ACTION	Specifies records that shall be kept for three years	Consider for sites at which hazardous wastes are generated
HW		3745-52-41	A,B	Annual report	ACTION	Requires generators to prepare annual report to Ohio EPA	Applicable at sites generating wastes for offsite shipment
HW		3745-54-13	A	General analysis of hazardous waste	ACTION	Prior to any treatment, storage or disposal of hazardous wastes, a representative sample of the waste must be chemically and physically analyzed.	Pertains to any site at which hazardous is to be treated, stored or disposed of (or has been disposed of).

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CATEGORY	ORC	OAC	PARAGRAPH	CAPTION	TYPE (Location/ Chemical/ Action-Specific)	TEXT	POTENTIAL APPLICATION
HW		3745-54-14	A,B,C	Security for hazardous waste facilities	ACTION	Hazardous waste facilities must be secured so that unauthorized and unknowing entry are minimized or prohibited.	Pertains to any site at which hazardous is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-15	A,C	Inspection requirements for hazardous waste facilities	ACTION	Hazardous waste facilities must be inspected regularly to detect malfunctions, deteriorations, operational errors and discharges. Any malfunctions or deteriorations detected shall be remedied expeditiously.	Pertains to any site at which hazardous is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-16		Personnel training	ACTION	Establishes requirements for training of personnel at hazardous waste facilities	Pertains to any site at which hazardous is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-18	A,B,C	Location standards for hazardous waste t/s/d facilities	LOCATION	Restricts the siting of hazardous waste facilities in areas of seismic activity or floodplains.	Pertains to any site at which hazardous is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-31		Design & operation of hazardous waste facilities	ACTION	Hazardous waste facilities must be designed, constructed, maintained and operated to minimize the possibility of fire, explosion or unplanned release of hazardous waste or hazardous constituents to the air, soil or surface water which could threaten human health or the environment.	Pertains to any site at which hazardous is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-32	A,B,C,D	Required equipment for hazardous waste facilities	ACTION	All hazardous waste facilities must be equipped with emergency equipment, such as an alarm system, fire control equipment and a telephone or radio.	Pertains to any site at which hazardous is to be treated, stored or disposed of (or has been disposed of). Specifications
HW		3745-54-33		Testing & maintenance of equipment; hazardous waste facilities	ACTION	All hazardous waste facilities must test and maintain emergency equipment to assure proper operation.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-34		Access to communications or alarm system; hazardous waste facilities	ACTION	Whenever hazardous waste is being handled, all personnel involved shall have immediate access to an internal alarm or emergency communication device.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-37	A,B	Arrangements/ agreements with local authorities	ACTION	Arrangements or agreements with local authorities, such as police, fire department and emergency response teams must be made. If local authorities will not cooperate, documentation of that non-cooperation should be provided.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-52	A-F	Content of contingency plan; hazardous waste facilities	ACTION	Hazardous waste facilities must have a contingency plan that addresses any unplanned release of hazardous wastes or hazardous constituents into the air, soil or surface water. This rule establishes the minimum required information of such a plan.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-53	A,B	Copies of contingency plan; hazardous waste facilities	ACTION	Copies of the contingency plan required by 3745-54-50 must be maintained at the facility and submitted to all local police departments, fire departments, hospitals local emergency response teams and the Ohio EPA.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of)
HW		3745-54-54	A	Amendment of contingency plan; hazardous waste facilities	ACTION	The contingency plan must be amended if it fails in an emergency, the facility changes (in its design, construction, maintenance or operation), the list of emergency coordinators change or the list of emergency equipment.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-55		Emergency coordinator; hazardous waste facilities	ACTION	At all times there should be at least one employee either on the premises or on call to coordinate all emergency response measures.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-56	A-I	Emergency procedures; hazardous waste facilities	ACTION	Specifies the procedures to be followed in the event of an emergency.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been disposed of).
HW		3745-54-73	A,B	Operating record	ACTION	Specifies records to be kept at TSD facilities	Consider for sites with on-site treatment, storage or disposal
HW		3745-54-77	A	Additional reports	ACTION	Requires facilities to report fires, explosions or other mishaps	Consider at sites with treatment, storage or disposal on-site

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CATEGORY	ORC	OAC	PARAGRAPH	CAPTION	TYPE (Location/ Chemical/ Action-Specific)	TEXT	POTENTIAL APPLICATION
HW		3745-55-11	A,B,C	General closure performance standard; hazardous waste facility	ACTION	Requires that all hazardous waste facilities be closed in a manner that minimizes the need for further maintenance, controls, minimizes, eliminates or prevents post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off or hazardous waste decomposition products to the ground or surface water or the atmosphere.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been treated, stored or disposed of).
HW		3745-55-12	B	Content of closure plan; hazardous waste facilities	ACTION	Specifies the minimum information required in a closure plan for Ohio EPA to determine the adequacy of the plan.	Substantive requirements pertain to any site at which hazardous waste is to be treated, stored or disposed of (or has been treated, stored or disposed of).
HW		3745-55-14		Disposal/ decon of equipment, structures & soils	ACTION	Requires that all contaminated equipment, structures and soils be properly disposed of or decontaminated. Removal of hazardous wastes or constituents from a unit may constitute generation of hazardous wastes.	Pertains to any site at which hazardous waste is to be treated, stored or disposed of (or has been treated, stored or disposed of).
HW		3745-55-17	B	Post-closure care and use of property	ACTION	Specifies the post-closure care requirements, including maintenance, monitoring and post-closure use of property.	Pertains to all sites with land-based hazardous waste units (landfills and surface impoundments, waste piles, land treatment units and tanks that meet requirements of landfills after closure). This includes existing land-based areas of contamination.
HW		3745-55-18	B	Post-closure plan	ACTION	Presents the information necessary for Ohio EPA to determine the adequacy of a post-closure plan.	Pertains to all sites with land-based hazardous waste units (landfills and surface impoundments, waste piles, land treatment units and tanks that meet requirements of landfills after closure). This includes existing land-based areas of contamination.
HW		3745-55-19	B	Notice to local land authority	ACTION	Requires that a record of the type, location and quantity of hazardous wastes disposed of in each unit be submitted to the local land authority and the director of the Ohio EPA. Also requires that a notation to the deed to the facility property be made indicating that the land was used to manage hazardous wastes and that certain use restrictions may apply to the property.	Pertains to all sites with land-based hazardous waste units (landfills and surface impoundments, waste piles, land treatment units and tanks that meet requirements of landfills after closure). This includes existing land-based areas of contamination.
HW		3745-55-91	A,B,D	Assessment of existing tank systems integrity	ACTION	Requires that each existing tank used to store or treat hazardous waste that does not have secondary containment be tested to assure tank integrity.	Pertains to any site which has existing hazardous waste treatment or storage tanks that lack secondary containment.
HW		3745-55-92	A-G	Design & installation of new tank systems or components	ACTION	Requires a secondary containment system for tanks and assessment to determine tank integrity.	Pertains to any site at which hazardous waste will be either stored or treated in tanks.
HW		3745-55-93	A-G,I	Containment and detection of releases for tank systems	ACTION	Requires secondary containment and leak detection systems for tanks.	Pertains to any site at which hazardous waste will be either stored or treated in tanks.
HW		3745-55-94	A,B,C	General operating requirements for tank systems	ACTION	Specifies general operating requirements for tank systems.	Pertains to any site at which hazardous waste will be either stored or treated in tanks.
HW		3745-55-95	A-D	Inspections of tank systems	ACTION	Requires inspections at least once each operating day.	Pertains to any site at which hazardous waste will be either stored or treated in tanks.
HW		3745-55-96	A,B,C,E	Response to leaks or spills of tank systems	ACTION	Requires that unfit tanks be removed from use and further releases be prevented.	Pertains to any site at which hazardous waste will be either stored or treated in tanks.
HW		3745-55-97	A,B	Closure and post-closure care for tank systems	ACTION	Specifies closure and post-closure requirements for tank systems.	Pertains to any site at which hazardous waste will be either stored or treated in tanks. Specifies the minimum information required.
HW		3745-57-03	A-I	Landfill design and operating requirements	ACTION	Presents design and operating requirements for landfills. Includes liner, leachate collection and removal, run-on/run-off control, etc.	Pertains to all sites at which a hazardous waste landfill will either be located or an existing landfill will be expanded. This rule also pertains to existing land-based areas of contamination.
HW		3745-57-05	A,B	Monitoring and inspections of landfills	ACTION	Requires inspection of landfills during construction or installation and operation.	Pertains to all sites at which a hazardous waste landfill will either be located or an existing landfill will be expanded. This rule pertains to existing land-based areas of contamination.
HW		3745-57-09		Surveying and record keeping	ACTION	Establishes requirements for surveying and recording locations and contents of cells	Pertains to all sites at which a hazardous waste landfill will either be located or an existing landfill will be expanded. This rule also pertains to existing land-based areas of contamination.

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HW		3745-57-10	A,B	Landfill closure and post-closure care	ACTION	Specifies closure and post-closure requirements for hazardous waste landfills. Includes final cover and maintenance.	Pertains to all sites at which a hazardous waste landfill will either be located or an existing landfill will be expanded. This rule pertains to existing land-based areas of contamination.
HW		3745-57-74	A-K	Staging piles	ACTION	Design requirements for temporary waste staging piles	Pertains to remedial site where waste will be temporarily stored in piles
HW		3745-66-11	A,B,C	Closure performance standard	ACTION	Owner shall close facility in manner that minimizes need for further maintenance and reduces or eliminates pollution of ground water, surface water or atmosphere.	Consider for remedial plans that may require extended operation and maintenance of equipment. Consider alternatives with less long-term o&m. Applicable for rcra facilities, appropriate and relevant for other sites.
DW		3745-81-11	A,B,C	Maximum contaminant levels for inorganic chemicals	CHEMICAL	Presents maximum contaminant levels for inorganics.	Pertains to any site which has contaminated ground or surface water that is either being used, or has the potential for use, as a drinking water source.
DW		3745-81-12	A,B,C	Maximum contaminant levels for organic chemicals	CHEMICAL	Presents MCLs for organics.	Pertains to any site which has contaminated ground or surface water that is either being used, or has the potential for use, as a drinking water source.
GW		3745-9-03	A-C	Monitoring well	ACTION	Standards for design and closure of wells, compliance with DDAGW guidance	Pertains to all ground water wells on the site that either will be installed or have been installed since Feb. 15, 1975. Would pertain during the FS if new wells are constructed for treatability studies.
GW		3745-9-05	A1,B-H	Well construction	ACTION	Specifies minimum construction requirements for new ground water wells in regards to casing material, casing depth, potable water, annular spaces, use of drive shoe, openings to allow water entry, contaminant entry.	Pertains to all ground water wells on the site that either will be installed or have been installed since Feb. 15, 1975. Would pertain during the FS if new wells are constructed for treatability studies.
GW		3745-9-07	A-C	Well grouting for construction of closure	ACTION	Establishes specific grouting procedures	Pertains to all ground water wells on the site that either will be installed or have been installed since Feb. 15, 1975. Would pertain during the fs if new wells are constructed for treatability studies.
GW		3745-9-10	A,B,C	Abandoned well sealing	ACTION	Procedures for closing and sealing wells.	Pertains to all ground water wells on the site that either will be installed or have been installed since Feb. 15, 1975.

Notes:

ARAR	Applicable or Relevant and Appropriate Requirements	APC	Air Pollution Control	HAZ	Hazardous
ODNR	Ohio Department of Natural Resources	UIC	Underground Injection Control	PRGRPH	Paragraph
GW	Groundwater	DERR	Division of Environmental Response and Revitalization	O&M	Operation and Maintenance
DW	Drinking Water	OAC	Ohio Administrative Code	Ohio EPA	Ohio Environmental Protection Agency
DSW	Division of Surface Water	ORC	Ohio Revised Code	Chem	Chemical
Loc	Location	POTW	Publicly-Owned Treatment Works	TSD	Treatment, Storage or Disposal
Act	Action	ESA	Endangered Species Act	U.S. DOT	United States Department of Transportation
Fac	Facility	FCA	Flood Control Act	U.S.C.	United States Code
CFR	Code of Federal Regulations	ORC	Ohio Revised Code	VOC	Volatile Organic Compound
CWA	Clean Water Act	RCRA	Resource Conservation and Recovery Act	EPA	Environmental Protection Agency
HW	Hazardous Waste	U.S.C.	United States Code		