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Region 2 RAC2
Remedial Action Contract

Final Feasibility Study Report

Mansfield Trail Dump Site, Operable Unit 2 (Groundwater)

Remedial Investigation/Feasibility Study

Byram Township, New Jersey

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580487

CDM Smith

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Acronyms

µg/kg	microgram per kilogram
µg/L	microgram per liter
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
amsl	above mean sea level
AOC	Area of Contamination
AOP	advanced oxidation process
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BTV	background threshold value
CAMU	Corrective Action Management Unit
CDM Smith	CDM Federal Programs Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
COC	contaminant of concern
COPC	chemical of potential concern
CSM	conceptual site model
CVOC	chlorinated volatile organic compound
DNAPL	dense non-aqueous phase liquid
DPE	dual-phase extraction
EES JV	Engineering and Environmental Solutions Joint Venture
EPA	United States Environmental Protection Agency
ESL	ecological screening level
FS	feasibility study
ft	foot
ft^2	square foot
ft^2/day	square foot per day
GAC	granular activated carbon
GRA	general response action
GWQS	Ground Water Quality Standards
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
ISTR	in situ thermal remediation
LDR	Land Disposal Restrictions
LNAPL	light non-aqueous phase liquid
LOAEL	lowest observed adverse effect level
mg/kg	milligram per kilogram
mg/L	milligram per liter
MNA	monitored natural attenuation
NAPL	non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

NJDEP	New Jersey Department of Environmental Protection
O&M	operation and maintenance
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDI	pre-design investigation
POET	point-of-entry treatment
ppm	part per million
PRB	permeable reactive barrier
PRG	preliminary remediation goal
RAC	Remedial Action Contract
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROI	radius of influence
SLERA	screening level ecological risk assessment
SRC	site-related contaminant
SVE	soil vapor extraction
T/M/V	toxicity, mobility, or volume
TBCs	to be considered
TCE	trichloroethene
TCLP	Toxicity Characteristic Leaching Procedure
TRZ	target remediation zone
TSCA	Toxic Substances Control Act
UCL	upper confidence limit
UTS	Universal Treatment Standards
UV	ultraviolet
VOC	volatile organic compound
WA	Work Assignment
ZVI	zero-valent iron

Executive Summary

Introduction

CDM Federal Programs Corporation (CDM Smith) received Work Assignment (WA) 070-RICO-A238 under the Remedial Action Contract (RAC) 2 Contract No. EP-W-09-002 to conduct a remedial investigation/feasibility study (RI/FS) for the United States Environmental Protection Agency (EPA), Region 2 at the Mansfield Trail Dump Site, Operable Unit 2 (OU2) (the site), located in Byram Township, New Jersey.

Site Location and Description

The site consists of former waste disposal areas (source area) located on wooded, undeveloped properties and associated groundwater contamination extending into an adjacent residential neighborhood in Byram Township, Sussex County, New Jersey. Trichloroethene (TCE) and other site contaminants have migrated in groundwater from the source area to nearby residential supply wells at concentrations significantly above background.

For the purposes of this investigation, the site has been divided into two operable units (OUs) to address the contamination. This feasibility study (FS) was conducted as part of OU2, which is made up of the source area and the downgradient (north) residential and drainage areas that have been impacted by contamination. OU1 addresses impacted potable wells in the adjacent residential neighborhood in Byram Township and has been addressed separately in a focused feasibility study.

Site History

Five distinct dump areas were identified in the source area and are referred to as Dump Areas A through E. Dumping activities are estimated to have begun between 1956 and 1959 and dumping stopped sometime between 1973 and 1974; disposed material is believed to be septic and industrial waste. Historical photographs show trenches in Dump Areas A and D. Although no trenches were identified in Dump Areas B, C, and E, all three areas were covered with fill. In total, more than 75,000 square feet (ft^2) was estimated to be covered with fill. Most of the waste disposal appears to have taken place in the trenches. The site has not been developed for industrial or other uses.

Summary of Previous Investigations

In May 2005, the Sussex County Department of Health and Human Services and New Jersey Department of Environmental Protection (NJDEP) became aware of contamination when TCE concentrations were identified above New Jersey drinking water standards in a private bedrock drinking water well. This discovery triggered NJDEP to sample approximately 75 private wells in the area from 2005 through 2006. Based on these results, point-of-entry treatment (POET) systems were installed in 18 residences. Starting from 2006, indoor air and sub-slab soil gas samples have been collected regularly from homes throughout the residential area to identify and address potential vapor intrusion concerns. NJDEP and EPA have installed monitoring wells in

and around the source area to delineate the groundwater plume. In 2011, the Mansfield Trail Dump Site was added to the National Priorities List. In 2012, EPA excavated contaminated soils from Dump Areas A, B, D, and E as part of a removal action.

Nature and Extent of Contamination

The nature and extent of contamination in site media was assessed by comparing remedial investigation (RI) sample results to the screening criteria and calculated background threshold values (BTVs) to evaluate contamination detected in site soils, groundwater, surface water, sediment, and vapor. Volatile organic compounds (VOCs), primarily TCE and its breakdown products, are considered the primary site-related contaminants (SRCs) because historically they have been the most widely detected contaminants (previously in the dump area soils) and have recently been detected in soils, groundwater, surface water, and vapor.

Other SRCs include 1,4-dioxane, polychlorinated biphenyls (PCBs) (specifically Aroclor 1254 and Aroclor 1260), and metals (particularly lead and chromium). These are considered secondary SRCs due to their more limited distribution, concentrations, and/or frequency of detections as compared to chlorinated volatile organic compounds (CVOCs).

Summary of Volatile Organic Compound Contamination

- Although the majority of VOC contamination in the source area was removed by EPA in 2012, concentrations of VOCs in groundwater are still elevated. The groundwater plume consists mainly of TCE, and the highest concentrations are found beneath Dump Areas A and D. Bedrock groundwater contamination quickly decreases moving away from the elevated source area and migrates into the overburden aquifer (in the residential area) at lower concentrations. Cis-1,2-dichloroethene (cis-1,2-DCE) follows a similar pattern in groundwater.

- Elevated concentrations of TCE continue to be found in the sub-slab vapor at some residences but indoor air concentrations of TCE show a decreasing trend. Concentrations confirm the effectiveness of vapor mitigation systems.

Summary of Other Contamination

- Polycyclic aromatic hydrocarbons (PAHs) were detected at elevated concentrations in sediment adjacent to the former railroad bed next to the site. Although PAH contamination was found in soil at a few locations in and around the dump areas, the concentrations in soil were much lower than those found in sediment. The contaminated sediment was likely related to the rail ties or other processes that left behind these materials (not site-related).

- 1,4-dioxane was found in site groundwater and surface water. The overall extent of the 1,4-dioxane appears similar to that of the VOC contamination observed.

- PCBs, primarily Aroclor 1254 and Aroclor 1260, were detected in both the dump areas and an adjacent residential area above RI screening criteria. Generally, the PCBs appeared in surface soils [upper 2 feet (ft)] concentrated in an area northwest of Dump Area A and continued downslope into the rear (southern) portion of a property along Brookwood Road.

- Lead and chromium were both detected above RI screening criteria in soil samples from the dump areas and the adjacent residential area. In the dump areas, lead and chromium exceedances of RI screening criteria were primarily located in the surface soils. Distribution patterns were similar to PCBs. Both metals were detected in sediments and surface water. Lead was detected only slightly exceeding RI screening criteria in groundwater.

Conceptual Site Model

Volatile Organic Compounds

The original sources of VOC contamination at the site were the wastes disposed of in the dump areas. Over time, contamination dissolved in rainwater and migrated along subsurface bedrock fractures both vertically and horizontally to reach groundwater. Although these waste materials and contaminated overburden soils were excavated in 2012, contamination is likely still present in bedrock features in the vadose zone and the saturated zone. Because of the complex fracture network in bedrock, contamination may be present in discontinuous fractures (potentially in the dense non-aqueous phase liquid [DNAPL] phase) and may be sorbed to fine particles of glacial material that may have migrated downward over time and infilled fractures.

Once in groundwater, contamination migrates downgradient through advection in the secondary porosity of the bedrock, as evidenced by the detection of VOCs in downgradient monitoring wells. Mass is volatilizing off the groundwater over the plume as evidenced by the TCE detections in vapor samples within the residential area.

Data collected at the site indicate natural attenuation mechanisms are actively attenuating groundwater contaminant concentrations. Evidence for natural attenuation at the site includes:

- The historical dataset of residential wells indicates a downward trend in concentrations prior to the 2012 excavation, potentially indicating natural attenuation and/or reduction in source zone mass discharge.
- Compound Specific Isotope Analysis (CSIA) indicates that degradation is occurring in groundwater between the shallowest ports of the source zone wells (e.g., where mass is discharging to groundwater from the vadose zone source) and the downgradient wells.
- Microbiology sample results indicate that the principal zone of reactivity for destructive attenuation appears to be under and directly adjacent to the former dump areas.
- CSIA and microbial data indicate that both microbial reductive dehalogenation and aerobic cometabolic degradation of TCE are biodegradation mechanisms actively attenuating groundwater concentrations at the site.
- Dilution and dispersion are active attenuation mechanisms at the site.

In the vadose zone, volatilization is an attenuation mechanism reducing contaminant mass that can serve as a source of groundwater contamination. However, this process is likely mass transfer limited if the contamination is in dead-end fractures.

Polychlorinated Biphenyls and Metals

In general, metals are retained strongly in soil at the relatively neutral pH conditions found in uncontaminated environments. Similarly, PCBs strongly sorb to soil and sediment. Physical transport (e.g., erosion and entrainment of contaminated soil particles in surface runoff) is the primary transport mechanism. This transport mechanism explains the presence of these contaminants in the surface soil downslope from the dump areas, in the direction of surface water runoff.

Risk Assessment

Human Health Risk Assessment

A baseline human health risk assessment (HHRA) was conducted to characterize potential human health risks associated with the site in the absence of any additional remedial action. The HHRA included evaluation of risks to potential receptors, including utility workers and trespassers in the Former Dump Area, recreational users of the bike trail, nearby residents, recreational users of Cowboy Creek, and future construction workers in the Former Dump Area if the site is redeveloped.

Elevated potential risks/hazards were identified for current and future residents assumed to use untreated impacted groundwater from the core of the plume at the site and assumed to contact surface soil in yards. Potential risks/hazards associated with soil in the Former Dump Area and Bike Trail Area and with sediment and surface water in Cowboy Creek were not elevated.

Cancer risks for current and future residents were primarily due to vinyl chloride and TCE in groundwater. Non-cancer hazards for current and future residents were driven primarily by potential exposure to TCE in groundwater, and to a lesser extent cobalt and cis-1,2-DCE in groundwater. Non-cancer hazards from exposure to lead in residential surface soil and groundwater were evaluated separately from other contaminants, and modeling indicated that lead in the Residential Area poses an elevated risk.

The HHRA included a screening evaluation of potential health risks from vapor migrating from groundwater into enclosed houses via vapor intrusion. This exposure pathway is currently incomplete because mitigation systems are in place for residences that were affected by vapor intrusion. Based on vapor intrusion screening, TCE and chloroform are present in the vadose zone below houses and in indoor air at concentrations that are elevated relative to human health screening levels. Therefore, vapor intrusion may be a source of risk to receptors at the site if mitigation systems are removed or not maintained, or if the shallow groundwater plume migrates below houses that do not have mitigation systems.

Screening Level and Step 3a Ecological Risk Assessment

A screening level and Step 3a ecological risk assessment was conducted for soils, sediment, and surface water at the site. Based on the Step 3a results, there was no unacceptable risk to terrestrial wildlife receptors. Exposure to zinc in sediment resulted in unacceptable risk to the spotted sandpiper, an invertivorous avian receptor. However, a comparison of the range of background zinc concentrations in sediment to the range of zinc concentrations in site sediments indicated that it is unclear whether zinc concentrations are site-related. Further, the calculation of

a preliminary remedial goal protective of the spotted sandpiper resulted in a value less than background. Therefore, it was determined that action to address zinc in sediment was not warranted.

Remedial Action Objectives

Based on the RI results and site-specific human health and ecological risk assessments, remedial action objectives (RAOs) were developed for soils and groundwater. The remediation of contaminated soil and groundwater is expected to decrease SRC concentrations in vapor, sediment, and surface water.

Contaminated soil RAOs:

- Reduce or eliminate exposure of human receptors to contaminated soil at concentrations exceeding remedial goals.
- Prevent or minimize contaminated soil from serving as a source of contamination to sediment, surface water, and groundwater.

Contaminated groundwater RAOs:

- Restore the impacted aquifer to its most beneficial use as a source of drinking water by reducing contaminant levels to the remedial goals.
- Prevent or minimize unacceptable risk from exposure (via direct contact, ingestion, or inhalation) to contaminated groundwater attributable to the site.
- Minimize the potential for further migration of groundwater containing site contaminants at concentrations greater than remedial goals.

Although RAOs have not been developed for soil vapor, vapor monitoring will be included as part of a long-term monitoring plan and monitoring requirements for sub-slab and indoor air will be developed during the design phase. RAOs have not been developed for surface water since actions taken to address groundwater and soil are anticipated to reduce the marginally elevated concentrations in surface water. The impacts of upgradient groundwater and soil remediation on surface water concentrations would be verified with sampling during the remedial action.

Preliminary Remediation Goals

To meet the RAOs, preliminary remediation goals (PRGs) were developed to aid in defining the extent of contaminated media requiring remedial action and developing cost estimates in the FS. PRGs are chemical-specific remediation goals for each medium and/or exposure route that are expected to be protective of human health and the environment. They have been derived based on applicable or relevant and appropriate requirements (ARARs), risk-based levels (human health and ecological), and comparison to background concentrations, with consideration given to other factors such as analytical detection limits, guidance values, and other pertinent information.

Preliminary Remediation Goals for Soil

Regulatory requirements and impact to groundwater screening criteria were considered in the development of the PRGs for soil. Although the property containing the former dump areas is currently zoned as residential, current and anticipated future use of the property is expected to be non-residential. However, due to zoning, the NJDEP residential direct contact soil remediation standards are considered applicable requirements for the dump areas (source area) and the residential area of the site. For the purposes of this FS, the former dump area soils are referred to as non-residential soils, due to current and anticipated future land use. The NJDEP residential direct contact soil remediation standards are considered applicable requirements. These standards were used in the development of non-residential and residential soil PRGs.

The NJDEP default Impact to Ground Water Soil Remediation Standards are "to be considered" (TBCs) requirements. However, based on site hydrogeological investigations, it appears soil contamination in the dump areas may be continuing to leach into groundwater. Therefore, NJDEP impact to groundwater values were considered in the development of the non-residential PRGs in the former dump areas.

Preliminary Remediation Goals for Groundwater

NJDEP's Ground Water Quality Standards (GWQS) are applicable chemical-specific ARARs. Groundwater at the site is classified as Class IIA, suitable for drinking water use. Federal and NJDEP drinking water standards are also ARARs. For all SRCs, NJDEP's GWQS are the most stringent promulgated standards and were used to develop the PRGs. Since NJDEP's GWQS were developed with consideration for human health risks, site-specific risk-based criteria were not developed.

Target Remediation Zones

Target remediation zones (TRZs) are zones that will be considered for treatment during the FS. Soil and groundwater contaminated at levels above the PRGs were identified based on data collected during the RI and historical data. TRZs were developed based on these data and the conceptual site model (CSM).

Soil Contaminated with Polychlorinated Biphenyls and Metals

The TRZs for soil contaminated with non-VOCs have been divided into a residential area (TRZs delineated based on exceedances of residential PRGs) and non-residential areas (TRZs delineated based on exceedances of non-residential PRGs).

Lead and PCBs were detected at concentrations exceeding residential PRGs downslope of Dump Area A. This includes the residential property and the area upslope of the residential property but outside of Dump Area A to prevent re-contamination of the residential property.

Small areas of contamination exceeding non-residential PRGs have been discovered in the dump areas. This includes small areas of PCB contamination detected above the PRG in Dump Area B and Dump Area E. For costing purpose during the FS, the non-residential TRZ will comprise these two areas. Additional refinement of TRZs will be completed as part of the remedial design.

Source Zone and Groundwater Contaminated with Volatile Organic Compounds

The TRZ for VOCs encompasses all areas of the site where VOCs have been detected or are inferred to be present above the PRGs. This area is predominantly fractured bedrock overlain by a thin layer of overburden.

Since groundwater contamination has continued to be detected in some cases over 50 ft below the bottom of the excavations, it is inferred that residual source material is present in the unexcavated zones under (and potentially around) the dump areas. Thus, the source zone encompasses both the vadose zone and the saturated zone under the footprints of the dump areas.

The remaining contaminated groundwater outside the footprints of the dump areas is referred to as the distal plume. This zone extends from the edge of the source area downgradient past Brookwood Road.

Remedial Action Alternatives

Remediation technologies and process options were screened against site-specific conditions using three criteria: (1) effectiveness, (2) implementability, and (3) relative cost. Representative process options were selected from the retained remedial technologies to develop separate remedial alternatives for the non-VOC overburden soils and the VOC source zone and groundwater.

Soil Remedial Action Alternatives

The three alternatives developed for the residential area overburden soils are listed as follows:

- Alternative S-1 – No Action
- Alternative S-2 – Capping
- Alternative S-3 – Excavation and Off-site Disposal of Contaminated Soils

In situ treatment technologies for soil were not retained due to implementability concerns stemming from cobbles in soil and difficulty conducting in situ soil treatment on a steep forested slope.

Alternatives S-2 and S-3 would include the following common elements:

- Pre-design investigation (PDI), including additional sampling, wetland survey, and stormwater modeling
- Remedial design
- Clearing and grubbing
- Excavation of contaminated soils in specific locations in and around the dump areas and disposal off-site

- Engineering controls, including erosion control or diversion and temporary fencing
- Five-year reviews

Alternative S-1 – No Action

No remedial action would be implemented under this alternative. The no action alternative was retained in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan, commonly called the National Contingency Plan or NCP, to serve as a baseline for comparison with the other alternatives.

Alternative S-2 – Capping

Under this alternative, the contaminated soils in the residential area would be capped to eliminate exposure pathways to human and ecological receptors. New drainage pathways would be incorporated into the cap to allow for surface runoff from the dump areas upgradient to discharge safely and in a controlled manner.

A deed restriction would be implemented by the local government to restrict disturbance to the soil cover and intrusive activities near the residential yard for the duration of construction and operation and maintenance (O&M) of the cap.

A long-term O&M plan would be implemented to ensure the effectiveness of the cap in eliminating exposure pathways to human and ecological receptors. The cap would be inspected regularly to ensure the cap is stable and intact and has not been damaged in any way. Maintenance would be conducted as needed to repair or restore the cap.

Alternative S-3 – Excavation and Off-site Disposal of Contaminated Soil

Under this alternative, the contaminated soils in the residential area would be excavated and disposed off-site. The excavation activities would take precaution to avoid disturbing tree roots. All excavated soils would be properly characterized and disposed. Confirmation sampling would be conducted to verify that soil concentrations meet PRGs.

Groundwater and Bedrock Vadose Zone Remedial Action Alternatives

The five alternatives developed to address groundwater and bedrock vadose zone contamination are listed as follows:

- Alternative GW-1 – No Action
- Alternative GW-2 – Capping of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume
- Alternative GW-3 – Capping and SVE of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume
- Alternative GW-4 – Capping and SVE of Source Area Vadose Zone, In Situ Treatment in Source Area Saturated Zone, and MNA of Distal Plume
- Alternative GW-5 – Capping, DPE of Source Area Vadose and Saturated Zones, and MNA of Distal Plume

Alternatives GW-2 through GW-5 would include the following common elements:

- PDI, including sampling existing monitoring wells and investigating the bedrock vadose zone at the dump areas to identify potential contamination or DNAPL
- Remedial design
- Clearing and grubbing
- Capping (with an impervious cap to prevent infiltration of rainwater into the vadose zone at the dump areas)
- Monitored natural attenuation in the distal plume
- Surface water long-term monitoring
- Site restoration
- Institutional controls
- Five-year reviews

Alternative GW-1 – No Action

No remedial action would be implemented under this alternative. The No Action alternative was retained in accordance with the NCP to serve as a baseline for comparison with the other alternatives.

Alternative GW-2 – Capping of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume

Under this alternative, the contaminated vadose zone in the target treatment zones in the source area would be capped to reduce infiltration of rainwater, thus limiting the migration of vadose zone contamination into groundwater. Monitored natural attenuation (MNA) would be implemented for the groundwater plume in the source area and the distal plume.

Alternative GW-3 – Capping and SVE of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume

The contaminated source area vadose zone would be capped as described in Alternative GW-2 while soil vapor extraction (SVE) would be implemented to actively treat any residual contamination in this zone. The cap would serve as an impermeable barrier to prevent the SVE wells from drawing air from aboveground. A pilot study would be conducted prior to implementation to determine design parameters for the SVE treatment. SVE wells would be installed within the confirmed extents of the source area vadose zone, and vapor monitoring points would be installed to track the progress of removing vapor-phase contamination.

MNA would be implemented for the groundwater plume in the source area.

Alternative GW-4 – Capping and SVE of Source Area Vadose Zone, In Situ Treatment in Source Area Saturated Zone, and MNA of Distal Plume

In situ treatment via amendment injections would be conducted to treat the groundwater plume in the source area. A treatability study would be conducted to determine the most effective amendment for the site contaminants and geology. A pilot study would be conducted to identify site-specific parameters for the remedial design. SVE and capping would be implemented as described in Alternative GW-3 for the contaminated vadose zone.

Alternative GW-5 – Capping, DPE of Source Area Vadose and Saturated Zones, and MNA of Distal Plume

SVE and groundwater extraction would be combined in a dual-phase extraction (DPE) remedy to treat both the contaminated vadose zone and the groundwater plume in the source area. Capping would be implemented as described in Alternative GW-2. Design parameters for a DPE system would be obtained through the performance of a pilot study. DPE wells would be installed within the confirmed extents of the source area TRZ. Vapor monitoring points would be installed to track the progress of removing vapor-phase contamination. Existing monitoring wells would be sampled to track the progress of removing groundwater contamination.

Section 1
Introduction

CDM Federal Programs Corporation (CDM Smith) received Work Assignment (WA) 070-RICO-A238 under the Remedial Action Contract (RAC) 2 Contract No. EP-W-09-002 to conduct a remedial investigation/feasibility study (RI/FS) for the United States Environmental Protection Agency (EPA), Region 2 at the Mansfield Trail Dump Site, Operable Unit 2 (OU2) (the site), located in Byram Township, New Jersey.

CDM Smith has completed the Draft Remedial Investigation (RI) Report (CDM Smith 2018a) to document the current site conditions and to address data gaps identified from review of previous investigations. Data collected by CDM Smith and from previous investigations have characterized the site sufficiently to define the nature and extent of the source material and the site-related contaminants (SRCs) in groundwater, soil, surface water, sediment, soil vapor, and indoor air. CDM Smith also has completed the Draft Human Health Risk Assessment (HHRA) (CDM Smith 2018b), the Final Screening Level Ecological Risk Assessment (SLERA) (CDM Smith 2018c), and the Final Ecological Risk Assessment Step 3a Analysis (CDM Smith 2018d).

This feasibility study (FS) was prepared in accordance with the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA 1988). This FS presents the rationale for screening and evaluating a range of remedial technologies and developing remedial alternatives to remediate the soil and groundwater contamination at the site.

1.1 Purpose and Organization of Report

The purpose of this FS is to identify, develop, screen, and evaluate a range of remedial alternatives for the contaminated media and provide the regulatory agencies with sufficient information to select a feasible and cost-effective remedial alternative that protects public health and the environment from potential risks at the site. This FS report is composed of four sections described below.

- **Section 1 – Introduction** provides a summary of the EPA RI, including site description, site history, site physical characteristics, RI sampling results, nature and extent of contamination, conceptual site model (CSM), and human health and ecological risks.
- **Section 2 – Development of Remedial Action Objectives and Screening of Technologies** presents a list of remedial action objectives (RAOs) developed by considering characterization of contaminants, risk assessments, and compliance with site-specific applicable or relevant and appropriate requirements (ARARs); delineates the quantities of contaminated media; identifies general response actions (GRAs); and identifies and screens remedial technologies and process options.
- **Section 3 – Development and Screening of Remedial Action Alternatives** presents the remedial alternatives developed by combining the feasible technologies and process

options and provides the conceptual design assumptions and descriptions of each alternative.

- **Section 4 – Detailed Analysis of Remedial Action Alternatives** provides a detailed analysis of each alternative with respect to the following seven criteria: (1) overall protection of human health and the environment; (2) compliance with the ARARs; (3) long-term effectiveness and permanence; (4) reduction of toxicity, mobility, or volume (T/M/V) through treatment; (5) short-term effectiveness; (6) implementability; and (7) costs. Two additional criteria—state acceptance and community acceptance—are not evaluated in this FS. This section also provides an overall comparative analysis of the remedial alternatives.

- **Section 5 – References** provides a list of references in the FS.

1.2 Site Location and Description

The site consists of former waste disposal trenches (referred to herein as former dump areas, or the source area) located on wooded, undeveloped properties and associated soil and groundwater contamination extending into an adjacent residential neighborhood in Byram Township, Sussex County, New Jersey (Figures 1-1 and 1-2). The former dump areas are on the high point of a ridge in an easement cleared for large overhead utility lines. Trichloroethene (TCE) has migrated in groundwater from the source area to nearby residential supply wells at concentrations significantly above background. Cis-1,2-dichloroethene (cis-1,2-DCE) also has been detected in the impacted residential wells.

For the purposes of this investigation, the site has been divided into two operable units (OUs) to address the contamination.

- OU1 addresses the residential properties downgradient of the former dump areas where residential potable wells are known to be impacted by the site's contaminated groundwater plume.

- OU2 addresses the contamination in and around the former waste disposal trenches and associated groundwater contamination.

This FS was conducted as part of OU2. OU1 has been addressed separately in a focused feasibility study (CDM Smith 2017).

The OU2 site is made up of several areas that are shown in Figure 1-2 and include the dump areas and the residential and drainage areas downgradient that have been impacted by contaminant transport.

1.2.1 Dump Areas

- The former dump areas, also referred to as the source area in this FS report, were first identified in 2009 by the New Jersey Department of Environmental Protection (NJDEP) during an effort to identify the source of the TCE contamination detected in the nearby residential wells. Subsequent reconnaissance efforts conducted by NJDEP, EPA, and their contractors in December 2009 and May 2010 indicated (EES JV 2016):

- Dump Area A consists of two trenches located on a ridgeline that trends southwest to northeast, directly upslope of and overlooking the Brookwood and Ross Roads neighborhood to the west. The upper trench and lower trench are approximately 120 ft long and 10 ft wide, with original excavated depths ranging from 3 to 5 ft.
- Dump Area B consists of a trench/low-lying area that is approximately 132 ft long by 15 ft wide and is bermed on three sides.
- Dump Area C consists of an open, roughly circular patch of disturbed vegetation approximately 140 ft in diameter adjacent to Dump Area B.
- Dump Area D is the largest dump area, consisting of four trenches of varying size (Trenches 1 through 4).
- Dump Area E (between Dump Areas B and D) was first observed during EPA's May 2010 reconnaissance. It consisted of four parallel mounds surrounding three trenches.

1.2.2 Residential Areas

The residential areas include residential properties along Brookwood and Ross Roads north and northwest of the source area.

1.2.3 Drainage Areas

Surface drainage features near the site include drainage ditches and two streams: Cowboy Creek and Lubbers Run. Drainage ditches run along both sides of a former railroad bed that was transformed into a walking and biking trail east of the source area (Figure 1-2). The drainage ditches flow into Cowboy Creek just north of the source area. Cowboy Creek then flows westward into Lubbers Run north of the residential areas (Figure 1-1). The northern end of the Cowboy Creek area is bounded by the Byram Township primary and intermediate schools.

1.3 Site History

TCE was discovered in a private bedrock drinking water well in 2005 during testing associated with a routine real estate transaction. This discovery triggered the Sussex County Department of Health and NJDEP to sample approximately 75 private wells in the area from 2005 through 2006. Based on these results, point-of-entry treatment (POET) systems were installed in 18 residences, 17 were installed by NJDEP and 1 was installed by a homeowner (EES JV 2016). Further investigations identified potential vapor intrusion concerns and lead to the installation of sub-slab depressurization systems inside five affected residences (Weston 2010).

In 2010, in the process of determining a source of the contaminated groundwater, the EPA Environmental Science Division analyzed aerial photography of the site using photographs from 1956, 1959, 1961, 1962, 1963, 1966, 1970, 1973, and 1974. The studies found areas at the property that appeared to have been used for extensive dumping; these areas are now referred to as Dump Areas A through E. Activities began between 1956 and 1959 when the first trenches in Area D were noted. The aerial photography indicates that dumping stopped sometime between 1973 and 1974. The series of photographs shows the development of trenches in Dump Areas A and D. Although no trenches were identified in Dump Areas B, C, and E, all three areas were

covered with fill. In total, more than 75,000 ft^2 were estimated to be covered with fill. The photographs indicated that a road used to access the railroad tracks is currently part of the Mansfield Bike Trail and was most likely used to access the site for the dumping (EES JV 2016). Dumping activities are estimated to have begun between 1956 and 1959 and dumping stopped sometime between 1973 and 1974. Disposed material is believed to be septic and industrial waste, and most of the waste disposal appears to have taken place in trenches (Weston 2013). The photographs also indicated the site has not been developed for industrial or other uses.

1.3.1 Current Conditions

Currently, public access to the former dump areas is not inhibited by fencing or other measures. A public pedestrian and bicycle path, which originates at the elementary school to the west of the former dump areas, passes directly through the site and continues along the east side of the Cowboy Creek area. Several dirt paths leave this trail and continue up into the upper dump areas or down into the railroad cut and the whole area appears to intermittently be used for four-wheeler trails.

The Cowboy Creek area north of the Brookwood Road residences appears to have some use as a recreation area, as several tree forts or tree stands were observed in the area.

1.4 Summary of Previous Investigations and Actions

A detailed summary of the data and reports completed prior to the EPA RI is provided in the Draft RI Report (CDM Smith 2018a). Previous site investigations mainly focused on three site areas: the residential area in the northern portion of the site with groundwater impacted by TCE; the dump areas, which are identified as the source area for the groundwater contamination; and the adjacent drainage areas. Figure 1-3 presents a timeline of the investigations performed at the site.

Previous investigations at the site and their results are briefly summarized below.

- In May 2005, the Sussex County Department of Health and Human Services and NJDEP became aware of contamination when TCE concentrations were identified above New Jersey drinking water standards in a private bedrock drinking water well.
- From 2005 to 2006, NJDEP sampled 75 residential wells and a groundwater seep discharging behind a Brookwood Road home. Results for the residential wells prompted the installation of POET systems in 18 homes. TCE and cis-1,2-DCE were detected in the results from the groundwater seep (Weston 2010).
- From 2006 to 2008, NJDEP collected indoor air and sub-slab soil gas samples from homes throughout the residential area. TCE concentrations were generally above New Jersey state screening levels, prompting the installation of sub-slab depressurization systems inside five affected residences (Weston 2010).
- In 2009, NJDEP identified the five waste disposal areas (Dump Areas A through E) as the likely source of downgradient TCE contamination. Subsequently, NJDEP installed two shallow bedrock monitoring wells and collected soil samples from the dump areas.

- In 2010, EPA continued NJDEP's investigations and installed additional monitoring wells. EPA conducted well water sampling at 21 residences.
- In March 2011, the Mansfield Trail Dump Site was added to the National Priorities List, based on the affected residential areas and the Hazard Ranking System results (EES JV 2016).
- From 2011 to 2012, EPA collected sub-slab and indoor air samples from residences.
- In 2012, EPA's Emergency and Rapid Response Services contractor implemented a removal action at Dump Areas A, B, D, and E. Emergency and Rapid Response Services delineated impacted areas, characterized waste, excavated and disposed of contaminated soils, conducted post-removal confirmation sampling, and backfilled and graded each excavation. Dump Area C was not excavated because the delineation sampling did not reveal contaminant concentrations exceeding NJDEP Site Remediation Soil Cleanup Standards for impact to groundwater. According to the Final Removal Action Report (Weston 2013), approximately 11,700 tons of non-hazardous waste, 224 tons of hazardous D040 waste meeting treatment, and 159 tons of hazardous D040 waste exceeding treatment according to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) were removed and transported off-site. Hazardous waste, which was likely principal threat waste, was removed.
- In 2014, EPA's contractor, Engineering and Environmental Solutions Joint Venture (EES JV), performed RI activities at this site. The contractor collected environmental data, including overburden soil samples, subsurface soil samples, rock core samples, groundwater samples, surface water samples, sediment samples, and vapor samples and performed site reconnaissance activities.

1.5 Physical Characteristics of the Study Area

1.5.1 Topography and Drainage

The site is located along the spine of a northeast-southwest trending ridge forming the western edge of the drainage basin for Lake Hopatcong. One of the source areas, Dump Area A, is situated at the top of the ridge. The northwest side of the ridge slopes down to the residential area along Brookwood Road and Brookwood Drive. The slope becomes more gradual northwest of the residential area, flattening into the Cowboy Creek Area. Southeast of the ridge crest, the topography quickly drops to a flat area containing Dump Areas B, C, D, and E. The eastern edge of the lower dump areas is bounded by a former railroad bed, which is within steep narrow valley.

A public pedestrian and bicycle path runs north-south parallel to the former railroad bed and connects to Stanhope-Sparta Road via an overpass in the southern portion of the site. An intermittent stream flows in a drainage swale within the railroad bed that forms the eastern boundary of the dump areas. The stream flows north and joins with Cowboy Creek to travel northwest in a well-defined channel through a wetland. This wetland area receives runoff from surrounding hills, including the site ridge to the south. Cowboy Creek then travels west-southwest before meeting with Lubbers Run.

Topography and general drainage pathways are shown in Figure 1-4.

1.5.2 Geology and Hydrogeology

The following subsections provide the regional hydrogeologic setting.

1.5.2.1 Regional Geology and Hydrogeology

1.5.2.1.1 Regional Geology

The site is in a physiographic province known as the Highlands. The Highlands include rugged terrain and mountainous uplands consisting of erosion-resistant rocks in northeast-southwest trending ridges. The rocks of the Highlands are over one billion years old and once were part of ancient mountain belts (Appalachian Mountains) formed from colliding tectonic plates.

1.5.2.1.2 Regional Hydrogeology

Regional groundwater flows to the northwest. The surficial glacial deposits can contain groundwater sufficient for domestic and public supply wells and several public water supply systems exist within a 5-mile radius of the impacted residential community. The nearest public water supply is operated by East Brookwood Estates Property Owners Association, Inc. and is located less than a mile to the west.

Many of the surrounding public supply well systems draw from the surficial glacial deposits. For instance, wells at the north end of Budd Lake draw water from Illinoian and late Wisconsinan glaciolacustrine sand and gravel units. Sandy till associated with terminal moraine supplies a few domestic wells and public supply wells in the Netcong well field. The valley fill sediments provide storage and recharge for the underlying bedrock aquifers. The gneiss and carbonate rock aquifers are tapped by Stanhope and Netcong well fields.

1.5.2.2 Site-Specific Geology and Hydrogeology

1.5.2.2.1 Site Geology

Overburden deposits cover the entire site, with exception of where bedrock outcrops on the steep northwest face of the ridge and in the former railroad bed. Most of the overburden encountered consisted of a non-stratified, loose, dry brown to gray sand/silt mix with varied amounts of gravel and cobbles. The overburden is relatively thin (less than 5 ft thick) along the top and flanks of the ridge. Overburden thickness generally increases in the flat areas to the southeast of the ridge within the source area.

Bedrock outcrops are located across the site, and the depth to bedrock elsewhere at the site ranges from near-surface to approximately 25 ft below ground surface (bgs). In the residential area north of the site, the bedrock elevation drops almost 300 ft from the ridge north toward Cowboy Creek. The bedrock surface in the source area was observed as being uneven and fractured. The upper 5–10 ft of the bedrock is extremely weathered, fractured, and unstable, as evidenced by drilling notes and casing depths.

In the former dump areas, the removal action excavated overburden down to bedrock. An unsaturated zone of fractured bedrock (referred to herein as the bedrock vadose zone) is present above the saturated zone; the bedrock vadose zone is approximately 40 ft thick under Dump Area A. The deeper bedrock is a hard crystalline gneiss and syenite bedrock with low primary porosity

and low potential for contaminant matrix diffusion. Because of the low primary porosity, groundwater flow is primarily in the secondary porosity of the rock, which is formed by the weathered zone in the shallow bedrock and by features (e.g., bedding planes and fractures) in the bedrock. Site geology is summarized in cross section A-A' and B-B' in Figures 3-5a and 3-5b, respectively, in Appendix A. Cross section A-A' is oriented from southeast to northwest while cross section B-B' is oriented from southwest to northeast.

Borehole geophysical and packer testing found that, in general, the transmissive fractures occur at a frequency of less than one fracture every 2 ft, and the highest density of transmissive fractures occurs in the upper 100 ft of each boring. In the hard crystalline bedrock at the site, these bedding planes and fractures are quite thin, on the order of thousandths of a foot. Thus, with very thin fractures spaced at less than one fracture every 2 ft, there is a limited amount of secondary porosity in the subsurface where water can flow. This limited aquifer storativity manifested itself during the RI fieldwork as a significant difference in observed potentiometric surface between sampling events (as can be seen in Figure 3-5a in Appendix A). Stereonets mapping the transmissive fractures found one cluster of fracture features in the northwest quadrant dipping generally to the southeast at a dip angle of 45 degrees and a second cluster of features in the southeast quadrant dipping generally to the west-northwest at a dip angle of about 55 degrees.

1.5.2.2.2 Groundwater Zones

Four groundwater zones are present at the site—overburden zone, shallow bedrock zone, intermediate bedrock zone, and deep bedrock zone—and are described below. These zones were identified through an analysis of hydrogeology, including evaluation of rock cores, borehole geophysics, and hydraulic parameters.

Overburden

In the source area, the saturated zones in the overburden are discontinuous and limited to the lower dump areas between the ridge and the former railroad bed. Overburden underlies the residential area and Cowboy Creek area. At other locations at the source area, the overburden is unsaturated because infiltrating rainwater drains into the underlying bedrock surface. The overburden is an equivalent porous medium.

Shallow Bedrock

This zone directly underlies the source area (in the elevation range of 800–900 ft above mean sea level [amsl]) and pinches out to the west toward the residential area and Cowboy Creek. The shallow bedrock zone is defined by a higher density of transmissive or potentially transmissive fractures in the upper 100 ft of each borehole in the source area. The shallow bedrock groundwater flow is shown in Figure 3-8 in Appendix A.

Intermediate Bedrock

This zone underlies the shallow zone, occurs in the elevation range of 650–800 ft amsl (approximately 150 to 300 ft bgs) and pinches out to the west toward Cowboy Creek. The intermediate zone is characterized by fewer transmissive or potentially transmissive fractures than the shallow and deep zones. The intermediate groundwater flow system is shown in Figure 3-9 in Appendix A.

Deep Bedrock
This zone underlies the intermediate zone, occurs in the elevation range of 500–650 ft amsl (greater than 300 ft bgs), is laterally continuous from beneath the source area to the west toward Cowboy Creek, and is defined by higher concentration of transmissive fractures than the intermediate zone. The deep zone provides a pathway for groundwater to move in the bedrock system horizontally from beneath the source area toward the Cowboy Creek area. The deep bedrock groundwater flow is shown in Figure 3-10 in Appendix A.

1.5.2.2.3 Groundwater Movement

Groundwater flow is depicted in cross section and plan view in Figures 3-5a, 3-5b, 3-8, 3-9, and 3-10 in Appendix A.

- Precipitation enters the overburden at the top of the ridge (the source area), flows down through the vadose zone in the shallow bedrock, and enters the saturated zone.
- From this high point in the groundwater flow system, some groundwater flows down to the northwest through a set of very thin (thousandths of a foot) transmissive features, with some groundwater flowing down to the southeast in another set of very thin transmissive features.
- Groundwater flows downward and toward the northwest from the shallow zone into the intermediate zone or discharges to seeps along the bedrock cliff face. Some of the flow in the intermediate zone discharges to the overburden, between wells MLS-9 and MLS-11, and some of the flow enters the deep zone. In the deep zone, groundwater flows to the northwest toward the Cowboy Creek area.
- Most residential wells are open boreholes and interconnect the intermediate and deep zones, thereby providing a vertical conduit for groundwater migrating from the source area to mix and move vertically between zones. Based on the observations obtained during geophysical logging, vertical fluid movement would be expected to happen under ambient conditions, i.e., with the pump off, and would be exacerbated by pumping.
- Drawdown caused by pumping from the residential wells is expected to affect horizontal groundwater movement because the cone of depression caused by pumping will be strongly influenced by the orientation of the transmissive features in the bedrock. Water level data to determine the cone of depression are not currently available, but the greatest drawdown would be expected to be along strike, i.e., northeast-southwest, and/or along dip azimuth, i.e., northwest-southeast.

1.5.3 Ecological Characterization

The dump areas offer an edge habitat since they are directly within the cleared utility easement and are surrounded by forested areas. The edge habitat includes a variety of grasses and herbaceous plants throughout the utility easement that offer food and habitat for a variety of fauna. In addition, the easement provides a corridor for animals to travel throughout the area. The steep slope from the dump areas sloping down northward to the residences supports a mature deciduous forest that continues into the Cowboy Creek area. This general area also consists of a freshwater creek (Cowboy Creek) and a wetland. Habitats throughout the site appear

suitable to support a variety of ecological receptors and communities. While not observed, it is likely that a variety of bird, mammal, reptile, and amphibian populations can be supported by the available habitat.

Threatened and endangered species that may exist at or near the site include the Indiana bat (*Myotis sodalis*), threatened northern long-eared bat (*Myotis septentrionalis*), threatened bog turtle (*Clemmys muhlenbergii*), and threatened small whorled pogonia (*Isotria medeoloides*). Although these species were not observed during the survey, the project area contains suitable habitat for each of the species.

Species of concern (rare wildlife species) that may exist at or near the site included several bird species, one mammal species—bobcat (*Lynx rufus*)—and one reptile species of concern—wood turtle (*Glyptemys insculpta*).

1.6 Nature and Extent of Contamination

The nature and extent of contamination in site media was assessed by comparing RI sample results to the screening criteria and calculated BTVs to evaluate contamination detected in site soils, groundwater, surface water, sediment, and vapor. Volatile organic compounds (VOCs), primarily TCE and its breakdown products, are considered the primary SRCs since they have historically been the most widely detected contaminants (previously in the dump area soils) and have recently been detected at elevated concentrations in soils, groundwater, surface water, and vapor. VOC contamination is discussed in Sections 1.6.1, 1.6.2, and 1.6.3.

Other SRCs include 1,4-dioxane, semi-volatile organic compounds (specifically polycyclic aromatic hydrocarbons [PAHs]), pesticides, polychlorinated biphenyls (PCBs) (specifically Aroclor 1254 and Aroclor 1260), and metals (particularly lead and chromium). These are considered secondary SRCs due to their more limited distribution, concentrations, and/or frequency of detections as compared to VOCs. Secondary SRCs are discussed in Section 1.6.4.

Validated data collected during the 2014/2015 EES JV investigations and the 2017/2018 CDM Smith investigations were primarily used to conduct the evaluation.

1.6.1 Volatile Organic Compound Contamination in Soil

1.6.1.1 Soil Contamination at the Source Area

Pre-excavation sampling was conducted in 2009 and 2010 to determine the source of the TCE and cis-1,2-DCE groundwater contamination, beginning in 2009 with an NJDEP soil sampling event at Dump Areas A, B, and D. Results of these investigations revealed contamination was mainly present as TCE and cis-1,2-DCE at Dump Areas A, B, D, and E. Figures 4-1a and 4-1b in Appendix A present the extent of TCE and cis-1,2-DCE contamination in surface and subsurface soils in the dump areas prior to the removal actions. TCE up to 20,000 milligrams per kilogram (mg/kg), a concentration indicative of non-aqueous phase TCE, was detected in shallow samples from Dump Area A. The contaminated source materials and soils were removed from Dump Areas A, B, D, and E by EPA in 2012 (Weston 2013).

In August and September 2013, EES JV conducted shallow overburden field screening in the source area. Based on results of the screening, direct push technology borings were advanced in

the source area in November and December 2013. Review of the results found that the majority of the VOC contamination was removed from the dump areas. Figures 4-5a and 4-5b in Appendix A present the extent of TCE and cis-1,2-DCE contamination in surface and subsurface soils after removal activities.

In addition to sampling and excavation within the dump areas and surrounding overburden soils, some of the initial RI field investigations in 2014 and 2015 targeted other potential continuing sources of VOC contamination below the dump areas. This included a bedrock matrix diffusion study and observations and sampling during drilling to determine if non-aqueous phase liquid (NAPL) was encountered. NAPL was encountered at 68 ft bgs in a rubble zone in a rock core (CB-3) and between 100 and 150 ft bgs in a bedrock well (MLS-2), both north of Dump Area D. However, sampling of the NAPL at MLS-2 and field observations of the NAPL in CB-3 concluded that the NAPL encountered were mainly light non-aqueous phase liquids (LNAPLs) consisting primarily of fuels and oil products. When compared to VOC concentrations in the recent groundwater sampling results (Rounds 2 and 3), the observed LNAPLs were not contributing significantly to the overall groundwater plume (i.e., contamination was not widely detected). Since no significant pure dense non-aqueous phase liquid (DNAPL) source was encountered during investigations, DNAPL present in bedrock may exist as immobile DNAPL in limited quantities (e.g., a limited percentage of the pore volume is saturated with DNAPL) or mixed with LNAPLs (as observed in MLS-2) in localized areas of the bedrock. Given the elevated concentrations of TCE in the waste that was removed, the presence of residual DNAPL is likely. Residual DNAPL can slowly dissolve into infiltrating rainwater and create a continuing source of groundwater contamination.

1.6.1.2 Soil Contamination Downgradient

VOCs were not detected above RI screening criteria in the residential soils and downgradient sediments.

1.6.2 Volatile Organic Compounds Contamination in Groundwater

VOCs, primarily chlorinated volatile organic compounds (CVOCs), were detected in groundwater initially in 2005 by NJDEP. Investigations to determine the extent of the VOC contamination involved sampling numerous residential wells and monitoring wells during various times.

As discussed previously, the source area contamination historically has consisted of CVOCs (primarily TCE and cis-1,2-DCE). CVOCs have been the most detected contaminants in groundwater, based on previous investigations (Section 1.4). Thus, this subsection focuses on the extent of CVOCs found in the site groundwater during the most recent groundwater sampling events (November 2017 and January 2018) and compares that data to groundwater sampling performed during the 2014 EES JV investigation. Residential well data collected since 2004 were used to evaluate the potential change in groundwater CVOC contamination based on the source removal conducted in the dump areas.

The November 2017 sampling event was a comprehensive round and is used to describe the full current extent of CVOC contamination. The results are shown in Figures 4-6 through 4-10 in Appendix A. The highest concentrations of TCE and other CVOCs detected during November 2017 were in the bedrock monitoring wells installed beneath the dump areas with TCE concentrations

up to 180 micrograms per liter (µg/L) beneath Dump Area A and up to 88 µg/L beneath Dump Area D. The migration of groundwater from the elevated dump areas to the north-northwest is limited to flow from the elevated areas through the fractured bedrock system, discharging to surficial seeps and the downgradient overburden groundwater, or flowing deeper into the bedrock system. Sampling data from the overburden groundwater (in the residential and Cowboy Creek areas) and from seeps and other shallow groundwater discharges from or near the bedrock cliff face confirm that TCE contamination has followed these pathways. The extent of bedrock groundwater contamination quickly decreases when moving away from the elevated source area.

Cis-1,2-DCE concentrations were found primarily at the northern end of Dump Area D (MLS-2) and east of Dump Area E (MLS-6) in the shallower portion of the bedrock aquifer with maximum concentrations in MLS-2 at 230 µg/L (from 35 to 50 ft bgs). This suggests that the source of groundwater CVOC contamination in this area is localized, possibly made up of a different blend of CVOCs or more degraded as compared to the source of the TCE below Dump Area A, which shows little evidence of degradation. The migration of cis-1,2-DCE into the downgradient overburden aquifer and deep bedrock mirrors that of TCE but at lower concentrations.

The data from the November 2014 groundwater sampling event showed a system with low water levels after a period with limited precipitation. TCE concentrations at the water table below the dump areas were more elevated, and contamination generally decreased with depth and was not detected at a distance as far from the source area or as deep within the deep bedrock flow system as observed in 2017.

Within the residential wells downgradient of the former dump areas, TCE concentrations appear to be generally consistent over time. There appears to have been a slight decreasing trend from 2005 to 2012. Concentrations from the 2013 sampling, which was 1 year after the source removal activities, generally increased and then began a downward trend in the years that followed. The increase in concentrations may have been caused by the disturbance of a vadose zone source during excavation or drilling that may have mobilized contamination into the system. However, differences in November 2014 and 2017 sampling results in the source area indicate that concentrations are complicated by the amount of infiltration entering the system.

1.6.3 Volatile Organic Compound Contamination in Indoor Air

Multiple rounds of sub-slab and indoor air samples collected at residences associated with the residential wells (from 2011 to 2017) were analyzed. TCE concentrations in sub-slab vapor and indoor air at the BYR-DW113 property show a decreasing trend beginning in January 2014. Elevated concentrations of TCE in sub-slab vapor have persisted over time at the BYR-DW125 property. However, the decreasing indoor air concentrations reflect the effectiveness of the existing sub-slab depressurization system. On the other hand, persistently high indoor air concentrations of TCE in the BYR-DW115 property without correspondingly elevated sub-slab concentrations suggest a potential indoor background source of TCE that may be affecting sampling results.

1.6.4 Summary of Other Contaminants

1.6.4.1 Semi-Volatile Organic Compounds

PAHs were detected above RI screening criteria and BTVs in surface soils at a few locations in and around the dump areas and in sediment adjacent to the former railroad bed next to the site. The soil and sediment PAH data suggest only minor isolated impacts. The PAHs found at the site are likely related to the rail ties or other processes that left behind these materials (not site-related). Figure 4-16 and Figure 4-17 in Appendix A show results for benzo(a)pyrene in the dump area and in the sediment adjacent to the railroad bed, respectively.

In addition, 1,4-dioxane was found in site groundwater and surface water. Maximum detections were noted in the wells screened below the dump areas, and the overall extent of the 1,4-dioxane appears similar to that of the CVOC contamination observed. Slightly elevated concentrations suggest the site as a possible source, but concentrations show this to be a secondary concern to the CVOC contamination.

1.6.4.2 Pesticides

Pesticides did not exceed RI screening criteria in site soils, surface water, or groundwater samples. Pesticides were found above screening criteria at the sediment sample in the former railroad bed area, but the sediment contamination at that location is an isolated exceedance and is likely not site related.

1.6.4.3 Polychlorinated Biphenyls

PCB Aroclors (particularly Aroclor 1254 and Aroclor 1260) were detected in both the dump areas and an adjacent residential area. Generally, the PCBs appeared confined to the upper 2 ft of soil concentrated in an area northwest of Dump Area A and continued downslope into the rear (southern) portion of a residential property on Brookwood Road (location of the BYR-DW120 residential well). Figure 4-18 in Appendix A shows the concentrations of Aroclor 1254 in the residential area.

PCBs were not detected in other site media, including sediments, surface water, or groundwater.

1.6.4.4 Metals

Lead and chromium were both detected above RI screening criteria in soil samples from the dump areas and the adjacent residential area. In the dump areas, lead and chromium exceedances of RI screening criteria were primarily located in the surface soils (less than 2 ft bgs). Much like the PCBs, the most elevated lead and chromium concentrations were concentrated in an area north of Dump Area A and continued downslope into the rear (southern) portion of a property on Brookwood Road. Figures 4-19 and 4-20 in Appendix A show results for lead and chromium in the residential area.

Both metals were detected in sediments and surface water. Lead was detected only slightly exceeding RI screening criteria in groundwater. The lead and chromium data in surface water and sediment suggest natural background conditions for the creeks.

There were several other metals besides lead and chromium that were detected above RI screening criteria in soils, sediment, and surface water. These metals either exceeded criteria in

few locations or were found below the BTVs calculated based on the background samples. No additional metals were found above screening criteria in site groundwater.

1.7 Conceptual Site Model

The CSM is based on data collected during the RI and integrates information on geology, hydrogeology, source areas, and receptors. Figure 1-5 shows the CSM for the site.

1.7.1 Physical Setting with Respect to Volatile Organic Compound Contaminant Migration

- Since the contaminated dump areas were excavated to bedrock, residual contamination is likely present in the underlying fractured bedrock in the source area. This fractured bedrock has both an unsaturated zone (the vadose zone) and a saturated zone.
- Contamination can reside (be stored) in low-transmissivity bedrock features that are not regularly flushed by infiltrating rainwater (in the bedrock vadose zone) or flowing groundwater (in the saturated zone). These features are referred to as “dead-end” features and may store DNAPL or contaminant mass that can slowly transfer out into the more transmissive features, sustaining the groundwater plume.
- Some fractures, particularly in the shallow parts of the bedrock vadose zone, may be infilled with fine particles (clays and silts) from the overburden or from a higher degree of weathering. Sorbed contaminant mass may be present in these infilled fractures; this contaminant mass can slowly desorb over time, maintaining the groundwater plume.
- DNAPL potentially stored in more transmissive rubble zones is likely to be more mobile than DNAPL in dead-end fractures, acting as a continuing source of contaminant mass.
- Transmissive fractures, capable of serving as conduits for infiltrating rainwater, are abundant. The combination of rainwater and transmissive fractures attached to storage zones sets the scene for contaminant discharge and mobilization to occur after rain events. This is evidently occurring given the continuing presence of groundwater contamination at the site.
- Groundwater migrates from the higher elevation dump areas to the north and northwest, discharging to surficial seeps and the overburden groundwater in the lower areas or flowing deeper into the bedrock system.
- The measured transmissivity in fractured bedrock was widely variable—as to be expected in non-porous media—and ranged from less than 0.001 square feet per day (ft^2/day) to 345 ft^2/day. However, in general, the upper bedrock is more weathered and would be expected to have higher conductivity.

1.7.2 Sources

- The original sources of VOC contamination at the site were the wastes disposed in the dump areas. Percent-level TCE (20,000 mg/kg) was detected in the sludge-like material at Dump Area A.

- The waste material and overburden in these areas were excavated in 2012 as part of the EPA Removal Action; excavation did not proceed into the bedrock because of the difficulty of removing bedrock and because confirmation sampling did not indicate a need. However, VOC levels indicative of DNAPL were originally found in the waste material.

- Since groundwater contamination was detected in some cases over 50 ft below the bottom of the EPA Removal Action excavation, it is inferred that residual source material is present in the unexcavated zones under (and potentially around) dump areas. Residual source material (DNAPL) may be present in the saturated zone.

- During rain events, discharge of contamination from the residual sources into groundwater occurs.

1.7.3 Contaminant Migration Pathways and Fate

- When the waste material was present, contamination infiltrated the vadose zone under the dump areas dissolved in rainwater but also potentially as DNAPL. Over time, dissolved contamination migrated along fractures both vertically and horizontally with the infiltrating rainwater. DNAPL may have migrated through fractures under the force of gravity. Contamination evidently reached groundwater and continues to reach groundwater.

- Because of the complex fracture network in bedrock and most of the features identified were hairline or discontinuous fractures, contamination may be present in discontinuous fractures in the DNAPL phase and may be sorbed to fine particles of glacial material that may have migrated downward over time and infilled fractures. Critically, many of these reservoirs of residual contamination may only be tangentially connected to transmissive fractures. As rainwater continues to leach downward, the rainwater will pick up some but not all of the contamination stored in discontinuous dead-end fractures.

- The rate of mass transfer of the DNAPL that may be present in dead-end fractures into the infiltrating rainwater is limited by the rate of dissolution of the DNAPL. This net dissolution rate may be limited considering that the surface area of DNAPL in dead-end fractures exposed to infiltrating rainwater, which flows in more transmissive fractures, is likely limited.

- DNAPL and contaminants in groundwater will typically transfer into the walls of fractures in porous bedrock (like sandstone) by diffusion (e.g., matrix diffusion). However, the matrix diffusion study conducted prior to the RI did not find evidence for widespread matrix diffusion. This is expected considering the hard crystalline bedrock at the site has low primary porosity (unlike sandstone).

- Once in groundwater, contamination migrates downgradient through advection in the secondary porosity (i.e., the void space in bedrock created by fractures and features) of the bedrock, as evidenced by the detection of VOCs in downgradient monitoring wells.

- Mass is volatilizing off the groundwater over the plume. This process led to the decision to install vapor mitigation systems in structures over the plume.

- In groundwater, natural attenuation data indicate that the biodegradation mechanisms—microbial reductive dehalogenation and aerobic cometabolic degradation—are actively attenuating groundwater concentrations at the site. Additionally, concentrations of CVOCs are reduced by dilution and dispersion.
- In the vadose zone, volatilization is an attenuation mechanism, reducing contaminant mass that can serve as a source of groundwater contamination. However, this process is likely mass transfer limited if the contamination is in dead-end fractures.

1.7.4 Conceptual Site Model for Polychlorinated Biphenyls and Metals

- PCBs, lead, and chromium were detected in shallow soils in an area north of Dump Area A and downslope into the rear of a residential property on Brookwood Road.
- In general, metals are retained strongly in soil at the relatively neutral pH conditions found in uncontaminated environments. Similarly, PCBs strongly sorb to soil and sediment.
- For PCBs and metals, physical transport (e.g., erosion and entrainment of contaminated soil particles in surface runoff) is the primary transport mechanism. This transport mechanism explains the presence of these contaminants in the surface soil downslope from the dump areas, in the direction of surface water runoff.

1.8 Risk Assessment

1.8.1 Human Health Risk Assessment

A baseline HHRA was performed for the Mansfield Trail Dump Site (CDM Smith 2019) to characterize potential human health risks associated with the site in the absence of any additional remedial action. The HHRA included evaluation of risks to potential receptors, including utility workers and trespassers in the Former Dump Area, recreational users of the bike trail, nearby residents, recreational users of Cowboy Creek, and future construction workers in the Former Dump Area if the site is redeveloped.

Exposure pathways evaluated for soil in the HHRA include ingestion of and dermal contact with soil by utility workers, trespassers, bike trail recreational users, residents, and construction workers. In addition, inhalation of contaminants from soil was evaluated for trespassers in the Former Dump Area using off-road vehicles who could be exposed to airborne particulates and for future construction workers in the Former Dump Area who could be exposed to vapor emissions from surface and subsurface soil. Exposure pathways evaluated for groundwater include ingestion of and dermal contact with groundwater and inhalation of vapor released during showering and bathing by residents. Exposure pathways evaluated for surface water and sediment include ingestion of and dermal contact with Cowboy Creek by recreational users. The exposure pathway evaluated for potential vapor intrusion into buildings is inhalation by residents.

Potential cancer effects were evaluated by calculating probabilities that an individual will develop cancer over a lifetime exposure based on projected intakes and chemical-specific dose-response information. To characterize potential non-cancer health effects, comparisons were made between estimated intakes of substances and toxicity thresholds. In general, EPA recommends an

acceptable cancer risk range of 1×10^{-6} (1 in one million) to 1×10^{-4} (1 in 10,000) and non-cancer health hazard index (HI) of unity as threshold values for potential human health impacts (EPA 1989). These values aid in determining whether additional remedial action is necessary at the site.

Elevated potential risks/hazards were identified for current and future residents assumed to use untreated impacted groundwater from the core of the plume at the site and assumed to contact surface soil in yards. Potential risks/hazards associated with soil in the Former Dump Area and Bike Trail Area and with sediment and surface water in Cowboy Creek were not elevated. Although the property containing the former dump areas is currently zoned as residential, current and anticipated future use of the property is expected to be non-residential. When conservatively assuming residential exposures in the former dump areas, the cancer risk and non-cancer HI for adult residents are at or below EPA's risk thresholds. The total non-cancer HI for child receptors to soils in the former dump areas is 2 and exceeds EPA's target of 1; however, no HI exceeds 1 for any primary target organ, and therefore noncancer health effects would be unlikely. Cancer risk is also likely overestimated due to the conservative assumption that chromium is in the hexavalent form.

Cancer risks for current/future residents (2×10^{-2}) exceeded EPA's acceptable range of 1×10^{-6} to 1×10^{-4}, mainly from chromium, vinyl chloride, and TCE in groundwater and from chromium in soil. The cancer risk may have been overestimated because it was assumed that all the chromium is in the more toxic hexavalent form and included a maximum detected concentration in groundwater that was anomalously higher than other detected concentrations. It is likely that chromium at the site is primarily in the trivalent form based on earlier composite waste sample analysis from the Former Dump Area (Weston 2010) that did not detect hexavalent chromium. However, the total risk (4×10^{-3}) from other carcinogens, primarily due to vinyl chloride and TCE, still exceeded EPA's acceptable cancer risk range.

For non-cancer hazards, the total HIs for current and future residents were above EPA's threshold of unity at the site (111 for both adults and children). The estimated non-cancer hazards were driven primarily by potential exposure to TCE and chromium in groundwater, and to a lesser extent by nickel, cobalt, and cis-1,2-DCE in groundwater. When outlier concentrations of chromium and nickel in groundwater were excluded from the calculations, total HIs still exceeded EPA's threshold of unity, mainly due to TCE in groundwater, and to a lesser extent cobalt and cis-1,2-DCE in groundwater.

Health risks from lead in residential surface soil and groundwater were evaluated separately from other contaminants using a model that estimates the blood lead concentration. Based on the results of the model, lead in the Residential Area poses an elevated risk because more than 41 percent of children (ages 12 to 72 months) incidentally ingesting soil and consuming groundwater as tap water could have blood lead concentrations that exceed the blood lead level reference value of 5 µg/dL.

Residents may be exposed to volatile chemicals of potential concern (COPCs) via inhalation of vapor emanating from groundwater into enclosed structures via vapor intrusion. This exposure pathway is currently incomplete because mitigation systems are in place for residences that were affected by vapor intrusion, but the pathway was evaluated to determine the potential for risk in

the absence of mitigation. Based on vapor intrusion screening, TCE and chloroform are present in the vadose zone below houses and in indoor air at concentrations that are elevated relative to human health screening levels. Therefore, vapor intrusion may be a source of risk to receptors at the site if mitigation systems are removed or not maintained, or if the shallow groundwater plume migrates below houses that do not have mitigation systems.

1.8.2 Screening Level Ecological Risk Assessment

A SLERA was performed for the Mansfield Trail Dump Site (CDM Smith 2018c). A SLERA is a conservative approach to estimate potential ecological risk. The SLERA included evaluation of soil, sediment, and surface water samples from the site and its immediate surroundings using a comparison of contaminant concentrations in soil, sediment, and surface water to ecological screening criteria. The SLERA included the performance of food chain exposure modeling using conservative input parameters (e.g., maximum contaminant concentrations and highest ingestion rates with lowest body weights, assuming receptors spend all their time on the site).

The overall conclusion of the SLERA was that contaminants at the site pose risk to ecological receptors and that additional ecological evaluation, in the form of a Step 3a Ecological Risk Assessment, is warranted.

1.8.3 Step 3a Ecological Risk Assessment

The objective of the Step 3a assessment was to determine if chemicals of potential ecological concern (COPECs) identified in the SLERA pose risk under more realistic conservative assumptions. During the Step 3a assessment, refined exposure point concentrations were calculated based upon 95 percent upper confidence limit (UCL) values and background inorganic results were considered. Screening of soil, sediment, and surface water media contaminants indicated exceedances of screening values. Further, food chain modeling was conducted using more realistic exposure frequency and ingestion variables. The results of the Step 3a assessment indicated fewer risks from exposure to chemicals detected in site media when compared to the SLERA. Overall, food chain modeling results indicated no risk to terrestrial soil receptors based upon the calculation of lowest observed adverse effect level (LOAEL) hazard quotients (HQs). In the aquatic environment, risk was identified to the invertivorous bird (the spotted sandpiper) from exposure to zinc. However, based upon a comparison of the range of site sediment zinc concentrations to background sediment zinc concentrations, it is unclear whether zinc sediment concentrations are site related. In addition, a preliminary remedial goal for zinc was calculated based upon risk to the spotted sandpiper. This value was less than site background concentrations, and therefore it was determined that action to address zinc in sediment was not warranted.

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Section 2

Development of Remedial Action Objectives and Screening of Technologies

The RAOs are media-specific goals for protecting human health and the environment. They serve as the basis for the development of remedial action alternatives and specify what the cleanup action will accomplish. The process of identifying the RAOs follows the identification of affected media and contaminant characteristics and evaluation of exposure pathways, contaminant migration pathways, and exposure limits to receptors.

To achieve the RAOs, preliminary remediation goals (PRGs) were developed as the benchmarks in the technology screening process and the development, screening, and detailed evaluation of alternatives. PRGs are developed based on federal- or state-promulgated ARARs, risk-based levels (human health and ecological), and background concentrations, with consideration given to other factors such as analytical detection limits and guidance values.

Data from the Draft RI Report (CDM Smith 2018a) and the 2016 EES JV data evaluation summary report (EES JV 2016) were used for the screening, evaluation, and selection of remedial technologies and development, screening, and evaluation of remedial action alternatives in accordance with CERCLA.

Section 121(d) of CERCLA, as amended, requires that any remedial action must, at minimum, achieve overall protection of human health and the environment and comply with ARARs. Other criteria that do not meet the definition of an ARAR are known as "to be considered" (TBCs) criteria, which may be used to develop PRGs and may be considered during evaluation of remedial alternatives.

The remedial action alternatives developed in subsequent sections of this FS are required to attain applicable federal, state of New Jersey, and local environmental requirements. Technical requirements of the ARARs must be met by the remedial action alternatives. However, 40 Code of Federal Regulations (CFR) 121(d)(4) allows selection of remedies that will not attain all ARARs provided one of the conditions listed below is satisfied.

- The remedial action is an interim measure where the final remedy will attain the ARARs upon completion.
- Compliance with all ARARs will result in greater risk to human health and the environment than other options.
- Compliance with all ARARs is technically impracticable.
- The remedial action will attain the equivalent of the ARARs.

- For state requirements, the state has not consistently applied the requirement in similar circumstances.
- Compliance with the ARARs will not provide a balance between protecting public health, welfare, and the environment at the site and the availability of funding for response at other facilities (fund balancing).

ARARs apply to actions or conditions located on-site and off-site. On-site actions implemented under CERCLA are exempt from administrative requirements of federal and state regulations (such as permits), as long as the substantive requirements of the ARARs are met. Off-site actions are subject to the full requirements of the applicable standards or regulations, including all administrative and procedural requirements.

2.1 Development of Remedial Action Objectives

The RAOs for all impacted media, including soil and groundwater, are developed in this section. The process for developing RAOs follows the identification of contaminants of concern (COCs) for each medium based on COPCs from the HHRA and the Step 3a assessment; identification of federal and state ARARs and other guidance; development of human health and ecological risk-based cleanup levels; and selection of the PRGs based on the ARARs, guidance values, risk-based values, or background concentrations. Generally, where a chemical-specific ARAR exists, it provides the basis for the corresponding PRG. If more than one applicable chemical-specific ARAR exists, the most stringent applicable requirements are generally applied first. The selected PRGs are the levels of COCs that will be protective of human health and the environment and provide the basis for the evaluation of remedial technologies. A detailed discussion of the contaminants and media of concern and development of RAOs is provided below.

2.1.1 Identification of Contaminants of Concern

The draft RI report identified TCE and cis-1,2-DCE as the primary SRCs. TCE and cis-1,2-DCE were found primarily in groundwater below the dump areas and the residential area downgradient. Vinyl chloride was observed in groundwater in limited areas in the dump areas. For other contaminants, 1,4-dioxane was detected in groundwater but at low concentrations (less than 10 µg/L), and 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane(1,1-DCA), and 1,1-dichloroethene(1,1-DCE) were observed at relatively elevated concentrations. These four other contaminants tended to be co-located with TCE, cis-1,2-DCE, and/or vinyl chloride, which exceeded RI screening criteria at greater magnitudes. Therefore, TCE, cis-1,2-DCE, and vinyl chloride will be used as indicator compounds for delineating the extent of groundwater contamination.

In soils, CVOCs (TCE, cis-1,2-DCE, vinyl chloride, and chlorobenzene) were detected at elevated concentrations but were not widespread. High concentrations of PAHs (benzo(a)pyrene and dibenzo(a,h)anthracene) were detected in the overburden soils in sporadic locations in the dump areas.

Other contaminants in soils, including metals (particularly lead and chromium) and PCBs (specifically Aroclor 1254 and Aroclor 1260), were found primarily within the dump areas and the residential area and are considered SRCs. The site-specific HHRA indicated that chromium, if

present in hexavalent form in site soil, could pose risk to human health. However, since hexavalent chromium previously had been sampled in the dump areas and had been found to be non-detect (Weston 2010), the chromium in soils identified in the draft RI are most likely representative of trivalent chromium, which is less toxic and mobile than hexavalent chromium and would not pose risks to human health. Therefore, chromium will not be retained as a COC.

As mentioned in Section 1.8.3, the site-specific Step 3a assessment noted that concentrations of zinc in sediment could pose risk to aquatic-feeding ecological receptors (based on exceeding the ecological screening level [ESL] and the LOAEL). However, it is unclear whether zinc sediment concentrations are site-related since the maximum background zinc concentration (248 mg/kg) was greater than site sediment zinc concentrations (maximum of 220.5 mg/kg). Furthermore, the calculated sediment zinc cleanup value that would meet a LOAEL HQ of 1 would be 60 mg/kg, which is well below the 95 percent UCL background (139.8 mg/kg) and the ESL (120 mg/kg). Therefore, it is not considered to be feasible as a remedial goal and the cleanup value would default to the background concentration. Since the background concentration range exceeds the range of zinc concentrations in site sediments, no remediation is warranted for zinc and it will not be retained as a COC.

PRGs for the retained COCs are discussed in Section 2.3.

2.1.2 Identification of Contaminated Media

Five impacted media were identified at the site:

- Soil
- Groundwater
- Soil vapor
- Sediment
- Surface water

2.1.2.1 Soil

Although the removal action removed the original sources of TCE and cis-1,2-DCE contamination at the dump areas, concentrations indicative of DNAPL were originally found in waste materials at the site. After the removal action in 2012, sparse detections of TCE in post-excavation confirmation samples ranged from 15 micrograms per kilogram (µg/kg) up to 140 µg/kg down to approximately 4 ft bgs. Since groundwater contamination was detected in some cases over 50 ft below the bottom of the excavation, residual contamination may be present in the unexcavated vadose zone under (and potentially around) dump areas.

Lead and PCB contamination was identified in shallow overburden soils north of Dump Area A and downslope into a residential area. PCBs were detected above the non-residential RI screening criteria in the southwest corner of Dump Area B (2,120 µg/kg) from 0 to 2 ft bgs and in the center of Dump Area E (1,990 µg/kg) at 3 to 5 ft bgs. Lead was detected in groundwater, sediments, and surface water (discussed below); however, PCBs were not observed in any other media aside from soil.

Select PAHs were detected above RI screening criteria at two locations in overburden surface soils (0–1 ft bgs). These contaminants are likely not site-related, and per the HHRA, do not pose a risk to human health.

PRGs need to be developed for the aforementioned contaminants to remediate the contaminated soil to protect human health.

The bedrock vadose zone under the dump areas may contain residual contamination. This zone is not at the surface and does not present a human health risk; PRGs will not be developed for the bedrock vadose zone. That said, residual contamination in the bedrock vadose zone is considered in the remedial alternatives in this FS because it is an anticipated source of mass discharge to groundwater, sustaining elevated concentrations in groundwater (a medium for which PRGs are established).

2.1.2.2 Groundwater

Contaminated groundwater at the site consists primarily of TCE and cis-1,2-DCE. Contamination underlying the dump areas has migrated to the overburden aquifer in the residential and Cowboy Creek areas at concentrations up to 11 µg/L of TCE. TCE-contaminated groundwater has migrated deeper into the fractured bedrock at concentrations of up to 180 µg/L in the upper portion of the saturated bedrock (nearly 65–80 ft bgs) and up to 130 µg/L in the deepest bedrock monitoring well ports at 460–475 ft bgs. The distribution of cis-1,2-DCE is similar to that of TCE; however, cis-1,2-DCE was observed at concentrations largely below the RI screening criterion with a maximum observed concentration of 240 µg/L. Residual source material (DNAPL) may be present in the saturated zone.

Other contaminants detected at elevated concentrations in groundwater include 1,1,1-TCA, 1,1-DCA, and chlorobenzene. Concentrations of 1,4-dioxane above the NJDEP groundwater criteria of 0.4 µg/L were detected in 7 of 42 groundwater samples during Round 3 of the RI. Lead, which is present in shallow soils, exceeded the RI screening criterion in groundwater in two of four samples, with a maximum concentration of 9.5 µg/L.

PRGs need to be developed to remediate the contaminated groundwater to protect human health and the environment.

2.1.2.3 Vapor

TCE has been detected in sub-slab vapor and indoor air at select residences in the residential area downgradient of the dump areas. The contamination has likely volatilized from the TCE groundwater plume. Sub-slab depressurization systems have been installed at impacted residences to address the soil vapor contamination issue. EPA has been conducting regular monitoring events in the residential areas to ensure vapor intrusion is being effectively mitigated and human receptors in the residences are not impacted. RAOs will not be developed for soil vapor, as EPA will continue to address vapor intrusion at these residential properties.

2.1.2.4 Sediment

In sediment, lead and chromium were detected at concentrations up to 76.8 mg/kg and 16.1 mg/kg, respectively, but all detections were below the BTV. PAHs exceeded the RI screening criteria and BTV in one sediment sample adjacent to a former railroad bed. However, the PAH

concentrations observed in this sample were an order of magnitude higher than those found in site soils, suggesting non-site related impacts from rail ties or other processes. Three pesticides (gamma-chlordane, 4,4'-DDE, and 4,4'-DDT) were detected in the same sample, but the low concentration suggests the contamination in the sediment sample is likely non-site related. No other SRCs were detected in sediment. Therefore, no remedial action is considered necessary for sediment, and no PRGs will be developed.

2.1.2.5 Surface Water

In surface water, TCE was detected but at a low concentration in one location (SW-03 at 0.15 µg/L). TCE is the primary contaminant in the site groundwater that migrates to the Cowboy Creek area of surface water. Other SRCs were similarly detected at low concentrations (1,4-dioxane at up to 0.12J µg/L and lead at up to 6.1 µg/L). Chromium was detected at concentrations up to 127 µg/L, likely because of particulates in turbid samples. Chromium was not detected in groundwater during the 2017 groundwater sampling event and only detected in one sample during the 2014 groundwater sampling event. Therefore, the chromium detected in surface water is not likely site-related.

The HHRA determined SRCs in surface water do not pose human health risks, and surface water did not pose an ecological risk to birds or mammals. Dissolved metals concentrations in surface water did not exceed respective screening levels, and therefore risk to fish was likely overestimated based on total metals concentrations, which likely contained sediment solids entrained in the samples and thus were not representative. Since there is a direct pathway from groundwater to surface water, by remediating the contaminated groundwater, site-related contamination in surface water (primarily TCE and 1,4-dioxane from groundwater discharge) are expected to be significantly reduced. Therefore, no remedial action is considered necessary for surface water. However, a monitoring plan is recommended for surface water as part of the remedial alternatives to ensure that VOCs from contaminated groundwater do not impact surface water (by exceeding NJDEP Surface Water Quality Criteria) in the future.

2.1.3 Remedial Action Objectives

The RAOs were developed for soils and groundwater. The remediation of contaminated soil and groundwater is expected to decrease SRC concentrations in vapor, sediment, and surface water.

The RAOs for contaminated soils are summarized below.

- Reduce or eliminate exposure of human receptors to contaminated soil at concentrations exceeding remedial goals.
- Prevent or minimize contaminated soil from serving as a source of contamination to sediment, surface water, and groundwater.

The RAOs for contaminated groundwater are summarized below.

- Restore the impacted aquifer to its most beneficial use as a source of drinking water by reducing contaminant levels to the remedial goals .

- Prevent or minimize unacceptable risk from exposure (via direct contact, ingestion, or inhalation) to contaminated groundwater attributable to the site.
- Minimize the potential for further migration of groundwater containing site contaminants at concentrations greater than remedial goals.

Although RAOs have not been developed for soil vapor, vapor monitoring will be included as part of a long-term monitoring plan and monitoring requirements for sub-slab and indoor air will be developed during the design phase. RAOs have not been developed for surface water since actions taken to address groundwater and soil are anticipated to reduce the marginally elevated concentrations in surface water. The impacts of upgradient groundwater and soil remediation on surface water concentrations would be verified with sampling during the remedial action.

2.2 Potential Applicable or Relevant and Appropriate Requirements, Guidelines, and Other Criteria

As required under Section 121 of CERCLA, remedial actions carried out under Section 104 or secured under Section 106 must be protective of human health and the environment and attain the levels or standards of control for hazardous substances, pollutants, or contaminants specified by the ARARs of federal environmental laws and state environmental and facility siting laws, unless waivers are obtained. According to EPA guidance, remedial actions must consider non-promulgated TBCs criteria or guidelines if the ARARs do not address a particular situation.

The degree to which these environmental and facility siting requirements must be met varies, depending on the applicability of the requirements. Applicable requirements must be met to the full extent required by law. CERCLA provides that permits are not required when a response action is taken on-site. The National Oil and Hazardous Substances Pollution Contingency Plan, commonly called the National Contingency Plan or NCP, defines the term “on-site” as the areal extent of contamination and all suitable areas in proximity to the contamination necessary for the implementation of the response action (40 CFR 300.5). Although permits are not required, the substantive requirements of the applicable permits must be met. On the other hand, only the relevant and appropriate portions of non-applicable requirements must be achieved and only to the degree that they are substantive rather than administrative in nature.

CERCLA requires that on-site remedial actions attain or waive federal environmental ARARs or more stringent state environmental ARARs upon completion of the remedial action. The purpose of ARARs is to define the minimum level of protection that must be provided by a remedy selected and implemented. Additional protection may be required, if necessary, to protect human health and the environment.

2.2.1 Definition of Applicable or Relevant and Appropriate Requirements

Under CERCLA, as amended, a federal- or state-promulgated requirement may be either “applicable” or “relevant and appropriate” to a site-specific remedial action, but not both. The distinction is critical to understand the constraints imposed on remedial alternatives by environmental regulations other than CERCLA.

2.2.1.1 Applicable Requirements

Applicable requirements pertain to those cleanup standards; standards of control; and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are more stringent than federal requirements may be applicable. Applicable requirements are defined in the NCP, 40 CFR 300.5 – Definitions.

2.2.1.2 Relevant and Appropriate Requirements

Relevant and appropriate requirements pertain to those cleanup standards; standards of control; and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site per se, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Relevant and appropriate requirements are defined in the NCP, 40 CFR 300.5 – Definitions.

The determination that a requirement is relevant and appropriate is a two-step process that includes (1) the determination that the requirement is relevant and (2) the determination that the requirement is appropriate. In general, this involves a comparison of a number of site-specific factors, including an examination of the purpose of the requirement and the purpose of the proposed CERCLA action, the medium and substances regulated by the requirement and those involved in the proposed remedial action, the actions or activities regulated by the requirement and those involved in the remedial action, and the potential use of resources addressed in the requirement and the remedial action. When the analysis results in a determination that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable (EPA 1988).

2.2.1.3 Other Requirements To Be Considered

These requirements pertain to federal and state criteria, advisories, guidelines, or proposed standards that are not generally enforceable but are advisory and that do not have the status of potential ARARs. Guidance documents or advisory TBCs criteria may be used to determine the necessary level of remediation to be protective of human health and/or the environment where no specific ARARs exist for a chemical or situation or where such ARARs are not sufficient to be protective.

2.2.1.4 Classification of Applicable or Relevant and Appropriate Requirements

Three classifications of requirements are defined by EPA in the ARAR determination process: chemical-, location-, and action-specific. Additionally, TBCs criteria are evaluated. TBCs criteria are not federally enforceable standards but may be technically or otherwise appropriate to consider in developing site- or media-specific PRGs.

2.2.1.4.1 Chemical-Specific ARARs and TBCs Criteria

Chemical-specific ARARs include those laws and regulations governing the release of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These ARARs and TBCs criteria usually are health- or risk-based values or

methodologies. They establish acceptable amounts or concentrations of chemicals that may be found in, or discharged to, the ambient environment. They may define acceptable exposure levels for a specific contaminant in an environmental medium. They may be actual concentration-based cleanup levels, or they may provide the basis for calculating such levels. Examples of chemical-specific ARARs are PCB cleanup values for soils under the Toxic Substances Control Act (TSCA) or Maximum Contaminant Levels specified for public drinking water that are applicable to groundwater aquifers used for drinking water. Table 2-1 summarizes the chemical-specific ARARs and TBCs identified for this site and their considerations for this FS.

2.2.1.4.2 Location-Specific ARARs and TBCs Criteria

Location-specific ARARs are design requirements or activity restrictions based on the geographical or physical position of a site and its surrounding area. Location-specific requirements set restrictions on the types of remedial activities that can be performed based on site-specific characteristics or location. Examples include areas in a floodplain, a wetland, or a historic site. Location-specific criteria can generally be established early in the RI/FS process since they are not affected by the type of contaminant or the type of remedial action implemented. Table 2-2 summarizes the location-specific ARARs and TBCs identified for this site and their considerations for this FS.

2.2.1.4.3 Action-Specific ARARs and TBCs Criteria

Action-specific ARARs are technology-based, establishing performance, design, or other similar action-specific controls and restrictions for particular remedial actions. These action-specific ARARs are considered in the screening and evaluation of various technologies and process options in subsequent sections of this report. Table 2-3 summarizes the action-specific ARARs and TBCs identified for this site and their considerations for this FS.

2.2.2 Resource Conservation and Recovery Act Land Disposal Restrictions Requirements, Areas of Contamination, and Corrective Action Management Units

2.2.2.1 Resource Conservation and Recovery Act Land Disposal Restrictions Requirements

Elevated concentrations of lead were detected in the contaminated soil at the site. Currently, there is no available documentation (i.e., manifests) indicating the exact origins of the contaminated soil. Therefore, it is not possible to definitively identify whether these wastes are F-, K-, P-, or U-listed wastes. However, the previous removal action at the dump areas included the Toxicity Characteristic Leaching Procedure (TCLP) sampling for Resource Conservation and Recovery Act (RCRA) metals. The results of the sampling indicated that the excavated materials from the dump areas contained leachate concentrations of lead ranging from 0.005 milligrams per liter (mg/L) to 0.16 mg/L, which did not exceed the TCLP regulatory limit for lead (5 mg/L) (Weston 2013). Based on the previous sampling results, it is unlikely that any further excavated soils will exceed TCLP regulatory limits.

However, using the 20 times rule, soil lead concentrations would have to be at least 100 mg/kg to possibly fail the TCLP test. At the site, lead has been found in post-removal action soils at concentrations of over 1,000 mg/kg. Therefore, it is possible for soils from the site to exceed the

TCLP regulatory limit for lead. If this happens, the contaminated soils will be classified as hazardous (characteristic) waste and will need to comply with RCRA Land Disposal Restrictions (LDR) requirements by meeting soil treatment standards specified under 40 CFR 268.49. The soil treatment standards mandate reduction of any underlying hazardous constituents in the soil by 90 percent or 10 times the Universal Treatment Standards (UTS), whichever is higher. Removal of the characteristic is required if the soil is ignitable, corrosive, or reactive. Treatment is required for each underlying hazardous constituent, including PCBs. Generators can reasonably apply knowledge of the likely contaminants present and use that knowledge to select appropriate underlying hazardous constituents, or classes of constituents for monitoring.

2.2.2.2 Areas of Contamination and Corrective Action Management Units

Consolidation of excavated contaminated soil in locations with similar types of contamination on-site will not trigger the RCRA LDR. According to the Area of Contamination (AOC) Policy (EPA 1996), EPA interprets RCRA to allow certain discrete areas of generally dispersed contamination to be considered RCRA units (usually landfills). Because an AOC is equated to a RCRA land-based unit, consolidation and in situ treatment of hazardous waste within the AOC does not create a new point of hazardous waste generation for the purposes of RCRA. This RCRA AOC policy is applicable to Superfund sites and is referred to as the Superfund AOC policy or Superfund AOC rules in this report. This interpretation allows wastes to be consolidated or treated in situ within an AOC without triggering LDR or minimum technology requirements. (NJDEP has similar requirements under "Technical Requirements for Site Remediation" New Jersey Administrative Code 7:26E [Technical Rules].) The AOC interpretation may be applied to any hazardous remediation waste, including non-media wastes, that is in or on the land. The AOC policy only covers consolidation and other in situ waste management techniques carried out within an AOC.

EPA's Corrective Action Management Unit (CAMU) rule is specially intended for treatment, storage, and disposal of hazardous remediation waste. Under the CAMU rule, EPA and authorized states (e.g., New Jersey) may develop and impose site-specific design, operating, closure, and post-closure requirements for CAMUs in lieu of the minimum technology requirements for land-based units. Although a strong preference exists for using CAMUs to facilitate treatment, remediation waste placed in approved CAMUs does not have to meet LDR treatment standards. NJDEP Technical Rules allow backfill of treated wastes that may exceed the remediation standards or criteria.

The main differences between the CAMU rule and the AOC policy are that when a CAMU is used, waste may be treated ex situ and then placed in a CAMU; CAMUs may be located in uncontaminated areas at a facility; and wastes may be consolidated into CAMUs from areas that are not contiguously contaminated. CAMUs must be approved by EPA as an ARAR during a CERCLA cleanup using a record of decision.

2.2.3 Polychlorinated Biphenyl Management under TSCA and NJDEP Remediation Program

TSCA provides federal PCB remediation policy. The TSCA regulations dealing with the remediation of soil as "bulk remediation waste" are primarily found in 40 CFR 761.61(a–c). TSCA does not regulate PCBs at concentrations less than 1 part per million (ppm). For above 1 ppm

PCBs, TSCA stipulates a range of cleanup levels based upon high and low occupancy scenarios that are identified in 40 CFR 761.61(a)4:

- High Occupancy Areas (≥16.8 hours per week for non-porous surfaces or ≥6.7 hours per week for bulk remediation waste) – The cleanup level for bulk PCB remediation waste in high occupancy areas is ≤1 ppm without further conditions. High occupancy areas where bulk PCB remediation waste remains at concentrations >1 ppm and ≤10 ppm must be covered with a cap (a minimum of 10 inches of soil).
- Low Occupancy Areas (<16.8 hours per week for non-porous surfaces or <6.7 hours per week for bulk remediation waste) – The cleanup level for bulk PCB remediation waste in low occupancy areas is ≤25 ppm unless otherwise specified. Bulk PCB remediation wastes may remain at a cleanup site at concentrations >25 ppm and ≤100 ppm if the site is covered with a cap.

The NJDEP Site Remediation Program policy does not require remediation for PCBs detected below 0.2 ppm. In a non-residential or restricted use scenario, soils with PCB concentrations above 0.2 ppm require a deed notice and when above 1 ppm require a deed notice and cap. NJDEP policy allows for contaminants with appropriate institutional and engineering controls to be non-permanently remediated as long as the remedy is found to be protective of human health and the environment. However, NJDEP does not routinely allow capping for the remediation of the impact to groundwater pathway.

PCB remediation wastes must be disposed of using one (or a combination, if appropriate) of the approved disposal options. Non-liquid cleanup waste (e.g., non-liquid cleaning materials and personal equipment) at any concentration and bulk PCB remediation wastes at concentrations <50 ppm may be disposed of at an approved PCB disposal facility; or when disposed pursuant to Section 761.61(a) or (c), a permitted municipal solid waste or non-municipal non-hazardous waste facility; or a RCRA Section 3004 or Section 3006 permitted hazardous waste landfill. Bulk PCB remediation waste at concentrations ≥50 ppm must be disposed of in a RCRA Section 3004 or 3006 permitted hazardous waste landfill or an approved PCB disposal facility (e.g., incinerator and chemical waste landfill) via an approved alternate disposal method (EPA 2005).

PCBs alone are not considered hazardous under RCRA since they are addressed under the TSCA regulations; however, land disposal restrictions do address PCBs when mixed with a waste that is considered hazardous under RCRA, such as lead-contaminated soil that exceeds TCLP limit for lead. The treatment and disposal requirements for hazardous waste are discussed under Section 2.2.2. Previous TCLP sampling results at the site have not exceeded the TCLP criterion for lead (5 mg/L), but it is possible for further excavated soils to fail the TCLP test based on the current concentrations of lead in soils at the site. Therefore, some lead contaminated soil with PCBs may be considered characteristic waste.

2.2.4 Principal Threat Wastes

Principal threat wastes are identified by the NCP (40 CFR 300.430) as source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

Generally, these include liquids and other highly mobile materials or materials having high concentrations of toxic compounds.

Principal threat waste may still be present in the fractured bedrock. VOC levels indicative of DNAPL were originally found in the waste materials that were removed in the 2012 removal action. The removal action targeted the overburden soils and not the underlying bedrock. Residual DNAPL, though not detected in the RI or observed in the confirmation samples from the removal action, may still be present in low-transmissivity fractures in this underlying bedrock. The mobility of any residual principal threat waste would be limited if it is present in low-transmissivity fractures; however, dissolved-phase contamination dissolving from the residual principal threat waste could still migrate with groundwater advection.

2.3 Preliminary Remediation Goals

To meet the RAOs defined in Section 2.1.3, PRGs were developed to aid in defining the extent of contaminated media requiring remedial action and developing cost estimates in the FS. PRGs are chemical-specific remediation goals for each medium and/or exposure route that are expected to be protective of human health and the environment. They have been derived based on ARARs, risk-based levels (human health and ecological), and comparison to the background concentrations, with consideration given to other factors such as analytical detection limits, guidance values, and other pertinent information.

2.3.1 Preliminary Remediation Goals for Soil

Regulatory requirements and impact to groundwater screening criteria were considered in the development of the PRGs for soil. Although the property containing the former dump areas is currently zoned as residential, current and anticipated future use of the property is expected to be non-residential. However, due to the zoning, the NJDEP residential direct contact soil remediation standards are considered applicable requirements for the dump areas (source area) and the residential area of the site. For the purposes of this FS, the former dump area soils are referred to as non-residential soils, due to the current and foreseeable future land use. The NJDEP residential direct contact soil remediation standards are considered applicable requirements. These standards were used in the development of non-residential and residential soil PRGs.

The NJDEP default Impact to Ground Water Soil Remediation Standards are TBCs requirements. However, based on site hydrogeological investigations, it appears soil contamination in the dump areas may be continuing to leach into groundwater. Therefore, NJDEP impact to groundwater values were considered in the development of the non-residential PRGs in the former dump areas.

Of particular note is the residential PRG for lead, which in addition to a maximum concentration PRG of 400 mg/kg (stipulated in the NJDEP Residential Direct Contact Soil Remediation Standards) requires the average sitewide concentration to be less than 200 mg/kg.

The PRGs for soil are presented in Table 2-4a.

2.3.2 Preliminary Remediation Goals for Groundwater

NJDEP Ground Water Quality Standards (GWQS) are applicable chemical-specific ARARs. Groundwater at the site is classified as Class IIA, suitable for drinking water use. Federal and NJDEP drinking water standards are ARARs For all SRCs, NJDEP GWQS are the most stringent promulgated standards and were used to develop the PRGs. Since NJDEP GWQS were developed with consideration for human health risks, site-specific risk-based criteria were not developed.

The PRGs for groundwater are presented in Table 2-4b. Select PRGs are highlighted for indicator compounds and will be used to drive site remediation.

Vinyl chloride, TCE, and 1,4-dioxane were selected as indicator compounds due to the magnitude and frequency of exceedances above PRGs. Other VOCs have similar distribution to the indicator compounds while exceeding PRGs less frequently and at less elevated concentrations.

Lead was encountered in groundwater at concentrations up to 22.8 µg/L during the 2014 sampling round but only was detected at concentrations up to 9.5 µg/L during the 2017 sampling round. Based on the limited distribution of lead in groundwater combined with the low levels of exceedances above the PRG (5 µg/L), the lead PRG will not be used to drive site remediation. However, lead concentrations will continue to be monitored as part of a long-term monitoring program.

Groundwater is being used by the residences. NJDEP has installed POET systems for those residences as an emergency removal action. An alternate water supply, including construction of a waterline, was selected as the OU1 remedy.

2.4 Target Remediation Zones

Target remediation zones (TRZs) are zones that will be considered for treatment during the FS. Soil and groundwater contaminated at levels above the PRGs were identified based on data collected during the RI and historical data. TRZs were developed based on these data and the CSM.

The original sources of contamination at the site were wastes disposed in the dump areas. The waste material and overburden in these areas were excavated in 2012; excavation did not proceed deeper because of the difficulty of removing bedrock and because confirmation sampling did not indicate a need.

2.4.1 Soil Contaminated with Polychlorinated Biphenyls, Metals, and Semi-Volatile Organic Compounds

The TRZs for soil have been divided into residential areas (TRZs delineated based on exceedances of residential PRGs) and non-residential areas (TRZs delineated based on exceedances of non-residential PRGs). These are shown in Figures 2-1 and 2-2 and are described below.

Residential Area: PCBs and lead were detected at concentrations exceeding residential PRGs downslope of Dump Area A and into a downslope residential property on Brookwood Road. The residential area TRZ will encompass this area bounded to the south by the northern edge of Dump Area A and bounded to the north by the back of the residential property house. Although

the area north of Dump Area A, outside of the residential property boundary, is currently used as non-residential, contaminated soils will be compared to residential PRGs because this area is upslope of the residential property and contaminated soil can be carried by surface runoff into the residential property in the future to re-contaminate the residential yard.

Non-residential Areas: A limited area of PCB contamination exceeding non-residential PRGs was detected in the southwest corner of Dump Area B and a limited area in the center of Dump Area E. These areas will be included in the non-residential TRZ to be addressed as part of the overburden soil remedial alternatives. Additional delineation of this TRZ will be completed during the design phase.

2.4.2 Source Zone and Groundwater Contaminated with Volatile Organic Compounds

The TRZ for VOCs encompasses all areas of the site where VOCs have been detected or are inferred above the PRGs. This area is predominantly fractured bedrock overlain by a thin layer of overburden. The following terminology is used in this FS to compartmentalize the TRZ:

Source Zone: VOC levels indicative of DNAPL were originally found in the dumped waste material (waste material that was previously excavated to the extent practicable). These dump areas are labeled as Dump Areas A through D and are shown in Figure 1-2. Since groundwater contamination has continued to be detected in some cases over 50 ft below the bottom of the excavations, it is inferred that residual source material is present in the unexcavated zones under (and potentially around) the dump areas. No chlorinated solvent DNAPL was encountered during the RI. Thus, the source zone encompasses both the vadose zone and the saturated zone under the footprints of the dump areas. The maximum TCE concentration in groundwater during the RI was 180 µg/L in port 3 of MLS-3.

Distal Plume: The remaining contaminated groundwater outside the footprints of the dump areas is referred to as the distal plume. This zone extends from the edge of the source area downgradient past Brookwood Road (Figure 2-3).

2.5 General Response Actions

GRAs are broad remedial actions that may satisfy the RAOs and that characterize the range of remedial responses appropriate for the media of concern at the site. Following the development of GRAs, one or more remedial technologies and process options are identified for each General Response Action (GRA) category. Although an individual response action may alone be capable of satisfying the RAOs, combinations of GRAs are usually required to adequately address site contamination. The following sections present the GRAs that may be applicable to each contaminated medium at the site and detail the subsequent technology screening process. The technologies and process options remaining after screening were assembled into the alternatives that are discussed in Section 3.

2.5.1 No Action

The NCP and CERCLA require the evaluation of a no action alternative as a basis for comparison with other remedial alternatives. Under the no action response, no remedial actions are

implemented, the current status of the site remains unchanged, and no action would be taken to reduce the potential for exposure to contamination.

2.5.2 Institutional and Engineering Controls

Institutional controls typically are restrictions placed to minimize future use of the site (e.g., deed notices for groundwater use restrictions and/or land use restrictions and public education). Engineering controls are restrictions placed to minimize access (e.g., fencing) or other measures to reduce exposure (e.g., alternate drinking water sources). These limited measures are implemented to provide some protection of human health and the environment from exposure to site contaminants. Institutional and engineering controls are generally used in conjunction with other remedial technologies; alone they are not effective in preventing contaminant migration or reducing contamination.

2.5.3 Monitoring

Monitoring activities include activities such as sampling and analysis to track the fate and transport of the contaminants (e.g., long-term monitoring) and inspections performed to assess the risks of exposure. These measures do not decrease the T/M/V of contaminants but do assist in delineating the nature and extent of contamination over time. Hence, they are generally used in conjunction with other remedial technologies and are not effective alone in achieving the PRGs for the contaminants.

2.5.4 Monitored Natural Attenuation

Monitored natural attenuation (MNA) is a response action by which the volume and toxicity of contaminants are reduced through naturally occurring processes. MNA is usually used for contaminated groundwater and soil. Extensive modeling and monitoring are performed as part of the MNA response action to demonstrate that contaminants do not represent a significant risk and that attenuation is occurring in a timely manner. In general, processes that reduce contamination levels include dilution, dispersion, volatilization, adsorption, biodegradation, and chemical reactions with other subsurface constituents.

2.5.5 Containment

Containment actions use physical or low-permeability barriers to minimize or eliminate contaminant migration and to eliminate the exposure pathways to human receptors and the ecologic system. These measures are typically used at the source of contamination.

Containment technologies do not involve treatment to reduce the toxicity or volume of contaminants. Response actions require long-term monitoring to determine whether containment technologies are performing successfully. The NCP prefers treatment over containment since treatment provides a permanent remedy. Hence, this GRA is typically combined with other response actions.

2.5.6 Removal

Removal response actions are methods typically used to excavate contaminated soil or extract groundwater via pumping. Excavation and groundwater extraction technologies provide no treatment but may be used prior to treatment and/or disposal response actions to remove wastes

from designated areas. These methods merely transfer the contaminants to be managed under another response action.

2.5.7 Treatment

Treatment involves the destruction of contaminants in the affected media, transfer of contaminants from one medium to another, or transformation of the contaminants to a less mobile form, resulting in the reduction of the T/M/V of the contaminants and achieving a higher degree of protection of human health and the environment. Treatment technologies vary among environmental media and contaminants and may consist of chemical, physical, thermal, and/or biological processes. Treatment can be implemented either in situ or ex situ. This GRA is usually preferred unless site- or contaminant-specific characteristics make it technically infeasible or cost prohibitive. The use of treatment technologies to achieve RAOs is favored by CERCLA.

2.5.8 Disposal and Discharge

Disposal response actions involve the transfer of excavated soil, sediments, source materials, and/or other materials to an off-site facility permitted for the specific waste type(s) or consolidation of the excavated materials on-site in accordance with RCRA and state regulations.

Discharge response actions for groundwater involve the discharge of extracted and treated groundwater via on-site injection, on-site surface recharge, or surface water discharge following treatment to meet regulatory discharge and disposal requirements or discharge to a publicly owned treatment works if pre-treatment standards are met.

2.6 Identification and Screening of Remedial Technologies and Process Options

For each GRA, various remedial technologies and their associated process options are considered for the response action. The term technology refers to general categories of remediation methods. Each technology may have several process options that refer to the specific material, equipment, or method used to implement a technology. These technologies describe broad categories used in remedial action alternatives but do not address details, such as performance data, associated with specific process options.

Table 2-5a identifies a broad range of remedial technologies and process options for soil; a preliminary screening is conducted separately for the VOC source zone (consisting of VOC source area TRZ) and the non-VOC overburden areas (consisting of the residential soil TRZ and the non-residential area TRZ). Table 2-5b identifies a broad range of remedial technologies and process options for groundwater with separate preliminary screenings for the bedrock groundwater in the source area (source area TRZ) and groundwater in the downgradient areas (distal plume). Both tables provide a preliminary screening of these technologies and process options based on technical implementability.

The retained technologies and process options are evaluated against the three criteria—effectiveness, implementability, and relative cost—specified in the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA 1988). Among these three

criteria, the effectiveness criterion outweighs the implementability and relative cost criteria. Brief definitions of the criteria, as they apply to the screening process, are provided below.

Effectiveness

This evaluation criterion focuses on the effectiveness of process options to reduce the T/M/V of contamination for long-term protection and to meet the RAOs and PRGs. It also evaluates the potential impacts to human health and the environment during construction and implementation and how proven and reliable the process is with respect to site-specific conditions. Technologies and process options that are not effective are eliminated using this criterion.

Implementability

This evaluation criterion encompasses both the technical and administrative feasibility of the technology or process option. It includes an evaluation of pretreatment requirements, remedial construction requirements, residuals management, the relative ease or difficulty of operation and maintenance (O&M), and the availability of qualified vendors. Technologies and process options that are not implementable at the site are eliminated using this criterion.

Relative Cost

Cost plays a limited role in the screening process. Both capital and O&M costs are considered. The cost analysis is based on engineering judgment, and each process is evaluated as to whether costs are low, medium, or high relative to the other options within the same GRA category.

The screening of potential applicable remedial technologies and process options is presented below for soil and groundwater separately. Retained technology from this second round of screening (summarized in Tables 2-5a and 2-5b) are used in Section 3 to develop remedial alternatives.

2.6.1 Identification and Screening of Remedial Technologies and Process Options for Bedrock Vadose Zone and Overburden Soil Areas

Remedial technologies retained from preliminary screening for soils (Table 2-5a) are further identified and screened in this section. Although heavily TCE-contaminated soil within the unsaturated zone at the dump areas has been addressed via an excavation removal action, the groundwater contamination trends beneath the dump areas suggest mass may be present in the unsaturated bedrock zone. Thus, remedial technologies in this section are discussed for addressing the vadose zone in the dump areas and surface soils in the residential area. Some technologies introduced for the vadose zone will help reduce groundwater contamination in the source area. If applicable, impacts of these technologies on groundwater contamination will be discussed here. Remedial technologies and process options that could achieve the RAOs, either alone or in combination with other technologies and process options, are summarized in Table 2-6a and were used to develop the alternatives discussed in Section 3.

2.6.1.1 No Action

No action is not a technology. The NCP requires that a no action alternative be considered as a basis for comparison.

Effectiveness
No action is used as a baseline against which other technologies may be compared. It generally does not provide measures that would comply with the ARARs or otherwise meet the RAOs. No action has been retained as required by the NCP.

Implementability
No action is implementable, given that no action would be required.

Relative Cost
No action involves no capital, O&M, or administrative cost.

Conclusion
The NCP requires that no action be retained for further consideration.

2.6.1.2 Institutional and Engineering Controls

Institutional controls consist of legal and administrative actions that control the use of the site to prevent or minimize human exposure to contaminants at unacceptable risk levels. Engineering controls consist of installation of engineering systems to prevent or reduce exposure to contaminants. Institutional controls and engineering controls do not reduce T/M/V of contamination. Institutional and engineering controls generally require long-term monitoring of contaminant concentrations and migration to support decision-making on continuation or modification of institutional and engineering control measures.

2.6.1.2.1 Land Use Controls

Land use controls, also called deed restrictions, are administrative measures that restrict the way the land can be developed or used when contamination is allowed to remain at a site above the remediation goals. For example, land use controls can restrict subsurface intrusive activities (e.g., excavation).

Land use controls were not retained for the VOC source zone during the preliminary technology screening (Table 2-5a) so they are only discussed below in relation to the non-VOC overburden areas.

Effectiveness for Non-VOC Overburden Areas – This option, when properly enforced and executed, would aid in prevention of human exposure to contaminated soil at unacceptable levels, especially in the residential area. However, land use controls would not reduce T/M/V of the contaminated soil.

Implementability for Non-VOC Overburden Areas – This option would be implementable.

Relative Cost – Land use controls would have low capital and operational costs.

Conclusion – Land use controls are retained for further evaluation with other remedial technologies for the non-VOC overburden areas.

2.6.1.2.2 Fencing and Signs

Fencing installed around contaminated areas limits access and minimizes direct human exposure to contaminated soil. Fencing is often installed with signs that indicate the risks. Fencing may be used in combination with other remedial technologies to protect human health during remedial construction activities such as excavation and removal.

Effectiveness for Source Area –A fence would not be needed in the source area to prevent human exposure since the soils in the source area do not present significant risk to human health. However, this option would be effective when combined with active treatment technologies for preventing contact or interference with the source area while the active treatment is occurring.

Effectiveness for Non-VOC Overburden Areas – This option can be effective to minimize human exposure to the contaminated soils in the residential area, especially for children ages 12 to 72 months, which is the demographic at the highest risk of exposure to lead in the residential area through ingestion of soil. In the non-residential TRZs, fencing and signage would not be needed, as the overburden contamination does not pose unacceptable risk to human health.

Implementability for Source Area – The source area is currently unoccupied and unpaved, and this option would be easily implementable.

Implementability for Non-VOC Overburden Areas – This option would be implementable, but property owner permission needs to be acquired before accessing the residential area.

Relative Cost – Fencing and signage would have low capital and operational costs.

Conclusion – Fencing and signage are retained for further evaluation with other remedial technologies for the residential area and for the source area.

2.6.1.2.3 Community Awareness

Community awareness involves information and education programs to enhance awareness of potential hazards, available technologies that are capable of addressing the contamination, and the remediation progress to the local community. Educational programs would protect human health by bringing increased awareness to the public of the contaminated conditions in site media and would enhance implementation of other institutional or engineering controls (such as land use controls) within the contaminated area.

Effectiveness – This option would be effective when combined with other technologies that could reduce exposure and T/M/V.

Implementability – This option would be implementable.

Relative Cost – Community awareness would have low capital and operational costs.

Conclusion – Community awareness is retained for further evaluation with other remedial technologies for both the source area and the residential area.

2.6.1.3 Containment

Containment technologies are implemented to prevent direct contact to contaminants and reduce contaminant mobility and/or rainwater infiltration. Containment does not directly impact contaminant toxicity and volume. By reducing contaminant mobility, exposures to human and ecological receptors are minimized or eliminated. Containment technologies are typically accompanied by a long-term O&M and monitoring program to verify that the containment measures continue to be effective.

2.6.1.3.1 Capping

Capping can isolate contaminated media from direct contact with humans, biota, or surface runoff. Additionally, an impermeable surface cap can significantly reduce infiltration into contaminated soils by diverting rainwater away from the contaminated zone, thereby reducing the leaching of contaminants from the vadose zone into the groundwater.

Effectiveness for Source Area –A properly designed, installed, and maintained low-permeability cap would be effective in minimizing stormwater infiltration that would induce contaminant migration from the vadose zone to the groundwater, thus reducing the mobility of contaminants. This would likely be an effective remedy, as rainwater infiltration is a large component of contaminant migration to the bedrock aquifer in the source area. Capping would not eliminate migration due to movement via diffusion, but migration through diffusion is a slow process. Capping would not reduce the toxicity and volume of the contaminated media. Capping is used as a key component for an effective soil vapor extraction (SVE) system.

Effectiveness for Non-VOC Overburden Areas – Installation of a cap would be effective in preventing direct contact with contaminated soil that is the largest exposure pathway for human health risk in the residential area. To ensure the cap is effective on the steep stope surface of the residential area, regular maintenance would need to be required. Capping in non-residential TRZs would likely not be cost effective due to the limited extents of the TRZ areas.

Implementability for Source Area – The source area is currently unoccupied and unpaved. Capping could easily be implemented in the open, undeveloped areas around the vadose zone source areas. Capping would require a rigorous inspection and maintenance program.

Implementability for Non-VOC Overburden Areas – The residential area is vegetated with large trees and is steep with bedrock outcrops dispersed throughout. In certain areas it may be difficult to implement capping, but with stable and durable materials, capping is not impossible. Capping would be much easier in the flatter non-residential TRZs. Capping would require a rigorous inspection and maintenance program.

Relative Cost – Capping involves moderate capital and low O&M costs.

Conclusion – Capping is retained for further consideration in combination with other technologies and process options for both the source area and the non-VOC overburden areas.

2.6.1.4 Removal

2.6.1.4.1 Excavation

Excavation uses standard earthwork equipment to remove contaminated soil for consolidation, treatment, and/or disposal. In general, heavy machinery (e.g., backhoes, bulldozers, and end-loaders) can be used to remove large quantities of soil; manual excavation is useful for removal of small amounts of soil at sensitive areas (e.g., next to utilities) or when heavy machinery cannot access certain areas. Implementation of excavation becomes more difficult and complicated with increasing depth due to accessibility, structural stability, and safety concerns. Dewatering would be required for excavations below the water table. Once excavated, the materials would be stored or stockpiled in a containment area to prevent the spread of contaminants prior to sampling, analysis, and disposal.

Effectiveness for Source Area – Excavation could be an effective technology for removing potential contaminant mass in the vadose zone. Although the dump areas (Dump Areas A, B, D, and E) have previously been excavated and backfilled with soil from the surrounding area, groundwater contamination beneath the dump areas suggest contaminant mass may be present in the vadose zone. The pre-design investigation (PDI) will delineate the contamination in the vadose zone exceeding the PRGs.

Effectiveness for Non-VOC Overburden Areas – Excavation would be an effective technology for removing the lead and PCB contamination in the residential area TRZ and the contamination in the non-residential TRZs.

Implementability for Source Area – Excavation of contaminated vadose zone in the source area would be difficult to implement at the site, especially since the vadose zone is primarily bedrock. The overlying overburden is thin at many of the dump areas due to the previous excavation removal action. Any remaining overburden is overlain by fill from native soil in the areas surrounding the dump areas (except in Dump Area C, which had not been previously excavated). Depending on the location of the contaminant mass identified in the vadose zone, excavation may be a limited option.

Implementability for Non-VOC Overburden Areas – Excavation of soils in the residential area may be difficult considering the steep slope of the contaminated area (approximately 14 percent slope at the steepest point based on the RI topographic survey) and the heavy vegetation. If major trees are to be preserved, excavation may require small enough equipment to navigate the densely forested terrain and take precautions to not destroy tree roots. Spots of contamination could be left in place if they are inaccessible. Otherwise, clear cutting the area would make it easier to conduct complete excavation in the area. Excavation would be much easier on the non-residential TRZs since dump areas B and E are relatively flat, open areas.

Relative Cost –Excavation involves moderate to high capital costs but would not require O&M costs.

Conclusion – Excavation is not retained for further consideration in the source area due to implementability concerns. However, excavation is retained for the non-VOC overburden areas.

2.6.1.4.2 Soil Vapor Extraction

An SVE system applies a vacuum to soil to enhance volatilization and remove volatilized contaminants. Vapor extraction can be conducted ex situ on excavated soil using perforated pipes in mounds or in situ with vapor extraction wells. The extraction systems are coupled with blowers or vacuum pumps to create a vacuum. Increased air flow through the soil allows enhanced mass transfer from adsorbed, dissolved, and free product phases in the soil to the vapor phase. An off-gas treatment system is used often to treat the contaminated vapor prior to discharge to the atmosphere. Depending on the depth of soil being remediated, vertical extraction wells, horizontal extraction pipes, or trenches may be used. Surface caps are often used in conjunction with SVE to reduce emissions of fugitive vapors, increase the vacuum radius of influence, prevent surface water infiltration, and prevent vertical short-circuiting of the air flow.

Vapor extracted from the SVE system can be treated with ex situ treatment technologies (Section 2.6.2.5).

SVE was not retained for the non-VOC overburden areas during the preliminary technology screening (Table 2-5a), so it is only discussed below in relation to the source area.

Effectiveness for Source Area – An SVE system may be effective in the shallow overburden vadose zone at the source area. However, the bedrock vadose zone has many more fractures and preferential pathways that may lead to uneven air flow in the vadose zone. However, SVE in bedrock vadose zones has been demonstrated to be possible. Since the area is unpaved, installation of an impermeable cap (Section 2.6.1.3.1) may be helpful to prevent short-circuiting air flow to the atmosphere.

Implementability for Source Area – SVE is implementable at the dump areas especially because the area is open and unoccupied. Experienced vendors and required equipment would be available. A pilot study would be necessary prior to the design and implementation of an SVE system to measure the achievable radius of influence of the applied vacuum, the relationship between air flow and applied vacuum, and the contaminant concentrations in the extracted soil vapor. Additionally, a permit for off-gas treatment and discharge may be required to implement an SVE system. SVE systems are typically operated in continuous mode at the beginning of the remedial action then switched to pulsed mode until concentrations in the extracted vapors either drop to non-detectable levels or to asymptotic levels. A cost-effectiveness analysis generally is conducted before the system is shut down.

Relative Cost – SVE would involve low to moderate capital and low O&M costs.

Conclusion – SVE is retained for further consideration for the source area.

2.6.1.4.3 Dual-Phase Extraction

Dual-phase extraction (DPE) involves the combined extraction of soil vapor and groundwater using extraction wells screened across the vadose zone soils and the saturated groundwater zone. A pump may be used to extract groundwater while a vacuum is applied to the wellhead to extract soil gas. Both aqueous and vapor streams would require ex situ treatment (Section 2.6.2.5). Contaminant volatilization and recovery is facilitated by increasing pressure and concentration gradients. Groundwater extraction would decrease the water table and expose more soils to the

applied vacuum for mass removal in the expanded vadose zone by SVE. Groundwater extraction also would remove contaminants in shallow groundwater within the aquifer (Section 2.6.2.4). DPE is considered an effective technology for mass reduction of VOC contamination from contaminated soils and the interface of soil and groundwater.

DPE was not retained for the non-VOC overburden areas during the preliminary technology screening (Table 2-5a), so it is only discussed below in relation to the source area.

Effectiveness for Source Area – DPE would be effective for initial mass reduction at the source area if contamination is found at the interface between the vadose zone and groundwater during the PDI. No sampling has been conducted in the bedrock vadose zone of the source area, so it is unclear if any vadose zone contamination is present near the groundwater table or is located at a shallower depth. As noted for SVE, the bedrock vadose zone is fractured, which may lead to preferential pathways causing uneven air flow in the vadose zone.

Implementability for Source Area – DPE is implementable at the dump areas especially because the area is open and unoccupied. Experienced vendors and required equipment would be available. A pilot study would be necessary prior to the design and implementation of a DPE system to measure the achievable radius of influence of the applied vacuum, the relationship between air flow and applied vacuum, and the contaminant concentrations in the extracted soil vapor. Additionally, a permit for off-gas treatment and discharge may be required.

Cost – This technology would involve medium capital and O&M costs.

Conclusion – This technology is retained for further consideration for the source area.

2.6.1.5 Treatment

Treatment involves the destruction of contaminants in the affected media, transfer of contaminants from one media to another, or alteration of the contaminants, thereby making them innocuous. The result is a reduction in T/M/V of the contaminants. Treatment technologies vary among environmental media and can consist of chemical, physical, thermal, and biological processes. Treatment can occur in the subsurface or aboveground. This GRA is usually preferred unless site- or contaminant-specific characteristics make it infeasible from a constructability perspective or if it is cost prohibitive. Ex situ treatment of extracted groundwater from DPE is discussed under Section 2.6.2.5.

2.6.1.5.1 Vapor-Phase Granular Activated Carbon

Vapor-phase granular activated carbon (GAC) is usually used to remove contaminants from the vapor or gas phase in combination with an SVE system, in in situ thermal remediation (ISTR), or downstream of air strippers in the treatment train. Contaminants are adsorbed onto the GAC and removed from the air flow prior to discharge to the atmosphere. The used GAC can be either regenerated after contaminants break through or disposed of in an appropriate manner.

Vapor-phase GAC was not retained for the non-VOC overburden areas during the preliminary technology screening (Table 2-5a), so it is only discussed below in relation to the source area.

Effectiveness for Source Area – Activated carbon adsorption would be effective in removing TCE and cis-1,2-DCE. It would not be effective in the removal of vinyl chloride. An additional

treatment method, such as potassium permanganate oxidation, would be required to remove vinyl chloride, if present. Vinyl chloride has been detected in the underlying bedrock groundwater in the source area but may not be present in the vadose zone.

Implementability for Source Area – This technology would be implementable, and the equipment and materials would be readily available. Vapor-phase GAC can be used directly for an SVE system or in the treatment train for off-gas management in a groundwater pump and treat remedy. This technology generally does not require a treatability study. Discharging the treated gas of any off-gas system generally would require a permit.

Relative Cost – This technology would involve medium capital and O&M costs.

Conclusion – This technology is retained for further consideration for the source area.

2.6.1.5.2 Potassium Permanganate Oxidation

When vinyl chloride is present in the vapor, potassium permanganate can be used to oxidize the contaminant after the treatment with vapor-phase GAC. Typically, an ion exchange resin (zeolite) is impregnated with a solution of potassium permanganate. Potassium permanganate will react to form three compounds: potassium hydroxide, manganese tetroxide, and manganese dioxide. The manganese tetroxide will oxidize vinyl chloride into potassium chloride and carbon dioxide. The potassium chloride will remain in the pore structure of the substrate that contains the hydrated potassium permanganate.

Potassium permanganate oxidation was not retained for the non-VOC overburden areas during the preliminary technology screening (Table 2-5a), so it is only discussed below in relation to the source area.

Effectiveness for Source Area – Potassium permanganate oxidation would be effective in removing contaminants, including cis-1,2-DCE and vinyl chloride from the off-gas.

Implementability for Source Area – Using potassium permanganate impregnated zeolite to remove vinyl chloride in the soil vapor or off-gas would be implementable. The equipment and materials would be readily available through vendors. This technology could be implemented with SVE or ISTR technologies, or as part of the off-gas treatment in a DPE remedy. This technology generally does not require a treatability study.

Relative cost – This technology would involve medium capital and medium O&M costs.

Conclusion – Potassium permanganate oxidation is retained for further consideration for the source area.

2.6.1.5.3 In Situ Thermal Remediation

ISTR technologies heat the subsurface unsaturated and saturated zones, resulting in desorption and volatilization of contaminants. Volatilized contaminants are extracted from the subsurface using a vapor recovery system, such as an SVE system, and are treated prior to discharge to the air. Thermal technologies are effective in removing VOC contaminants in heterogeneous and low-permeability soils and generally require shorter treatment times (months) compared to many other remedial technologies. However, in situ thermal treatment could involve an extensive

drilling program and high overall costs. Electrical resistance heating uses electrical current passing through the soil to elevate subsurface temperatures. Thermal conductive heating uses an array of heated vertical steel wells to heat the subsurface via thermal conduction; steam injection are thermal technologies potentially applicable for conditions observed at the site.

ISTR was not retained for the non-VOC overburden areas during the preliminary technology screening (Table 2-5a), so it is only discussed below in relation to the source area.

Effectiveness for Source Area – ISTR may not be effective for remediating the VOC contamination at the site if volatilized contaminants cannot be fully extracted from the vadose zone, especially in the unsaturated bedrock where fractures and preferential pathways may determine the movement of vapor-phase contaminants. If volatilizing the contaminants creates a positive pressure in the subsurface, contaminant vapors may be pushed downgradient to affect the nearby residential area. Residences currently affected by vapor intrusion have active mitigation systems (such as a sub-slab depressurization system) installed. ISTR is generally not cost-effective when used to treat contamination with low concentrations.

Implementability for Source Area – Implementing ISTR for the vadose zone in the dump areas would be possible, considering the open spaces in the dump areas. However, thorough vapor monitoring would need to be conducted to ensure the ISTR treatment does not affect the downgradient residences. Any vapor recovery system (like SVE) implemented would have to ensure a negative pressure is kept in the subsurface. The recovery system would need to be properly designed and installed to prevent cooling and re-condensing of contaminants in the subsurface.

Relative Cost – The capital and short-term O&M costs for this ISTR would be high.

Conclusion – ISTR is not retained for further consideration.

2.6.1.5.4 In Situ Soil Flushing

In situ soil flushing floods contaminated soils in the subsurface with an amendment such as a solution of water and additives or solvents. The contaminants are then mobilized by solubilization, formation of emulsions, or a chemical reaction with the flushing solutions. This technology is typically used in the saturated zone with an injection well and extraction well recirculation setup to deliver the solution and recover the flushing fluid. However, to treat potential contamination in the vadose zone, amendments can be introduced into the shallow subsurface and allowed to percolate downward into the groundwater aquifer, treating both the unsaturated and saturated zones.

Effectiveness for Source Area– Due to the fractured bedrock geology of the vadose zone in the source area, ensuring thorough contact with areas of contamination may prove difficult especially if the contamination resides in less permeable dead zones. If not controlled or tested properly, in situ soil flushing may lead contaminants, injected amendments, or byproducts to spread out laterally (affecting the downgradient residential areas) or vertically (driving contaminants deeper into the bedrock aquifer).

Effectiveness for Non-VOC Overburden Areas – In situ soil flushing may possibly remove lead and PCBs. However, given the different COCs in the residential TRZ and non-residential TRZs, some agents or additives may be more effective for removing one type of COC over another. Pilot study tests would need to be conducted to determine the appropriate amendment mixtures to effectively remove all the COCs. In addition, the proximity of the contaminated soils to residential wells would make it difficult to prevent flushing amendments from migrating into the groundwater and interfering with the residential wells.

Implementability for Source Area – This technology would be technically implementable. A pilot study would be necessary prior to the design and implementation to ensure proper contact with amendments and to determine what amendment is most suitable for the site geology and contaminants (either bioremediation, in situ chemical oxidation (ISCO), or in situ chemical reduction (ISCR) amendments as described in Section 2.6.2).

Implementability for Non-VOC Overburden Areas – Since the contamination is primarily in the top 2 ft of soil, amendments can be introduced at the surface and allowed to percolate downward. In-place mixing can improve contact with the contaminants by spreading and mixing amendments with conventional earth-moving equipment or small tilling equipment. However, in-place mixing would be difficult to conduct, considering the variability in soil thickness in the residential area (from no soil in a bedrock outcrop area to 2 ft of soil in other areas). It would be difficult to bring any equipment larger than hand-held instruments out to the forested, steep rocky slope. It would be easier to implement in the non-residential TRZs, but the footprints of the TRZs would likely be minimal and would require smaller equipment.

Relative Cost – This process involves moderate capital and moderate O&M costs.

Conclusion – In situ soil flushing is not retained due to effectiveness and implementability concerns.

2.6.1.5.5 In Situ Stabilization

Similar to soil flushing, in situ stabilization delivers amendment to the subsurface, but rather than mobilizing the contaminant into amendment solution, the amendment is used to reduce the hazard potential of the contaminant by converting it to a less soluble, mobile, or toxic form through physical or chemical reactions with the contaminant (EPA 2006b).

Effectiveness for Source Area – Stabilization is not typically effective for the VOCs in the source area since they are highly mobile.

Effectiveness for Non-VOC Overburden Areas – Stabilization can be used effectively to reduce mobility of lead with chelating compounds. Although typically considered more appropriate for addressing inorganic contamination, stabilization has been used successfully to remediate PCBs.

Implementability for Source Area – This technology would be technically implementable. A pilot study would be necessary prior to the design and implementation to ensure proper contact with amendments and to determine what amendment is most suitable for the site geology and contaminants (bioremediation, ISCO, or ISCR amendments as described in Section 2.6.2).

Implementability for Non-VOC Overburden Areas – Since the contamination is primarily in the top 2 ft of soil, amendments can be introduced at the surface and allowed to percolate downward. In-place mixing can improve contact with the contaminants by spreading and mixing amendments with conventional earth-moving equipment or small tilling equipment. However, in-place mixing would be difficult to conduct considering the variability in soil thickness in the residential area (from no soil in a bedrock outcrop area to 2 ft of soil in other areas). It would be difficult to bring any equipment larger than hand-held instruments out to the forested, steep rocky slope. It would be easier to conduct in-place mixing in the non-residential TRZs given the more open and level space. However, pilot studies, including leachability tests, would need to be conducted to determine the best type or mixture of stabilization agents suitable for the site geology and contaminant combinations.

Relative Cost – This process involves moderate capital and moderate O&M costs.

Conclusion – In situ soil stabilization is not retained due to effectiveness and implementability concerns.

2.6.1.6 Disposal

Disposal response actions for soil involve the disposal of excavated soil at an off-site facility permitted for the specific waste type. Based on available data, the excavated soil would most likely be non-hazardous.

2.6.1.6.1 Off-site Disposal at Non-hazardous Waste Landfill

This option involves disposing the contaminated soil at an off-site non-hazardous waste (RCRA Subtitle D) disposal facility. Off-site landfills are commercially owned, permitted facilities that minimize potential environmental impacts of waste disposal. Landfilling is considered a non-treatment alternative and less acceptable than treatment alternatives by CERCLA. Soils that pass the TCLP could be disposed of in a Subtitle D landfill. However, the final determination would be based on the evaluation of a suite of parameters by the landfill.

Excavation was not retained for the source area (See Section 2.6.1.4.1), so off-site disposal is only discussed below in relation to the non-VOC overburden areas (residential and non-residential TRZs).

Effectiveness for Non-VOC Overburden Areas – Landfill disposal would be effective in preventing direct contact and in reducing the mobility of contaminants. The volume and toxicity of the waste would not be reduced. Based on the lead contaminant concentrations detected in vadose zone soils, most of the excavated soils likely will be within TCLP criteria and could be taken to a Subtitle D landfill. However, it is possible for some excavated soils to exceed TCLP criteria and thus would need to be disposed of in a hazardous waste landfill (see Section 2.6.1.6.2). On the other hand, the PCB concentrations in both the residential and non-residential TRZs do not exceed the LDR UTS of 10 mg/kg (that would categorize the excavated soil as hazardous waste) and are far less than the 50 mg/kg threshold for disposal at a TSCA landfill.

Implementability for Non-VOC Overburden Areas – This technology would be technically implementable.

Relative Cost – This process involves moderate capital and no O&M costs.

Conclusion – This technology is retained for further consideration in the non-VOC overburden areas.

2.6.1.6.2 Off-site Disposal at Hazardous Waste Landfill

If any of the contaminated excavated soils are determined by TCLP testing to be hazardous, it must be disposed of in a RCRA Subtitle C landfill and requires treatment to meet the LDR UTS at a hazardous waste treatment facility prior to disposal.

If any PCB concentrations in soils are greater than 50 mg/kg, the soils need to be disposed of at a TSCA landfill.

Excavation was not retained for the source area (See Section 2.6.1.4.1) so off-site disposal is only discussed below in relation to the non-VOC overburden areas.

Effectiveness for Non-VOC Overburden Areas – Landfill disposal would be effective in preventing direct contact and in reducing the mobility of contaminants. The volume and toxicity of the waste would not be reduced. Based on the lead contaminant concentrations detected in the residential TRZ soils, most of the excavated soils will likely be within TCLP criteria and could be taken to a Subtitle D landfill. However, it is possible for some excavated soils to exceed TCLP criteria and thus would need to be disposed of in a hazardous waste landfill. Similarly, although it is expected that most of any excavated soils in the non-residential TRZs likely would be within TCLP criteria, benzo(a)pyrene did exceed the LDR UTS of 3.4 mg/kg from one sample in the center of Dump Area E. Although it is possible that some excavated soils from the non-residential TRZs may be taken to a Subtitle C landfill as hazardous waste, it is unlikely that treatment will be required to meet the LDR UTS.

Implementability for Non-VOC Overburden Areas – This technology would be technically implementable.

Relative Cost – This process involves high capital and no O&M costs.

Conclusion – This technology is retained for further consideration in the non-VOC overburden areas.

Table 2-6a summarizes the retained remedial technologies and process options for remediation of source area and non-VOC overburden areas.

2.6.2 Identification and Screening of Remedial Technologies and Process Options for Saturated Bedrock

Following the preliminary screening for groundwater in Table 2-5b, the retained technologies and process options are further identified and screened in this section. Remedial technologies and process options that could achieve the RAOs, either alone or in combination with other technologies and process options, are summarized in Table 2-6b and were used to develop the alternatives discussed in Section 3.

2.6.2.1 No Action

The NCP requires the evaluation of a no action alternative as a basis for comparison with other remedial alternatives. Under the no action response action, no remedial actions would be conducted to reduce exposure to the contaminated soil or groundwater.

Effectiveness – The no action response would not be effective at this site because contamination is present above ARARs and poses human health risks. It does not protect the environment and does not provide measures that would comply with ARARs or RAOs.

Implementability – The no action alternative is implementable given that no action would be required.

Relative Cost – The no action alternative involves no capital, O&M, or administrative costs.

Conclusion – No action is retained as a baseline for comparison to other alternatives as required by the NCP.

2.6.2.2 Institutional Controls

Institutional controls consist of legal and administrative actions that control the use of the site groundwater to prevent or minimize human exposure to contaminants at unacceptable risk levels. Institutional controls do not reduce the T/M/V of contamination. Institutional controls generally require long-term monitoring of contaminant concentrations and migration to support decision-making on continuation or modification of institutional control measures.

2.6.2.2.1 Groundwater Use Restrictions

A groundwater use restriction is an institutional control that restricts the installation of wells within the contaminated aquifer, thus preventing human exposure to contaminated groundwater at concentrations posing unacceptable risks. Groundwater use restrictions or well drilling restrictions are generally administrated by NJDEP. An institutional control measure for groundwater would minimize the potential for human exposure to site contaminants prior to the completion of a groundwater remedy.

Effectiveness –Groundwater use restrictions, when properly enforced and executed, would prevent human exposure to contaminated groundwater at unacceptable levels. However, groundwater use restrictions alone would neither prevent contamination from migrating nor reduce the T/M/V of the contaminated media. Currently, private potable wells screened in the bedrock exist and are used by the adjacent residential neighborhood in Byram Township. Although residential wells with impacts from contaminated groundwater have been installed with POET systems, groundwater use restrictions would restrict installation of any new wells within the contaminated aquifer. NJDEP is expected to continue maintaining eligible POET systems and the existing potable wells will be monitored as part of the remedial action planned for the residential neighborhood under OU1.

Implementability – Groundwater use restrictions would limit the current and future use of the underlying groundwater and would require the local government to enforce and monitor the effectiveness of controls over the long term.

Relative Cost – The cost to implement groundwater use restrictions is low.

Conclusion – Groundwater use restrictions are retained for further consideration in coordination with other remedial technologies.

2.6.2.2.2 Community Awareness

Community awareness involves information and education programs to enhance awareness of potential hazards, available technologies that are capable to address the contamination, and the remediation progress to the local community. Educational programs would protect human health by bringing increased awareness to the public of the contaminated conditions in site media and would enhance implementation of other institutional or engineering controls (such as groundwater use restrictions) within the contaminated area.

Effectiveness – This option would be effective when combined with other technologies that could reduce exposure and T/M/V.

Implementability – This option would be implementable.

Relative Cost – Community awareness would have low capital and operational costs.

Conclusion – Community awareness is retained for further evaluation in coordination with other remedial technologies.

2.6.2.2.3 Monitoring

Monitoring includes periodic sampling and analysis of the impacted groundwater. It may be conducted parallel with and/or after the completion of active remediation if contaminants exceeding the PRGs remain on-site and could naturally attenuate. This program would provide data and evidence of the breakdown and/or movement of the contaminants and the progress of remedial activities. Monitoring can be implemented for short duration or long term. Data collected by the monitoring program would be used in five-year reviews.

Effectiveness – Monitoring alone would not be effective in reducing the T/M/V of the contaminated media and would not prevent contaminant migration at this site. However, a properly designed monitoring program would be effective in providing information on site conditions to decision-makers.

Implementability – Monitoring is a proven and reliable process and can be easily implemented.

Relative Cost – Monitoring involves low capital and moderate O&M costs.

Conclusion – Monitoring is retained for further consideration.

2.6.2.3 Monitored Natural Attenuation

MNA refers to the remedial action that relies on naturally occurring attenuation processes to decrease contaminant concentrations and mass and achieve site-specific remediation goals within a reasonable time frame. Natural attenuation processes that reduce contaminant concentrations include destructive (e.g., biodegradation and chemical reactions with other

subsurface constituents) and non-destructive mechanisms (e.g., volatilization, dilution/dispersion, and adsorption/desorption).

Chlorinated solvents, such as TCE, biodegrade predominantly by microbial reductive dechlorination under anaerobic conditions.

Evidence collected during the RI indicates that both microbial reductive dehalogenation and aerobic cometabolic degradation of TCE are biodegradation mechanisms actively attenuating groundwater concentrations at the site. This conclusion was drawn from compound-specific isotope analysis data and evaluation of the microbial community (see Section 5.5.2 of the RI). The destructive attenuation appears to be most active under and directly adjacent to the dump areas. Although the evidence for biodegradation is more limited for cis-1,2-DCE, concentrations of cis-1,2-DCE remain below PRGs outside of bedrock well MLS-2 and the amount of parent product (TCE) makes it unlikely that buildup of cis-1,2-DCE would exceed PRGs in the future. Similarly, for vinyl chloride, destructive attenuation evidence is limited, likely due to degradation stalling at cis-1,2-DCE in most wells. The exception is port 4 in MLS-3, which has significantly greater populations of *Dehalococcoides sp.* compared to other wells (the only bacterium known to fully dechlorinate TCE through vinyl chloride to ethene).

Evidence of destructive attenuation was not collected for 1,4-dioxane; however, biodegradation of this contaminant under aerobic conditions is possible (Mahendra et al. 2013; Adamson et al. 2015) and concentrations of this compound have remained low (within approximately one order of magnitude of the PRGs).

Dilution and dispersion continue to reduce concentrations for all site contaminants in the transmissive bedrock fractures, albeit non-destructively. Groundwater concentrations of TCE and breakdown constituents (cis-1,2-DCE and vinyl chloride) are attenuated through volatilization as shown by the presence of VOCs in sub-slab vapor samples from the nearby residential neighborhood. Vapor intrusion issues are being addressed separately by EPA (through sub-slab depressurization systems and regular monitoring events).

Historical concentrations in the wells along Brookwood Road exhibited statistically significant declining concentration trends prior to the removal action in 2012 (statistics are shown in Appendix B). These trends are a sign of natural attenuation and a reduction in mass discharge from the source. The increase in concentrations seen in these Brookwood Road wells after the removal action shows that downgradient concentrations are driven by advection from upgradient groundwater sources. In this case, concentrations went up because the vadose zone source was exposed and disturbed during the removal action. The converse is likely true: if source zone remediation is conducted, plume concentrations will likely decrease. This is frequently not the case in systems dominated by matrix back-diffusion but is likely the case at the Mansfield Trail Dump Site because of the relatively lower degree of diffusion into and out of the hard crystalline bedrock aquifer.

Effectiveness – MNA alone is not likely to reduce concentrations to PRGs within a reasonable time frame because of continued mass discharge from the vadose zone to the saturated zone. However, MNA in conjunction with other technologies is considered effective for this site because:

- Historical concentration trends in the plume are declining in statistically meaningful ways;
- Both non-destructive and destructive attenuation mechanisms have been documented to be occurring; and
- Matrix back-diffusion is likely relatively minimal in the hard crystalline bedrock.

Implementability – MNA is implementable at the site. Materials and services necessary to model and monitor the contaminant dynamics are readily available.

Relative Cost – MNA would involve moderate capital costs and moderate O&M costs.

Conclusion – MNA is retained for further consideration in conjunction with other technologies that address the source zone, specifically those that reduce mass discharge to the saturated zone and/or decrease mass flux in the saturated zone.

2.6.2.4 Groundwater Extraction

Extraction technologies involve placing extraction wells to intercept the flow of contaminated groundwater and hydraulically prevent contaminants from migrating downgradient. Groundwater extraction can be used at the source area for contaminant removal. The extracted groundwater is typically treated ex situ and disposed of on- or off-site. Extraction wells are effective when combined with other treatment and discharge technologies. Groundwater extraction is effective in providing hydraulic control and contaminant removal at sites where the soil is permeable, the hydrogeology is well understood, and the pumping rate necessary to maintain hydraulic control is sustainable. It is generally not effective for contaminant removal where the contaminants are distributed in heterogeneous low permeability materials.

If vadose zone treatment areas are in the same locations as the groundwater target treatment zones, DPE may be selected as a combination technology of SVE and groundwater extraction. A pump may be used to extract groundwater while a vacuum is applied to the wellhead to extract soil gas. Both aqueous and vapor streams would require ex situ treatment; however, this section discusses extraction of groundwater only.

Effectiveness –Since primary porosity is low, transmissivity comes from secondary porosity in weathered zones, bedding planes, and fractures. The bedrock consists of three different zones: (1) a shallow zone defined by a higher density of transmissive or potentially transmissive fractures in the source area, (2) an intermediate zone characterized by few transmissive or potentially transmissive fractures, and (3) the deep zone that has a higher concentration of transmissive fractures than the intermediate zone. Private potable wells in the residential neighborhood downgradient have been drawing groundwater from the intermediate and deep zones for years. Therefore, groundwater extraction is possible but variable transmissivity in the bedrock may lead to variable effectiveness in treating the different zones. The bedrock is a hard crystalline bedrock with low potential for matrix diffusion. Therefore, back-diffusion from the rock matrix is unlikely to be an issue. A larger concern is the more weathered shallower bedrock that consists of a greater density of dead-end fractures and rubble zones. Groundwater sampling has indicated that rainwater picks up some but not all of the contamination stored in these areas. Contamination stored in dead-end fractures would be difficult to remove with groundwater

extraction. Residual contamination may cause tailing or lead to rebound after treatment. Groundwater extraction in the intermediate and deep zones may affect or be affected by the residential wells downgradient that are screened across the intermediate and deep zones.

Implementability – Installation of groundwater extraction wells would be technically implementable for the site. Necessary equipment and materials would be readily available. Space is available at the source area (dump areas). Groundwater extraction to prevent or minimize contaminant migration to a public supply well or wells would not be necessary given impacted residences downgradient are equipped with POET systems to treat contaminated groundwater.

Relative Cost – Groundwater extraction would involve high capital and O&M costs.

Conclusion – Groundwater extraction is retained for further consideration.

2.6.2.5 Ex Situ Treatment

Treatment involves the destruction of contaminants in the affected media, transfer of contaminants from one media to another, or alteration of the contaminants, thereby making them innocuous. The result is a reduction in T/M/V of the contaminants. Treatment technologies vary among environmental media and can consist of chemical, physical, thermal, and biological processes. Treatment can occur in the subsurface or aboveground (discussed below). Treatment (either ex situ or in situ) is usually preferred unless site- or contaminant-specific characteristics make it infeasible from a constructability perspective or if it is cost prohibitive.

If groundwater extraction, DPE, air sparging, or ISTR is selected as part of the remedy, an ex situ treatment system would be required to remove contaminants from the extracted groundwater or vapor before discharge. This section provides a description and screening discussion of ex situ treatment technologies for extracted groundwater or vapor effluent.

2.6.2.5.1 Air Stripping

Air stripping is a physical mass transfer process that uses clean air to remove dissolved VOCs from water by increasing the surface area of the groundwater exposed to air. Commonly used systems include the countercurrent packed column, multiple-chamber fine-bubble aeration systems, venturi systems, and low-profile sieve tray air strippers. In a countercurrent packed column, contaminated groundwater is sprayed through nozzles at the top of the column; it flows downward through packing materials. In a low-profile sieve tray air stripper, contaminated groundwater flows across the surface of a series of perforated trays. In both systems, clean air is forced into the system by a blower in a direction opposite to groundwater flow (e.g., from the bottom, flowing upward). In a multiple chamber fine bubble aeration system, contaminated groundwater flows through aeration tank chambers, and air is introduced at the bottom of each chamber through diffusers, forming thousands of fine bubbles. As the fine air bubbles travel upward through the water, mass transfer occurs at the bubble/water interface. System efficiency increases with decreasing bubble diameter.

In general, the water stream exiting the air stripper can be discharged to surface water or groundwater. The vapor effluent likely would require treatment (e.g., vapor-phase GAC) before discharge to the atmosphere.

Effectiveness – Air stripping is a proven technology, effective in removing TCE, cis-1,2-DCE, and vinyl chloride from extracted groundwater. However, based on Henry's law constant for 1,4-dioxane and previous treatment cases at other sites, it is unlikely that air stripping would reduce concentrations of 1,4-dioxane to the PRG from the already low concentrations observed at the site (4.1 µg/L and below).

Implementability – Air stripping would be easily implementable. Vendors and equipment would be readily available to provide air strippers for groundwater VOC removal. This process option would need to be implemented with groundwater extraction and discharge technologies.

Relative Cost – Air stripping would have low capital and O&M costs.

Conclusion – Air stripping is retained for further consideration.

2.6.2.5.2 Liquid-Phase Granular Activated Carbon

Liquid-phase GAC is usually used to remove contaminants from groundwater in combination with a groundwater extraction technology. Groundwater is pumped through one or more vessels containing GAC. Contaminants are adsorbed onto the GAC and removed from the groundwater prior to discharge. The used GAC can be either regenerated after contaminants break through or disposed of in an appropriate manner.

Effectiveness – Activated carbon adsorption would be effective in removing TCE and cis-1,2-DCE. It would not be effective in the removal of vinyl chloride. An additional treatment method, such as advanced oxidation process (AOP), would be required to remove vinyl chloride. Liquid-phase GAC has been shown to be effective at reducing concentrations of 1,4-dioxane from high initial concentrations (1,500 µg/L or more) and would likely not be successful at treating the low concentrations observed at the site.

Implementability – This technology would be implementable, and the equipment and materials would be readily available. Liquid-phase GAC can be used directly in a groundwater pump and treat remedy or DPE system. This technology generally does not require a treatability study. Discharging the treated groundwater generally would require a permit.

Relative Cost – This technology would involve medium capital and O&M costs.

Conclusion – This technology is retained for further consideration.

2.6.2.5.3 Vapor-Phase Granular Activated Carbon

Vapor-phase GAC is usually used to remove contaminants from the vapor or gas phase in combination with an SVE system, ISTR, or downstream of air strippers in the treatment train. Contaminants are adsorbed onto the GAC and removed from the air flow prior to discharge to the atmosphere. The used GAC can be either regenerated after contaminants break through or disposed of in an appropriate manner.

Effectiveness – Activated carbon adsorption would be effective in removing TCE and cis-1,2-DCE. It would not be effective in the removal of vinyl chloride. An additional treatment method, such as potassium permanganate oxidation, would be required to remove vinyl chloride, if present.

Implementability – This technology would be implementable, and the equipment and materials would be readily available. Vapor-phase GAC can be used directly for an SVE system or in the treatment train for off-gas management in a groundwater pump and treat remedy. This technology generally does not require a treatability study. Discharging the treated gas of any off-gas system generally would require a permit.

Relative Cost – This technology would involve medium capital and O&M costs.

Conclusion – This technology is retained for further consideration.

2.6.2.5.4 Potassium Permanganate

When vinyl chloride is present in the vapor, potassium permanganate can be used to oxidize the contaminant after the treatment with vapor-phase GAC. Typically, an ion exchange resin (zeolite) is impregnated with a solution of potassium permanganate. Potassium permanganate will react to form three compounds: potassium hydroxide, manganese tetroxide, and manganese dioxide. The manganese tetroxide will oxidize vinyl chloride into potassium chloride and carbon dioxide. The potassium chloride will remain in the pore structure of the substrate that contains the hydrated potassium permanganate.

Effectiveness – Potassium permanganate oxidation would be effective in removing contaminants not removed with vapor-phase GAC (such as vinyl chloride) from the off-gas.

Implementability – Using potassium permanganate impregnated zeolite to remove vinyl chloride in the soil vapor or off-gas would be implementable. The equipment and materials would be readily available through vendors.

Relative cost – This technology would involve medium capital and medium O&M costs.

Conclusion – This technology is retained for further consideration.

2.6.2.5.5 Advanced Oxidation Processes

This process option is used when destruction of contaminants is preferred or when contaminants cannot be removed with GAC or air stripping. Extracted groundwater would be pumped through a reactor where it is combined with ozone and/or hydrogen peroxide and irradiated with ultraviolet (UV) light. Organic contaminants are destroyed because of the synergistic action of the oxidant with UV light. The system may require off-gas treatment to destroy unreacted ozone and volatilized contaminants.

Effectiveness – AOP would be an effective method to treat chlorinated VOC contaminants in extracted groundwater. It should be noted that high turbidity or high ferrous iron content in the water can cause interference and reduce the effectiveness and would require pre-treatment. Based on the RI, neither turbidity nor high ferrous iron content appears to be an issue for groundwater at the site. However, AOP decomposition products, such as organic acids, may potentially form. AOP is most cost-effective for treating high concentration-low groundwater flow streams. However, groundwater concentrations at the site are relatively low and dilute. AOP has been seen to successfully reduce concentrations of 1,4-dioxane from low initial contaminant (4.6 to 15 μg/L) concentrations to less than 1 μg/L (EPA 2006a).

Implementability – This technology would be implementable. Vendors and equipment for UV and oxidation technology would be readily available. It would need to be implemented with groundwater extraction and discharge technologies.

Relative Cost – This technology would involve high capital and O&M costs. A UV or oxidation system is generally costlier than an equivalently sized GAC unit. It also would require more electricity to operate.

Conclusion – This technology is retained for further consideration.

2.6.2.6 In Situ Treatment

Several in situ treatment technologies are identified and evaluated below.

2.6.2.6.1 Air Sparging/In-Well Air Stripping

Air sparging involves the injection of air into the contaminated aquifer. Injected air strips organic contaminants and helps to flush the contaminants into the unsaturated zone. Air sparging, properly installed and operated, is generally most effective for removal of volatile, relatively insoluble organics from a highly permeable, relatively uniform sandy aquifer (Bass et al. 2000). If the mass of VOCs is great enough, SVE is frequently implemented in conjunction with air sparging to remove the vapor-phase contamination from the vadose zone by vacuum extraction and vapor treatment, if required.

In-well air stripping combines both air sparging with air stripping (described above). The in-well air stripping technology is designed to create a three-dimensional vertical circulation pattern in an aquifer by drawing contaminated groundwater from the aquifer through one screened section (usually the bottom screen) of a two-screened well, treating the water within the well and then discharging it into the aquifer through another screened section (usually the top screen) without bringing the contaminated groundwater aboveground. When the vertical circulation pattern is generated, the treated groundwater may be circulated several times in the aquifer before it flows downgradient, which would greatly enhance contaminant removal from low-permeability zones compared to a pump and treat technology. The withdrawal of contaminated groundwater is usually achieved using the air-lifting mechanism. As in regular air sparging, contaminants that transfer into the vapor phase in the well are removed by vacuum extraction and treated (if required) prior to discharge to the atmosphere. The difference in the horizontal and vertical transmissivity influences the radius of influence of the system. Proper design and testing need to be done to prevent the spreading of contamination.

Effectiveness –Fractures in the bedrock at the site promote preferential flow paths for groundwater. Effectiveness would be impacted by the ability to drive the air bubbles directly through the contaminated zones, which would be challenging given the variable transmissivity of the bedrock zones (shallow, intermediate, deep) and the depth of contamination (up to 400 ft bgs).

In-well air stripping systems could effectively treat the CVOCs if the air stripping inside the well is effective. Hydrogeologically, the withdrawal of contaminated groundwater and the establishment of vertical circulation pattern in the formation could intercept the contaminant plume. Issues that may result in failure of an in-well stripping include (1) short circuiting around the well, resulting

in limited radius of influence and (2) high ratio between vertical hydraulic conductivity and horizontal hydraulic conductivity, preventing the establishment of a circulation loop in the designed treatment zone. The behavior of in-well air stripping would be difficult to predict given the wide variance of hydraulic conductivity representing the fracture dominated bedrock flow. Recirculation could be limited or prevented depending on the presence and orientation of the bedrock fractures.

Desorption and mass discharge from fractures and any residual DNAPL could lengthen the time frame for remediation by air sparging and in-well air stripping. A pilot test would be necessary to confirm effectiveness. Neither air sparging nor air stripping would be as effective for 1,4-dioxane as for TCE, cis-1,2-DCE, and vinyl chloride.

Implementability – Achieving uniform delivery is a key implementation hurdle for air sparging. Evenly injecting air in both the low permeability and high permeability sections of the bedrock may be challenging due to the geological heterogeneity. The system may be operated for longer than normal or pulsed to address residual contamination in dead-end fractures. Reactivity cannot be sustained without operating the system actively for a long time.

Relative Cost – This technology would involve moderate capital and O&M costs.

Conclusion – This process option is not retained for further evaluation due to effectiveness and implementability concerns.

2.6.2.6.2 In Situ Chemical Reduction

The most widely used reductant for ISCR of CVOCs is zero-valent iron (ZVI). ZVI has been applied in several ways to remediate contaminants: in a permeable reactive barrier (PRB), in nano-scale through injection, and in micro-scale through injection or with permeability enhancement. ZVI has been combined with organic carbon amendments for in situ remediation of groundwater and saturated soils. Achieving delivery of the reductant to the contaminated zones and ensuring adequate contact of the reductant with contaminants would be critical for effective treatment.

Effectiveness – ISCR has proven to be effective in degrading CVOCs. However, the effectiveness of ISCR depends on the ability to contact the contamination with the amendments. Different transmissivities of the different bedrock zones may lead to variability in distribution of amendment. Injecting amendment into the subsurface is typically best at delivering the amendment to more transmissive zones. At the site, a key concern is the potential presence of contaminant mass in dead-end fractures; it would be difficult to emplace amendment into dead-end fractures. However, ZVI has been proven to have long-term reactivity, which would be beneficial in capturing the eventual mass transfer out of the dead-end fractures and into the more transmissive zones, where the amendment would likely reside. 1,4-dioxane has not been seen to degrade effectively in anaerobic conditions, so ISCR would likely not be an effective treatment for it. A bench-scale study and pilot test would be necessary to confirm effectiveness in each of the bedrock zones (shallow, intermediate, deep).

Implementability – ISCR (ZVI) may be emplaced through trenching technology or through injection. Due to the depth of contamination and the difficulty of excavating bedrock, trenching technology would not be implementable. ISCR amendments composed of particles that are

smaller than the fracture apertures in the bedrock could be emplaced by injection or recirculation, which would distribute the amendment into preferential pathways and would need to be closely monitored so as not to affect surrounding structures. Distributing ZVI would be much more difficult in fractured bedrock if fractures are not well connected. The system would need to be carefully designed to verify no harmful byproducts would enter residential wells or Cowboy Creek downgradient.

Cost – This technology would involve high capital cost. Depending on the delivery technology and the depth required to be achieved, the O&M cost could be minimal (mainly monitoring) when replenishment of the amendment is not required.

Conclusion – This technology is retained for further consideration.

2.6.2.6.3 In Situ Chemical Oxidation

ISCO is an aggressive approach involving the injection of chemical oxidants into the subsurface that destroy organic contaminants in saturated soils and groundwater. Complete oxidation of the contaminants results in their breakdown into less toxic compounds, such as carbon dioxide, water, and chloride. The commonly used oxidants include Fenton's reagent, persulfate, potassium permanganate, and/or ozone. Permanganate and activated persulfate can oxidize TCE effectively and are relatively stable in the subsurface.

Factors that must be considered when implementing ISCO include site-specific geology, the ability to distribute the oxidants into the contaminated media, and the soil oxidant demand. The effectiveness of ISCO treatment is dependent on distributing the oxidant to achieve direct contact between the oxidants and the contaminants. This can be challenging in heterogeneous geology. ISCO is a non-selective oxidation process. The oxidants would react with the contaminants and naturally occurring compounds in soil, including organic compounds and select metals. Thus, an excess of oxidants would be required to satisfy the oxidant demand of the native soil. ISCO treatment results in an oxidizing condition within the treatment area, which could hinder any natural reductive dechlorination processes temporarily.

Effectiveness – Similar to ISCR, the effectiveness of ISCO depends on the ability to contact the contamination with the amendments. ISCO is usually used in the highly contaminated area or the source area where the oxidants would not be wasted on soil oxidant demand. The oxidants used in ISCO treatment are generally short-lived (hours to months). At the site, residual contamination is likely present in dead-end fractures where delivery of ISCO would be unlikely (amendment injection typically favors more transmissive zones). Mass transfer out of the dead-end fractures may occur over time, after the reactivity of the ISCO has diminished. This would lead to tailing or rebound in concentrations after treatment. For this reason, ISCO treatment would have limited effectiveness. ISCO is generally not an effective technology for a dilute plume when repeated treatment would be required and would depend on the rate that the low-concentration contaminants migrate into the treatment zone. A bench-scale study and pilot test would be necessary to confirm effectiveness, identify soil oxidant demand, and investigate the site-specific methods for effective oxidant distribution.

Persulfate has been observed to be an effective chemical oxidant for treatment of 1,4-dioxane in bedrock at high initial concentrations (300 µg/L to 460 µg/L), but it is unclear whether chemical

oxidation would be effective at such low concentrations as observed at the site. Temporarily inducing oxidizing conditions in the treatment area may however encourage the biodegradation of 1,4-dioxane under aerobic conditions.

Implementability – Achieving uniform delivery is the key implementation hurdle for ISCO. Given the variable transmissivity of the different bedrock zones, amendment delivery should be implementable, but injection wells would need to be drilled to different depths for targeting contamination in the different zones. Distributing the amendment would be much more difficult in fractured bedrock if fractures are not well connected; the oxidants may be distributed into fractures that do not need treatment, which results in waste of oxidants. The system would need to be carefully designed to verify no harmful byproducts would enter residential wells or Cowboy Creek downgradient.

Relative Cost – ISCO would involve high capital and potentially high O&M costs when repeated injections are required.

Conclusion – ISCO is not retained for further evaluation due to effectiveness concerns.

2.6.2.6.4 In Situ Bioremediation

In situ bioremediation technology biologically transforms contaminants into non-toxic compounds over a wide range of concentrations in groundwater. Enhanced anaerobic biodegradation involves the injection of an electron donor, nutrients, and/or dechlorinating microorganisms (i.e., bioaugmentation), as necessary, into the subsurface. This combined delivery stimulates the natural reactions of microorganisms to degrade TCE and its daughter products in an environment otherwise low in organic content. Additionally, the reducing conditions can lead to the formation of reduced iron minerals in the subsurface that create abiotic degradation pathways for VOCs (Adamson et al. 2011).

Common electron donors include lactate, whey, and emulsified vegetable oil. Lactate and whey generally last 3 to 6 months in the subsurface, whereas emulsified vegetable oil and integrated carbon or ZVI amendments may last for 2 or 3 years.

The anaerobic bioremediation process can generate secondary impacts, especially the solubilization of methane, carbon dioxide, and metal naturally occurring in the soil matrix. These impacts are the result of the enhanced reducing conditions in the groundwater (iron, arsenic [released when iron is reduced], manganese solubilization) and degradation of the contaminants by microbes (methane and carbon dioxide generation). The iron and manganese precipitate once oxidizing conditions return to the remediation zone and the methane dilutes and disperses; however, arsenic can be soluble in both reduced and oxidized form (ITRC 2008). These impacts are transient and usually localized to just the anaerobic remediation zone, but the recovery processes can take years, depending upon the rate of re-oxygenation of the remediation zone.

Effectiveness – The effectiveness of bioremediation depends on the ability to deliver bio-stimulating amendments to the zones where the contamination resides. Different transmissivities of the different bedrock zones may lead to variability in distribution of amendment. However, a solid amendment, such as whey, or enhancements to the amendments, such as shear-thinning fluids or activated carbon-based amendments designed to coat soil particles quickly, could be

used in highly transmissive zones (like the shallow bedrock zone) to improve amendment retention and establish enough time to establish reactivity. Bioremediation has been well established for successfully treating CVOCs like TCE and daughter products as seen at the site. A field pilot test would be necessary to confirm effectiveness and identify the radius of influence for amendment distribution. Slow mass transfer from dead-end fractures may cause tailing or lead to rebound after treatment. However, long-lasting amendments, including amendments with sorptive capabilities, may be helpful in sustaining reactivity to capture and treat the slow mass discharge from dead-end fractures.

1,4-dioxane has been seen only to effectively degrade in aerobic conditions as present in the shallower zones of the bedrock. However, the 1,4-dioxane contamination appears mainly in the deeper zones, which are more anaerobic. Therefore, enhancing anaerobic biodegradation of CVOCs may be counterproductive to the biodegradation of 1,4-dioxane, which requires aerobic conditions.

Implementability – Achieving uniform delivery is a key implementation hurdle for in situ bioremediation. To address the potential for sustained mass discharge from the fractured bedrock at the site, a recirculation system could be installed to distribute amendment laterally under the dump areas to promote long-term contact and reactivity with the contaminants. The system would need to verify no harmful byproducts would enter residential wells or Cowboy Creek downgradient. A recirculation layout may be helpful in keeping the amendment-treated groundwater from reaching downgradient.

Relative Cost – This technology would involve medium capital and low to medium O&M costs.

Conclusion – In situ bioremediation is retained for further evaluation.

2.6.2.6.5 Permeable Reactive Barrier

A PRB is an installed barrier perpendicular to the natural plume flow path to remove contaminants through reaction with the permeable reactive medium. This in situ treatment method combines a passive chemical or biological treatment zone with subsurface fluid flow management. The PRB can be installed via a continuous trench backfilled with the treatment material or as a collection of injection or recirculation wells to place reactive materials such as ZVI or bioremediation amendments.

Effectiveness –Different transmissivities of the different bedrock zones may lead to variability in distribution of amendment. The less transmissive intermediate bedrock zone may act as a confining layer between the shallow and deep zones and groundwater may not pass easily through the PRB in the intermediate zone. The PRB may be more effective in the shallow source area of the groundwater plume. Due to the fracture-dominated bedrock flow, it is possible for some contamination to travel differently than the overall natural flow path, thus missing contact with the PRB. A field pilot test would be necessary to confirm effectiveness and identify the proper amendment to use. Reactivation or reinstallation of PRBs may be necessary to address persistent mass discharge.

Implementability – Due to the depth of contamination and the difficulty of excavating bedrock, trenching a PRB would not be implementable. Trenchless methods using injection have

successfully placed PRBs to 115 ft bgs. However, implementing a PRB at depths required to treat the site contamination has not been proven. Equipment and experienced vendors for PRB installation would be commercially available. The system would also need to verify no harmful byproducts would enter residential wells or Cowboy Creek downgradient.

Relative Cost – This technology would involve medium capital and low to medium O&M costs.

Conclusion – This technology is not retained for further evaluation due to implementability and effectiveness concerns.

2.6.2.7 Discharge

When groundwater extraction and ex situ treatment are used, the treated water could be discharged on- or off-site. Potential on- and off-site discharge options for groundwater are evaluated below.

2.6.2.7.1 On-site Injection

The on-site discharge technology involves injecting treated groundwater into the aquifer using a series of wells. The injection can be used as part of a hydraulic control design. Groundwater collected from extraction wells or DPE would need to be treated to applicable groundwater standards prior to discharge to the subsurface. On-site injection could be used as a delivery method for distributing amendments during in situ treatment.

Effectiveness – The effectiveness of this option would rely on proper injection well design and construction, including adequate pipe sizing, proper placement of the wells, and reliable construction materials. It also would depend on the water quality. Water with high iron content could clog the injection well screen. Biofouling may occur and would require regular maintenance. The effectiveness of this technology would rely on the ability to install wells in a zone that can accept the amount of water to be injected. For this site, the bedrock would be suitable to screen the injection wells.

Implementability – Discharge of treated effluent to one or more injection wells would be implementable as there is space in the source area (dump areas). If both injection and extraction wells are required, how to space the well screens horizontally and vertically needs to be carefully evaluated and may require the use of a groundwater model. The treated effluent would need to be monitored and tested rigorously to ensure no unwanted chemicals are reinjected into the aquifer, which may impact the residential wells or Cowboy Creek downgradient.

Relative Cost – This technology would involve medium capital costs and low to medium O&M costs.

Conclusion – On-site injection is retained for further consideration.

2.6.2.7.2 Surface Discharge

Groundwater can be disposed of to a nearby surface water channel or drainage system. The groundwater would need to be treated to meet surface discharge criteria.

Effectiveness – A drainage ditch is located east of the source area near railroad tracks. On-site discharge would be effective as long as a proper drainage system can be built to accommodate the flow to the discharge channel.

Implementability – Surface discharge would be easy to implement by connecting to the existing drainage ditch. However, the treated effluent would need to be monitored and tested rigorously to ensure no unwanted chemicals are discharged to the drainage ditch, which will eventually discharge into Cowboy Creek downgradient.

Relative Cost – A surface discharge system would involve low capital and O&M costs.

Conclusion – On-site surface discharge is retained for further consideration.

Table 2-6b summarizes the retained remedial technologies and process options for remediation of the saturated bedrock zone in the source area and for the groundwater in the downgradient areas.

The retained technologies and process options will be combined to form remedial alternatives for the remediation of the contaminated site media in Section 3.

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Section 3

Development and Screening of Remedial Action Alternatives

The objective of this section is to describe remedial action alternatives for the different TRZs (source area, residential area, and non-residential areas) at the site under its current conditions. To address the site-specific RAOs, alternatives were created by combining the technologies and process options retained in Section 2.

3.1 Development of Remedial Action Alternatives for Soil

3.1.1 Overview

Several technologies and process options were retained for contaminated soils in the residential area and the two isolated contaminated soil areas in Dump Areas B and E based on the screening in Section 2. The retained technologies and process options (summarized in Table 2-6a) were combined to develop remedial action alternatives.

To develop remedial alternatives for the non-VOC TRZs, representative process options were selected from the same groups of remedial technologies, as appropriate. However, other process options may be applicable and should be considered during the remedial design stage of the project.

The three alternatives developed for the non-VOC overburden soils are listed as follows:

- Alternative S-1 – No Action
- Alternative S-2 – Capping
- Alternative S-3 – Excavation and Off-site Disposal of Contaminated Soils

3.1.2 Common Elements

The common elements included as part of Alternatives S-2 and S-3 are described here. This FS describes a conceptual approach for the remedial action, and many assumptions are made for order of magnitude costing purposes. The final approach for remedial action would be determined during the RD.

3.1.2.1 Pre-Design Investigation

During the remedial design, a PDI would be performed to conduct additional sampling and refine the vertical and horizontal extents of the areas requiring remediation. This would include a wetland survey around Dump Area B to identify any wetlands potentially within the TRZ. Additionally, stormwater modeling would be conducted for the residential area TRZ to ensure the stormwater management technologies are appropriately implemented or modified as necessary for compliance with New Jersey stormwater management and permitting requirements.

3.1.2.2 Remedial Design

Based on data collected during the PDI and before the PDI, a remedial design would be conducted to provide rationale, detailed approaches, and cost estimates for the remedial action.

3.1.2.3 Clearing and Grubbing

The residential area is currently forested and heavily vegetated. Clearing and grubbing would be performed prior to any active remedy implementation at the site. Work would be conducted to remove shrubs and small trees and avoid uprooting larger trees as much as possible. In addition, a small ponded area or wetland is located near Dump Area B. Site work would avoid this area to prevent disruption of the pond habitat and the wetland.

3.1.2.4 Excavation of Polychlorinated Biphenyl Contaminated Soils

Limited excavation of PCB contaminated soils would be conducted in specific locations in and around the dump areas. As described in Section 2.1.2, these locations include an area at the center of Dump Area E and in the southwest corner of Dump Area B (Figures 2-1 and 2-2). During the PDI, these non-residential TRZs would be further delineated to refine the areas of excavation. However, for cost estimation purposes, it is assumed that a 20 ft by 20 ft area would be excavated around each sample area that exceeded non-residential PRGs. It is assumed that 10 percent of the excavated soils would be hazardous and 90 percent would be non-hazardous. The excavated soils would then be disposed of off-site. If the PDI reveals additional spots of contamination not addressed by existing alternatives, those additional discovered spots would be excavated as part of this common element to meet PRGs.

3.1.2.5 Engineering Controls

An erosion control or diversion structure would be installed at the northern edge of the TRZ (downslope) to prevent any contaminated soils from migrating off the site to other areas. Temporary fencing would be installed around the TRZ to prevent human contact and reduce or mitigate human health risks while the remedy is being constructed. The engineering controls would be removed after either confirmation sampling or site reviews verify that the contaminants are below PRGs.

3.1.2.6 Five-Year Reviews

Five-year reviews would be conducted for all alternatives, as required by CERCLA. The reviews would assess any ongoing risks to human health and the environment and the effectiveness of remediation and institutional controls. The data collected during the long-term monitoring program would be used in the reviews. Based on each review, a decision would be made for future management of the site.

3.1.3 Alternative S-1 – No Action

No remedial action would be implemented under this alternative. The no action alternative was retained in accordance with the NCP to serve as a baseline for comparison with the other alternatives.

3.1.4 Alternative S-2 – Capping

Under this alternative, the contaminated soils in the residential area (consisting of the residential yard and the upgradient area up to the edge of Dump Area A) would be capped to eliminate exposure pathways to human and ecological receptors (Figure 3-1). This alternative consists of the following components:

3.1.4.1 Pre-Design Investigation and Remedial Design

During the remedial design, a PDI would be performed to conduct additional sampling and refine the vertical and horizontal extents of the areas requiring remediation. Additional work during the PDI would include a geotechnical subsurface investigation to identify the site profile and engineering properties of the subsurface conditions. The geotechnical investigation would include soil probing and sample collection. Data collected as part of the geotechnical investigation would be used to evaluate the stability and constructability of the proposed cap cover system for the remedial design.

3.1.4.2 Capping

After the PDI delineates the soil contamination in the residential area, the extents of the cap would be confirmed and capping would be implemented. For cost-estimating purposes, the cap is assumed to cover the entire area of the overburden soil TRZ and be composed of a 6-inch granular cap underlying 6 inches of loam and seed. The cap would be covered with erosion control fabric for stabilization on the steep slope. Since existing natural drainage pathways in the residential yard would be disturbed or covered by the cap installation, new drainage pathways would be incorporated into the cap to allow for surface runoff from the dump areas upgradient to discharge safely and in a controlled manner. For cost estimation purposes, the new drainage pathways would consist of three drainage swales at 100 ft apart running east-west (perpendicular to the slope direction) that would connect to a longer swale that would run parallel to the slope direction. All drainage swales would be lined with rip rap.

3.1.4.3 Excavation of Polychlorinated Biphenyl Contaminated Soils

Excavation of PCB contaminated soils would be as described in Section 3.1.2.

3.1.4.4 Institutional and Engineering Controls

Engineering controls would be implemented as described in Section 3.1.2. Institutional controls in the form of a deed restriction would be implemented by the local government to restrict disturbance to the soil cover and intrusive activities near the residential yard for the duration of construction and O&M of the cap.

3.1.4.5 Operation and Maintenance

A long-term O&M plan would be implemented to ensure the effectiveness of the cap in eliminating exposure pathways to human and ecological receptors. The cap would be inspected regularly to ensure the cap is stable and intact and has not been damaged in any way. For cost estimation purposes, the inspections are assumed to occur quarterly. Maintenance activities may include reapplying and recompacting or repairing cap materials in select areas if the cover has been eroded or removing trees that have fallen over and disturbed the cap. The O&M would occur

in perpetuity, but for cost estimation purposes, the O&M period would be evaluated for a default 30-year period.

3.1.5 Alternative S-3 – Excavation and Off-site Disposal of Contaminated Soils

Under this alternative, the contaminated soils in the residential area would be excavated and disposed off-site. This alternative consists of the following components:

3.1.5.1 Pre-Design Investigation and Remedial Design

During the remedial design, a PDI would be performed to conduct additional sampling and refine the vertical and horizontal extents of the areas requiring remediation. Additional work during PDI would include a geotechnical subsurface investigation to identify the site profile and engineering properties of the subsurface conditions. The geotechnical investigation would include soil probing, sample collection, and a geophysical survey that would be used to delineate areas of variable soil thickness and areas of bedrock outcrop and help bound the excavation extents to target during the remedial action. Data collected as part of the geotechnical investigation would be used to evaluate the scope of excavation and constructability of the remedial design.

3.1.5.2 Excavation

After the PDI delineates the soil contamination in the residential area, the excavation extents would be confirmed. For cost-estimating purposes, it is assumed that the excavation would be conducted with a combination of small excavation equipment and hand excavation. The excavation activities would take precaution to avoid disturbing tree roots by prohibiting excavation within 4 ft of a tree and conducting hand excavation in areas that are near trees.

Excavation of PCB contaminated soils would be as described in Section 3.1.2.

3.1.5.3 Off-Site Disposal of Excavated Soil

All excavated soils contaminated with lead, PAHs, and/or PCBs would be properly characterized and disposed of at a Subtitle D landfill if it is non-hazardous, a Subtitle C landfill if it is hazardous, or a TSCA disposal facility for the PCB TSCA waste (i.e., PCB concentrations greater than 50 mg/kg). For cost estimation purposes, it is assumed that 10 percent of the excavated soils would be hazardous and 90 percent would be non-hazardous.

3.1.5.4 Confirmation Sampling

Confirmation sampling would be conducted after excavation to verify that soil concentrations meet PRGs and average human health risk in the residential area is within EPA's acceptable risk range. If confirmation sampling reveals additional contamination, further hand excavation would be performed in the area where the contamination is identified.

3.1.5.5 Site Restoration

After site soils are confirmed to meet PRGs, areas where hot spot excavation was conducted would be backfilled with imported clean fill and topsoil, hand compacted, and hand graded to the extent possible. Drainage pathways, if previously disturbed during excavation activities, would be restored to original conditions.

3.2 Development of Groundwater and Bedrock Vadose Zone Remedial Action Alternatives

3.2.1 Overview

Several technologies and process options were retained for the groundwater and bedrock vadose zone contamination in the source area vadose zone, source area saturated zone, and distal plume. The retained technologies and process options (summarized in Tables 2-6a and 2-6b) were combined to develop remedial action alternatives.

The alternatives developed to address VOC contamination are listed as follows:

- Alternative GW-1 – No Action
- Alternative GW-2 – Capping of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume
- Alternative GW-3 – Capping and SVE of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume
- Alternative GW-4 – Capping and SVE of Source Area Vadose Zone, In Situ Treatment in Source Area Saturated Zone, and MNA of Distal Plume
- Alternative GW-5 – Capping, DPE of Source Area Vadose and Saturated Zones, and MNA of Distal Plume

3.2.2 Common Elements

The common elements included as part of Alternatives GW-2 through GW-5 are described here. Note that this FS describes a conceptual approach for the remedial action, and many assumptions are made for order of magnitude costing purposes. The final approach for remedial action would be determined during the remedial design.

3.2.2.1 Pre-Design Investigation

During the remedial design, a PDI would be performed to refine the vertical and horizontal extents of the areas requiring remediation. The PDI activities would include a round of sitewide groundwater sampling from existing monitoring wells and an investigation into the bedrock vadose zone at the dump areas to identify potential contamination or DNAPL.

3.2.2.2 Remedial Design

Based on data collected during the RI and PDI, a remedial design would be conducted to provide rationale, detailed approaches, and cost estimates for the remedial action.

3.2.2.3 Clearing and Grubbing

Clearing and grubbing would be performed prior to any active remedy implementation at the site.

3.2.2.4 Capping

Cap installation would be completed with widely available construction equipment and techniques. The source area is an open area and would be easily accessible for staging and

necessary equipment. The purpose of the cap is to prevent infiltration of rainwater into the vadose zone at the dump areas. It also serves to prevent short-circuiting the SVE system under Alternatives GW-3, GW-4, and GW-5.

For cost estimating purposes, the cap is assumed to consist of multilayers that may include a compacted clay layer, a geocomposite drainage blanket, and seeded top soil. The cap design would be determined during the remedial design. For alternatives involving SVE, a multilayer cap may not be necessary if SVE can effectively reduce mass discharge to groundwater. In this case, a temporary cap to prevent short-circuiting may be all that is required.

Regular monitoring and maintenance of the cap, along with institutional controls to restrict incompatible uses of the source area in the future, would be required in perpetuity.

3.2.2.5 Monitored Natural Attenuation in the Distal Plume

MNA would be conducted in the distal plume to confirm that contaminant concentrations are decreasing. (As discussed in Section 2.6.2.3, historical concentrations in the wells along Brookwood Road exhibited statistically significant declining concentration trends prior to the removal action in 2012.) For cost-estimating purposes, it is assumed that wells in the distal plume would be sampled annually for VOCs and MNA parameters to ensure that natural attenuation is occurring. Additional wells may be necessary for the monitoring program; these would be installed during the remedial action. Vapor intrusion would be monitored in structures overlying the distal plume. MNA would continue until contaminant concentrations in monitoring wells are consistently below PRGs. Monitoring of the residential wells within the distal plume would be conducted by the OU1 remedial action. Therefore, the OU2 remedial action would coordinate with OU1 remedial action to ensure groundwater sampling data from the residential wells can be accessed and used for OU2.

3.2.2.6 Surface Water and Vapor Long-Term Monitoring

A long-term surface water and vapor monitoring plan would be developed to confirm that groundwater discharge from the VOC contaminated groundwater in the distal plume is not impacting surface water and vapor receptors are protected. For cost estimating purposes, it is assumed that annual collection of four surface water samples and vapor at 10 structures would be collected. Additionally, the cost estimates include maintenance of existing vapor mitigation systems at the site.

3.2.2.7 Site Restoration

After the cap is installed over the source area vadose zone, the site would be restored as much as possible, including grading and seeding activities.

3.2.2.8 Institutional Controls

Institutional controls would be implemented to protect receptors and prevent interference during remediation. Institutional controls may include a classification exception area for groundwater and zoning requirements for capped areas.

3.2.2.9 Five-Year Reviews

Five-year reviews would be conducted for all alternatives as required by CERCLA. The reviews would assess any ongoing risks to human health and the environment and the effectiveness of remediation and institutional controls. The data collected during the long-term monitoring program would be used in the reviews. Based on each review, a decision would be made for future management of the site.

3.2.3 Alternative GW-1 – No Action

No remedial action would be implemented under this alternative. The no action alternative was retained in accordance with the NCP to serve as a baseline for comparison with the other alternatives.

3.2.4 Alternative GW-2 – Capping of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume

Under this alternative, the contaminated vadose zone in the target treatment zones in the source area would be capped to reduce infiltration of rainwater, thus limiting the migration of vadose zone contamination into groundwater. MNA would be implemented for the groundwater plume in the source area and the distal plume. A plan view of this alternative is presented in Figure 3-3.

3.2.4.1 Pre-Design Investigation and Remedial Design

The PDI and remedial design would be conducted prior to the remedial action as described in Section 3.2.2.

3.2.4.2 Capping for Source Area Vadose Zone

After the PDI delineates the vadose zone contamination and the groundwater plume in the source area, the extent of the capping would be confirmed and capping would be implemented as described in Section 3.2.2. For costing purposes, it is assumed that Dump Areas A and D would be capped (approximately 46,000 ft^2).

3.2.4.3 Monitored Natural Attenuation in Source Area Groundwater Plume

MNA would be conducted in the source area groundwater plume concurrently with MNA in the distal plume (as described in Section 3.2.2). MNA for the distal plume, site restoration, institutional controls, and five-year reviews would be conducted as described in Section 3.2.2.

3.2.5 Alternative GW-3 – Capping and SVE of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume

Under this alternative, the contaminated vadose zone in the source area would be capped to reduce infiltration of rainwater, thus limiting the migration of vadose zone contamination into groundwater. SVE wells would be installed to actively treat any residual contamination in the vadose zone. The cap would serve as an impermeable barrier to prevent the SVE wells from drawing air from aboveground. MNA would be implemented for the groundwater plume in the source area. A plan view of this alternative is presented in Figure 3-4.

For costing purposes, it is assumed that Dump Areas A and D would be capped (approximately 46,000 ft^2), and SVE would be limited to Dump Area A (10,000 ft^2) and Dump Area D (36,000 ft^2).

3.2.5.1 Pre-Design Investigation and Remedial Design

The PDI and remedial design would be conducted prior to the remedial action as described in Section 3.2.2.

3.2.5.2 Pilot Study

Design parameters for an SVE system would be obtained through the performance of a pilot study. The pilot study would be conducted to determine flow rates, required vacuum, radius of influence (ROI) of each SVE well, and the effectiveness of the SVE remedy in the fractured bedrock geology of the source area vadose zone. The pilot study also would evaluate treatment requirements of the collected vapors. Because of its solubility and low-volatility, 1,4-dioxane is unlikely to be present in significant amounts in the SVE treatment train.

Because the costs of the PDI and pilot study would be incurred during the remedial design phase, the costs for the PDI and pilot study will not be included as part of this FS.

3.2.5.3 Capping of Source Area Vadose Zone

Capping would be implemented as described in Section 3.2.2.

3.2.5.4 Soil Vapor Extraction of Source Area Vadose Zone

After the PDI delineates the vadose zone contamination and the SVE pilot study confirms SVE is an effective remedy for the site, SVE wells would be installed within the confirmed extents of the source area vadose zone TRZ. For costing purposes, the TRZ would include Dump Areas A and D. Vapor monitoring points would be installed to track the progress of removing vapor-phase contamination. Piping would be laid aboveground for transferring the extracted soil vapor to a treatment system. The treatment system would be installed aboveground in the source area and consist of a prefabricated, skid-mounted unit brought on-site to treat the extracted soil vapor prior to discharge to the atmosphere. The treatment system would likely consist of compressors, piping, an air-water separator, as necessary, and vapor-phase activated carbon units. An air permit would be obtained. Vapor discharge would meet New Jersey discharge permit requirements. The air flow rate (vacuum) and concentrations of contaminants, oxygen, and carbon dioxide in the extracted vapor would be monitored regularly. Additional sampling and analysis would be conducted on the vapor effluent streams to ensure discharge permit requirements are met.

3.2.5.5 Monitored Natural Attenuation in Source Area Groundwater Plume

MNA for the source area groundwater plume would be conducted as described in Alternative GW-2 (Section 3.2.4). MNA for the distal plume, site restoration, institutional controls, and five-year reviews would be conducted as described in Section 3.2.2.

3.2.6 Alternative GW-4 – Capping and SVE of Source Area Vadose Zone, In Situ Treatment in Source Area Saturated Zone, and MNA of Distal Plume

In situ treatment via amendment injections would be conducted to treat the groundwater plume in the source area. SVE and capping would be implemented as described in Alternative GW-3 for the contaminated vadose zone. A cross sectional view of this alternative is presented in Figure 3-5.

For costing purposes, it is assumed that Dump Areas A and D would be capped (approximately 46,000 ft^2), and SVE and in situ treatment would be limited to Dump Area A (10,000 ft^2) and Dump Area D (36,000 ft^2).

3.2.6.1 Pre-Design Investigation and Remedial Design

The PDI and remedial design would be conducted prior to the remedial action as described in Section 3.2.2. Additional pre-design investigation for in situ treatment may involve:

Pilot Study and Treatability Study

An SVE pilot study would be conducted as described under Alternative GW-3 (Section 3.2.5).

A treatability study would be conducted for the in situ treatment remedy in groundwater. Different amendments would be tested to select the amendment with the most long-lasting effects in the geology of the highly fractured shallow bedrock zone and highest treatment efficacy for the site COCs.

A pilot study would identify site-specific parameters for the remedial design. Objectives of a pilot study for in situ treatment in heterogenous, highly fractured bedrock may be:

- *Identify zones of transmissive, high mass flux fractures for amendment injection.* Fractured bedrock technologies are available that rely on strips or cylinders of activated carbon to identify zones of mass flux in fractured bedrock. These technologies, accompanied by pump testing using packers and borehole geophysics, could achieve this objective.
- *Pilot test the injection methodology.* Using the results of the hydraulic and contaminant flux measurements, amendment distribution techniques could be piloted to develop full-scale design parameters, such as flow rates and borehole spacing.
- *Evaluate expected time frame for in situ treatment.* As described in the CSM for this site, contaminant mass may be present in dead-end or low-transmissivity fractures. Injection of amendment preferentially enters the more transmissive fractures. Thus, mass transfer from the low-transmissivity fractures to the reactive zones in the high-transmissivity fractures may control the time for cleanup at the site. The rate of mass transfer can be measured using methodology described in Schaefer et al. (2018) and ESTCP Project ER-201330 (ESTCP 2018).

Because the costs of the PDI and pilot study would be incurred during the remedial design phase, the costs for the PDI and pilot study will not be included as part of this FS.

Soil Vapor Extraction

SVE would be implemented as described under Alternative GW-3 (Section 3.2.5).

Capping

Capping would be implemented as described in Section 3.2.2.

In Situ Treatment in Source Area Groundwater Plume

For costing purposes, it is assumed that a combination colloidal activated carbon amendment, combined with a colloidal ZVI amendment, would be injected into a 40 ft thickness of the

saturated zone starting at the water table. Given the heterogeneity of the fracture network, it is assumed that a network of boreholes approximately 25 ft apart would be installed within Dump Areas A and D. The boreholes would be lined with a flexible liner. Passive flux meters and packers could be used to characterize the transmissivity of the fractures and identify the high mass flux fractures. For costing purposes, it is assumed that amendment would be distributed only one time via injection.

Performance monitoring of the in situ treatment is assumed for the five subsequent years, accomplished through groundwater sampling of monitoring wells within the treatment zone footprint.

MNA for the distal plume, site restoration, institutional controls, and five-year reviews would be conducted as described in Section 3.2.2.

3.2.7 Alternative GW-5 – Capping, DPE of Source Area Vadose and Saturated Zones, and MNA of Distal Plume

SVE and groundwater extraction would be combined in a DPE remedy to treat both the contaminated vadose zone and the groundwater plume in the source area. Capping would be implemented as described in Alternative GW-2. A cross sectional view of this alternative is presented in Figure 3-6.

For costing purposes, it is assumed that Dump Areas A and D would be capped (approximately 46,000 ft^2), and DPE would be limited to Dump Area A (10,000 ft^2) and Dump Area D (36,000 ft^2).

3.2.7.1 Pre-Design Investigation and Remedial Design

The PDI and remedial design would be conducted prior to the remedial action as described in Section 3.2.2.

3.2.7.2 Pilot Study

Design parameters for a DPE system would be obtained through the performance of a pilot study. The pilot study would be conducted to determine flow rates, required vacuum, ROI of a DPE well, and the effectiveness of the DPE remedy in the fractured bedrock geology of both the saturated and unsaturated zones. The pilot study would investigate the storativity of the fractured rock aquifer to determine the most effective design (with the fractures, the amount of water that could be pumped by the DPE system may be limited). The pilot study would evaluate treatment requirements of the collected vapors and collected groundwater for chlorinated solvents and 1,4-dioxane.

Because the costs of the PDI and pilot study that would be incurred during the remedial design phase, the costs for the PDI and pilot study will not be included as part of this FS.

3.2.7.3 Capping

Capping would be implemented as described in Section 3.2.2.

3.2.7.4 Dual-Phase Extraction

After the PDI delineates the vadose zone contamination and the DPE pilot study confirms DPE is an effective remedy for the site, several DPE wells would be installed within the confirmed

extents of the source area TRZ. The number of DPE wells would be determined during the design phase using data collected from the pumping test to be performed during the pilot test and would depend on the pumping rate and the radius of influence achieved that would capture the TRZ source plume. Vapor monitoring points would be installed to track the progress of removing vapor-phase contamination. Existing monitoring wells would be sampled to track the progress of removing groundwater contamination. Piping would be laid aboveground for transferring the extracted soil vapor and extracted groundwater to separate treatment systems.

The vapor treatment system would be installed aboveground in the source area and consist of a prefabricated, skid-mounted unit brought on-site to treat the extracted soil vapor prior to discharge to the atmosphere. The treatment system would likely consist of compressors, piping, an air-water separator, as necessary, and vapor-phase activated carbon units. An air permit would be obtained. Vapor discharged would meet New Jersey discharge permit requirements. The air flow rate (vacuum) and concentrations of contaminants, oxygen, and carbon dioxide in the extracted vapor would be monitored regularly.

The water treatment system would be installed in the same area/building as the vapor treatment system and would treat extracted water prior to discharge. Based on the presence of vinyl chloride and 1,4-dioxane (contaminants not easily removed by activated carbon) in the groundwater, it is assumed for costing purposes that advanced oxidation would be used in the treatment train. Depending on the groundwater extraction rate of the DPE system, the treated water might be discharged to the on-site drainage system with appropriate permits or be re-injected into the subsurface. Additional sampling and analysis would be conducted on the vapor and water effluent streams to ensure discharge permit requirements for each medium are met.

MNA for the distal plume, site restoration, institutional controls, and five-year reviews would be conducted as described in Section 3.2.2.

3.3 Alternative Screening

Since only a limited number of remedial alternatives were developed, all the alternatives are carried forward through the detailed description and evaluation. Screening of remedial action alternatives is not performed.

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Section 4

Detailed Analysis of Remedial Action Alternatives

The remedial alternatives described in Section 3 are evaluated in this section against the criteria described below.

4.1 Evaluation Criteria

EPA's nine evaluation criteria address statutory requirements and considerations for remedial actions in accordance with the NCP and additional technical and policy considerations proven to be important for selecting among remedial alternatives (EPA 1988). The following subsections describe the nine evaluation criteria used in the detailed analysis of remedial alternatives.

In accordance with EPA's climate change action plan, CDM Smith has performed a preliminary vulnerability evaluation of the remedial alternatives included in this FS as a first step toward identifying, prioritizing, and implementing site-specific measures for increasing resilience to climate change impacts. Appendix C includes a table identifying potential climate change impacts that could prove disruptive, vulnerabilities, and potential high-priority adaptation measures that could be implemented. It is expected that the table will be revised and detailed through subsequent project phases, monitoring measures, and tracking modifications over time.

4.1.1 Overall Protection of Human Health and the Environment

Each alternative is assessed to determine whether it can provide adequate protection of human health and the environment (short- and long-term) from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site. Evaluation of this criterion focuses on how site risks are eliminated, reduced, or controlled through treatment, engineered controls, or institutional controls and whether an alternative poses any unacceptable cross-media impacts.

4.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

CERCLA Section 121(d), 42 United States Code 9621(d), 40 CFR Part 300 (1990), the NCP, and guidance and policy issued by EPA require that remedial actions under CERCLA comply with substantive provisions of ARARs from the state and federal environmental laws and commonwealth facility siting laws during and at the completion of the remedial action.

4.1.2.1 Identification of Applicable or Relevant and Appropriate Requirements

The definition and identification of ARARs have been described and discussed in detail in Section 2.2. Three classifications of requirements are defined by EPA in the ARAR determination process. ARARs are defined as chemical, location, or action specific. An ARAR can be one or a combination of all three types of ARARs. The federal and New Jersey ARARs for the site are listed in Tables 2-1 and 2-2. Each alternative is evaluated to determine how chemical- and action-specific ARARs would be met.

4.1.3 Long-Term Effectiveness and Permanence

Long-term effectiveness evaluates the likelihood that the remedy would be successful and the permanence it affords. Factors to be considered, as appropriate, are discussed below.

- Magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals are considered to the degree that they remain hazardous, considering their T/M/V and propensity to bioaccumulate.
- Adequacy and reliability of controls used to manage treatment residuals and untreated waste remaining at the site. This factor includes an assessment of containment systems and institutional controls to determine if they are sufficient to ensure any exposure to human and ecological receptors is within protective levels. This factor also addresses the long-term reliability of management controls for providing continued protection from residuals, the assessment of the potential need to replace technical components of the alternative, and the potential exposure pathways and risks posed should the remedial action need replacement.

4.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Each alternative is assessed for the degree to which it employs a technology to permanently and significantly reduce T/M/V, including how treatment is used to address the principal threats posed by the site. Factors to be considered, as appropriate, include:

- The treatment processes the alternatives employ and materials they would treat
- The amount of hazardous substances, pollutants, or contaminants that would be destroyed or treated, including how the principal threat(s) would be addressed
- The degree of expected reduction in T/M/V of the waste due to treatment
- The degree to which the treatment is irreversible
- The type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate such hazardous substances and their constituents
- Whether the alternative would satisfy the statutory preference for treatment as a principal element of the remedial action

4.1.5 Short-Term Effectiveness

This criterion reviews the effects of each alternative during the construction and implementation phase of the remedial action until remedial response objectives are met. The short-term impacts of each alternative are assessed, considering the following factors, as appropriate:

- Short-term risks that might be posed to the community during implementation of an alternative

- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures
- Potential adverse environmental impacts resulting from construction and implementation of an alternative and the reliability of the available mitigation measures during implementation in preventing or reducing the potential impacts
- Time until protection is achieved for either the entire site or individual elements associated with specific site areas or threats

4.1.6 Implementability

The technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation is evaluated under this criterion. The ease or difficulty of implementing each alternative is assessed by considering the following factors:

- Technical feasibility
  - Technical difficulties and unknowns associated with the construction and operation of a technology
  - Reliability of the technology, focusing on technical problems that will lead to schedule delays
  - Ease of undertaking additional remedial actions, including what, if any, future remedial actions would be needed and the difficulty to implement additional remedial actions
- Administrative feasibility
  - Activities bedded to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions)
- Availability of services and materials
  - Availability of adequate off-site treatment, storage capacity, and disposal capacity and services
  - Availability of necessary equipment and specialists and provisions to ensure any necessary additional resources

4.1.7 Cost

Detailed cost estimates for each alternative were developed for the FS according to *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). Detailed cost estimates for the alternatives are included in Appendix D and include:

- Capital costs
- Annual O&M costs

- Periodic costs
- Present value of capital and annual O&M costs

4.1.8 State (Support Agency) Acceptance

Commonwealth (support agency) acceptance is a modifying criterion under the NCP. Assessment of commonwealth acceptance will not be completed until comments on the final FS report are submitted to EPA. Thus, commonwealth acceptance is not considered in the detailed analysis of alternatives presented in the FS.

4.1.9 Community Acceptance

Community acceptance is a modifying criterion under the NCP. Assessment of community acceptance will include responses to questions that any interested person in the community may have regarding any component of the remedial alternatives presented in the final FS report. This assessment will be completed after EPA receives public comments on the proposed plan during the public commenting period. Thus, community acceptance is not considered in the detailed analysis of alternatives presented in the FS.

4.2 Detailed Analysis of Remedial Alternatives

This section provides detailed analysis of the remedial alternatives developed in Section 3 for the site. All remedial alternatives were retained for detailed analysis.

4.2.1 Detailed Analysis of Soil Remedial Alternatives

4.2.1.1 Summary of Alternatives

- Alternative S-1: No Action
- Alternative S-2: Capping
- Alternative S-3: Excavation and Off-site Disposal of Contaminated Soils

Table 4-1 presents a side-by-side view of the criteria analysis for all the soil alternatives.

4.2.2 Detailed Analysis of Groundwater and Bedrock Vadose Zone Remedial Alternatives

4.2.2.1 Summary of Alternatives

- Alternative GW-1 – No Action
- Alternative GW-2 – Capping of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume
- Alternative GW-3 – Capping and SVE of Source Area Vadose Zone and MNA of Source Area Saturated Zone and Distal Plume
- Alternative GW-4 – Capping and SVE of Source Area Vadose Zone, In Situ Treatment in Source Area Saturated Zone, and MNA of Distal Plume

- Alternative GW-5 – Capping, DPE of Source Area Vadose and Saturated Zones, and MNA of Distal Plume

Table 4-2 presents a side-by-side view of the criteria analysis for all the groundwater and bedrock vadose zone alternatives.

4.3 Comparative Analysis of Remedial Alternatives

A comparison among the three soil remedial alternatives and the five VOC remedial alternatives are evaluated against the seven criteria in Sections 4.3.1 and 4.3.2, respectively.

4.3.1 Comparative Analysis of Soil Remedial Alternatives

4.3.1.1 Overall Protection of Human Health and the Environment

Alternative S-1 would not provide protection of human health and the environment, since no action would be taken to eliminate the exposure pathways to human and ecological receptors and no action would be taken to remediate site contamination. Alternatives S-2 and S-3 would achieve the RAOs and would provide protection to human health and the environment. The exposure pathways to human and ecological receptors would be eliminated.

Under Alternative S-2, the contaminated soils would be capped. Under Alternative S-3, the contaminated soils would be removed from the site and disposed off-site.

Under Alternative S-2, the cap and associated drainage/stormwater management features would need to be inspected and maintained regularly, and institutional controls would need to be implemented for continuous protection of human health and the environment. A deed restriction would need to be enforced to prevent human contact with subsurface soils.

Alternative S-3 provides the highest degree of protection to human health and the environment by removing the contamination from the site entirely.

4.3.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

NJDEP promulgated non-residential direct contact soil remediation standard and residential direct contact soil remediation standards are applicable chemical-specific ARARs for contaminated soils. Direct contact soil remediation standards were used as the PRGs (see Table 2-4a).

Alternative S-1 would not meet the PRGs since no action would be taken. Alternatives S-2 and S-3 would meet the PRGs since the contaminated soils would be contained or removed from the site. Location- and action-specific ARARs would be met by following the health and safety requirements and complying with all necessary regulations and permits. There may be difficulties in meeting stormwater management requirements in Alternatives S-2 and S-3 due to space and terrain limitations. A wetland survey would be conducted before spot excavation of PCBs near Dump Area B to ensure any wetlands in the vicinity are properly protected. Tables 2-2 and 2-3 summarize the location- and action-specific ARARs and their FS considerations.

4.3.1.3 Long-Term Effectiveness and Permanence

Alternative S-1 would not provide any long-term effectiveness and permanence since no action would be taken to remove the contamination or eliminate the exposure pathways to human and ecological receptors. Alternatives S-2 and S-3 would provide long-term effectiveness and permanence to varying degrees as discussed below.

- Magnitude of residual risk – The magnitude of residual risk would not be changed under Alternative S-2; however, the exposure pathways to human and ecological receptors would be eliminated as the contaminated soils in the residential TRZ would be capped while the contamination in the non-residential TRZ would be excavated and disposed of off-site. Alternative S-3 would not have any residual risks since all contaminated soils above the PRGs would be removed from the site.

- Adequacy and reliability of controls – The adequacy and reliability of the caps under Alternative S-2 rely on routine inspection and maintenance of the cap and the enforcement of the institutional controls (including deed restrictions) in perpetuity. Without adequate inspection and maintenance, erosion or damage of the cap may re-expose the contaminated soils, in particular in the steep slope areas. For Alternative S-3, control measures for residual contamination would not be necessary since all contamination above the PRGs would be removed from the site.

4.3.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-1 would not have any reduction of T/M/V through treatment since no action would be taken. Alternative S-2 would reduce the mobility of the contaminants through capping, but the toxicity and volume of contamination would not change. Alternative S-3 would reduce the T/M/V from the site since all contaminated soils would be transported off-site for disposal.

4.3.1.5 Short-Term Effectiveness

Alternative S-1 would not have any short-term impact since no action would be taken. Alternatives S-2 and S-3 may both impact local traffic along Brookwood Road during the short term if equipment requires access through the front of the residential property to access certain areas of the residential yard. Alternative S-3 would have the highest requirements for transportation of contaminated materials for off-site disposal, but this could be done via the road along the dump areas rather than on Brookwood Road through the residential community. Alternative S-2 would have the largest quantity of import materials, which could be done from the dump areas. Construction would generate noise and dust during the day, which would be controlled to minimize impact to the residential community.

Both Alternatives S-2 and S-3 require construction equipment on-site that could impact the residential property and the surrounding community. The duration of on-site construction would be longest for Alternative S-3 at an estimated 6 months, indicating that this alternative would have the most short-term impact to the community. Alternative S-2 would require an estimated 5 months of construction.

The on-site capping of lead and PCB contaminated soils in the residential TRZ under Alternative S-2 would be approximately 0.5 ft higher than existing grade. Under Alternative S-3, excavation

and backfill would alter the grade to be 0.5 ft lower than existing grade. The drainage pattern would be designed to ensure that stormwater runoff would be managed appropriately with the proper discharge permits and would minimize the impact to the residential property. Depending on the complexity of the stormwater management tools and infrastructure required to comply with New Jersey stormwater management and permitting requirements, the actual construction duration could be extended, especially for Alternative S-2.

4.3.1.6 Implementability

Alternative S-1 is easiest to implement since no action would be taken. Alternatives S-3 is implementable. Equipment and experienced vendors for excavation and backfill are available.

Alternative S-2 has the highest complexity in design, implementation, and long-term monitoring since it involves the design and construction of a cap along a steep slope. The cap installation of over an acre may trigger a stormwater management requirement, such as installation of a stormwater retention pond. This could be problematic since there is no suitable space for the pond. Additionally, a long-term inspection and maintenance plan would need to be developed for Alternative S-2 and to maintain or repair the cap. Funding would need to be set aside for this activity to ensure continued protection of human health and the environment. Stormwater management would need to be considered for Alternative S-3 but to a lesser extent, as excavation would not affect the permeability of the residential area as much as capping under Alternative S-2. There are no O&M requirements under Alternative S-3.

A deed restriction would be required for Alternative S-2 to prevent disturbance of the cap. A deed restriction may not be administratively acceptable.

4.3.1.7 Cost

Alternative S-1 has the lowest present worth since no action would be taken. Alternative S-2 has the highest present worth costs due to O&M costs associated with the cap. Alternative S-3 has a similar but slightly lower present worth, mainly due to high capital costs from off-site disposal of contaminated soils.

4.3.2 Comparative Analysis of Groundwater and Bedrock Vadose Zone Remedial Alternatives

4.3.2.1 Overall Protection of Human Health and the Environment

Alternative GW-1 would not provide protection of human health and the environment since no action would be taken to eliminate the exposure pathways to receptors and no action would be taken to remediate site contamination. Alternatives GW-2, GW-3, GW-4, and GW-5 would achieve the RAOs and would provide protection to human health and the environment, although extended time frames are likely for achieving PRGs given the fractured bedrock geology (discussed in Section 4.3.3). Alternative GW-2 involves solely capping and MNA. Evidence collected during the RI indicates that both microbial reductive dehalogenation and aerobic cometabolic degradation of TCE are biodegradation mechanisms actively destroying contaminant mass in site groundwater. Because of the complex fractured rock geology, it is uncertain if capping can achieve enough reduction in mass discharge from the vadose zone to the saturated zone such that natural attenuation is enough to reduce VOC concentrations to PRGs in a reasonable time frame. Alternative GW-3 would add to the technologies applied in Alternative GW-2 by including SVE in

the vadose zone, again with the desired outcome being that the combination of capping (flux reduction), SVE (mass reduction), and natural attenuation would eventually be sufficient to meet PRGs and protect human health and the environment. Alternatives GW-4 and GW-5 would each provide higher degrees of treatment and potentially would achieve protection of human health and the environment sooner than GW-2 and GW-3. Discussion of remedial time frames is in Section 4.3.3.

4.3.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

COCs are currently present in groundwater at concentrations exceeding PRGs and thus are not currently in compliance with chemical-specific ARARs. Alternative GW-1 would not take any active measures to evaluate future compliance with ARARs. Alternatives GW-2 would eventually reach compliance with chemical-specific ARARs through capping (containment), natural attenuation, and monitoring. Alternatives GW-3, GW-4, and GW-5, in addition to capping, would use active treatment to achieve ARARs and PRGs. Alternatives GW-2 through GW-5 would be implemented to comply with location- and action-specific ARARs. Tables 2-2 and 2-3 summarize the location- and action-specific ARARs and their FS considerations.

4.3.2.3 Long-Term Effectiveness and Permanence

Alternative GW-1 would not provide any long-term effectiveness and permanence since no action would be taken to remove the contamination or eliminate the exposure pathways to receptors. Alternatives GW-2 through GW-5 would provide long-term effectiveness and permanence to varying degrees as discussed below.

- Magnitude of residual risk – The magnitude of residual risk is greatest for Alternative GW-2 since no active removal or destruction of contaminants would occur. Alternative GW-2 would rely on the cap to prevent infiltration of rainwater, which could mobilize VOC mass stored in the vadose zone. Alternative GW-3, capping and SVE, would be next since active treatment would be limited to the vadose zone. Alternatives GW-4 and GW-5 would have the least amount of residual risk because groundwater would be treated in addition to the vadose zone.

- Adequacy and reliability of controls – The adequacy and reliability of the caps for Alternatives GW-2 through GW-5 would rely on routine inspection and maintenance and the enforcement of the institutional controls. Without adequate inspection and maintenance, erosion or damage of the cap may expose the source materials. The requirement for maintaining the integrity of caps for Alternative GW-2 is the highest, since there would be no additional treatment. The active treatment components (SVE, in situ treatment, and DPE) under Alternatives GW-3 through GW-5 are reliable technologies. However, the adequacy of controls would need to be determined during the design through PDI and pilot studies as the site has complex geology (e.g., dead-end fractures) and potential NAPLs.

4.3.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The comparative reduction in T/M/V through treatment of the five alternatives is presented in Exhibit 4-1 below.

Exhibit 4-1. Comparative Analysis of T/M/V Reduction

Alternative	Toxicity	Mobility	Volume
GW-1 – No Action			
GW-2 – Capping, MNA	√ (MNA)	√ (Capping)	√ (MNA)
GW-3 – Capping, SVE, MNA	√ (SVE, MNA)	√ (Capping)	√ (SVE, MNA)
GW-4 – Capping, SVE, In Situ Treatment, MNA	√ (In Situ Treatment)	√ (Capping)	√ (SVE, MNA)
GW-5 – Capping, DPE, MNA	√ (DPE, MNA)	√ (Capping, DPE)	√ (DPE, MNA)

Alternative GW-1 would not achieve reduction of T/M/V through treatment. Capping under Alternatives GW-2 through GW-5 would reduce the infiltration of the rainwater, thereby reducing the mobility of the VOCs in the vadose zone. MNA, SVE, in situ treatment, and DPE under Alternatives GW-2 through GW-5 are all treatment technologies, and all have varying degrees of capability of reducing the toxicity and volume of VOCs. In situ treatment could potentially achieve reduction of toxicity and volume the fastest because the transmissive fractures where contamination flux is the greatest could be identified during a pre-design investigation using borehole geophysics and transmissivity testing, and a long-lasting amendment would be emplaced in these features. As mass transfers out of the poorly transmissive "dead-end" fractures into these more transmissive features over time, the emplaced amendment in the transmissive features would be used to capture that mass before the contamination has a chance to move downgradient. Pilot testing of the ability to emplace amendment in the very thin fractures at the site would be needed.

Alternative GW-5 would rely on the same principle of a treatment technology capturing mass in the transmissive features for an extended duration. In the case of GW-5, that technology would be the groundwater extraction element of the DPE. However, given the low storativity of the fractured bedrock aquifer and the observed large swings in the potentiometric surface, it may be difficult to operate a long-term groundwater extraction system effectively.

4.3.2.5 Short-Term Effectiveness

Alternative GW-1 would not have any short-term impact since no action would be taken. Alternative GW-2 would have low to moderate impact in the remote non-residential area where the remediation would take place due to the construction of the cap and periodic maintenance. Alternative GW-3 would have low to moderate impacts. Alternatives GW-4 and GW-5 would have moderate impacts because of the need for drilling to install the injection or DPE system and operations of the injection or DPE system, which would continue for several years. Discussion of remedial time frames is in Section 4.3.3.

4.3.2.6 Implementability

Alternative GW-1 is easiest to implement since no action would be taken. Alternative GW-2 would be the next easiest to implement since the capping work would be conducted on the surface, with minimal constructability concerns. Alternatives GW-3, GW-4, and GW-5 share a common implementability concern due to working in the fractured rock subsurface: the complexity of the

fracture network with variations in transmissivity of fractures means that it would potentially be difficult to effectively identify and target the transmissive fractures for each technology. For GW-4, emplacing amendment into the very thin fractures at the site may lead to clogging and diversion of contaminant flow into untreated zones. O&M for the groundwater extraction portion of Alternative GW-5 would likely be difficult because of the hydrogeological setting: limited secondary porosity; limited transmissive features; and the target remediation zone being on top of a ridge, which means drawdown could be fairly rapid and pumping rates may have to be changed frequently.

Alternatives GW-2 through GW-5 may trigger the need to install a stormwater retention pond due to disturbance of ground surface and/or installation of an impermeable cap.

4.3.2.7 Cost

Alternative GW-1 has the lowest present worth since no action would be taken. Alternatives GW-4 and GW-5 have the highest present worth costs; O&M costs are far less for Alternative GW-4 in situ treatment compared to DPE (Alternative GW-5). The remaining alternatives do not have an active groundwater treatment component and therefore the costs are proportional to the number of technologies involved.

4.3.3 Discussion of Time Frames for Remediation

The time frames for achieving RAOs by each groundwater and bedrock vadose zone alternative are discussed in this section. The CSM shows mass is present in dead-end fractures and may to a limited degree be diffused into the bedrock matrix, after treatment. This mass will slowly transport to the more transmissive zones where active treatment would be most effective at reducing concentrations. This re-contamination of transmissive zones post-treatment is called "rebound." In a fractured quartzite/gneiss bedrock, Schaefer et al. (2018) observed rebound of 5 percent of the starting concentration after 151 days.

Remediation time frames were modeled using REMChlor-MD. This model is used for evaluating contaminant transport, incorporating matrix diffusion effects (ESTCP 2019).

REMChlor-MD was used to estimate the time frame for achieving the PRG for TCE (1 µg/L) for different degrees of remediation. Since no pilot tests have been conducted to determine the percent mass reduction by the technologies in the alternatives (which is the principal input to REMChlor-MD for modeling different remediation technologies), engineering judgment was used to develop the estimated percent reduction in mass or the percent reduction in mass discharge from vadose zone to groundwater.

The impact of these removal percentages on TCE concentrations was modeled in the following important hydrogeologic zones at the site:

1. The target remediation zone in the shallow zone is shown in Figure 3-5a in Appendix A.
2. The target remediation zone in the set of transmissive fractures is shown in the Intermediate Zone for MLS-3 in Figure 3-5a in Appendix A

3. The same set of transmissive fractures, but at a point 500 ft downgradient of the target remediation zone.

The model was calibrated to the extent practicable using groundwater concentrations and the characterization of hydrogeology presented in the RI. Model inputs are shown in Appendix E. Additionally, the attenuation rate identified in the residential wells (Appendix B) was used in the evaluation.

REMChlor-MD only provides planning-level estimates. There is uncertainty in the predictions primarily due to the complex fractured bedrock hydrogeology and uncertainty about the total mass of TCE in the subsurface. Planning-level plots of concentration versus time and the inputs used in the modeling are included as Appendix E. Exhibit 4-2 shows the estimated time frame for concentrations to be reduced to PRGs.

Exhibit 4-2. Time Frame to Reduce TCE Concentrations to PRGs

Alternative	GW-1 No Action	GW-2 Capping + MNA	GW-3 Capping + SVE + MNA	GW-5 Capping + DPE + MNA	GW-4 Capping + Injections + MNA
Estimated percent reduction in mass discharge from vadose zone to groundwater	0%	50%	80%	90%	99%
Estimated years to reach PRG in the **target remediation zone – shallow zone**	>500 years	>500 years	>500 years	>500 years	~150 years
Estimated years to reach PRG in the **target remediation zone – set of transmissive fractures in the intermediate zone**	>500 years	>500 years	>400 years	>300 years	~80 years
Estimated years to reach PRG in the **500 ft downgradient of target remediation zone – set of transmissive fractures in the intermediate zone**	>500 years	>400 years	>300 years	>200 years	~30 years

The modeling shows remedial actions that achieve 99 percent reduction of mass discharge (e.g., Alternative GW-4) have the greatest opportunity to achieve PRGs in the TRZs and downgradient in the plumes in a reasonable time frame. The modeling shows extended time frames (>200 years) for remediation are likely for alternatives that remove 90 percent or less source zone mass (e.g., Alternatives GW-1 through GW-4).

4.3.4 Cost Sensitivity Analysis for Groundwater and Bedrock Vadose Zone Remedial Alternatives

Exhibits 4-3 and 4-4 are sensitivity modeling exercises. Exhibit 4-3 shows the impacts on costs of the treatment area increases by 50 percent over the assumed area in this FS and O&M time frames are 50 percent longer than what is assumed in this FS.

Exhibit 4-3. Cost Sensitivities – Size and Time

Alternative	FS Cost Estimate	Treatment Area (50% Larger)	O&M (50% Longer)
GW-1 – No Action	$0	$0	$0
GW-2 – Capping, MNA	$4.1M	$4.3M	$4.1M
GW-3 – Capping, SVE, MNA	$6.5M	$7.1M	$6.8M
GW-4 – Capping, SVE, In Situ Treatment, MNA	$9.1M	$10.6M	$9.4M
GW-5 – Capping, DPE, MNA	$7.9M	$8.4M	$8.3M

Compared to the other alternatives, Alternative GW-4 costs are most sensitive to the treatment area due to the increased costs for amendment injection in the treatment volume. The sensitivity to O&M is less for this alternative since in situ treatment does not require O&M. For the remaining alternatives, the sensitivities are comparable to treatment area and O&M.

Exhibit 4-4 shows the sensitivity of costs on the performance of SVE. Assuming a temporary cap is first installed during the SVE system operation to prevent short-circuiting, the subsequent SVE performance (has the SVE effectively reduced mass discharge to groundwater) would determine if a multilayered cap (as is costed in each FS alternative) and the associated long-term O&M are needed. If SVE meets operational objectives, then no multilayered cap would be needed. This would reduce costs for Alternatives GW-3, GW-4, and GW-5 by roughly $1.5M.

Exhibit 4-4. Cost Sensitivities – SVE Performance

Alternative	FS Cost Estimate	SVE Reduces Mass Discharge; No Multilayered Cap Needed
GW-1 – No Action	$0	$0
GW-2 – Capping, MNA	$4.1M	Not applicable (no SVE)
GW-3 – Capping, SVE, MNA	$6.5M	$5.0M
GW-4 – Capping, SVE, In Situ Treatment, MNA	$9.1M	$7.6M
GW-5 – Capping, DPE, MNA	$7.9M	$6.4M

Section 5

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Tables

Table 2-1
Chemical-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARAR	Status	Requirement Synopsis	Feasibility Study Consideration
Federal	EPA Regional Screening Level (RSL) (November 2017)	To Be Considered	Establishes risk-based screening levels for the protection of human health.	The RSL will be considered in the development of the PRGs if there are no applicable standards.
Federal	National Primary Drinking Water Standards (40 CFR 141) - MCLs	Applicable	Establishes health- and/or technology-based standards for public drinking water systems. Also establishes drinking water quality goals set at levels at which no adverse health effects are anticipated, with an adequate margin of safety. Groundwater at the site is currently used as a source of drinking water by the downgradient residential community. However, all private residential wells with impacted groundwater are supplied with point-of-entry treatment systems to address the contamination in the groundwater.	The standards will be used to develop the PRGs to accommodate the use of site groundwater as a source of drinking water supply.
Federal	Clean Water Act, Ambient Water Quality Criteria (40 CFR 131)	To Be Considered	Sets criteria for water quality based on protection of human health and protection of aquatic life.	The standards will be used as guidelines to assess the effect of source removal on groundwater and surface water quality.
Federal	Toxic Substances Control Act (TSCA) (40 CFR Part 761 (as amended by the Frank R. Lautenberg Chemical Safety for the 21st Century Act [June 2016]))	To Be Considered	Provides soil cleanup levels for low/high occupancy areas.	The cleanup levels will be considered to develop the PRGs for the site.
State	New Jersey Residential Direct Contact and Non-Residential Direct Contact Soil Remediation Standards (NJAC 7:26D)	Applicable	Establishes standards for soil cleanups.	The standards will be used to develop the PRGs.
State	New Jersey Impact to Groundwater Soil Remediation Standards (NJAC 7:26D)	To Be Considered	Establishes criteria for soil cleanups.	The criteria will be considered in developing the PRGs.

Table 2-1
Chemical-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARAR	Status	Requirement Synopsis	Feasibility Study Consideration
State	New Jersey Sediment Quality Criteria (NJAC 7:26E)	To Be Considered	Establishes criteria for sediment cleanups.	The criteria will be considered in developing the PRGs.
State	New Jersey Department of Environmental Protection, Site Remediation Program, Ecological Screening Criteria (March 2009)	To Be Considered	Establishes screening criteria for surface water, sediment, and soils based on risk to ecological receptors	The criteria will be considered in the development of the PRGs if there are no applicable standards.
State	New Jersey Ground Water Quality Standards Class IIA (NJAC 7:9C)	Applicable	Establishes the water quality standards for the State's groundwater cleanups based on the type of groundwater use. Groundwater at the site is classified as Class IIA, suitable for drinking water use.	The standards will be used to develop the PRGs.
State	New Jersey Drinking Water Quality Standards (NJAC 7:10)	Relevant and Appropriate	Establishes drinking water standards (MCLs) for the State.	The standards will be used to develop the PRGs to accommodate any future use of site groundwater as a drinking water source.
State	New Jersey Surface Water Quality Standards (NJAC 7:9B)	Applicable	Establishes water quality standards for the protection and enhancement of surface water bodies, including those at the Site (Cowboy Creek).	The standards will be used to develop the PRGs.

Acronyms:

ARARs - Applicable or Relevant and Appropriate Requirements
CFR - Code of Federal Regulations
MCLs - Maximum Contaminant Levels
N.J.A.C. - New Jersey Administrative Code
PRGs - Preliminary Remediation Goals
RSL - regional screening level
TSCA - Toxic Substances Control Act

Table 2-2
Location-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARARs	Status	Requirement Synopsis	Feasibility Study Consideration
Wetlands and Floodplains Standards and Regulations				
Federal	Statement of Procedures on Floodplain Management and Wetlands Protection (40 CFR 6 Appendix A)	Relevant and Appropriate	This Statement of Procedures sets forth Agency policy and guidance for carrying out the provisions of Executive Orders (EO) 11988 and 11990.	The Site has both freshwater forested/shrub wetlands and floodplains surrounding Cowboy Creek and Lubbers Run, downgradient of the dump areas. Alternatives will take into consideration floodplain management and wetlands protection.
Federal	Policy on Floodplains and Wetland Assessments for CERCLA Actions (OSWER Directive 9280.0-12, 1985)	Applicable	Superfund actions must meet the substantive requirements of EO 11988, EO 11990, and 40 CFR part 6, Appendix A.	The Site has both freshwater forested/shrub wetlands and floodplains surrounding Cowboy Creek and Lubbers Run, downgradient of the dump areas. Alternatives will take into consideration floodplain management and wetlands protection.
Federal	National Environmental Policy Act (NEPA) (42 USC 4321; 40 CFR 1500 to 1508)	Relevant and Appropriate	This requirement sets forth EPA policy for carrying out the provisions of EO 11990 and EO 11988.	The Site has both freshwater forested/shrub wetlands and floodplains surrounding Cowboy Creek and Lubbers Run, downgradient of the dump areas. The requirement will be considered during the development of alternatives.
Federal (Non-Regulatory)	Wetlands Executive Order (EO 11990)	Relevant and Appropriate	Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance natural and beneficial values of wetlands.	Freshwater forested/shrub wetlands are present downgradient of the Site in the vicinity of Cowboy Creek and Lubbers Run. A freshwater pond is mapped in the National Wetlands Inventory near the dump areas, however, was not confirmed during site reconnaissance. Remedial alternatives that involve construction will include all practicable means of minimizing harm to wetlands. Wetlands protection considerations must be incorporated into the planning and decision making of remedial alternatives.
Federal (Non-Regulatory)	Floodplain Management (EO 11988)	Relevant and Appropriate	Federal agencies are required to reduce the risk of flood loss, to minimize the impact of floods, and to restore and preserve the natural and beneficial values of floodplains.	The potential effects of any action (e.g. construction of impervious surface) will be evaluated to ensure that the planning and decision making reflect consideration of flood hazards and floodplains management, including restoration and preservation of natural undeveloped floodplains.

Table 2-2
Location-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARARs	Status	Requirement Synopsis	Feasibility Study Consideration
Federal	Clean Water Act Section 404 (40 CFR 230-233)	Applicable	Under this requirement, no activity that adversely affects a wetland is permitted if a practicable alternative that does not affect wetlands is available. If no practicable alternative exists, impacts on wetlands must be mitigated.	Freshwater forested/shrub wetlands are present downgradient of the Site in the vicinity of Cowboy Creek and Lubbers Run. A freshwater pond is mapped in the National Wetlands Inventory near the dump areas, however, was not confirmed during site reconnaissance. The effects of remedial actions on wetlands will be evaluated during the identification, screening, and evaluation of alternatives. Permits may be required for some alternatives.
State	New Jersey Freshwater Wetlands Protection Act Rules (NJAC 7:7A, NJSA 13:98-1)	Applicable	This act establishes permitting requirements for regulated activity disturbing wetlands (e.g. any excavation, dredging, drainage, construction, etc.).	Freshwater forested/shrub wetlands are present downgradient of the Site in the vicinity of Cowboy Creek and Lubbers Run. A freshwater pond is mapped in the National Wetlands Inventory near the dump areas, however, was not confirmed during site reconnaissance. This requirement will be met during the screening, evaluation, and development of alternatives.
State	Wetlands Permit (NJSA 13:9A-1)	Applicable	This act restricts the dredging, filling, removing, or otherwise altering or polluting a wetland.	Freshwater forested/shrub wetlands are present downgradient of the Site in the vicinity of Cowboy Creek and Lubbers Run. A freshwater pond is mapped in the National Wetlands Inventory near the dump areas, however, was not confirmed during site reconnaissance. This requirement will be considered during the screening, evaluation and development of alternatives. Permits may be required for some alternatives.

Table 2-2
Location-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARARs	Status	Requirement Synopsis	Feasibility Study Consideration
Wildlife Habitat Protection Standards and Regulations				
Federal	Endangered Species Act (16 USC 1531 et seq.; 40 CFR 400)	Applicable	This act establishes standards for the protection of threatened and endangered species.	The USFWS reported that the site is located within areas that provide habitat for several federally listed threatened and endangered species. The potential effects of federally listed endangered and threatened species will be considered during the identification, screening, and evaluation of alternatives.
Federal	Migratory Bird Treaty Act (MBTA, 1 USC 03 *et seq* .)	Applicable	This act establishes standards for the protection of migratory bird species, including individual birds or their nests or eggs.	The USFWS provided a list of birds that exist on the USFWS Birds of Conservation Concern list and are known to have vulnerabilities within the project area. The potential effect on these birds will be considered during the identification, screening, and evaluation of alternatives.
State	New Jersey Endangered and Nongame Species Conservation Act (NJSA 23:2A-1 - 15)	Applicable	This act protects and conserves endangered and nongame species.	The NJDEP's Natural Heritage Program identified a natural heritage priority site that is approximately 0.5 mile northeast of the Cowboy Creek area (downgradient of the site). The potential effects on New Jersey listed endangered and nongame species will be considered during the identification, screening, and evaluation of alternatives.
State	New Jersey Endangered Plant Species List Act (NJAC 7:5B)	Applicable	This act protects endangered plant species.	The NJDEP Natural Heritage Program reported that the site contains populations of two unnamed plant species that are imperiled in the state. The effects on endangered plant species will be evaluated during the identification, screening, and evaluation of alternatives.
Cultural Resources, Historic Preservation Standards and Regulations				
Federal	National Historical Preservation Act Regulations (36 CFR Part 800)	Applicable	This requirement establishes procedures to provide for preservation of historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	The impact of proposed remedy on historical and archeological sensitive areas will be evaluated during the identification, screening, and evaluation of alternatives.

Acronyms:

ARARs - Applicable or Relevant and Appropriate Requirements
CERCLA - Comprehensive Environmental Response Compensation and Liability Act
CFR - Code of Federal Regulations
EO - executive order
MBTA - Migratory Bird Treaty Act
NEPA - National Environmental Policy Act
NJAC - New Jersey Administrative Code
NJSA - New Jersey Statues Annotated
OSWER - Office of Solid Waste and Emergency Response
USC - United States Code
USFWS - United States Fish and Wildlife Service

Table 2-3
Action-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARARs	Status	Requirement Synopsis	Feasibility Study Consideration
General - Site Remediation				
Federal	National Contingency Plan (40 CFR 300, Subpart E)	Applicable	This regulation outlines contingency planning procedures for remedial actions and off-site removal actions, in case of accidental spill or release of hazardous materials.	This standard will be applied to any investigative, planning, or other remediation activities performed at the site.
Federal	OSHA Recording and Reporting Occupational Injuries and Illnesses (29 CFR 1904)	Applicable	This regulation outlines the record keeping and reporting requirements for an employer under OSHA.	These regulations apply to the companies contracted to implement the remedy. All applicable requirements will be met.
Federal	OSHA Occupational Safety and Health Standards (29 CFR 1910)	Applicable	These regulations specify an 8-hour time-weighted average concentration for worker exposure to various organic compounds. Training requirements for workers at hazardous waste operations are specified in 29 CFR 1910.120.	Proper respiratory equipment will be worn if it is not possible to maintain the work atmosphere below the 8-hour time-weighted average at these specified concentrations.
Federal	OSHA Safety and Health Regulations for Construction (29 CFR 1926)	Applicable	This regulation specifies the type of safety equipment and procedures to be followed during site remediation.	All appropriate safety equipment will be on-site, and appropriate procedures will be followed during remediation activities.
Federal	RCRA Identification and Listing of Hazardous Wastes (40 CFR 261)	Applicable	This regulation describes methods for identifying hazardous wastes and lists known hazardous wastes.	This regulation is applicable to the identification of hazardous wastes that are generated, treated, stored, or disposed during remedial activities.
Federal	RCRA Standards Applicable to Generators of Hazardous Wastes (40 CFR 262)	Applicable	Describes standards applicable to generators of hazardous wastes.	Standards will be followed if any hazardous wastes are generated on-site.
Federal	RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities – General Facility Standards (40 CFR 264.10–264.19)	Relevant and Appropriate	This regulation lists general facility requirements including general waste analysis, security measures, inspections, and training requirements.	Facility will be designed, constructed, and operated in accordance with this requirement. All workers will be properly trained.
State	New Jersey Technical Requirements for Site Remediation (NJAC 7:26E)	Applicable	This regulation provides the minimal technical requirements to investigate and remediate contamination at the site.	The regulation will be applied to any hazardous waste operation during remediation of the site.
State	New Jersey Uniform Construction Code (NJAC 5:23)	Applicable	This code provides the requirements for construction performed during remediation of the site.	This code will be applied to any construction performed during remediation of the site.
State	New Jersey Hazardous Waste Regulations - Identification and Listing of Hazardous Waste (NJAC 7:26G-5)	Applicable	This regulation describes methods for identifying hazardous wastes and lists known hazardous wastes.	This regulation will be applicable to the identification of hazardous wastes that are generated, treated, stored, or disposed of during remedial activities.

Table 2-3
Action-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARARs	Status	Requirement Synopsis	Feasibility Study Consideration
State	New Jersey Stormwater Management Rule (NJAC 7:8)	Applicable	This regulation sets the requirements for stormwater management during construction.	The requirements will be met by obtaining all necessary permits during construction.
State	New Jersey Soil Erosion and Sediment Control Act (NJAC 2:90, NJSA 16:52A)	Applicable	This act outlines the requirements for soil erosion and sediment control measures.	This act will be considered during the development of alternatives.
State	New Jersey Noise Control (NJAC 7:29)	Applicable	This standard provides the requirements for noise control.	This standard will be applied to any remediation activities performed at the site.
Waste Transportation				
Federal	Department of Transportation (DOT) Rules for Transportation of Hazardous Materials (49 CFR Parts 107, 171, 172, 177 to 179)	Applicable	This regulation outlines procedures for the packaging, labeling, manifesting, and transporting hazardous materials.	Any company contracted to transport hazardous material from the site will be required to comply with this regulation.
Federal	RCRA Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)	Applicable	Establishes standards for hazardous waste transporters.	Any company contracted to transport hazardous material from the site will be required to comply with this regulation.
State	New Jersey Transportation of Hazardous Materials (N.J.A.C. 16:49)	Applicable	This regulation establishes recordkeeping requirements and standards related to the manifest system for hazardous wastes.	Any company contracted to transport hazardous material from the site will be required to comply with this regulation.
Waste Disposal				
Federal	RCRA Land Disposal Restrictions (40 CFR 268)	Applicable	This regulation identifies hazardous wastes restricted for land disposal and provides treatment standards for land disposal.	Hazardous wastes will be treated to meet disposal requirements.
Federal	RCRA Hazardous Waste Permit Program (40 CFR 270)	Applicable	This regulation establishes provisions covering basic EPA permitting requirements.	All permitting requirements of EPA must be complied with.
Federal	Area of Contamination Policy (55 CFR 8758-8760, March 8, 1990)	Applicable	This policy establishes rules for consolidation of contiguous waste within an Area of Contamination.	Hazardous wastes may be consolidated and contained within a specific area based on these rules.
Federal	Corrective Action Management Units (40 CFR 264.552)	Applicable	These regulations provide exceptions to LDR requirements and establish rules for consolidation and treatment of noncontiguous waste within the site.	Hazardous wastes at the site are unlikely to exceed LDR requirements.

Table 2-3
Action-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARARs	Status	Requirement Synopsis	Feasibility Study Consideration
State	New Jersey Land Disposal Restrictions (LDR) (NJAC 7:26G-11)	Applicable	These regulations established standards for treatment and disposal of hazardous wastes.	Hazardous wastes must comply with the treatment and disposal standards.
Water Discharge or Subsurface Injection				
Federal	National Pollutant Discharge Elimination System (NPDES) (40 CFR 100 et seq.)	Applicable	NPDES permit requirements for point source discharges must be met, including the NPDES Best Management Practice (BMP) Program. These regulations include, but are not limited to, requirements for compliance with water quality standards, a discharge monitoring system, and records maintenance.	Project will meet NPDES permit requirements for point source discharges.
Federal	Clean Water Act Section 404 (33 CFR Parts 320-323, 40 CFR 230-233)	Applicable	This requirement restricts discharge of dredged or fill material to wetlands or waters of the United States and provides a permitting program for situations with no other practical alternative.	This requirement will be considered during the development of alternatives.
Federal	Ambient Water Quality Criteria (40 CFR 131.36)	Applicable	This regulation establishes toxics criteria for those states not complying with Clean Water Act Section 303(c)(2)(B).	The criteria will be considered during the evaluation of discharge practices during any remedial action.
Federal	Effluent Guidelines and Standards for the Point Source Category (40 CFR 414)	Applicable	These regulations establish effluent limitations on direct discharge and indirect discharge point sources.	The project will meet the standards for the point source category.
State	The New Jersey Pollutant Discharge Elimination System (NJPDES) (NJAC 7:14A)	Applicable	This permit governs the discharge of any wastes into or adjacent to State waters that may alter the physical, chemical, or biological properties of State waters.	The project will meet NJPDES permit requirements for any surface water discharges or groundwater discharges, such as injection of reagent for in situ treatment.
Off-Gas Management				

Table 2-3
Action-specific ARARs, Criteria, and Guidance
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Regulatory Level	ARARs	Status	Requirement Synopsis	Feasibility Study Consideration
Federal	Clean Air Act (CAA)—National Ambient Air Quality Standards (NAAQs) (40 CFR 50)	Applicable	These provide air quality standards for particulate matter, lead, NO_2, SO_2, CO, and volatile organic matter.	During remediation and treatment, air emissions will be properly controlled and monitored to comply with these standards.
Federal	Standards of Performance for New Stationary Sources (40 CFR 60)	Relevant and Appropriate	Set the general requirements for air quality.	During remediation and treatment, air emissions will be properly controlled and monitored to comply with these standards.
Federal	National Emission Standards for Hazardous Air Pollutants (40 CFR 61)	Applicable	These provide air quality standards for hazardous air pollutants.	During remediation and treatment, air emissions will be properly controlled and monitored to comply with these standards.
Federal	Federal Directive - Control of Air Emissions from Superfund Air Strippers (OSWER Directive 9355.0-28)	Applicable	Provides guidance on control of air emissions from air strippers used at Superfund Sites for groundwater treatment.	During treatment, air emissions will be properly controlled and monitored to comply with these standards.
State	New Jersey Air Pollution Control Act (NJAC 7:27)	Applicable	This regulation describes requirements and procedures for obtaining air permits and certificates, and rules that govern the emission of contaminants into the ambient atmosphere.	This standard will be applied to any remediation activities performed at the site.
State	New Jersey Ambient Air Quality Standards (NJAC 7:27-13)	Applicable	This standard provides the requirements for ambient air quality control.	This standard will be applied to any remediation activities performed at the site.

Acronyms:

ARARs - Applicable or Relevant and Appropriate Requirements
CAA - Clean Air Act
CAMU - Corrective Action Management Units
CFR - Code of Federal Regulations
CO - Carbon monoxide
EPA - Environmental Protection Agency
LDR - Land Disposal Restrictions
NAAQS - National Ambient air Quality Standards
NJPDES - New Jersey Pollutant Discharge Elimination System
NO_2 - Nitrogen dioxide
NPDES - National Pollutant Discharge Elimination System
OSHA - Occupational Safety and Health Administration
OSWER - Office of Solid Waste and Emergency Response
PCB - polychlorinated biphenyl
RCRA - Resource Conservation and Recovery Act
SO_2 - Sulfur dioxide
TSCA - Toxic Substances control Act
UIC - Underground Injection Control

Table 2-4a
Preliminary Remediation Goals for Soil
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

CAS No.	Chemical Name	Unit	NJDEP Residential Direct Contact Soil Remediation Standards [1]	NJDEP Default Impact to Groundwater Soil Remediation Standards [2]	Background Threshold Value [3]	Maximum Concentrations Observed (Dump Areas)	Residential Preliminary Remediation Goals	Maximum Concentrations Observed (Residential Areas)
Volatile Organic Compounds (VOCs)								
Polychlorinated Biphenyls (PCBs)								
1336-36-3	PCBs [4]	mg/kg	0.2	NA	NA	4.5 J	0.2	4.1 J
Inorganics								
7439-92-1	Lead [5]	mg/kg	400	NA	155.2	442	400	1,460

Notes:

[1] NJDEP 2012. Residential Direct Contact Health-Based Criteria and Soil Remediation Standards. Last amended September 18, 2017; http://www.nj.gov/dep/rules/rules/njac7_26d.pdf

[2] NJDEP 2008. Guidance Document, Development of Site-Specific Impact to Groundwater Soil Remediation Standards Using the Soil-Water Partition Equation, Version 2.0. November 2013; http://www.nj.gov/dep/srp/guidance/rs/igw_intro.htm

[3] Background threshold values (BTVs) displayed are surface soils BTVs developed by EES JV for SVOCs and metals based on a statistical evaluation of background analytical results using EPA's ProUCL, version 5.0 and EPA's Technical Guide - Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations, September 2013.

[4] PCBs Maximum Concentrations Observed is based on combined concentrations of detected aroclors at any one location.

[5] EPA Region 2 recently indicated lead concentrations at residential properties (in addition to meeting the 400 mg/kg maximum concentration PRG) shall be subject to meeting a 200 mg/kg property wide average cleanup goal.

Highlighted PRGs were exceeded and will drive site remediation.

µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
CAS No. = Chemical Abstracts Service number
NA = not applicable
NJDEP = New Jersey Department of Environmental Protection

NL = not listed
J = estimated
J+ = estimated, biased high
BTV = background threshold value
PRG = preliminary remediation goal

CDM Smith

Table 2-4b
Preliminary Remediation Goals for Groundwater
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

CAS No.	Chemical Name	Unit	National Primary Drinking Water Standards (EPA MCLs) [1]	NJ Groundwater Quality Standards [2]	NJ Drinking Water Standards [3]	Preliminary Remediation Goals [4]	Maximum Concentration Observed [5]
Volatile Organic Compounds (VOCs)							
71-55-6	1,1,1-Trichloroethane	µg/L	200	30	30	30	160
75-34-3	1,1-Dichloroethane	µg/L	NL	50	50	50	170
75-35-4	1,1-Dichloroethene	µg/L	7	1	2	1	5.4
123-91-1	1,4-Dioxane	µg/L	NL	0.4	NL	0.4	7.3
108-90-7	Chlorobenzene	µg/L	100	50	50	50	160
156-59-2	cis-1,2-Dichloroethene	µg/L	70	70	70	70	240
79-01-6	Trichloroethene	µg/L	5	1	1	1	190
75-01-4	Vinyl Chloride	µg/L	2	1	2	1	44
Inorganics							
7439-92-1	Lead	µg/L	15	5	15	5	9.5

Notes:

[1] EPA 2009. National Primary Drinking Water Standards (EPA 816-F-09-004, May 2009); http://water.epa.gov/drink/contaminants/upload/mcl-2.pdf.

[2] NJDEP 2010. New Jersey Ground Water Quality Standards Class IIA (N.J.A.C. 7:9C, July 22, 2010, readopted without change on March 4, 2014); https://www.nj.gov/dep/rules/rules/njac7_9c.pdf.

[3] NJDEP 2009. New Jersey Drinking Water Standards (February 10, 2009); http://www.nj.gov/dep/standards/drinking%20water.pdf.

[4] Preliminary Remediation Goals (PRGs) were selected from the lowest of the EPA MCLs, NJ Groundwater Quality Standards, and NJ Drinking Water Standards.

[5] Maximum concentration observed is shown as the highest result from both Rounds 2 and 3.

Highlighted PRGs are for indicator compounds and will be used to drive site remediation

µg/L = micrograms per liter

CAS No. = Chemical Abstracts Service number

EPA = United States Environmental Protection Agency

MCL = Maximum Contaminant Level

NJ = New Jersey

NJDEP = New Jersey Department of Environmental Protection

NL = not listed

Table 2-5a
Identification and Preliminary Technology Screening of Remedial Technology and Process Options - Soil
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Retained for Source Area Fractured Bedrock	Retained for Non-VOC Overburden Areas	Technological Implementability Screening Comments
No Action	None	Not Applicable	No Action	✓	✓	Required for consideration by NCP.
Institutional/Engineering Controls	Access restrictions	Land use controls	Restrictions on subsurface intrusive activities (e.g., excavation) to prevent human exposure	✓	✓	Potentially applicable.
		Fencing and signs	Installation of fencing around contaminated areas with signs to indicate risk	✓	✓	
	Community awareness	Community awareness	Educational programs to enhance awareness of contaminated conditions and assist in implementation of other institutional/engineering controls	✓	✓	Potentially applicable.
MNA	MNA	MNA	Monitoring the progress of natural attenuation processes in decreasing contaminant concentrations to the remediation goals within a reasonable timeframe	×	×	Difficult to monitor soil contaminant concentrations and generally not being evaluated.
Containment	Capping	Capping	Installation of an surface cap to isolate contaminated soils from direct contact or from leaching contamination into groundwater	✓	✓	Potentially applicable but likely difficult to implement in the steep slope of the residential area.
Removal	Excavation	Excavation	Removal of contaminated soil for consolidation, treatment, and/or disposal	✓	✓	Potentially applicable for the overburden in the source area and the residential area but not for bedrock vadose zone in the source area.
	Extraction	Soil vapor extraction	Applied vacuum to soils to enhance volatilization and remove volatilized contaminants for ex situ treatment	✓	×	Potentially applicable in the source area. Would not be effective for removing contaminants in the non-VOC overburden areas (lead/PCBs).
		Dual-phase extraction	Combined extraction of soil vapor and groundwater in extraction wells for ex situ treatment	✓	×	
Treatment	Ex situ treatment	Vapor-phase GAC	Removal of contaminants from vapor by adsorbing onto GAC	✓	×	Potentially applicable in the source area. Not retained for the non-VOC overburden areas because SVE was not retained.
		Potassium permanganate	Oxidation of vinyl chloride in vapor into potassium chloride and carbon dioxide	✓	×	Potentially applicable. Not retained for the non-VOC overburden areas because SVE was not retained.
		Thermal oxidation	Destruction of high concentrations of contaminants through combustion or oxidation by mobilizing them at elevated temperatures into vapor streams	×	×	Formation of acid gases during vapor combustion of contaminants may be a risk. Usually not used for cases with low contaminant concentrations.
		Thermal desorption	Physical separation process using low temperatures to volatilize high concentrations of organic materials from excavated soils to be treated	×	×	Not needed for the source area as site concentrations are not high enough. Would not be effective for removing contaminants in the non-VOC overburden areas (lead/PCBs).
	In situ treatment	In situ thermal remediation	Heating of subsurface soils resulting in desorption and volatilization of contaminants; most effective in areas where DNAPL is potentially present	✓	×	Potentially applicable in the source areas. Would not be effective for removing contaminants in the non-VOC overburden areas (lead/PCBs).
		In situ bioremediation	Injection of an organic substrate and/or microorganisms into the subsurface to stimulate the biological degradation of contaminants	×	×	Adequate distribution of amendment would be difficult to achieve in the vadose zone. Distribution may be improved with in situ soil mixing, but would only be possible in the shallow overburden not bedrock vadose zone. Would not be effective for removing contaminants in the non-VOC overburden areas (lead/PCBs).
		In situ chemical oxidation	Injection of strong chemical oxidants into the subsurface to destroy organic contaminants	×	×	
		In situ soil flushing	Adding amendment to soil to mobilize contaminants with flushing solution	✓	✓	Potentially applicable.
		In situ soil stabilization	Adding amendment to soil to stabilize contaminants with physical or chemical reactions	✓	✓	Potentially applicable.
Disposal	Offsite disposal	Offsite disposal at nonhazardous waste landfill	Disposal of excavated soil at an offsite nonhazardous waste (RCRA Subtitle D) facility	✓	✓	Potentially applicable.
		Offsite disposal at hazardous waste landfill	Disposal of excavated soil at an offsite hazardous waste (RCRA Subtitle C) landfill if contaminated soil exceeds TCLP criteria	×	✓	Not needed for source area as contamination in soil is low and not likely to exceed TCLP criteria. Potentially applicable for non-VOC overburden areas based on observed concentrations of lead and PAHs.

Green indicates retained technologies

Acronyms
NCP - National Contingency Plan
GAC - granular activated carbon
DNAPL - dense nonaqueous phase liquid
MNA - monitored natural attenuation
TCLP - toxicity characteristic leaching procedure
RCRA - Resource Conservation and Recovery Act
POTW - publicly owned treatment works
VOC - volatile organic compound

Table 2-5b
Identification and Technology Screening of Remedial Technology and Process Options - Groundwater
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

General Response Action	Remedial Technology	Process Option	Description	Retained for Bedrock Groundwater in the Source Areas	Retained for Groundwater in Downgradient Areas (Residential Area and Cowboy Creek)	Technological Implementability Screening Comments
No Action	None	Not applicable	No Action	✓	✓	Required for consideration by NCP.
Institutional Controls	Access restrictions	Groundwater use restrictions	Restrictions on usage/ installation of wells within area of the groundwater plumes to prevent human exposure	✓	×	Potentially applicable for source areas. Private potable wells already exist in the residential areas but are being treated with POET systems.
	Community awareness	Community awareness	Educational programs to enhance awareness of contaminated conditions and assist in implementation of other institutional/engineering controls	✓	✓	Potentially applicable.
	Monitoring	Monitoring	Periodic sampling and analysis of groundwater in monitoring wells	✓	✓	Potentially applicable.
MNA	MNA	MNA	Natural attenuation processes to decrease contaminant concentrations to the remediation goals within a reasonable timeframe	✓	✓	Potentially applicable.
Containment	Vertical barriers	Slurry walls	Excavated trench around areas of contamination filled with low-permeability bentonite slurry	×	×	Difficult to excavate into the bedrock of the source areas. Would also interfere with hydraulic flow to residential wells downgradient.
		Sheet pile barriers	Interlocked steel sheet pilings driven into ground around area of contamination	×	×	Difficult to install into the bedrock of the source areas. Would also interfere with hydraulic flow to residential wells downgradient.
Removal	Extraction	Groundwater Extraction	Installation of wells to extract contaminated groundwater for ex situ treatment and hydraulically prevent contaminants from migrating downgradient	✓	×	Potentially applicable in the source areas. However, groundwater extraction in the downgradient areas would compete with the private residential wells.
Treatment	Ex situ treatment	Air stripping	Mass transfer of dissolved VOCs from groundwater into clean air	✓	×	Potentially applicable in the source areas. Not retained in the downgradient areas because groundwater extraction is not retained.
		Liquid-phase GAC	Removal of contaminants from liquid by adsorbing onto GAC	✓	×	
		Vapor-phase GAC	Removal of contaminants from groundwater by adsorbing onto GAC	✓	×	
		Potassium Permanganate	Removal of vapor-phase vinyl chloride through oxidation into potassium chloride and carbon dioxide	✓	×	Potentially applicable in the source areas, especially for vinyl chloride. Not retained in the downgradient areas because groundwater extraction is not retained.
		AOP	Mixing ozone and/or hydrogen peroxide into groundwater under UV light to destroy contaminants by oxidation	✓	×	Potentially applicable in the source areas, especially for 1,4-dioxane. Not retained in the downgradient areas because groundwater extraction is not retained.
	In Situ Treatment	Air sparging/In-well air stripping	Injection of air or oxygen into contaminated aquifer to strip VOCs into the unsaturated zone	×	×	Potentially applicable in the source areas. Not retained in the downgradient areas due to vapor intrusion concerns that would result from moving VOCs into the vapor phase.
		In situ chemical reduction	Injection of strong chemical reductant into contaminated aquifer to chemically reduce contaminants to non-hazardous compounds	✓	×	Potentially applicable in the source areas. Implementing in the downgradient areas may lead to injected amendments or byproducts migrating into residential wells or Cowboy Creek.
		In situ chemical oxidation	Injection of strong chemical oxidants into contaminated aquifer to destroy organic contaminants	✓	×	
		In situ thermal remediation	Heating of the aquifer to cause contaminants to evaporate into the unsaturated zone	×	×	Potentially applicable for a DNAPL source zone (if present). Difficult to implement for the larger groundwater plume at the depths required. Also difficult to implement in the distal plume in the downgradient areas due to the large area and very low concentrations.
		In situ bioremediation	Injection of an organic substrate and/or microorganisms into contaminated aquifer to stimulate the biological degradation of contaminants into nontoxic compounds	✓	×	Potentially applicable in the source areas. Implementing in the downgradient areas may lead to injected amendments or byproducts migrating into residential wells or Cowboy Creek.
		Permeable Reactive Barrier	Injection in a barrier formation perpendicular to the plume flow path to remove contaminants through reaction with the permeable reactive medium	×	×	Difficult to implement due to radial flow of groundwater. Implementing in the downgradient areas may lead to injected amendments or byproducts migrating into residential wells or Cowboy Creek.
Discharge	Onsite Discharge	Onsite injection	Injection of treated groundwater into aquifer	✓	×	Potentially applicable. Not retained in the downgradient areas because groundwater extraction is not retained.
	Offsite Discharge	Surface discharge	Discharge of treated groundwater to a nearby surface water body or drainage system	✓	×	
		Discharge to POTW	Discharge of treated water to a POTW facility via a sanitary sewer	×	×	Difficult to reach nearby sewers due to distance and elevation.

Green indicates retained technologies

Acronyms

NCP - National Contingency Plan
GAC - granular activated carbon
AOP - Advanced Oxidation Process
VOC - volatile organic compound
DCE - dichlorethene
DNAPL - dense nonaqueous phase liquid
UV - ultraviolet
MNA - monitored natural attenuation
POTW - publicly owned treatment works
POET - point-of-entry treatment system

Table 2-6a
Summary of Identification and Technology Screening of Remedial Technology and Process Options - Soil
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

General Response Action	Remedial Technology	Process Option	Retained for the Source Area Fractured Bedrock	Retained for the Non-VOC Overburden Areas
No Action	None	Not Applicable	✓	✓
Institutional Controls	Access Restrictions	Land Use Controls	✓	✓
		Fencing and Signs	✓	✓
	Community Awareness	Community Awareness	✓	✓
Containment	Capping	Capping	✓	✓
Removal	Excavation	Excavation	✓	✓
	Extraction	Soil Vapor Extraction	✓	×
		Dual Phase Extraction	✓	×
Treatment	Ex Situ Treatment	Vapor Phase GAC	✓	×
		Potassium Permanganate	✓	×
	In Situ Treatment	In Situ Thermal Remediation	×	×
		In Situ Soil Flushing	×	×
		In Situ Soil Stabilization	×	×
Disposal	Offsite Disposal	Offsite Disposal at Non-Hazardous Waste Landfill	✓	✓
		Offsite Disposal at Hazardous Waste Landfill	×	✓

Green indicates retained technologies

Acronyms

GAC - granular activated carbon

MNA - monitored natural attenuation

AOP - advanced oxidation process

Table 2-6b
Summary of Identification and Technology Screening of Remedial Technology and Process Options - Groundwater
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

General Response Action	Remedial Technology	Process Option	Retained for the Source Area	Retained for the Downgradient Areas
No Action	None	Not Applicable	✓	✓
Institutional Controls	Access Restrictions	Groundwater Use Restrictions	✓	✓
	Community Awareness	Community Awareness	✓	✓
	Monitoring	Monitoring	✓	✓
MNA	MNA	MNA	✓	✓
Removal	Extraction	Groundwater Extraction	✓	×
Treatment	Ex Situ Treatment	Air Stripping	✓	×
		Liquid-Phase GAC	✓	×
		Potassium Permanganate	✓	×
		Advanced Oxidation Process	✓	×
	In Situ Treatment	Air Sparging/In-Well Air Stripping	×	×
		In Situ Chemical Reduction	✓	×
		In Situ Chemical Oxidation	×	×
		In Situ Bioremediation	✓	×
		Permeable Reactive Barrier	×	×
Discharge	Onsite Discharge	On-Site Injection	✓	×
	Offsite Discharge	Surface Discharge	✓	×

Green indicates retained technologies

Acronyms

GAC - granular activated carbon

haz - hazardous

MNA - monitored natural attenuation

AOP - advanced oxidation process

Table 4-1
Detailed Analysis of Soil Remedial Alternatives
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

EVALUATION CRITERION	ALTERNATIVE S-1 No Action	ALTERNATIVE S-2 Capping	ALTERNATIVE S-3 Excavation and Offsite Disposal of Contaminated Soil
Summary of Components	Under this alternative, no action would be taken. The contaminant concentrations would not be remediated nor monitored to document changes in contaminant concentrations or provide data to determine that remedial action objectives (RAOs) would be or were met.	▪ Pre-design investigation (PDI) ▪ Remedial design ▪ Clearing and grubbing ▪ Institutional and engineering controls ▪ Capping in residential area ▪ Long-term maintenance of the cap ▪ Excavation of polychlorinated biphenyls (PCB) contaminated soils in dump areas ▪ Five-year reviews ▪ Site restoration	▪ PDI ▪ Remedial design ▪ Engineering controls ▪ Excavation in residential area ▪ Excavation of PCB contaminated soil ▪ Off-site disposal ▪ Confirmation sampling ▪ Five-year reviews ▪ Site restoration
Overall Protection of Human Health and the Environment	All non-volatile organic compound (VOC) contaminants of concern in the residential area soils (lead and PCBs) and in the dump area overburden soils (PAHs and PCBs) are currently present above PRGs in soils. In particular, the soil contamination at the residential area would continue to serve as a potential risk to human health and the environment. This alternative would not meet the RAOs.	This alternative would provide protection of human health and the environment. Capping would prevent exposure of surface soils in the residential area to human and ecological receptors. Institutional controls by way of a deed restriction would also prevent human contact to any contamination in subsurface soils. During the construction period, temporary fencing would be enacted to prevent exposure to human and ecological receptors while the cap is being installed in the residential area. Exposure pathways in the non-residential target remediation zones (TRZs) would be eliminated or reduced by the excavation of contaminated soils. This alternative would meet the RAOs.	This alternative would provide protection of human health and the environment. Exposure pathways would be eliminated or reduced by the excavation of contaminated soils. During the construction period, temporary fencing would be enacted to prevent exposure to human and ecological receptors while excavation is ongoing. This alternative would meet the RAOs.
Compliance with ARARs	This alternative would not achieve PRGs (chemical-specific ARARs) for soils. Location-specific and action-specific ARARs do not apply to this alternative because no remedial action would be conducted.	The alternative would achieve PRGs for soil since contaminated soils exceeding the residential PRGs would be capped and the contaminated soils exceeding non-residential PRGs would be excavated and disposed offsite. This alternative would be designed and implemented in compliance with action-specific ARARs. A freshwater pond is mapped in the National Wetland inventory adjacent to Dump Areas B and C but was not confirmed during the site reconnaissance. A wetland survey would be conducted to confirm the status of the ponded area. If the area is determined to be a wetland, wetland protection considerations would be incorporated into the design and implementation of the remedy during the excavation of the non-residential TRZs in the dump areas to comply with location-specific ARARs. In addition, capping in the residential area may affect stormwater runoff and drainage patterns. Therefore, stormwater management techniques would be carefully implemented to ensure compliance with the New Jersey stormwater management requirements (action-specific ARAR).	The alternative would achieve PRGs for soil since contaminated soils exceeding the PRGs would be removed and disposed of offsite. This alternative would be designed and implemented in compliance with action-specific ARARs. A freshwater pond is mapped in the National Wetland inventory adjacent to Dump Areas B and C but was not confirmed during the site reconnaissance. A wetland survey would be conducted to confirm the status of the ponded area. If the area is determined to be a wetland, wetland protection considerations would be incorporated into the design and implementation of the remedy during the excavation of small spots in the overburden of the dump areas to comply with location-specific ARARs. In addition, excavation and backfill in the residential area may affect stormwater runoff and drainage patterns. Therefore, stormwater management techniques would be carefully implemented to ensure compliance with the New Jersey stormwater management requirements (action-specific ARAR).

Table 4-1
Detailed Analysis of Soil Remedial Alternatives
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

EVALUATION CRITERION	ALTERNATIVE S-1 No Action	ALTERNATIVE S-2 Capping	ALTERNATIVE S-3 Excavation and Offsite Disposal of Contaminated Soil
Long-term Effectiveness and Permanence (Magnitude of Residual Risk and Adequacy and Reliability of Controls)	This alternative would not be considered a permanent remedy because no action would be implemented to reduce the level of contamination or verify any naturally occurring reduction. It would not have long-term effectiveness.	The alternative would provide long-term effectiveness and permanence by eliminating or minimizing exposure pathways to human and ecological receptors, thereby reducing the magnitude of residual risk. The adequacy and reliability of the institutional and engineering controls in eliminating the human exposure pathways depends on enforcement of deed restrictions by the local government and routine inspections and maintenance of the cap. No institutional or engineering controls would be necessary for the non-residential TRZs since all contaminated soils would have been removed from the site.	The alternative would provide long-term effectiveness and permanence by permanently and irreversibly removing contaminants in soils, thereby minimizing or eliminating the magnitude of residual risk to human health and the environment. No institutional or engineering controls would be necessary after excavation since all contaminated soils would have been removed from the site.
Reduction of Toxicity/ Mobility/Volume (T/M/V) through Treatment	No reduction of contaminant T/M/V through treatment would be achieved under this alternative.	This alternative would reduce mobility of lead and PCB contaminated soils through capping. However, toxicity and volume would not be reduced for lead and PCBs in the residential area. Excavation of the spots of overburden contamination in the non-residential TRZs would transfer the T/M/V of PCBs exceeding PRGs in the source areas into landfills.	This alternative would not treat contaminated soils but instead the T/M/V of contamination would be transferred to landfills.
Short-term Effectiveness	This alternative would not pose short-term impacts to onsite workers or the community as no remedial action would be conducted. It would not have adverse environmental impacts to habitat or vegetation at the site. This alternative will not meet RAOs within a reasonable time frame.	This alternative would have moderate short-term impacts due to PDI activities and construction activities involved in installing the cap. Due to the steep incline on the slope of the residential area, the treatment area would have to be accessed both through the back of the residential property (from the former dump areas) and from the front of the residential property (from Brookwood Road). This would be temporarily disruptive to residences in the area. Excavation activities in the non-residential TRZs would likely be far enough away from the residential area to not have any short-term effects on the community. Engineering controls would be established to minimize the impact while the use of personal protective equipment (PPE) by workers would minimize exposure. The construction duration of this alternative is estimated to be 5 months. This alternative is expected to meet RAOs after construction is complete.	This alternative would have moderate short-term impacts due to PDI activities and construction activities involved in the excavation. Most of the equipment and operations would occur in the former dump areas south of the residential property which are currently unoccupied and undeveloped lands. Construction activities in the residential property yard would generate noise during the day and possibly increase local traffic along Brookwood Road if excavation equipment requires access from the front of the residential property for certain areas. Engineering controls would be established to minimize the impact while the use of PPE by workers would minimize exposure. Excavation activities in the non-residential TRZs would likely be far enough away from the residential area to not have any short-term effects on the community. The construction duration of this alternative is estimated to be 6 months. This alternative is expected to meet RAOs by the end of the construction period.

Table 4-1
Detailed Analysis of Soil Remedial Alternatives
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

EVALUATION CRITERION	ALTERNATIVE S-1 No Action	ALTERNATIVE S-2 Capping	ALTERNATIVE S-3 Excavation and Offsite Disposal of Contaminated Soil
Implementability	This alternative is implementable.	This alternative is implementable. Equipment and experienced vendors are readily available. Challenges to technical feasibility include the steep slope which may be difficult for equipment to install a stable cap on. The bedrock outcrops in the residential yard may also interfere with cap stability. Maintenance may be more intensive than a typical cap because of the slope angle and the potential for shallow rooted trees to fall and damage the cap. In addition, any installed stormwater management or runoff diversion structures (such as drainage swales) would have to be inspected and maintained also. Therefore, long-term inspection and maintenance of the cap might be challenging. An inspection and maintenance plan would need to be developed and funding would need to be provided for this activity to ensure continued protection of human health and the environment. If required, finding a space for the storm water retention pond would be challenging. Challenges to administrative feasibility include requiring access to the residential yard, property owner approval for a deed restriction, and proper discharge permits for the stormwater management/runoff diversion structures installed as part of the cap.	This alternative is implementable. Equipment and experienced vendors are readily available. Challenges to administrative feasibility include requiring access to the residential yard for construction activities.
Present Worth with Discounting	$0	$2.47 million	$2.40 million

Acronyms:
ARAR – applicable or relevant and appropriate requirement
PDI – pre-design investigation
PPE – personal protective equipment
PRG – preliminary remedial goal
RAO – remedial action objective
PCB – polychlorinated biphenyls
T/M/V – toxicity/mobility/volume
TRZ – target remediation zone

Table 4-2
Detailed Analysis of Groundwater and Bedrock Vadose Zone Remedial Alternatives
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

EVALUATION CRITERION	ALTERNATIVE GW-1 No Action	ALTERNATIVE GW-2 Capping, MNA	ALTERNATIVE GW-3 Capping and SVE, MNA	ALTERNATIVE GW-4 Capping, SVE, In Situ Treatment, MNA	ALTERNATIVE GW-5 Capping, DPE, MNA
Summary of Components	Under this alternative, no action would be taken. The contaminant concentrations would not be remediated nor monitored to document changes in contaminant concentrations or provide data to determine that RAOs would be or were not met.	▪ PDI at the source area ▪ Remedial design ▪ Institutional controls ▪ Cap installation, monitoring, and maintenance at the source area (Dump Areas A and D) ▪ MNA in the source area plume and distal plume ▪ Five-year reviews ▪ Site restoration	▪ PDI and SVE pilot study at the source area ▪ Remedial design ▪ Institutional controls ▪ Cap installation, monitoring, and maintenance at the source area (Dump Areas A and D) ▪ SVE installation, operation, and maintenance in the source area vadose zone ▪ SVE performance evaluation at the source area ▪ MNA in the source area plume and distal plume ▪ Five-year reviews ▪ Site restoration	▪ PDI, SVE pilot study, and treatability study at the source area ▪ Remedial design ▪ Institutional controls ▪ Cap installation, monitoring, and maintenance at the source area (Dump Areas A and D) ▪ SVE installation, operation, and maintenance in the source area vadose zone ▪ SVE performance evaluation at the source area ▪ In situ treatment of source area plume via amendment injections ▪ MNA in the distal plume ▪ Five-year reviews ▪ Site restoration	▪ PDI and DPE pilot study at the source area ▪ Remedial design ▪ Institutional controls ▪ Cap installation, monitoring, and maintenance at the source area (Dump Areas A and D) ▪ DPE installation, operation, and maintenance in the source area vadose zone and source area plume ▪ DPE performance evaluation at the source area ▪ MNA in the distal plume ▪ Five-year reviews ▪ Site restoration
Overall Protection of Human Health and the Environment	Contamination is present above PRGs in groundwater and continues to impact residential supply wells. This alternative would not meet the RAOs or provide protection of human health and the environment.	Capping would reduce the discharge of mass from the vadose zone into groundwater. Natural attenuation would be expected to reduce groundwater concentrations to below the PRGs over time since mass discharge from the residual contamination in the vadose zone to groundwater would be limited by the capping. During remediation, exposure to contaminated groundwater would be prevented through institutional and engineering controls (restricting well installation). This alternative would meet the RAOs over time.	In addition to the protection provided by capping as described in Alternative 2, soil vapor extraction would actively remove contamination from the vadose zone, further reducing mass discharge to groundwater. Natural attenuation would be expected to reduce groundwater concentrations to below the PRGs over time. During remediation, exposure to contaminated groundwater would be prevented through institutional and engineering controls (restricting well installation). This alternative would meet the RAOs over time.	In addition to the protection provided by capping, SVE, and MNA as described in Alternative 3, Alternative 4 would involve active in situ treatment of the groundwater. In situ treatment would provide more rapid protection of human health and the environment by destroying contaminant mass in the saturated zone at the source. Natural attenuation would provide an additional level of protection. During remediation, exposure to contaminated groundwater would be prevented through institutional and engineering controls (restricting well installation). This alternative would meet the RAOs over time.	In addition to the protection provided by capping as described in Alternative 2, Alternative 5 would involve removal of mass from the vadose zone and the saturated zone via dual phase extraction. The groundwater extraction would also provide a level of hydraulic control to prevent contaminated groundwater from migrating downgradient towards receptors. Natural attenuation would provide an additional level of protection. During remediation, exposure to contaminated groundwater would be prevented through institutional and engineering controls (restricting well installation). This alternative would meet the RAOs over time.
Compliance with ARARs	This alternative would not achieve chemical-specific ARARs or PRGs. No location-specific ARARs apply to this alternative. Action-specific ARARs do not apply to this alternative because no remedial action would be conducted.	The alternative would achieve PRGs for groundwater, which were derived from chemical-specific ARARs for protection of groundwater, in the long term. This alternative would be designed and implemented in compliance with action- and location-specific ARARs. Action-specific ARARs may include stormwater management requirements and use of corrective action management unit (CAMU) rules. Location-specific ARAR may include wetland and habitat protections.	The alternative would achieve PRGs for groundwater, which were derived from chemical-specific ARARs for protection of groundwater. This alternative would be designed and implemented in compliance with action- and location-specific ARARs. Action-specific ARARs may include air discharge permit requirements, stormwater management requirements, and use of CAMU rules. Location-specific ARAR may include wetland and habitat protections.	The alternative would achieve PRGs for groundwater, which were derived from chemical-specific ARARs for protection of groundwater. This alternative would be designed and implemented in compliance with action- and location-specific ARARs. Action-specific ARARs may include injection permit, air discharge permit requirements, stormwater management requirements, and use of CAMU rules. Location-specific ARARs may include wetland and habitat protections.	The alternative would achieve PRGs for groundwater, which were derived from chemical-specific ARARs for protection of groundwater. This alternative would be designed and implemented in compliance with action- and location-specific ARARs. Action-specific ARARs may include injection permit, air discharge permit requirements, stormwater management requirements, and use of CAMU rules. Location-specific ARARs may include wetland and habitat protections.

Table 4-2
Detailed Analysis of Groundwater and Bedrock Vadose Zone Remedial Alternatives
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

EVALUATION CRITERION	ALTERNATIVE GW-1 No Action	ALTERNATIVE GW-2 Capping, MNA	ALTERNATIVE GW-3 Capping and SVE, MNA	ALTERNATIVE GW-4 Capping, SVE, In Situ Treatment, MNA	ALTERNATIVE GW-5 Capping, DPE, MNA
Long-term Effectiveness and Permanence (Magnitude of Residual Risk and Adequacy and Reliability of Controls)	This alternative would not be considered a permanent remedy because no action would be implemented to reduce the level of contamination or verify any naturally occurring reduction. It would not have long-term effectiveness.	The underlying hypothesis for this alternative is that residual contamination is present in the vadose zone, and precipitation and snowmelt infiltrates into the vadose zone, carrying contamination into the groundwater adding to the exceedances of PRGs in groundwater. During the RI, the presence of residual vadose zone mass was inferred by the continuing presence of groundwater contamination even though the sources (the dump areas) had been removed. If residual vadose zone contamination is in fact the primary reason for groundwater contamination, then capping would slow the discharge of mass from the vadose zone to groundwater. Vadose zone contamination would remain in place, but its migration would be limited as long as the cap is able to divert precipitation away from the contaminated vadose zone under the dump areas. Long-term effectiveness and permanence would depend on continued maintenance of the cap. If mass discharge to groundwater is sufficiently reduced by the cap, then natural attenuation in the aquifer would reduce concentrations prior to reaching receptors along Brookwood Road. Natural attenuation would effectively and permanently reduce groundwater contamination; however, natural attenuation can have limited impact if there is a continuing influx of contamination from the vadose zone, or if mass transfer out of low-permeability fractures in the saturated zone is significant. The reliability of institutional controls in eliminating the human exposure pathway to contaminated groundwater relies on enforcement by local government.	The long-term effectiveness from capping as described in Alternative 2 would apply for Alternative 3. In addition, SVE would permanently and irreversibly remove contamination from the vadose zone, further reducing mass discharge to groundwater. The effectiveness of SVE may be limited by the fractured rock geology. If a significant amount of mass is "hidden" in low transmissivity fractures, then the effectiveness of SVE would be limited by the rate of mass transfer out of those fractures into the more transmissive zones where air is being moved by the SVE system. Pre-design investigation and pilot testing could be used to answer these questions. If mass discharge to groundwater is sufficiently reduced by the cap and SVE, then natural attenuation in the aquifer would reduce concentrations prior to reaching receptors along Brookwood Road. Natural attenuation would effectively and permanently reduce groundwater contamination. However, natural attenuation can have limited impact if there is a continuing influx of contamination from the vadose zone, or if mass transfer out of low-permeability fractures in the saturated zone is significant. The reliability of institutional controls in eliminating the human exposure pathway to contaminated groundwater relies on enforcement by local government.	The long-term effectiveness from capping and SVE in Alternative 3 would apply for Alternative 4. Distributing amendment into the fractured bedrock may be difficult considering the complex network and clogging may occur if fractures are too thin versus the particle size of the amendment emplaced. Pilot testing would be needed to evaluate amendment distribution. If distribution is successful, in combination with the mass discharge reduction from the SVE, a long-lasting amendment would be expected to permanently and effectively reduce concentrations in groundwater leaving the source zone. A long-lasting amendment would be key since mass transfer out of low-transmissivity fractures and into the more transmissive fractures – which is where amendment could feasibly be emplaced—would likely be driving the timeframe for remediation. Natural attenuation would then be expected to reduce residual concentrations between the source zone and the receptors. The reliability of institutional controls in eliminating the human exposure pathway to contaminated groundwater relies on enforcement by local government.	The long-term effectiveness from capping and SVE (applied here as DPE) in Alternative 3 would apply for Alternative 4. The complex network may make it difficult to effectively find and target the transmissive fractures for groundwater extraction. The limited storativity in the aquifer, in addition to the fact that the treatment zones are on a topographic high point, indicates that only a relatively low flowrate of groundwater may be needed to hydraulically control mass discharge from the source zones to the distal plume. Mass transfer out of low-transmissivity fractures and into the more transmissive fractures – which is where groundwater could be more readily extracted—would likely be driving the timeframe for remediation. In other words, it is likely that groundwater concentrations in the extraction zone may stabilize with DPE, yet remain above the PRGs Natural attenuation would then be expected to reduce residual concentrations between the source zone and the receptors. Long-term effectiveness will be dependent upon continued operation and maintenance of the DPE system. The reliability of institutional controls in eliminating the human exposure pathway to contaminated groundwater relies on enforcement by local government.

Table 4-2
Detailed Analysis of Groundwater and Bedrock Vadose Zone Remedial Alternatives
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

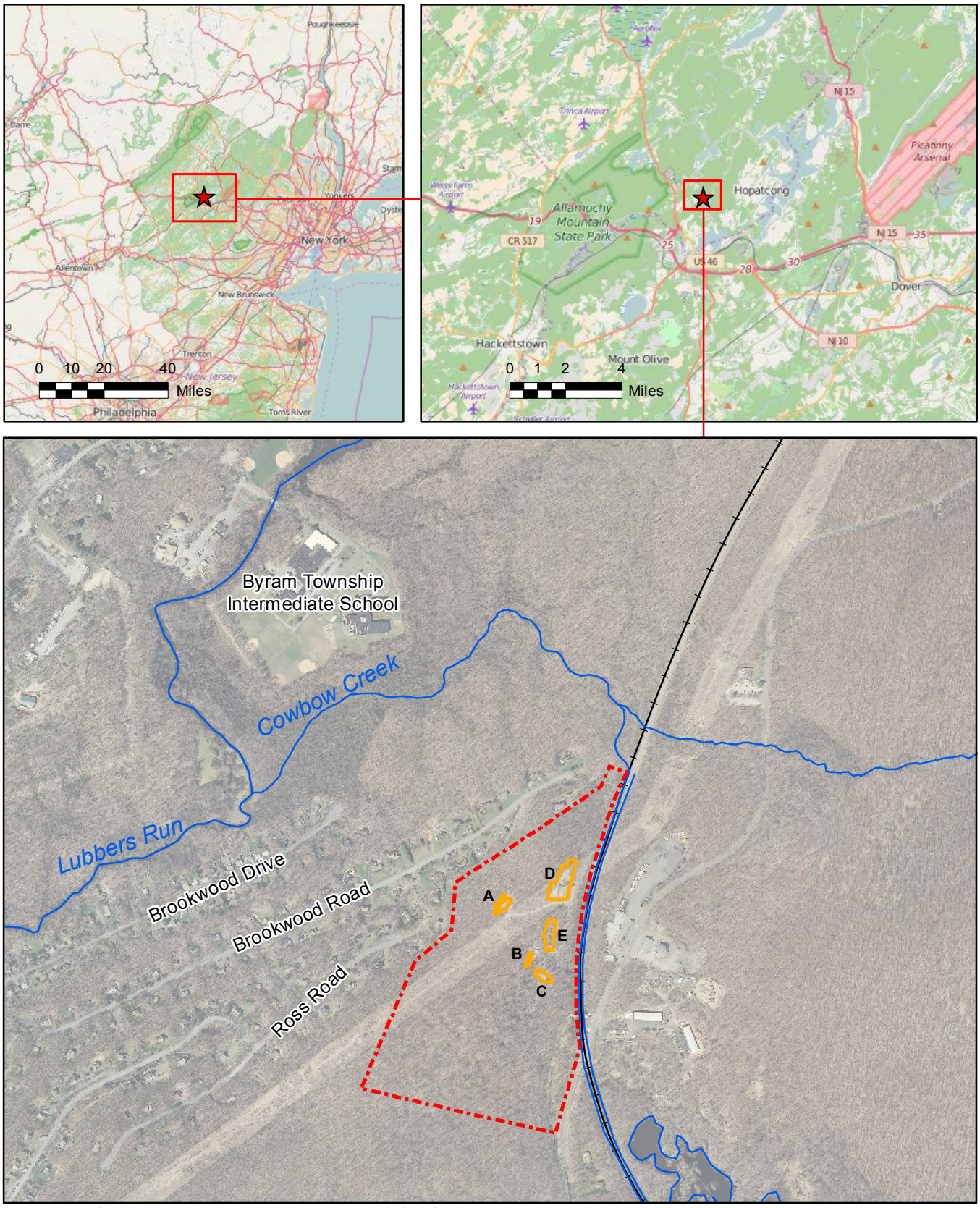
EVALUATION CRITERION	ALTERNATIVE GW-1 No Action	ALTERNATIVE GW-2 Capping, MNA	ALTERNATIVE GW-3 Capping and SVE, MNA	ALTERNATIVE GW-4 Capping, SVE, In Situ Treatment, MNA	ALTERNATIVE GW-5 Capping, DPE, MNA
Reduction of Toxicity/ Mobility/Volume through Treatment	No reduction of contaminant T/M/V through treatment would be achieved under this alternative.	This alternative would reduce the mobility of contamination in the vadose zone by installing a cap to reduce infiltration of rainwater. However, this is containment, and not treatment. Natural attenuation in groundwater would reduce the volume of contamination in groundwater.	This alternative would reduce the mobility of contamination in the vadose zone by installing a cap to reduce infiltration of rainwater. SVE treatment would reduce the volume of contamination at the site. Natural attenuation in groundwater would reduce the volume of contamination in groundwater.	This alternative would reduce the mobility of contamination in the vadose zone by installing a cap to reduce infiltration of rainwater. SVE treatment would reduce the volume of contamination at the site. In situ treatment via amendment injection would reduce T/M/V in groundwater as long as the amendment is distributed effectively and the amendment retains reactivity. Natural attenuation would reduce the volume of contamination in groundwater.	This alternative would reduce the mobility of contamination in the vadose zone by installing a cap to reduce infiltration of rainwater. SVE treatment (a component of DPE) would reduce the volume of contamination at the site. Groundwater extraction treatment (the second component of DPE) would reduce the mobility and volume of contaminated groundwater as long as the groundwater extraction system can be operated and maintained effectively. Natural attenuation would reduce the volume of contamination in groundwater.
Short-term Effectiveness	This alternative would not pose short-term impacts to onsite workers or the community as no remedial action would be conducted. It would not have adverse environmental impacts to habitat or vegetation at the site. This alternative would not meet RAOs within a reasonable time frame.	This alternative would have low to moderate short-term impacts in a remote area due to PDI activities and cap installation and maintenance. Engineering controls would be established to minimize the impact while the use of personal protective equipment (PPE) by workers would minimize exposure. The construction duration of this alternative is estimated to be less than one year. It is estimated that capping would reduce mass discharge from the vadose zone to groundwater within five years, but natural attenuation would require greater than 400 years to reach groundwater PRGs.	This alternative would have low to moderate short-term impacts in a remote area due to PDI activities and system installation, operations, and maintenance of the SVE system and cap, including regular changeout of filter media. Engineering controls would be established to minimize the impact while the use of PPE by workers would minimize exposure. The operation of the SVE system is estimated to be 4 to 5 years before asymptotic mass removal is achieved and natural attenuation is then relied upon. It is estimated this alternative would take greater than 300 years to meet RAOs and groundwater PRGs.	This alternative would have moderate short-term impacts in a remote area due to PDI activities and system installation, operations, and maintenance of the SVE system and cap, including regular changeout of filter media. Injection of amendment takes on the order of months and would be a short-term impact. Engineering controls would be established to minimize the impact while the use of PPE by workers would minimize exposure. The operation of the SVE system is estimated to be 4 to 5 years before asymptotic mass removal is achieved. Flux reduction in groundwater should also occur within five years after injection. Natural attenuation would still be important to eventually achieve PRGs in groundwater, estimated to be within 150 years at the source zone and 30 years 500 feet downgradient.	This alternative would have moderate short-term impacts in a remote area due to PDI activities and system installation, operations, and maintenance of the DPE system and cap, including regular changeout of filter media. Engineering controls would be established to minimize the impact while the use of PPE by workers would minimize exposure. The operation of the DPE system is estimated to be for 10 years before asymptotic mass removal levels are achieved. At this point, natural attenuation would be relied on to reach groundwater PRGs, a process likely exceeding 200 years.

Table 4-2
Detailed Analysis of Groundwater and Bedrock Vadose Zone Remedial Alternatives
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

EVALUATION CRITERION	ALTERNATIVE GW-1 No Action	ALTERNATIVE GW-2 Capping, MNA	ALTERNATIVE GW-3 Capping and SVE, MNA	ALTERNATIVE GW-4 Capping, SVE, In Situ Treatment, MNA	ALTERNATIVE GW-5 Capping, DPE, MNA
Implementability	This alternative is implementable.	Services and materials would be readily available to implement this alternative. Stormwater management requirements may be difficult to meet due to the limited availability of land and the bedrock formation.	Due to the fractured rock geology, where fractures have widely varying transmissivity, installing an SVE system that effectively draws vapor throughout the vadose zone may be difficult. If significant mass is present in low-transmissivity fractures, it would be difficult to effectively target those zones with SVE. A pilot study would be needed for SVE. Capping is implementable with readily available services and materials. Stormwater management requirements may be difficult to meet due to the limited availability of land and the bedrock formation.	The implementability concerns for SVE in Alternative 3 apply for this alternative. The fractured rock geology with thin fractures and varying fracture transmissivity means that effectively distributing amendment for in situ treatment may be difficult. A pilot test would be needed to verify distribution. No operations and maintenance for the groundwater treatment component of this alternative is required. Capping is implementable with readily available services and materials. Stormwater management requirements may be difficult to meet due to the limited availability of land and the bedrock formation.	The implementability concerns for SVE in Alternative 3 apply for this alternative. The fractured rock geology with widely varying fracture transmissivity means that identifying and targeting zones for groundwater extraction that prevent contamination from migrating offsite may be difficult. Pilot tests would be needed to verify extraction. It is important to note that long-term operations and maintenance is likely for this alternative. The limited storativity in the aquifer and observed large swings in the water table elevation mean that drawdown by pumping could be rapid, and operations would need to be fine-tuned. Capping is implementable with readily available services and materials. Stormwater management requirements may be difficult to meet due to the limited availability of land and the bedrock formation.
Present Worth with Discounting	$0	$4.1 million	$6.5 million	$9.1 million	$7.9 million

Acronyms:
ARAR – applicable or relevant and appropriate requirement
DPE – Dual Phase Extraction
MNA – monitored natural attenuation
PDI – pre-design investigation
PPE – personal protective equipment
PRG – preliminary remedial goal
RAO – remedial action objective
SVE – soil vapor extraction
T/M/V – toxicity/mobility/volume

Figures



Images adapted from EES JV Revised Data Evaluation Summary Report (2016)

Legend

Source Study Area

Source Areas

N

0 0.25 0.5 1 Miles

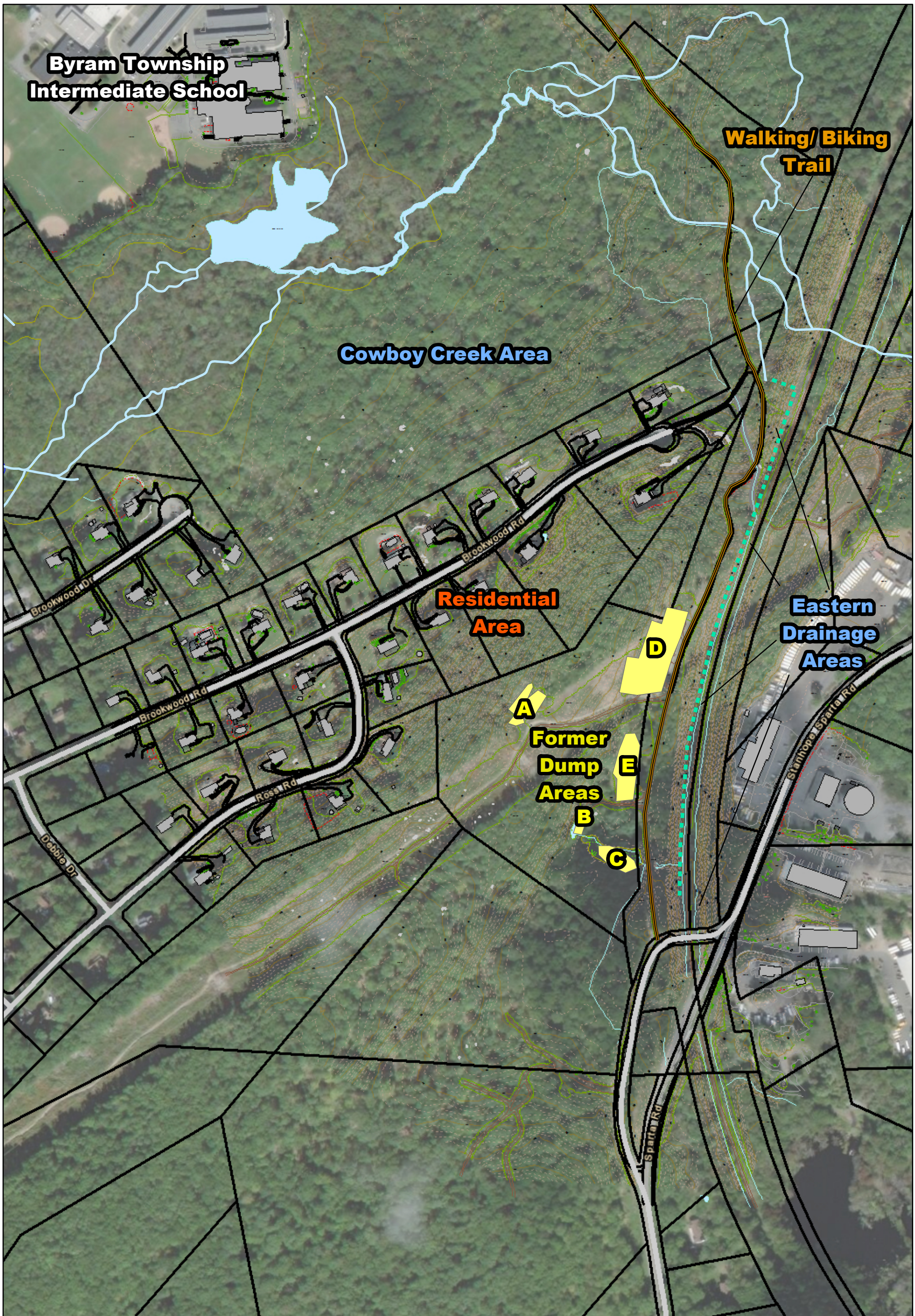
CDM Smith

Figure 1-1

Site Location Map

Mansfield Trail Dump Site, OU2

Byram Township, NJ



Former Dump Areas
Other Parcels
Cowboy Creek
Intermittent Stream

Topographic Contours
50 ft Contours
5 ft Contours

N

0 150 300 600 Feet

Figure 1-2
Site Plan
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

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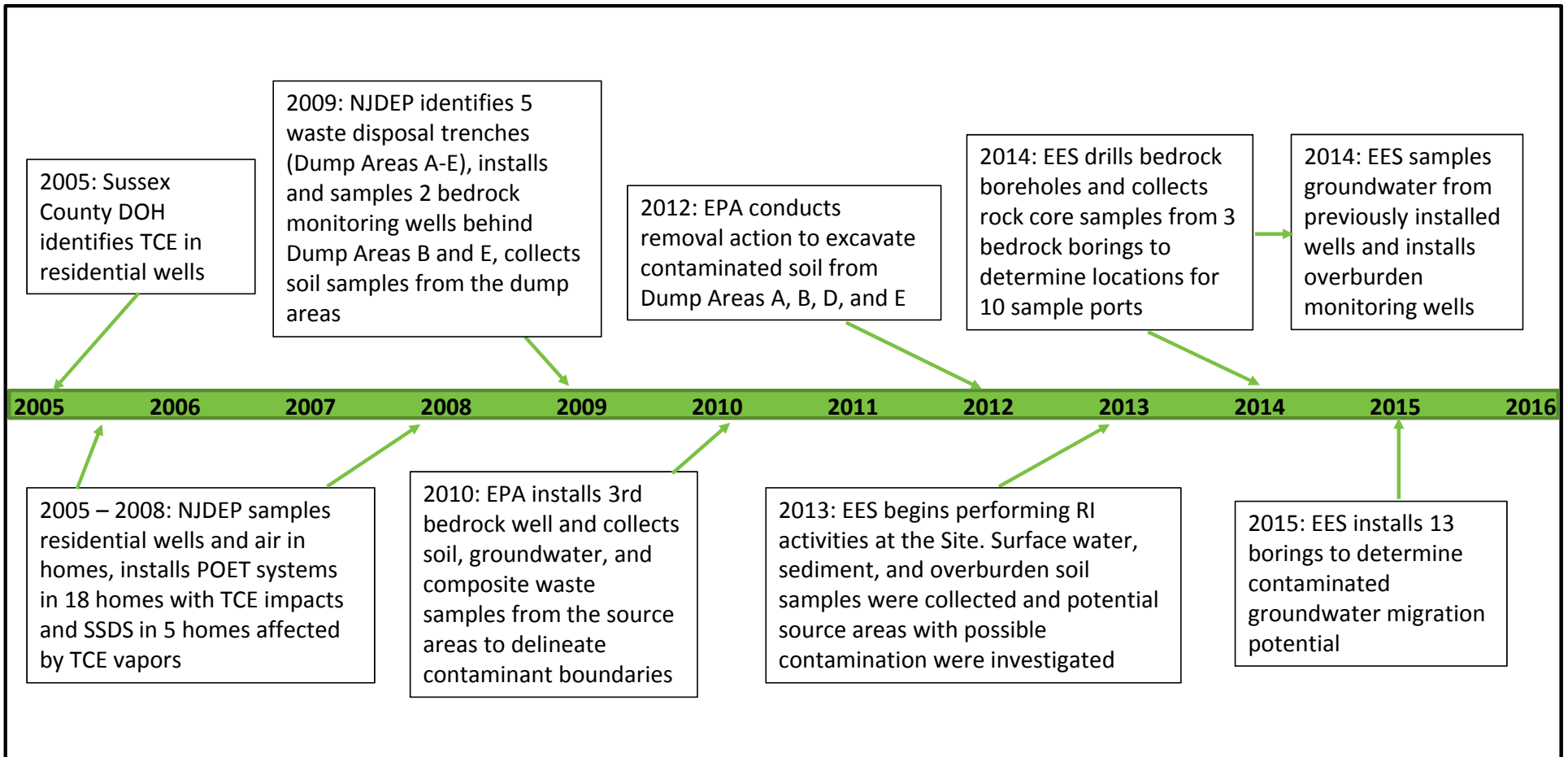

Acronyms
DOH: Department of Heath
EES: Engineering and Environmental Solutions
EPA: U.S. Environmental Protection Agency
NJDEP: New Jersey Department of Environmental Protection
RI: remedial investigation
TCE: trichloroethene

CDM Smith

Figure 1-3
Previous Investigations Timeline
Mansfield Trail Dump, OU2
Bryam Township, NJ

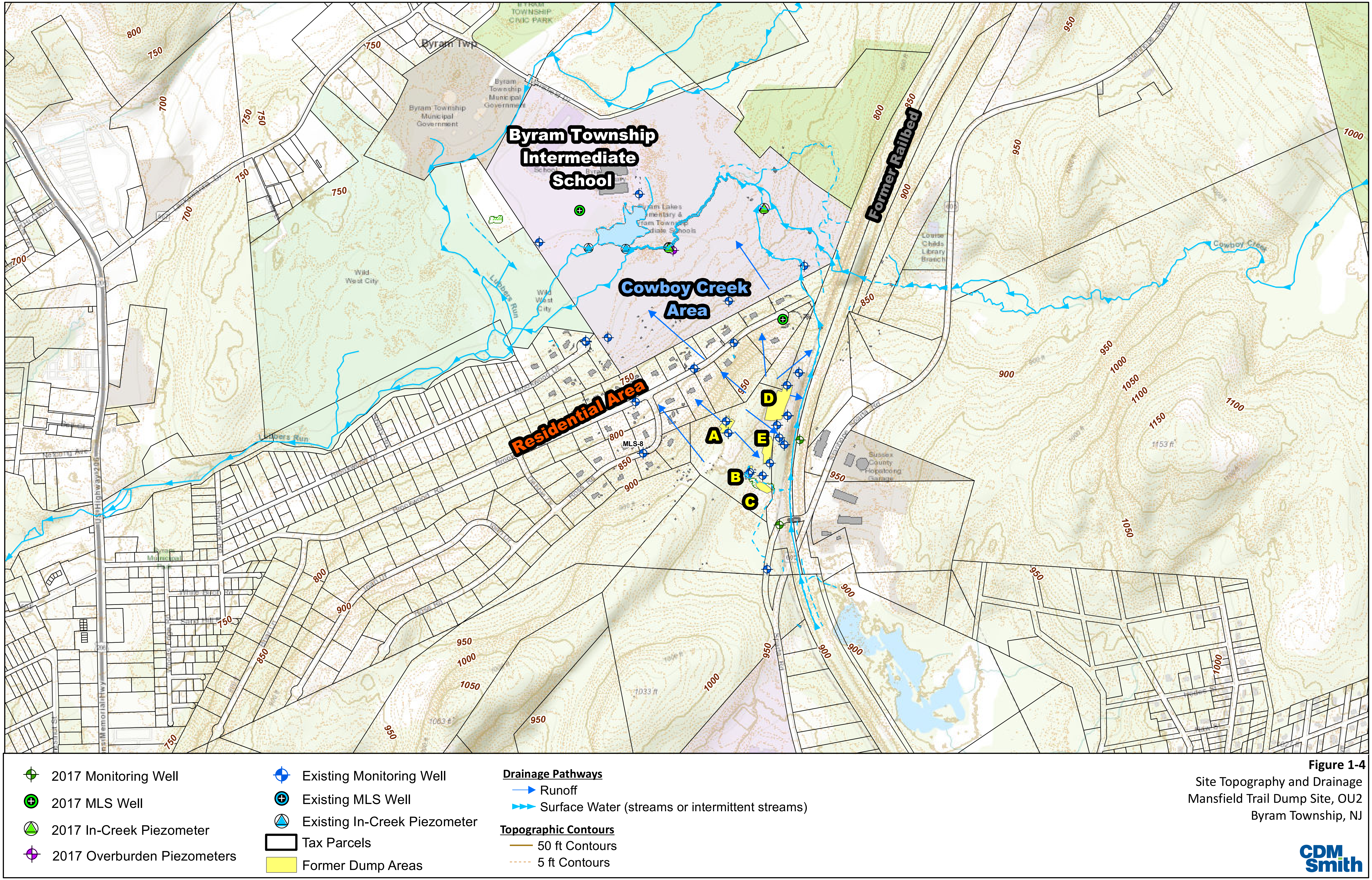

Figure 1-4
Site Topography and Drainage
Mansfield Trail Dump Site, OU2
Byram Township, NJ

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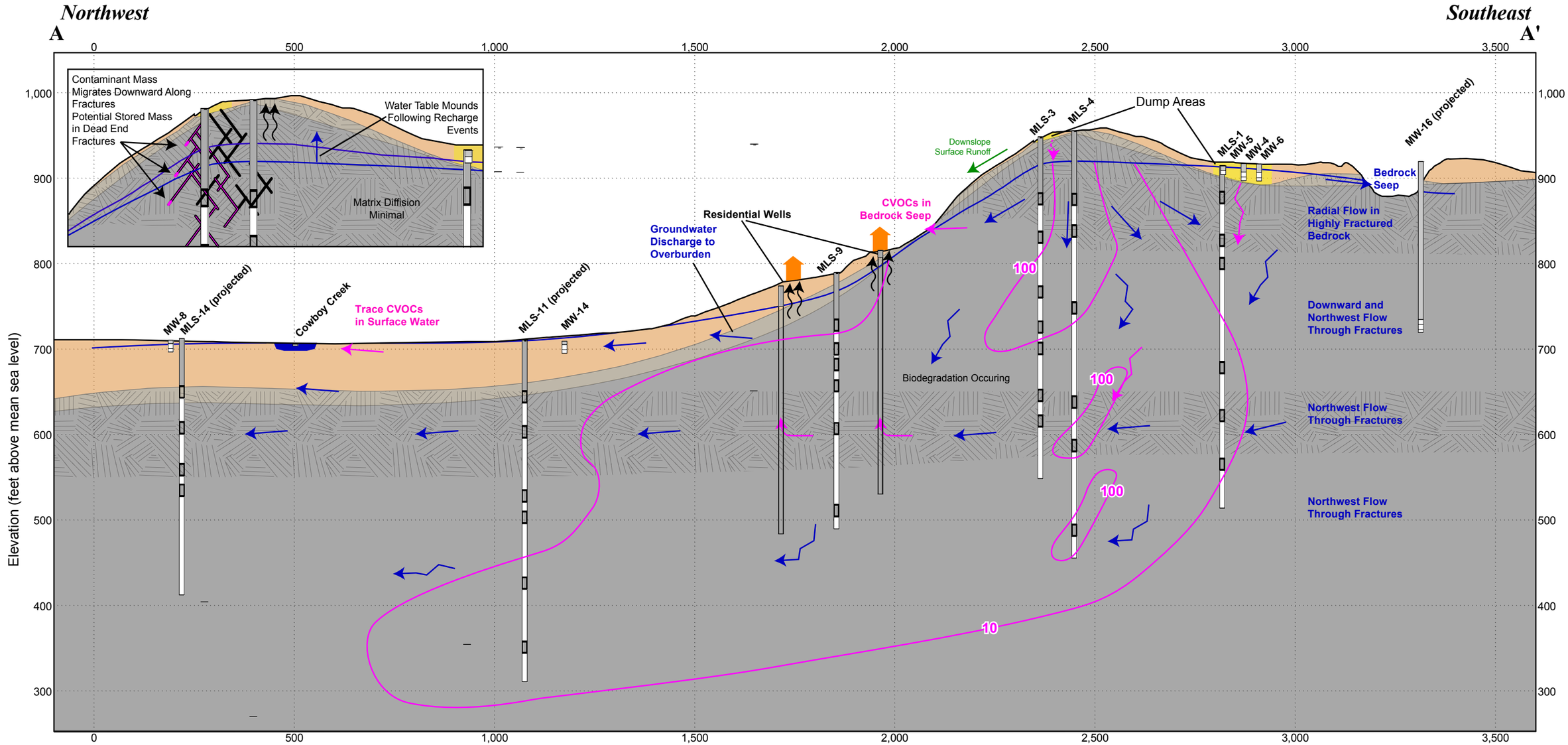

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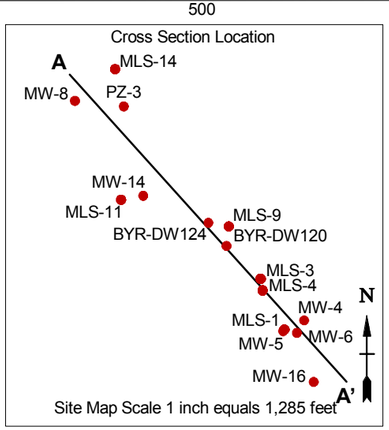


- Overburden
- Weathered Bedrock
- Bedrock
- Fractured/Transmissive Zone
- Vapor Migration
- Casing
- Screened Interval
- Open Borehole
- CVOC approximate groundwater contamination extent (dashed where inferred)
- FLUTe Liner
- FLUTe Sampling Port
- Groundwater flow pathway
- Contaminant flow pathway
- Shallow Potentiometric Surface

Horizontal Scale (feet): 0 – 250

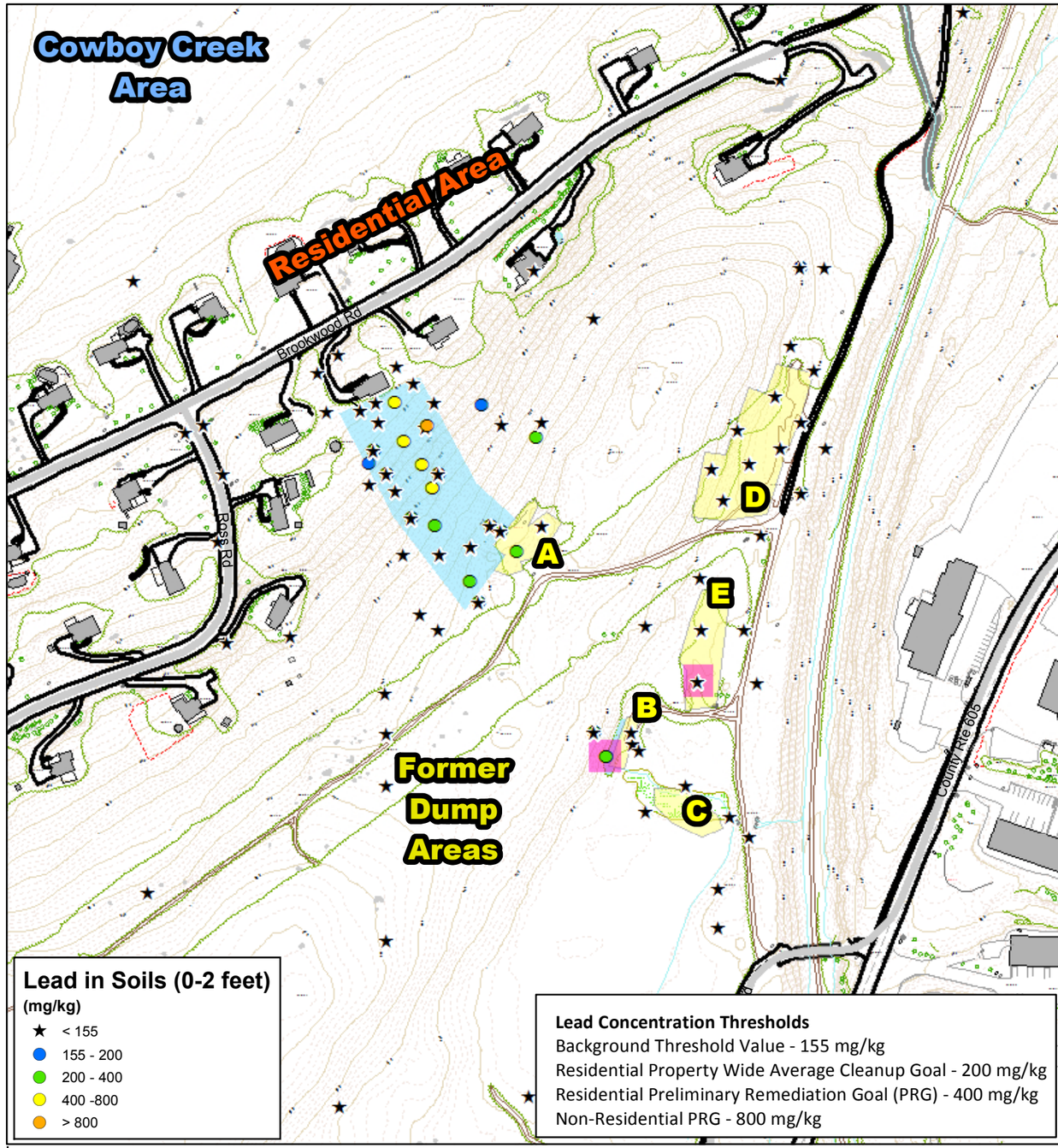
Vertical Scale (feet): 0 – 120

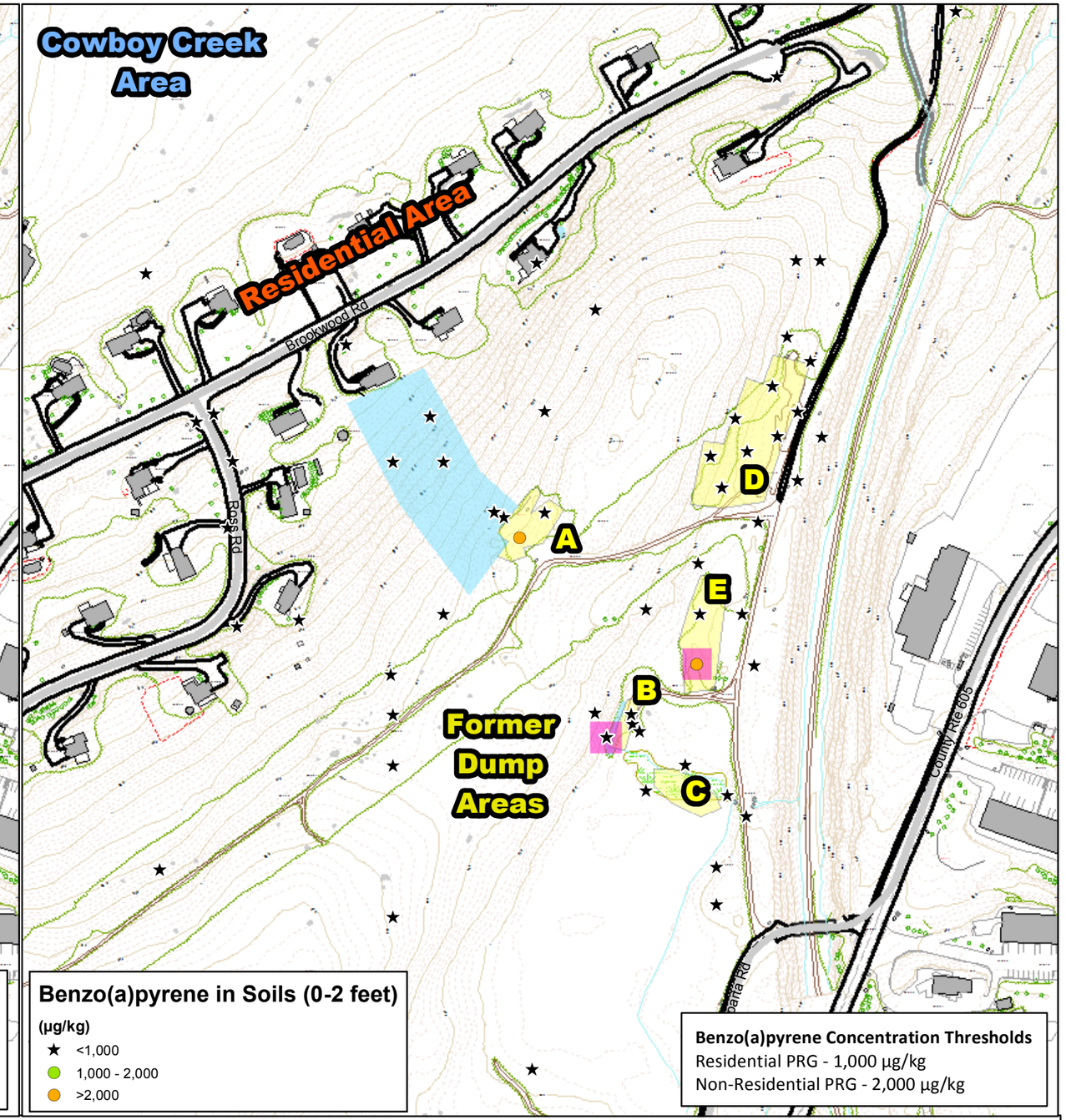
Vertical Exaggeration: 2x

CDM Smith

Figure 1-5
Conceptual Site Model
Mansfield Trail Dump Site, OU2
Byram Township, NJ

STANDARD CROSS SECTION: MANSFIELD MANSFIELD.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 4/10/18 REV.





Former Dump Areas
Non-Residential Target Remediation Zone
Residential Target Remediation Zone

Topographic Contours
50 ft Contours
5 ft Contours

Notes
1. Soil sampling results are presented for sampling events performed following the removal actions in 2012.
2. Data is color coded by concentration groups to represent various thresholds and to assist in presenting where contamination is present.

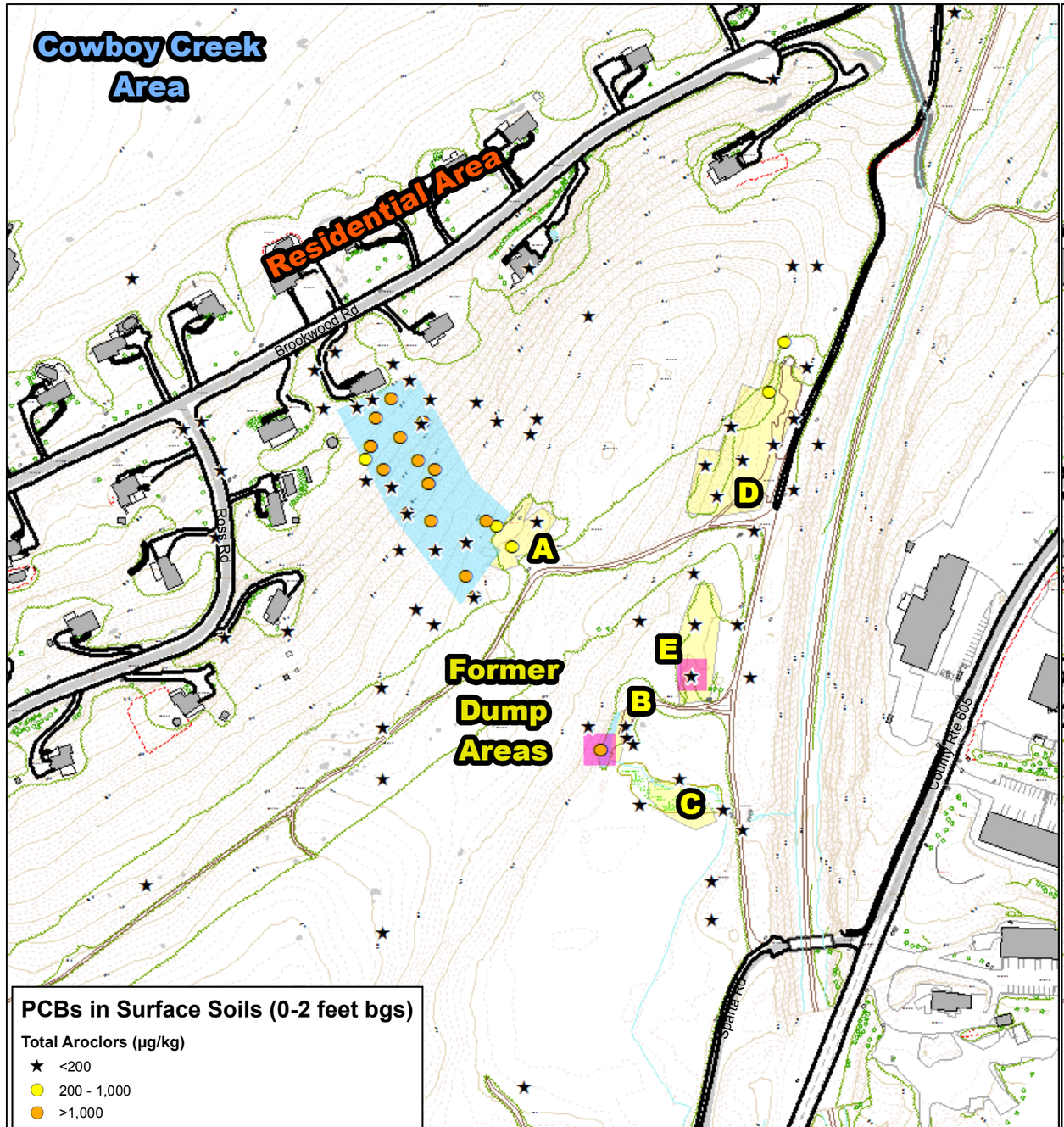
N

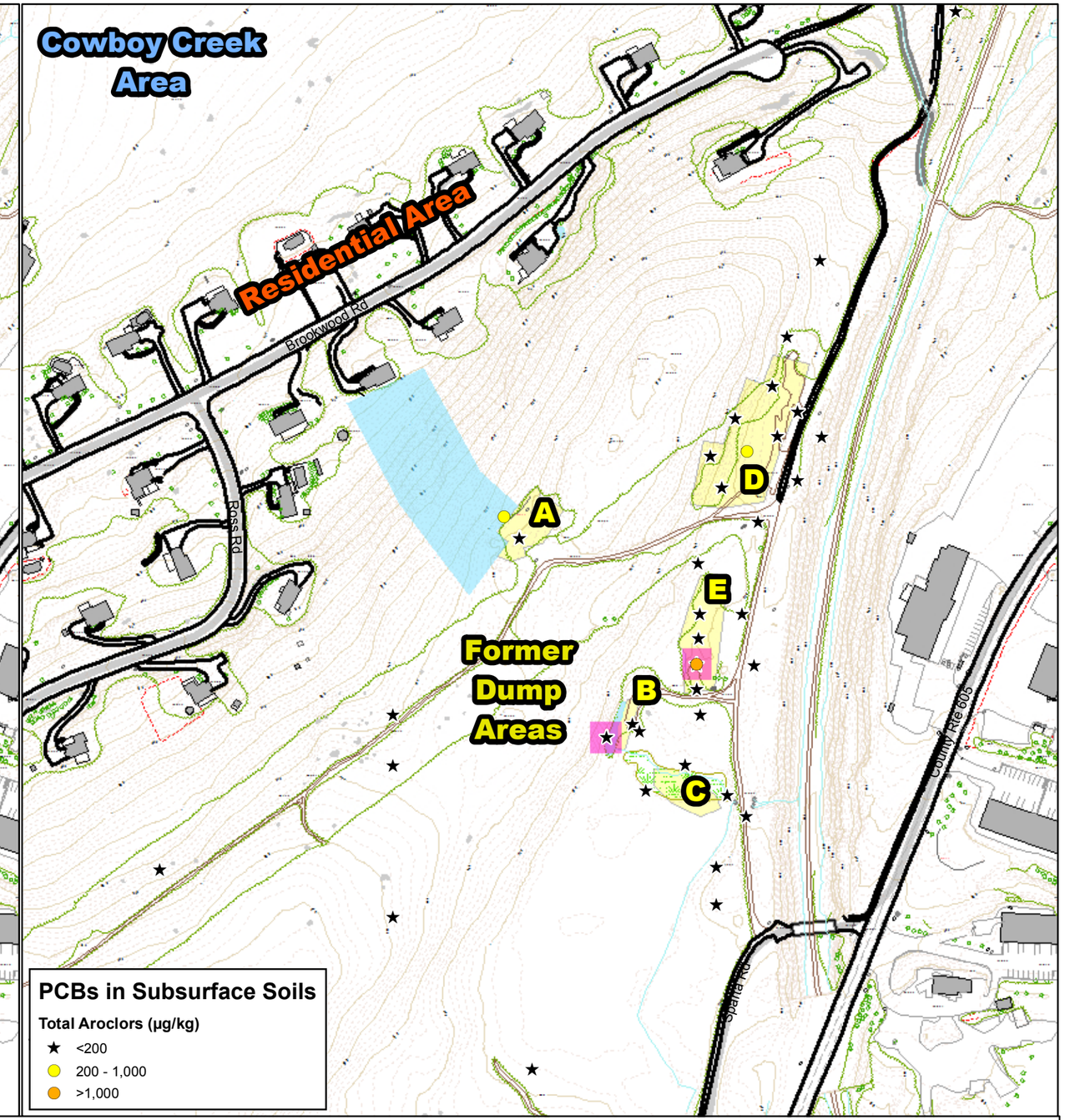
0 125 250 500 Feet

Figure 2-1
Soil Target Remediation Zones with Lead and Benzo(a)pyrene Sample Results
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

schlosserm N:\Mansfield Trail Dump Site\MXD\070\FS\Figure 2-1_Soil_TRZ_Lead_PAHs_rev.mxd 5/2/2019





Former Dump Areas
Non-Residential Target Remediation Zone
Residential Target Remediation Zone

Topographic Contours
50 ft Contours
5 ft Contours

Notes
1. Soil sampling results are presented for sampling events performed following the removal actions in 2012.
2. Data is color coded by concentration groups to represent various PRGs and to assist in presenting where contamination is present.

PCB Preliminary Remediation Goals (PRGs)
Residential PRG - 200 µg/kg
Non-Residential PRG - 1000 µg/kg

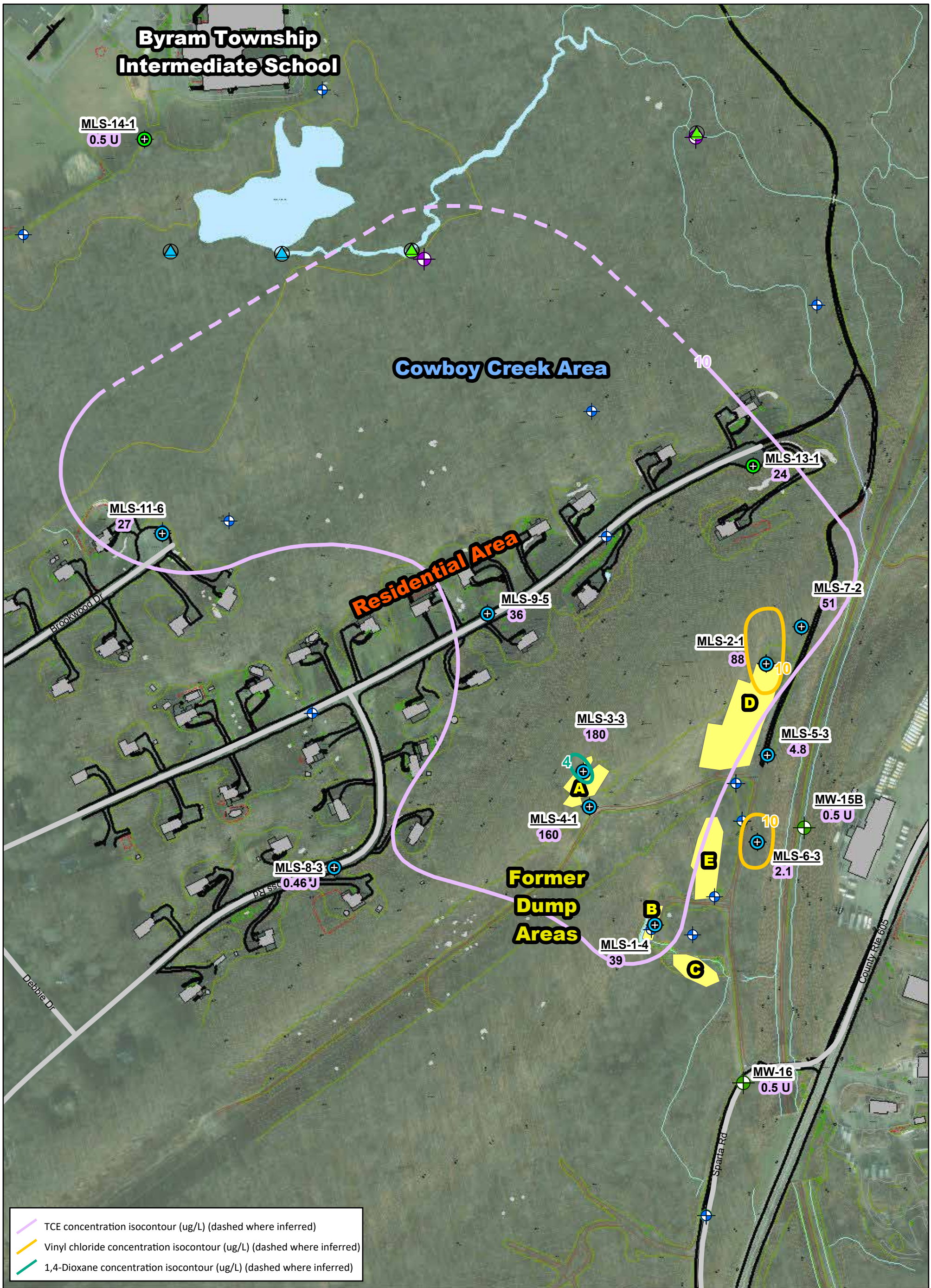
N

0 125 250 500 Feet

Figure 2-2
Soil Target Remediation Zone with PCB Sample Results
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

schlosserm N:\Mansfield Trail Dump Site\MXD\070\FS\Figure 2-2_Soil_TRZ_PCBs.mxd 5/2/2019



2017 Monitoring Well
2017 MLS Well
2017 In-Creek Piezometer
2017 Overburden Piezometers
Existing Monitoring Well
Existing MLS Well
Existing In-Creek Piezometer
Former Dump Areas

MLS-1-P1 Monitoring Well
0.5 U TCE Concentration (ug/L)

Notes
1. Groundwater results are presented for the November 2017 sampling. The port with the highest concentration is presented.
2. Acronyms:
D - dilution
J- estimated value
TCE - Trichloroethene
U- non detect

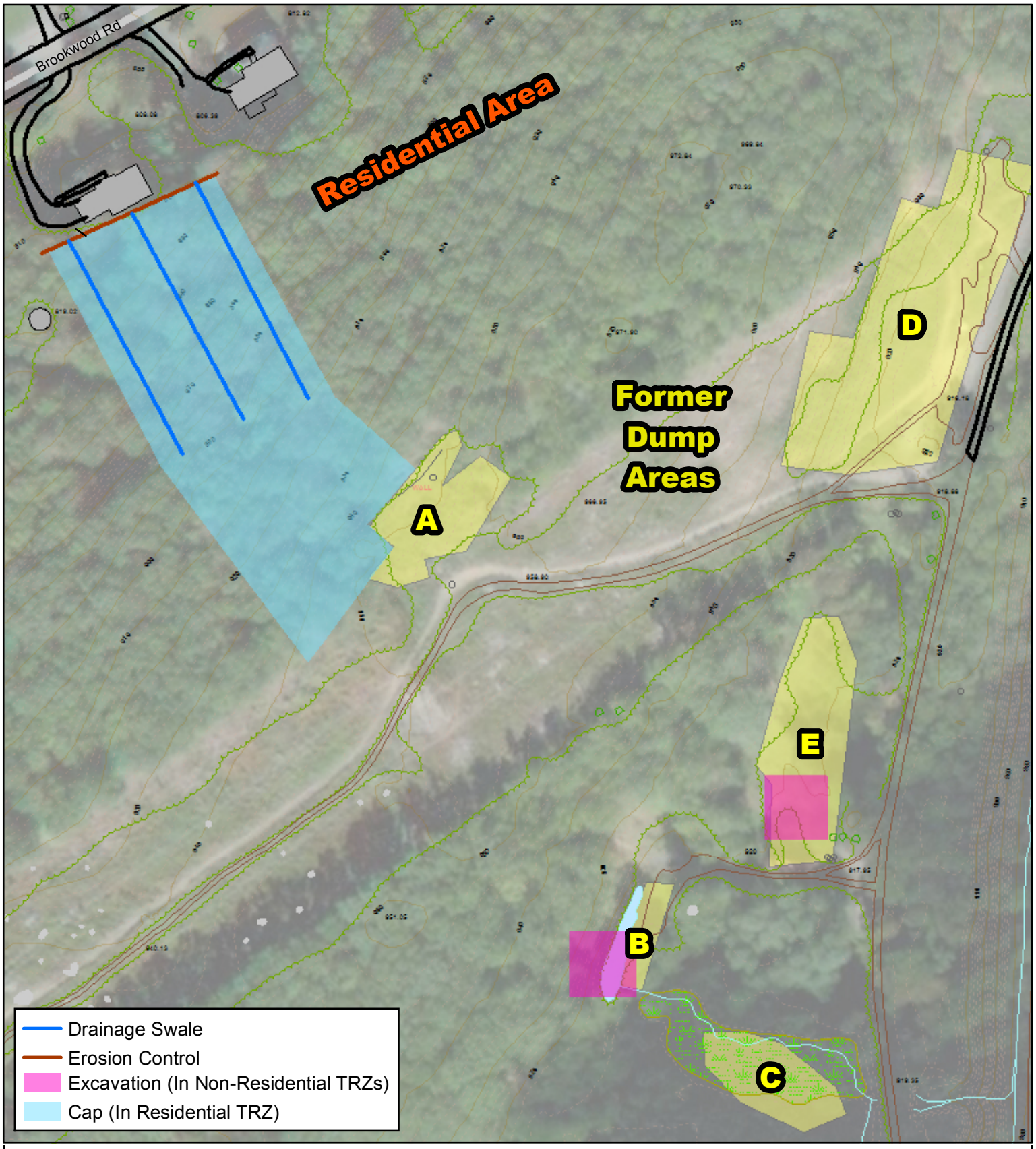
N

0 125 250 500 Feet

Figure 2-3
Groundwater Target Remediation Zones November 2017 - Round 2 Mansfield Trail Dump Site, OU2 Byram Township, NJ

CDM Smith

ButtonJS C:\IMS\GIS\Mansfield Trail Dump Site\MXD\070\RI\Draft RI\Figure_4-7_R2_BR_TCE_CIS.mxd 4/22/2018



Former Dump Areas

Notes

1. TRZ - Target Remediation Zone
2. The non-residential TRZs are not to scale and are assumed to be 20 ft by 20 ft areas. TRZ extents will be confirmed in a pre-design investigation.

Topographic Contours

50 ft Contours

5 ft Contours

N

0 50 100 200 Feet

Figure 3-1

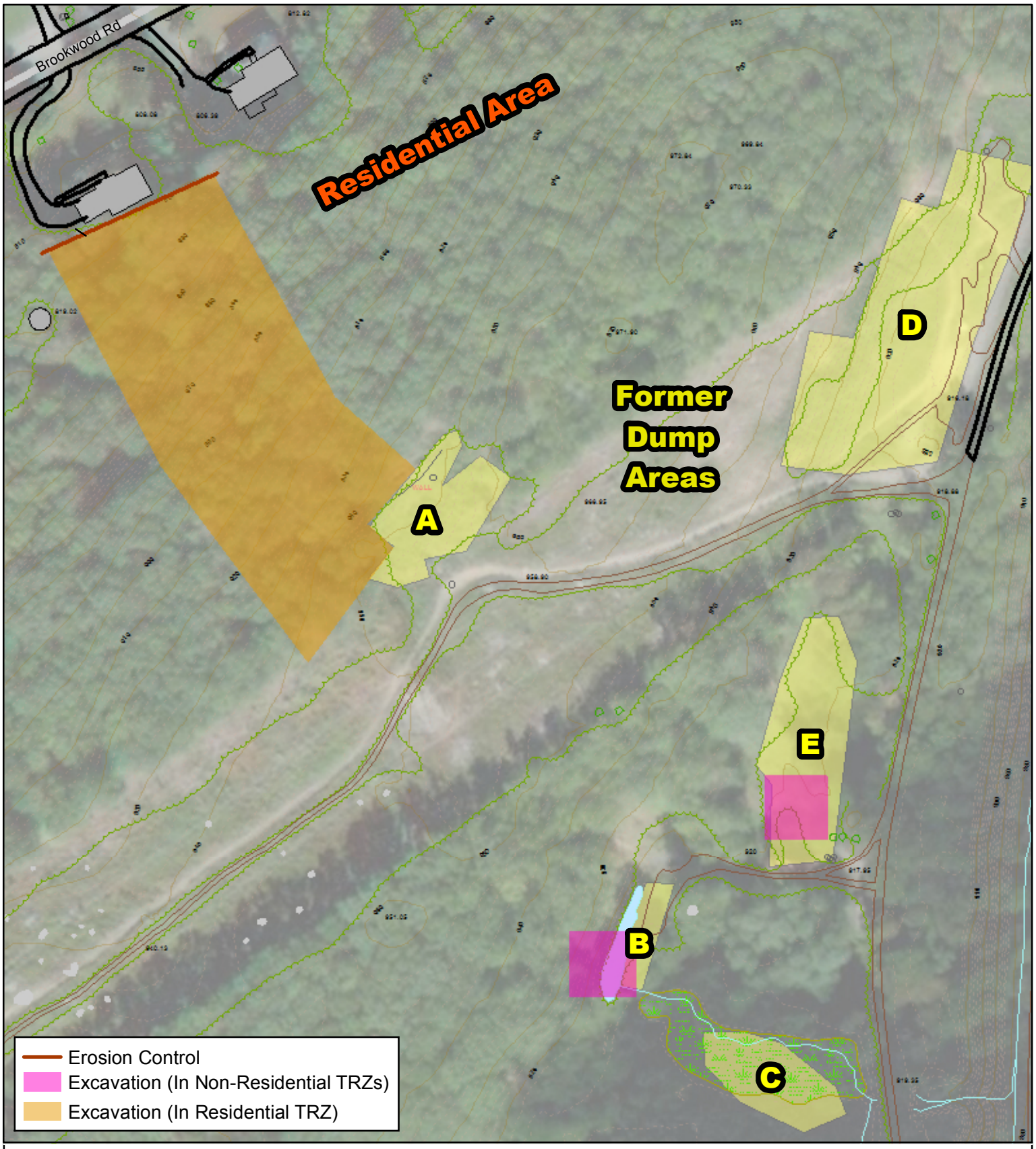
Alternative S-2 - Capping

Mansfield Trail Dump Site, OU2

Byram Township, NJ

CDM Smith

schlosserm N:\Mansfield Trail Dump Site\MXD\070\FS\Figure 3-1 Non-VOC Alternative 2.mxd 4/30/2019



Former Dump Areas

Topographic Contours

50 ft Contours

5 ft Contours

Notes

1. TRZ - Target Remediation Zone
2. The non-residential TRZs are not to scale and are assumed to be 20 ft by 20 ft areas. TRZ extents will be confirmed in a pre-design investigation.

N

0 50 100 200 Feet

Figure 3-2

Alternative S-3 - Excavation and Off-site Disposal
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

schlosserm N:\Mansfield Trail Dump Site\MXD\070\FS\Figure 3-2 Non-VOC Alternative 3.mxd 4/30/2019

Alternative GW-2 Notes:

1. **Cap**: For cost estimating purposes, the cap which covers Dump Areas A and D (46,000 square feet) is assumed to consist of multiple layers that may include a compacted clay layer, a geocomposite drainage blanket, and seeded top soil. The purpose of the multilayer cap is to prevent infiltration of rainwater into the vadose zone at the dump areas.
2. **MNA**: MNA would be conducted in the saturated zone of the source area and the distal plume.

Cowboy Creek Area

Residential Area

Former Dump Areas

Multilayer Cap

MLS-14-1 0.5 U
MLS-13-1 24
MLS-11-6 27
MLS-9-5 36
MLS-7-2 51
MLS-2-1 88
MLS-3-3 180
MLS-5-3 4.8
MLS-4-1 160
MW-15B 0.5 U
MLS-8-3 0.46 J
MLS-6-3 2.1
MLS-1-4 39
MW-16 0.5 U

A B C D E

10 4 10

Legend

- 1,4-Dioxane Concentration Isocontour (µg/L)
- Vinyl Chloride Concentration Isocontour (µg/L)
- TCE Concentration Isocontour (µg/L)
- TCE Concentration Isocontour (µg/L) (Inferred)
- Cap

- 2017 Monitoring Well
- 2017 MLS Well
- 2017 In-Creek Piezometer
- 2017 Overburden Piezometers
- Existing Monitoring Well
- Existing MLS Well
- Existing In-Creek Piezometer
- Former Dump Areas

MLS-1-P1 Monitoring Well
0.5 U TCE Concentration (µg/L)

Notes
1. Groundwater results are presented for the November 2017 sampling. The port with the highest concentration is presented.
2. Acronyms:
D - dilution
J- estimated value
MNA - monitored natural attenuation
TCE - Trichloroethene
U- non detect

N

0 125 250 500 Feet

Figure 3-3
Alternative GW-2 - Capping and MNA
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

schlosserm N:\Mansfield Trail Dump Site\MXD\070\FS\Alternative Figures\Figure_3-3_Alternative GW-2.mxd 5/23/2019

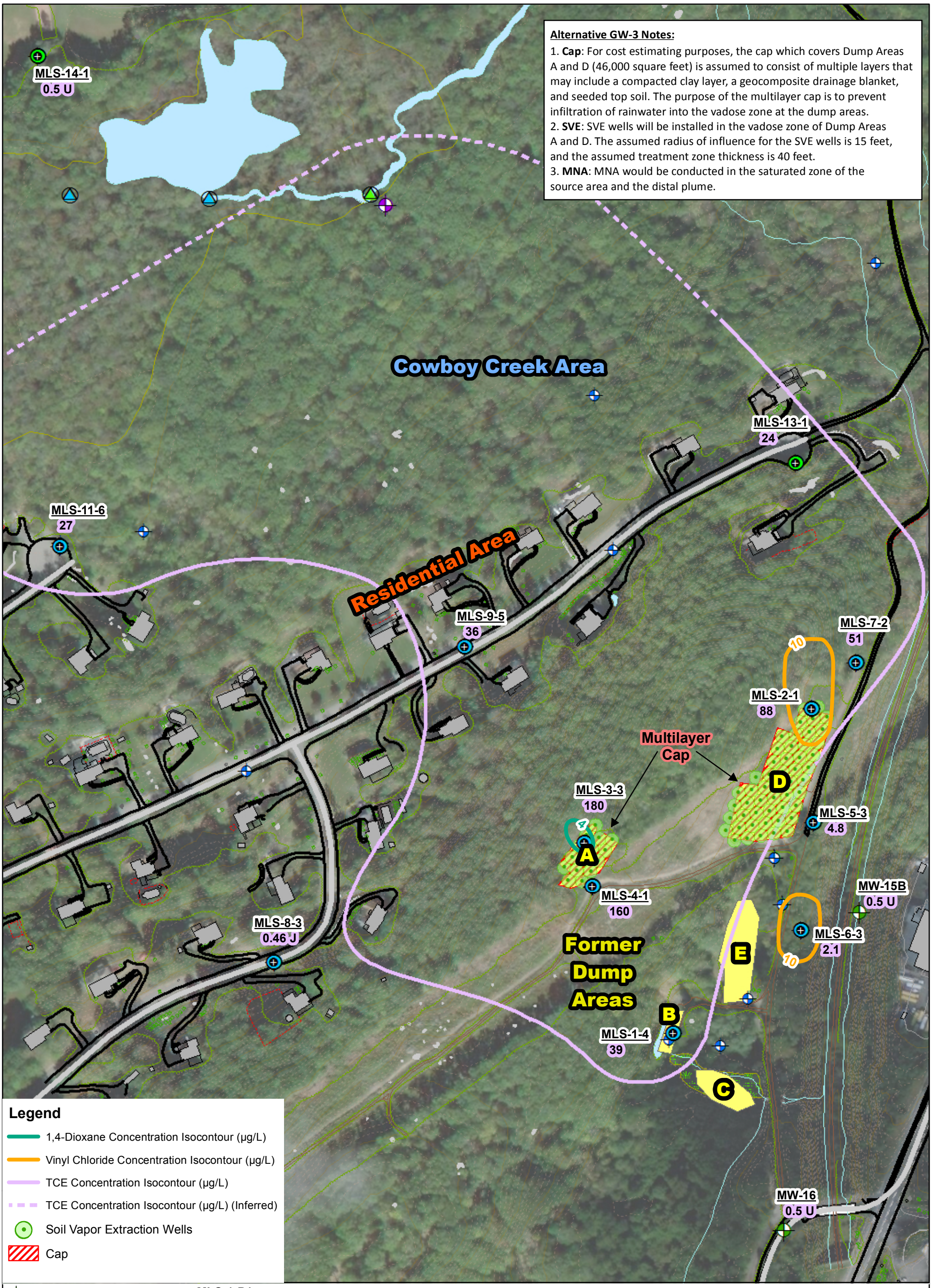
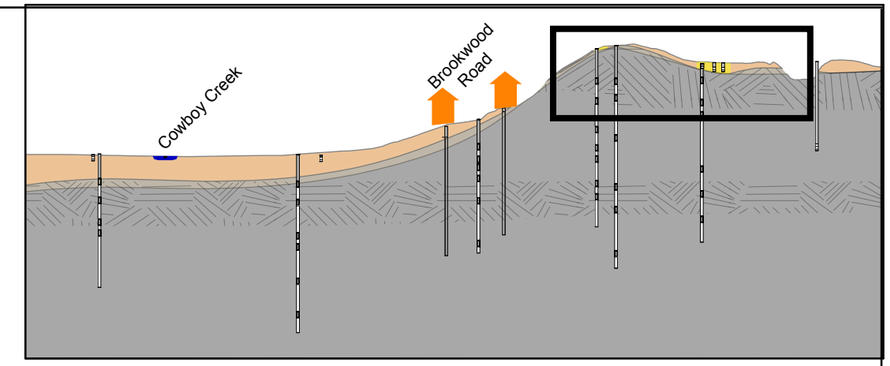
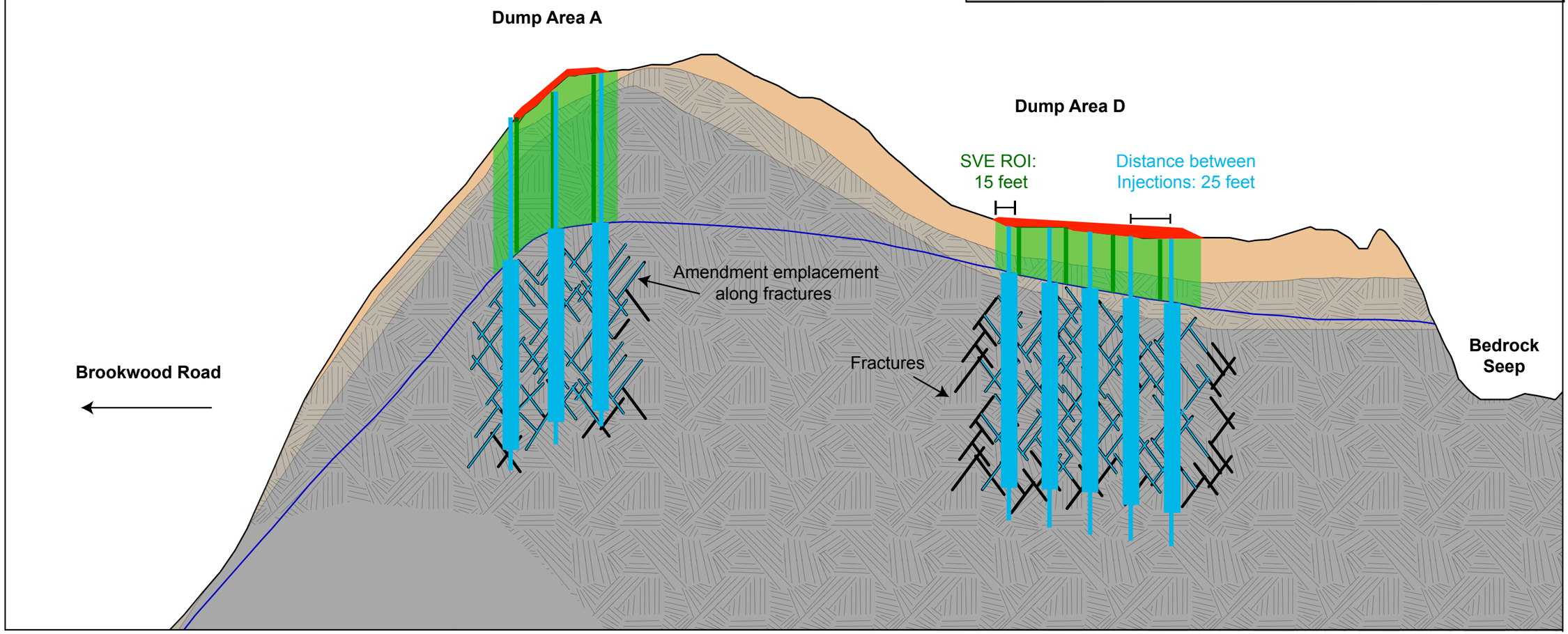


Figure 3-4
Alternative GW-3 - Capping, SVE, and MNA
Mansfield Trail Dump Site, OU2
Byram Township, NJ

schlosserm N:\Mansfield Trail Dump Site\MXD\070\FS\Alternative Figures\Figure_3-4_Alternative GW-3.mxd 5/23/2019

A combination colloidal activated carbon amendment and colloidal ZVI amendment would be injected into a 40-foot thickness of the saturated zone. It is assumed that amendment boreholes will be spaced approximately 25 feet apart, and amendment would be injected only one time. Amendment will preferentially target zones of mass flux in the fractured bedrock.





Overburden
Weathered Bedrock
Bedrock
Fractured/Transmissive Zone
Multilayer Cap
Shallow Potentiometric Surface
SVE Well and Radius of Influence
Amendment Injections

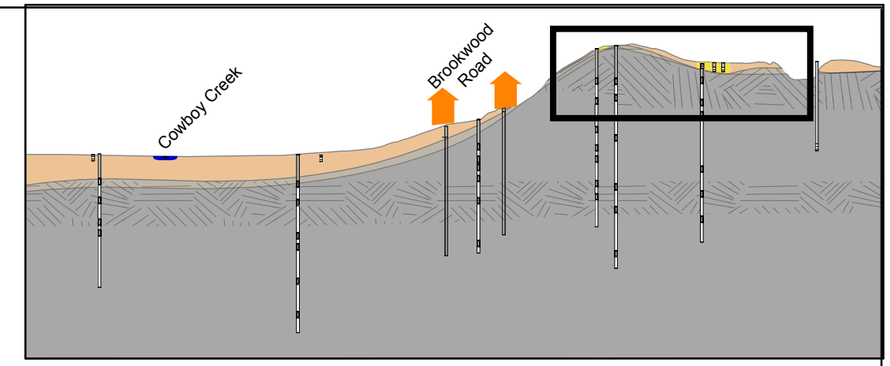
Acronyms:
MNA - monitored natural attenuation
ROI - radius of influence
SVE - soil vapor extraction
ZVI - zero valence iron

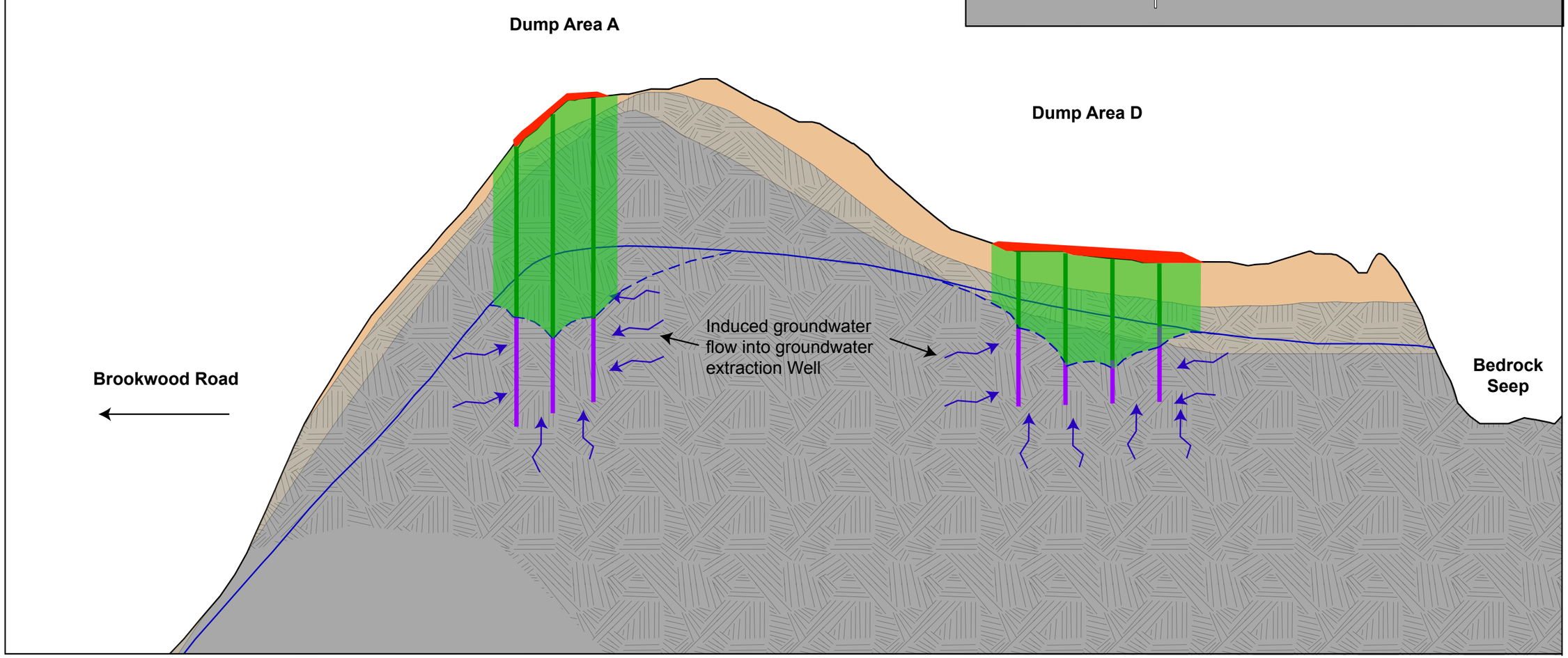
CDM Smith

Figure 3-5
Alternative GW-4
Capping, SVE, In Situ Treatment, and MNA
Mansfield Trail Dump Site, OU2
Byram Township, NJ

STANDARD CROSS SECTION: MANSFIELD MANSFIELD.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 4/10/18 REV.

Soil vapor and dual phase extraction wells will be installed in the vadose zone of Dump Areas A and D. The assumed radius of influence for the SVE wells is 15 feet. It is assumed that half of the SVE well locations will be converted to dual phase extraction wells. Extracted soil vapor and extracted groundwater would travel through aboveground piping networks and be treated in separate treatment systems.





Overburden
Weathered Bedrock
Bedrock
Fractured/Transmissive Zone
SVE Well and Radius of Influence
Multilayer Cap
Current Shallow Potentiometric Surface
Groundwater Extraction Well
Estimated Cone of Depression
Groundwater Flow

Acronyms:
DPE - dual phase extraction
MNA - monitored natural attenuation
SVE - soil vapor extraction

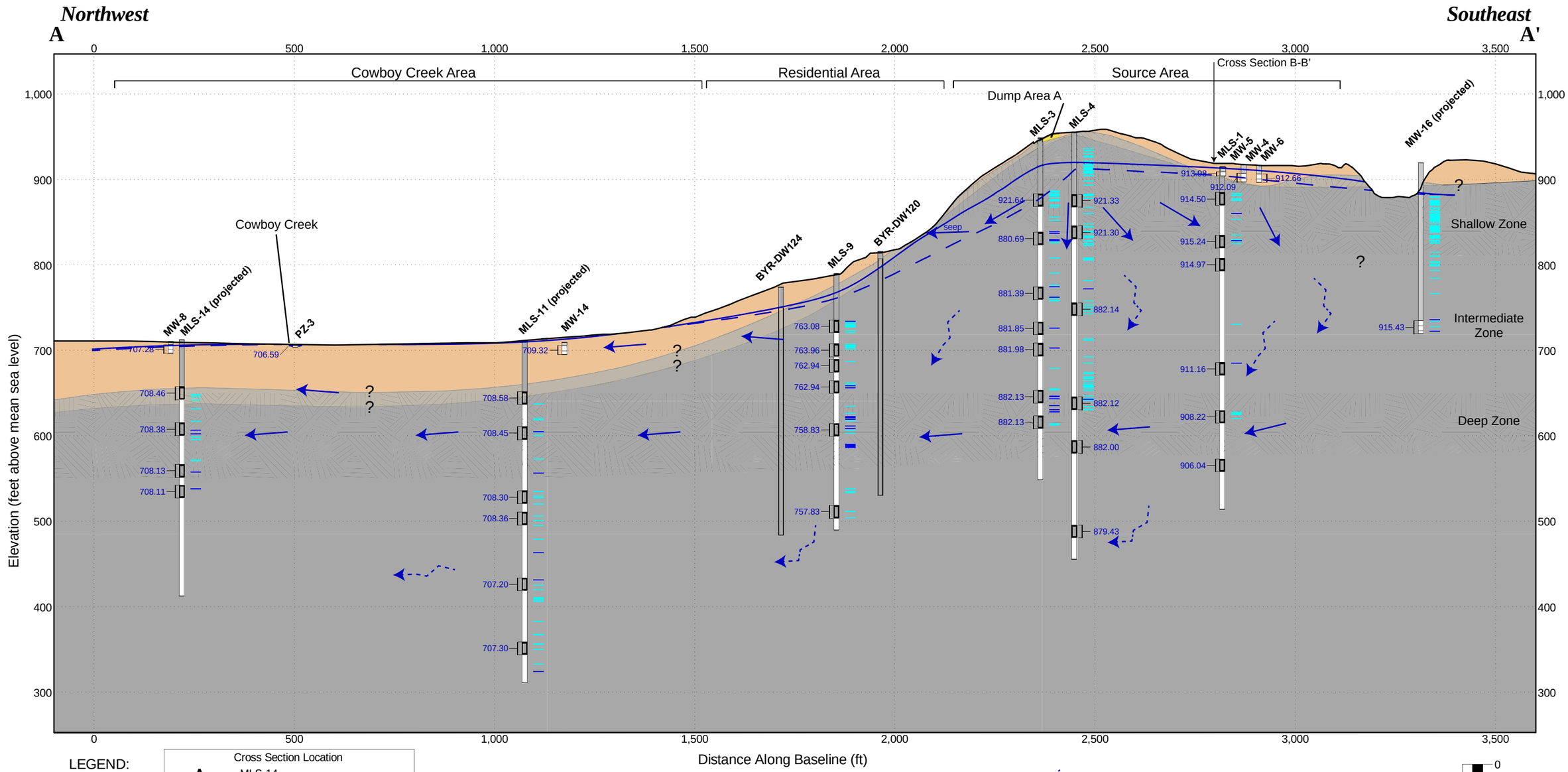
CDM Smith

Figure 3-6
Alternative GW-5 - Capping, DPE, and MNA
Mansfield Trail Dump Site, OU2
Byram Township, NJ

STANDARD CROSS SECTION: MANSFIELD MANSFIELD.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 4/10/18 REV.

Appendix A

Selected Figures from the Remedial Investigation and Step 3a



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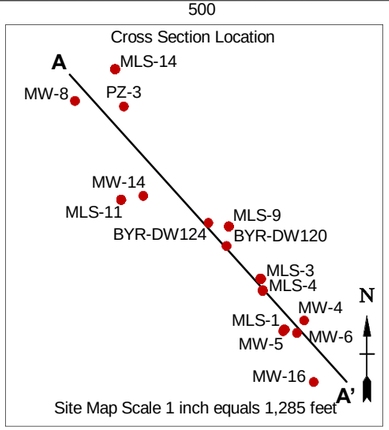


- Overburden
- Weathered Bedrock
- Bedrock
- Fractured/Transmissive Zone
- ? Contact is inferred
- Casing
- Screened Interval
- Open Borehole
- Transmissive Fracture (Category 1)
- Potentially Transmissive Fracture (Category 2)

*transmissive fractures are represented as 1-foot vertical intervals for clarity

- FLUTe Liner
- FLUTe Sampling Port
- Fracture flow through competent bedrock and down dip
- Fracture flow through transmissive bedrock zones
- 708.13 Water Level Elevation (1/2018)
- Shallow Potentiometric Surface (01/2018)
- Shallow Potentiometric Surface (12/2015)

*prepared using shallowest multilevel port water level elevations and overburden well water level elevations

Horizontal Scale (feet): 0 – 250

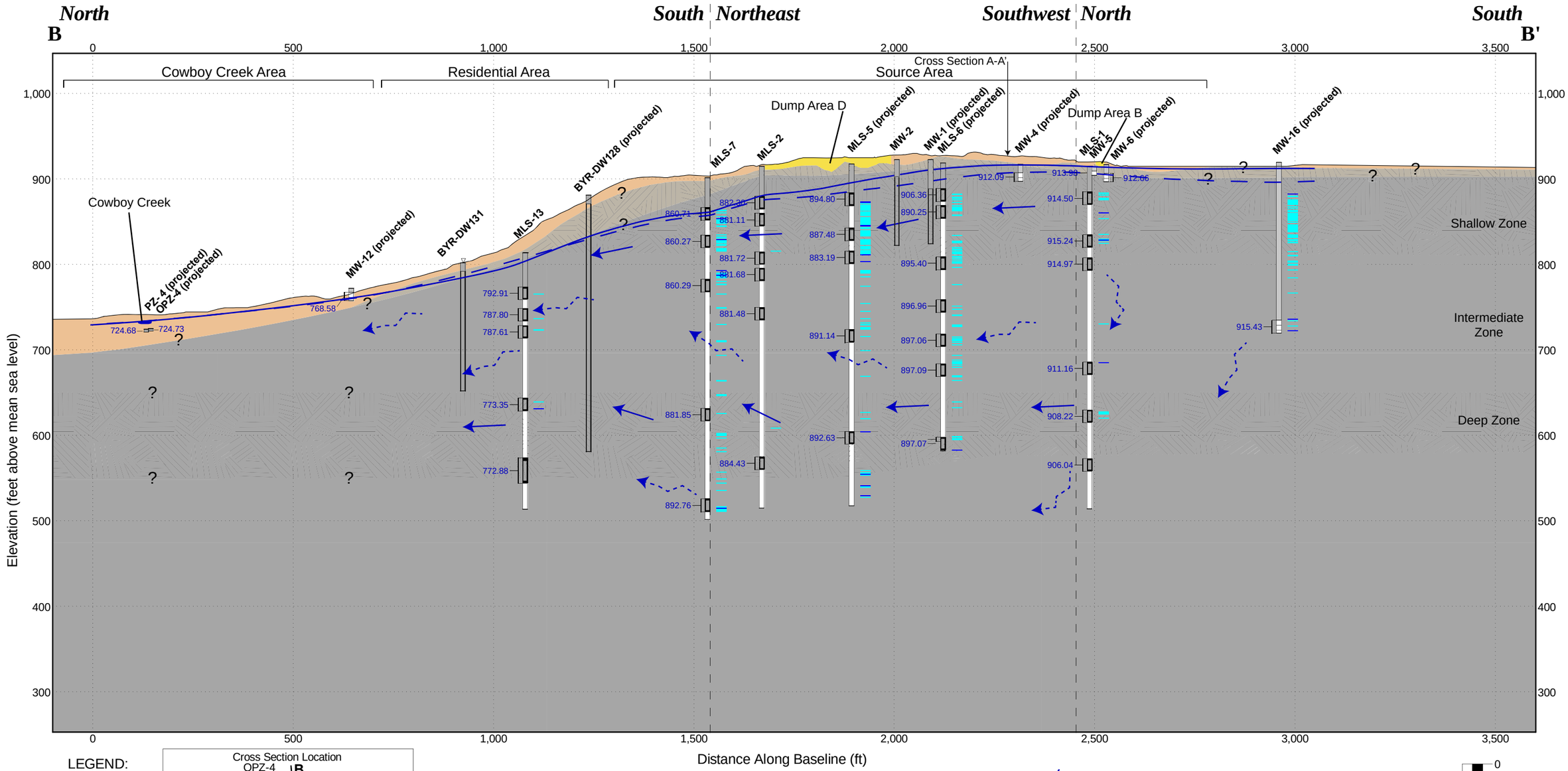
Vertical Exaggeration: 2x

Vertical Scale (feet): 0 – 120

CDM Smith

Figure 3-5a
Geologic Cross Section A-A'
Mansfield Trail Dump Site, OU2
Byram Township, NJ

STANDARD CROSS SECTION: MANSFIELD MANSFIELD.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 4/10/18 REV.



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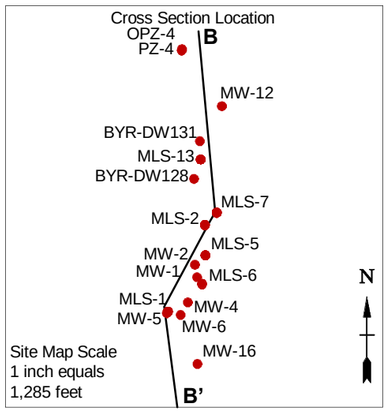


- Overburden
- Weathered Bedrock
- Bedrock
- Fractured/Transmissive Zone
- ? Contact is inferred
- Casing
- Screened Interval
- Open Borehole
- Transmissive Fracture (Category 1)
- Potentially Transmissive Fracture (Category 2)

*transmissive fractures are represented as 1-foot vertical intervals for clarity

- FLUTe Liner
- FLUTe Sampling Port
- Fracture flow through competent bedrock and along strike
- Fracture flow through transmissive bedrock zones

708.13 Water Level Elevation (1/2018)

Shallow Potentiometric Surface (01/2018)

Shallow Potentiometric Surface (12/2015)

*prepared using shallowest multilevel port water level elevations and overburden well water level elevations

0 250 Horizontal Scale (feet)

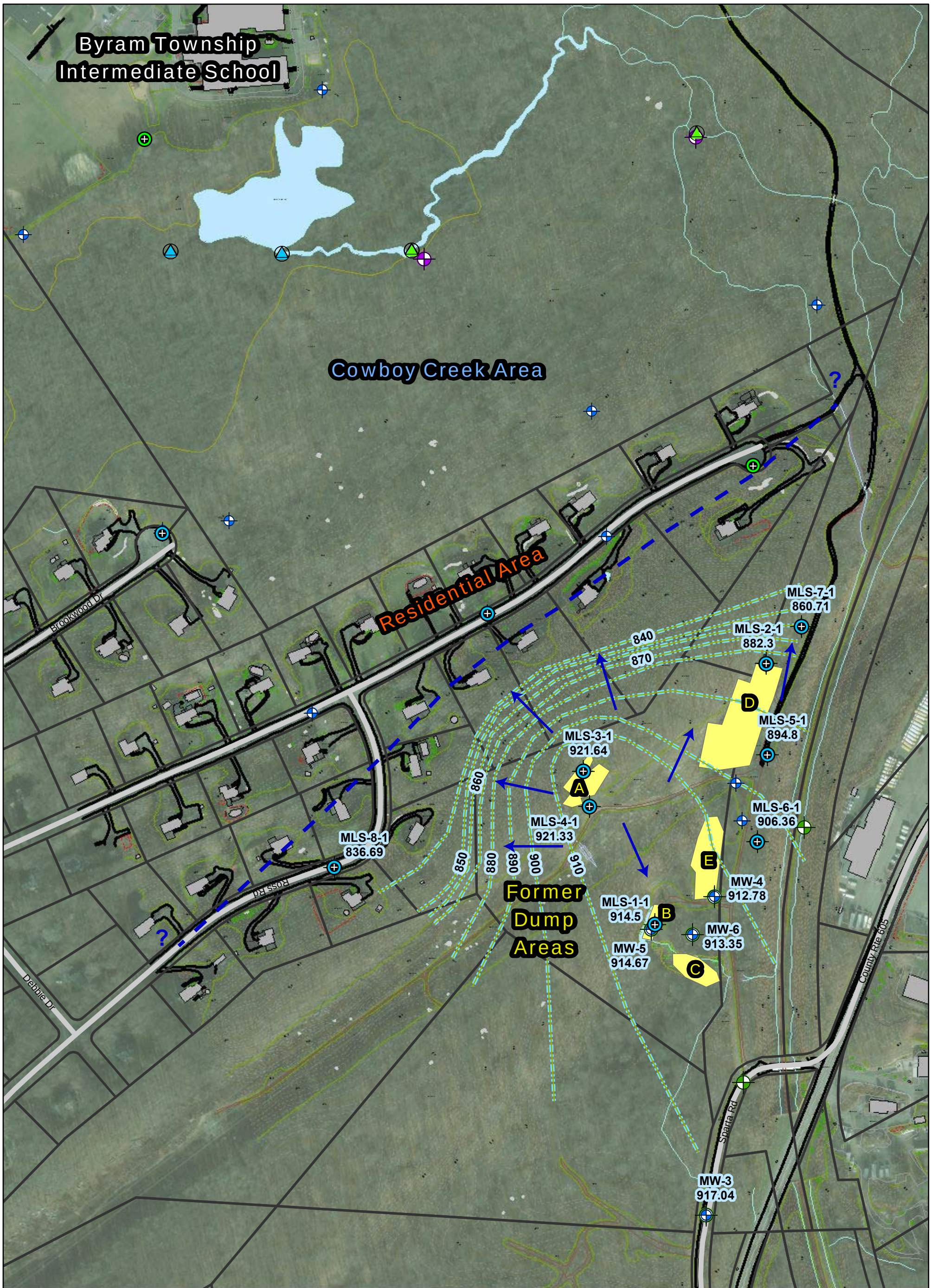
Vertical Exaggeration: 2x

0 120 Vertical Scale (feet)

CDM Smith

Figure 3-5b
Geologic Cross Section B-B'
Mansfield Trail Dump Site, OU2
Byram Township, NJ

STANDARD CROSS SECTION: MANSFIELD MANSFIELD.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 4/12/18 REV.



2017 Monitoring Well
2017 MLS Well
2017 In-Creek Piezometer
2017 Overburden Piezometers
Existing Monitoring Well
Existing MLS Well
Existing In-Creek Piezometer
Tax Parcels
Former Dump Areas

MW-5 Monitoring Well
356.11 Water level (ft above amsl)

Potentiometric Surface Contour (feet amsl)

Approximate Groundwater Flow Direction

Approximate Extent of Shallow Zone

Notes
1. Groundwater levels are presented from January 2018.
2. Acronyms:
amsl - above mean sea level

N

0 125 250 500 Feet

Figure 3-8
Shallow Bedrock Groundwater Flow (Source Zone)
January 2018
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

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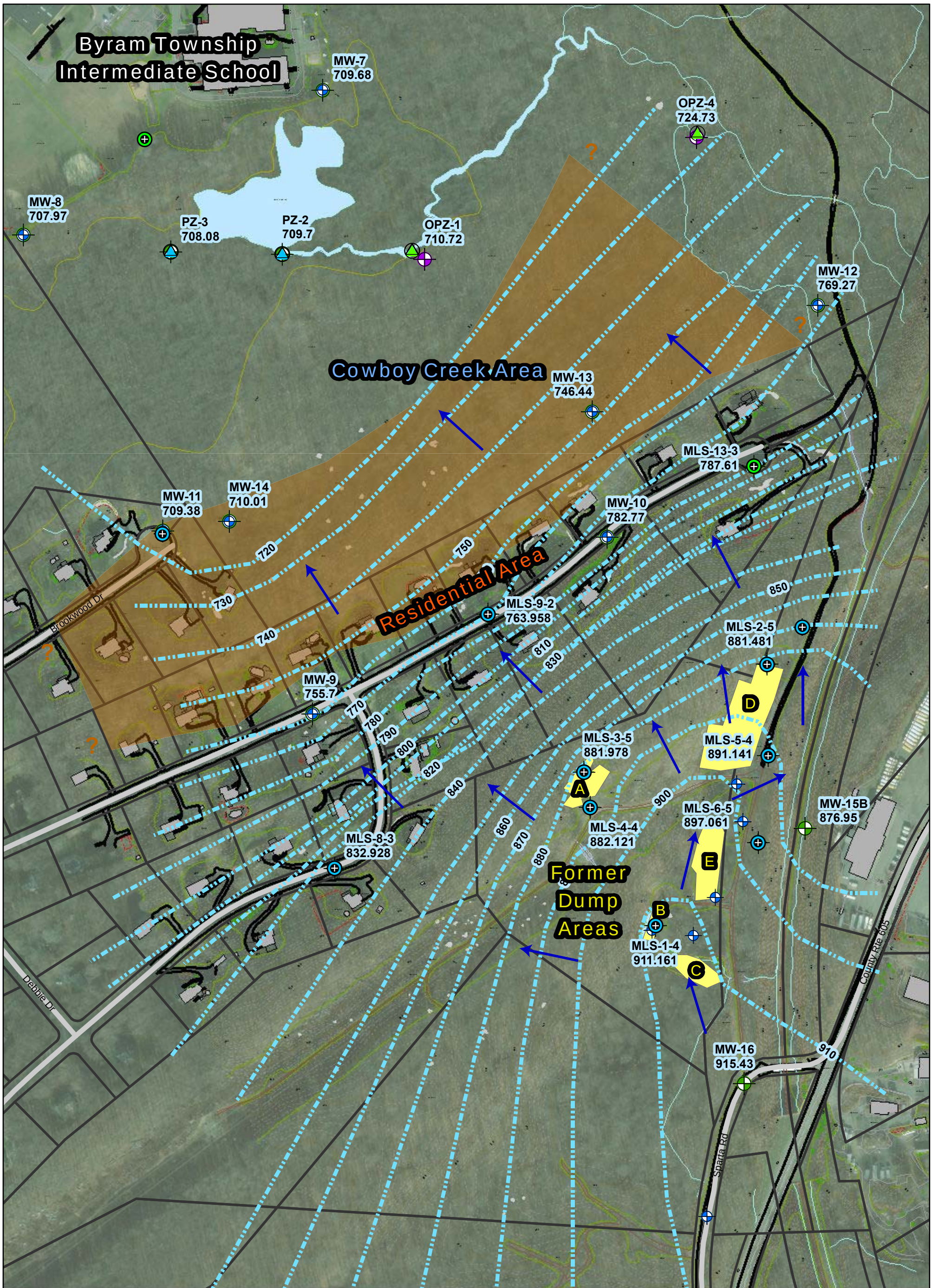


2017 Monitoring Well
2017 MLS Well
2017 In-Creek Piezometer
2017 Overburden Piezometers
Existing Monitoring Well
Existing MLS Well
Existing In-Creek Piezometer
Tax Parcels
Former Dump Areas

MW-5 Monitoring Well
356.11 Water level (ft above amsl)

Potentiometric Surface Contour (feet amsl)

Approximate Groundwater Flow Direction

Approximate Interface of Intermediate Groundwater Flow System Entering Overburden

Notes
1. Groundwater levels are presented from January 2018.
2. Acronyms:
amsl - above mean sea level

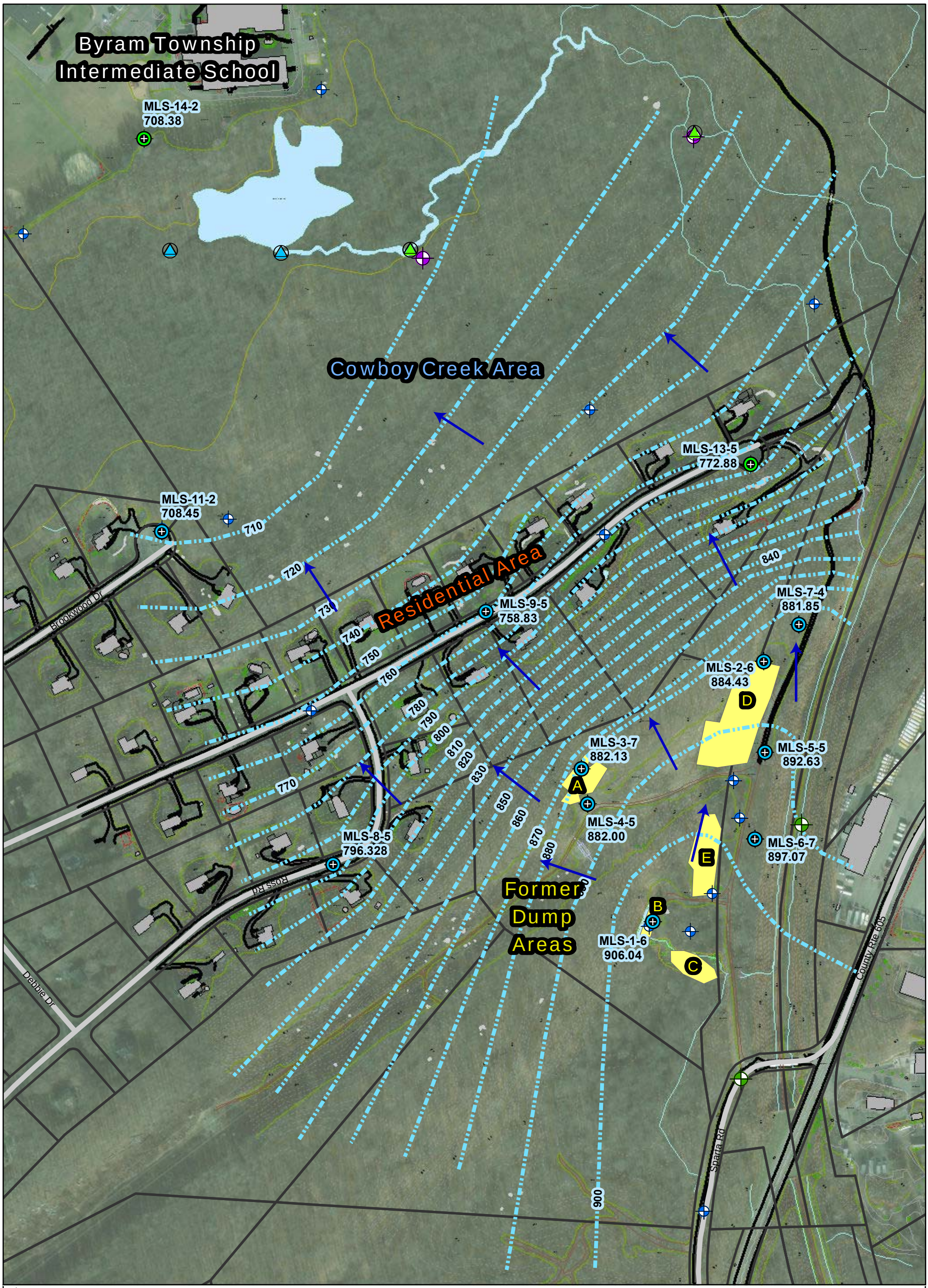
N

0 125 250 500 Feet

Figure 3-9
Intermediate Groundwater Flow System
January 2018
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

ButtonJS C:\IMS\GIS\Mansfield Trail Dump Site\MXD\070\RI\Draft RI\Figure_3-9_IntGWFlow.mxd 4/26/2018



2017 Monitoring Well
2017 MLS Well
2017 In-Creek Piezometer
2017 Overburden Piezometers
Existing Monitoring Well
Existing MLS Well
Existing In-Creek Piezometer
Tax Parcels
Former Dump Areas

MW-5 Monitoring Well
356.11 Water level (ft above amsl)

Potentiometric Surface Contour (feet amsl)

Approximate Groundwater Flow Direction

Notes
1. Groundwater levels are presented from January 2018.
2. Acronyms:
amsl - above mean sea level

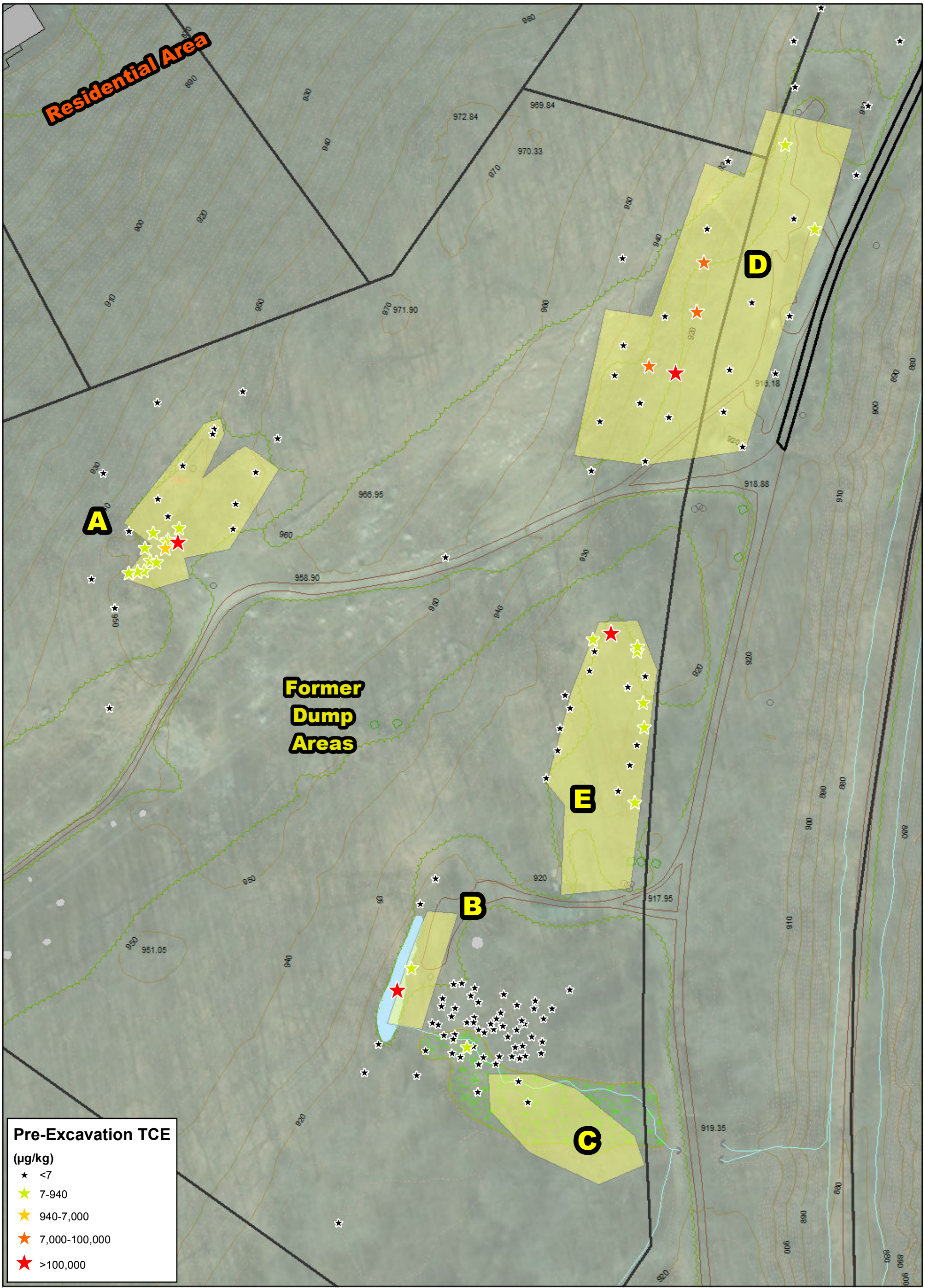
N

0 125 250 500 Feet

Figure 3-10
Deep Bedrock Groundwater Flow
January 2018
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

ButtonJS C:\IMS\GIS\Mansfield Trail Dump Site\MXD\070\RI\Draft RI\Figure_3-10_DeepBRFLOW.mxd 4/26/2018



Former Dump Areas

Tax Parcels

Topographic Contours

50 ft Contours

5 ft Contours

Soil Screening Criteria

EPA RSL - 940 µg/kg (Human Health)

NJDEP RSDCSC - 7,000 µg/kg (Human Health)

NJ IGW - 7 µg/kg (Eco)

Notes

1. Soil sampling results are presented for sampling events performed prior to or during the removal actions in 2012.
2. Data is color coded by concentration groups to represent various screening criteria and to assist in presenting where contamination is present.

N

0 37.5 75 150 Feet

Figure 4-1a

TCE in Former Dump Area Soils (Pre-Excavation)

Mansfield Trail Dump Site, OU2

Byram Township, NJ

CDM Smith

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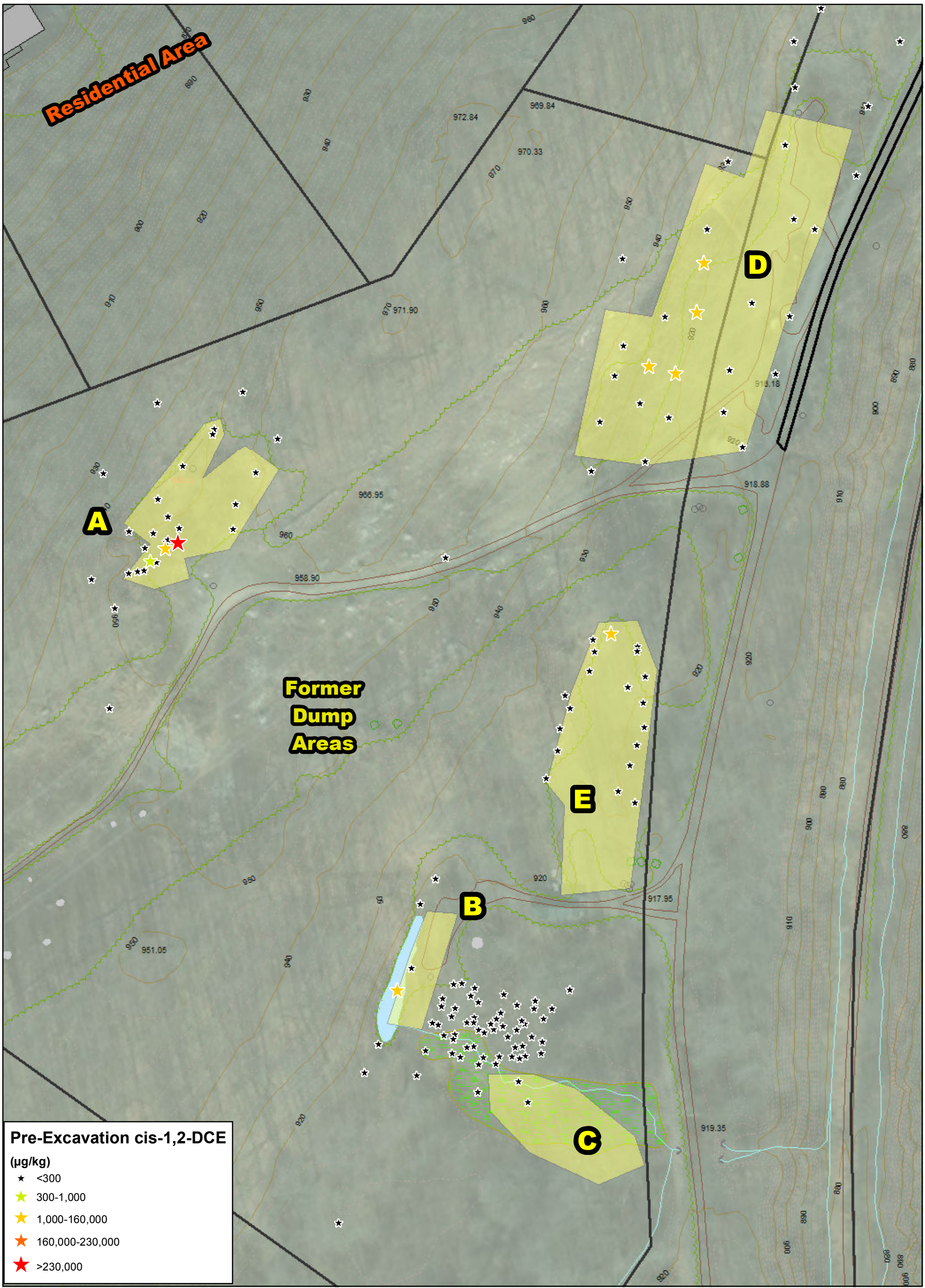


Former Dump Areas

Tax Parcels

Topographic Contours

50 ft Contours

5 ft Contours

Soil Screening Criteria

NJ IGW - 300 µg/kg

EPA RSL - 160,000 µg/kg (Human Health)

NJDEP RSDCSC - 230,000 µg/kg (Human Health)

Notes

1. Soil sampling results are presented for sampling events performed prior to or during the removal actions in 2012.
2. Data is color coded by concentration groups to represent various screening criteria and to assist in presenting where contamination is present.

N

0 37.5 75 150 Feet

Figure 4-1b

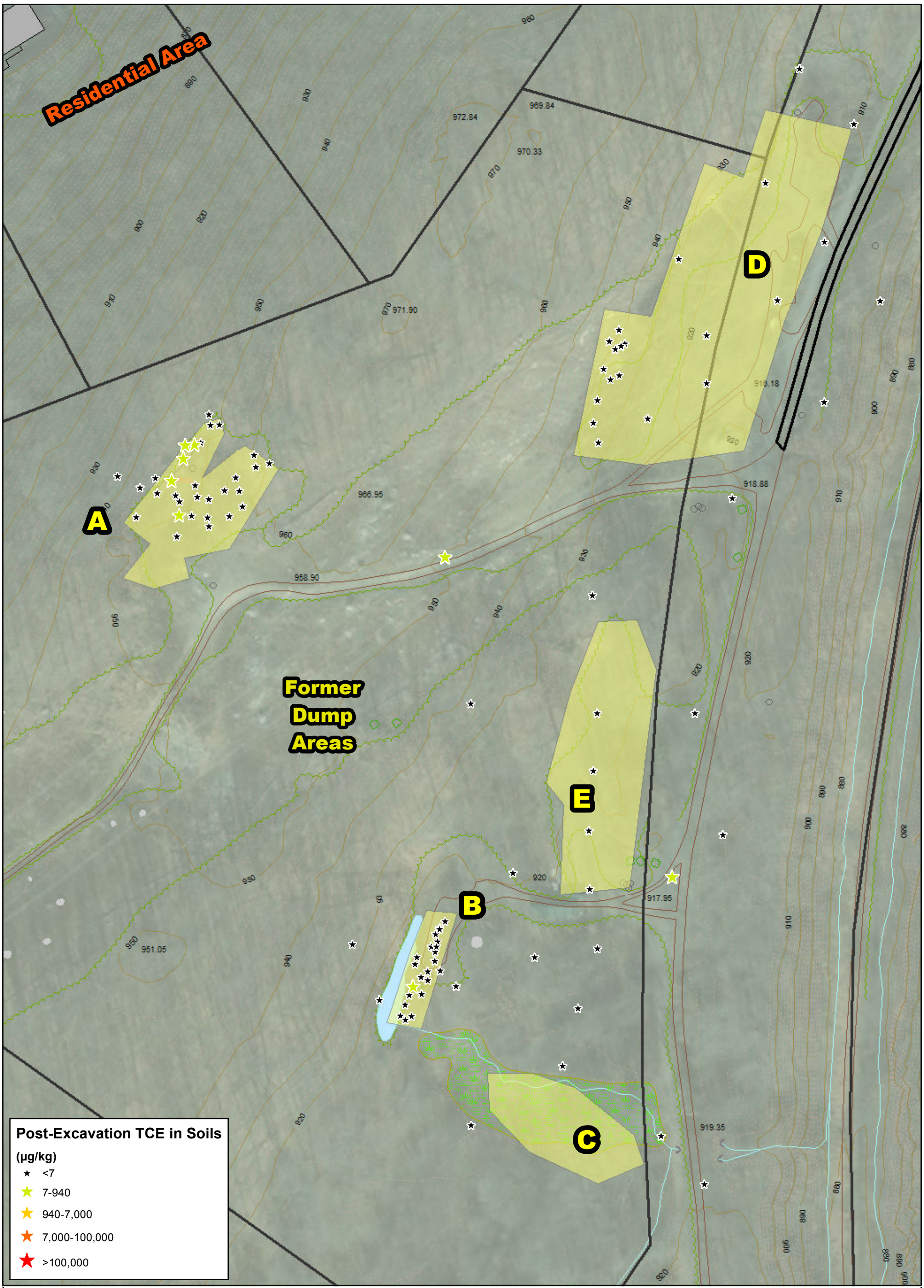
cis-1,2-DCE in Former Dump Area Soils (Pre-Excavation)

Mansfield Trail Dump Site, OU2

Byram Township, NJ

CDM Smith

ButtonJS C:\IMS\GIS\Mansfield Trail Dump Site\MXD\070\RI\Draft RI\Fig_4-1b_Pre_ex_CIS.mxd 4/22/2018



Former Dump Areas

Tax Parcels

Topographic Contours

50 ft Contours

5 ft Contours

Soil Screening Criteria

EPA RSL - 940 ug/kg (Human Health)

NJDEP RSDCSC - 7,000 ug/kg (Human Health)

NJ IGW - 7 ug/kg (Eco)

Notes

1. Soil sampling results are presented for sampling events performed following the removal actions in 2012.
2. Data is color coded by concentration groups to represent various screening criteria and to assist in presenting where contamination is present.

N

0 37.5 75 150 Feet

Figure 4-5a

TCE in Former Dump Area Soils (Post-Excavation)

Mansfield Trail Dump Site, OU2

Byram Township, NJ

CDM Smith

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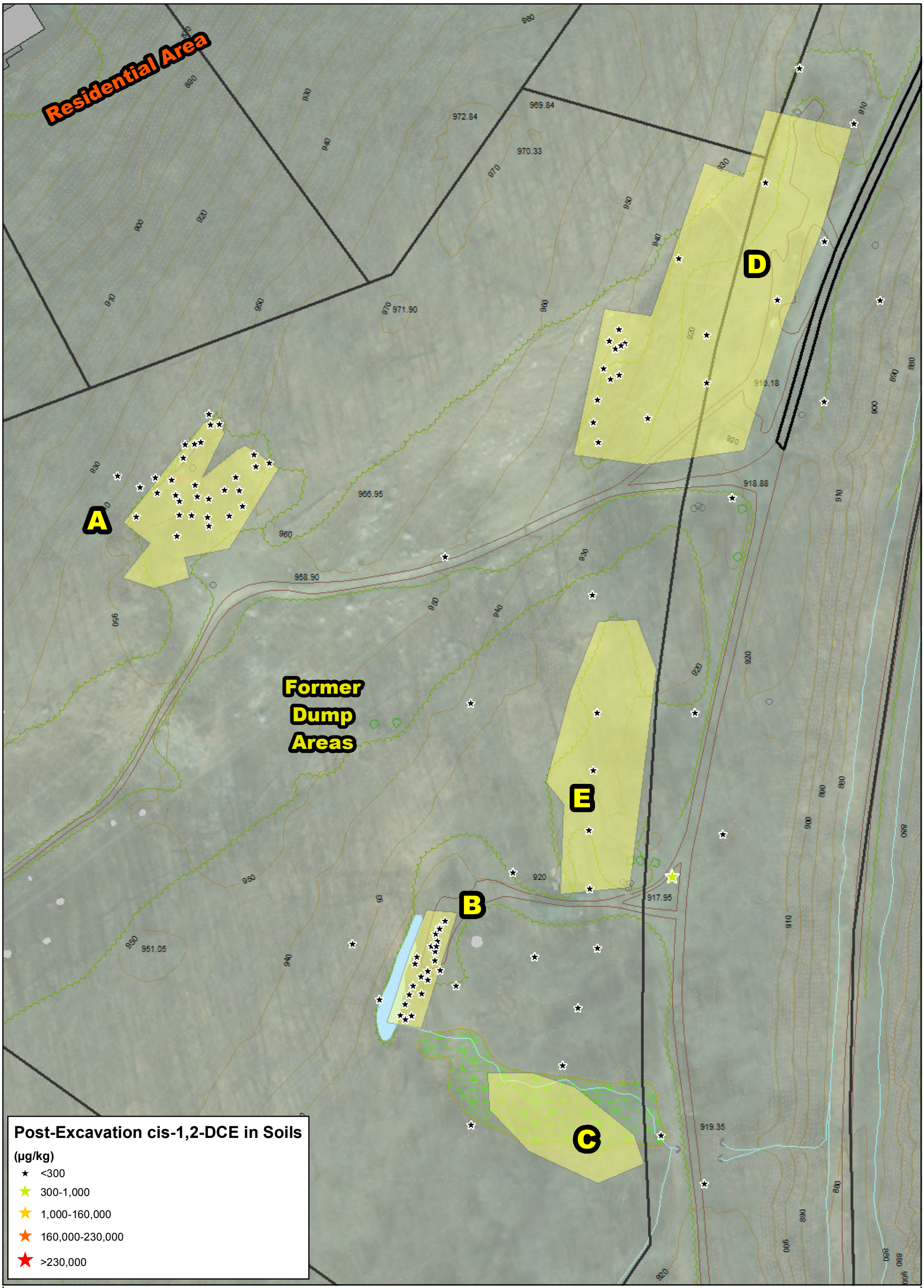

Former Dump Areas
Tax Parcels
Topographic Contours
50 ft Contours
5 ft Contours

Soil Screening Criteria
NJ IGW - 300 µg/kg
EPA RSL - 160,000 µg/kg (Human Health)
NJDEP RSDCSC - 230,000 µg/kg (Human Health)

Notes
1. Soil sampling results are presented for sampling events performed after the removal actions in 2012.
2. Data is color coded by concentration groups to represent various screening criteria and to assist in presenting where contamination is present.

N

0 37.5 75 150 Feet

Figure 4-5b
cis-1,2-DCE in Former Dump Area Soils (Post-Excavation)
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

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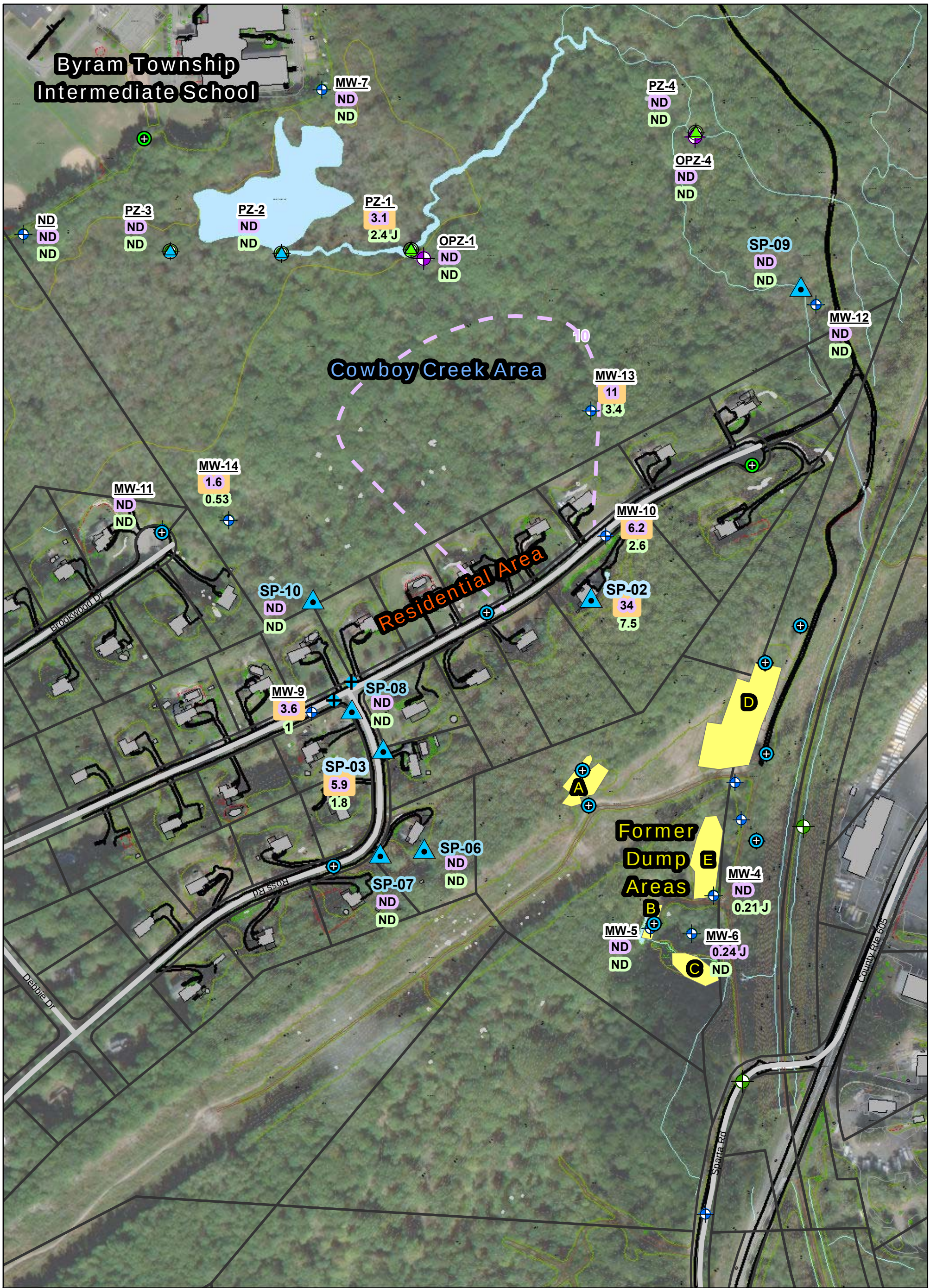

2017 Monitoring Well
2017 MLS Well
2017 In-Creek Piezometer
2017 Overburden Piezometers
Existing Monitoring Well
Existing MLS Well
Existing In-Creek Piezometer
Seep and Surface Soil
Catch Basin Water

Tax Parcels
Former Dump Areas

MW-X
ND
ND
Monitoring Well
TCE Concentration (ug/l)
cis-1,2-DCE Concentration (ug/L)

Notes
1. Groundwater results are presented for the November 2017 sampling.
2. Seep results (in blue) are presented for the 2017 sampling round.
3. Exceedances of the RI screening criteria are highlighted orange.
4. Acronyms:
J - estimated value
ND - non detect
TCE - Trichloroethene

TCE concentration isocontour (ug/L)

N

0 125 250 500 Feet

Figure 4-6
TCE and CIS-1,2-DCE in Overburden Groundwater
November 2017 (Round 2)
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

ButtonJS C:\IMS\GIS\Mansfield Trail Dump Site\MXD\070\RI\Draft RI\Figure_4-6_R2_OB_TCE_CIS_AR_REQ.mxd 6/11/2018

2017 Monitoring Well
2017 MLS Well
2017 In-Creek Piezometer
2017 Overburden Piezometers
Existing Monitoring Well
Existing MLS Well
Existing In-Creek Piezometer
Tax Parcels
Former Dump Areas

MLS-1-P1 Monitoring Well
ND TCE Concentration (ug/l)
ND cis-1,2-DCE Concentration (ug/L)

Notes
1. Groundwater results are presented for the November 2017 sampling. The port with the highest concentration is presented.
2. Exceedances of RI screening criteria are highlighted orange.
3. Acronyms:
D - dilution
J - estimated value
ND - non detect
TCE - Trichloroethene

N

0 125 250 500 Feet

Figure 4-7
TCE and cis-1,2-DCE in Bedrock Groundwater
November 2017 (Round 2)
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

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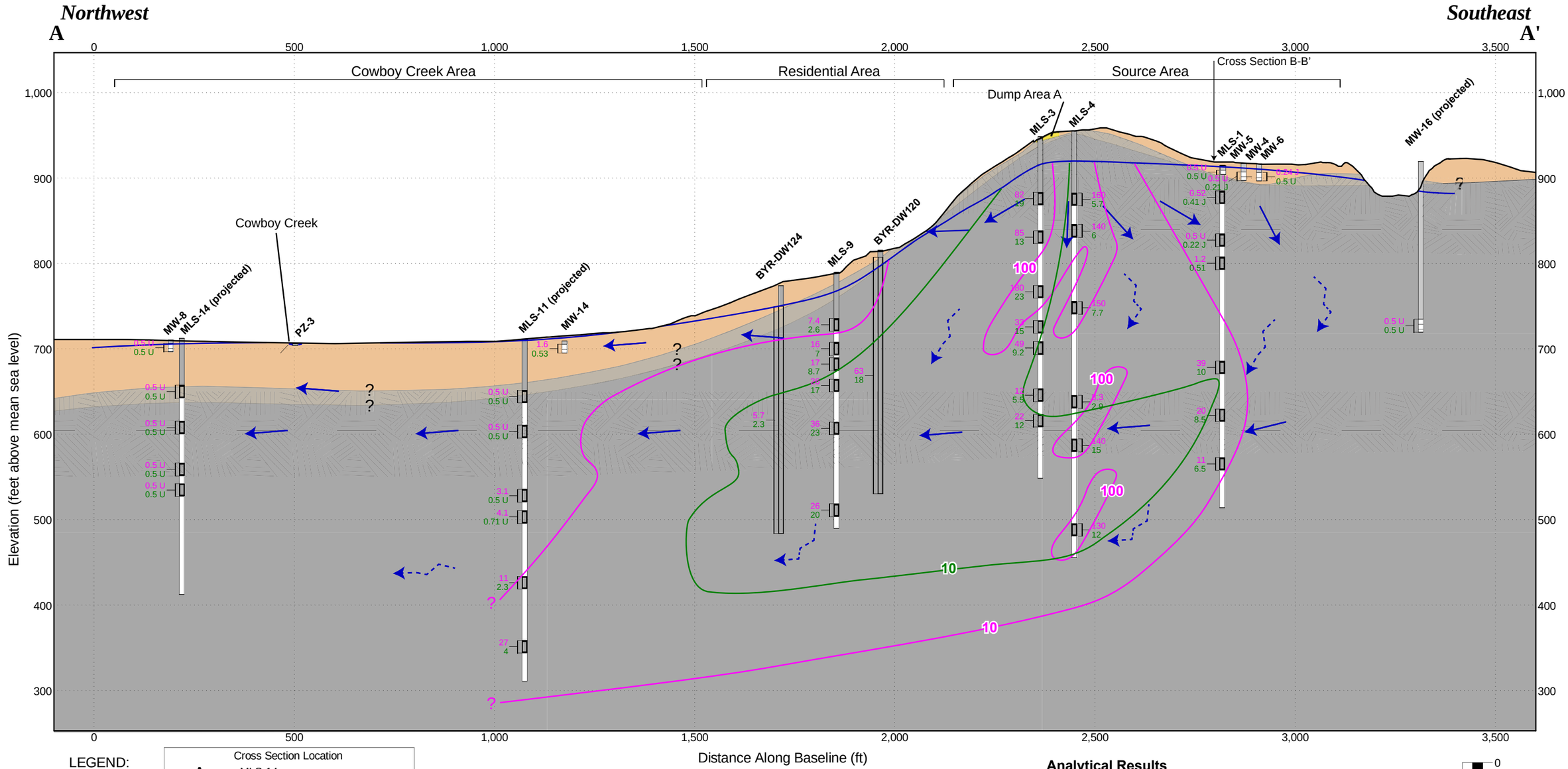
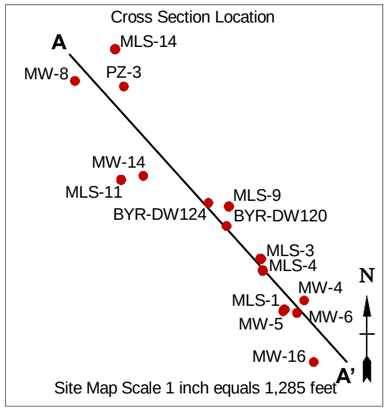


LEGEND:

Fracture flow through competent bedrock and down dip

Fracture flow through transmissive bedrock zones



Overburden

Weathered Bedrock

Bedrock

Fractured/Tranmissive Zone

? Contact is inferred

Casing

Screened Interval

Open Borehole

Sample Interval

FLUTe Liner

FLUTe Sampling Port

TCE approximate groundwater contamination extent (dashed where inferred)

cis-1,2-DCE approximate groundwater contamination extent (dashed where inferred)

Shallow Potentiometric Surface (01/2018)

Analytical Results
Trichlorothene (TCE)
cis-1,2-Dichloroethene (cis-1,2-DCE)
All results in micrograms per liter
U - not detected, detection limit is value to left
J - estimated concentration
NC - not collected

*Residential well data collected 10/2017

0 250
Horizontal Scale (feet)

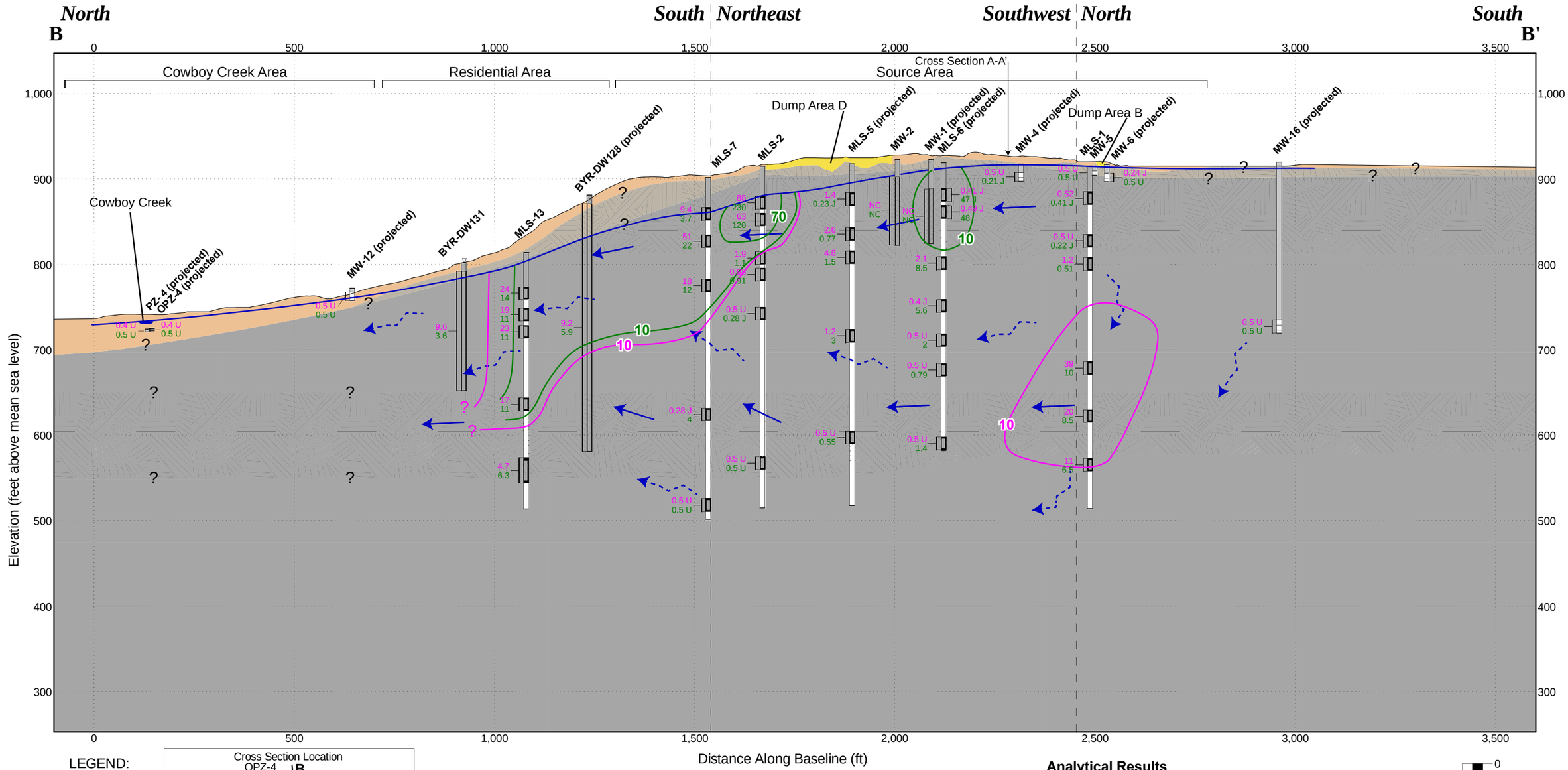
0 120
Vertical Scale (feet)

Vertical Exaggeration: 2x

CDM Smith

Figure 4-8
Cross Section A-A'
TCE and cis-1,2-DCE in Groundwater
November 2017 - Round 2
Mansfield Trail Dump Site, OU2
Byram Township, NJ

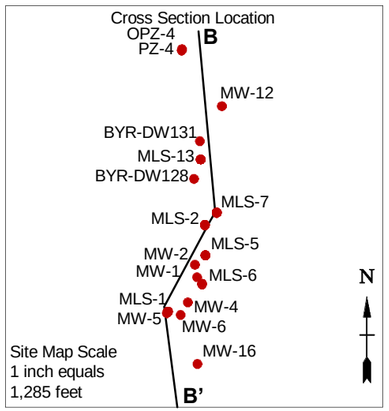
STANDARD CROSS SECTION: MANSFIELD MANSFIELD.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 4/10/18 REV.



LEGEND:

Fracture flow through competent bedrock and along strike

Fracture flow through transmissive bedrock zones



Overburden

Weathered Bedrock

Bedrock

Fractured/Transmissive Zone

? Contact is inferred

Casing

Screened Interval

Open Borehole

Sample Interval

FLUTe Liner

FLUTe Sampling Port

TCE approximate groundwater contamination extent (dashed where inferred)

cis-1,2-DCE approximate groundwater contamination extent (dashed where inferred)

Shallow Potentiometric Surface (01/2018)

*Residential well data collected 10/2017

Analytical Results
Trichlorothene (TCE)
cis-1,2-Dichloroethene (cis-1,2-DCE)
All results in micrograms per liter
U - not detected, detection limit is value to left
J - estimated concentration
NC - not collected

0 250
Horizontal Scale (feet)

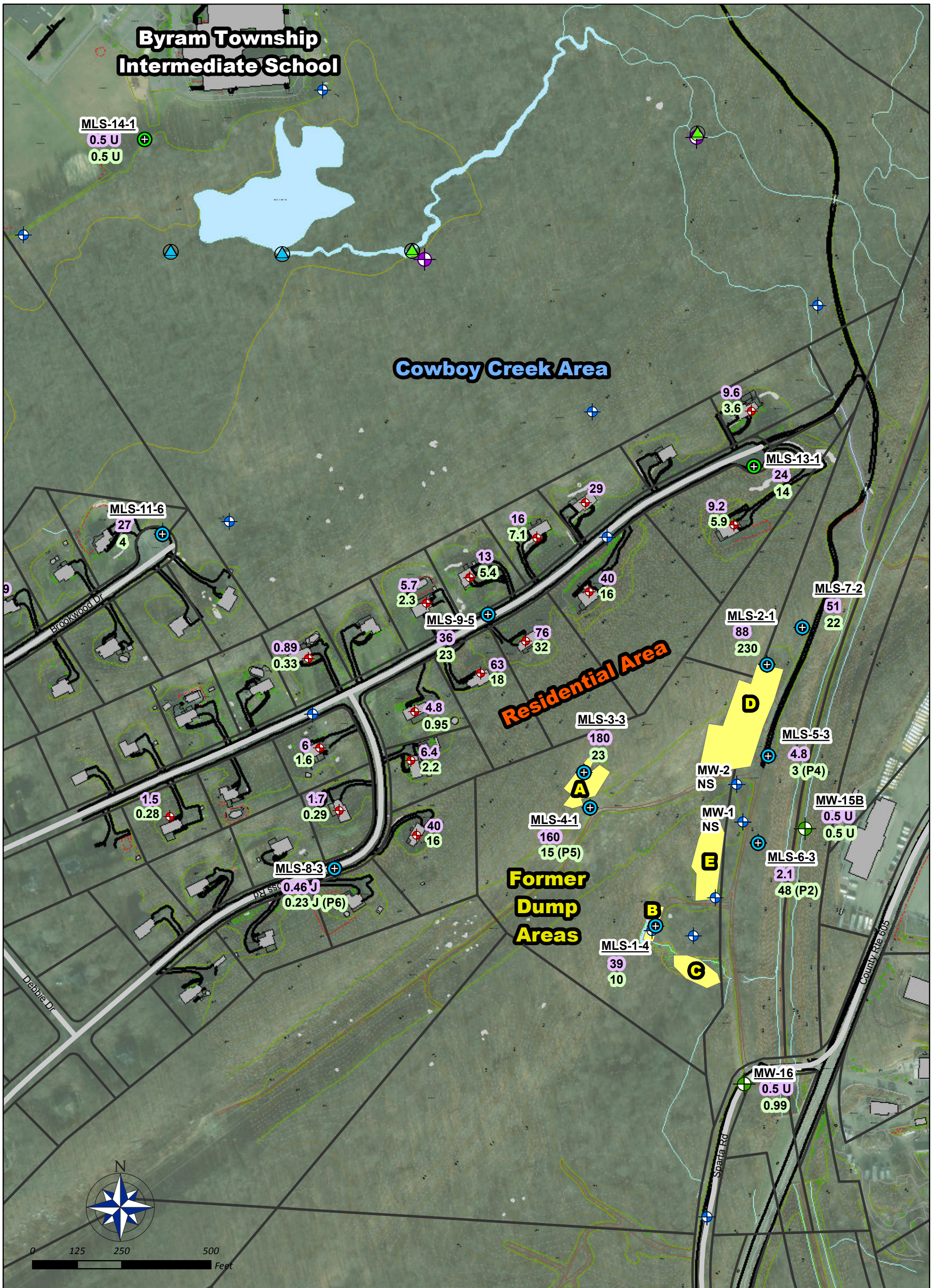
Vertical Exaggeration: 2x

0 120
Vertical Scale (feet)

Figure 4-9
Cross Section B-B'
TCE and cis-1,2-DCE in Groundwater
November 2017 - Round 2
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

STANDARD CROSS SECTION: MANSFIELD MANSFIELD.GPJ STANDARD_ENVIRONMENTAL_PROJECT.GDT 4/12/18 REV.



2017 Monitoring Well
2017 MLS Well
2017 In-Creek Piezometer
2017 Overburden Piezometers
Existing Monitoring Well
Existing MLS Well
Existing In-Creek Piezometer
Residential Well

Tax Parcels
Former Dump Areas

MLS-1-P1 Monitoring Well
0.5 U TCE Concentration (ug/l)
0.5 U cis-1,2-DCE Concentration (ug/L)

Acronyms
J- estimated value
TCE - Trichloroethene
U- non detect

Notes
1. Groundwater results are presented for the November 2017 sampling. The port with the highest concentration is presented.
2. Residential well data is posted without a property address, but is adjacent to the residential well.

Figure 4-10
TCE and cis-1,2-DCE in Residential Wells
November 2017 (Round 2)
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

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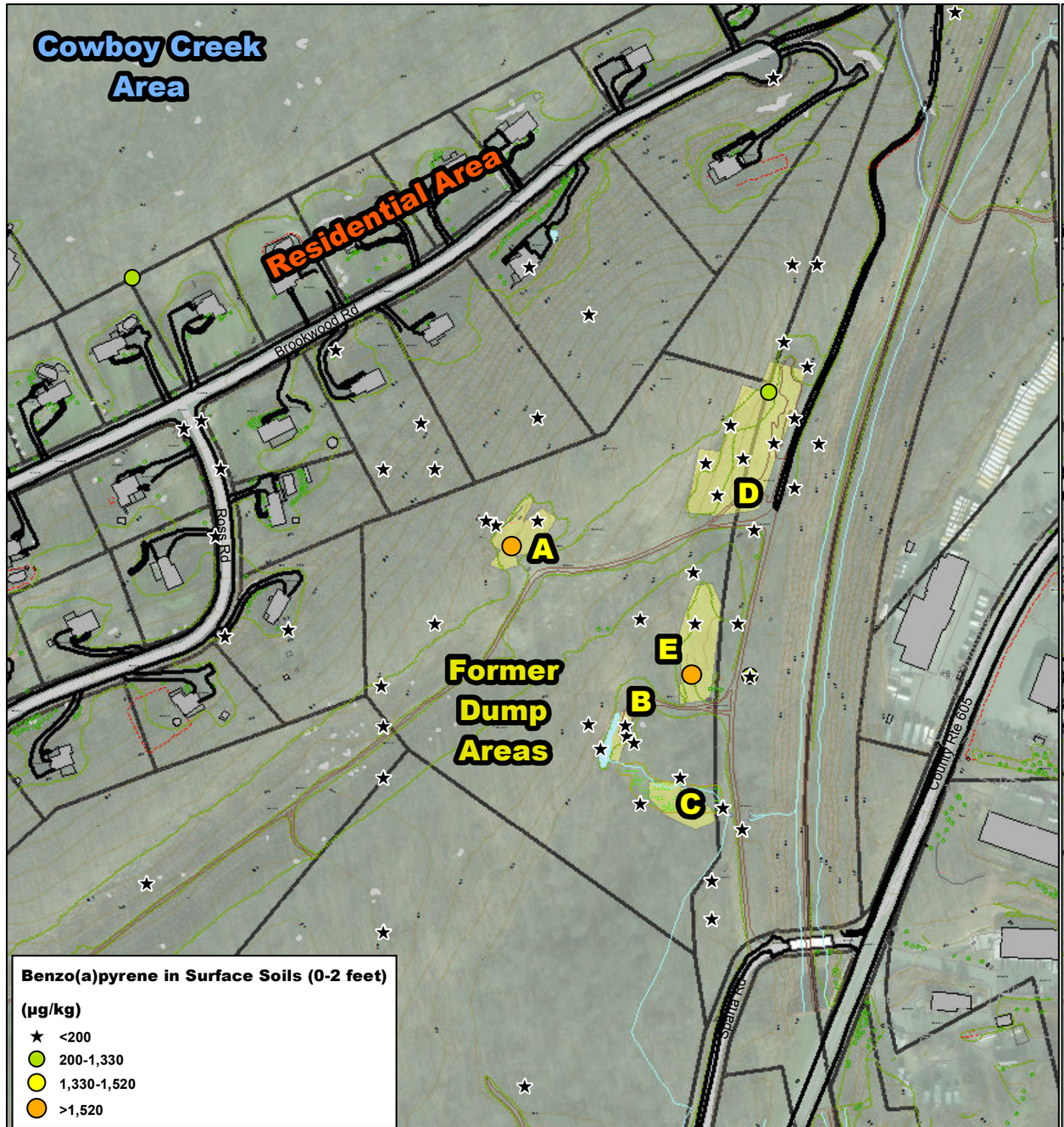

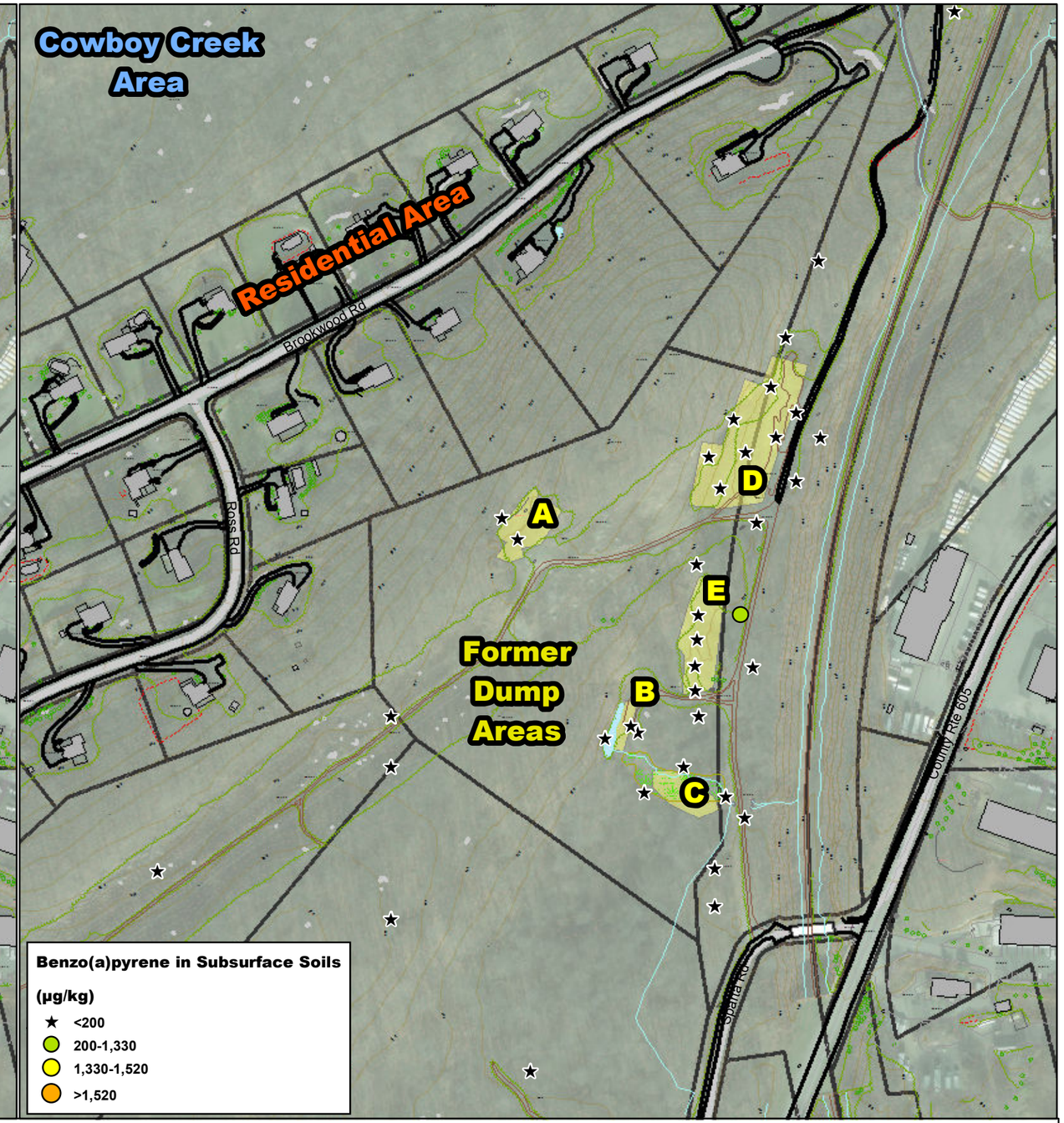

Former Dump Areas
Tax Parcels

Topographic Contours
50 ft Contours
5 ft Contours

Notes
1. Soil sampling results are presented for sampling events performed following the removal actions in 2012.
2. Data is color coded by concentration groups to represent various screening criterias and to assist in presenting where contamination is present.

Soil Screening Criteria
EPA RSL - 110 µg/kg (Human Health)
NJDEP RSDCSC - 200 µg/kg (Human Health)
ECO SSLs - 1,100 µg/kg (Eco)
Site Background - 1,329 µg/kg

N
0 125 250 500 Feet

Figure 4-16
Post-Excavation Soil Sample Results
Benzo(a)pyrene
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

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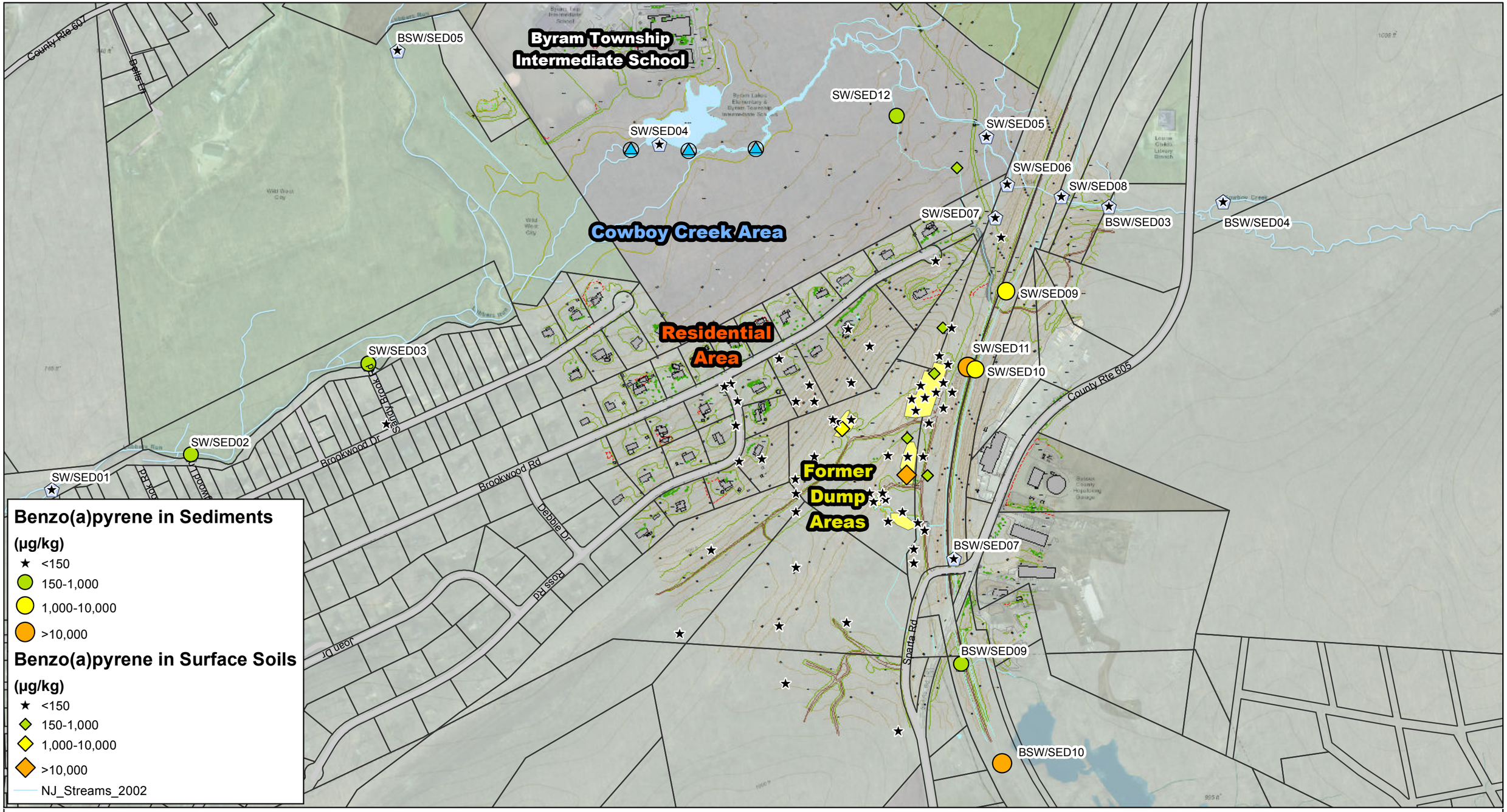


2017 RI Sampling Locations

In-Creek Piezometer (Surface Water and Sediment Co-Located)

Initial RI Sampling Locations

2014 Sediment/ Surface Water Sample

Existing In-Creek Piezometer (co-located surface water and sediment sample)

Former Dump Areas

Tax Parcels

Sediment Screening Criteria

EPA RSL - 110 µg/kg (Human Health)

NJDEP Freshwater Sediment - 150 µg/kg (Eco)

Site Background - 20,185 µg/kg

Topographic Contours

50 ft Contours

5 ft Contours

Notes

1. Sediment and soil sampling results are presented for sampling events performed following the removal action in 2012.
2. Data is color coded by concentration groups to represent various screening criteria and to assist in presenting where contamination is present.

N

0 250 500 1,000 Feet

Figure 4-17

Sediment Sample Results - PAHs

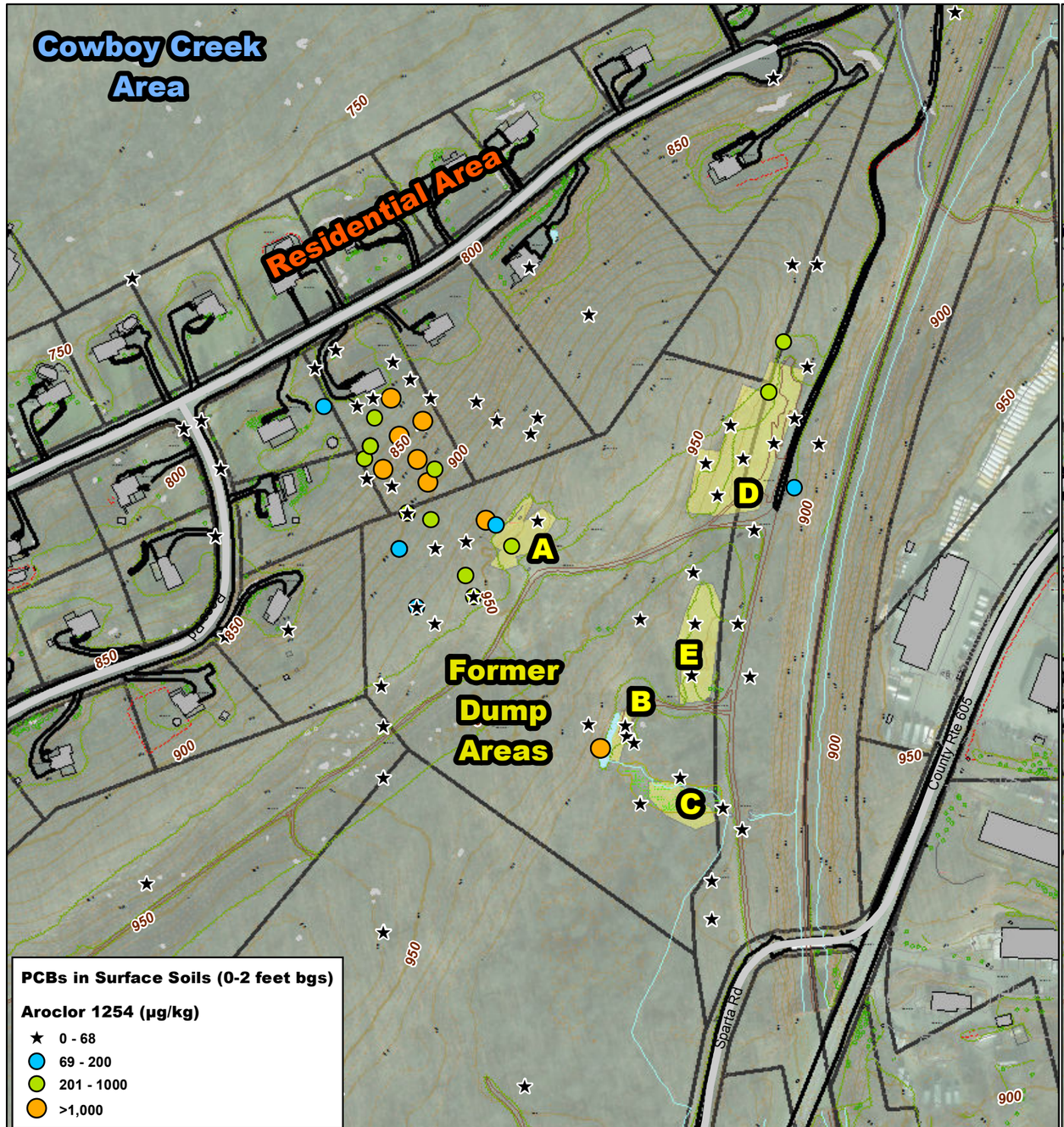
Benzo(a)pyrene

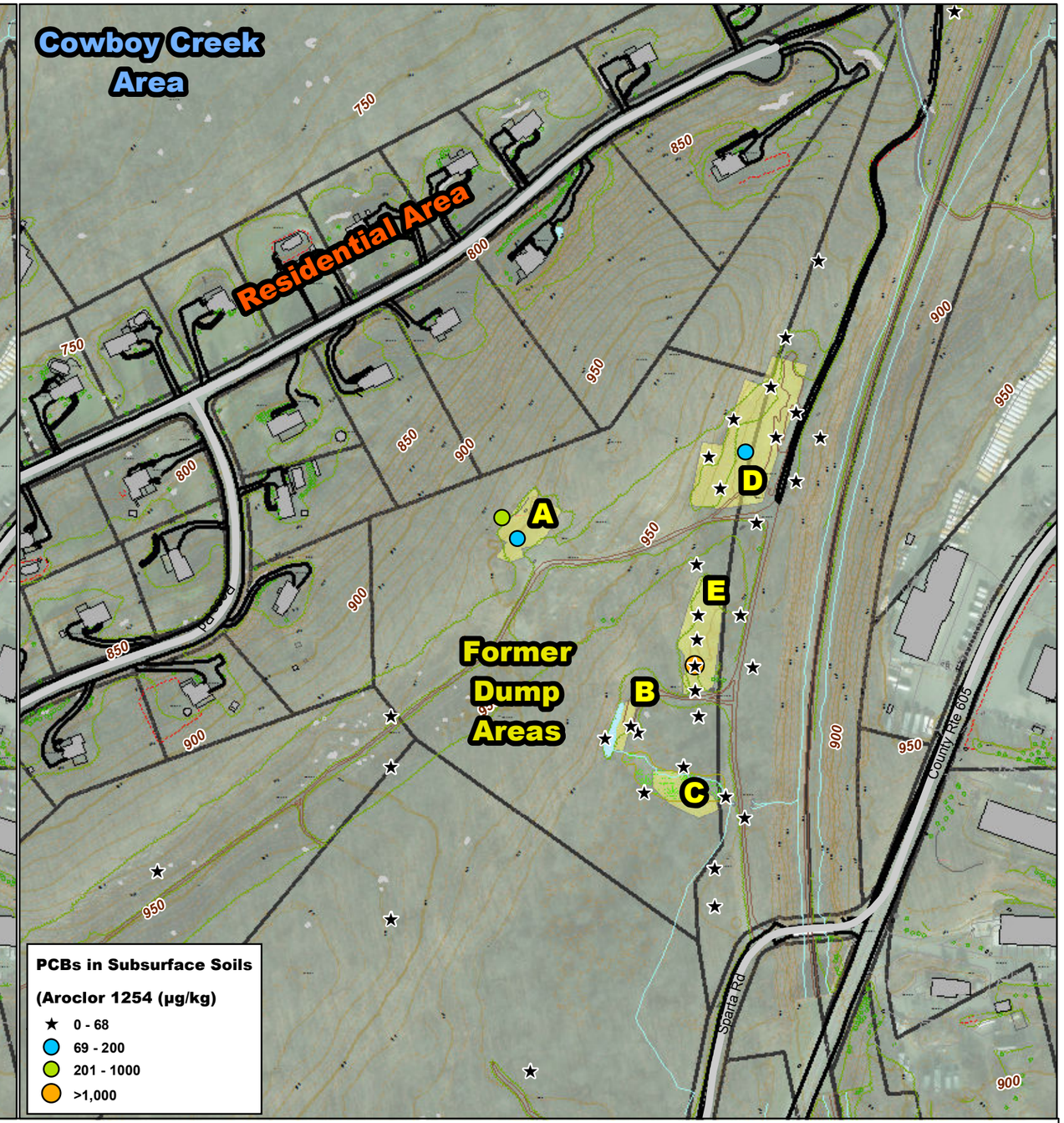
Mansfield Trail Dump Site, OU2

Byram Township, NJ

CDM Smith

ButtonJS C:\JMS\GIS\Mansfield Trail Dump Site\MXD\070\RI\Draft RI\Figure 4-17_BAPinSED.mxd 4/26/2018





Former Dump Areas
Tax Parcels

Topographic Contours
50 ft Contours
5 ft Contours

Notes
1. Soil sampling results are presented for sampling events performed following the removal actions in 2012.
2. Data is color coded by concentration groups to represent various screening criteria and to assist in presenting where contamination is present.

Soil Screening Criteria
Site Background - 68 µg/kg
NJDEP RSDCSC - 200 µg/kg (Human Health)
EPA ECo SSLs - 371 µg/kg (Eco)
NJDEP NRSDCSC - 1,000 µg/kg (Human Health)

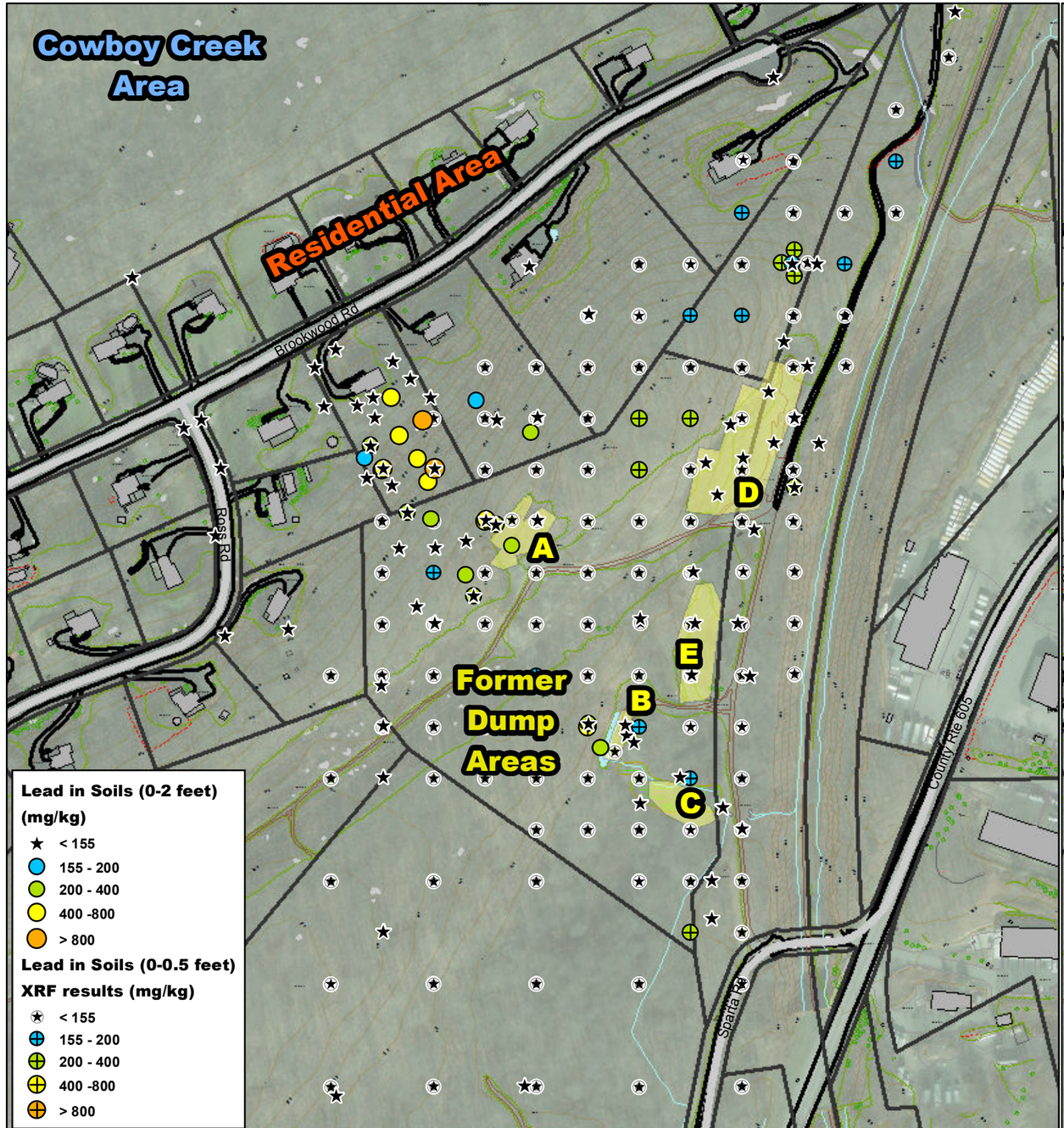
N

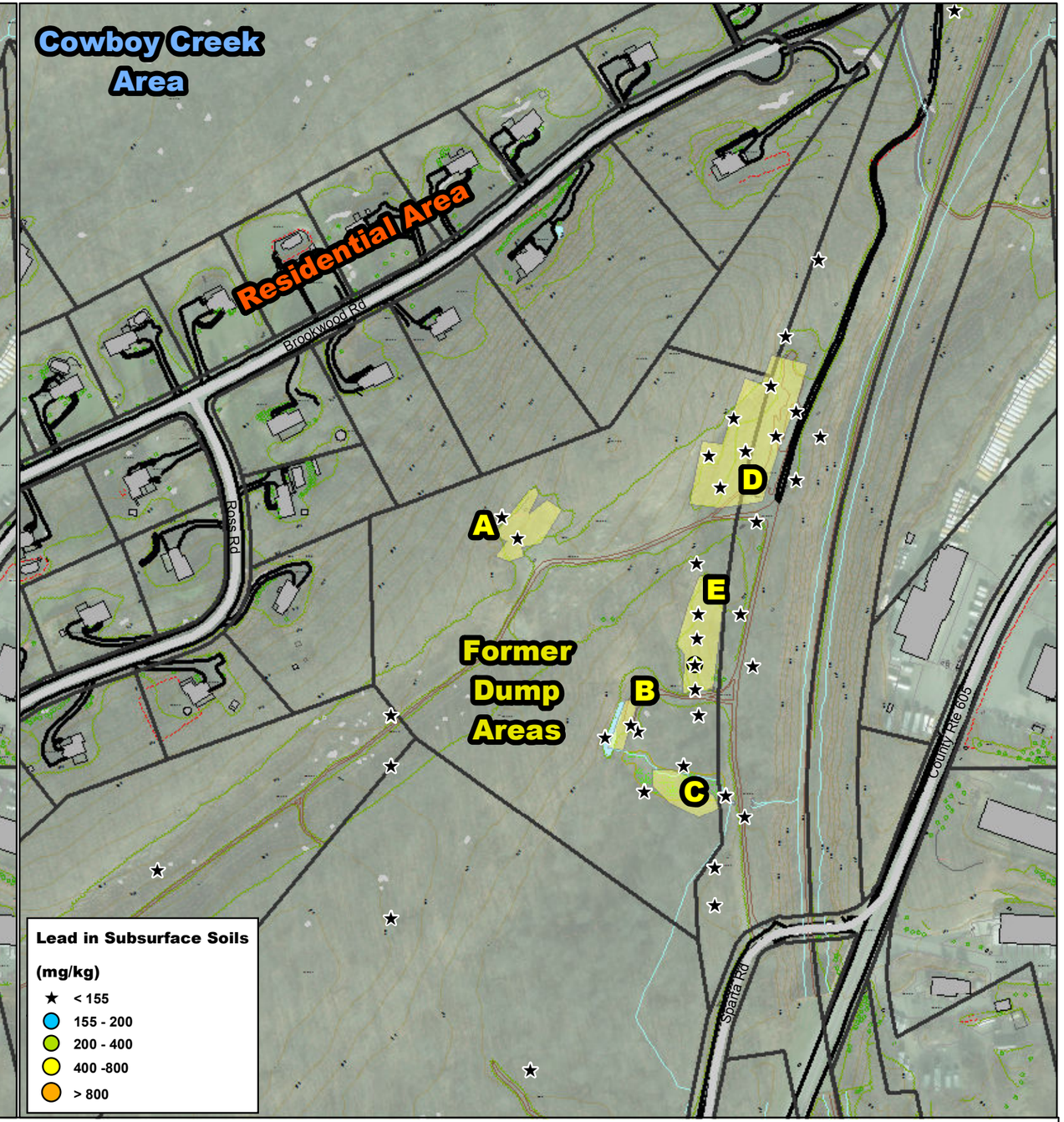
0 125 250 500 Feet

Figure 4-18
Post-Excavation Soil Sample Results
Aroclor-1254
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

ButtonJS C:\JMS\GIS\Mansfield Trail Dump Site\MXD\070\RI\Draft RI\Figure_4-18_Soil_PCBs.mxd 4/26/2018





Former Dump Areas
Tax Parcels

Topographic Contours
50 ft Contours
5 ft Contours

Notes
1. Soil sampling results are presented for sampling events performed following the removal actions in 2012.
2. Data is color coded by concentration groups to represent various screening criteria and to assist in presenting where contamination is present.

Soil Screening Criteria
Site Background - 155 mg/kg
NJDEP RSDCSC - 200 mg/kg (Human Health)
EPA RSL - 400 mg/kg (Human Health)
NJDEP NRSDCSC - 800 mg/kg (Human Health)

N

0 125 250 500 Feet

Figure 4-19
Post-Excavation Soil Sample Results - Lead
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

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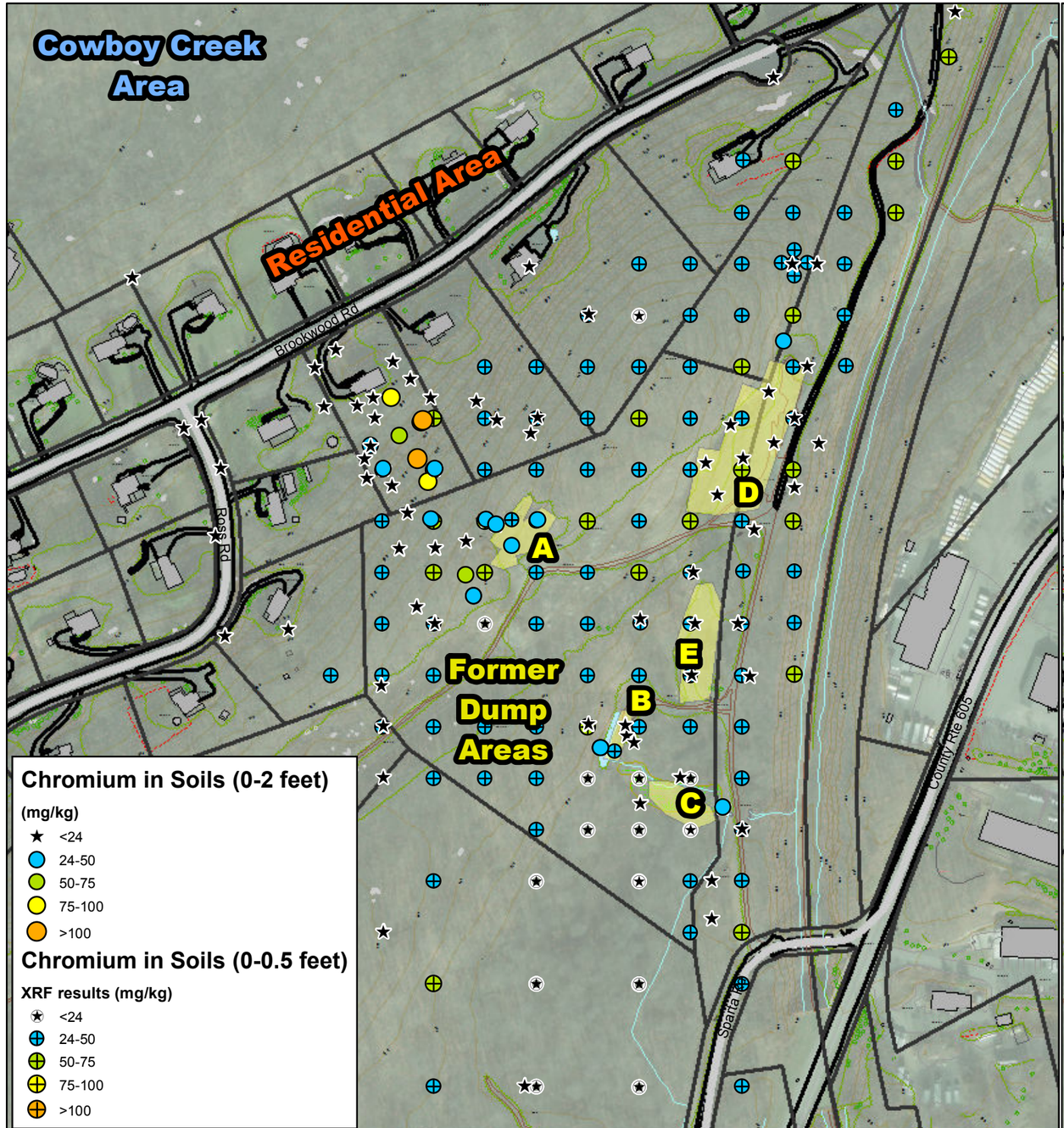

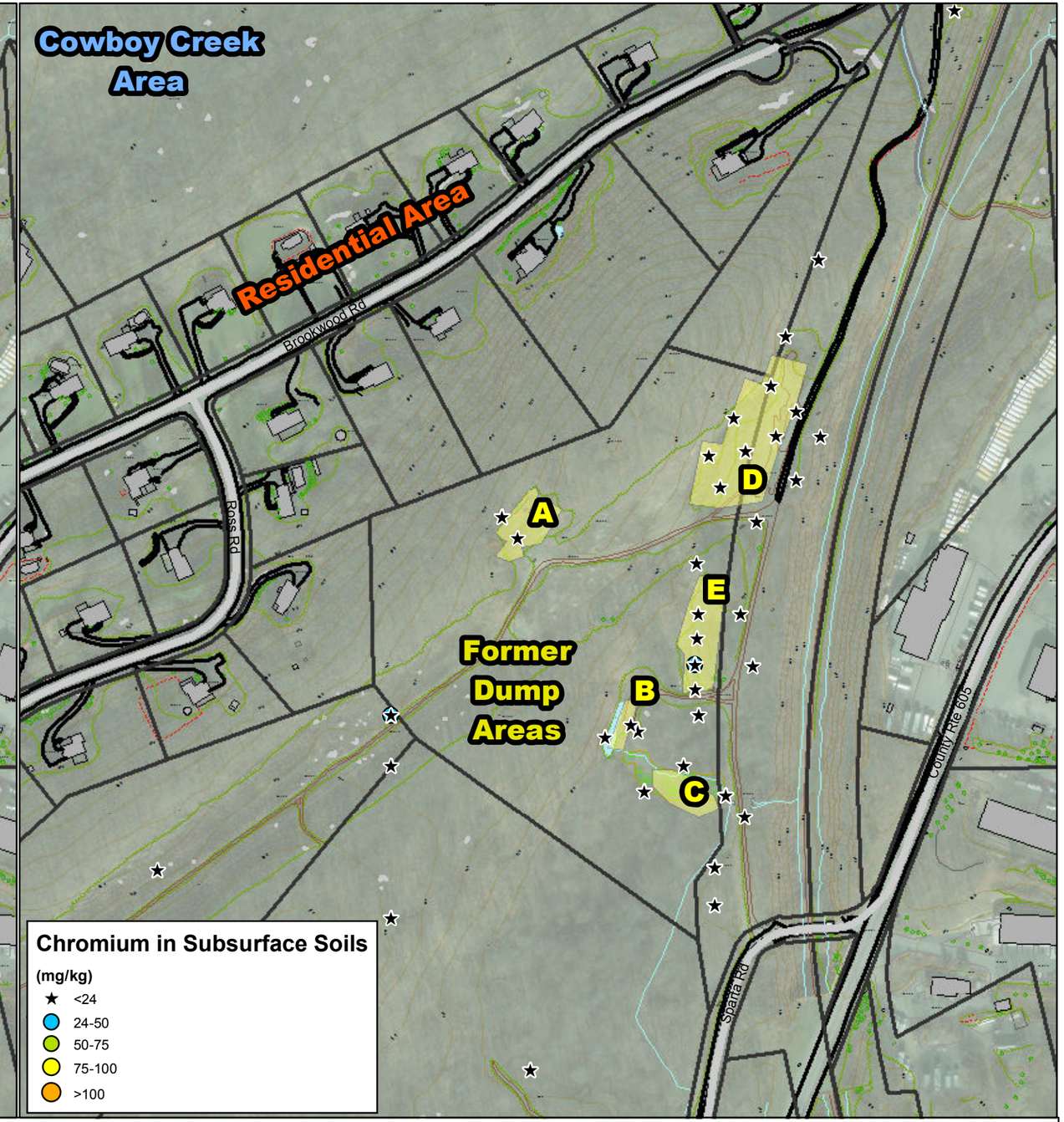

Former Dump Areas

Tax Parcels

Topographic Contours

50 ft Contours

5 ft Contours

Notes

1. Soil sampling results are presented for sampling events performed following the removal actions in 2012.
2. Data is color coded by concentration groups to represent various screening criteria and to assist in presenting where contamination is present.

Soil Screening Criteria

EPA RSL - 0.3 mg/kg (Human Health - if hexavalant)
NJDEP RSDCSC - 1 mg/kg (Human Health - if hexavalant)
Site Background - 24 mg/kg

N

0 125 250 500 Feet

Figure 4-20
Post-Excavation Soil Sample Results - Chromium
Mansfield Trail Dump Site, OU2
Byram Township, NJ

CDM Smith

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Appendix B

Natural Attenuation Statistics

Appendix B

Natural Attenuation Statistics

CDM Smith completed a statistical analysis of the residential well groundwater data collected from several wells along Brookwood Road and Ross Road. Trichloroethene (TCE) data collected before the removal action completed in 2012 was used for the analysis. Only data from before the removal action was used because concentrations increased immediately after the removal action due to the disturbance of the vadose zone; data prior to the removal action is more representative of natural attenuation. The analysis was completed for seven wells (BYR-DW117, BYR-DW120, BYR-DW122, BYR-DW125, BYR-DW127, BYR-DW129, BYR-DW130, ROSS ROAD) as shown in **Figure 1** below.

CDM Smith used EPA's ProUCL Software to understand the trends in the data and determine if TCE concentrations were statistically decreasing. Mann-Kendall and Theil-Sen trend tests were run on the data. In order to determine a first order rate of attenuation, CDM Smith calculated the natural log of the concentration for all data points. This data set was then input into ProUCL.

According to the results of the Mann-Kendall test, four out of eight wells were found to have statistically decreasing TCE concentrations. The four wells with statistically decreasing concentrations of TCE were BYR-DW117, BYR-DW120, BYR-DW125, and BYR-DW127 (**Figure 1**). The other four wells had insufficient evidence to identify a significant trend. The Mann-Kendall test values and p-values are summarized on **Table 1**.

The Theil-Sen test was then performed on the four wells that were identified as having statistically decreasing concentrations of TCE. The Theil-Sen calculated slope and the 95% lower and upper confidence limits for this value are shown on **Table 2**. **Figure 1** shows the attenuation rates for the wells with statistically decreasing TCE concentrations.

Table 1
Mann-Kendall Test Results for Residential Wells
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

Well	Mann-Kendall Test Value (S)	Mann-Kendall Standardized Value of S	Mann-Kendall P-Value	Mann-Kendall Conclusion
BYR-DW117	-20	-2.351	0.00937	Statistically significant evidence of a decreasing trend
BYR-DW120	-20	-2.351	0.00937	Statistically significant evidence of a decreasing trend
BYR-DW122	-14	-1.608	0.0539	Insufficient evidence to identify a significant trend
BYR-DW125	-25	-2.516	0.00594	Statistically significant evidence of a decreasing trend
BYR-DW127	-16	-1.856	0.0317	Statistically significant evidence of a decreasing trend
BYR-DW129	-3	-0.376	0.354	Insufficient evidence to identify a significant trend
BYR-DW130	-16	-1.564	0.0589	Insufficient evidence to identify a significant trend
ROSS ROAD	9	1.5	0.0664	Insufficient evidence to identify a significant trend

Notes:
1. The level of significance used for this analysis was the default for ProUCL, p=0.05.

Table 2
Theil-Sen Test Results for Residential Wells
Mansfield Trail Dump Site, OU2
Byram Township, New Jersey

Well	LCL of Theil-Sen Slope (1/day)	Theil-Sen Slope (1/day)	UCL of Theil-Sen Slope (1/day)	TCE Concentration - October 2017 (µg/L)
BYR-DW117	-5.67E-04	-3.83E-04	-2.07E-04	6
BYR-DW120	-4.66E-04	-2.57E-04	-1.06E-04	63
BYR-DW125	-4.08E-04	-2.39E-04	-7.03E-05	40
BYR-DW127	-5.76E-04	-3.20E-04	-4.38E-05	16

Notes:
1. The level of significance used for this analysis was the default for ProUCL, p=0.05.

Acronyms:
LCL - lower confidence limit
PRG - preliminary remediation goal
TCE - trichloroethene
UCL - upper confidence limit
µg/L - microgram per liter

Residential Well

Residential Well with POET System

Tax Parcels

Former Dump Areas

BYR-DW129 - included in statistical analysis, statistically significant decreasing trend

-5.76E-04 - attenuation rate in units of 1/day

BYR-DW129 - included in statistical analysis, insufficent evidence to identify significant trend

BYR-DW129 - not included in statistical analysis

N

0 250 500 1,000 Feet

Figure 1
Statistical Analysis of Residential Wells
Mansfield Trail Dump Site, OU1
Byram Township, NJ

CDM Smith

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Appendix C

Potential Climate Change Impacts

Appendix C
Preliminary Climate Change Vulnerability Evaluation
Mansfield Trail Dump, Operable Unit 2
Byram Township, New Jersey

Potential Points of System Vulnerability		Potential System Disruption				To-Be-Considered Adaptation Measures for High-Priority Vulnerabilities
		Power Interruption	Physical Damage	Water Damage	Reduced Access	
Long Term Monitoring/Monitored Natural Attenuation						
Underground and At-Grade Components	Monitoring wells	Medium	Low	Low	Medium	Well-head protection; monitoring events scheduled around extreme weather events; backup power from off-grid sources for bedrock wells
Soil Vapor Extraction System						
Extraction System	Extraction and Monitoring Wells		Low		Low	
	Vacuum	Medium	Medium	Low	Medium	Well-head protection; backup power from off-grid sources
	Monitoring equipment	Medium	Medium	Low	High	Remote access; backup power from off-grid sources
At-Grade Components	Pipe system		Low	Low	Low	
Aboveground Components of the Treatment System	Electrical controls	Medium	Low	Low	Medium	Backup power from off-grid sources
	Transfer and discharge pumps	Medium	Low	Low		Backup power from off-grid sources
	Pipe system		Medium			
	Electric equipment	Medium	Low	Medium	Medium	Backup power from off-grid sources
	GAC Units		Low	Low		
Site Operations and Infrastructure	Treatment system unit	Medium	Medium	Medium	Medium	Backup power from off-grid sources; potential shoring/footing (geotechnical) considerations
	Electricity lines	High	Medium	Medium	High	TBD in concert with Jersey Central Power & Light (JCP&L)
Groundwater Extraction System (Part of Dual Phase Extraction)						
Extraction System	Wells		Low		Low	
	Extraction pumps	Medium	Medium	Low	Medium	Well-head protection; backup power from off-grid sources
	Monitoring equipment	Medium	Medium	Low	High	Remote access; backup power from off-grid sources
At-Grade Components	Pipe system		Low	Low	Low	
Aboveground Components of the Treatment System	Electrical controls	Medium	Low	Low	Medium	Remote access; backup power from off-grid sources
	Transfer and discharge pumps	Medium	Low	Low		
	Pipe system		Medium			
	Electric equipment	Medium	Low	Medium	Medium	Backup power from off-grid sources
	GAC Units		Low	Low		
	Monitoring Wells		Low	Low	Medium	Well-head protection
Site Operations and Infrastructure	Treatment system unit	Medium	Medium	Medium	Medium	Backup power from off-grid sources; potential shoring/footing (geotechnical) considerations
	Electricity lines	High	Medium	Medium	High	TBD in concert with JCP&L
In Situ Treatment						
Deployment and Aboveground components	Injection wells		Low		Low	
	Injection and transfer pumps and aboveground controls	High	High	High	High	Temporary/portable
	Electrical equipment	Medium	Low	Medium		Power from off-grid sources; temporary
	Piping		Low	Low	Low	
	Liquid amendment storage and transfer		Low	Low	Low	
	Exposed machinery and vehicles		Medium	Medium	High	Temporary
	Water supplies	Medium	Medium	Medium	High	Temporary

Acronyms:
GAC - granular activated carbon
TBD - to be determined
JCP&L - Jersey Central Power & Light

Appendix D

Cost Estimates

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	JGG	CHECKED BY:	MS
CDM Federal Programs Corporation	JOB NO.:	101995.3323.070	DATE :	01/10/2019	DATE CHECKED:	1/11/2019
	CLIENT:	EPA			PAGE NO. :	2 CAP

Description: Cost Estimate for Alternative GW-2

Institutional Controls Capital Costs

Risk Communication Controls

Includes community awarenesss meetings as part of risk communication

Number of Community Awareness Meetings, EA: 2 *Assumed*

Quantities per Meeting

General Superintendent, HR:	16
Project Manager, HR:	16
Project Engineer, HR:	16
Per Diem, DY:	6

Total Quantities for Community Awareness Activities

General Superintendent, HR:	**32**
Project Manager, HR:	**32**
Project Engineer, HR:	**32**
Per Diem, DY:	**12**
Community Awareness Activities Allowance, LS:	**1**

Cap Construction and Startup

Estimated length and width measured from Figure 1-2 (Site Plan) at longest location for each dump area. Estimated perimeter measured from Figure 1-2 (Site Plan) for each dump area.

Table 1: Dump Area Assumed Areas

Dump Area	Area (SF)	Area (Ac)	Estimated Length (LF)	Estimated Width (LF)	Estimated Perimeter (LF)
A	10,000	0.23	154	86	577
D	36,000	0.83	318	129	912
Total	**46,000**	**1.06**	**472.00**	**215**	**1,489**

Project Schedule

Pre-Construction Schedule

Pre-Construction Work Plans and Meetings (RA Work), Procurement, DY: 90

Construction Schedule

Mobilzation - Permits and Field Trailer Compound Establishment, DY:	10
Site Survey, DY:	5
Site Preparation (Decon Areas, Staging Area), DY:	5
Grading and cover system installation, DY:	60
Final Site Restoration and Demobilization, DY:	15
Total Construction Duration, DY:	**95**

Post-Construction Schedule

Project Closeout, DY: 90

Total Duration

Total Project Duration, DY:	**275**
Total Project Duration, MO:	**10**

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	JGG	CHECKED BY:	MS
	JOB NO.:	101995.3323.070	DATE :	01/10/2019	DATE CHECKED:	1/11/2019
CDM Federal Programs Corporation	CLIENT:	EPA			PAGE NO. :	2 CAP

Cover Capital Costs

Mobilization/Demobilization

Mobilization/Demobilization - Field Trailer Compound Establishment, EA:	2
Mobilization/Demobilization - Heavy Equipment, EA:	4
Mobilization/Demobilization - Large Equipment, EA:	4
Mobilization/Demobilization - Medium Equipment, EA:	4
Mobilization/Demobilization - Self-Propelled Equipment, EA:	8

Survey

Assumes survey throughout all dump areas. Assume 100% increase in dump area.

Overage for Surveying Area, %:	100	
Access Road Area, SF:	43,200	
Dump Area A Surveying Area, SF:	20,000	*Dump area plus 10%, rounded to hundreds*
Dump Area D Surveying Area, SF:	72,000	*Dump area plus 10%, rounded to hundreds*
Total Surveying Area, SF:	**135,200**	*Rounded to hundreds*
Total Surveying Area, AC:	**3.1**	
Surveying Report, EA:	**1.0**	

Construction Safety and Traffic Control

Includes traffic control and safety barricade setup at properties for implementation of remedial work

Reflecting Barricade with Light, EA:	**50**	
Orange Safety Fence with Post, LF:	**1,000**	
3" x 1,000' Yellow Caution Tape, RL:	**50**	
Signage Work Area, AC:	1.06	
Signage Frequency, EA/AC:	4	*Assumed*
Total Signs, EA:	**5**	*Rounded up to nearest whole number*
Number of Flaggers, EA:	2	*Assumed*
Capping Project Duration, DY:	60	
Flagger Percentage, %:	25	*Assumed*
Flagger Required, DY:	15	
Flagger Required, HR:	240	

Access Road Construction

Estimated Length of Access Roads, LF:	**1,800**	*Estimated from Google Maps*
Assumed Width of Access Road, FT:	24	
Assumed Depth of Gravel for Access Road, IN:	18	
Area for Clearing and Grubbing, SF:	43,200	
Area for Clearing and Grubbing, AC:	**1.0**	*Rounded up to nearest whole number*
Rough Grading, ECY:	2,400	
Rough Grading, LCY:	**2,667**	
Volume of Gravel for Access Roads, ECY:	2,400	
Volume of Gravel for Access Roads, LCY:	2,667	
Road Area, SY:	4,800	

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	JGG	CHECKED BY:	MS
	JOB NO.:	101995.3323.070	DATE :	01/10/2019	DATE CHECKED:	1/11/2019
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Erosion Control

Estimated from Figure 1-2: Site Plan. One approximately 350 ft silt fence upgradient of Dump Area D and one approximately 650 ft silt fence downgradient of Dump Areas A and B.

Silt Fence, LF:	1,000	*Estimated, see above*
Straw Bales, LF:	100	*Assumed*
Percentage of Disturbed Areas for Erosion Control Blankets, %:	50%	*Assumed*
Total Cover Areas, SF:	46,000	
Erosion Control Blankets, SF:	23,000	*Assumed for repository and Cover areas only*
Erosion Control Blankets, SY:	2,556	*Rounded up to nearest whole number*

Clearing and Grubbing

Clearing and grubbing area, SF:	**46,000**	*Based on aggregate area of dump sites*
Overage area for clearing and grubbing, %:	**20%**	
Total Clearing and Grubbing Area, SF:	**55,200**	
Total Clearing and Grubbing Area, AC:	**1.3**	

Dust Control

Assumes water-based dust suppression during implementation of remedial work, including cap construction

Cover Installation Time, DY:	30	
Percent of Installation Time that Requires Dust Control, %:	80%	*Assumed*
Estimated Excavation Time, DY:	24	*Assumes 80% of installation time*
Estimated Dust Control Time, HR:	192	*Assumes water truck on hand for all excavation*

In Place Cover of Dump Area A

Assumes an 18" cover consisting of a and geotextile and earthen cap of subsoil and Topsoil overlaying a geomembrane. Cover will be a hydroseeded vegetated cap.

Cover with Subsoil and Topsoil

Assumed Subsoil Depth for Cover, IN:	12	
Assumed Surface Layer Depth for Cover, IN:	6	
Overlap for Geotextile, %:	10	
Overlap for Geomembrane, %:	10	
Estimated Horizontal Extent of Cover, SF:	10,000	*See Table 1 above*
Additional area assumed for grading, %:	10%	
Area to be graded, SF:	11,000	*Rounded to hundreds*
Subsoil Cover Volume, ECY:	400	*Rounded to hundreds*
Subsoil Cover Volume, LCY:	600	
Topsoil Cover Volume, ECY:	200	*Rounded to hundreds*
Topsoil Cover Volume, LCY:	300	
Total Cover Volume, ECY:	600	
Total Cover Volume, LCY:	900	
Exterior Perimeter of geotextile, LF:	577	
Surficial area of geotextile, SF:	10,000	
Total area of geotextile, SF:	12,731	*Includes overlap and anchor trench*

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	JGG	CHECKED BY:	MS
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Geotextile anchor trench width, FT:	1.5	
Geotextile anchor trench depth, FT:	1.5	
Length for geotextile anchor trench, FT/LF:	3	
Area of geotextile for anchor trench, SF:	1,731	
Total geotextile, MSF:	12.7	
Total geotextile, SY:	1,420	*Rounded up to nearest 10*
Total area of geotextile, SF:	11,731	*Does not include overlap*
Total area of geotextile, MSF:	12	*Rounded up to nearest whole number*
Total area of geotextile, SY:	1,310	*Rounded up to nearest 10*
Exterior Perimeter of geomembrane, LF:	577	
Surficial area of geomembrane, SF:	10,000	
Total area of geomembrane, SF:	12,731	*Includes overlap and anchor trench*
Geomembrane anchor trench width, FT:	1.5	
Geomembrane anchor trench depth, FT:	1.5	
Length for geomembrane anchor trench, FT/LF:	3	
Area of geomembrane for anchor trench, SF:	1,731	
Total geomembrane, MSF:	12.7	
Total geomembrane, SY:	1,420	*Rounded up to nearest 10*
Total area of geomembrane, SF:	11,731	*Does not include overlap*
Total area of geomembrane, MSF:	12	*Rounded up to nearest whole number*
Total area of geomembrane, SY:	1,310	*Rounded up to nearest 10*
Hydroseeding		
Additional impacted area for Hydroseeding, %:	10	
Cover seeding area, SF:	11,000	*Dump area plus 10%, rounded to hundreds*
Cover seeding area, MSF:	11	

In Place Cover of Dump Area D

Assumes an 18" cover consisting of a and geotextile and earthen cap of subsoil and Topsoil overlaying a geomembrane. Cover will be a hydroseeded vegetated cap.

Cover with Subsoil and Topsoil		
Assumed Subsoil Depth for Cover, IN:	12	
Assumed Surface Layer Depth for Cover, IN:	6	
Overlap for Geotextile, %:	10	
Overlap for Geomembrane, %:	10	
Estimated Horizontal Extent of Cover, SF:	36,000	*See Table 1 above*
Additional area assumed for grading, %:	10%	
Area to be graded, SF:	39,600	*Rounded to hundreds*
Subsoil Cover Volume, ECY:	1,300	*Rounded to hundreds*
Subsoil Cover Volume, LCY:	1,800	
Topsoil Cover Volume, ECY:	700	*Rounded to hundreds*
Topsoil Cover Volume, LCY:	1,000	
Total Cover Volume, ECY:	2,000	
Total Cover Volume, LCY:	2,800	
Exterior Perimeter of geotextile, LF:	912	
Surficial area of geotextile, SF:	36,000	
Total area of geotextile, SF:	42,336	*Includes overlap and anchor trench*

Cost Estimate for Alternative 2
Capping and MNA
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New Jersey

CDM Smith
CDM Federal Programs Corporation

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Geotextile anchor trench width, FT:	1.5	
Geotextile anchor trench depth, FT:	1.5	
Length for geotextile anchor trench, FT/LF:	3	
Area of geotextile for anchor trench, SF:	2,736	
Total geotextile, MSF:	42.3	
Total geotextile, SY:	4,710	*Rounded up to nearest 10*
Total area of geotextile, SF:	38,736	*Does not include overlap*
Total area of geotextile, MSF:	39	*Rounded up to nearest whole number*
Total area of geotextile, SY:	4,310	*Rounded up to nearest 10*
Exterior Perimeter of geomembrane, LF:	912	
Surficial area of geomembrane, SF:	36,000	
Total area of geomembrane, SF:	42,336	*Includes overlap and anchor trench*
Geomembrane anchor trench width, FT:	1.5	
Geomembrane anchor trench depth, FT:	1.5	
Length for geomembrane anchor trench, FT/LF:	3	
Area of geomembrane for anchor trench, SF:	2,736	
Total geomembrane, MSF:	42.3	
Total geomembrane, SY:	4,710	
Total area of geomembrane, SF:	38,736	
Total area of geomembrane, MSF:	39	
Total area of geomembrane, SY:	4,310	
Hydroseeding		
Overlap for Hydroseeding, %:	10	
Cover seeding area, SF:	39,600	*Dump area plus 10%, rounded to hundreds*
Cover seeding area, MSF:	40	
Total In Place Cover of all Dump Areas		
Grading, SF:	50,600	
Grading, SY:	**5,630**	*Rounded to tens*
Total area of geomembrane, SF:	**55,067**	
Total area of geomembrane, SY:	**6,130**	
Total area of geotextile, SF:	**55,067**	*Includes overlap and anchor trench*
Total area of geotextile, SY:	**6,130**	*Rounded up to nearest 10*
Subsoil Cover Volume, ECY:	**1,700**	*Rounded to hundreds*
Subsoil Cover Volume, LCY:	**2,400**	
Topsoil Cover Volume, ECY:	**900**	*Rounded to hundreds*
Topsoil Cover Volume, LCY:	**1,300**	
Total Cover Volume, ECY:	**2,600**	
Total Cover Volume, LCY:	**3,700**	
Hydroseeding		
Cover seeding area, SF:	**50,600**	*Dump area plus 10%, rounded to hundreds*
Cover seeding area, MSF:	**50.6**	

Cost Estimate for Alternative 2
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Install Surface Water Drainage Swale at Dump Area A

Assumes drainage swales along upgradient and sides of dump area.

Offset from dump area, FT:	5	
Length of Swale, LF:	769	*Based on cover dimensions and offset*
Bottom Width, FT	2	
Depth, FT:	3	
Side slope, H:V	2 :1	
Freeboard Top Width, FT:	14	
Surface area, SF:	10,766	
Excavation volume for drainage swales, CF/FT:	24	
Excavation volume for drainage swales, CF:	18,456	
Excavation volume for drainage swales, BCY:	690	
Excavation volume for drainage swales, LCY:	830	
Excavation volume for drainage swales, ECY:	750	
Riprap Thickness, FT:	**1**	
Riprap Area, CF/FT:	16	
Volume of riprap, CF:	12,304	
Volume of Riprap, BCY:	460	
Volume of Riprap, LCY:	560	.
Volume of Riprap, ECY:	500	

Install Surface Water Drainage Swale at Dump Area D

Assumes drainage swales along upgradient and sides of dump area.

Offset from dump area, FT:	5	
Length of Swale, LF:	1,190	*Based on cover dimensions and offset*
Bottom Width, FT	2	
Depth, FT:	3	
Side slope, H:V	2 :1	
Freeboard Top Width, FT:	14	
Surface area, SF:	16,660	
Excavation volume for drainage swales, CF/FT:	24	
Excavation volume for drainage swales, CF:	28,560	
Excavation volume for drainage swales, BCY:	1,060	
Excavation volume for drainage swales, LCY:	1,280	
Excavation volume for drainage swales, ECY:	1,150	
Riprap Thickness, FT:	**1**	
Riprap Area, CF/FT:	16	
Volume of riprap, CF:	19,040	
Volume of Riprap, BCY:	710	
Volume of Riprap, LCY:	860	.
Volume of Riprap, ECY:	770	
Total Area, AC:	**3,050**	*Rounded up to nearest whole number*
Surveying Report Allowance, LS:	**1**	

Cost Estimate for Alternative 2
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Total Install of Surface Water Drainage Swale at All Dump Areas

Excavation, BCY:	1,750
Volume of Riprap, BCY:	1,170
Volume of Riprap, LCY:	1,420
Volume of Riprap, ECY:	1,270

Notes:

Green highlighting indicates percentages, volumes, and areas summarized in the SS Assumption:
Yellow highlighting indicates assumed values
Blue bold quantities are cost estimate input values for the cost worksheets

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	JGG	CHECKED BY:	MS
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Annual Site Maintenance and Monitoring

Cover O&M

Total Cover Areas, AC: 1.2

Assumptions by Year

	Cover Areas	
Annual Percentage of Reseeding (Years 1-5), %:	10%	*Assumed*
Annual Percentage of Reseeding (Years 6-10), %:	5%	*Assumed*
Annual Percentage of Reseeding (Years 11-25), %:	2.5%	*Assumed*
Cover/Backfill O&M (Years 1-5), DY/AC:	1	*Assumed*
Cover/Backfill O&M (Years 6-10), DY/AC:	0.5	*Assumed*
Cover/Backfill O&M (Years 11-25), DY/AC:	0.25	*Assumed*
Number of workers, EA:	2	
Hours per day, HR/DY:	10	

Inspection

Years	Insp. HR
1-5	**10**
6-10	**10**
11-30	**10**

Inspection report

Project Manager, HR:	**12**
Project Engineer, HR:	**32**
General Office Support, HR:	**8**

Operation and Maintenance

Years	O&M DY	HR	Seeding MSF
1-5	**3**	60	**5.1**
6-10	**2**	40	**2.5**
11-30	**1**	20	**1.3**

Notes:

Green highlighting indicates percentages, volumes, and areas summarized in the SS Assumptions
Yellow highlighting indicates assumed values
Blue bold quantities are cost estimate input values for the cost worksheets

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

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CDM Federal Programs Corporation	PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY: MS
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Description: Cost Estimate for Alternative GW-2

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

This is a problem of the form find (P given A, i, n) or (P/A,i,n)

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

P = Present Worth
A= Annual amount
i = interest rate

Cap OM&M

Years 1-5

n =	5	n =	0
i =	7%	i =	7%
The multiplier for $(P/A)_2$ =	4.100		0.000
Multiplier for year 2-5	**4.100**		

	QTY	UNIT(S)	UNIT COST	TOTAL COST
Cover OM&M (Years 1 through 5)	1	YR	$29,804	$29,804
Contingency (Scope and Bid)	30%			$8,941
SUBTOTAL				$38,745
Project Management	7%			$2,712
Technical Support	15%			$5,812
TOTAL				**$47,269**
Present Worth				**$193,812**

Cost Estimate for Alternative 2
Capping and MNA
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New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	MS
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Description: Cost Estimate for Alternative GW-2

Years 6-10

n =	10	n =	5
i =	7%	i =	7%
The multiplier for $(P/A)_2$ =	7.024		4.100
Multiplier for year 6-10	**2.923**		

	QTY	UNIT(S)	UNIT COST	TOTAL COST
Cover OM&M (Years 1 through 5)	1	YR	$22,197	$22,197
Contingency (Scope and Bid)	30%			$6,659
SUBTOTAL				$28,856
Project Management	7%			$2,020
Technical Support	15%			$4,328
TOTAL				**$35,204**
Present Worth				**$102,916**

Years 11-30

n =	30	n =	10
i =	7%	i =	7%
The multiplier for $(P/A)_2$ =	12.409		7.024
Multiplier for year 11-30	**5.385**		

	QTY	UNIT(S)	UNIT COST	TOTAL COST
Cover OM&M (Years 1 through 5)	1	YR	$14,702	$14,702
Contingency (Scope and Bid)	30%			$4,411
SUBTOTAL				$19,113
Project Management	7%			$1,338
Technical Support	15%			$2,867
TOTAL				**$23,318**
Present Worth				**$125,577**

Cost Estimate for Alternative 2
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Description: Cost Estimate for Alternative GW-2

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

This is a problem of the form find (P given A, i, n) or (P/A,i,n)

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

P = Present Worth
A= Annual amount
i = interest rate

MNA & LTM

Years 1 - 30

n =	30	n =	0
i =	7%	i =	7%
The multiplier for $(P/A)_2$ =	12.409		0.000
Multiplier for year 1 - 30	**12.409**		

	QTY	UNIT(S)	UNIT COST	TOTAL COST
MNA and LTM	1	YR	$126,000	$126,000
SUBTOTAL				**$126,000**
Present Worth				**$1,563,539**

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CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	**COMPUTED BY :**	C.G.	**CHECKED BY:**	F.T.
JOB NO.:	101995.3323.070	**DATE :**	12/14/18	**DATE CHECKED:**	1/28/19
CLIENT:	EPA				

Description: Individual Cost Item Backup for Alternative GW-2

No. 7 **Monitored Natural Attenuation and Long Term Monitoring of Surface Water**

Number of monitoring wells	20	wells
Surface water samples	4	samples
Buildings for vapor intrusion	10	buildings
Surface water QC samples	1	samples
Number of samplers	2	people
Number of 10 hour sampling days	8	days

LTM Project management						
Project Manager	24	hr	$160	=	$	3,840
Office support	24	hr	$110	=	$	2,640
Mob/demob						
Project Manager	4	hr	$160	=	$	640
Engineer	8	hr	$110	=	$	880
Field Tech	24	hr	$85	=	$	2,040
Sampling						
Field Tech 1	80	hour	$85	=	$	6,800
Geologist	80	hour	$100	=	$	8,000
Per diem (2 people)	16	day	$298	=	$	4,768
Car rental (2 cars)	8	day	$190	=	$	1,520
Equipment & PPE	1	LS	$3,000	=	$	3,000
Shipping	8	day	$100	=	$	800
Misc	8	day	$100	=	$	800
Sampling Analysis (includes QC samples)						
Aqueous VOCs	35	ea	$120	=	$	4,200
Aqueous Metals	29	ea	$100	=	$	2,900
MEE (aq)	17	ea	$120	=	$	2,040
TOC (aq)	17	ea	$30	=	$	510
Nitrate (aq)	17	ea	$25	=	$	425
Nitrite (aq)	17	ea	$25	=	$	425
Sulfate (aq)	17	ea	$25	=	$	425
Ferrous Iron (aq)	17	ea	$18	=	$	306
Chloride (aq)	17	ea	$15	=	$	255
Alkalinity (aq)	17	ea	$20	=	$	340
Microbiology	17	ea	$800	=	$	13,600
Vapor	13	ea	$210	=	$	2,730
Data Summary						
Data validation	115	hr	$150	=	$	17,250
Tabulate the data and prepare figures	1	LS	$10,000	=	$	10,000
Prepare the data evaluation report	1	LS	$25,000	=	$	25,000

O&M of Sub-Slab Depressurization System

Assume that inspections of the sub-slab depressurization system would be conducted over 1 week per year

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Assume that minor maintenance of the sub-slab depressurization system would be required at 3 out of 5 of the buildings with sub-slab depressurization systems per year

Engineer	40	hr	$110	=	$	4,400
Field Tech	40	hr	$85	=	$	3,400
Maintenance Costs	3	ea	$400	=	$	1,200
Annual Total					**$**	**126,000**

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CDM Federal Programs Corporation

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INSTITUTIONAL CONTROLS CAPITAL COSTS: (Assumed to be Incurred During Year 0)

Community Awareness	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
General Superintendant	32	HR	$125.00	$4,000.00	Previous Work	
Project Manager	32	HR	$160.00	$5,120.00	Previous Work	
Project Engineer	32	HR	$110.00	$3,520.00	Previous Work	
Per Diem	12	DY	$94.00	$1,128.00	GSA - 2019	Standard Rate
Community Awareness Activities Allowance	1	LS	$2,000.00	$2,000.00	Allowance	Per estimator
			Subtotal	**$15,768.00**		

CAP CONSTRUCTION CAPITAL COSTS: (Assumed to be Incurred During Year 0)

Mobilization/Demobilization	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Mob/Demob - Heavy Equipment	4	EA	$3,600.00	$14,400.00	RS Means 2019	01 54 36 50 1600
Mob/Demob - Large Equipment	4	EA	$1,225.00	$4,900.00	RS Means 2019	01 54 36 50 1500
Mob/Demob - Medium Equipment	4	EA	$1,075.00	$4,300.00	RS Means 2019	01 54 36 50 1400
			Subtotal	**$23,600.00**		

Surveying	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Surveying Crew	3	AC	$6,250.00	$19,375.00	RS Means 2019	02 21 13 09 0100
Surveying Reporting Allowance	1	LS	$10,000.00	$10,000.00	Allowance	Per estimator
			Subtotal	**$29,375.00**		

Construction Safety and Traffic Control	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Sign Installation	5	EA	$121.00	$605.00	RS Means 2019	10 14 53 20 1300
Reflecting Barricade with Light	5	EA	$142.95	$714.75	Vendor Quote	Source: Global Industries, 2018
Orange Safety Fence with Post	1,000	LF	$2.04	$2,040.00	Vendor Quote	Source: Aramsco, 2018
3" x 1,000' Yellow Caution Tape	50	RL	$12.04	$602.00	Vendor Quote	Source: Aramsco, 2018
Flaggers	240	HR	$75.00	$18,000.00	Previous Work	
			Subtotal	**$21,961.75**		

Access Road Improvements	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Clearing and Grubbing	1.3	AC	$7,400.00	$9,620.00	RS Means 2019	31 11 10 10 0200
Rough Grading	1	LS	$2,400.00	$2,400.00	RS Means 2019	31 22 13 20 0250
Gravel - Hauling	2,667	LCY	$12.60	$33,604.20	RS Means 2019	31 23 23 20 1025
Gravel - Placement (incl. material)	2,667	LCY	$40.00	$106,680.00	RS Means 2019	31 05 13 10 0300
Gravel - Compaction	2,400	ECY	$0.46	$1,104.00	RS Means 2019	31 23 23 23 5040
			Subtotal	**$153,408.20**		

Erosion Control	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Silt Fence	1,000	LF	$2.17	$2,170.00	RS Means 2019	31 25 14 16 1000
Straw Bales	100	LF	$8.15	$815.00	RS Means 2019	31 25 14 16 1250
Erosion Control Blankets	2,556	SY	$5.55	$14,185.80	RS Means 2019	31 25 14 16 0120
			Subtotal	**$17,170.80**		

Power Line Protection	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Power Line Allowance	1	LS	$50,000.00	$50,000.00	Allowance	Per estimator
			Subtotal	**$50,000.00**		

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Clearing and Grubbing of Dump Areas	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Clearing and Grubbing	1.3	AC	$7,400.00	$9,620.00	RS Means 2019	31 11 10 10 0200
			Subtotal	**$9,620.00**		

Dust Control	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Watering Truck	192	HR	$70.50	$13,536.00	RS Means 2019	01 54 33 40 6950
Operator	192	HR	$90.00	$17,280.00	Previous Work	
			Subtotal	**$30,816.00**		

Cover Construction	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Rough Grading	1	LS	$5,350.00	$5,350.00	RS Means 2019	32 22 13 20 0280
Finish Grading	5,630	SY	$0.27	$1,520.10	RS Means 2019	31 22 16 10 3310
Gemembrane Placement (incl. materials and instal	55,067	SF	$0.65	$35,793.55	Vendor Quote	Agru America, 2018
Geotextile Placement (incl. materials and installati	55,067	SF	$0.35	$19,273.45	Vendor Quote	Agru America, 2018
Subsoil - Hauling	2,400	LCY	$12.60	$30,240.00	RS Means 2019	31 23 23 20 1025
Subsoil - Placement (incl. material)	2,400	LCY	$31.50	$75,600.00	RS Means 2019	31 05 16 10 0600
Subsoil - Compaction	1,700	ECY	$1.84	$3,128.00	RS Means 2019	31 23 23 23 5640
Topsoil - Hauling	1,300	LCY	$12.60	$16,380.00	RS Means 2019	31 23 23 20 1025
Topsoil - Placement (incl. material)	1,300	LCY	$38.50	$50,050.00	RS Means 2019	31 05 13 10 0800
Hydro Seed Mix with Mulch and Fertilizer	50.6	MSF	$65.00	$3,289.00	RS Means 2019	32 92 19 14 4600
Fencing	1,200.0	LF	$16.00	$19,200.00	Previous work	
			Subtotal	**$259,824.10**		

Runon/Runoff Control	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Excavation of Drainage Ditches	1,750	BCY	$7.40	$12,950.00	RS Means 2019	31 23 16 13 0062
Riprap - Hauling	1,420	LCY	$12.60	$17,892.00	RS Means 2019	31 23 23 20 1025
Riprap - Placement (incl. material)	1,420	LCY	$82.00	$116,440.00	RS Means 2019	31 37 13 10 0100
			Subtotal	**$147,282.00**		

Total Cap Construction Cost **$743,057.85**

ANNUAL OPERATION MAINTENANCE AND MONITORING (O&M) COSTS

Annual OM&M - Years 1 through 5	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Inspection						
Project Engineer	10	HR	$110.00	$1,100.00	Previous Work	
Pickup Truck, 3/4 Ton	1	DY	$58.50	$58.50	RS Means 2019	01 54 33 40 7100
Site Inspection Report						
Project Manager	12	HR	$160.00	$1,920.00	Previous Work	
Project Engineer	32	HR	$110.00	$3,520.00	Previous Work	
General Office Support	8	HR	$75.00	$600.00	Previous Work	
O&M						
Cap O&M	60	HR	$370.00	$22,200.00	Previous Work	
Seeding with push spreader	5.1	MSF	$79.50	$405.45	RS Means 2019	32 92 19 14 4400
			Subtotal	**$29,803.95**		

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	JGG	CHECKED BY:	MS
JOB NO.:	101995.3323.070	DATE :	01/10/2019	DATE CHECKED:	1/11/2019
CLIENT:	EPA			PAGE NO. :	Cost Worksheet

Annual OM&M - Years 6 through 10	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Inspection						
Project Engineer	10	HR	$110.00	$1,100.00	Previous Work	
Pickup Truck, 3/4 Ton	1	DY	$58.50	$58.50	RS Means 2019	01 54 33 40 7100
Site Inspection Report						
Project Manager	12	HR	$160.00	$1,920.00	Previous Work	
Project Engineer	32	HR	$110.00	$3,520.00	Previous Work	
General Office Support	8	HR	$75.00	$600.00	Previous Work	
O&M						
Cap O&M	40	HR	$370.00	$14,800.00	Previous Work	
Seeding with push spreader	2.5	MSF	$79.50	$198.75	RS Means 2019	32 92 19 14 4400
			Subtotal	**$22,197.25**		

Annual OM&M - Years 11 through 30	QTY	UNIT(S)	UNIT COST	TOTAL COST	COST SOURCE	COMMENTS
Inspection						
Project Engineer	10	HR	$110.00	$1,100.00	Previous Work	
Pickup Truck, 3/4 Ton	1	DY	$58.50	$58.50	RS Means 2019	01 54 33 40 7100
Site Inspection Report						
Project Manager	12	HR	$160.00	$1,920.00	Previous Work	
Project Engineer	32	HR	$110.00	$3,520.00	Previous Work	
General Office Support	8	HR	$75.00	$600.00	Previous Work	
O&M						
Cap O&M	20	HR	$370.00	$7,400.00	Previous Work	
Seeding with push spreader	1.3	MSF	$79.50	$103.35	RS Means 2019	32 92 19 14 4400
			Subtotal	**$14,701.85**		

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith CDM Federal Programs Corporation	PROJECT:	Mansfield Trail	COMPUTED BY :	JG	CHECKED BY:	MS
	JOB NO.:	101995.3323.070	DATE :	1/10/2019	DATE CHECKED:	1/11/2019
	CLIENT:	EPA			PAGE NO. :	GA

General Assumptions

Estimated Work Week and Work Day Duration

Days per work week:	5	
Hours per workday:	8	

Assumed Material Properties

Soil Bulking factor:	1.2	*Conversion from BCY to LCY*
Soil Compaction Factor:	0.9	*Conversion from BCY to ECY*
Soil Compaction Factor:	0.75	*Conversion from LCY to ECY*
Rock / Excavated Waste Bulking factor:	1.2	*Conversion from BCY to LCY*
Rock / Excavated Waste Compaction Factor:	1.08	*Conversion from BCY to ECY*
Rock / Excavated Waste Compaction Factor:	0.9	*Conversion from LCY to ECY*
Riprap Bulking Factor:	1.50	*Conversion from BCY to LCY*
Riprap Compaction Factor:	1.30	*Conversion from BCY to ECY*
Riprap Compaction Factor:	0.87	*Conversion from LCY to ECY*
Sand Bulking Factor:	1.12	*Conversion from BCY to LCY*
Sand Compaction Factor:	0.95	*Conversion from BCY to ECY*
Sand Compaction Factor:	0.85	*Conversion from LCY to ECY*
Gravel Bulking Factor:	1.12	*Conversion from BCY to LCY*
Gravel Compaction Factor:	0.95	*Conversion from BCY to ECY*
Gravel Compaction Factor:	0.85	*Conversion from LCY to ECY*

BCY - bank cubic yard - in place volume prior to excavation
LCY - loose cubic yards - volume after excavation
ECY - embankment cubic yards (aka compacted cubic yards) - volume after compaction

Density of Sand, TN/CY:	1.30	*Means Handbook, Sand, Dry*
Density of Gravel, TN/CY:	1.39	*Means Handbook, Gravel, Dry*
Density of Riprap, TN/CY:	1.50	*Means Handbook, Granite, Loose*
Density of Soil, TN/CY:	1.11	*Means Handbook, Earth, Dry*
Assumed Density of Mine Waste, TN/CY:	1.35	*Assumed*
Density of Lime Amendment, TN/CY:	1.22	*Based on density provided by lime supplier*
Assumed Sludge Specific Gravity:	1.40	*Based on density at similar site*
Assumed Density of Sludge, TN/CY:	1.18	*Assumed*

Cost Estimate for Alternative GW-2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

	Description	Cost
CAPITAL COSTS		
	Community Awareness	$16,000
	General Requirements	$773,000
	Cap Construction	$744,000
	First Year O&M	$30,000
	Subtotal	*$1,563,000*
	Contingency (20%)	$313,000
	Subtotal	*$1,876,000*
	General Contractor Bond and Insurance 5%	$93,800
	Subtotal	*$1,969,800*
	General Contractor Markup (profit) 10%	$196,980
	Total Remedial Action Capital Costs	***$2,167,000***
OPERATION AND MAINTENANCE COSTS		
	Annual OM&M for Cap	
	Present Value of Cap OM&M - Years 1 through 5	$193,812
	Present Value of Cap OM&M - Years 6 through 10	$102,916
	Present Value of Cap OM&M - Years 11 through 30	$125,577
	Subtotal	*$422,305*
	Annual Monitoring Cost for MNA and LTM	$126,000
	Present worth of Monitoring (30 Years)	$1,564,000
	Total Present Worth Costs	***$1,987,000***
PRESENT WORTH		
	Total Capital Cost	$2,167,000
	Total OM&M Cost	$1,987,000
	Total Present Worth	**$4,154,000**

Notes:

Percentages used for indirect costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

Costs presented for this alternative are expected to have an accuracy between -30% to +50% of actual costs, based on the scope presented. They are prepared solely to facilitate relative comparisons between alternatives for FS evaluation purposes.

Total present worth is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost.

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	MS
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/10/2019
CLIENT:	EPA			PAGE NO. :	1 GR

Description: Cost Estimate for Alternative GW-2

1. General Requirements

General conditions to include the project-dedicated site supervisory staff, development of work plans, site photographs/videos, project signs, insurance, mobilization/demobilization, and costs not covered elsewhere.
Estimate assumes that following the remedial design, the RA Contractor will mobilize to the site and complete the remedial action including the site preparation, SVE installation, treatment, and site restoration prior to project end.

Project Schedule

Assume the following project schedule:

Pre-Construction Work Plans and Meetings (RA Work), procurement		90	days
Field Construction:			
Mobilization - Permits and Field Trailer Compound Establishment		10	days
Site Survey		5	days
Site Preparation (Decon areas, staging area)		5	days
Cap Construction		95	days
Final Site Restoration and Demob		15	days
Total Construction Duration		130	days
Project Closeout		90	days
Total Project Duration	=	**310**	**days**
	=	**11**	**months**

General Conditions

A) Project Management and office support

Assume Project Manager and General Office Support for the duration of project, Project Engineer for duration of construction:

Project Manager (24 hours per month)	264	hr	$160	=	$42,240
Project Engineer (40 hours per month)	260	hr	$110	=	$28,600
General office support (20 hours per month)	220	hr	$75	=	$16,500
Total management and office support				=	**$87,340**

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:					6 work plans	
Estimated # of Hours Required per Work Plan:						
Project Engineer	180	hr	$110	=	$19,800	per workplan
Project Manager	20	hr	$160	=	$3,200	per workplan
Total Work Plan Preparation Cost				=	**$138,000**	

C) Permits

Permit Specialist	90	hr	$110	=	$9,900
Project Manager	40	hr	$160	=	$6,400
Total Permitting Cost				=	**$16,300**

D) Procurement

Procurement Staff	150	hr	$110	=	$16,500
Project Manager	50	hr	$160	=	$8,000
General Office Support	20	hr	$110	=	$2,200
Total procurement and office support				=	**$26,700**

E) Onsite supervisory

Assume the following full time site supervisory staff for the duration of construction:

Superintendent (8 hours per day)	1040	hr	$110	=	$114,400
HSO/QC (8 hours per day)	1040	hr	$110	=	$114,400
Site Engineer (8 hours per day)	760	hr	$110	=	$83,600
Total Onsite Supervisory Staff for Construction Duration				=	**$312,400**

Cost Estimate for Alternative 2
Capping and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	MS
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/10/2019
CLIENT:	EPA			PAGE NO. :	1 GR

F) Remedial Construction Report							
Project Manager		40	hr	$160	=	$6,400	
Project Engineer		300	hr	$110	=	$33,000	
Project Chemist		80	hr	$110	=	$8,800	
Total Remedial Construction Report Preparation Cost						**$48,200**	
G) Site Photographs/Videos		1	LS	$10,000	=	$10,000	
H) Project Signs		1	LS	$3,000	=	$3,000	
I) Other Direct Costs		1	LS	$20,000	=	$20,000	
J) Site Survey		1	LS	$40,000	=	$40,000	
SUBTOTAL GENERAL CONDITIONS						**$701,940**	
Safety and Health Requirements							
Level D PPE for all onsite staff		95	days	$100	=	$9,500	
TOTAL H&S COSTS						**$9,500**	
Temporary Fencing							
Metal/Chain Fencing		1520	LF	$8	=	$12,160	
Labor for Installation		1520	LF	$12	=	$18,240	
Total Temporary Fencing Costs						**$30,400**	
Temporary Facilities							
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.							
Mobilization/Demobilization		1	LS	$900	=	$1,000	
Utility Hookups		1	LS	$1,500	=	$1,500	
Trailer rental (2 trailer)		11	month	$500	=	$5,500	
Power draw per trailer	5	kW/hr					
Total cost of power consumption	3660	kW/month	$0.24	kW/hr	=	$18,923	for 2 trailers
Cleaning service and others		11	month	$300	=	$3,300	
TOTAL TEMPORARY FACILITY COSTS						**$30,223**	
TOTAL COST FOR GENERAL REQUIREMENTS						**$773,000**	

Cost Estimate for Alternative GW-3
Capping, SVE, and MNA
Mansfield Trail Superfund Site
New Jersey

	Description	Cost
CAPITAL COSTS		
	General Requirements	$1,252,000
	Cap Construction (from Alternative GW-2)	$744,000
	First Year cap maintenance (from Alternative GW-2)	$30,000
	SVE System Construction and Startup	$661,000
	First Year SVE Operation and Maintenance	$254,000
	Subtotal	*$2,941,000*
	Contingency 20%	$589,000
	Subtotal	*$3,530,000*
	General Contractor Bond and Insurance 5%	$177,000
	Subtotal	*$3,707,000*
	General Contractor Markup (profit) 10%	$371,000
	Total Remedial Action Capital Costs	**$4,078,000**
OPERATION MAINTENANCE AND MONITORING COSTS		
	Annual OM&M for Cap (from Alternative GW-2)	
	Present Value of Cap OM&M - Years 1 through 5	$193,812
	Present Value of Cap OM&M - Years 6 through 10	$102,916
	Present Value of Cap OM&M - Years 11 through 30	$125,577
	Subtotal	*$422,305*
	Annual SVE O&M	$146,000
	Present worth of SVE O&M Years 2-5 Operation	$463,000
	Annual Monitoring Cost for MNA and LTM (from Alternative GW-2)	$126,000
	Present worth of Monitoring (30 Years) (from Alternative GW-2)	$1,564,000
PRESENT WORTH		
	Total Capital Cost	$4,078,000
	Total OM&M Cost	$2,450,000
	Total Present Worth	**$6,528,000**

Note: The project cost presented herein represents only feasibility study level, and is thus subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost estimate is -30% to +50%. Present worth calculation assumes 7% discount rate after inflation is considered.

Cost Estimate for Alternative 3
Capping, SVE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CLIENT:	EPA				

Description: Cost Estimate for Alternative GW-3

3. SVE System Construction and Startup

Without a field test, the flow rate and vacuum for a conceptual design are not available. Therefore, costs of similar projects are used in this cost estimate.

Project Schedule

Environmental well installation	3.3	months
Treatment system construction	1.0	months
Treatment system installation	1.5	months
System startup	0.5	months
Total Construction Duration	**6.3**	**months**
	27	**weeks**

Mob/demob	1	LS	$12,000	=	$12,000
Decon pad	1	LS	$800	=	$800
Decon of equipment	8	Hr	$200	=	$1,600

Soil Vapor Extraction Well Installation

Area of Treatment Zone	46000	sq ft
Treatment zone thickness	40	ft
Radius of Influence of SVE wells	15	ft
Number of SVE well locations	66	
Number of Screened intervals per location	2	ea
Shallow zone depth	20	ft
Deep zone depth	40	ft

Drilling - 8 inch diameter Air Rotary	3960	Ft	$45	=	$178,200
2-inch PVC well screen	1320	Ft	$28	=	$36,960
2-inch PVC well casing	2640	Ft	$24	=	$63,360
Well surface completion and piping	66	ea	$500	=	$33,000
IDW handling	1	ea	$5,000	=	$5,000
IDW temporary storage and disposal	1	LS	$15,000	=	$15,000
TOTAL FOR WELL INSTALLATION					**$ 345,920**

Cost Estimate for Alternative 3
Capping, SVE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
	JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CDM Federal Programs Corporation	CLIENT:	EPA				

Above ground piping and treatment system installation

Assume the piping will convey the extracted vapor to an aboveground system housed nearby for vapor treatment.
Assume treatment system will include vacuum blower, water-air separator, and vapor phase activated carbon
Assume that any GAC treatment requires an integral humidity control unit to combat any negative effects of high temperatures and high humidity.

SVE system
Assume vacuum level is 26"HgV. Assume each well air flow rate is 20 SCFM..
Assume system comes prepackaged in Conex box.

Pre-packaged system	1	LS	$80,000	=	$80,000
GAC	1	LS	$66,413	=	$66,413
Plumbing and ducting	1	LS	$16,000	=	$16,000
Electrical Wiring and Controls	1	LS	$50,000	=	$50,000
System Installation	1	LS	$50,000	=	$50,000
TOTAL FOR ABOVEGROUND SYSTEM AND YARD PIPING					**$ 262,413**

System startup
Assume two weeks for initial startup testing, two engineers on site for two weeks, plumber and electrician onsite for two weeks

Electrician	80	hr	$110	=	$8,800
Plumber	80	hr	$110	=	$8,800
Project Engineer	80	hr	$165	=	$13,200
Environmental Engineer	80	hr	$100	=	$8,000
Vapor samples	20	ea	$220	=	$4,400
Per diem and car rental	10	day	$861	=	$8,610
TOTAL FOR SYSTEM START UP					**$ 51,810**

TOTAL SVE SYSTEM CONSTRUCTION AND START UP COSTS	**$661,000**

Cost Estimate for Alternative 3
Capping, SVE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CLIENT:	EPA				

Description: Cost Estimate for Alternative GW-3

1. General Requirements

General conditions to include the project-dedicated site supervisory staff, development of work plans, site photographs/videos, project signs, insurance, mobilization/demobilization, and costs not covered elsewhere.
Estimate assumes that following the remedial design, the RA Contractor will mobilize to the site and complete the remedial action including the site preparation, SVE installation, treatment, and site restoration prior to project end.

Project Schedule

Assume the following project schedule:

Pre-Construction Work Plans and Meetings (RA Work), procurement		90	days
Field Construction:			
Mobilization - Permits and Field Trailer Compound Establishment		20	days
Site Survey		5	days
Site Preparation (Decon areas, staging area)		5	days
Cap Construction		95	days
SVE Well and system Installation		136	days
System Start up		20	days
Final Site Restoration and Demob		15	days
Total Construction Duration		296	days
Project Closeout		90	days
Total Project Duration	=	**476**	**days**
	=	**23**	**months**

General Conditions

A) Project Management and office support

Assume Project Manager and General Office Support for the duration of project, Project Engineer for duration of construction:

Project Manager (24 hours per month)	544	hr	$160	=	$87,075
Project Engineer (40 hours per month)	907	hr	$110	=	$99,773
General office support (20 hours per month)	454	hr	$75	=	$34,014
Total management and office support				=	**$220,862**

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:					6	work plans
Estimated # of Hours Required per Work Plan:						
Project Engineer	180	hr	$110	=	$19,800	per workplan
Project Manager	20	hr	$160	=	$3,200	per workplan
Total Work Plan Preparation Cost				=	**$138,000**	

C) Permits

Permit Specialist	90	hr	$110	=	$9,900
Project Manager	40	hr	$160	=	$6,400
Total Permitting Cost				=	**$16,300**

D) Procurement

Procurement Staff	150	hr	$110	=	$16,500
Project Manager	50	hr	$160	=	$8,000
General Office Support	20	hr	$110	=	$2,200
Total procurement and office support				=	**$26,700**

Cost Estimate for Alternative 3
Capping, SVE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CLIENT:	EPA				

E) Onsite supervisory						
Assume the following full time site supervisory staff for the duration of construction:						
Supervisor (8 hours per day)	2368	hr	$110	=	$260,480	
HSO/QC (8 hours per day)	2368	hr	$110	=	$260,480	
Geologist (8 hours per day)	1088	hr	$110	=	$119,680	
Total Onsite Supervisory Staff for Construction Duration				=	**$640,640**	
F) Remedial Construction Report						
Project Manager	40	hr	$160	=	$6,400	
Project Engineer	300	hr	$110	=	$33,000	
Project Chemist	80	hr	$110	=	$8,800	
Total Remedial Construction Report Preparation Cost					**$48,200**	
G) Site Photographs/Videos	1	LS	$10,000	=	$10,000	
H) Project Signs	1	LS	$3,000	=	$3,000	
I) Other Direct Costs	1	LS	$20,000	=	$20,000	
J) Site Survey	1	LS	$40,000	=	$40,000	
SUBTOTAL GENERAL CONDITIONS					**$1,163,702**	
Safety and Health Requirements						
Assume the superintendent will serve as the Site Health and Safety Officer (SHSO):						
Level D PPE for all onsite staff	296	days	$100	=	$29,619	
TOTAL H&S COSTS					**$29,619**	
Temporary Fencing						
Metal/Chain Fencing	1520	LF	$8	=	$12,160	
Labor for Installation	1520	LF	$12	=	$18,240	
Total Temporary Fencing Costs					**$30,400**	
Temporary Facilities						
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.						
Mobilization/Demobilization	1	LS	$900	=	$1,000	
Utility Hookups	1	LS	$1,500	=	$1,500	
Trailer rental (2 trailer)	14	month	$1,000	=	$13,671	
Power draw per trailer	5	kW/hr				
Total cost of power consumption	1830	kW/month	$0.15	kW/hr	=	$7,506	for 2 trailers
Cleaning service and others	14	month	$300	=	$4,102	
TOTAL TEMPORARY FACILITY COSTS					**$27,779**	
TOTAL COST FOR GENERAL REQUIREMENTS					**$1,252,000**	

Cost Estimate for Alternative 3
Capping, SVE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT: Mansfield Trail	COMPUTED BY : C.G.	CHECKED BY: F.T.
CDM Federal Programs Corporation	JOB NO.: 101995.3323.070	DATE : 12/14/18	DATE CHECKED: 1/28/19
	CLIENT: EPA		

Description: Cost Estimate for Alternative GW-3

4. First Year Operations, Maintenance and Monitoring of SVE System

Costs of similar projects are used
Assume two systems operating with a 10 HP blower; each system requires 7 carbon changes per year.
Assume one operator will check the system once per week, assume weekly samples of vapor influent/effluent per week for first three months, then monthly samples thereafter

Power Cost for Both Systems

Blower horsepower	10	HP				
System power draw	5	kW				
Total power draw	12.5	kW				
Total cost of power consumption/year	109,500	kW/year	$0.15	kW/hr	=	$16,425
Carbon changeout	1	LS	$35,000		=	$35,000
					subtotal	$51,425

	Quantity	Unit	Systems	Unit Cost		Extended Cost
Operation of SVE systems	1	LS	1	$51,425	=	$51,425
One operator	416	hr	1	$90	=	$37,440
Supervisor for management	96	hr	1	$125	=	$12,000
SVE operation maintenance	1	LS	1	$10,000	=	$10,000
Monthly reporting	16	hr	1	$110	=	$1,760
Vapor samples	72	ea	1	$220	=	$15,840

Performance Evaluation

Assume performance evaluation based solely on SVE system influent samples due to difficulty collecting representative samples of the fractured bedrock.

	Quantity	Unit	Unit Cost		Extended Cost
Data Validation and Management					
Assume 0.75 hr per sample					
Samples management/validation	54	hr	$110	=	$5,940
Sampling Report					
Project Manager	16	hr	$160	=	$2,560
Environmental Engineer	60	hr	$110	=	$6,600
Geologist	50	hr	$110	=	$5,500
Admin Clerk	16	hr	$75	=	$1,200
TOTAL FOR FIRST YEAR OM&M COSTS					**$254,000**

5. Annual Operations, Maintenance and Monitoring of SVE System

Costs of similar projects are used
Assume two systems operate for year 2-5
Assume one operator will check the system once per week, assume influent vapor sample quarterly, effluent vapor samples after lead GAC and after Lag GAC once per month

	Quantity	Unit	Systems	Unit Cost		Extended Cost
Maintenance of SVE system	1	LS	1	$25,712.50	=	$25,713
Carbon changeout	1	LS	1	$20,000	=	$20,000
One operator	416	hr	1	$100	=	$41,600
Supervisor for management	120	hr	1	$125	=	$15,000
SVE operation optimization	1	LS	1	$10,000	=	$10,000
Monthly reporting	10	hr	1	$110	=	$1,100
Vapor samples	52	ea	1	$220	=	$11,440

Cost Estimate for Alternative 3
Capping, SVE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CLIENT:	EPA				

Performance Evaluation

Assume performance evaluation based solely on SVE system influent samples due to difficulty collecting representative samples of the fractured bedrock.

	Quantity	Unit	Unit Cost		Extended Cost
Data Validation and Management					
Assume 0.75 hr per sample					
Samples management/validation	39	hr	$110	=	$4,290
Sampling Report					
Project Manager	16	hr	$160	=	$2,560
Environmental Engineer	60	hr	$110	=	$6,600
Geologist	50	hr	$110	=	$5,500
Admin Clerk	16	hr	$75	=	$1,200
TOTAL FOR ANNUAL INTERMITTENT OM&M COSTS					**$146,000**

Cost Estimate for Alternative GW-3
Capping, SVE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CLIENT:	EPA				

Description: Cost Estimate for Alternative GW-3

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

This is a problem of the form find (P given A, i, n) or (P/A,i,n)

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

P = Present Worth
A= Annual amount
i = interest rate

Multiplier is (P/A) for five years minus (P/A) for year 1)

n = 10
i = 7%

OM&M SVE for Years 2-5

n =	5	n =	1
i =	7%	i =	7%
The multiplier for $(P/A)_2$ =	4.100		0.935
Multiplier for year 2-5	**3.166**		

Cost Estimate for Alternative GW-4
Capping, SVE, In Situ Treatment, MNA
Mansfield Trail Superfund Site
New Jersey

Ref	Description	Cost
CAPITAL COSTS		
	General Requirements	$1,787,000
	Cap Construction (from Alternative GW-2)	$744,000
	First year Cap O&M (from Alternative GW-2)	$30,000
	SVE Construction (from Alternative GW-3)	$661,000
	First year SVE O&M (from Alternative GW-3)	$254,000
	In Situ Treatment	$1,024,000
	First Year In Situ Treatment Performance Monitoring	$124,000
	Subtotal	*$4,624,000*
	Contingency 20%	$925,000
	Subtotal	*$5,549,000*
	General Contractor Bond and Insurance 5%	$278,000
	Subtotal	*$5,827,000*
	General Contractor Costs (Profit) 10%	$583,000
	Total Remedial Action Capital Costs	**$6,410,000**
OPERATION AND MAINTENANCE COSTS		
	Annual OM&M for Cap (from Alternative GW-2)	
	Present Value of Cap OM&M - Years 1 through 5	$193,812
	Present Value of Cap OM&M - Years 6 through 10	$102,916
	Present Value of Cap OM&M - Years 11 through 30	$125,577
	Subtotal	*$422,305*
	Annual O&M for SVE System Operation Year 2-5 (from Alternative GW-3)	$146,000
	Present worth of O&M Years 2-5 Operation (from Alternative GW-3)	*$463,000*
	Annual In Situ Treatment Performance Monitoring Year 2-5	$77,700
	Present worth of In Situ Treatment Performance Monitoring	*$246,000*
	Annual Monitoring Cost for MNA and LTM (from Alternative GW-2)	$126,000
	Present worth of Monitoring (30 Years) (from Alternative GW-2)	*$1,564,000*
PRESENT WORTH		
	Total Capital Cost	$6,410,000
	Total OM&M Cost	$2,696,000
	Total Present Worth	**$9,106,000**

Note: The project cost presented herein represents only feasibility study level, and is thus subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost estimate is -30% to +50%. Present worth calculation assumes 7% discount rate after inflation is considered.

Cost Estimate for Alternative 4
Capping, SVE, and In Situ Treatment
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	70	DATE :	12/13/18	DATE CHECKED:	1/28/2019
CLIENT:	USEPA				

Description: Cost Estimate for Alternative GW-4
8. General Requirements for In Situ Treatment

Assume amendments will be distributed via an injection/extraction well combination

Project Schedule
Assume the following project schedule:

Pre-Construction Work Plans and Meetings (RA Work), procurement		90	days
Field Construction			
Mobilization - Field Trailer Compound Establishment		10	days
Cap construction		95	days
SVE Well and system installation		136	days
SVE system startup		20	days
In Situ Treatment		176	days
Final Site Restoration and Demob		15	days
Total Construction Duration		452	days
Project Closeout		90	days
Total Project Duration	=	**632**	**days**
	=	**30**	**months**

General Conditions
A) Project Management and office support
Assume Project Manager and General Office Support for the duration of project, Project Engineer for duration of construction:

Project Manager (24 hours per month)	722	hr	$160	=	$115,528
Project Engineer (40 hours per month)	1,203	hr	$110	=	$132,376
General office support (20 hours per month)	602	hr	$75	=	$45,128
Total management and office support				=	**$293,033**

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:					6 work plans	
Estimated # of Hours Required per Work Plan:						
Project Engineer	220	hours at	$110	per hour	$24,200	per workplan
Project Manager	30	hours at	$160	per hour	$4,800	per workplan
Total Work Plan Preparation Cost				=	**$174,000**	

C) Permits

Permit Specialist	90	hr	$110	=	$9,900
Project Manager	40	hr	$160	=	$6,400
Total Permitting Cost				=	**$16,300**

D) Procurement

Procurement Staff	150	hr	$110	=	$16,500
Project Manager	50	hr	$160	=	$8,000
General Office Support	20	hr	$110	=	$2,200
Total procurement and office support				=	**$26,700**

Cost Estimate for Alternative 4
Capping, SVE, and In Situ Treatment
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	70	DATE :	12/13/18	DATE CHECKED:	1/28/2019
CLIENT:	USEPA				

E) Onsite supervisory							
Assume the following full time site supervisory staff for the duration of construction:							
Supervisor (8 hours per day)		3616	hr	$110	=	$397,760	
HSO/QC (8 hours per day)		3616	hr	$110	=	$397,760	
Resident engineer (8 hours per day)		2656	hr	$110	=	$292,160	
Total Onsite Supervisory Staff for Construction Duration					=	**$1,087,680**	
F) Remedial Construction Report							
Project Manager		40	hr	$160	=	$6,400	
Project Engineer		300	hr	$110	=	$33,000	
Project Chemist		80	hr	$110	=	$8,800	
Total Remedial Construction Report Preparation Cost						**$48,200**	
G) Site Photographs/Videos		1	LS	$10,000	=	$10,000	
G) Other Direct Costs		1	LS	$15,000	=	$15,000	
H) Site Survey		1	LS	$8,000	=	$8,000	
SUBTOTAL GENERAL CONDITIONS						**$1,678,913**	
Safety and Health Requirements							
Assume the superintendent will serve as the Site Health and Safety Officer (SHSO):							
Level D PPE for all onsite staff		452	days	$100	=	$45,180	
TOTAL H&S COSTS						**$45,180**	
Temporary Fencing							
Metal/Chain Fencing		1520	LF	$8	=	$12,160	
Labor for Installation		1520	LF	$12	=	$18,240	
Total Temporary Fencing Costs						**$30,400**	
Temporary Facilities							
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.							
Mobilization/Demobilization		1	LS	$900	=	$1,000	
Utility Hookups		1	LS	$1,500	=	$1,500	
Trailer rental (2 trailer)		22	month	$500	=	$11,000	
Power draw per trailer	5	kW/hr					
Total cost of power consumption	1830	kW/month	$0.15	kW/hr	=	$12,078	for 2 trailers
Cleaning service and others		22	month	$300	=	$6,600	
TOTAL TEMPORARY FACILITY COSTS						**$32,178**	
TOTAL COST FOR GENERAL REQUIREMENTS						**$1,787,000**	

Cost Estimate for Alternative 4
Capping, SVE, and In Situ Treatment
Mansfield Trail Superfund Site
New Jersey

CDM Smith

CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	70	DATE :	12/13/18	DATE CHECKED:	1/28/19
CLIENT:	EPA				

Description: Individual Cost Item Backup for Alternative GW-4

	Quantity	Unit	Unit Cost		Extended Cost
9. In Situ Treatment					
A Amendment Injection					
Assume amenmdent distributed in subsurface through an injection/extraction well combination					
Assume only one round of injection will be performed					
Square Footage of Treatment Zone	46,000	ft^2			
Total Depth	125	ft			
Injected thickness (fractured bedrock)	75	ft			
Distance between boreholes	25.0	ft			
Number of boreholes	94	boreholes			
Number of fractures in injection zone	100	fractures			
Average fracture aperture	0.0006	ft			
Injection zone effective pore volume	2,760	ft^3			
	20,645	gallons			
Injection volume per borehole	220	gallons			
Injected volume per two foot interval	1	gallons			
Assume injection rate at 5 gpm, time per interval	0	minutes			
Total number of two foot intervals	3,516	intervals			
Intervals per day, assuming 4x manifolding	20	intervals			
Days for injections	176	days			
Well Installation and IDW					
Assume boreholes are drilled with air rotary and lined with flexible liner					
Mob/demob	1	LS	$1,500	=	$ 1,500
Drilling Crew Per Diem	176	per day	$300	=	$ 52,739
Decon pad	1	LS	$500	=	$ 500
Steam cleaning	20	hours	$225	=	$ 4,500
Drilling - 8 inch diameter Air Rotary	11720	ft	$45	=	$ 527,389
FLUTe liner	94	ea	$1,900	=	$ 178,140
Well development (8 hours per well)	750	hours	$95	=	$ 71,256
Well surface completion	94	ea	$400	=	$ 37,503
Transport/handling IDWs	20	hours	$175	=	$ 3,500
Site restoration	1	LS	$1,500		$ 1,500
IDW temporary storage and disposal	1	LS	$15,000	=	$ 15,000
Subtotal					$ 893,527
Amendment Injections					
Amendment + injection services (turnkey)	21,677	gal	$3	=	$65,031
Injection rounds	2	rounds			
					$130,062.24
Total for In Situ Treatment					**$1,023,589**
Total In Situ Treatment					**$ 1,024,000**

Cost Estimate for Alternative 4
Capping, SVE, and In Situ Treatment
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	70	DATE :	12/13/18	DATE CHECKED:	1/28/19
CLIENT:	USEPA				

Description: Individual Cost Item Backup for Alternative GW-4

No. 10 **First Year In Situ Treatment Performance Monitoring**

Costs per Round

	Quantity	Unit	Unit Cost		Extended Cost
Number of groundwater samples	12	samples			
Number of samplers	2	people			
Number of GW sampling days	3	days			
Sampling Project Planning (e.g., Staffing, Lab Procurement, Obtaining Equipment)					
Project Manager	10	hr	$160	=	$1,600
Geologist	30	hr	$110	=	$3,300
Procurement Specialist	20	hr	$110	=	$2,200
Field Sampling Labor					
Mob/demob	60	hr	$110	=	$6,600
Sampling	72	hr	$110	=	$7,920
Travel Expense and per Diem					
Van and car rental	3	day	$95	=	$285
Per diem	3	day	$288	=	$864
Sampling Equipment, Shipping, Consumable Supplies					
Equipment & PPE	1	ea	$3,500	=	$3,500
Shipping	3	day	$200	=	$600
Misc	3	day	$200	=	$600
Sampling Analysis					
VOCs	19	ea	$120	=	$2,280
MEE (aq)	19	ea	$120	=	$2,280
TOC (aq)	13	ea	$30	=	$390
Nitrate/nitrite (aq)	13	ea	$25	=	$325
Sulfate (aq)	13	ea	$25	=	$325
Ferrous Iron (aq)	13	ea	$18	=	$234
Chloride (aq)	13	ea	$15	=	$195
Alkalinity (aq)	13	ea	$20	=	$260
Data Validation and Management					
Assume 0.75 hr per sample					
Samples management/validation	87	hr	$110	=	$9,570
Sampling Report					
Project Manager	16	hr	$160	=	$2,560
Environmental Engineer	100	hr	$110	=	$11,000
Geologist	25	hr	$110	=	$2,750
Admin Clerk	20	hr	$75	=	$1,500
Total In Situ Treatment Sampling Event Cost					$62,000
Total In Situ Treatment Performance Monitoring (First Year, Two Events)				**$**	**124,000**

Cost Estimate for Alternative 4
Capping, SVE, and In Situ Treatment
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	70	DATE :	12/13/18	DATE CHECKED:	1/28/19
CLIENT:	USEPA				

Description: Individual Cost Item Backup for Alternative GW-4

No. 10	**Annual In Situ Treatment Monitoring (2-5 Years)**					
	Assume sampling will be performed once per year					
	Project Manager	20	hr	$160	=	$3,200
	Geologist/Engineer	100	hr	$110	=	$11,000
	Admin clerk	20	hr	$75	=	$1,500
	Sampling and Reporting	1	LS	$62,000	=	$62,000
	Total Annual In Situ Treatment Performance Monitoring					**$77,700**

Cost Estimate for Alternative 4
Capping, SVE, and In Situ Treatment
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	70	DATE :	12/13/18	DATE CHECKED:	1/28/19
CLIENT:	USEPA				

Description: Cost Estimate for Alternative GW-4

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

This is a problem of the form find (P given A, i, n) or (P/A,i,n)

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

P = Present Worth
A= Annual amount
i = interest rate

Multiplier is (P/A) for five years minus (P/A) for year 1)

n = 10
i = 7%

O&M SVE for Years 2-5

n =	5	n =	1
i =	7%	i =	7%
The multiplier for $(P/A)_2$ =	**4.100**		0.935
Multiplier for year 2-5	**3.166**		

Performance Evaluation

$$P/F = (1+i)^{-n}$$

n = 5
i = 7%
The multiplier for $(P/A)_2$ = **0.713**

MNA & LTM

Years 1 - 30

n =	30	n =	0
i =	7%	i =	7%
The multiplier for $(P/A)_2$ =	12.409		0.000
Multiplier for year 1 - 30	**12.409**		

Cost Estimate for Alternative GW-5
Capping, DPE, and MNA
Mansfield Trail Superfund Site
New Jersey

	Description	Cost
CAPITAL COSTS		
	General Requirements	$1,206,000
	Cap Construction (from Alternative GW-2)	$744,000
	First Year cap maintenance (from Alternative GW-2)	$30,000
	DPE System Construction and Startup	$1,311,000
	First Year DPE Operation and Maintenance	$262,000
	Subtotal	*$3,553,000*
	Contingency 20%	$711,000
	Subtotal	*$4,264,000*
	General Contractor Bond and Insurance 5%	$214,000
	Subtotal	*$4,478,000*
	General Contractor Markup (profit) 10%	$359,000
	Total Remedial Action Capital Costs	**$4,837,000**
OPERATIONS, MONITORING & MAINTENANCE COSTS		
	Annual OM&M for Cap (from Alternative GW-2)	
	Present Value of Cap OM&M - Years 1 through 5	$193,812
	Present Value of Cap OM&M - Years 6 through 10	$102,916
	Present Value of Cap OM&M - Years 11 through 30	$125,577
	Subtotal	*$422,305*
	Annual OM&M for DPE System Operating Intermittently	$172,000
	Present worth of OM&M Years 2-10 Operation	$1,048,000
	Annual Monitoring Cost for MNA and LTM (from Alternative GW-2)	$126,000
	Present worth of Monitoring (30 Years) (from Alternative GW-2)	$1,564,000
PRESENT WORTH		
	Total Capital Cost	$4,837,000
	Total OM&M Cost	$3,035,000
	Total Present Worth	**$7,872,000**

Note: The project cost presented herein represents only feasibility study level, and is thus subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost estimate is -30% to +50%. Present worth calculation assumes 7% discount rate after inflation is considered.

Cost Estimate for Alternative 5
Capping, DPE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT: Mansfield Trail	COMPUTED BY : C.G.	CHECKED BY: F.T.
CDM Federal Programs Corporation	JOB NO.: 101995.3323.070	DATE : 12/14/18	DATE CHECKED: 1/28/19
	CLIENT: EPA		

Description: Cost Estimate for Alternative GW-5

1. General Requirements

General conditions to include the project-dedicated site supervisory staff, development of work plans, site photographs/videos, project signs, insurance, mobilization/demobilization, and costs not covered elsewhere.
Estimate assumes that following the remedial design, the RA Contractor will mobilize to the site and complete the remedial action including the site preparation, DPE installation, treatment, and site restoration prior to project end.

Project Schedule

Assume the following project schedule:

Pre-Construction Work Plans and Meetings (RA Work), procurement		90	days
Field Construction Duration			
Mobilization - Permits and Field Trailer Compound Establishment		10	days
Site Survey		5	days
Site Preparation (Decon areas, staging area)		5	days
Cap installation		95	days
Drilling and Installation		140	days
System Start up		20	days
Final Site Restoration and Demob		15	days
Total Construction Duration		290	days
Project Closeout		90	days
Total Project Duration	=	**470**	**days**
	=	**22**	**months**

General Conditions

A) Project Management and office support

Assume Project Manager and General Office Support for the duration of project, Project Engineer for duration of construction:

Project Manager (24 hours per month)	537	hr	$160	=	$85,897
Project Engineer (40 hours per month)	895	hr	$110	=	$98,424
General office support (20 hours per month)	447	hr	$75	=	$33,554
Total management and office support				=	**$217,875**

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:					6 work plans	
Estimated # of Hours Required per Work Plan:						
Project Engineer	180	hr	$110	=	$19,800	per workplan
Project Manager	20	hr	$160	=	$3,200	per workplan
Total Work Plan Preparation Cost				=	**$138,000**	

C) Permits

Permit Specialist	90	hr	$110	=	$9,900
Project Manager	40	hr	$160	=	$6,400
Total Permitting Cost				=	**$16,300**

D) Procurement

Procurement Staff	150	hr	$110	=	$16,500
Project Manager	50	hr	$160	=	$8,000
General Office Support	20	hr	$110	=	$2,200
Total procurement and office support				=	**$26,700**

Cost Estimate for Alternative 5
Capping, DPE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.
JOB NO.:	101995.3323.070	DATE :	12/14/18
CLIENT:	EPA		
CHECKED BY:	F.T.		
DATE CHECKED:	1/28/19		

E) Onsite supervisory							
Assume the following full time site supervisory staff for the duration of construction:							
Supervisor		2320	hr	$110	=	$255,200	
HSO/QC		2320	hr	$110	=	$255,200	
Geologist		1120	hr	$110	=	$123,200	
Total Onsite Supervisory Staff for Construction Duration					=	**$633,600**	
F) Remedial Construction Report							
Project Manager		40	hr	$160	=	$6,400	
Project Engineer		300	hr	$110	=	$33,000	
Project Chemist		80	hr	$110	=	$8,800	
Total Remedial Construction Report Preparation Cost						**$48,200**	
G) Site Photographs/Videos		1	LS	$2,000	=	$2,000	
H) Project Signs		1	LS	$3,000	=	$3,000	
I) Other Direct Costs		1	LS	$20,000	=	$20,000	
J) Site Survey		1	LS	$10,000	=	$10,000	
SUBTOTAL GENERAL CONDITIONS						**$1,115,675**	
Safety and Health Requirements							
Assume the superintendent will serve as the Site Health and Safety Officer (SHSO):							
Level D PPE for all onsite staff		160	days	$100	=	$15,975	
TOTAL H&S COSTS						**$15,975**	
Temporary Fencing							
Metal/Chain Fencing		1520	LF	$8	=	$12,160	
Labor for Installation		1520	LF	$12	=	$18,240	
Total Temporary Fencing Costs						**$30,400**	
Temporary Facilities							
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.							
Mobilization/Demobilization		1	LS	$900	=	$1,000	
Utility Hookups		1	LS	$1,500	=	$1,500	
Trailer rental (2 trailer)		22	month	$500	=	$11,185	
Power draw per trailer	5	kW/hr					
Total cost of power consumption	3660	kW/month	$0.14	kW/hr	=	$22,924	for 2 trailers
Cleaning service and others		22	month	$300	=	$6,711	
TOTAL TEMPORARY FACILITY COSTS						**$43,320**	
TOTAL COST FOR GENERAL REQUIREMENTS						**$1,206,000**	

Cost Estimate for Alternative 5
Capping, DPE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
	JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CDM Federal Programs Corporation	CLIENT:	EPA				

Description: Cost Estimate for Alternative GW-5

3. DPE System Construction and Startup

Without a field test, the flow rate and vacuum for a conceptual design are not available. Therefore, costs of similar projects are used in this cost estimate.

Project Schedule

Environmental well installation	3.5	months
Treatment system construction	1.0	months
Treatment system installation	1.5	months
System startup	0.5	months
Total Construction Duration	**6.5**	**months**
	28	**weeks**

Mob/demob	1	LS	$12,000	=	$12,000
Decon pad	1	LS	$800	=	$800
Decon of equipment	8	Hr	$200	=	$1,600

DPE Well Installation

Area of Treatment Zone	46000	sq ft
Treatment zone thickness	40	ft
Radius of Influence of SVE	15	ft
Number of SVE well locations	66	wells
Assume half of locations are GW extraction	33	wells
Total number of screened intervals	99	ea
SVE screen depth	30	ft
GW extraction screen depth	125	ft

Drilling - 10 inch diameter Air Rotary	6105	Ft	$60	=	$366,300
2-inch PVC well screen	2640	Ft	$28	=	$73,920
2-inch PVC well casing	3465	Ft	$24	=	$83,160
Well surface completion and piping	66	ea	$500	=	$33,000
Well development and surface completion	66	ea	$400	=	$26,400
IDW handling	20	hrs	$175	=	$3,500
IDW temporary storage and disposal	1	LS	$15,000	=	$15,000
TOTAL FOR WELL INSTALLATION					**$ 615,680**

Cost Estimate for Alternative 5
Capping, DPE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
	JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CDM Federal Programs Corporation	CLIENT:	EPA				

Above ground piping and treatment system installation

Assume the piping will convey the extracted vapor to an aboveground system housed nearby for vapor treatment.
Assume treatment system will include vacuum blower, water-air separator, and vapor phase activated carbon
Assume that any GAC treatment requires an integral humidity control unit to combat any negative effects of high temperatures and high humidity.

DPE system
Assume vacuum level is 26"HgV. Assume each well air flow rate is 20 SCFM
Assume GW extraction at 1 gallon per minute per well
Assume system comes prepackaged in Conex box.

Pre-packaged vapor treatment system	1	LS	$80,000	=	$80,000
Advanced Oxidation water trmt system	1	LS	$273,000	=	$273,000
GAC	1	LS	$115,000	=	$115,000
Plumbing and ducting	1	LS	$25,000	=	$25,000
Discharge connection	1	LS	$50,000		$50,000
Electrical Wiring and Controls	1	LS	$50,000	=	$50,000
System Installation	1	LS	$50,000	=	$50,000
TOTAL FOR ABOVEGROUND SYSTEM AND PIPING					**$ 643,000**

System startup
Assume two weeks for initial startup testing, two engineers on site for two weeks, plumber and electrician onsite for two weeks

Electrician	80	hr	$110	=	$8,800
Plumber	80	hr	$110	=	$8,800
Project Engineer	80	hr	$165	=	$13,200
Environmental Engineer	80	hr	$100	=	$8,000
Vapor samples	20	ea	$220	=	$4,400
Per diem and car rental	10	day	$861	=	$8,610
TOTAL FOR SYSTEM START UP					**$ 51,810**

TOTAL DPE SYSTEM CONSTRUCTION AND START UP COSTS	**$1,311,000**

Cost Estimate for Alternative 5
Capping, DPE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT: Mansfield Trail	COMPUTED BY : C.G.	CHECKED BY: F.T.
CDM Federal Programs Corporation	JOB NO.: 101995.3323.070	DATE : 12/14/18	DATE CHECKED: 1/28/19
	CLIENT: EPA		

Description: Cost Estimate for Alternative GW-5

4. First Year Operations, Maintenance and Monitoring of DPE System

Costs of similar projects are used
Assume two systems operating with a 10 HP blower; each system requires 7 carbon changes per year.
Assume one operator will check the system once per week, assume weekly samples of vapor influent/effluent per week for first three months, then monthly samples thereafter

System Operation

Blower horsepower	10	HP				
System power draw	7.5	kW				
GW Pumps power draw	5	kW				
Total power draw	20	kW				
Total cost of power consumption/year	175,200	kW/year	$0.15	kW/hr	=	$26,280
Carbon changeout	1	LS	$50,000		=	$50,000
Peroxide	436	gal	$2.50	$/gal	=	$1,090
UV lamps changeout	14	lamps	$352	$/lamp	=	$4,928

	Quantity	Unit	Unit Cost		Extended Cost
Operation of DPE systems	1	LS	$76,280	=	$76,280
One operator	416	hr	$90	=	$37,440
Supervisor for management	96	hr	$125	=	$12,000
DPE operation maintenance	1	LS	$10,000	=	$10,000
Monthly reporting	16	hr	$110	=	$1,760
Vapor samples	72	ea	$220	=	$15,840
Water samples	72	ea	$60	=	$4,320

Performance Evaluation

Assume performance evaluation based solely on SVE system influent samples due to difficulty collecting representative samples of the fractured bedrock.

	Quantity	Unit	Unit Cost		Extended Cost
Data Validation and Management					
Assume 0.75 hr per sample					
Samples management/validation	54	hr	$110	=	$5,940
Sampling Report					
Project Manager	16	hr	$160	=	$2,560
Environmental Engineer	60	hr	$110	=	$6,600
Geologist	50	hr	$110	=	$5,500
Admin Clerk	16	hr	$75	=	$1,200

TOTAL FOR FIRST YEAR OM&M COSTS **$262,000**

5. Annual Operations, Maintenance and Monitoring of DPE System

Costs of similar projects are used
Assume two systems operate for year 2-5
Assume one operator will check the system once per week, assume influent vapor sample quarterly, effluent vapor samples after lead GAC and after Lag GAC once per month

	Quantity	Unit	Unit Cost		Extended Cost
O&M of DPE system	1	LS	$32,298	=	$32,298
Carbon changeout	1	LS	$30,000	=	$30,000
One operator	416	hr	$100	=	$41,600
Supervisor for management	120	hr	$125	=	$15,000
SVE operation optimization	1	LS	$10,000	=	$10,000
Monthly reporting	8	hr	$110	=	$880
Water samples	72	ea	$60	=	$4,320
Vapor samples	72	ea	$220	=	$15,840

Performance Evaluation

Cost Estimate for Alternative 5
Capping, DPE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CLIENT:	EPA				

Assume performance evaluation based solely on SVE system influent samples due to difficulty collecting representative samples of the fractured bedrock. Groundwater performance evaluated using MNA samples.

	Quantity	Unit	Unit Cost		Extended Cost
Data Validation and Management					
Assume 0.75 hr per sample					
Samples management/validation	54	hr	$110	=	$5,940
Sampling Report					
Project Manager	16	hr	$160	=	$2,560
Environmental Engineer	60	hr	$110	=	$6,600
Geologist	50	hr	$110	=	$5,500
Admin Clerk	16	hr	$75	=	$1,200
TOTAL FOR ANNUAL INTERMITTENT OM&M COSTS					**$172,000**

Cost Estimate for Alternative 5
Capping, DPE, and MNA
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	C.G.	CHECKED BY:	F.T.
	JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/19
CDM Federal Programs Corporation	CLIENT:	EPA				

Description: Cost Estimate for Alternative GW-5

PRESENT WORTH CALCULATIONS

Assume discount rate is 7%:

This is a recurring cost every year for n years.

This is a problem of the form find (P given A, i, n) or (P/A,i,n)

$$P = A \times \frac{(1+i)^n - 1}{i(1+i)^n}$$

P = Present Worth
A= Annual amount
i = interest rate

Multiplier is (P/A) for five years minus (P/A) for year 1)

n =	10	n =	1
i =	7%	i =	7%
The multiplier for $(P/A)_2$ =	7.024		0.935
Multiplier for year 2-5	**6.089**		

OM&M DPE for Years 2-10

Cost Estimate for Alternative S-2
Capping
Mansfield Trail Superfund Site
New Jersey

	Description	Cost
CAPITAL COSTS		
01	General Requirements	$607,000
02	Site Preparation/Site Work	$118,000
03	Cap Construction	$424,150
04	Excavation, Backfill, Transportation and Disposal	$60,000
	Subtotal	*$1,209,150*
	Contingency (30%: 20% scope + 10% bid contingency)	$363,000
	Subtotal	*$1,632,150*
	General Contractor Markup (profit) 10%	$163,215
	Total Remedial Action Capital Costs	**$1,796,000**
OPERATION AND MAINTENANCE COSTS		
05	Annual Inspection, Operations, and Maintenance for Cap	$54,000
	Present worth of Inspection, Operations, and Maintenance (30 years)	*$670,100*
PRESENT WORTH		
	Total Capital Cost	$1,796,000
	Total O&M Cost	$671,000
	Total Present Worth	**$2,467,000**

Note: Percentages used for indirect costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.

The project cost presented herein represents only feasibility study level, and is thus subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost estimate is -30% to +50%. Present worth calculation assumes 7% discount rate after inflation is considered.

Total present worth is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost.

Cost Estimate for Non-VOC Alternative 2
Capping
Mansfield Trail Superfund Site
New Jersey

CDM Smith CDM Federal Programs Corporation	PROJECT:	Mansfield Trail	COMPUTED BY :	Y.L	CHECKED BY: F.T.
	JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED: 1/28/2019
	CLIENT:	EPA			

Description: FS Cost Estimate for Alternative S-2 - Individual Cost Item Backup

1. General Requirements

General conditions to include the project-dedicated site supervisory staff, development of work plans, site photographs/videos, project signs, insurance, mobilization/demobilization, and costs not covered elsewhere.

Estimate assumes that following the remedial design, the RA Contractor will mobilize to the site and complete the remedial action including the site preparation, cap installation, and site restoration prior to project end.

Project Schedule						
Assume the following project schedule:						
Pre-construction work plans and meetings			3	months		
Field Construction:						
Field mobilization (permits and trailer compound establishment)			0.5	months		
Site Preparation			0.5	months		
Cap Installation and Excavation, Backfill, Transportation and Disposal			3	months	10	weeks
Final Site Restoration and Demob			1	months		
Total Construction Duration			**5**	**months**	**22**	**weeks**
Project Closeout			1	months		
Total Project Duration		=	**9**	**months**		
General Conditions						
A) Project Management and office support						
Assume Project Manager and General Office Support for the duration of project, Project Engineer for duration of construction:						
Project Manager (24 hours per month)	216	hr	$160	=	$34,560	
Project Engineer (40 hours per month)	10	hr	$110	=	$1,100	
General office support (20 hours per month)	180	hr	$75	=	$13,500	
Total management and office support				=	**$49,160**	
B) Work Plan Preparation						
Estimated # of Pre-Construction Work Plans Required:					4 work plans	
Estimated # of Hours Required per Work Plan:						
Project Engineer	180	hr	$110	=	$19,800	per workplan
Project Manager	20	hr	$160	=	$3,200	per workplan
Total Work Plan Preparation Cost				=	**$92,000**	
C) Permits						
Permit Specialist	90	hr	$110	=	$9,900	
Project Manager	40	hr	$160	=	$6,400	
Total Permitting Cost				=	**$16,300**	
D) Procurement						
Procurement Staff	150	hr	$110	=	$16,500	
Project Manager	50	hr	$160	=	$8,000	
General Office Support	20	hr	$110	=	$2,200	
Total procurement and office support				=	**$26,700**	

Cost Estimate for Non-VOC Alternative 2
Capping
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	Y.L	CHECKED BY:	F.T.	
JOB NO.:	101995.3323.070	DATE :	12/14/18	DATE CHECKED:	1/28/2019	
CLIENT:	EPA					

E) Onsite supervisory						
Assume the following full time site supervisory staff for the duration of construction:						
Superintendent (8 hours per day)	840	hr	$110	=	$92,400	
HSO/QC (8 hours per day)	840	hr	$110	=	$92,400	
Site Engineer (8 hours per day)	504	hr	$110	=	$55,440	
Total Onsite Supervisory Staff for Construction Duration				=	**$240,240**	
F) Remedial Construction Report						
Project Manager	40	hr	$160	=	$6,400	
Project Engineer	300	hr	$110	=	$33,000	
Project Chemist	80	hr	$110	=	$8,800	
Total Remedial Construction Report Preparation Cost					**$48,200**	
G) Site Photographs/Videos	1	LS	$10,000	=	$10,000	
H) Project Signs	1	LS	$3,000	=	$3,000	
I) Other Direct Costs	1	LS	$20,000	=	$20,000	
J) Site Survey	1	LS	$40,000	=	$40,000	
SUBTOTAL GENERAL CONDITIONS					**$545,600**	
Safety and Health Requirements						
Assume PPE required for 10 people per work day for the duration of construction activities.						
Total Construction Duration:		22	weeks			
PPE (5 days a week)	110	day	$100	=	$11,000	
Total Safety and Health Costs					**$11,000**	
Temporary Fencing						
Metal/Chain Fencing	1242	LF	$8	=	$9,936	
Labor for Installation	1242	LF	$12	=	$14,904	
Total Temporary Fencing Costs					**$24,840**	
Temporary Facilities						
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.						
Mobilization/Demobilization	1	LS	$900	=	$1,000	
Utility Hookups	1	LS	$1,500	=	$1,500	
Trailer rental (2 trailer)	9	month	$500	=	$4,500	
Power draw per trailer	5	kW/hr				
Total cost of power consumption	3660	kW/month	$0.24	kW/hr	=	$15,482 for 2 trailers
Cleaning service and others	9	month	$300	=	$2,700	
TOTAL TEMPORARY FACILITY COSTS					**$25,182**	
TOTAL COST FOR GENERAL REQUIREMENTS					**$607,000**	

Cost Estimate for Non-VOC Alternative 2
Capping
Mansfield Trail Superfund Site
New Jersey

CDM Smith	**PROJECT:**	Mansfield Trail	**COMPUTED BY :**	YL	**CHECKED BY:** F.T.
	JOB NO.:	101995.3323.070	**DATE :**	12/26/2018	**DATE CHECKED:** 1/28/2019
CDM Federal Programs Corporation	**CLIENT:**	EPA			

Description: FS Cost Estimate for Alternative S-2 - Individual Cost Item Backup

02 - Site Work

Residential Soils TRZ - Area 1		24,386 SF			
Residential Soils TRZ - Area 2		17,600 SF			
Residential Soils TRZ - Area 3		30,624 SF			
Total		72,610 SF		1.67 acres	
Clearing and Grubbing					
Assume area of remediation + 10% for clearing around perimeter					
Clearing and grubbing	1.9	acre	$6,000	=	**$11,400**
Mobilization and Demobilization of Construction Equipment					
Equipment Operator (heavy)	2	day	$880	=	$1,760
Labor - Foreman	2	day	$600	=	$1,200
Laborer	8	day	$560	=	$4,480
Mini-Excavator	2	day	$300	=	$600
Small Bull Dozer (D4) to place cap	2	day	$400	=	$800
Bob Cat Loader	2	day	$300	=	$600
Tractor/Trailer - flat bed (includes fuel)	24	hr	$100	=	$2,400
Tractor/Trailer - lowboy (include fuel)	24	hr	$135	=	$3,240
Truck - pick up	2	day	$120	=	$240
Engineering	1	LS	$5,000	=	$5,000
Subtotal Mobilization Cost					$20,320
Subtotal Demobilization Cost (assume same as Mobilization)					$20,320
Build Decon Pad					
Equipment Operator (heavy)	1	day	$880	=	$880
Labor - Foreman	1	day	$600	=	$600
Laborer	4	day	$560	=	$2,240
Small Bull Dozer (D4) to place cap	1	day	$400	=	$400
Bob Cat Loader	1	day	$300	=	$300
Granular Cap Materials	45	ton	$30	=	$1,350
Truck - pick up	2	day	$120	=	$240
Subtotal Decon Pad Cost					$6,010
Surveying					
Survey would be conducted both prior to and after capping and after site restoration					
Surveyor onsite during final grading					
Total Surveying Duration:		22	weeks		
Professional Surveyor	40	hr	$120	=	$4,800
Surveyor	220	hr	$75	=	$16,500
Assistant surveyor	220	hr	$65	=	$14,300
Submittals	1	LS	$20,000	=	$20,000
Subtotal for surveying					**$55,600**
Erosion Control					
Total Construction Duration:		22 weeks			
Total Length of Erosion Measure		180 LF			

Cost Estimate for Non-VOC Alternative 2
Capping
Mansfield Trail Superfund Site
New Jersey

CDM Smith	PROJECT:	Mansfield Trail	COMPUTED BY :	YL	CHECKED BY:	F.T.
	JOB NO.:	101995.3323.070	DATE :	12/26/2018	DATE CHECKED:	1/28/2019
CDM Federal Programs Corporation	CLIENT:	EPA				

Assume daily output of silt fencing at 1,300 LF and hay bales at 2,500 LF.					
Erosion control installation	2	hr	$100	=	$168
Silt fence	180	LF	$1.82	=	$328
Hay bale	180	LF	$13.65	=	$2,457
Maintenance	5	month	$279	=	$1,395
Subtotal for erosion controls					**$4,348**
Total for Site Work					**$118,000**

Cost Estimate for Non-VOC Alternative 2
Capping
Mansfield Trail Superfund Site
New Jersey

CDM Smith	**PROJECT:**	Mansfield Trail	**COMPUTED BY :**	YL	**CHECKED BY:** F.T.
	JOB NO.:	101995.3323.070	**DATE :**	1/23/2019	**DATE CHECKED:** 1/28/2019
CDM Federal Programs Corporation	**CLIENT:**	EPA			

Description: FS Cost Estimate for Alternative S-2 - Individual Cost Item Backup

03 - Construction of Cap

Total Placement Area (Residential TRZ only)			72,610 SF		
Furnish and place 6" loam, seed, erosion fabric					
Total Placement Volume (Residential TRZ only)			36,305 CF		1,345 CY
Installation Duration (production at 100 CY/day)			14 days		
	Quantity	Unit	Unit cost		Extended Cost
Equipment Operator (heavy)	28	day	$880	=	$24,640
Labor - Foreman	14	day	$600	=	$8,400
Laborer	56	day	$560	=	$31,360
Mini-Excavator	14	day	$300	=	$4,200
Small Bull Dozer (D4) to place cap	14	day	$400	=	$5,600
Bob Cat Loader	14	day	$300	=	$4,200
Furnish Erosion Fabric	73000	SF	$0.80	=	$58,400
Furnish loam (1.4 tons/CY)	1883	ton	$40	=	$75,320
Furnish seed (1 bag/1000 SF)	73	bag	$60	=	$4,380
Total Furnish and Place Loam, Seed, and Erosion Fabric Cost					$216,500
Place Cap Materials (6")					
Total Placement Volume (Residential TRZ only)			36,305 CF		1,345 CY
Cap Installation Duration (production at 100 CY/day)			14 days		
Equipment Operator (heavy)	28	day	$880	=	$24,640
Labor - Foreman	14	day	$600	=	$8,400
Laborer	56	day	$560	=	$31,360
Mini-Excavator	14	day	$300	=	$4,200
Small Bull Dozer (D4) to place cap	14	day	$400	=	$5,600
Bob Cat Loader	14	day	$300	=	$4,200
Granular Cap Materials (1.4 tons/CY)	1883	ton	$30	=	$56,490
Truck - pick up	28	day	$120	=	$3,360
Total Backfill Cost					$138,250

Cost Estimate for Non-VOC Alternative 2
Capping
Mansfield Trail Superfund Site
New Jersey

CDM Smith	**PROJECT:**	Mansfield Trail	**COMPUTED BY :**	YL	**CHECKED BY:** F.T.
	JOB NO.:	101995.3323.070	**DATE :**	1/23/2019	**DATE CHECKED:** 1/28/2019
CDM Federal Programs Corporation	**CLIENT:**	EPA			

Description: FS Cost Estimate for Alternative S-2 - Individual Cost Item Backup

Drainage Swales for Stormwater Management						
Assume drainage swales are 4' wide, 1' deep, 250' long						
Total length of drainage swales (3)				750	LF	
Total square footage of drainage swales (3)				3,000	LF	
Total volume of rip-rap required				3,000	CF	111 CY
Drainage Swale Installation Duration (Production at 75 LF/day)				10	days	
Equipment Operator (heavy)	10	day	$880	=		$8,800
Labor - Foreman	10	day	$600	=		$6,000
Laborer	40	day	$560	=		$22,400
Mini-Excavator	10	day	$300	=		$3,000
Bob Cat Loader	10	day	$300	=		$3,000
Furnish rip-rap (1.8 tons/CY)	200	ton	$125	=		$25,000
Truck - pick up	10	day	$120	=		$1,200
Total Drainage Cost						$69,400
Total Duration of Cap Construction				38	days	
TOTAL FOR CAP CONSTRUCTION:					**$424,150**	

Cost Estimate for Alternative S-3
Excavation
Mansfield Trail Superfund Site
New Jersey

No.	Description	Cost
	Remedial Action	
01	General Requirements	$532,000
02	Site Preparation/Site Work	$111,300
03	Excavation and Backfill of Contaminated Soils	$501,290
05	Transportation and Disposal of Excavated Soils	$505,000
06	Post-excavation Sampling	$28,000
	Subtotal	*$1,677,590*
	Contingency (30%: 20% scope + 10% bid contingency)	$503,277
	Subtotal	*$2,180,867*
	General Contractor Markup (profit) 10%	$218,087
	Total Remedial Action Capital Costs	**$2,399,000**
	PRESENT WORTH	
	Total Capital Cost	$2,399,000
	Total Present Worth	**$2,399,000**

Note: Percentages used for indirect costs are based on guidance from Section 5.0 of "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study", EPA 2000.
The project cost presented herein represents only feasibility study level, and is thus subject to change pending the results of the pre-design investigation, which is intended to collect sufficient data to assist in the development of remedial design and associated detailed cost estimate. Expected accuracy range of the cost estimate is -30% to +50%. Present worth calculation assumes 7% discount rate after inflation is considered.
Total present worth is rounded to the nearest $1,000. Inflation and depreciation are excluded from the present value cost.

Cost Estimate for Non-VOC Alternative 3
Excavation
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	**COMPUTED BY :**	YL	**CHECKED BY:**	FT
JOB NO.:	101995.3323.070	**DATE :**	12/26/18	**DATE CHECKED:**	1/28/19
CLIENT:	EPA				

Description: FS Cost Estimate for Alternative S-3 - Individual Cost Item Backup

01 - General Requirements

Project Schedule

Assume the following construction schedule:

Pre-construction work plans and meetings	3	months		
Field Construction:				
Field mobilization (permits and trailer compound establishment)	0.5	months		
Site preparation	0.5	months		
Excavation and T&D	4	months	18	weeks
Final site restoration and demobilization	1	months		
Total Construction Duration	**6**	**months**	**26**	**weeks**
Project closeout	1	months		
Total Project Duration =	**10**	**months**	**43**	**weeks**

General Conditions

A) Project Management and Site Supervisory

Assume the following Staff for 20 hours per week for the duration of project:

Project Manager (16 hours per month)	$160	per hour	
Project Engineer (12 hours per month)	$110	per hour	
Procurement Staff (5 hours per month)	$90	per hour	
Total management and office support			$43,300

B) Work Plan Preparation

Estimated # of Pre-Construction Work Plans Required:		3	work plans
Project Engineer	$110	per hour	
Project Manager (quarter time)	$160	per hour	
Total Work Plan Preparation Cost:			$72,000

C) Permits

Permit Specialist	80	hr	$125	=	$10,000
Project Manager	30	hr	$160	=	$4,800
Total Permit Preparation Cost:					$14,800

D) Onsite supervisory

Assume the following site supervisory staff for the duration of construction:

Assume the following full time site supervisory staff for the duration of construction:

Superintendent (8 hours per day)	1008	hr	$110	=	$110,880
HSO/QC (8 hours per day)	1008	hr	$110	=	$110,880
Site Engineer (8 hours per day)	672	hr	$110	=	$73,920
Total Onsite Supervisory Staff for Construction Duration				=	**$295,680**

Cost Estimate for Non-VOC Alternative 3
Excavation
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	YL	CHECKED BY:	FT
JOB NO.:	101995.3323.070	DATE :	12/26/18	DATE CHECKED:	1/28/19
CLIENT:	EPA				

Description: FS Cost Estimate for Alternative S-3 - Individual Cost Item Backup

E) Remedial Action Report					
Project Manager	40	hr	$160	=	$6,400
Project Engineer	200	hr	$110	=	$22,000
CAD Operator	40	hr	$90	=	$3,600
Reviewers	40	hr	$180	=	$7,200
Total Remedial Action Report Cost:					$39,200
F) Other Costs					
Site Photographs/Videos	1	LS	$10,000	=	$10,000
Project Signs	1	LS	$3,000	=	$3,000
Total Other Costs:					$13,000
Subtotal General Conditions:				**$477,980**	
Safety and Health Requirements					
Assume PPE required for 10 people per work day for the duration of construction activities.					
Total Construction Duration:		26	weeks		
PPE (5 days a week)	130	day	$100	=	$13,000
					$13,000
Temporary Fencing					
Metal/Chain Fencing	1242	LF	$8	=	$9,936
Labor for Installation	1242	LF	$12	=	$14,904
Total Temporary Fencing Costs					**$24,840**
Temporary Facilities					
Temporary Facilities to include the field trailers, utilities, cleaning services, and office equipment and supplies.					
Assume two project trailers required (1 for Contractor, 1 for EPA)					
Trailer rental (2 trailers)	6	month	$866	=	$5,196
Utilities	6	month	$585	=	$3,510
Utilities hookup	1	LS	$2,000	=	$2,000
Toilet, Portable	6	month	$252	=	$1,512
Cleaning service and others	6	month	$505	=	$3,030
					$15,248
TOTAL COST FOR GENERAL REQUIREMENTS					**$532,000**

Cost Estimate for Non-VOC Alternative 3
Excavation
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

PROJECT:	Mansfield Trail	COMPUTED BY :	YL	CHECKED BY:	FT
JOB NO.:	101995.3323.070	DATE :	12/26/2018	DATE CHECKED:	1/28/19
CLIENT:	EPA				

Description: FS Cost Estimate for Alternative S-3 - Individual Cost Item Backup

02 - Site Work

Residential TRZ	72,610	SF
Non-Residential TRZ near Dump Area B	400	SF
Non-Residential TRZ Area in Dump Area E	400	SF
Total	73,410	SF

Clearing and Grubbing

Assume area of remediation + 10% for clearing around perimeter

Clearing and grubbing	1.84	acre	$5,400	=	$9,936

Surveying

Survey would be conducted both prior to excavation and after site restoration (one week each)

Surveyor onsite during excavation (for depth verification, quantity measurement, final grading)

Total Surveying Duration: 18 weeks

Professional Surveyor	40	hr	$120	=	$4,800
Surveyor	180	hr	$75	=	$13,500
Assistant surveyor	180	hr	$65	=	$11,700
Submittals	1	LS	$20,000	=	$20,000
Subtotal for surveying					$50,000

Mobilization

Equipment Operator (heavy)	2	day	$880	=	$1,760
Labor - Foreman	2	day	$600	=	$1,200
Laborer	8	day	$560	=	$4,480
Mini-Excavator	2	day	$300	=	$600
Small Bull Dozer (D4) to place cap	2	day	$400	=	$800
Bob Cat Loader	2	day	$300	=	$600
Tractor/Trailer - flat bed (includes fuel)	24	hr	$100	=	$2,400
Tractor/Trailer - lowboy (include fuel)	24	hr	$135	=	$3,240
Truck - pick up	2	day	$120	=	$240
Engineering	1	LS	$5,000	=	$5,000
Subtotal Mobilization Cost					$20,320
Subtotal Demobilization Cost (assume same as Mobilization)					$20,320

Build Decon Pad

Equipment Operator (heavy)	1	day	$880	=	$880
Labor - Foreman	1	day	$600	=	$600
Laborer	4	day	$560	=	$2,240
Small Bull Dozer (D4) to place cap	1	day	$400	=	$400
Bob Cat Loader	1	day	$300	=	$300
Granular Cap Materials	45	ton	$30	=	$1,350
Truck - pick up	2	day	$120	=	$240
Subtotal Decon Pad Cost					$6,010

Cost Estimate for Non-VOC Alternative 3
Excavation
Mansfield Trail Superfund Site
New Jersey

CDM Smith	**PROJECT:**	Mansfield Trail	**COMPUTED BY :**	YL	**CHECKED BY:** FT
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Description: FS Cost Estimate for Alternative S-3 - Individual Cost Item Backup

Erosion Control

Total Project Construction Duration:	6	months			
Length of Erosion Measure	180	LF			
Assume daily output of silt fencing at 1,300 LF and hay bales at 2,500 LF.					
Erosion control installation	2	hr	$100	=	$168
Silt fence	180	LF	$1.82	=	$328
Hay bale	180	LF	$13.65	=	$2,457
Maintenance	6	month	$279	=	$1,674
Subtotal					$4,627
Total for Site Work					**$111,300**

Cost Estimate for Non-VOC Alternative 3
Excavation
Mansfield Trail Superfund Site
New Jersey

CDM Smith
CDM Federal Programs Corporation

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Description: FS Cost Estimate for Alternative S-3 - Individual Cost Item Backup

04 - Excavation, Backfill, Drainage

Excavation Volume (1' depth) in Residential TRZ	72,610 CF		
Excavation Volume (2' depth) in Non-Rez TRZ near Dump Area B	800 CF		
Excavation Volume (5' depth) in Non-Rez TRZ in Dump Area E	2,000 CF		
Total Excavation Volume	75,410 CF	2,793	CY
Backfill Volume (6" depth) in Residential TRZ	36,305 CF		
Backfill Volume (2' depth) in Non-Rez TRZ near Dump Area B	800 CF		
Backfill Volume (5' depth) in Non-Rez TRZ in Dump Area E	2,000 CF		
Total Backfill Volume	36,305 CF	1,345	CY

Excavation

Excavation Duration (production at 50 CY/day) 56 days

	Quantity	Unit	Unit cost		Extended Cost
Equipment Operator (heavy)	112	day	$880	=	$98,560
Labor - Foreman	56	day	$600	=	$33,600
Laborer	224	day	$560	=	$125,440
Mini-Excavator	56	day	$300	=	$16,800
Bob Cat Loader	56	day	$300	=	$16,800
Truck - pick up	112	day	$120	=	$13,440
Total Excavation Cost					$304,640

Backfill

Backfill Duration (production at 100 CY/day) 14 days

Equipment Operator (heavy)	28	day	$880	=	$24,640
Labor - Foreman	14	day	$600	=	$8,400
Laborer	56	day	$560	=	$31,360
Mini-Excavator	14	day	$300	=	$4,200
Small Bull Dozer (D4) to place backfill	14	day	$400	=	$5,600
Bob Cat Loader	14	day	$300	=	$4,200
Granular Cap Materials (1.4 tons/CY)	1883	ton	$30	=	$56,490
Truck - pick up	28	day	$120	=	$3,360
Total Backfill Cost					$138,250

Cost Estimate for Non-VOC Alternative 3
Excavation
Mansfield Trail Superfund Site
New Jersey

CDM Smith	**PROJECT:**	Mansfield Trail	**COMPUTED BY :**	YL	**CHECKED BY:** FT
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Drainage					
Drainage Duration				10 days	
Equipment Operator (heavy)	10	day	$880	=	$8,800
Labor - Foreman	10	day	$600	=	$6,000
Laborer	40	day	$560	=	$22,400
Mini-Excavator	10	day	$300	=	$3,000
Bob Cat Loader	10	day	$300	=	$3,000
Generator	10	day	$500	=	$5,000
3-inch pumps (4 total)	10	day	$600		$6,000
FRAC Tank	3	month	$1,000	=	$3,000
Truck - pick up	10	day	$120	=	$1,200
Total Drainage Cost					$58,400
Duration of excavation, backfill, drainage				80 days	
Total for Excavation of Contaminated Soil					**$501,290**

Cost Estimate for Non-VOC Alternative 3
Excavation
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New Jersey

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CDM Federal Programs Corporation

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Description: FS Cost Estimate for Alternative S-3 - Individual Cost Item Backup

05 - Transportation and Disposal

T&D of Excavated Soils

Assume 25% volume increase of soil after excavation			in-place		excavated
Total Excavation/Removal Volume			2,793 BCY		3,491 LCY
Assume TCLP testing reveals excavated soil to be 10% hazardous, 90% non-hazardous			Unit Cost		Extended Cost
Transportation and Disposal of Non-Hazardous Waste - Soil	3,142	ECY	$117	=	$367,629
Transportation and Disposal of Hazardous Waste - Soil	349	ECY	$314	=	$109,626

Labor and equipment costs for loading trucks for offsite disposal

Assume 20 four-axle dump trucks, 25 ton, 18 CY payload

Excavator diesel, 1 CY capacity	$1,301	per day
Equipment Operator (heavy)	$880	per day
Laborer	$560	per day
Total rate per day	$2,741	per day
Time for loading the material for offsite disposal	10	days
Total Equipment and Labor	$27,410	
Total Transportation and Disposal Costs	**$505,000**	

Cost Estimate for Non-VOC Alternative 3
Excavation
Mansfield Trail Superfund Site
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CDM Federal Programs Corporation

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Description: FS Cost Estimate for Alternative S-3 - Individual Cost Item Backup

06 - Waste Characterization Sampling and Post Excavation Sampling

Waste Charaterization Sampling

To check whether TCLP requirements are met:

1 sample per 500 CY of total volume of soil

A) Estimated Number of Waste Characterization Samples

Total Number of samples:	7	samples
Add QC samples for duplicates:	**8**	**samples**

B) Laboratory Analysis Fees

Waste Characterization Analytical Cost per sample	$1,200
Total Laboratory Analysis Costs:	**$9,600**

C) Waste Characterization Sample Collection

Assume 1 hour per sample for an environmental technician to collect each sample

Environmental Technician	$85	per hour	**$680**

D) Sample Packaging and Shipping Costs

Assume shipping cost is 5% of analytical cost:	**$480**

E) Data Validation of Waste Characterization Samples

Assume waste characterization samples will be used as clean final verification samples requiring validation.

# of samples requiring validation :	8	samples
Assume 1 hour per sample for data validation by a chemist	8	hours
Add 30 hours for QCSR report:	30	hours
Total Chemist Hours:	38	hours

Chemist	$100	per hour	**$3,800**

TOTAL WASTE CHARACTERIZATION SAMPLING: $14,560

Post Excavation Sampling

Assume 5 samples collected a day (10 hour day)

Number of samples	10	
Number of samples for including QC	11	
Days to Sample	2	days

	Quantity	Unit	Unit cost	Extended Cost
Environmental Technician	16	hour	$ 85	$ 1,360
Engineer	8	hour	$ 110	$ 880
Shipping	2	day	$ 100	$ 200
Analytical cost (TAL Metals)	11	EA	$ 85	$ 935
Analytical cost (PCBs)	11	EA	$ 93	$ 1,023
Tabulate the data	1	LS	$ 2,000	$ 2,000
Prepare the data report	1	LS	$ 7,000	$ 7,000
TOTAL POST EXCAVATION SAMPLING				**$ 13,398**

TOTAL FOR WASTE CHARACTERIZATION AND POST EXCAVATION SAMPLING $28,000

Appendix E

Estimates of Time Frames for Meeting PRGs

REMChlor-MD is a modeling tool that calculates planning-level estimates of contaminant concentrations in the plume and source zone under different remedial scenarios, taking into account matrix diffusion processes as well as advection and dispersion (ESTCP, 2019). REMChlor-MD was calibrated using site-specific hydrogeology data and measurements of TCE concentrations in the source zones and downgradient. The model inputs and the sources of the inputs are presented in the table below. The source zone mass removal percentages applied to each alternative were based on engineering judgement and not on pilot test data. As such, the results should be used for planning-level discussions and not be considered guarantees or otherwise of technology performance. Results for the source zone (shallow bedrock and intermediate bedrock) and 500 feet downgradient in the intermediate bedrock are shown on time versus concentration plots on the following pages.

ESTCP, 2019. Falta, R. A Practical Approach for Modeling Matrix Diffusion Effects in REMChlor. Project ER-201426.

REMChlor-MD model inputs	Shallow bedrock	Intermediate Bedrock
Test interval thickness	25 ft (Figure 3-5B in Appendix A)	1.15 ft (MLS-3 FLUTe profile, RI Report Appendix C-2; CDM Smith, 2018)
Fracture spacing	1.67 ft (RI Report Appendix C-1 (CDM Smith, 2018)	0.38 ft (MLS-3 FLUTe profile, RI Report Appendix C-2; CDM Smith, 2018)
Hydraulic Gradient	0.003 (Figure 3-5B in Appendix A)	0.225 (Figure 3-5A in Appendix A)
Transmissivity	30 ft^2/day (packer test, Table 3-3 from CDM Smith, 2018)	28.5 ft^2/day (packer test, Table 3-3 from CDM Smith, 2018)
Fracture aperture	0.0005 ft (calculated using Cubic Law [note 1])	0.000636 (calculated using Cubic Law [note 1])
Source mass at time of release, year of release, starting concentration	5 kg released in 1960, 120 µg/L (iterative based on site data)	10 kg released in 1960, 500 µg/L (iterative based on site data)
Fracture retardation factor	1.3 (estimated)	1.3 (estimated)
Matrix retardation coefficient	6 (calculated from bulk density and fraction organic carbon of matrix, Appendix F of EES JV, 2016)	6 (calculated from bulk density and fraction organic carbon of matrix, Appendix F of EES JV, 2016)
Attenuation rate	0.11/year (Appendix B)	0.11/year (Appendix B)
Total Porosity	0.03 (Appendix F of EES JV, 2016)	0.03 (Appendix F of EES JV, 2016)
Gamma	1 (estimated)	1 (estimated)

Notes

1) $b = [12Tu/gN]^{1/3}$

b = hydraulic aperture (ft)

T = transmissivity (ft2/sec)

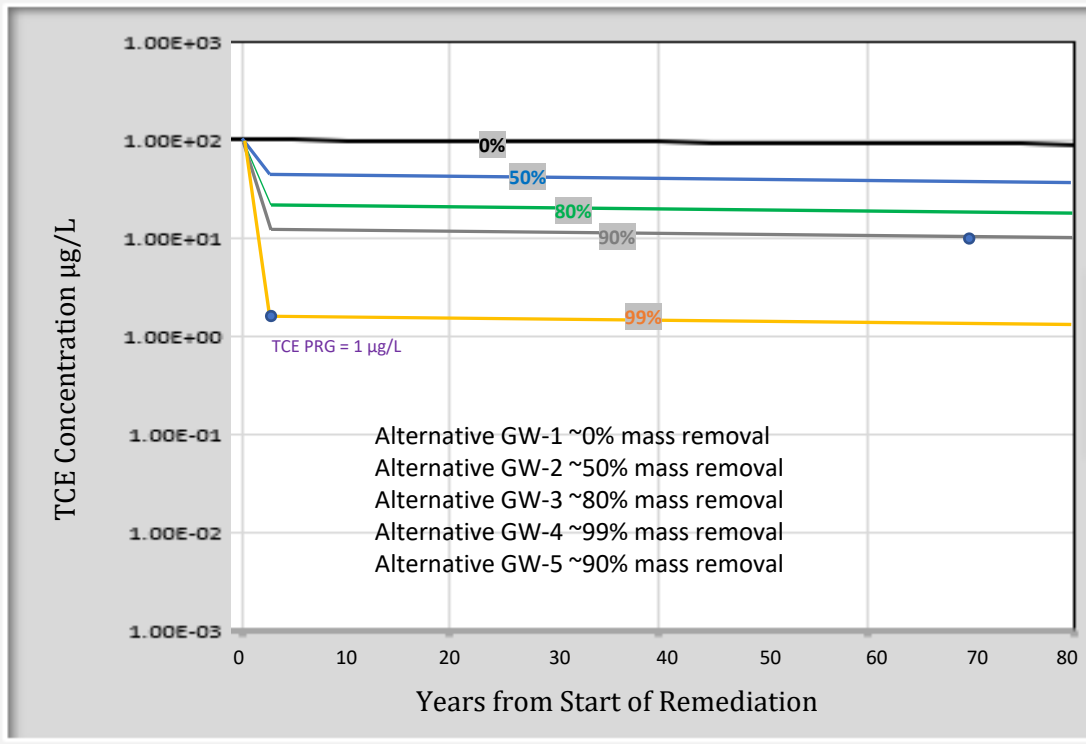
u = kinematic viscosity of water at 10 °C

N= Number of flowing fractures in the test interval

g = gravitational acceleration

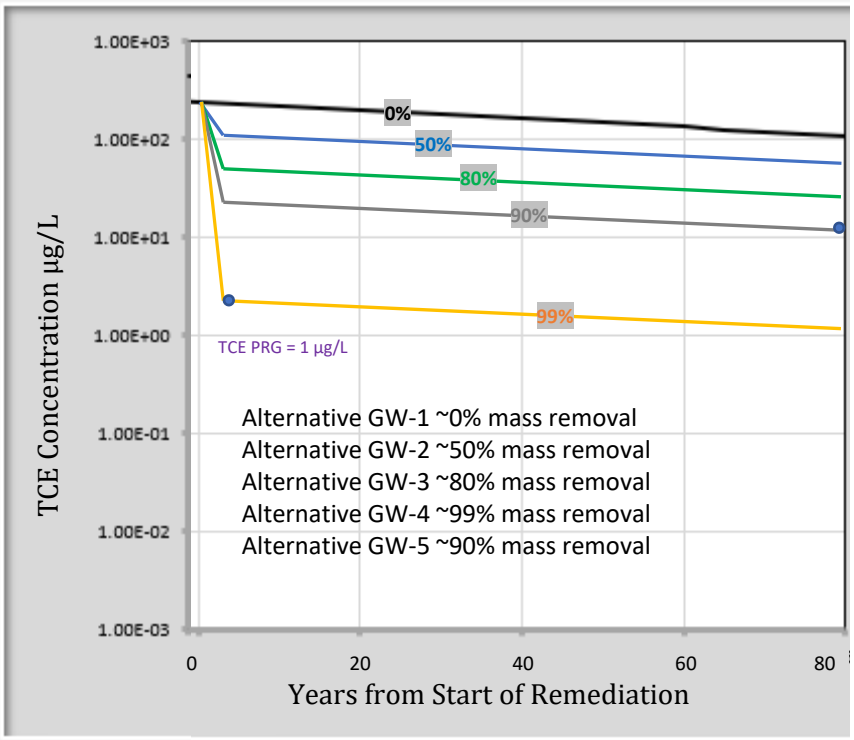
CDM Smith

Estimated TCE Concentration
Target Remediation Zone Shallow Bedrock
for Varying Source Zone Mass Removal Percentages

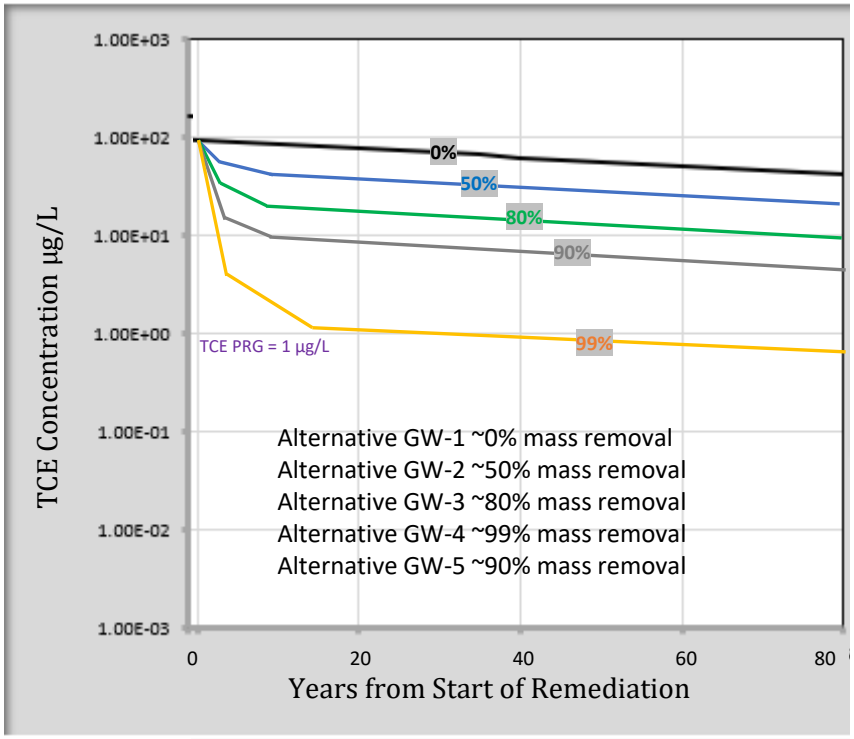


CDM Smith

Estimated TCE Concentration Target Remediation Zone Intermediate Bedrock for Varying Source Zone Mass Removal Percentages



Estimated TCE Concentration. 500 feet Downgradient of Source in Intermediate Bedrock for Varying Source Zone Mass Removal Percentages



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