REMEDIAL ALTERNATIVES ANALYSIS REPORT
(PART 1)
FORMER YORK NAVAL ORDNANCE PLANT
1425 EDEN ROAD
YORK, PA 17402

Prepared for:

Harley-Davidson Motor Company
Operations, Inc.
York, PA

December 2014

Prepared by:

Groundwater Sciences Corporation

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Respectfully submitted,

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LIST OF ACRONYMS AND ABBREVIATIONS

11DCA	1,1-dichloroethane
11DCE	1,1-dichloroethene
Act 2	Land Recycling and Environment Remediation Standards Act, Act 2 of 1995, 35 P.S. § 6026.101
AMF	American Machine & Foundry Company
AMO	AMO Environmental Decisions, Inc.
AOC	area of concern
ARAR	Applicable or Relevant and Appropriate Requirements
BADCT	Best Available Demonstrated Control Technology
bgs	below ground surface
BPA	Burn Pile Area
BSRA	Bunker and Shell Range Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis12DCE	cis-1,2-dichloroethene
COC	constituents of concern
CPA	Central Plant Area
CVOC	chlorinated volatile organic compounds
DNAPL	dense non-aqueous phase liquid
DOT	Department of Transportation
EI	Environmental Indicators
ERH	Electrical Resistance Heating
fYNOP	former York Naval Ordnance Plant
GRA	General Response Actions
GSC	Groundwater Sciences Corporation
GWTS	groundwater extraction and treatment system

Harley-Davidson	Harley-Davidson Motor Company Operations, Inc.
ISTD	In-Situ Thermal Desorption
IWTP	industrial wastewater treatment plant
Langan	Langan Engineering and Environmental Services, Inc.
MCL	Maximum Contaminant Levels
MEC	Munitions and Explosives of Concern
MIP	Membrane Interface Probe
mm	millimeter
MNA	Monitored Natural Attenuation
MOA	Memorandum of Agreement
MSC	Medium Specific Concentration
MTBE	methyl tertiary-butyl ether
MW	monitoring well
NBldg2	North Building 2
NBldg4	North Building 4
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NETT	North End Test Track
NIR	Notice of Intent to Remediate
NPA	North Plant Area
NPBA	Northeast Property Boundary Area
NPDES	National Pollutant Discharge Elimination System
OE	ordnance and explosives
PADEP	Pennsylvania Department of Environmental Protection
PADER	Pennsylvania Department of Environmental Resources

PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
RA	Risk Assessment
RAA	Remedial Alternative Analysis
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
REWAI	R.E. Wright Associates, Inc.
RFA	RCRA Facility Assessment
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RSL	Regional Screening Level
SAIC	Science Applications International Corporation
SDWA	Safe Drinking Water Act
SPBA	Southeast Property Boundary Area
SPA	South Plume Area
SRI	Supplemental Remedial Investigation
SSS	Site-Specific Standard
SWMU	Solid Waste Management Unit
TBC	To Be Considereds
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TGM	Technical Guidance Manual
UECA	Uniform Environmental Covenants Act
USACE	United States Army Corps of Engineers

USEPA	United States Environmental Protection Agency
UST	underground storage tank
VC	vinyl chloride
VOCs	volatile organic compounds
WPA	Western Property Area
WPL	West Parking Lot
YCIDA	York County Industrial Development Authority
YNOP	York Naval Ordnance Plant

EXECUTIVE SUMMARY

This Remedial Alternatives Analysis Report (Part 1) (RAA Report) presents the findings of initial feasibility study process steps completed as part of an analysis of potential remedial alternatives at the former York Naval Ordnance Plant (fYNOP) located at 1425-1445 Eden Road, Springettsbury Township, York, Pennsylvania (Site). This report was prepared on behalf of Harley-Davidson Motor Company Operations, Inc. (Harley-Davidson) with review by fYNOP project team members from the United States Army Corps of Engineers (USACE).

This RAA Part 1 consists of the first step in risk management decision-making to support selection of a remedy that eliminates, reduces, or controls risks to human health and the environment associated with historical releases of Site constituents of concern (COCs), and includes the portion of the feasibility study process up to, and including development of candidate remedial alternatives. The information contained in this RAA Report Part 1 is intended to help focus subsequent screening of candidate remedial alternatives and selection of remedial alternatives for each of the remedial action areas that will be combined to form a final remedy for the fYNOP Site.

Applicable or relevant and appropriate requirements (ARAR) and To Be Considered guidances (TBCs) were identified and listed. ARARs and TBCs were subdivided as chemical-specific, location-specific, and action-specific.

Preliminary Remedial Action Objectives (RAOs) were developed for the Site, and listed, as follows:

1. Prevent exposure of human receptors to soil beneath existing building slabs and paved areas if, following removal of these capping measures, the concentrations of COCs in those soils would result in recalculated risk or hazard levels exceeding the Act 2 statutory limits of excess cancer risk equals 10E-4 and hazard index equals 1.0.

2. Prevent exposure of human receptors to vapor intrusion into structures if the concentrations of COCs in those vapors would result in risk or hazard levels exceeding the Act 2 statutory limits of excess cancer risk equals 10E-4 and hazard index equals 1.0.

3. Prevent ingestion by human receptors of groundwater having concentrations of COCs exceeding the applicable Pennsylvania Drinking Water Standards.

4. Reduce mass flux of COCs from the source areas beneath the fYNOP property to levels that will permit ambient water quality criteria for surface water to be met in Codorus Creek.

5. Remove or apply best practices to in-place closure of unpermitted, pre-1980 solid waste disposal areas on the fYNOP property.

The fYNOP site was subdivided in six preliminary remedial action areas, based on the findings of previous soil and groundwater investigations, and on having similar characteristics pertinent to development and screening of remedial alternatives. The preliminary remedial action areas are listed below:

1. Northeast Property Boundary Area (NPBA) – consisting of the perimeter road area, and offsite residential area to the north.
2. Eastern Area – consisting of the eastern perimeter road area, the former cyanide spill area, and the landfill area.
3. Southeast Property Boundary Area (SPBA) and South Plume Area (SPA) – including the southeast perimeter road, the sanitary sewer area, the drum storage area, and the groundwater plume to the south of the Site.
4. Bunker and Shell Range Area (BSRA) – primarily consisting of the Building 14 firing range, former Building 16 backstop/butts and the former spent 37-mm shell disposal areas.
5. North End Test Track (NETT) – an area of former waste disposal, handling and storage.
6. Western Property Area (WPA) – consisting of the former area of industrial plant operations and the downgradient areas to the west, including the North Plant Area (NPA), the Central Plant Area (CPA), the West Parking Lot (WPL) and the Codorus Creek/Levee Area.

General Response Actions (GRAs) consisting of broad categories of remedial technologies were identified to achieve proposed RAOs for groundwater, surface water, soil and bedrock sources. Remedial technologies applicable to the GRAs were identified based on a review of literature, vendor information, performance data, and GSC experience in developing candidate remedial alternatives under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Act 2. GRAs, remedial technology types, and process options were initially screened regarding their potential application to Site contaminants and Site conditions with respect to effectiveness, implementability and cost.

Possible remedial alternatives were developed using retained candidate technologies for each of the six remedial action areas.

The last section of this report describes the recommended scope of the RAA Part 2 to be performed after the completion of additional groundwater SRI activities and performance of a groundwater risk assessment. The recommendations include preliminary screening to reduce the number of alternatives chosen for detailed analysis, a detailed analysis of retained alternatives against the Act 2 and National Contingency Plan (NCP) criteria, followed by a comparative analysis of alternatives.

1 INTRODUCTION

This Remedial Alternatives Analysis Report (Part 1) (RAA Report) presents the findings of initial feasibility study process steps completed as part of an analysis of potential remedial alternatives at the former York Naval Ordnance Plant (fYNOP) located at 1425-1445 Eden Road, Springettsbury Township, York, Pennsylvania (Site). A portion of the fYNOP Site is currently occupied by the Harley-Davidson Motor Company Operations, Inc. (Harley-Davidson) facility. Fifty-eight of the 230 acres have been transferred to the York County Industrial Development Authority (YCIDA). YCIDA plans to redevelop the property. A Site location map is provided on **Figure 1.0-1**. This Site-wide remedial alternatives analysis is directed by an agreement between Harley-Davidson and the United States Government, under which the Site is being investigated and remediated. This report has been prepared by Groundwater Sciences Corporation (GSC) on behalf of Harley-Davidson with review by fYNOP project team members from the United States Army Corps of Engineers (USACE). Project coordination was performed by AMO Environmental Decisions, Inc. (AMO). Official public information about the facility can be found at the public web-link, http://yorksiteremedy.com.

The fYNOP is enrolled in the One Cleanup Program, and as a result the United States Environmental Protection Agency (USEPA) and the Pennsylvania Department of Environmental Protection (PADEP) are working together on the cleanup. The remedial approach taken by the responsible parties is to follow the requirements of the Pennsylvania Land Recycling and Environmental Remediation Standards Act (Act 2), with the added component of being substantially compliant with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), as defined in 40 CFR Parts 9 and 300 (USEPA, 1994).

- Section 304 (j) of Act 2: Remedy Evaluation lists six evaluation criteria that must be considered in selecting a remedy under Act 2. Five of these six criteria are virtually identical to criteria included in the NCP. The sixth criterion not included in the NCP is a cost/benefit analysis. The Act 2 regulations published in 25 Pa. Code Chapter 250 and guidance published in the Technical Guidance Manual (TGM) provide no further direction on performing a remedial alternatives analysis.

- Section 410(a) of Act 2: A cleanup plan is required to be submitted to the Department for approval when the site-specific standard is selected as the remediation goal. The cleanup plan shall evaluate the relative abilities of the alternative remedies to achieve the site-specific standard and propose a remedial measure which shall achieve the standard established according to the procedures contained in this subchapter. The person submitting the plan shall evaluate additional alternative remedies that have been requested for evaluation by the Department in accordance with the act.

The feasibility study process steps followed in this RAA are those described in the NCP and USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Interim Final (USEPA, 1988) (RI/FS Guidance), as well as the plain meaning of the Act 2 criteria. Therefore, the evaluation criteria include the following:

- Overall Protection of Human Health and the Environment (NCP)
- Compliance with ARARs (NCP)
- Long Term Effectiveness and Permanence (Act 2 and NCP)
- Reduction of Toxicity, Mobility, or Volume of Contamination through Treatment (Act 2 and NCP)
- Short Term Impacts and Effectiveness (Act 2 and NCP)
- Implementability (Act 2 and NCP)
- Cost (Act 2 and NCP)
- Health and Economic Cost/Benefit (Act 2)

The NCP has a ninth criterion called State and Community Acceptance, which Act 2 does not include. Under the One Site program, the fYNOP team is striving to follow the Act 2 guidance to the extent practicable, and therefore, State and Community Acceptance is not included as an evaluation criteria.

The RAA Part 1 consists of the first step in risk management decision-making to support selection of a remedy that eliminates, reduces, or controls risks to human health and the environment associated with historical releases of Site constituents of concern (COCs).

The scope of the RAA Part 1 includes the portion of the feasibility study process up to, and including, development of candidate remedial alternatives. Specific elements of the feasibility study process that were completed for this RAA Part 1 include:

- Identification of Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considereds (TBCs) for cleanup response and remedial actions;
- Development of preliminary Remedial Action Objectives (RAOs);
- Identification of General Response Actions;
- Development of preliminary remedial action areas based on results of previous Site investigation and remediation activities;
- Identification and screening of candidate remedial technologies with potential applicability to Site conditions and COCs; and
- Development of candidate remedial alternatives for each of the preliminary remedial action areas.

The RAOs are deemed to be preliminary as they have been developed prior to completion of additional groundwater Site characterization (Groundwater Remedial Investigation Part 2) activities and performance of a Site-Specific human health and ecological risk assessment for groundwater (Groundwater Risk Assessment [RA]).

1.1 Purpose of Remedial Alternatives Analysis Part 1

The purpose of the RAA Part 1 is to evaluate remedial technologies and develop remedial alternatives that have the potential to minimize the potential risks posed to human health and the environment by Site COCs. The information contained in this RAA Report Part 1 is intended to help focus subsequent screening of candidate remedial alternatives and selection of remedial alternatives for each of the remedial action areas that will be combined to form a final remedy for the fYNOP Site. It is intended that the RAA will consider remedial alternatives in the context of a Site-wide solution, although certain soil impacts may be addressed individually.

1.2 Regulatory Framework

Harley-Davidson began remedial environmental investigations at the Site in 1984. Initially, work was reported to and reviewed by the Pennsylvania Department of Environmental Resources (PADER), Waste Management Division. In 1989, USEPA performed a RCRA Facility Assessment (RFA) of the facility. As a result of this assessment, 73 Solid Waste Management Units (SWMUs) were identified, needing further investigation. These SWMUs were a combination of major areas of concern (AOCs) discussed in hydrogeologic reports and former and existing manufacturing facilities and processes. The locations of these SWMUs are shown on **Figure 1.2-1** as blue squares, which in some cases overlap where processes, like tanks, are closely spaced. This figure also points out the location and describes 31 AOCs that may have contributed to observed contamination in groundwater at the Site.

Harley-Davidson, as the current owner, and the United States (represented by USACE), as a prior owner, established a cost sharing arrangement for costs incurred in response to environmental contamination at the facility. A Trust Fund was established to handle the cost sharing of those response actions. The agreement provided that Harley-Davidson would manage the project at the York facility, and that the project would be carried out in substantial compliance with the NCP as defined by 40 CFR §300.700.

On May 20, 2002, fYNOP initially committed to USEPA's "Facility Lead Program" under the RCRA Corrective Action Program in response to USEPA's invitation to participate. That commitment was subsequently replaced when fYNOP entered into the One Cleanup Program established by the USEPA Region III and the PADEP, pursuant to a Memorandum of Agreement (MOA) dated April 24, 2004.

The One Cleanup program initiative began on February 7, 2005, when fYNOP submitted a Notice of Intent to Remediate (NIR) to a site-specific standard to PADEP under the PADEP's Land Recycling Program established by the Land Recycling and Environmental Remediation Standards

Act, Act 2 of 1995, 35 P.S. § 6026.101 (Act 2). Public notice of the NIR under Act 2 was published in the *Pennsylvania Bulletin* on March 19, 2005. Participation in the program was acknowledged by letters dated July 15, 2005, and September 28, 2005, from James J. Burke of USEPA and Eugene A. DePasquale of PADEP to Sharon R. Fisher of Harley-Davidson. USEPA and PADEP also acknowledged the cost-sharing agreement between Harley-Davidson and the United States, and recognized that site assessment and remediation under the One Cleanup Program would be substantially consistent with the NCP although conducted within the Act 2 framework.

In September of 2005, USEPA completed a letter called Documentation of Environmental Indicator Determination. The findings of that letter indicated the following:

> "Based on a review of the information contained in this EI Determination, 'Current Human Exposures' are expected to be 'Under Control' at the Harley-Davidson Motor Company facility, USEPA ID # PAD 001 643 619, located at 1425 Eden Road, York, Pennsylvania under current and reasonably expected conditions. This determination will be re-evaluated when the Agency/State becomes aware of significant changes at the facility."

In August of 2014, USEPA reevaluated the RCRA Corrective Action Environmental Indicators (EI) for the fYNOP Site, and changed the 'Current Human Exposures' to "IN – More information is needed to make a determination". The "Documentation of Environmental Indicator Determination" form signed by Griff Miller and Paul Gotthold from EPA Region 3 was transmitted to the fYNOP Team by email on 8/27/14.

1.3 Background

This section provides a brief summary of the findings of remedial investigations of soil and groundwater pertinent to this RAA. Specifically, the following subsections summarize the Site setting and history, physical characteristics, previous investigations and remediation, nature and extent of contamination, and contaminant fate and transport.

1.3.1 Site Setting and History

The fYNOP consists of an active motorcycle manufacturing facility, owned by Harley-Davidson, and situated on approximately 172 of the original 230 acres, and the remainder is a mostly vacant industrial site, currently owned by YCIDA. In 2012, fifty-eight acres of the western portion of the property were transferred to the YCIDA, which is actively seeking developers. As shown on **Figure 1.3-1**, the facility is bordered on the south by Route 30 and industrial/commercial properties; on the west by 84 Lumber, a railroad line, uninhabited wetland/wooded areas, the Codorus Creek levee, and northward flowing Codorus Creek; and on the southeast, east and north by residential properties. The West Parking Lot (WPL), Central Plant Area (CPA), and numerous other Site features are called out on this figure. The northeastern and eastern third of the site is undeveloped woodlands. The south-central area is occupied by the main Harley-Davidson manufacturing facility. The western third of the property is the location of former manufacturing buildings, with all but one building removed (the building slabs and parking areas have been left in place).

The Site was initially developed in 1941 by the York Safe and Lock Company, a United States Navy contractor, for the manufacture, assembly, and testing of 40 millimeter (mm) twin and quadruple gun mounts, complete with guns. In 1944, the Navy took ownership of the fYNOP site and possession of the York Safe and Lock Company facility. The Navy owned and operated the facility as the York Naval Ordnance Plant (YNOP) until 1964, switching operations after World War II to overhaul war service weapons and to manufacture rocket launchers, 3-inch/50-caliber guns, 20-mm aircraft guns, and power drive units for 5-inch/54-caliber guns. In 1964, the Navy sold the YNOP to American Machine & Foundry Company (AMF), who continued similar manufacturing. In 1969, AMF merged with Harley-Davidson. In 1973, Harley-Davidson moved its motorcycle assembly operations to the AMF York facility. In 1981, AMF sold the York facility to Harley-Davidson. Harley-Davidson has continued motorcycle assembly operations at the York facility since 1981.

1.3.2 Physical Characteristics

The Site is located in central York County, north of the City of York, PA (**Figure 1.0-1**). This area is drained by the Codorus Creek, a tributary to the Susquehanna River with a 237 square mile drainage area above the point where it enters the Site. Hills rim the fYNOP Site on the north and east, forming somewhat of a bowl-like configuration. The eastern one third of the Site is fairly steeply sloping to the west (4 to 20%), forming an upland area to the east of the flat-lying CPA. From the base of the hills to the Codorus Creek, the land surface underlying the CPA slopes very gently (0.5%) to the west.

The surface of the Site is immediately underlain by either fill (associated with site industrial and roadway construction), residual soil produced from the weathering of the underlying bedrock, or alluvium. From R.E. Wright Associates, Inc. (REWAI, 1986) natural residual soils are comprised of sandy silt, clayey silts, and silt loam deposits from four primary soil series (Duffield, Glenelg, Elk and Chester). These soil series are derived primarily from parent bedrock formations consisting of quartzitic sandstone and limestone.

Two geologic rock types underlie the Site. Solution-prone (karst) gray carbonate bedrock (limestone and dolostone) underlies the flat lowland (western) portion of the Site. Quartzitic sandstone underlies the more steeply sloping hills and upland area on the eastern part of the Site. The limestone is a karstic carbonate aquifer with groundwater migrating through solution-enhanced discontinuities and overlying unconsolidated materials. The quartzitic sandstone is a much less permeable aquifer; with minimal primary porosity, groundwater flows through tight bedding plane partings, joints and fractures, which are not solution-enhanced as they are in the carbonate bedrock. Groundwater flow is generally westward, from the upland area at the eastern part of the Site toward Codorus Creek; however, localized groundwater flow is also controlled by an active groundwater extraction and treatment system on-Site, that otherwise intercepts groundwater flow to Codorus Creek.

1.3.3 Previous Investigations and Remediation

Numerous environmental investigations and remedial efforts have been conducted at the Site. Starting in 1984, Harley-Davidson began an investigation of potential environmental impacts in the eastern portion of the facility (Gettysburg Electronics, 1984). Groundwater investigations beginning in 1986 revealed the presence of volatile organic compounds (VOCs) in groundwater directly under the Site. The interim remedy for addressing the VOCs in groundwater included groundwater capture via extraction wells and treatment of the groundwater using air stripping in association with thermal treatment or carbon adsorption to control off-gasses, followed by on-Site discharge of the treated groundwater back into an unnamed tributary of Codorus Creek, locally called Johnsons Run. The groundwater extraction and treatment system (GWTS) was constructed in 1990 and has continued operations to date. The status of the GWTS is reported to the PADEP and USEPA via annual reports. The discharge point for treated groundwater was moved from Johnsons Run to the Codorus Creek after National Pollutant Discharge Elimination System (NPDES) renewal permitting in 2007. The current location of the discharge point is shown on **Figure 1.3-1**.

Various soil remedial efforts have also been conducted on-Site and are specified in the Soils Remedial Investigation (RI) report (Science Applications International Corporation [SAIC], 2009), as well as in several other follow-on interim remedial actions/reports. References to soil remediation efforts are also included in a discussion of preliminary remedial action areas provided in Section 2.3 of this report.

In 1998, a Site-wide RI was initiated. The results of that study—including more detailed summaries of soil, groundwater, sediment, and surface water sampling—are provided in a draft report entitled “Interim Site-wide Remedial Investigation Report, Harley-Davidson Motor Company, York, Pennsylvania Facility” (Langan Engineering and Environmental Services, Inc. [Langan], 2002). The purpose of the RI work was to characterize the Site for the development of appropriate remedial measures. This was facilitated through the investigation of potential source areas, further development of the conceptual model, and evaluation of migration and exposure pathways. The report resulted in the need to prepare a comprehensive document that compiled the remedial site activities completed and developed a scope of work to address data gaps. The fYNOP team (Harley-Davidson, USACE, and consultants AMO and SAIC) addressed that need with the Field Sampling Plan for Supplemental Remedial Investigations (SRI) (SAIC, 2006).

Two soil vapor intrusion studies were conducted for fYNOP by Langan in 2005 and 2007. Langan stated that the results of the soil vapor model using conservative assumptions and Site-specific characteristics indicate that the vapor pathway due to volatilization and migration of constituents in groundwater is not complete. The reports of those investigations conclude there is no apparent on-

Site or off-Site risk to human health via the vapor intrusion pathway associated with the property. In addition, an off-Site soil vapor intrusion investigation was performed. The off-Site investigation was outlined in a letter to the USEPA dated June 29, 2007. All soil-vapor results were below the PADEP soil gas screening criteria, which reaffirms that there is no off-Site human health risk via the vapor intrusion pathway associated with the Harley-Davidson property in this area. This potential pathway will be included and addressed as part of the Groundwater Risk Assessment.

In December 2009, Harley-Davidson submitted to both agencies a report entitled Draft Supplemental Remedial Investigations Soils Report (SAIC, 2009). The report was accepted and approved by EPA and PADEP as final and complete under the One Clean-up Program, as recorded in a letter from both agencies to Ms. Sharon Fisher of Harley-Davidson dated March 17, 2010. Areas of soil exceedances of PADEP Medium Specific Concentrations (MSCs) for direct contact (nonresidential) and soil to groundwater (residential used aquifers) were delineated. Subsequently, numerous areas were remediated by the following actions:

- Bldg 67 and Metal Chip Bin area removal/closure;
- UST Tank 009 removal and release characterization;
- Building 51 Hazardous waste storage facility demo and closure;
- Former industrial wastewater conveyance line cleaning/abandonment;
- Former Bldg 41/WWTP demo/removal;
- Former vapor degreaser pit removals in Bldg 4;
- Closure of former Electrical Transformer Areas;
- Source characterization activities of the former W Bldg 2 Corridor and Bldg 58 Areas.

In September 2011, a report entitled Supplemental Remedial Investigation Groundwater Report Part 1 (hereinafter referred to as “the Groundwater SRI Report”) was completed (GSC, September 2011). This report summarized environmental investigations completed on-Site from 1984 through 2006, and developed conclusions regarding Site groundwater conditions based on analysis of the entire body of information and data collected from 1984 to 2010. The report contains a description of the site specific geology, hydrogeology, nature and extent of COCs and the fate and transport of the COCs in the aquifer. Also included are an exposure pathway assessment and recommendations for further investigation to close data gaps.

1.3.4 Nature and Extent of Contamination

Soil remedial investigations at the Site have indicated that COCs in soil include metals (antimony, arsenic, cadmium, copper, hexavalent chromium, lead, mercury, nickel, selenium, silver, thallium, and zinc); VOCs; polycyclic aromatic hydrocarbons (PAHs); polychlorinated biphenyls (PCBs); and total and free cyanide. These regulated substances appear to be restricted to specific source locations, several of which have already been subjected to remedial actions.

Groundwater remedial investigations and activities at the Site have indicated that the primary COCs due to concentration, detection frequency, and potential for off-Site migration are chlorinated solvents, including tetrachloroethene (PCE), trichloroethene (TCE), and 1,1,1-trichloroethane (TCA), and degradation products of these VOCs. Less frequent detections of hexavalent chromium, lead, benzene, ethylbenzene, methyl tertiary-butyl ether (MTBE), 1,4-dioxane, and cyanide have also been detected in groundwater samples from Site monitoring wells. The distribution of these constituents in groundwater suggests that they have originated from multiple sources.

1.3.5 Contaminant Fate and Transport

The aquifers underlying the Site are composed of fractured quartzitic sandstone and karstified carbonate rock. The karstified carbonate rock, which underlies the CPA, NPA, and WPL portions of the Site is well connected as a result of high fracture permeability and well distributed and interconnected solution channels. Chlorinated volatile organic compounds (CVOCs) were introduced to the ground surface in the form of dense nonaqueous-phase liquid (DNAPL) through spills, leaks, and on-site disposal from the 1940s into the 1980s and are pervasive throughout the Site at concentrations that exceed PADEP groundwater and soil-to-groundwater MSCs. At the fYNOP Site, the factors affecting the transport of a DNAPL release are highly dependent on the geologic characteristics at the location of the release (**Figures 1.3-2** and **1.3-3**). In the karst aquifer, DNAPL is directed along the pinnacled bedrock surface through vertical and lateral solution channels that are open (filled with water) or filled with water-saturated residuum and sediment (sand, silt, clay, gravels and rock fragments). The solution channels have appeared to allow deep (as deep as 200 feet or more below ground surface [bgs]) vertical migration of DNAPL into the aquifer. In addition to the numerous CVOCs, 1,4-dioxane, benzene, MTBE, chromium and cyanide occur above PADEP MSCs, but have limited distribution in the groundwater on site.

In the aquifer, some of the DNAPL slowly dissolved in the groundwater, undergoing a number of processes. Dissolved (aqueous) phase chlorinated solvents migrated through the aquifer transported by groundwater flow and generated plumes of dissolved CVOCs extending from each source area to a point of discharge to surface water or, currently, to an extraction well. Prior to operation of the pump and treat system, groundwater in the CPA/NPA/WPL migrated generally westward toward the Codorus Creek through residuum and solution-enhanced pathways in the carbonate bedrock.

The aqueous phase chemicals diffused into the rock matrix, and adsorbed onto organic carbon or mineral surfaces. In the aqueous phase, anaerobic bacteria break down PCE and TCE to cis-1,2-dichloroethene (cis12DCE) and vinyl chloride (VC) and the TCA to 1,1-dichloroethane (11DCA) and chloroethane. TCA also abiotically transforms to 1,1-dichloroethene (11DCE).

DNAPL has likely been present in the fYNOP aquifer for 60 or more years, since vapor degreasing operations began prior to 1948 (Key Reporters, 1991). During that time, the various processes described above, enhanced by interim remedial actions, have resulted in the reduction of the DNAPL mass (**Figure 1.3-4**). Even so, a number of areas remain as probable DNAPL sources. In addition, diffusion and sorption processes have stored CVOC mass in the aquifer, which is released slowly, resulting in a tailing effect for CVOC concentrations in groundwater. Primary source areas are the Building 58-66 Area, the North Building 2 (NBldg2) Corridor, the North Building 4 (NBldg4) Area, the northwest corner of the WPL, and the southwest corner of the WPL. In these areas, concentrations of CVOCs extend to depths of hundreds of feet.

1.4 Interim Remediation Progress

Results of an evaluation of the performance of an interim groundwater extraction system operational on Site since the 1990s are included in the Groundwater SRI report. The system appears to effectively prevent off-Site migration of groundwater from all areas of the Site except the South Property Boundary Area (SPBA) where studies indicate no human receptors are impacted. The performance evaluation is caveated by the potential that the vertical extent of CVOCs and the vertical extent of karst solution channels in the carbonate aquifer may be deeper than currently delineated, and is the subject of an ongoing investigation (SRI Groundwater, Part 2). Over 41,000 pounds of CVOCS have been removed by the groundwater extraction system (SAIC, 2013). The average rate of removal over the last 5 years is approximately 1,500 pounds per year.

The Groundwater SRI Part 1 report demonstrates that, over the last 20 years, large reductions in COC concentrations have occurred in groundwater, with TCE, the most widely distributed CVOC, reducing in concentration by 90 to 99% in most wells. The reduction is primarily a result of removal by dissolution into the groundwater that migrates from the source or is captured and removed by the pump and treat systems, natural degradation of the chlorinated solvents by bacteria and abiotically, and by sorption onto and diffusion of the dissolved phase into the matrix of aquifer solids. Although greatly reduced, concentrations of chlorinated solvents nonetheless exceed PADEP groundwater MSCs across most of the Site. Several facts (i.e., chlorinated solvents have not been used on-Site since 1994, there has been no known release of chlorinated solvents in over 25 years, and the groundwater pump and treat systems have been operating for over 20 years) provide an indication of the persistence of the COCs in groundwater at fYNOP.

Estimates of the mass remaining in the aquifer on Site using trend analysis exceed 60,000 pounds, and may be underestimated because DNAPL residual and accumulation zones could be present. On the order of 2,000 pounds of this mass is dissolved in groundwater in storage in the aquifer at any given time. The remaining mass is adsorbed onto and diffused into the matrix of the aquifer or is in the form of suspected residual or DNAPL accumulation zones. These undissolved sources of mass are very slowly released to the groundwater passing through the Site.

1.5 Soil Risk Assessment Findings

A human health risk assessment for direct exposure of human receptors to soil from ground surface to a depth of fifteen feet bgs has been completed for the Site. This risk assessment was developed in accordance with the Site-Specific Standard option under Act 2 of 1995 (Act 2) and associated PADEP Land Recycling Program Chapter 250 regulations. Results of the soil risk assessment were submitted to the PADEP and USEPA in a report entitled “Soils Risk Assessment – Former York Naval Ordnance Plant” (Soil RA), dated March 2012, (GSC, 2012) and approved by USEPA and PADEP in letters dated July 9, 2012 and July 10, 2012, respectively.

The risk assessment of soil exposures determined that noncarcinogenic hazard indices for each receptor were below the statutory limit of 1.0. This risk assessment also yielded potential carcinogenic risks that were within or below the acceptable Act 2 carcinogenic risk range of 10E-06 to 10E-04 for all receptors. Additionally, modeled exposures to lead in soils were determined to be within USEPA's acceptable levels. These results indicate that potential exposures to soil under current and hypothetical future land use conditions, as described in the report, are within acceptable limits under Act 2. Accordingly, the site-specific standard has been attained for those COCs in soils identified in the Soil RA report.

In selecting the soil sampling results on which the Soil RA was based, the exposure pathway to contaminated soils beneath existing building slabs and existing paved areas was considered to be eliminated by the presence of these capping features, which are considered engineering controls as defined under Act 2. An Environmental Covenant has been recorded for the YCIDA portion of the Site limiting the use to nonresidential and requiring that the capping features be maintained and a soil management plan, approved by PADEP, be implemented for any earth disturbance activity. Should future land use change from the currently assumed commercial/industrial use or additional impacts to soil are discovered, a revised risk assessment and/or remediation may be necessary for the protection of human health.

1.6 Anticipated Scope of Groundwater Risk Assessment

A human health and ecological RA of groundwater exposures has been initiated. It is acknowledged that the results of the groundwater RA may change the proposed remedial alternatives. It is anticipated that this risk assessment will assume that the potential exposure pathway to groundwater as drinking water under current and hypothetical future land use considerations will be incomplete based on the application of institutional controls to eliminate the drinking water pathway to groundwater both on and off the fYNOP property. As contemplated in the SRI Groundwater Report Part 1, diffuse groundwater discharge to surface water is a potential complete exposure pathway.

A preliminary assessment of the impact of groundwater chemical flux on surface water indicates that the ambient water quality criteria for Site COCs are not exceeded in Codorus Creek. This assessment is based on observed conditions in Codorus Creek concurrent with the long-time operation of a groundwater extraction and treatment system designed to prevent continued groundwater flux to the creek from sources on the fYNOP Site.

Groundwater RI activities currently underway include an extraction well shutdown test during which the potential impact of groundwater flux to surface water is being examined in the absence of source and plume control provided by the Site's extraction well network. Following completion of that testing, a further assessment of the need for remedial action to comply with the applicable provisions of Chapters 91-96, 97 (reserved) and 102-105 may be considered in the evaluation of this exposure pathway within the scope of the Groundwater RA. In the development of remedial alternatives presented in this report, a range of alternatives is presented to allow examination of both outcomes (with and without extraction and treatment of Site groundwater) by the combinations of technologies included in the alternatives retained for detailed and comparative analyses.

1.7 Additional Groundwater SRI Activities

Additional groundwater SRI activities have been initiated at the Site. The intent of these additional studies is to further evaluate certain identified data gaps, specifically the vertical extent of CVOCs in the aquifer, the depth of karst channels in the aquifer, the effect of karst channels on groundwater flow and contaminant migration, the interaction of storm water and surface water with the karst aquifer, and the likely impact of groundwater flux on Codorus Creek in the absence of groundwater extraction and treatment to control contaminant sources and plumes.

As noted above, the Soil RA addressed potential direct contact exposures to COCs in soil to a depth of 15 feet bgs, i.e., the maximum depth to which direct contact exposures to soil must be assessed. However, under Act 2, impacts associated with leaching of COCs from soil to groundwater must be addressed throughout the soil column. For this reason, a search for the originating source areas causing groundwater hot spots in the East Building 2 and the Building 58 areas was conducted using shallow wells and Membrane Interface Probe (MIP) studies. If located, those originating source areas may have represented a significant threat to groundwater quality beneath the fYNOP property, thereby identifying targets for soil remediation that would benefit groundwater quality. No such sources were located, suggesting that the contribution of COCs in soil in this area is insignificant when compared to the impacts to groundwater from comparatively high-concentration sources in bedrock. This appears to be the pattern throughout the Site, and it is the assumption of this RAA process that the results of the final SRI, when published, will not identify soil sources of impact to groundwater that the remedial action plan for this Site will have to address. Nonetheless, the alternatives presented in this report include those that would address the soil-to-groundwater pathway, particularly in the WPL area.

The field investigation portion of this work is on-going. A groundwater SRI report providing the results of these additional investigations is currently planned to be completed by the end of 2014.

1.8 Anticipated Remedial Approach

A meeting was held between the fYNOP technical team member and representatives of the USEPA (Griff Miller, Remedial Project Manager, and Joel Hennessy, Geologist) and PADEP (Pamela Trowbridge, Geologic Specialist). During that meeting, an approach to evaluating remedial alternatives was discussed at length. All parties agreed that the remedial alternatives analysis should focus on intended remedies and that an exhaustive evaluation of technologies that have no applicability was not necessary. The parties agreed to follow Pennsylvania's Act 2 program and guidance with a caveat that in some unspecified cases, EPA requirements or guidance may be employed, making the approach "Act 2 Plus". Based on the preceding discussions of results from the Soil RI, the Soil RA, the preliminary results of the Groundwater SRI and the anticipated results of the Groundwater RA, the following are remedial measures anticipated to be required to remediate the Site to the Site-Specific Standard (SSS):

- Institutional and engineering controls to eliminate direct contact exposure pathways to contaminated soil above a depth of 15 feet bgs;

- Institutional controls to eliminate direct contact exposure pathways to contaminated groundwater both on and off the fYNOP property;

- Engineering controls to prevent potentially unacceptable vapor intrusion into future structures constructed on the fYNOP property above areas of contaminated soil and groundwater;

- Combinations of monitoring, source control/removal, plume flux control, and/or regulatory waivers under Section 902 (B) (3) of Act 2 as necessary to attain surface water criteria in Codorus Creek, and surface and groundwater criteria in the area defined as the Site (impacted area);

- Removal or closure in place using best management practices of pre-1980 unpermitted solid waste disposal areas on the fYNOP property.

The first three of these remedial measures are anticipated to be necessary regardless of the outcome of the ongoing Groundwater SRI and RA. However, the eventual combination of remedial technologies that will comprise the remedial measures necessary to address potential impacts to Codorus Creek are dependent on the outcome of the ongoing Groundwater SRI and RA. Therefore, the development of remedial alternatives presented in this report encompasses the full range of technology options that may be necessary to attain the SSS for surface water.

1.9 Status of Solid Waste Management Units

As noted previously, 73 SWMUs were identified during an RFA conducted by USEPA in 1989, all of which are associated with contamination in soil or waste disposal areas. The results of the Soil RA and the preliminary analysis of the results of the Groundwater SRI indicate that no further action is necessary to remediate releases to these SWMUs in order to attain the SSS other than the removal or closure in place of solid waste disposal areas as mentioned in the previous subsection. Closure of all SWMUs is effectively accomplished through implementation of a Remedial Alternative, and no further SWMU closure documentation is anticipated.

1.10 Report Organization

This RAA Part 1 report is generally organized in accordance with USEPA guidance (USEPA, 1988), for reports describing results of the feasibility study process steps completed through development of candidate remedial alternatives. As such, the remainder of this report is organized in four additional sections, as described below:

- Section 2 provides an identification and/or discussion of the objectives of the RAA process (ARARs, TBCs, and preliminary RAOs), followed by an identification of General Response

Actions (GRAs), a description of preliminary remedial action areas, and identification and screening of candidate remedial technologies.

- Section 3 provides a description of possible remedial alternatives for each of the preliminary remedial action areas.
- Section 4 describes the recommended scope of the RAA Part 2; and
- Section 5 is a listing of references.

2 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section describes the results of identification and screening of remedial technologies to address the presence of regulated substances in groundwater, surface water, soil and bedrock within the Site and/or surrounding area that has been performed as part of the RAA. The process of identifying and screening technologies is completed in three general steps. The first step consists of the identification of preliminary remedial action objectives. The remedial action objectives in the feasibility study process include identification of "applicable or relevant and appropriate requirements" (ARARs), identification of "to be considereds" (TBCs), and development of RAOs. The second step consists of identification of candidate remedial technologies for each medium of interest, organized by GRAs, type of remedial technology and process options. Lastly, the third step consists of screening the technologies and process options using the criteria of effectiveness, implementability and relative cost.

2.1 Identification of ARARs and TBCs

Applicable requirements are defined as those promulgated Federal or state requirements (e.g., cleanup standards, standards of control) that specifically address a hazardous substance, pollutant, or contaminant found at a CERCLA site. Relevant and appropriate requirements are those promulgated Federal or state requirements that, while not applicable, address problems sufficiently similar to those encountered at CERCLA sites that their application is appropriate.

TBCs consist of other Federal, state, and local criteria, advisories, or guidances that may also apply to conditions found at the site. TBCs are not legally binding, but may be useful within the context of assessing remedial alternatives.

ARARs are generally divided into three categories: chemical-specific, location-specific and action-specific. Chemical-specific ARARs provide guidance on acceptable or permissible concentrations of regulated substances in different environmental media. Location-specific ARARs govern activities in critical environments such as floodplains, wetlands, endangered species habitats, or historically significant areas. Action-specific ARARs are technology- or activity-based requirements. The ARARs and TBCs identified below are those that are applicable to the evaluation of remedial technologies for different environmental media at the Site.

2.1.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs for the COCs identified at the Site are as follows:

- ***Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR 141)*** – MCLs have been promulgated for a number of organic and inorganic contaminants to regulate the concentration of these compounds in public drinking water.

- ***Clean Air Act of 1970 (42 CFR 85)*** **–** Promulgated national primary and secondary ambient air quality standards for air pollutants for protection of public health.

- ***PA Safe Drinking Water (25 PA Code, Chapter 109)*** **–** Standards for groundwater used as a drinking water source.

- ***PA Water Quality Standards (25 PA Code, Chapter 93)*** **–** Surface water quality standards promulgated for protection of human health and aquatic life.

- ***PA Water Quality Toxics Management Strategy (25 PA Code, Chapter 16)*** **–** Water quality criteria for various toxic substances promulgated for protection of human health and aquatic life.

- ***PA Land Recycling and Environmental Remediation Standards Act (Act 2)(25 PA Code, Chapter 250)*** **–** MSCs including Statewide Health Standard, Site-Specific Standard, and/or Background Standard, for organic and inorganic substances in groundwater and soil that are promulgated for site remediation.

- ***PA Air Pollution Control Act of 1971 (25 PA Code, Chapter 131)*** **–** Ambient air quality standards for discharges of air pollutants.

- ***Resource Conservation and Recovery Act (RCRA) Hazardous Waste Generator and Transporter Requirements (40 CFR 264)*** **–** Establishes responsibilities of generators and transporters of hazardous waste in the handling, transportation, and management of waste, SWMU closure and other RCRA closure activities.

Chemical-specific TBCs for Site-related COCs are as follows:

- ***Clean Water Act Ambient Water Quality Criteria* –** Non-promulgated ambient water quality criteria have been developed for carcinogenic and non-carcinogenic compounds for the protection of human health and aquatic life.

- ***EPA Groundwater Protection Strategy (USEPA, 1984)* –** Guidance for determining the classification and restoration goals for groundwater based on its value and vulnerability to contamination.

- ***EPA Region 3 Regional Screening Levels (RSLs)* –** TBCs for soil and tap water that may be used for selecting contaminants for risk assessment and/or fate and transport modeling.

- ***EPA Soil Screening Levels/Guidance and Generic Levels* –** Guidance with a methodology to calculate risk-based, site-specific soil screening levels for contaminants in soil that may be used to identify areas needing further investigation. Also includes generic soil screening levels for a number of contaminants in soil.

2.1.2 Location-Specific ARARs and TBCs

Error! Bookmark not defined. Location-specific ARARs and TBCs govern activities in critical environments such as wetlands, endangered species habitats, and historic locations.

- ***Protection of Wetlands and Floodplains (Executive Orders 11990 and 11988)* –** Potentially applicable to remedial actions conducted within wetlands and/or floodplains.

- ***Susquehanna River Basin Commission, Ground Water Protected Area Regulations, South-central Pennsylvania* –** Regulations to assure the effective management of water withdrawals to avoid depletion of natural stream flows and groundwater aquifers and to protect the quality of such waters.

- ***Federal Water Pollution Control Act (40 CFR 116.3)* –** Potentially applicable to water discharges at the site.

- ***Fish and Wildlife Coordination Act (16 USC 661)*** **–** Potentially applicable if surface water is diverted or disturbed during remedial actions.

- ***Fish and Wildlife Improvement Act of 1978 (16 USC 742)*** **–** Protects fish and wildlife against impacts that may affect their protective habitats.

- ***Fish and Wildlife Conservation Act of 1980 (16 USC 2901)*** **–** May be applicable to discharge of treated water.

- ***Endangered Species Act of 1973 (50 CFR 200)*** **–** Potentially applicable if any endangered or threatened species or habitats are present where remediation activities may occur.

- ***National Historic Preservation Act of 1966 (16 USC 470 et. Seq.)*** **–** Requires action be taken to recover and to preserve historic artifacts that may be threatened as the result of land alteration.

- ***National Archeological and Historic Preservation Act of 1974 (132 CFR 229)*** **–** Requires action to be taken to recover and to preserve scientific, prehistoric, historic, or archaeological artifacts that may be threatened as the result of land alteration.

2.1.3 Action-Specific ARARs and TBCs

Action-specific ARARs and TBCs are as follows:

- ***RCRA Hazardous Waste Generator and Transporter Requirements (40 CFR 262, 264 and 263)*** **–** Establishes responsibilities of generators and transporters of hazardous waste in the handling, transportation, and management of waste.

- ***Department of Transportation (DOT) Hazardous Materials Transport (49 CFR 107 and 171-179)*** **–** Regulations for the transportation of hazardous materials including packaging, marking, labeling and transportation methods.

- ***Clean Water Act NPDES*** **–** Requirements applicable for alternatives that include a water discharge.

- ***National Environmental Policy Act of 1970 (NEPA) (42 USC 4321)*** **–** Requires federal agencies to evaluate the environmental impacts associated with major actions that they fund, support, permit or implement.

- ***Occupational Health and Safety Act of 1970 (29 USC 651-678)*** **–** Regulates worker health and safety during implementation of remedial actions.

- ***PA National Pollutant Discharge Elimination System (25 PA Code, Chapter 92)*** **–** Requirements applicable for alternatives that include a water discharge.

- ***PA Land Recycling Program Technical Guidance Manual*** **–** Provides guidance on actions taken to implement the provisions of Act 2 of 1995 and the regulations promulgated thereunder at 25 PA Code, Chapter 250.

- ***PA Solid Waste Management Program, Management of Fill Policy*** **–** PA established policy for "clean fill" and "regulated fill" that may be used during remedial activities.

- ***PA Stormwater Management Act of 1978 (Act 167)*** **–** Requires the implementation of measures to control stormwater runoff.

- ***PA Erosion Control Regulations (25 PA Code, Chapter 102)*** **–** Requires the implementation of measures to control erosion and stormwater runoff.

- ***PA Drilling Water Wells (17 PA Code, Chapter 47)*** **–** Requirements for the installation and construction of groundwater wells.

- ***PA Hazardous Substances Transportation Regulations (PA Code, Title 13 and 15)*** **–** Regulations that govern the transport of flammable liquids and solids, oxidizing materials, poisons and corrosive liquids.

2.1.4 ARAR Waivers

Under certain circumstances, an ARAR may be waived. According to the USEPA, December 1989, these six statutory ARAR waivers include:

1. Interim Measures Waiver – Applies to when an interim measure that does not attain all ARARs is expected to be followed by a complete measure that will attain all ARARs.

2. Equivalent Standard of Performance Waiver – Applies to situations where an ARAR requires use of a particular design or method, but better remedial results could be achieved using an alternative design or method.

3. Greater Risk to Health and the Environment Waiver – Applied to situations where compliance with an ARAR will cause greater risk to human health and the environment than noncompliance.

4. Technical Impracticability Waiver – Applies to situations when compliance with an ARAR is technically impracticable from an engineering perspective due to limitations in engineering feasibility and/or reliability. Use of this waiver may also consider cost.

5. Inconsistent Application of State Standard Waiver – Applies to situations when evidence exists that demonstrates that a State Standard has not been or will not be consistently applied to other remedial sites within the State.

6. Fund-Balancing Waiver – Applies to situations when meeting an ARAR may require such a cost in relation to the added degree of protection or risk reduction afforded by that standard that remedial actions at other sites could be jeopardized.

2.1.5 Site-Specific Agreements

In addition to ARARs and TBCs, Harley-Davidson developed a plan to utilize EPA's "contained-in" policy for management of environmental media during remediation. This plan titled "Contained-In" Waste Determination for Environmental Media – Former York Naval Ordnance Plant Remedial Actions (SAIC, 2011) plus addendums were approved for soil, liquids and debris in a series of letters by PADEP in 2011.

2.2 Preliminary Remedial Action Objectives (RAOs)

RAOs are goals specific to media for protecting human health and the environment. Risk can be associated with current or potential future exposures. RAOs should specify: 1) the regulated substances that have been identified as COCs; 2) exposure routes and receptors; and 3) the acceptable level or range of levels for a regulated substance and potential exposure route. The following are the preliminary RAOs for this Site:

1. Prevent exposure of human receptors to soil beneath existing building slabs and paved areas if, following removal of these capping measures, the concentrations of COCs in those soils would result in recalculated risk or hazard levels exceeding the Act 2 statutory limits of excess cancer risk equals 10E-4 and hazard index equals 1.0. Note that there is an existing environmental covenant for the 58 acres transferred to the YCIDA to prevent this exposure.

2. Prevent exposure of human receptors to vapor intrusion into structures if the concentrations of COCs in those vapors would result in risk or hazard levels exceeding the Act 2 statutory limits of excess cancer risk equals 10E-4 and hazard index equals 1.0.

3. Prevent ingestion and contact by human receptors of groundwater and surface water having concentrations of COCs exceeding the applicable Pennsylvania drinking water standards or ambient water quality criteria.

4. Reduce mass flux of COCs from the source areas beneath the fYNOP property to levels that will permit ambient water quality criteria for surface water to be met in Codorus Creek.

5. Remove or apply best practices to in-place closure of unpermitted, pre-1980 solid waste disposal areas on the fYNOP property.

Remedial measures necessary to accomplish each of these five RAOs can be identified at this time to a reasonable degree of certainty with the exception of those necessary to achieve RAO #4. In this case, the results of the ongoing Groundwater SRI and the Groundwater RA will affect the level of remedial action effort that will be required to achieve RAO #4. For this reason, the alternatives presented in this report include a selection of remedial measures that would be necessary to address the full range of outcomes from the ongoing Groundwater SRI Part 2 and RA work. RAOs #3 and #4 may consider the use of Alternate Concentration Limits (ACLs) to meet those objectives.

2.3 Preliminary Remedial Action Areas

The fYNOP site has been subdivided into six preliminary remedial action areas, based on the findings of the supplemental remedial investigations of soil and groundwater as described in the SRI Soils Report (SAIC, 2009) and the Groundwater SRI Report Part 1 (GSC, 2011). The six remedial action areas are termed “preliminary” as they have been developed prior to completion of additional Groundwater SRI activities and completion of the Groundwater RA. The preliminary remedial action areas encompass SWMUs described in the SRI Soils Report and groundwater areas of concern described in the Groundwater SRI Report Part 1. In general, the six areas were identified by subdividing the fYNOP Site into separate and distinct geographic areas based on having the following similar characteristics pertinent to development and screening of remedial alternatives:

- operations history;
- geologic profiles;
- hydrogeologic settings;
- nature and extent of contamination;
- fate and transport considerations; and
- exposure/receptor conditions and existing institutional controls.

A description of each of these areas is provided in the following subsections. Locations of the areas are shown on **Figure 2.3-1**.

2.3.1 Northeast Property Boundary Area (NPBA)

The NPBA is located in the northeast corner of the Harley-Davidson property, and is physically upgradient and relatively remote from the industrial plant operations. The geologic profile in this area of the fYNOP Site consists of residual soil overlying non-carbonate fractured bedrock. VOCs (primarily TCE and some PCE) were first detected in groundwater in 1986. The NPBA was the alleged site of liquid waste disposal in the form of road oiling, weed control along the perimeter fence and rodent control.

Water supply wells were located immediately north of the NPBA. Three wells, designated RW-1 through 3 were not in use as water supplies when groundwater investigations began in 1986. A fourth well, RW-4 was in use, and provided water to one residence. In October 2007, Harley-Davidson paid to have the residence supplied by RW-4 to be connected to the York Water Company supply. The well was not abandoned and is currently used occasionally for irrigation.

A groundwater extraction system consisting of a row of groundwater extraction wells completed in quartzite bedrock along the northeastern property boundary served as an interim remedy to prevent off-site migration of groundwater containing chlorinated solvents. This extraction system has recently been shut down and monitoring performed to confirm that concentrations of COCs do not rebound to unacceptable levels causing off-site migration to the north. This investigation resulted in a recommendation that the extraction system remain off and described a continued monitoring plan. EPA concurred with the recommendation and plan by email of 4/17/14 from Griff Miller (EPA Region 3 RPM) to the fYNOP Team and PADEP.

2.3.2 Eastern Area

The Eastern Area consists of a large area along the eastern perimeter of the Harley-Davidson property that includes a number of SWMUs. The geologic profile in this area of the fYNOP Site consists of residual soil overlying non-carbonate fractured bedrock. Much of this area is physically upgradient and relatively remote from the industrial plant operations. A description of areas of concern and SWMUs located within this area of the Site are provided below.

- ***Eastern Perimeter Road Area*** **–** The Eastern Perimeter Road Area is located along the eastern boundary of the Harley-Davidson property (See **Figure 2.3-1**). It covers an area of approximately one half mile in length. It is a continuation of the northern and southern perimeter roads and has a common history with these areas. Historical waste disposal practices along the perimeter road and fence line similar to the NPBA activities are suspected of being sources of groundwater contamination.

- ***Former Cyanide Spill Area*** **–** The Former Cyanide Spill Area is located near monitoring well MW-2 on the eastern edge of the property (See **Figure 2.3-1**). Two separate burial areas, less than 100 feet apart, were discovered and excavated in 1984.

- ***Landfill Area*** **–** The Landfill in the east-central portion of the site consists of approximately 2.5 acres of fill material (See **Figure 2.3-1**). The fill is reported to be no more than 20 feet thick. According to Harley-Davidson, the eastern Landfill Area was created in 1964 during ownership by AMF. The RFA (A.T. Kearney, 1989) indicates that wastes were last placed in this unit in 1987. Post-1980 procedures by Harley-Davidson only allowed dumping of clean fill including lawn care debris, dirt, gravel, and uncontaminated concrete flooring from construction activities, according to interviews conducted in 1984.

2.3.3 Southeast Property Boundary Area (SPBA) and South Plume Area (SPA)

The SPBA includes the area of the southeast corner of the Harley-Davidson property and is associated with a narrow groundwater plume that extends off-Site to the south-southwest (See **Figure 2.3-1**). The geologic profile in the SPBA of the fYNOP Site consists of colluvial soil overlying non-carbonate fractured bedrock. The SPA to the south is characterized by residual and colluvial soil overlying carbonate bedrock. This area is hydrogeologically isolated from the remainder of the Site. Descriptions of specific subareas of potential concern within the SPBA and SPA are provided below.

- ***Southeast Perimeter Road*** **–** Historical accounts indicate that liquid waste was used to control weeds along the perimeter road in the past, and waste oils were used to reduce the dust on the road. It is suspected that waste materials were distributed in much the same way as described for the NPBA. Several studies were conducted; however, no source areas or MSC exceedances for soil have been identified in this area.

- ***Sanitary Sewer Area*** **–** The Sanitary Sewer Area is located along the southern property boundary of the facility. During 2002, Harley-Davidson constructed a sanitary sewer line connection from the Softail facility (Building 3) southward to an existing manhole near the United States Army Reserve Center (SAIC, 2003). During excavation for construction, VOCs were detected. Impacted soils were removed from the sanitary sewer excavation and transported off-site for disposal. During a follow-up investigation, the PADEP soil-to-groundwater MSC for hexavalent chromium was exceeded in one sample collected at SPBA-SB-024 from the 1 to 3 feet bgs interval. In addition, PCE was detected above the soil-to-groundwater Statewide MSC in boring SB-13 at a depth of 5 to 9 feet. No other MSC exceedances were detected.

- ***Drum Storage Area*** **–** The former drum storage area is located along the southern property boundary of the facility. This area is approximately 1.5 acres in size and bounds both sides of the service road extending south from Buildings 13 and 70. Historical accounts and aerial photographs from 1974 indicate that drums were stored along this road. Contents of the drums at that time are unknown. Soil gas studies were conducted throughout the area and the related Building 2 Drum Storage area, with no positive readings and there are no known sources or MSC exceedances for soil in this area.

- ***SPA*** **–** There are indications that groundwater migrates from the southeastern corner of the fYNOP site in a south-southwestward direction, transporting Site-related COCs. This potential is being further investigated as part of the GWRI (Part 2) currently being conducted.

  On-site sampling and modeling of vapor migration were completed by Langan and presented in the draft report titled "Indoor Vapor Pathway Screening Assessment – Supplemental RI Report" (March 2005). The report concluded that there was no off-Site risk to human health via the vapor intrusion pathway. As a result of the recent (8/27/14) reevaluation of the RCRA EI for the fYNOP site, USEPA has requested more information to evaluate the potential for VI into neighboring residences. The fYNOP team is preparing a work plan for this investigation at the time of the drafting of this report.

2.3.4 Bunker and Shell Range Area (BSRA)

The BSRA is located in the eastern portion of the Harley-Davidson property in the area west of the Eastern Area landfill (See **Figure 2.3-1**). This area of the former fYNOP site falls under a separate agreement between the U.S. government and Harley-Davidson. While some details are included in this document, remediation in this area will likely be addressed separately from the remainder of the Site due to the separate agreement. As work progresses in this area and on the Site-Wide remedial alternatives, future consideration will be given to combining remedial actions.

The BRSA includes an area that comprises Buildings 14, 15, 16 and 30 and the Building 14 firing range. The geologic profile in this area of the fYNOP Site consists of residual soil overlying non-carbonate fractured bedrock. Some seasonal springs and seeps have been identified in this area of the Site. The BSRA area is physically upgradient from the industrial plant operations, and is separated from the public and plant employees by chain-linked fencing and locked gates. This controlled area is only accessed by workers who have reason to enter, and are provided with ordnance awareness safety training. Most of Building 16 (above grade firing range) was demolished and all ordnance debris was removed in 2004; the south portion of Building 14 was razed and removed in 2010; and Buildings 15 and 30 (barn) were razed and removed in 2011. Remaining structures and areas of concern are secured with locks and warning signs and are inspected quarterly. Descriptions of remaining specific subareas of potential concern within the BSRA are provided below.

- ***Building 14 Firing Range* –** According to historical drawings, Building 14 consisted of a firing room and an assembly room, which took up the majority of the southern rectangular portion on the building. A long, narrow northern extension (18 feet wide by 328 feet long) is the firing range and extends from the firing room to the sand hopper and elevator. Part of the firing range is underground. Potential environmental concerns are related to the northern end of the firing range. Based on experience with Building 16, it is possible that sand used as a backstop and contained in the sand hopper/target room may have concentrations of lead that exceed MSCs. This structure requires removal of Munitions and Explosives of Concern (MEC). No investigation for releases of hazardous substances will be conducted in the building until all MEC has been removed.

- ***Building 16 Firing Backstops (Butts)*** **–** The remaining structure at Building 16 consists of two empty firing backstops (Butts). Potential environmental concerns are related to lead beneath the Butts, as the backstop sand was originally placed over a gravel floor. No investigation for releases of hazardous substances will be conducted until the remnant Butts have been demolished and removed, due to the deteriorating condition of the building.

- ***Former Spent 37-mm Shell Disposal Areas Nos. 1 & 2*** **–** The RFA (Kearney, 1989) describes SWMUs 20 and 21 as containing fired, exploded 37-mm shells and shell fragments and sand deposits. The shell fragments were buried with a sand deposit and contained no live rounds, according to the report. There was no indication in the report as to whether wastes were removed. The Soils RI recommends SWMUs 20/21 be included in the ordnance and explosives (OE) removal action at the site.

2.3.5 North End Test Track (NETT)

The NETT is located in the north-central portion of the Harley-Davidson property in the area west of the BSRA (See **Figure 2.3-1**). The geologic profile in this area of the fYNOP Site consists of residual soil overlying non-carbonate fractured bedrock. The NETT area is physically upgradient from the industrial plant operations. The area is currently fenced and partially covered with crushed concrete and used as a contractor storage area.

The NETT is located north of the existing Building 3 and is estimated to include an area of approximately 40,000 feet^2 with several distinct disposal areas. It was the site of liquid waste storage and disposal, as well as landfilling. Bomb line waste materials (grease), cyanide wastes, fly ash, and vapor degreaser still bottoms were disposed in this area. Thousands of drums of liquid waste were stored in this area during the 1970s; leaks and spills were reported to have occurred; and the drums were later removed in the 1980s. Soil to groundwater MSCs are exceeded for several CVOCs.

2.3.6 Western Property Area (WPA)

The WPA comprises the former area of industrial plant operations and the downgradient Codorus Creek/Levee Area to the west, and is outlined on **Figure 1.3-1**. This is a redefinition of the term since its last use in the Supplemental RI Groundwater Report (GSC, 2011). Particularly for groundwater remediation purposes, combining the NPA, the CPA, the WPL and the area west of the WPL to the Codorus Creek into one area will result in a more efficient and comprehensive discussion of remedial alternatives.

The geologic profile in this area of the WPA consists of fill, residual soil and karstic carbonate bedrock. This area includes numerous source areas and their associated groundwater plumes that contribute to the groundwater contaminant mass flux that would discharge to Codorus Creek in the absence of the ongoing groundwater extraction and treatment operations. The former industrial plant portion of the WPA includes numerous SWMUs and AOCs. These SWMUs and AOCs have been grouped into the three distinct subareas shown on **Figure 2.3-1** and described below.

- ***NPA* –** Locations that likely contributed COCs in this portion of the Site include: the Old Waste Containment Area that was used to store liquid wastes; the Industrial Wastewater Treatment Plant (IWTP) that was used to treat wastewater; a former metal chip bin area that resulted in releases of cutting oils, according to interviews of employees of the facility familiar with that practice; and a gasoline underground storage tank (UST) area where gasoline was released from subsurface piping. The NPA is characterized by a small plume of TCE and PCE that occurs northwest of Building 42 (MW-31D); a small plume of TCE and PCE that occurs under the IWTP (Building 41); and elevated concentrations of unleaded gasoline components (i.e., benzene, toluene, ethylbenzene, MTBE and xylenes) that are present in groundwater under the former UST and fueling dispenser between former Buildings 42 and 45.

- ***CPA* –** Locations that likely contributed COCs in this portion of the Site include: the former Building 2 vapor degreaser (near MW-55) and the TCA tank area (near CW-8) in the southern half of Building 2; cutting oil tank, the former wastewater sumps located in the corridor east of Building 2; the former chrome/zinc plating area and the area of Building 58 near the southeast corner of former Building 2; the corridor west of former Building 2; and the North Building 4 plating/sludge and vapor degreaser area. A highly concentrated plume of chlorinated solvents occurs in the groundwater between former Buildings 2 and 4 north of former Building 91. This plume commingles with a plume with similar constituents caused by activities involving the former northern vapor degreaser in the northwestern corner of Building 4. A plume of PCE trends northwestward from the southwestern corner of Building 4, also the former location of a vapor degreaser. Also commingled with this plume is chromium, which is a result of spills and leaks from a plating operation in Building 4, just south of the former northern vapor degreaser. The interim groundwater extraction system operates in this portion of the WPA.

- ***WPL*** **–** This portion of the Site includes areas near the western edge of the parking lot that were landfilled and used as a disposal area for liquid and solid waste. The highest concentrations of chlorinated solvents in the groundwater on Site (47 parts per million in MW-74S in September 1999) occurred in the southwest corner of the WPL. In 2004, Eden Road was relocated to connect the employee parking lot with the plant area. The relocation resulted in the construction of an elevated roadway and lined stormwater management basins over the immediate area of former disposal areas. An area where disposal of solids and liquids is suspected that is referred to as the Burn Pile Area (BPA) is located near the northwestern corner of the WPL.

  Soil-to-groundwater MSCs for CVOCs, metals, SVOC/PAHs and PCBs are exceeded in numerous areas within the disposal areas. High concentrations of CVOCs were found in the soil west of new Eden Road proximate to the BPA in the area of well location MW-96S&D (Area B – CVOC disposal area), and the area was capped to prevent infiltration of precipitation through Area B and reduce leaching to the water table. The interim groundwater extraction system operates in this portion of the WPA, designed with the goal of preventing groundwater from migrating westward off the fYNOP property.

- ***Codorus Creek/Levee Area*** **–** The Codorus Creek/Levee Area is included in the WPA as it includes locations of former groundwater plumes in bedrock that developed prior to the operation of the interim groundwater extraction system in the remainder of the WPA. West of the WPL property line and railroad tracks, the area consists of wetland areas and flood plain. Along the Codorus Creek, flood control levees were constructed and are maintained by the USACE.

2.4 General Response Actions

GRAs consist of broad categories of remedial technologies that have been identified to achieve proposed RAOs. Specific GRAs identified for one or more of the remedial action areas at the Site include the following:

- No Action – No-action alternative with respect to remediation as mandated by the CERCLA.
- Institutional Controls – Administrative mechanisms, such as environmental covenants, deed restrictions and use designations, and physical actions, such as posting and fencing to restrict Site access and use.
- Monitoring – Sampling and analysis of environmental media to support design of a remedial alternative, assess the effectiveness of a remedial alternative, and/or support risk management decision-making and selection of a remedy.
- Removal – Extraction of contaminated groundwater, extraction and/or enhanced dissolution of DNAPL, vapor extraction and excavation of contaminated soil.
- Disposal – Disposal of groundwater treatment related solids, recovered DNAPL, and contaminated soil at an off-Site facility.
- Containment – Hydraulic control of contaminated groundwater via extraction wells to limit mass flux to surface water and capping or chemical fixation to isolate contaminated soil from human and ecological receptors.
- *In Situ* Treatment – Remedies that involve processes to contain, destroy, or otherwise reduce the bioavailability or toxicity of contaminants in groundwater and soil. This GRA includes physical, chemical, or biological processes that are conducted on-Site, *in situ*.
- *Ex Situ* Treatment – Remedies that involve processes to contain, destroy, or otherwise reduce the bioavailability or toxicity of contaminants in groundwater and soil. This GRA includes physical, chemical, or biological processes that are conducted at on-Site or off-Site treatment facilities.

2.5 Identification and Screening of Technology Types

Identification and screening of remedial technologies has been performed using the processes outlined in the EPA's RI/FS guidance (USEPA, 1988) and the NCP (USEPA, 1994). First, technologies that may be capable of achieving proposed RAOs were identified. This initial step included development of a list of remedial technologies with potential application to Site contaminants and Site conditions. Second, the remedial technologies that were identified were screened based on effectiveness, implementability and relative cost. The purpose of these initial screening steps was to provide an inventory of candidate remedial technologies applicable to the Site that could be assembled into candidate remedial alternatives.

2.5.1 Candidate Technology Screening

In accordance with EPA guidance, an extensive list of technologies representing a broad range of GRAs was developed and screened. The remedial technologies were identified based on a review of literature, vendor information, performance data, and GSC experience in developing candidate remedial alternatives under CERCLA and Act 2. GRAs, remedial technology types, and process options were initially screened regarding their potential application to Site contaminants and Site conditions. Results of this initial screening step are summarized in **Table 2.5-1**. The table provides a list of candidate remedial technologies for each medium of interest, organized by GRAs, type of remedial technology, and process options. As indicated in the table, remedial technologies identified and retained for screening include 30 technologies/process options for groundwater, 2 technologies/process options for surface water, 15 technologies/process options for soil, and 30 technologies/process options for saturated zone sources in residual soil and bedrock.

The screening of candidate remedial technologies with potential applicability to Site conditions was conducted in accordance with the technology screening guidance described in the USEPA RI/FS Guidance (USEPA, 1988). As such, the potential remedial technology types and process options identified for each environmental medium at the Site were screened according to the following three criteria established by EPA:

- Effectiveness
- Implementability

- Cost

The "Effectiveness" of the remedial technology types and process options was evaluated based on their ability to meet RAOs under the conditions and limitations present at the Site. This criterion was used to evaluate the potential effectiveness of process options with a focus on:

- The ability to handle the estimated areas or volumes of media and to meet remediation goals;

- The potential impacts to human health and the environment during the construction and implementation phase of the process option; and

- The experience and reliability of the process option with respect to the conditions at the Site. Based on the effectiveness evaluation each potential technology / process option was generally ranked as high, moderate, low, or unknown (in the case of options without a proven track record).

"Implementability" refers to the relative degree of difficulty anticipated in implementing a particular technology / process option under the regulatory and technical constraints posed at the Site. This criterion was used to evaluate the technical and administrative feasibility of constructing, operating, and maintaining the technology / process option, as well as the availability of services and materials. Based on the implementability evaluation each potential technology / process option was generally rated as high, moderate, or low.

The purpose of the "Cost" criterion is to allow for a rough comparison of relative costs associated with the technology / process options. Cost is an appropriate criterion under Act 2. Nonetheless, at this stage in the RAA process, the cost criterion is qualitative and used for comparative purposes only. As such, the relative cost for each of the technology / process options was generally rated as high, moderate, or low.

2.5.2 Retained Candidate Technologies

Results of the screening of remedial technology / process options are summarized in **Table 2.5-2**. The table includes the GRAs, remedial technology types and process options retained in **Table 2.5-**

1 along with a summary of the results of the screening for effectiveness, implementability and relative cost. A listing of the remedial technologies that were retained for further evaluation during development of remedial alternatives for the six remedial action areas is listed below by environmental medium.

Groundwater

- No Action
- Institutional Controls
  - Deed Restrictions/Environmental Covenants
  - Annual Inspections – door-to-door surveys/field inspections, questionnaire mailings, contact with local public water purveyor
  - Vapor barriers for new structures
- Monitoring Options
  - Source Control Effectiveness Monitoring – multilevel monitoring system
  - Monitored Natural Attenuation (MNA) – multilevel monitoring system
- Removal Technologies
  - Extraction – groundwater extraction with vertical wells and groundwater collection trenches (includes point source extraction of spring discharges)
- Containment Technologies
  - Hydraulic Control – groundwater extraction with vertical wells
- *In-Situ* Treatment Technologies
  - Biological Treatment – enhanced biodegradation and bioaugmentation
- *Ex-Situ* Treatment Technologies
  - Physical Treatment – air stripping, aqueous phase carbon adsorption, and filtration (includes point source treatment of spring discharges)
  - Off-Gas Treatment – air quality dispersion monitoring, off-gas influent and effluent monitoring, thermal oxidation, and vapor phase carbon adsorption
- Disposal/Discharge Technologies
  - Discharge to Surface Water – discharge to storm sewer and discharge to stream
  - Discharge to Groundwater – injection well

Surface Water

- Monitoring Options
  - MNA – surface water monitoring points

    - Attainment Monitoring – surface water monitoring points

Soil

- No Action
- Institutional Controls
    - Deed Restrictions
    - Fencing
    - Vapor barriers for new structures
- Removal Technologies
    - Extraction – soil vapor extraction
    - Thermally-Enhanced Extraction – *In-Situ* Thermal Desorption (ISTD) with vapor extraction and Electrical Resistance Heating (ERH) with vapor extraction
    - Excavation – excavation with off-Site disposal
- Containment Technologies
    - Capping – concrete building foundation slabs, asphalt caps or soil cover
- *Ex-Situ* Treatment Technologies
    - Off-Gas Treatment – air quality dispersion monitoring, off-gas influent and effluent monitoring, thermal oxidation and vapor phase carbon adsorption

Saturated Zone Sources in Residual Soil and Bedrock

- No Action
- Institutional Controls
    - Deed Restrictions/Environmental Covenants
- Removal Technologies
    - Extraction – groundwater extraction with vertical wells
    - Thermally-Enhanced Extraction – ISTD with vapor extraction and ERH with vapor extraction
    - Enhanced Dissolution – flushing with treated groundwater
- Containment Technologies
    - Hydraulic Control – groundwater extraction with vertical wells
- *Ex-Situ* Treatment Technologies
    - Physical Treatment – air stripping, aqueous phase carbon adsorption, filtration and phase separation

  - Off-Gas Treatment – air quality dispersion monitoring, off-gas influent and effluent monitoring, thermal oxidation and vapor phase carbon adsorption
- Disposal/Discharge/Destruction Technologies
  - Discharge to Surface Water – discharge to stream
  - Discharge to Groundwater – injection well
  - Separate Phase Liquid Destruction – off-Site incineration

3 DEVELOPMENT OF POSSIBLE REMEDIAL ALTERNATIVES

This section provides a description of the possible remedial alternatives that have been developed for each of the preliminary remedial action areas. The alternatives provide a range of possible remedial options to achieve the preliminary RAOs identified for the Site. In this process, technically feasible technologies retained for further evaluation in Section 2 were assembled, either singly or in combination, to form remedial alternatives that provide varying levels of risk reduction. Descriptions of the possible alternatives assembled for each remedial action area are provided in the following subsections.

3.1 Northeast Property Boundary Area (NPBA)

A summary of possible remedial alternatives for the NPBA is provided in **Table 3.1-1**. As shown in the table, the alternatives assembled for this area address groundwater, surface water, and soil. Possible remedial alternatives developed for the NPBA include the following:

- **Alternative 1 – No Action.** No action will be taken to mitigate risk. The no action alternative is developed as a baseline case, as required by the NCP.
- **Alternative 2 – Institutional Controls.** Implement property-use and property-access restrictions limiting future property usage. The restrictions would be placed on the deed of the property and will be included in an environmental covenant that will run with the deed. Under this alternative, use of groundwater for drinking water would be prohibited and any excavation at the Site would be conducted with knowledge of residual contamination such that proper precautions are taken to protect site construction workers and site users from exposure to COCs in soil and groundwater. Existing fencing that surrounds this portion of the Harley-Davidson property would remain in-place and be maintained under this alternative. This alternative would also require 5-year reviews, and may require more frequent reviews pursuant to the Pennsylvania Uniform Environmental Covenants Act (UECA).
- **Alternative 3 – MNA.** This alternative relies on natural fate and transport processes to achieve RAOs without the use of active remedial measures. Under this alternative, periodic monitoring of groundwater and nearby surface water would be performed to track the

progress of reductions in COCs through natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.

- **Alternative 4 – MNA with Enhanced Biodegradation.** This alternative consists of the injection of amendments to enhance natural degradation processes with or without the addition of microbes (bioaugmentation). This alternative also relies on other natural fate and transport processes to achieve RAOs. Under this alternative, periodic monitoring of groundwater and nearby surface water would be performed to track the progress of reductions in COCs through enhanced biodegradation and other natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.
- **Alternative 5 – Resumption of Groundwater Extraction & Treatment.** Groundwater extraction with vertical wells in bedrock and treatment by air stripping with vapor phase carbon or aqueous phase carbon to enhance the rate of bedrock groundwater source reduction and hydraulically contain COCs in bedrock groundwater. Treated groundwater would be discharged to Codorus Creek. Under this alternative, periodic monitoring of groundwater and nearby surface water is performed to track the progress of reductions in COCs. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in Alternatives 3 and 4. The timing of the periodic monitoring would extend beyond the timing of active groundwater extraction.

3.2 Eastern Area

A summary of possible remedial alternatives for the Eastern Area is provided in **Table 3.2-1**. As shown in the table, the alternatives assembled for this area address groundwater and soil. Possible remedial alternatives developed for the Eastern Area include the following:

- **Alternative 1 – No Action.** No action will be taken to mitigate risk (See Section 3.1).
- **Alternative 2 – Institutional Controls.** Implement property-use and property-access restrictions limiting future property usage. The restrictions would be placed on the deed of the property and will be included in an environmental covenant that will run with the deed. Under this alternative, use of groundwater for drinking water would be prohibited and any excavation at the site would be conducted with knowledge of residual contamination such

that proper precautions are taken to protect site construction workers and site users from exposure to COCs in soil and groundwater. Existing fencing that surrounds this portion of the Harley-Davidson property would remain in-place and be maintained under this alternative. This alternative would also require 5-year reviews, and may require more frequent reviews pursuant to UECA.

- **Alternative 3 – MNA.** This alternative relies on natural fate and transport processes to achieve RAOs without the use of active remedial measures. Under this alternative, periodic monitoring of groundwater would be performed to track the progress of reductions in COCs through natural attenuation process. The institutional controls described for Alternative 2 are included in this alternative.
- **Alternative 4 – MNA with Enhanced Biodegradation.** This alternative consists of the injection of amendments to enhance natural degradation processes with or without the addition of microbes (bioaugmentation). This alternative also relies on other natural fate and transport processes to achieve RAOs. Under this alternative, periodic monitoring of groundwater would be performed to track the progress of reductions in COCs through enhanced biodegradation and other natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.
- **Alternative 5 – Landfill Capping.** Placement of an engineered soil cap on the former landfill as an engineering control. This alternative would likely include confirmation of the limits of landfilling and ensuring a 2 foot soil cap to provide an appropriate cover, or use of a geotextile along with the soil to provide an appropriate cap. This alternative could also include placement of additional fencing around the area of the landfill, depending on regulatory requirements (the landfill is a pre-1980 landfill that Harley-Davidson does not believe requires removal, further investigation, or more formal closure alternatives). The institutional controls described for Alternative 2 and the MNA components described for Alternative 3 are included in this alternative, but will also include a prohibition on excavation within the area of the landfill.
- **Alternative 6 – Landfill Excavation.** Excavation and off-Site disposal of the landfilled materials at a licensed secure landfill. The institutional controls described for Alternative 2 and the MNA components described for Alternative 3 are included in this alternative, but could be eliminated with confirmation sampling establishing removal of impacted soils.

3.3 Southeast Property Boundary Area (SPBA) and South Plume Area (SPA)

A summary of possible remedial alternatives for the SPBA and SPA are provided in **Table 3.3-1**. As shown in the table, the alternatives assembled for these areas address groundwater and soil. Vapor intrusion is not addressed, pending further field investigations. Possible remedial alternatives developed for the SPBA and SPA include the following:

- **Alternative 1 – No Action.** No action will be taken to mitigate risk (See Section 3.1).
- **Alternative 2 – Institutional Controls.** Implement Harley-Davidson property use and access restrictions limiting future property usage for the source area portion of the SPBA. The restrictions would be placed on the deed of the property in the form of an environmental covenant that would run with the deed. Under this alternative, use of groundwater for drinking water would be prohibited and any excavation at the site would be conducted with knowledge of residual contamination such that proper precautions are taken to protect site construction workers and site users from exposure to COCs in soil and groundwater. Existing fencing that surrounds this portion of the Harley-Davidson property would remain in-place and be maintained under this alternative. Institutional controls for the plume area that extends to the south of the Harley-Davidson property would consist of annual inspections to confirm the area continues to be served by public water and locally derived groundwater is not being used for drinking water on any of the properties over the plume. The annual inspections would include door-to-door surveys and field inspections, mailing of a questionnaire regarding water usage to property owners, and contact with the local public water supplier. This alternative would also require 5-year reviews, and may require more frequent reviews pursuant to UECA.
- **Alternative 3 – MNA.** This alternative relies on natural fate and transport processes to achieve RAOs without the use of active remedial measures. Under this alternative, periodic monitoring of groundwater would be performed to track the progress of reductions in COCs through natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.
- **Alternative 4 – MNA with Enhanced Biodegradation.** This alternative consists of the injection of amendments in the source area portion of the SPBA to enhance natural degradation processes with or without the addition of microbes (bioaugmentation). This

alternative also relies on other natural fate and transport processes to achieve RAOs. Under this alternative, periodic monitoring of groundwater would be performed to track the progress of reductions in COCs through enhanced biodegradation and other natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.

- **Alternative 5 – Groundwater Extraction & Treatment for Source Control.** Groundwater extraction with vertical wells in bedrock and satellite treatment by air stripping with vapor phase carbon or aqueous phase carbon to enhance the rate of bedrock groundwater source reduction and hydraulically contain COCs in bedrock groundwater. The bedrock groundwater extraction well or wells would be located within the Harley-Davidson property. Treated groundwater would be discharged to the storm sewer system subject to PADEP approval of a NPDES permit for treated groundwater. Under this alternative, periodic monitoring of groundwater would be performed to track the progress of reductions in COCs. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in Alternatives 3 and 4. The timing of the periodic monitoring would extend beyond the timing of active groundwater extraction.
- **Alternative 6 – Groundwater Extraction & Treatment for Source Control & Plume Reduction.** Groundwater extraction with vertical wells in bedrock and satellite treatment by air stripping with vapor phase carbon or aqueous phase carbon to enhance the rate of bedrock groundwater source reduction and hydraulically contain COCs in bedrock groundwater. A near-source bedrock groundwater extraction well or wells would be located within the Harley-Davidson property and a plume area bedrock extraction well would be located to the south within a public right-of-way. Underground conveyance piping would be used to transfer groundwater withdrawals to a satellite treatment system. Treated groundwater would be discharged to the storm sewer system subject to PADEP approval of a NPDES permit for treated groundwater. Under this alternative, periodic monitoring of groundwater would be performed to track the progress of reductions in COCs. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in Alternatives 3 and 4. The timing of the periodic monitoring would extend beyond the timing of active groundwater extraction.

3.4 Bunker and Shell Range Area (BSRA)

As stated in Section 2.3.4 this area of the former fYNOP site falls under a separate agreement between the U.S. government and Harley-Davidson. While some details are included in this document, remediation in this area, particularly the removal of ordnance will likely be addressed separately from the remainder of the Site due to the separate agreement. As work progresses in this area and on the Site-Wide remedial alternatives, future consideration will be given to combining remedial actions. Removal of ordnance is not considered in the following alternatives.

A summary of possible remedial alternatives for the BSRA is provided in **Table 3.4-1**. As shown in the table, the alternatives assembled for this area address groundwater, surface water (springs), and soil. These alternatives exclude any actions associated with a future ordnance and explosives removal. Possible remedial alternatives developed for the BSRA include the following:

- **Alternative 1 – No Action.** No action will be taken to mitigate risk (See Section 3.1).
- **Alternative 2 – Institutional Controls.** Implement property-use and property-access restrictions limiting future property usage. The restrictions would be placed on the deed of the property in the form of an environmental covenant that would run with the deed. Under this alternative, use of groundwater for drinking water would be prohibited and any excavation at the site would be conducted with knowledge of residual contamination such that proper precautions are taken to protect site construction workers and site users from exposure to COCs in soil and groundwater. Existing fencing that surrounds this portion of the Harley-Davidson property would remain in-place and be maintained under this alternative. This alternative would also require 5-year reviews, and may require more frequent reviews pursuant to UECA.
- **Alternative 3 – MNA.** This alternative relies on natural fate and transport processes to achieve RAOs without the use of active remedial measures. Under this alternative, periodic monitoring of groundwater would be performed to track the progress of reductions in COCs through natural attenuation process. The institutional controls described for Alternative 2 are included in this alternative.
- **Alternative 4 – MNA with Enhanced Biodegradation.** This alternative consists of the injection of amendments in bedrock to enhance natural degradation processes with or

without the addition of microbes (bioaugmentation). This alternative also relies on other natural fate and transport processes to achieve RAOs. Under this alternative, periodic monitoring of groundwater would be performed to track the progress of reductions in COCs through enhanced biodegradation and other natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.

- **Alternative 5 – Spring Water Collection & Treatment.** This alternative consists of collection of water discharging from springs and seeps via the use of collection trenches. The water collected would be transferred via underground conveyance piping to the existing groundwater treatment facility for treatment by air stripping with vapor phase carbon or aqueous phase carbon. Treated groundwater would be discharged to Codorus Creek. Under this alternative, periodic monitoring of groundwater and surface water would be performed to track the progress of reductions in COCs. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in Alternatives 3 and 4. The timing of the periodic monitoring would extend beyond the timing of active spring water collection and treatment.

3.5 North End Test Track (NETT)

A summary of possible remedial alternatives for the NETT is provided in **Table 3.5-1**. As shown in the table, the alternatives assembled for this area address groundwater and soil. Possible remedial alternatives developed for the NETT include the following:

- **Alternative 1 – No Action.** No action will be taken to mitigate risk (See Section 3.1).
- **Alternative 2 – Institutional Controls.** Implement property-use and property-access restrictions limiting future property usage. The restrictions would be placed on the deed of the property in the form of an environmental covenant that would run with the deed. Under this alternative, use of groundwater for drinking water would be prohibited and any excavation at the site would be conducted with knowledge of residual contamination such that proper precautions are taken to protect site construction workers and site users from exposure to COCs in soil and groundwater. Existing fencing that surrounds this portion of the Harley-Davidson property would remain in-place and be maintained under this

alternative. This alternative would also require 5-year reviews, and may require more frequent reviews pursuant to UECA.

- **Alternative 3 – MNA.** This alternative relies on natural fate and transport processes to achieve RAOs without the use of active remedial measures. Under this alternative, periodic monitoring of groundwater and surface water would be performed to track the progress of reductions in COCs through natural attenuation process. The institutional controls described for Alternative 2 are included in this alternative.
- **Alternative 4 – MNA with Enhanced Biodegradation.** This alternative consists of the injection of amendments in bedrock to enhance natural degradation processes with or without the addition of microbes (bioaugmentation). This alternative also relies on other natural fate and transport processes to achieve RAOs. Under this alternative, periodic monitoring of groundwater and surface water would be performed to track the progress of reductions in COCs through enhanced biodegradation and other natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.

3.6 Western Property Area (WPA)

A summary of possible remedial alternatives for the WPA is provided in **Table 3.6-1**. As shown in the table, the alternatives assembled for this area address groundwater, surface water, soil, and saturated zone sources in residual soil and bedrock. Possible remedial alternatives developed for the WPA include the following:

- **Alternative 1 – No Action.** No action will be taken to mitigate risk (See Section 3.1).
- **Alternative 2 – Institutional Controls.** Continue and, as needed, further implement YCIDA property use and access restrictions limiting future property usage for the NPA, CPA, and WPL portions of the WPA. Existing deed restrictions include a requirement that construction of new structures on the YCIDA property include engineering controls, such as vapor barriers and, as needed, sub-slab vapor mitigation systems to prevent the potential for vapor intrusion. The restrictions are, and further restrictions would be, placed on the deed of the property in the form of an environmental covenant that runs with the deed. Under current restriction, the property may only be used for nonresidential purposes, the use of

groundwater for drinking water is prohibited, and any excavation at the site must be conducted in accordance with a PADEP soil management plan to ensure that proper precautions are taken to protect site construction workers and site users from exposure to COCs in soil and groundwater. Existing concrete building foundation slabs and paved asphalt areas must remain undisturbed and in-place to serve as engineering controls, and disturbance requires a PADEP-approved soil management plan and replacement of the impervious surface as soon as practicable. These features may require maintaining the impervious cover as a formal, post-remediation control. Institutional controls for the Codorus Creek Levee Area and railroad corridor portion of the WPA would consist of annual inspections to confirm the area has not been used for the development of groundwater supplies for drinking water, provided an ordinance does not already restrict the usage. The annual inspections would include field inspections, mailing of a questionnaire regarding water usage to the property owner or owners, and contact with the local public water supplier. This alternative would also require 5-year reviews, and may require more frequent reviews pursuant to UECA.

- **Alternative 3 – MNA with Groundwater Flux Monitoring.** This alternative relies on natural fate and transport processes to achieve RAOs without the use of active remedial measures. Under this alternative, periodic monitoring of groundwater and surface water would be performed to track the progress of reductions in COC plume areas and COC mass flux from groundwater to surface water through natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.
- **Alternative 4 – MNA with Enhanced Biodegradation.** This alternative consists of the injection of amendments in bedrock to enhance natural degradation processes with or without the addition of microbes (bioaugmentation). This alternative also relies on other natural fate and transport processes to achieve RAOs. Under this alternative, periodic monitoring of groundwater and surface water would be performed to track the progress of reductions in COCs through enhanced biodegradation and other natural attenuation processes. The institutional controls described for Alternative 2 are included in this alternative.
- **Alternative 5 – Hot Spot Soil Vapor Extraction.** This alternative consists of soil vapor extraction targeting landfilled areas in the western portion of the WPL where high

concentrations in soil were detected during the soil RI. Depending on mass loading, the extracted vapors would be treated by either thermal oxidation or vapor phase carbon adsorption methods. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in alternatives 3 and 4. The timing of the periodic monitoring would extend beyond the timing of active soil vapor extraction.

- **Alternative 6 – Groundwater Extraction & Treatment.** Groundwater extraction with vertical wells in bedrock and treatment by air stripping with vapor phase carbon to hydraulically contain COCs in bedrock groundwater. This alternative is consistent with the interim groundwater extraction system operational in the WPA portion of the fYNOP Site since the 1990s. Treated groundwater would be discharged to Codorus Creek. Under this alternative, periodic monitoring of groundwater source zones and plume areas would be performed to track the progress of reductions in COCs. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in Alternatives 3, 4 and 5. The timing of the periodic monitoring would extend beyond the timing of active groundwater extraction.
- **Alternative 7 – Hot Spot Extraction and Clean Water Injection.** Groundwater extraction from vertical wells targeting saturated zone sources (“Hot Spots”) in residual soil and bedrock with the possible addition of clean water injection to enhance mass removal by enhanced dissolution of residual DNAPL and enhanced back diffusion and desorption. This alternative would include a component of groundwater extraction to maintain hydraulic control of groundwater plume areas. Groundwater withdrawals would be treated by air stripping with vapor phase carbon or aqueous phase carbon. Treated groundwater would either be re-injected or discharged to Codorus Creek. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in Alternatives 3 through 6. The timing of the periodic monitoring would extend beyond the timing of active groundwater extraction and clean water injection.
- **Alternative 8 – Hot Spot Thermal Treatment.** Thermal treatment by ISTD or ERH techniques targeting saturated zone sources (“Hot Spots”) in residual soil and bedrock. This alternative would also include vapor extraction, groundwater extraction and possibly DNAPL extraction (ISTD). This alternative would include a component of groundwater

extraction to maintain hydraulic control of groundwater plume areas. The vapor, groundwater, and DNAPL would be treated by a combination of numerous physical and off-gas treatment technologies. Treated groundwater would be discharged to Codorus Creek. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in Alternatives 3 through 7. The timing of the periodic monitoring would extend beyond the timing of thermal treatment.

- **Alternative 9 – Point Source Treatment of Spring Discharges.** This alternative consists of collection of groundwater from springs near their point of discharge to Codorus Creek. The groundwater would be extracted from the springs via the use of vertical wells or collection trenches. The water collected would either by treated using aqueous phase carbon at a satellite treatment facility near the springs or it would be transferred via underground conveyance piping to the existing groundwater treatment facility for treatment by air stripping with vapor phase carbon or aqueous phase carbon. Treated groundwater would be discharged to Codorus Creek. This alternative may also consider other passive or *in-situ* treatment options near the point of the spring discharge. Under this alternative, periodic monitoring of surface water would be performed to track the progress of reductions in COCs. The institutional controls described for Alternative 2 are included in this alternative along with the periodic monitoring included in Alternatives 3 through 8,. The timing of the periodic monitoring would extend beyond the timing of active groundwater extraction or *in-situ* treatment.

4 RECOMMENDATIONS FOR RAA PART 2

This section describes the recommended scope of the RAA Part 2 to be performed after the completion of additional groundwater SRI activities and performance of a groundwater risk assessment. In accordance with PA Act 2 and EPA guidance, the recommended scope of the RAA Part 2 includes: preliminary screening of remedial alternatives; detailed analysis of retained candidate alternatives; and direct comparison of the selected alternatives against each other based on each of the screening criteria listed in Section 1. A brief description of each of these work scope items is provided in the following subsections.

4.1 Preliminary Screening Criteria

Potential remedial alternatives will be screened against three broad criteria, including:

- Short-term and long-term effectiveness;
- implementability (including technical and administrative feasibility); and
- relative cost.

The purpose of this initial screening evaluation is to provide a more general screening step to reduce the number of alternatives chosen for a more thorough and extensive analysis. The cost analysis in this preliminary screening step will consist of an assessment of relative costs, based on professional judgment and experience, rather than development of quantitative cost estimates.

4.2 Detailed Analysis of Retained Alternatives

As stated in PA Act 2, Chapter 3, Section 304 (j), the detailed analysis of retained alternatives (and the comparative analysis that follows) will include consideration of the following six criteria:

1. Long-term risks and effectiveness of the proposed remedy that includes an evaluation of:

    i. The magnitude of risks remaining after completion of the remedial action.

    ii. The type, degree and duration of post-remediation care required, including, but not limited to, operation and maintenance, monitoring, inspections and reports and their frequencies or other activities which will be necessary to protect human health and the environment.

iii. Potential for exposure of human and environmental receptors to regulated substances remaining at the site.

iv. Long-term reliability of any engineering and voluntary institutional controls.

v. Potential need for repair, maintenance or replacement of components of the remedy.

vi. Time to achieve cleanup standards.

2. Reduction of the toxicity, mobility or volume of regulated substances, including the amount of regulated substances that will be removed, contained, treated or destroyed, the degree of expected reduction in toxicity, mobility or volume and the type, quantity, toxicity and mobility of regulated substances remaining after implementation of the remedy.

3. Short-term risks and effectiveness of the remedy, including the short-term risks that may be posed to the community, workers or the environment during implementation of the remedy and the effectiveness and reliability of protective measures to address short-term risks.

4. The ease or difficulty of implementing the proposed remedy, including commercially available remedial measures which are BADCT (designated as a "Best Available Demonstrated Control Technology"), degree of difficulty associated with constructing the remedy, expected operational reliability, available capacity and location of needed treatment, storage and disposal services for wastes, time to initiate remedial efforts and approvals necessary to implement the remedial efforts.

5. The cost of the remediation measure, including capital costs, operation and maintenance costs, net present value of capital and operation and maintenance costs and the total costs and effectiveness of the system.

6. The incremental health and economic benefits shall be evaluated by comparing those benefits to the incremental health and economic costs associated with implementation of remedial measures.

In addition to these six Act 2 criteria, the following NCP criteria not covered by the Act 2 criteria will also be applied to the detailed and comparative analysis of the retained alternatives.

1. ***Overall Protection of Human Health and the Environment:*** This criterion is an evaluation of the alternative's ability to protect public health and the environment, assessing how risks posed through each existing or potential pathway of exposure are eliminated, reduced or controlled through removal, treatment, engineering controls or institutional controls. The alternative's ability to achieve each of the RAOs is evaluated.

2. ***Compliance with ARARs:*** This criterion evaluates how the alternative complies with the ARARs, or if a waiver is required and how it is justified.

4.3 Comparative Analysis of Alternatives

The retained remedial alternatives for each remedial action area will be compared to each other based on the eight criteria described in Section 4.2. The purpose of this comparative analysis is to identify the relative advantages and disadvantages of each remedial action alternative. It is anticipated that this analysis will also include an evaluation of the relative cost benefit of each remedial alterative in the context of a Site-wide remedy.

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Tables

TABLE 2.5-1
Identification of Candidate Remedial Technologies
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS / REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POTENTIAL APPLICABILITY TO SITE CONDITIONS? YES	NO
Groundwater	**No Action**			
	No Action		X	
	Institutional Options			
	Deed Restrictions		X	
	Annual Inspections	Door-to-Door Surveys/Field Inspections	X	
	Annual Inspections	Questionnaire Mailings	X	
	Annual Inspections	Contact with Local Public Water Purveyor	X	
	Vapor Barriers for New Structures	Ventilation Systems/Sub-slab Depressurization Systems	X	
	Monitoring Options			
	Source Control Effectiveness Monitoring	Multilevel Monitoring System	X	
	Monitored Natural Attenuation	Multilevel Monitoring System	X	
	Removal Technologies			
	Extraction	Air Sparging/Vapor Extraction	X	
	Extraction	Groundwater Extraction with Vertical Wells	X	
	Extraction	Groundwater Collection Trenches	X	
	Containment Technologies			
	Hydraulic Control	Horizontal Wells		X
	Hydraulic Control	Groundwater Extraction with Vertical Wells	X	
	In-Situ Treatment Technologies:			
	Biological Treatment	Enhanced Bioremediation	X	
	Biological Treatment	Bioaugmentation	X	
	Biological Treatment	Phytoremediation		X
	Chemical Treatment	Chemical Reduction	X	
	Chemical Treatment	Chemical Oxidation	X	
	Physical/Chemical Treatment	Air Sparging		X
	Physical/Chemical Treatment	Bioslurping		X
	Physical/Chemical Treatment	Hydrofracturing Enhancements	X	
	Physical/Chemical Treatment	In-Well Air Stripping		X
	Physical/Chemical Treatment	Passive/Reactive Treatment Walls		X
	Ex-Situ Treatment Technologies			
	Biological Treatment	Bioreactors		X
	Biological Treatment	Constructed Wetlands		X
	Physical/Chemical Treatment	Adsorption/Absorption		X
	Physical/Chemical Treatment	Advanced Oxidization Processes		X
	Physical/Chemical Treatment	Ion Exchange		X
	Physical/Chemical Treatment	Precipitation/Coagulation/Flocculation		X
	Physical/Chemical Treatment	Sprinkler Irrigation		X
	Physical Treatment	Air Stripping	X	
	Physical Treatment	Aqueous Phase Carbon Adsorption	X	
	Physical Treatment	Filtration	X	
	Chemical Treatment	UV/Ozonation	X	
	Chemical Treatment	Chemical Oxidization	X	
	Off-Gas Treatment	Air Quality Dispersion Monitoring	X	
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring	X	
	Off-Gas Treatment	Thermal Oxidization	X	
	Off-Gas Treatment	Catalytic Oxidation	X	
	Off-Gas Treatment	Vapor Phase Carbon Adsorption	X	
	Disposal Technologies			
	Discharge to Surface Water	Discharge to Storm Sewer	X	
	Discharge to Surface Water	Discharge to Stream	X	
	Discharge to Groundwater	Injection Well	X	
Surface Water	**Monitoring Options**			
	Monitored Natural Attenuation	Surface Water Monitoring Points	X	
	Attainment Monitoring	Surface Water Monitoring Points	X	
Soil	**No Action**			
	No Action		X	
	Institutional Options			
	Deed Restrictions		X	
	Fencing		X	
	Vapor Barriers for New Structures	Ventilation Systems/Sub-slab Depressurization Systems	X	
	Removal Technologies			
	Extraction	Soil Vapor Extraction	X	
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction	X	
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction	X	
	Thermally-Enhanced Extraction	Steam Flooding		X
	Excavation	Excavation and Offsite Disposal	X	
	Containment Technologies			
	Capping	Concrete Building Foundation Slabs, Asphalt Cap, or Soil Cover	X	
	In-Situ Treatment Technologies:			
	Biological Treatment	Bioventing		X
	Biological Treatment	Phytoremediation		X
	Solidification/Chemical Fixation	Clay/ZVI Admixture	X	
	Physical/Chemical Treatment	Electrokinetic Separation		X
	Physical/Chemical Treatment	Fracturing		X
	Physical/Chemical Treatment	Soil Flushing		X
	Physical/Chemical Treatment	Solidification/Stabilization (In-Situ Vitrification)		X
	Ex-Situ Treatment Technologies			
	Biological Treatment	Biopiles		X
	Biological Treatment	Composting		X
	Biological Treatment	Landfarming		X
	Biological Treatment	Slurry Phase Biological Treatment		X
	Off-Gas Treatment	Air Quality Dispersion Monitoring	X	
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring	X	
	Off-Gas Treatment	Thermal Oxidization	X	
	Off-Gas Treatment	Catalytic Oxidation	X	
	Off-Gas Treatment	Vapor Phase Carbon Adsorption	X	
	Physical/Chemical Treatment	Chemical Extraction		X
	Physical/Chemical Treatment	Chemical Reduction/Oxidation		X
	Physical/Chemical Treatment	Dehalogenation		X
	Physical/Chemical Treatment	Soil Washing		X
	Physical/Chemical Treatment	Solidification/Stabilization		X

TABLE 2.5-1
Identification of Candidate Remedial Technologies
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS / REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POTENTIAL APPLICABILITY TO SITE CONDITIONS? YES	NO
Saturated Zone Sources in Residual Soil and Bedrock	**No Action**			
	No Action		X	
	Institutional Options			
	Deed Restrictions		X	
	Removal Technologies			
	Extraction	Total Fluids Extraction with Vertical Wells		X
	Extraction	Air Sparging/Vapor Extraction	X	
	Extraction	Groundwater Extraction with Vertical Wells	X	
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction	X	
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction	X	
	Thermally-Enhanced Extraction	Steam Flooding		X
	Enhanced Dissolution	Flushing with Treated Groundwater	X	
	Enhanced Dissolution	Surfactant Flushing		X
	Enhanced Dissolution	Cosolvent Flushing		X
	Containment Technologies			
	Hydraulic Control	Horizontal Wells		X
	Hydraulic Control	Groundwater Extraction with Vertical Wells	X	
	Physical Barriers	Grout Curtain Walls	X	
	In-Situ Treatment Technologies:			
	Biological Treatment	Enhanced Bioremediation	X	
	Biological Treatment	Bioaugmentation	X	
	Chemical Treatment	Chemical Reduction	X	
	Chemical Treatment	Chemical Oxidation	X	
	Physical/Chemical Treatment	Fracturing		X
	Physical Treatment	Engineered Permeability Modification	X	
	Physical Treatment	In-Situ Binding	X	
	Ex-Situ Treatment Technologies			
	Physical Treatment	Air Stripping	X	
	Physical Treatment	Aqueous Phase Carbon Adsorption	X	
	Physical Treatment	Filtration	X	
	Physical Treatment	Phase Separation	X	
	Chemical Treatment	UV/Ozonation	X	
	Chemical Treatment	Chemical Oxidization	X	
	Off-Gas Treatment	Air Quality Dispersion Monitoring	X	
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring	X	
	Off-Gas Treatment	Thermal Oxidization	X	
	Off-Gas Treatment	Catalytic Oxidation	X	
	Off-Gas Treatment	Vapor Phase Carbon Adsorption	X	
	Disposal Technologies			
	Discharge to Surface Water	Discharge to Storm Sewer	X	
	Discharge to Surface Water	Discharge to Stream	X	
	Discharge to Groundwater	Injection Well	X	
	Separate Phase Liquid Destruction	Offsite Incineration	X	

TABLE 2.5-2
Screening of Candidate Remedial Technologies
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	RETAINED	NOT RETAINED
Groundwater	**No Action**						
	No Action		Low - Not effective at reducing contamination and risk.	High - No effort required to implement.	Low	X	
	Institutional Options						
	Deed Restrictions		High - Effective at eliminating potential exposure pathways and reducing risk.	High - Land use and activity restrictions can be placed on the deed by the current property owners.	Low	X	
	Annual Inspections	Door-to-Door Surveys/Field Inspections	High - Annual inspections that combine door-to-door/field inspections, questionnaire mailings to residents, and contacts with local water supply purveyors are an effective method of confirming groundwater is not being used by properties in the area of the Site.	High - Similar annual inspection programs have been implemented at similar sites throughout south-central PA.	Low	X	
	Annual Inspections	Questionnaire Mailings				X	
	Annual Inspections	Contact with Local Public Water Purveyor				X	
	Vapor Barriers for New Structures	Vent.Systems/Depressurization Systems	High - Passive ventilation systems, active ventilation systems, and sub-slab depressurization systems are proven effective methods to mitigate the potential for vapors from groundwater to enter buildings.	High - Passive ventilation systems, active ventilation systems, and sub-slab depressurization systems, if deemed necessary, have been installed successfully in new structures throughout the region in similar hydrogeologic settings. The systems can be easily monitored to confirm the vapor intrusion pathway has been mitigated.	Low - Moderate	X	
	Monitoring Options						
	Source Control Effectiveness Monitoring	Multilevel Monitoring System	High - Existing monitoring array expected to effectively demonstrate the results of source control measures.	High - Multi-level monitoring network already in place.	Low	X	
	Monitored Natural Attenuation	Multilevel Monitoring System	High - Existing monitoring array expected to effectively evaluate potential MNA and long term response to selected remedy.	High - Multi-level monitoring network already in place.	Low	X	
	Removal Technologies						
	Extraction	Air Sparging/Vapor Extraction	Low - Effectiveness of this process option is expected to be low based on difficulties in air delivery due to the heterogeneity of the fracture networks in the carbonate and non-carbonate bedrock.	Moderate - Injection wells can be of conventional design, but there must be a sufficient number of vapor extraction wells in the air injection area to capture all the released vapors. It is not known if the overburden permeability above the water table is sufficient to allow capture of the released vapor. Numerous injection wells and vapor extraction points would likely be required to cover the full plume zone.	Moderate - High		X
	Extraction	Groundwater Extraction with Vertical Wells	High - This process option has been demostrated to be an effective method to provide source control and groundwater plume reduction in the northern property boundary area and the TCA Tank Area of the Site.	High - Extraction wells to replace or augment the current collection well system can be of conventional design. Aquifer testing and performance assessment during implementation would be necessary to assess capture.	Moderate	X	
	Extraction	Groundwater Collection Trenches	High - Collection trenches are a proven method for intercepting springs and seeps.	Moderate - Construction of a collection system to intercept springs and seeps can be achieved by using a conventional collection trench design. Current site conditions and the variable nature of spring flow may add difficulty to the implementation of this process option.	Moderate	X	
	Containment Technologies						
	Hydraulic Control	Groundwater Extraction with Vertical Wells	High - This process option has been demonstrated at the site to be an effective method at maintain hydraulic control of groundwater plumes in carbonate and non-carbonate bedrock.	High - This process option has already been implemented at the site.	Low - Moderate	X	
	In-Situ Treatment Technologies:						
	Biological Treatment	Enhanced Bioremediation	Low-Moderate - Proven effective method for enhancing reductive dechlorination at sites with existing reducing conditions and evidence of some reductive dechlorination. Variability in the rate and completeness of reductive dechlorination makes the duration of this process option difficult to predict. Effectiveness likely will be limited near the water table and in carbonate bedrock in the area of transmissive conduits.	Moderate - Injection wells in bedrock can be of conventional design. The locations, numbers, and injection rates of final injection well system must be determined through aquifer testing and performance assessment. It is not certain that conditions promoting reductive dechlorination can be established and maintained throughout the plume zone. Numerous injection wells would likely be required.	Moderate - High	X	
	Biological Treatment	Bioaugmentation	Low - The addition of microbes to enhance the native microbe population has had limited success at other sites where groundwater geochemical conditions are easily maintained. The effectiveness of such a process option at the site is somewhat uncertain and would require a microcosm study. Microbes that are available would not address many of the COCs.	Moderate - Similar to above.	Moderate - High	X	
	Chemical Treatment	Chemical Reduction	Low - Effectiveness will be limited primarily by incomplete contact between the injected reducing agents and the plume constituents because of the heterogeneity of the fracture network and flow pathways.	Moderate - Injection wells in bedrock can be of conventional design located throughout the plume zone. Treatment of full plume zone will be limited by heterogeneity of the fracture network in bedrock. The locations, numbers, and injection rates of the final well system must be determined through aquifer testing and performance assessment. Numerous injection wells would likely be required.	High		X
	Chemical Treatment	Chemical Oxidation	Low - Effectiveness will be limited primarily by incomplete contact between the injected oxidant and the plume constituents because of the heterogeneity of the fracture network and flow pathways.	Moderate - Injection wells in bedrock can be of conventional design located throughout the plume zone. Treatment of full plume zone will be limited by heterogeneity of the fracture network in bedrock. The locations, numbers, and injection rates of the final well system must be determined through aquifer testing and performance assessment. Numerous injection wells would likely be required.	High		X

TABLE 2.5-2
Screening of Candidate Remedial Technologies
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	RETAINED	NOT RETAINED
Groundwater	**Ex-Situ Treatment Technologies**						
	Physical Treatment	Air Stripping	High - Air stripping is a proven technology for the removal of VOCs from groundwater at the concentrations likely to be encountered in extracted groundwater. Its effectiveness for this application at the Site has been demonstrated.	High - Currently implemented at the site. Additional air stripping equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Low	X	
	Physical Treatment	Aqueous Phase Carbon Adsorption	High - GAC is a proven technology for the removal of VOCs from groundwater at the concentrations likely to be encountered in extracted groundwater.	High - GAC treatment equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Low - Moderate	X	
	Physical Treatment	Filtration	High - Filtration is a proven technology for the removal of total dissolved solids at the concentrations likely to be encountered in extracted groundwater.	High - Filtration equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Low	X	
	Chemical Treatment	UV/Ozonation	High - Typically, easily oxidized organic compounds, such as those with double bonds (e.g., TCE, PCE, and vinyl chloride), as well as simple aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in UV/ozonation processes.	Low to Moderate - Requirements for chemical storage and handling may limit implementation of this process option at the site. Implemetation is further limited by potential to precipitate solids and foul treatment equipment. UV/Ozonation equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate		X
	Chemical Treatment	Chemical Oxidization	High - Typically, easily oxidized organic compounds, such as those with double bonds (e.g., TCE, PCE, and vinyl chloride), as well as simple aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in chemical oxidation processes.	Low to Moderate - Requirements for chemical storage and handling may limit implementation of this process option at the site. Implemetation is further limited by potential to precipitate solids and foul treatment equipment. Oxidation equipment is readily available and can be installed in a treatment facility such as the one that has already been constructed at the Site. The aqueous stream being treated must provide for good transmission of UV light (high turbidity causes interference).	Moderate		X
	Off-Gas Treatment	Air Quality Dispersion Monitoring	High - Proven method for assessing off-gas dispersion for VOC treatment systems.	High - Screening level dispersion models area available at no cost from EPA. Meteorological data needed to run dispersion models is collected on site.	Low	X	
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring	High - Proven method for monitoring effectiveness of off-gas from VOC treatment systems.	High - easily implemented if required for monitoring off-gas of air stripper and SVE systems.	Low	X	
	Off-Gas Treatment	Thermal Oxidization	High - Thermal oxidation is effective for off-gas treatment of VOCs. Its use is increasing among remediation equipment vendors, and several variations in design are being marketed. Growing applications include treatment of air stripper and vacuum extraction gas-phase emissions.	High - Thermal oxidization equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate - High	X	
	Off-Gas Treatment	Catalytic Oxidation	Moderate to High - Catalytic oxidation is a mature technology, and its status as an implementable technology is well established. Nevertheless, the technology continues to evolve with respect to heat recovery techniques, catalysts to increase destruction efficiency and/or to extend the operating life of the catalyst bed, and performance data on a wider range of VOCs.	High - Catalytic oxidization equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate - High		X
	Off-Gas Treatment	Vapor Phase Carbon Adsorption	High - Effective at treating off-gas from VOC air stripping equipment and vapor extraction systems, and is successfully being used on this Site.	High - Equipment and carbon replacement services are readily available.	Moderate	X	
	Disposal Technologies						
	Discharge to Surface Water	Discharge to Storm Sewer	High - The storm sewer system in the area of the site is expected to be able to effectively convey treated groundwater from the site.	Moderate-High - Requires construction of a conveyance line and NPDES permitted outfall. Implementability of this process option varies depending on the location of the treatment system discharge relative to the existing storm sewer system.	Moderate - High	X	
	Discharge to Surface Water	Discharge to Stream	High - The existing discharge to Codorus Creek has been effective in conveying treated groundwater to surface water.	High - A conveyance line already exists that transports treated groundwater to Codorus Creek.	Low	X	
	Discharge to Groundwater	Injection Well	High - Process option proven to be an effective method at discharging treated groundwater. Design of this process option requires an assessment of pre-injection treatment requirements such as, filtration to lower total dissolved solids, pH adjustment, and/or temperature adjustment.	High - Injection wells in bedrock can be of conventional design. The locations, numbers, and injection rates of the final well system must be determined through aquifer testing and performance assessment.	Moderate - High	X	
Surface Water	**Monitoring Options**						
	Monitored Natural Attenuation	Surface Water Monitoring Points	High - Surface water monitoring network can be established based on the understanding of interactions between groundwater plumes and surface water stream segments gained through groundwater extraction well shutdown tests and dye tracer studies.	High - Current surface water monitoring network has demonstrated the implementability of this process option.	Low	X	
	Attainment Monitoring	Surface Water Monitoring Points	High - Surface water monitoring network can be established based on the understanding of interactions between groundwater plumes and surface water stream segments gained through groundwater extraction well shutdown tests and dye tracer studies.	High - Current surface water monitoring network has demonstrated the implementability of this process option.	Low	X	

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Screening of Candidate Remedial Technologies
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	RETAINED	NOT RETAINED
Soil	**No Action**						
	No Action		Low - Not effective at reducing contamination and risk.	High - No effort required to implement.	Low	X	
	Institutional Options						
	Deed Restrictions		High - Effective at eliminating potential exposure pathways and reducing risk.	High - Land use and activity restrictions can be placed on the deed by the current property owners.	Low	X	
	Fencing		High - Effective at limiting access and reducing human health risk.	High - The portion of the site currently owned by Harley-Davidison is surrounded by fencing.	Low	X	
	Vapor Barriers for New Structures	Vent.Systems/Depressurization Systems	High - Passive ventilation systems, active ventilation systems, and sub-slab depressurization systems are proven effective methods to mitigate the potential for vapors from soil to enter buildings.	High - Passive ventilation systems, active ventilation systems, and sub-slab depressurization systems, if deemed necessary, have been installed successfully in new structures throughout the region in similar hydrogeologic settings. The systems can be easily monitored to confirm the vapor intrusion pathway has been mitigated.	Low - Moderate	X	
	Removal Technologies						
	Extraction	Soil Vapor Extraction	Moderate - SVE is a treatment technology that has demonstrated effectiveness, typically over long-term implementation, for the removal of VOCs from the vadose zone. Effectives of this process option is limited at sites with fine-grained and/or stratified vadose zone soils.	Moderate - A field pilot study is necessary to establish the feasibility of the method as well as to obtain information necessary to design and configure the system. For the soil surface, geomembrane covers placed over soil surface to prevent short circuiting and to increase the radius of influence of the wells may be employed. Off-gas treatment, if required, may add to the cost and implementability.	Moderate - High	X	
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction	High - Process option has proven to be effective at removing VOCs from fine-grained and startified vadose zone soils.	Moderate - Site access sufficient for application of this process option but installation of numerous heater wells and extraction wells could result in sinkhole formation.	High	X	
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction	High - Process option has proven to be effective at removing VOCs from fine-grained and startified vadose zone soils.	Moderate - Site access sufficient for application of this process option but installation of numerous electrode boreholes and sheet piles could result in sinkhole formation.	High	X	
	Excavation	Excavation and Offsite Disposal	High - Excavation and offsite disposal is a proven technology for the reduction of source material in soil.	Moderate - This process option can be implemented in the undeveloped landfill area in the eastern portion of the site. Application of this process option in the West Parking Lot portion of the site could be limited by Site access constraints due to roadway and underground utility structures. Additional soil borings may be required to further delineate soil excavation limits in both areas of the site. Depth of source zones in the West Parking Lot Area may further limit implementation of this process option.	Low - High	X	
	Containment Technologies						
	Capping	Concrete Building Foundation Slabs, Asphalt Cap, or Soil Cover	Moderate - Capping is an effective process option for eliminating risk of direct contact to contaminated soil and limiting vertical infiltration of precipitation and mobilization of COCs to groundwater.	High - Concrete building foundation slabs, paved asphalt roadway and parking lots alreaqdy exist in potential source areas in the western portion fo the site. The are no site access constraints that with limit the feasibility of capping the landfill area in the eastern portion of the site. These features, however must be inspected and maintained.	Low - Moderate	X	
	In-Situ Treatment Technologies:						
	Solidification/Chemical Fixation	Clay/ZVI Admixture	Moderate - This process option has some demonstrated effectiveness in treatment of shallow VOC source zones in soil.	Low - This process option results in atreatment zone with clay, zero-valent iron, and site soil with low compressive and sheaqr strength. Resulting soil structure is unable to support redevelopment options such as parking lots, roadways, and/or buidlings.			X
	Ex-Situ Treatment Technologies						
	Off-Gas Treatment	Air Quality Dispersion Monitoring	High - Proven method for assessing off-gas dispersion for VOC treatment systems.	High - Screening level dispersion models area available at no cost from EPA. Meteorological data needed to run dispersion models is collected on site.	Low	X	
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring	High - Proven method for monitoring effectiveness of off-gas from VOC treatment systems.	High - easily implemented if required for monitoring off-gas of air stripper and SVE systems.	Low	X	
	Off-Gas Treatment	Thermal Oxidization	High - Thermal oxidation is effective for off-gas treatment of VOCs. Its use is increasing among remediation equipment vendors, and several variations in design are being marketed. Growing applications include treatment of air stripper and vacuum extraction gas-phase emissions.	High - Thermal oxidization equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate - High	X	
	Off-Gas Treatment	Catalytic Oxidation	Moderate to High - Catalytic oxidation is a mature technology, and its status as an implementable technology is well established. Nevertheless, the technology continues to evolve with respect to heat recovery techniques, catalysts to increase destruction efficiency and/or to extend the operating life of the catalyst bed, and performance data on a wider range of VOCs.	High - Catalytic oxidization equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate - High		X
	Off-Gas Treatment	Vapor Phase Carbon Adsorption	High - Effective at treating off-gas from VOC air stripping equipment and vapor extraction systems.	High - Equipment and carbon replacement services are readily available.	Moderate	X	

TABLE 2.5-2
Screening of Candidate Remedial Technologies
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	RETAINED	NOT RETAINED
Saturated Zone Sources in Residual Soil and Bedrock	**No Action**						
	No Action		Low - Not effective at reducing contamination and risk.	High - No effort required to implement.	Low	X	
	Institutional Options						
	Deed Restrictions		High - Effective at eliminating potential exposure pathways and reducing risk.	High - Land use and activity restrictions can be placed on the deed by the current property owners.	Low	X	
	Removal Technologies						
	Extraction	Air Sparging/Vapor Extraction	Low - Effectiveness of this process option is expected to be low based on difficulties in air delivery due to the heterogeneity of the fracture networks in carbonate and non-carbonate bedrock source areas.	Low - Injection wells can be of conventional design, but there must be a sufficient number of vapor extraction wells in the air injection area to capture all the released vapors. Hetreogeniety of bedrock fracturing in carbonate and non-carbonate bedrock source zones would likely severely limit implementation of this process option at the site.	Moderate - High		X
	Extraction	Groundwater Extraction with Vertical Wells	Moderate - High - The effectiveness of groundwater pumping for removal of source material will be limited by the uncertainty of the location and depth of the source area and the heterogeneity of the fracture network.	High - Pumping wells in bedrock can be of conventional design but located primarily within or close to the source area.	Moderate - High	X	
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction	Low - High - Process option has proven to be effective at removing VOCs from fractured bedrock. Effectiveness of this process option in carbonate bedrock source areas with numerous highly transmissive voids is uncertain.	Moderate - Site access sufficient for application of this process option but installation of numerous heater wells and extraction wells could be difficult in carbonate bedrock.	High	X	
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction	Low - High - Process option has proven to be effective at removing VOCs from fractured bedrock. Effectiveness of this process option in carbonate bedrock source areas with numerous highly transmissive voids is uncertain.	Moderate - Site access sufficient for application of this process option but installation of numerous heater wells and extraction wells could be difficult in carbonate bedrock.	High	X	
	Enhanced Dissolution	Flushing with Treated Groundwater	High - Flushing with treated groundwater has been demostrated to be an effective source reduction technique by enhanced the rate of NAPL dissolution and enhancing the chemical gradients driving the rates of back diffusion and desorption from source zones.	Moderate - Injection wells near source zones can be of conventional design. The locations, numbers, and injection rates of final injection well system must be determined through aquifer testing and performance assessment.	Moderate - High	X	
	Containment Technologies						
	Hydraulic Control	Groundwater Extraction with Vertical Wells	High - This process option is proven to be effective as a source reduction technology for sites with VOCs in fractured bedrock.	High - This process option has already been implemented in nearby plume areas of the site.	Low - Moderate	X	
	Physical Barriers	Grout Curtain Walls	Low - High - Process option is effective in site settings with discrete bedrock fracturing. Application of this process option in highly fractured non-carbonate or carbonate bedrock settings requires a detailed understanding of the geometry of fractures and conduits and their relationship to fully delineate source zones.	Low - The lack of a detailed delineation of source zones and the presence of up to 10% voids in the carbonate bedrock severely limits potential implementation of this process option at the site.	High		X
	In-Situ Treatment Technologies:						
	Biological Treatment	Enhanced Bioremediation	Low-Moderate - Proven effective method for enhancing reductive dechlorination at sites with existing reducing conditions and evidence of some reductive dechlorination. Variability in the rate and completeness of reductive dechlorination makes the duration of this process option difficult to predict. Effectiveness likely will be limited near the water table and in carbonate bedrock in the area of transmissive conduits (potential for flushing of microbial population).	Moderate - Injection wells in bedrock can be of conventional design. The locations, numbers, and injection rates of final injection well system must be determined through aquifer testing and performance assessment. It is not certain that conditions promoting reductive dechlorination can be established and maintained throughout the residual soil and fractured bedrock source zones. Numerous injection wells would likely be required.	Moderate - High		X
	Biological Treatment	Bioaugmentation	Low - The addition of microbes to enhance the native microbe population has had limited success at other sites where groundwater geochemical conditions are easily maintained. The effectiveness of such a process option at the site is somewhat uncertain and would require a microcosm study. Microbes that are available would not address many of the COCs.	Moderate - Similar to above.	Moderate - High		X
	Chemical Treatment	Chemical Reduction	Low - Effectiveness of this process option is limited in settings with residual soil and bedrock source zones primarily due to incomplete contact between the injected reducing agents and the source material.	Moderate - Injection wells in bedrock can be of conventional design located within the source zones. Treatment of the source zones will be limited by heterogeneity of the fracture network in bedrock. The locations, numbers, and injection rates of the final well system must be determined through aquifer testing and performance assessment. Numerous injection wells would likely be required.	High		X
	Chemical Treatment	Chemical Oxidation	Low - Effectiveness of this process option is limited in settings with residual soil and bedrock source zones primarily due to incomplete contact between the injected oxidants and the source material.	Moderate - Injection wells in bedrock can be of conventional design located throughout the source zones. Treatment of the source zones will be limited by heterogeneity of the fracture network in bedrock. The locations, numbers, and injection rates of the final well system must be determined through aquifer testing and performance assessment. Numerous injection wells would likely be required.	High		X
	Physical Treatment	Engineered Permeability Modification	Low - Grouting of discrete conduits in karst bedrock has a long and proven track record but case studies of the application of this geotechnical engineering process option to reduce groundwater flow through discrete DNAPL source zones are unavailable. Application of this technology without complete delineation of DNAPL source zones would have the potential to displace DNAPL and create new source zones and potentially increase rather than decrease mass flux to potential downgradient receptors.	Low - The lack of a detailed delineation of source zones and the presence of up to 10% voids in the carbonate bedrock severely limits potential implementation of this process option at the site.	Moderate - High		X

TABLE 2.5-2
Screening of Candidate Remedial Technologies
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	RELATIVE COST	RETAINED	NOT RETAINED
Saturated Zone Sources in Residual Soil and Bedrock	Physical Treatment	In-Situ Binding	Low - Application of admixtures to discrete conduits in Karst bedrock has a proven track record but case studies demonstrating application of this geotechnical engineering process option to create low permeability and/or reactive zones to bind or destroy source zone COCs located in clay-, silt-, sand-, and/or gravel-filled discrete conduits in karst bedrock are unavailable. Application of this technology without complete delineation of DNAPL source zones would have the potential to displace DNAPL and create new source zones and potentially increase rather than decrease mass flux to potential downgradient receptors.	Low - The lack of a detailed delineation of source zones and the presence of up to 10% voids in the carbonate bedrock severely limits potential implementation of this process option at the site.	Moderate - High		X
	Ex-Situ Treatment Technologies						
	Physical Treatment	Air Stripping	High - Air stripping is a proven technology for the removal of VOCs from groundwater at the concentrations likely to be encountered in extracted groundwater. Its effectiveness for this application at the Site has been demonstrated.	High - Currently implemented at the site. Additional air stripping equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Low	X	
	Physical Treatment	Aqueous Phase Carbon Adsorption	High - GAC is a proven technology for the removal of VOCs from groundwater at the concentrations likely to be encountered in extracted groundwater.	High - GAC treatment equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Low - Moderate	X	
	Physical Treatment	Filtration	High - Filtration is a proven technology for the removal of total dissolved solids at the concentrations likely to be encountered in extracted groundwater.	High - Filtration equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Low	X	
	Physical Treatment	Phase Separation	High - Phase separation is a proven technology for the separation of aqueous and non-aqueous components of extracted fluids.	High - Phase separation equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate	X	
	Chemical Treatment	UV/Ozonation	High - Typically, easily oxidized organic compounds, such as those with double bonds (e.g., TCE, PCE, and vinyl chloride), as well as simple aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in UV/ozonation processes.	Low to Moderate - Requirements for chemical storage and handling may limit implementation of this process option at the site. Implemetation is further limited by potential to precipitate solids and foul treatment equipment. UV/Ozonation equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate		X
	Chemical Treatment	Chemical Oxidization	High - Typically, easily oxidized organic compounds, such as those with double bonds (e.g., TCE, PCE, and vinyl chloride), as well as simple aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in UV/oxidation processes.	Low to Moderate - Requirements for chemical storage and handling may limit implementation of this process option at the site. Implemetation is further limited by potential to precipitate solids and foul treatment equipment. Oxidation equipment is readily available and can be installed in a treatment facility such as the one that has already been constructed at the Site. The aqueous stream being treated must provide for good transmission of UV light (high turbidity causes interference).	Moderate		X
	Off-Gas Treatment	Air Quality Dispersion Monitoring	High - Proven method for assessing off-gas dispersion for VOC treatment systems.	High - Screening level dispersion models area available at no cost from EPA. Meteorological data needed to run dispersion models is collected on site.	Low	X	
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring	High - Proven method for monitoring effectiveness of off-gas from VOC treatment systems.	High - easily implemented if required for monitoring off-gas of air stripper and SVE systems.	Low	X	
	Off-Gas Treatment	Thermal Oxidization	High - Thermal oxidation is effective for off-gas treatment of VOCs. Its use is increasing among remediation equipment vendors, and several variations in design are being marketed. Growing applications include treatment of air stripper and vacuum extraction gas-phase emissions.	High - Thermal oxidization equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate - High	X	
	Off-Gas Treatment	Catalytic Oxidation	Moderate to High - Catalytic oxidation is a mature technology, and its status as an implementable technology is well established. Nevertheless, the technology continues to evolve with respect to heat recovery techniques, catalysts to increase destruction efficiency and/or to extend the operating life of the catalyst bed, and performance data on a wider range of VOCs.	High - Catalytic oxidization equipment is readily available and can be installed in a treatment facility such as the one at the Site.	Moderate - High		X
	Off-Gas Treatment	Vapor Phase Carbon Adsorption	High - Effective at treating off-gas from VOC air stripping equipment and vapor extraction systems.	High - Equipment and carbon replacement services are readily available.	Moderate	X	
	Disposal Technologies						
	Discharge to Surface Water	Discharge to Storm Sewer	High - The storm sewer system in the area of the site is expected to be able to effectively convey treated groundwater from the site.	Moderate-High - Requires construction of a conveyance line and NPDES permitted outfall. Implementability of this process option varies depending on the location of the treatment system discharge relative to the existing storm sewer system.	Moderate - High		X
	Discharge to Surface Water	Discharge to Stream	High - The existing discharge to Codorus Creek has been effective in conveying treated groundwater to surface water.	High - A conveyance line already exists that transports treated groundwater to Codorus Creek.	Low	X	
	Discharge to Groundwater	Injection Well	High - Process option proven to be an effective method at discharging treated groundwater. Design of this process option requires an assessment of pre-injection treatment requirements such as, filtration to lower total dissolved solids, pH adjustment, and/or temperature adjustment.	High - Injection wells in bedrock can be of conventional design. The locations, numbers, and injection rates of the final well system must be determined through aquifer testing and performance assessment.	Moderate - High	X	
	Separate Phase Liquid Destruction	Offsite Incineration	High - Incineration is a proven technology for the destruction of separate phase VOCs.	High - Transportation and incineration services are both readily available to manage separate phase liquid generated at the site.	Moderate	X	

TABLE 3.1-1
Development of Remedial Alternatives - NPBA
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POSSIBLE REMEDIAL ALTERNATIVES 1. No Action	2. Institutional Controls	3. MNA	4. MNA w/ Enhanced Biodegradation	5. Resumption of Groundwater Extraction & Treatment
NORTHEAST PROPERTY BOUNDARY AREA (NPBA)							
Groundwater	**No Action**						
	No Action		X				
	Institutional Options						
	Deed Restrictions			X	X	X	X
	Annual Inspections	Door-to-Door Surveys/Field Inspections					
	Annual Inspections	Questionnaire Mailings					
	Annual Inspections	Contact with Local Public Water Purveyor					
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems					
	Monitoring Options						
	Source Control Effectiveness Monitoring	Multilevel Monitoring System					X
	Monitored Natural Attenuation	Multilevel Monitoring System			X	X	X
	Removal Technologies						
	Extraction	Groundwater Extraction with Vertical Wells					X
	Extraction	Collection Trenches					
	Containment Technologies						
	Hydraulic Control	Vertical Wells					X
	In-Situ Treatment Technologies:						
	Biological Treatment	Enhanced Bioremediation				X	
	Biological Treatment	Bioaugmentation				X	
	Ex-Situ Treatment Technologies						
	Physical Treatment	Air Stripping					X
	Physical Treatment	Aqueous Phase Carbon Adsorption					X
	Physical Treatment	Filtration					X
	Off-Gas Treatment	Air Quality Dispersion Monitoring					
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring					
	Off-Gas Treatment	Thermal Oxidization					
	Off-Gas Treatment	Vapor Phase Carbon Adsorption					X
	Disposal Technologies						
	Discharge to Surface Water	Discharge to Storm Sewer					
	Discharge to Surface Water	Discharge to Stream					X
	Discharge to Groundwater	Injection Well					
Soil	**No Action**						
	No Action		X				
	Institutional Options						
	Deed Restrictions			X	X	X	X
	Fencing		Existing	Existing	Existing	Existing	Existing
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems					
	Removal Technologies						
	Extraction	Soil Vapor Extraction					
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction					
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction					
	Excavation	Excavation and Offsite Disposal					
	Containment Technologies						
	Capping	Concrete Building Foundation Slabs, Asphalt Cap, or Soil Cover					
	Ex-Situ Treatment Technologies						
	Off-Gas Treatment	Air Quality Dispersion Monitoring					
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring					
	Off-Gas Treatment	Thermal Oxidization					
	Off-Gas Treatment	Vapor Phase Carbon Adsorption					

TABLE 3.2-1
Development of Remedial Alternatives - Eastern Area
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POSSIBLE REMEDIAL ALTERNATIVES					
			1. No Action	2. Institutional Controls	3. MNA	4. MNA w/ Enhanced Biodegradation	5. Landfill Capping	6. Landfill Excavation
EASTERN AREA								
Groundwater	**No Action**							
	No Action		X					
	Institutional Options							
	Deed Restrictions			X	X	X	X	X
	Annual Inspections	Door-to-Door Surveys/Field Inspections						
	Annual Inspections	Questionnaire Mailings						
	Annual Inspections	Contact with Local Public Water Purveyor						
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems						
	Monitoring Options							
	Source Control Effectiveness Monitoring	Multilevel Monitoring System						
	Monitored Natural Attenuation	Multilevel Monitoring System			X	X	X	X
	Removal Technologies							
	Extraction	Groundwater Extraction with Vertical Wells						
	Extraction	Collection Trenches						
	Containment Technologies							
	Hydraulic Control	Vertical Wells						
	In-Situ Treatment Technologies:							
	Biological Treatment	Enhanced Bioremediation				X		
	Biological Treatment	Bioaugmentation				X		
	Ex-Situ Treatment Technologies							
	Physical Treatment	Air Stripping						
	Physical Treatment	Aqueous Phase Carbon Adsorption						
	Physical Treatment	Filtration						
	Off-Gas Treatment	Air Quality Dispersion Monitoring						
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring						
	Off-Gas Treatment	Thermal Oxidization						
	Off-Gas Treatment	Vapor Phase Carbon Adsorption						
	Disposal Technologies							
	Discharge to Surface Water	Discharge to Storm Sewer						
	Discharge to Surface Water	Discharge to Stream						
	Discharge to Groundwater	Injection Well						
Soil	**No Action**							
	No Action		X					
	Institutional Options							
	Deed Restrictions			X	X	X	X	X
	Fencing		Existing	Existing	Existing	Existing	Existing	Existing
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems						
	Removal Technologies							
	Extraction	Soil Vapor Extraction						
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction						
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction						
	Excavation	Excavation and Offsite Disposal						X
	Containment Technologies							
	Capping	Concrete Building Foundation Slabs, Asphalt Cap, or Soil Cover					X	
	Ex-Situ Treatment Technologies							
	Off-Gas Treatment	Air Quality Dispersion Monitoring						
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring						
	Off-Gas Treatment	Thermal Oxidization						
	Off-Gas Treatment	Vapor Phase Carbon Adsorption						

TABLE 3.3-1
Development of Remedial Alternatives - SPBA and SPA
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POSSIBLE REMEDIAL ALTERNATIVES 1. No Action	2. Institutional Controls	3. MNA	4. MNA w/ Enhanced Biodegradation	5. Groundwater Extraction & Treatment for Source Control	6. Groundwater Extraction & Treatment for Source Control & Plume Reduction
SOUTHEAST PROPERTY BOUNDARY AREA (SPBA) AND SOUTH PLUME AREA (SPA)								
Groundwater	**No Action**							
	No Action		X					
	Institutional Options							
	Deed Restrictions			X	X	X	X	X
	Annual Inspections	Door-to-Door Surveys/Field Inspections		X	X	X	X	X
	Annual Inspections	Questionnaire Mailings		X	X	X	X	X
	Annual Inspections	Contact with Local Public Water Purveyor		X	X	X	X	X
	Monitoring Options							
	Source Control Effectiveness Monitoring	Multilevel Monitoring System					X	X
	Monitored Natural Attenuation	Multilevel Monitoring System			X	X		
	Removal Technologies							
	Extraction	Groundwater Extraction with Vertical Wells					X	X
	Extraction	Collection Trenches						
	Containment Technologies							
	Hydraulic Control	Vertical Wells					X	X
	In-Situ Treatment Technologies:							
	Biological Treatment	Enhanced Bioremediation				X		
	Biological Treatment	Bioaugmentation				X		
	Ex-Situ Treatment Technologies							
	Physical Treatment	Air Stripping					X	X
	Physical Treatment	Aqueous Phase Carbon Adsorption					X	X
	Physical Treatment	Filtration					X	X
	Off-Gas Treatment	Air Quality Dispersion Monitoring						
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring						
	Off-Gas Treatment	Thermal Oxidization						
	Off-Gas Treatment	Vapor Phase Carbon Adsorption					X	X
	Disposal Technologies							
	Discharge to Surface Water	Discharge to Storm Sewer					X	X
	Discharge to Surface Water	Discharge to Stream						
	Discharge to Groundwater	Injection Well						
Soil	**No Action**							
	No Action		X					
	Institutional Options							
	Deed Restrictions			X	X	X	X	X
	Fencing		Existing	Existing	Existing	Existing	Existing	Existing
	Removal Technologies							
	Extraction	Soil Vapor Extraction						
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction						
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction						
	Excavation	Excavation and Offsite Disposal						
	Containment Technologies							
	Capping	Concrete Building Foundation Slabs, Asphalt Cap, or Soil Cover						
	Ex-Situ Treatment Technologies							
	Off-Gas Treatment	Air Quality Dispersion Monitoring						
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring						
	Off-Gas Treatment	Thermal Oxidization						
	Off-Gas Treatment	Vapor Phase Carbon Adsorption						

TABLE 3.4-1
Development of Remedial Alternatives - BSRA
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POSSIBLE REMEDIAL ALTERNATIVES				
			1. No Action	2. Institutional Controls	3. MNA	4. MNA w/ Enhanced Biodegradation	5. Spring Water Collection & Treatment
BUNKER AND SHELL RANGE AREA (BSRA)							
Groundwater	**No Action**						
	No Action		X				
	Institutional Options						
	Deed Restrictions			X	X	X	X
	Annual Inspections	Door-to-Door Surveys/Field Inspections					
	Annual Inspections	Questionnaire Mailings					
	Annual Inspections	Contact with Local Public Water Purveyor					
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems					
	Monitoring Options						
	Source Control Effectiveness Monitoring	Multilevel Monitoring System					
	Monitored Natural Attenuation	Multilevel Monitoring System			X	X	X
	Removal Technologies						
	Extraction	Groundwater Extraction with Vertical Wells					
	Extraction	Collection Trenches					X
	Containment Technologies						
	Hydraulic Control	Vertical Wells					
	In-Situ Treatment Technologies:						
	Biological Treatment	Enhanced Bioremediation				X	
	Biological Treatment	Bioaugmentation				X	
	Ex-Situ Treatment Technologies						
	Physical Treatment	Air Stripping					X
	Physical Treatment	Aqueous Phase Carbon Adsorption					X
	Physical Treatment	Filtration					X
	Off-Gas Treatment	Air Quality Dispersion Monitoring					
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring					
	Off-Gas Treatment	Thermal Oxidization					
	Off-Gas Treatment	Vapor Phase Carbon Adsorption					X
	Disposal Technologies						
	Discharge to Surface Water	Discharge to Storm Sewer					
	Discharge to Surface Water	Discharge to Stream					X
	Discharge to Groundwater	Injection Well					
Surface Water	**Monitoring Options**						
	Monitored Natural Attenuation	Surface Water Monitoring Points			X	X	
	Attainment Monitoring	Surface Water Monitoring Points			X	X	X
Soil	**No Action**						
	No Action		X				
	Institutional Options						
	Deed Restrictions			X	X	X	X
	Fencing		Existing	Existing	Existing	Exisitng	Existing
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems					
	Removal Technologies						
	Extraction	Soil Vapor Extraction					
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction					
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction					
	Excavation	Excavation and Offsite Disposal					
	Containment Technologies						
	Capping	Concrete Building Foundation Slabs, Asphalt Cap, or Soil Cover					
	Ex-Situ Treatment Technologies						
	Off-Gas Treatment	Air Quality Dispersion Monitoring					
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring					
	Off-Gas Treatment	Thermal Oxidization					
	Off-Gas Treatment	Vapor Phase Carbon Adsorption					

TABLE 3.5-1
Development of Remedial Alternatives - NETT
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS / REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POSSIBLE REMEDIAL ALTERNATIVES			
			1. No Action	2. Institutional Controls	3. MNA	4. MNA w/ Enhanced Biodegradation
NORTH END TEST TRACK (NETT)						
Groundwater	**No Action**					
	No Action		X			
	Institutional Options					
	Deed Restrictions			X	X	X
	Annual Inspections	Door-to-Door Surveys/Field Inspections				
	Annual Inspections	Questionnaire Mailings				
	Annual Inspections	Contact with Local Public Water Purveyor				
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems				
	Monitoring Options					
	Source Control Effectiveness Monitoring	Multilevel Monitoring System				
	Monitored Natural Attenuation	Multilevel Monitoring System			X	X
	Removal Technologies					
	Extraction	Groundwater Extraction with Vertical Wells				
	Extraction	Collection Trenches				
	Containment Technologies					
	Hydraulic Control	Vertical Wells				
	In-Situ Treatment Technologies:					
	Biological Treatment	Enhanced Bioremediation				X
	Biological Treatment	Bioaugmentation				X
	Ex-Situ Treatment Technologies					
	Physical Treatment	Air Stripping				
	Physical Treatment	Aqueous Phase Carbon Adsorption				
	Physical Treatment	Filtration				
	Off-Gas Treatment	Air Quality Dispersion Monitoring				
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring				
	Off-Gas Treatment	Thermal Oxidization				
	Off-Gas Treatment	Vapor Phase Carbon Adsorption				
	Disposal Technologies					
	Discharge to Surface Water	Discharge to Storm Sewer				
	Discharge to Surface Water	Discharge to Stream				
	Discharge to Groundwater	Injection Well				
Soil	**No Action**					
	No Action		X			
	Institutional Options					
	Deed Restrictions			X	X	X
	Fencing		Existing	Existing	Existing	Exisitng
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems				
	Removal Technologies					
	Extraction	Soil Vapor Extraction				
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction				
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction				
	Excavation	Excavation and Offsite Disposal				
	Containment Technologies					
	Capping	Concrete Building Foundation Slabs, Asphalt Cap, or Soil Cover				
	Ex-Situ Treatment Technologies					
	Off-Gas Treatment	Air Quality Dispersion Monitoring				
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring				
	Off-Gas Treatment	Thermal Oxidization				
	Off-Gas Treatment	Vapor Phase Carbon Adsorption				

TABLE 3.6-1
Development of Remedial Alternatives - WPA
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

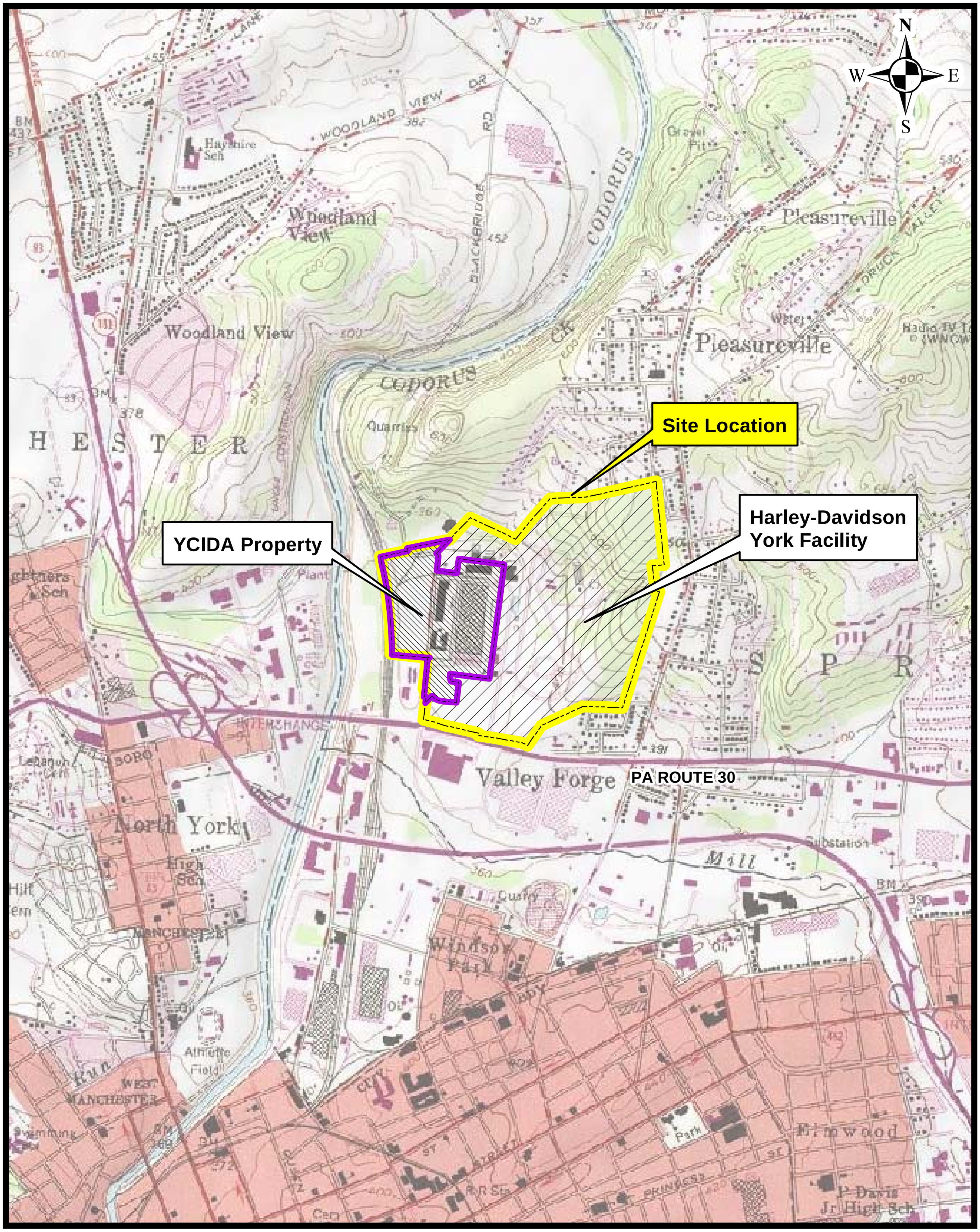
ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POSSIBLE REMEDIAL ALTERNATIVES								
			1. No Action	2. Institutional Controls	3. MNA w/ Groundwater Flux Monitoring	4. MNA w/ Enhanced Biodegradation	5. Hot Spot Soil Vapor Extraction in WPL	6. Groundwater Extraction & Treatment	7. Hot Spot Extraction and Injection	8. Hot Spot Thermal Treatment	9. Point Source Treatment of Spring Discharges
WESTERN PROPERTY AREA (WPA)											
Groundwater	**No Action**										
	No Action		X								
	Institutional Options										
	Deed Restrictions			X	X	X	X	X	X	X	X
	Annual Inspections	Field Inspections		X	X	X	X	X	X	X	X
	Annual Inspections	Questionnaire Mailings		X	X	X	X	X	X	X	X
	Annual Inspections	Contact with Local Public Water Purveyor		X	X	X	X	X	X	X	X
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems									
	Monitoring Options										
	Source Control Effectiveness Monitoring	Multilevel Monitoring System						X	X	X	
	Monitored Natural Attenuation	Multilevel Monitoring System			X	X	X	X	X	X	X
	Removal Technologies										
	Extraction	Groundwater Extraction with Vertical Wells						X	X	X	X
	Extraction	Collection Trenches									X
	Containment Technologies										
	Hydraulic Control	Vertical Wells						X	X	X	X
	In-Situ Treatment Technologies:										
	Biological Treatment	Enhanced Bioremediation				X					
	Biological Treatment	Bioaugmentation				X					
	Ex-Situ Treatment Technologies										
	Physical Treatment	Air Stripping						X	X	X	X
	Physical Treatment	Aqueous Phase Carbon Adsorption								X	X
	Physical Treatment	Filtration								X	
	Off-Gas Treatment	Air Quality Dispersion Monitoring								X	
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring								X	
	Off-Gas Treatment	Thermal Oxidization								X	
	Off-Gas Treatment	Vapor Phase Carbon Adsorption						X	X	X	X
	Disposal Technologies										
	Discharge to Surface Water	Discharge to Storm Sewer									
	Discharge to Surface Water	Discharge to Stream						X	X	X	X
	Discharge to Groundwater	Injection Well							X		
Surface Water	**Monitoring Options**										
	Monitored Natural Attenuation	Surface Water Monitoring Points									
	Attainment Monitoring	Surface Water Monitoring Points			X	X	X	X	X	X	X
Soil	**No Action**										
	No Action		X								
	Institutional Options										
	Deed Restrictions (see Note #1)			X	X	X	X	X	X	X	X
	Fencing										
	Vapor Barriers for New Structures	Ventilation Systems/Depressurization Systems									
	Removal Technologies										
	Extraction	Soil Vapor Extraction					X				
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction									
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction									
	Excavation	Excavation and Offsite Disposal									
	Containment Technologies										
	Capping (see Note #2)	Concrete Building Foundation Slabs, Asphalt Cap, or Soil Cover	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Existing
	Ex-Situ Treatment Technologies										
	Off-Gas Treatment	Air Quality Dispersion Monitoring					X				
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring					X				
	Off-Gas Treatment	Thermal Oxidization					X				
	Off-Gas Treatment	Vapor Phase Carbon Adsorption					X				

TABLE 3.6-1
Development of Remedial Alternatives - WPA
fYNOP, 1425 Eden Road, Springettsbury Township, York, PA

ENVIRONMENTAL MEDIUM	GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS	POSSIBLE REMEDIAL ALTERNATIVES								
			1. No Action	2. Institutional Controls	3. MNA w/ Groundwater Flux Monitoring	4. MNA w/ Enhanced Biodegradation	5. Hot Spot Soil Vapor Extraction in WPL	6. Groundwater Extraction & Treatment	7. Hot Spot Extraction and Injection	8. Hot Spot Thermal Treatment	9. Point Source Treatment of Spring Discharges
Saturated Zone Sources in Residual Soil and Bedrock	**No Action**										
	No Action		X								
	Institutional Options										
	Deed Restrictions			X	X	X	X	X	X	X	X
	Removal Technologies										
	Extraction	Groundwater Extraction with Vertical Wells						X	X	X	X
	Thermally-Enhanced Extraction	In-Situ Thermal Desorption (ISTD) with Vapor Extraction								X	
	Thermally-Enhanced Extraction	Electrical Resistance Heating (ERH) with Vapor Extraction								X	
	Enhanced Dissolution	Flushing with Treated Groundwater							X		
	Containment Technologies										
	Hydraulic Control	Groundwater Extraction with Vertical Wells						X		X	X
	Ex-Situ Treatment Technologies										
	Physical Treatment	Air Stripping						X		X	X
	Physical Treatment	Carbon Adsorption							X	X	X
	Physical Treatment	Filtration								X	
	Physical Treatment	Phase Separation								X	
	Off-Gas Treatment	Air Quality Dispersion Monitoring								X	
	Off-Gas Treatment	Off-Gas Influent and Effluent Monitoring								X	
	Off-Gas Treatment	Thermal Oxidization								X	
	Off-Gas Treatment	Vapor Phase Carbon Adsorption						X		X	X
	Disposal Technologies										
	Discharge to Surface Water	Discharge to Storm Sewer									
	Discharge to Surface Water	Discharge to Stream						X	X	X	X
	Discharge to Groundwater	Injection Well							X		
	Separate Phase Liquid Destruction	Offsite Incineration									

Notes:
1) Deed restrictions include the requirement that construction of new structrues on the YCIDA property include engineering controls, such as sub-slab depressurization systems, to prevent the potential for vapor intrusion.
2) The capping remedial technology may require patching of holes, gaps, or penetrations in the existing concrete and asphalt cap structures.

Figures



Portion of the York, PA
7.5-minute USGS Quadrangle
(2001)

YORK
QUADRANGLE LOCATION

Scale (feet)
0 495 990 1,980

Figure 1.0-1

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Site Location Map

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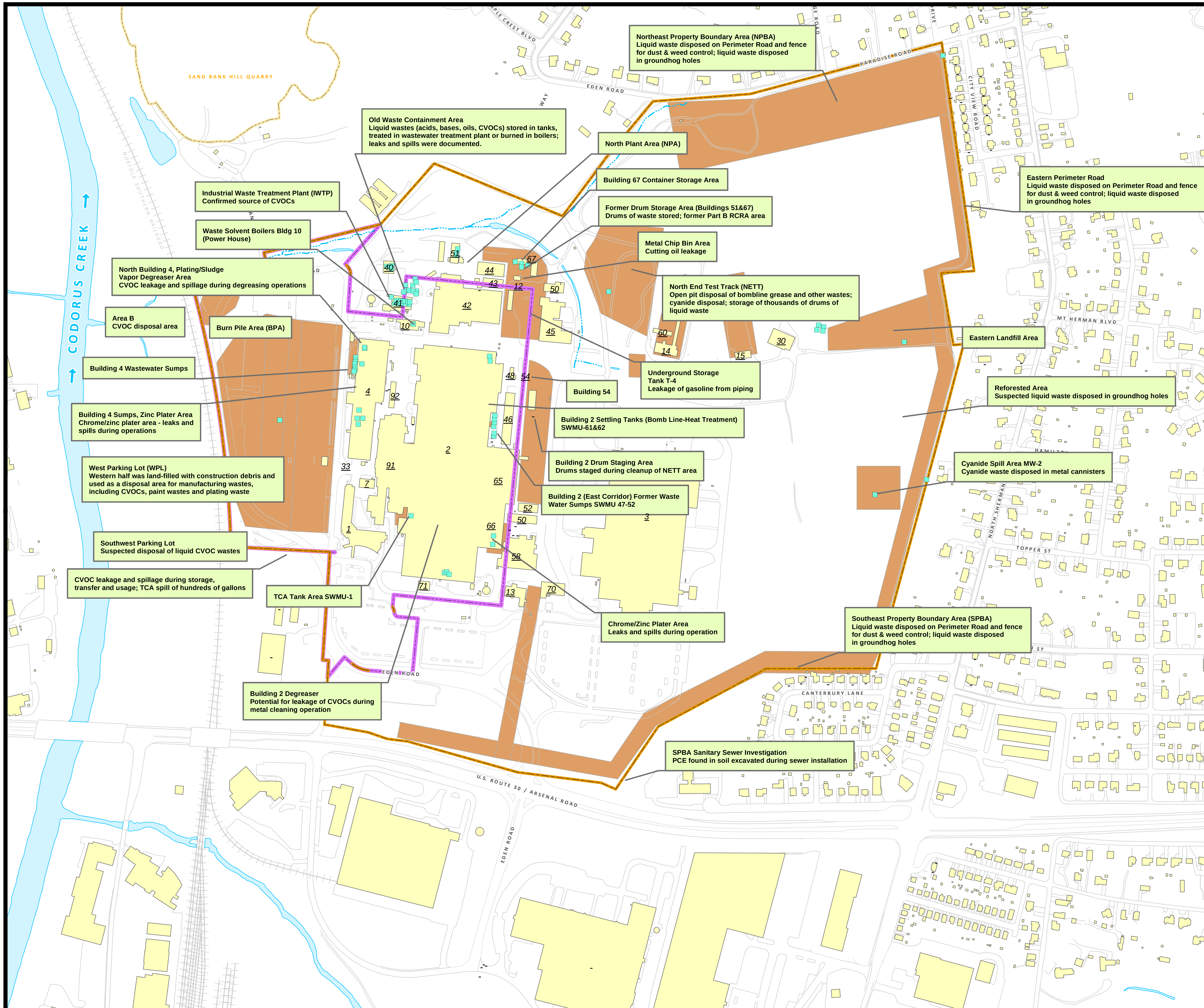

N
W
E
S

LEGEND

- Solid Waste Management Units
- FYNOP Property Boundary
- YCIDA Property Boundary
- Buildings
- Railroad (2006)
- Roads and Curb Boundary (2006)
- Areas of Concern

Reference: Figure 1-2, Field Sampling Plan For Supplemental RI (SAIC, June 2006).

ABBREVIATIONS:
BPA - Burn Pile Area
CPA - Central Plant Area
CVOC - Chlorinated Volatile Organic Compounds
IWTP - Industrial Waste Treatment Plant
NETT - North End Test Track
NPA - North Plant Area
NPBA - Northeast Property Boundary Area
SPBA - Southeast Property Boundary Area
TCA - 1,1,1-Trichloroethane
WPL - West Parking Lot

Scale (feet)
0 120 240 480

Figure 1.2-1

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Solid Waste Management Units and Areas of Concern

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 8/18/2011

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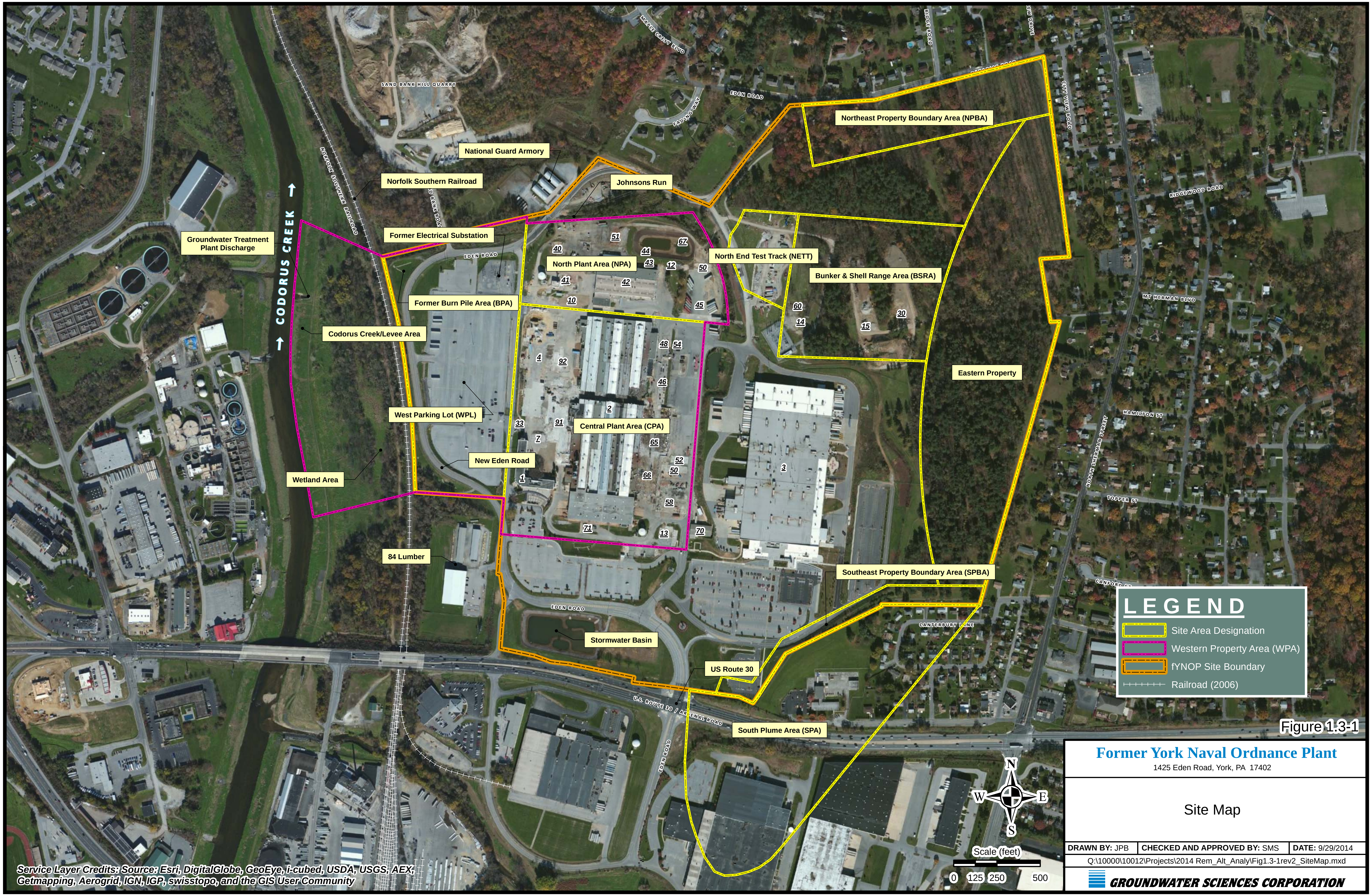
Northeast Property Boundary Area (NPBA)
National Guard Armory
Norfolk Southern Railroad
Johnsons Run
Groundwater Treatment Plant Discharge
CODORUS CREEK
Former Electrical Substation
North Plant Area (NPA)
North End Test Track (NETT)
Bunker & Shell Range Area (BSRA)
Former Burn Pile Area (BPA)
Codorus Creek/Levee Area
Eastern Property
West Parking Lot (WPL)
Central Plant Area (CPA)
New Eden Road
Wetland Area
84 Lumber
Southeast Property Boundary Area (SPBA)
Stormwater Basin
US Route 30
South Plume Area (SPA)
SAND BANK HILL QUARRY
EDEN ROAD
RIDGEWOOD ROAD
MT HERMAN BLVD
HAMILTON ST
TOPPER ST
CANTERBURY LANE
U.S. ROUTE 30 / ARSENAL ROAD
LEGEND
Site Area Designation
Western Property Area (WPA)
fYNOP Site Boundary
Railroad (2006)
Figure 1.3-1
Former York Naval Ordnance Plant
1425 Eden Road, York, PA 17402
Site Map
DRAWN BY: JPB
CHECKED AND APPROVED BY: SMS
DATE: 9/29/2014
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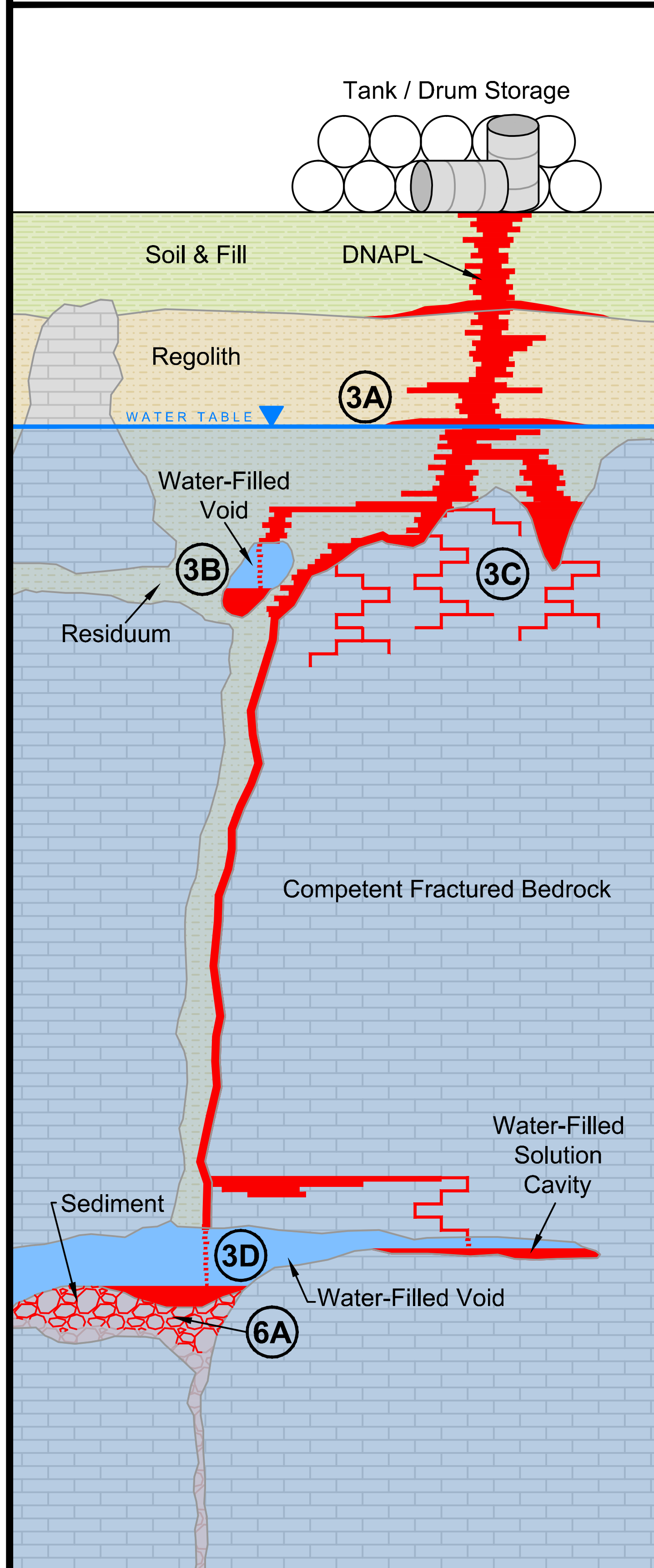
GROUNDWATER SCIENCES CORPORATION
Scale (feet)
0 125 250 500
N
S
E
W
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 1.3-2 Overview of Fate and Transport Mechanisms (Carbonate Bedrock Setting)

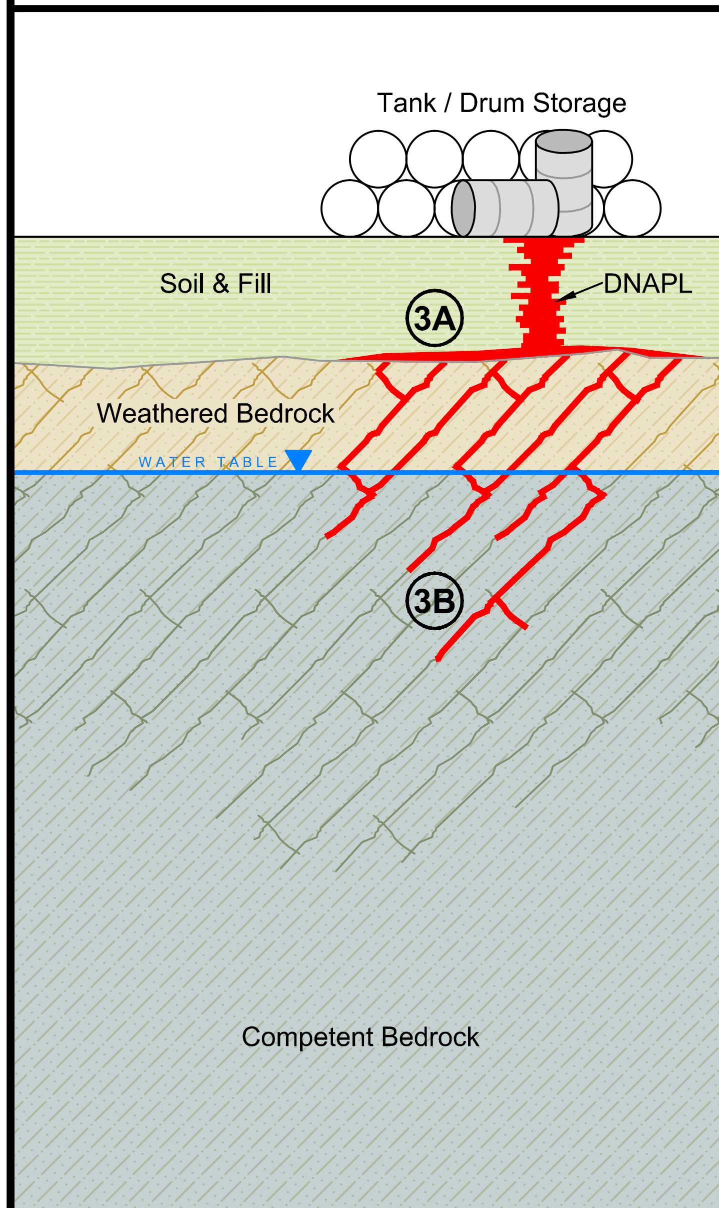
1. GEOLOGY



2. HYDROGEOLOGIC ZONES	3. NAPL TRANSPORT PROCESSES	4. AQUEOUS TRANSPORT PROCESSES	5. VAPOR TRANSPORT PROCESSES	6. FATE PROCESSES
VADOSE ZONE EPIKARST	3A DNAPL ACCUMULATION AND LATERAL SPREAD ALONG THE RESIDUUM/BEDROCK INTERFACE DIRECTED TO ZONES OF VERTICAL PERM. OR SINKING POINTS, OR POOLED IN CLOSED DEPRESSIONS	INFILTRATION UNSATURATED FLOW OF GRAVITATIONAL WATER DISSOLUTION FROM DNAPL RECHARGE AT WATER TABLE	DIFFUSIVE LOSS OF VAPOR TO ATMOSPHERIC & INDOOR AIR VAPOR DIFFUSION EVAPORATION FROM DNAPL VOLATILIZATION FROM THE WATER TABLE	AEROBIC DEGRADATION PARTITIONING FROM SOIL VAPOR TO PORE WATER (REVERSIBLE) SORPTION ONTO ORGANIC CARBON FRACTION OF FORMATION SOLIDS (REVERSIBLE) SORPTION RETARDED INTRAGRANULAR AQUEOUS DIFFUSION (REVERSIBLE)
SATURATED ZONE	3B DNAPL ACCUMULATION IN SEDIMENT-FILLED AND OPEN VOIDS (SOLUTION CAVITIES) 3C DNAPL SEEPAGE INTO FRACTURES AND BEDDING PLANES	LATERAL ADVECTION (FLOW) VERTICAL ADVECTION		SORPTION ONTO ORGANIC CARBON FRACTION OF FORMATION SOLIDS (REVERSIBLE)
KARST AQUIFER	3D DNAPL TRANSPORT DURING MODERATE TO HIGH TURBULENT FLOW IN SOLUTION-ENHANCED CONDUITS	TRANSPORT WITH SUSPENDED SEDIMENT IN SOLUTION-ENHANCED CONDUITS		6A SORPTION RETARDED AQUEOUS DIFFUSION INTO RESIDUUM AND ROCK MATRIX (REVERSIBLE) TRANSFORMATION OF PARENT COMPOUNDS TO DAUGHTER PRODUCTS SORPTION RETARDED INTRAGRANULAR AQUEOUS DIFFUSION (REVERSIBLE)

10012-001-B1 / 1-22-2014

Figure 1.3-3 Overview of Fate and Transport Mechanisms (Non-Carbonate Bedrock Setting)

1. GEOLOGY	2. HYDROGEOLOGIC ZONES	3. NAPL TRANSPORT PROCESSES	4. AQUEOUS TRANSPORT PROCESSES	5. VAPOR TRANSPORT PROCESSES	6. FATE PROCESSES
	VADOSE ZONE	(3A) DNAPL ACCUMULATION AND LATERAL SPREAD ALONG THE RESIDUUM/BEDROCK INTERFACE	INFILTRATION UNSATURATED FLOW OF GRAVITATIONAL WATER DISSOLUTION FROM DNAPL RECHARGE AT WATER TABLE	DIFFUSIVE LOSS OF VAPOR TO ATMOSPHERIC & INDOOR AIR VAPOR DIFFUSION EVAPORATION FROM DNAPL VOLATILIZATION FROM THE WATER TABLE	AEROBIC DEGRADATION PARTITIONING FROM SOIL VAPOR TO PORE WATER (REVERSIBLE) SORPTION ONTO ORGANIC CARBON FRACTION OF FORMATION SOLIDS (REVERSIBLE) SORPTION RETARDED INTRAGRANULAR AQUEOUS DIFFUSION (REVERSIBLE)
	SATURATED ZONE FRACTURED AQUIFER	(3B) DNAPL SEEPAGE INTO FRACTURES AND BEDDING PLANES	LATERAL ADVECTION (FLOW) VERTICAL ADVECTION		SORPTION ONTO ORGANIC CARBON FRACTION OF FORMATION SOLIDS (REVERSIBLE) SORPTION RETARDED AQUEOUS DIFFUSION INTO RESIDUUM AND ROCK MATRIX (REVERSIBLE) TRANSFORMATION OF PARENT COMPOUNDS TO DAUGHTER PRODUCTS SORPTION RETARDED INTRAGRANULAR AQUEOUS DIFFUSION (REVERSIBLE)

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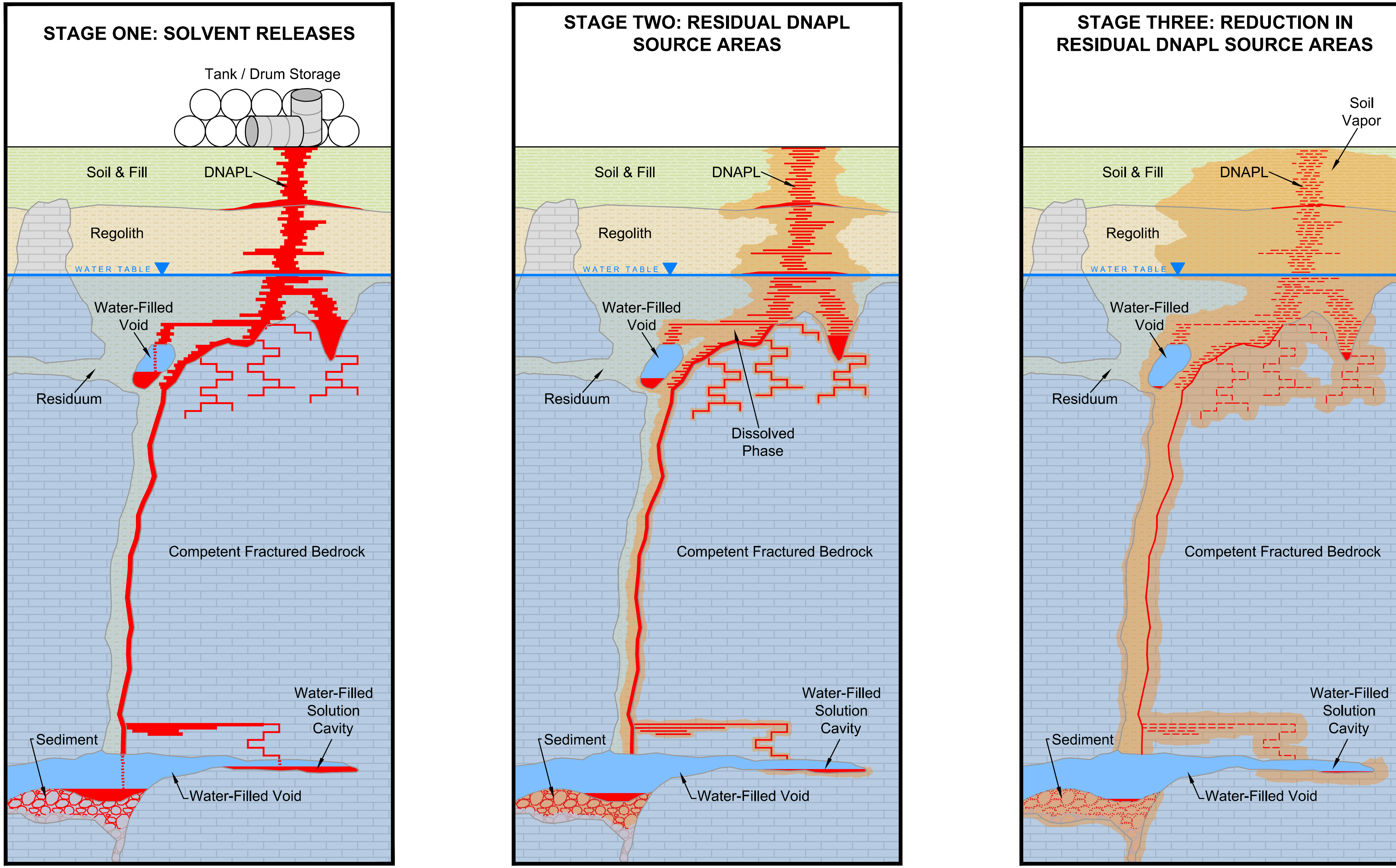
10012-003-B1 / 1-22-2014

Figure 1.3-4 Conceptual Model of DNAPL Fate and Transport in a Karst Aquifer



DNAPL penetration through soil fill, residual soil, and infilled voids, caverns, and cutters within epikarst layer in carbonate bedrock. DNAPL accumulation zones form at top of residual soil within the capillary fringe above the historical water table at the top of cutters infilled with fine-grained soils, and near the base of cutters, caverns, and voids within the carbonate bedrock.

DNAPL penetration has ceased. Development of residual DNAPL zones and high soil and bedrock concentrations due to processes of diffusion and sorption of CVOC mass from DNAPL pathways and accumulation zones. DNAPL may be transported from accumulation zones and suspended sediment during medium to high turbulent flow in water-filled solution cavities. DNAPL also dissolves and migrates with groundwater.

Majority of CVOC mass has spread into soil and bedrock due to diffusion. Localized DNAPL presence in areas of greatest initial accumulation. Reversed diffusion from the soil and bedrock into groundwater provides a continuing source of CVOCs to the groundwater.

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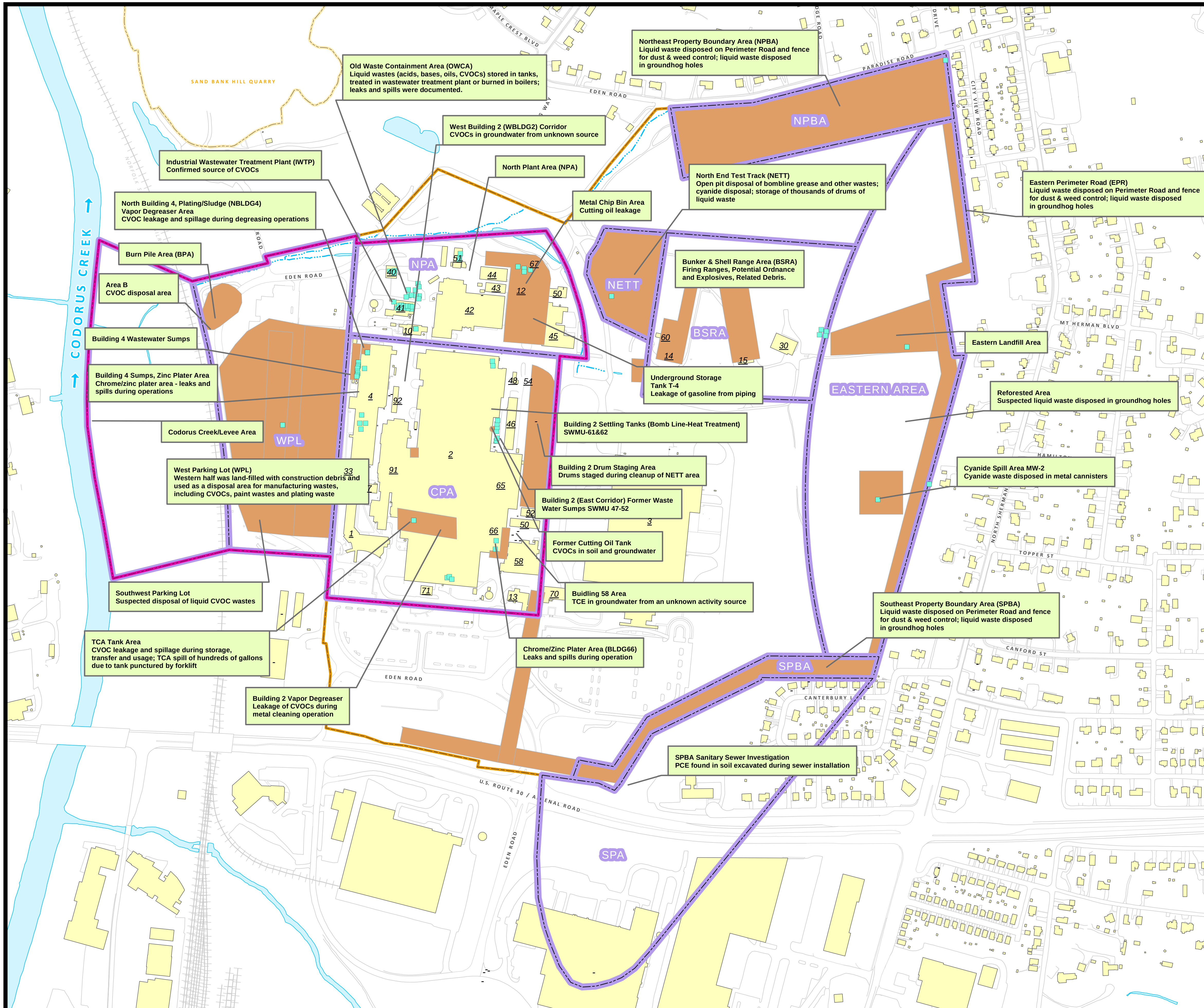
10012-002-A3 / 1-22-2014



LEGEND

- Solid Waste Management Units
- Western Property Area (WPA)
- Site Area Designation
- fYNOP Site Boundary
- Areas of Concern
- Buildings
- Railroad (2006)
- Roads and Curb Boundary (2006)

Reference: Figure 1-2, Field Sampling Plan For Supplemental RI (SAIC, June 2006).

ABBREVIATIONS:

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PCE - Tetrachloroethene
SPA - South Plume Area
SPBA - Southeast Property Boundary Area
TCA - 1,1,1-Trichloroethane
TCE - Trichloroethene
WPA- Western Property Area
WPL - West Parking Lot

Scale (feet)
0 125 250 500

Figure 2.3-1

Former York Naval Ordnance Plant

1425 Eden Road, York, PA 17402

Groundwater Areas of Concern

DRAWN BY: JPB	CHECKED AND APPROVED BY: SMS	DATE: 9/29/2014

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