Final

Record of Decision
Site 13 Former Public Works
Pentachlorophenol Dip Tank and Wash Rack

Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Contract Task Order 103

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Prepared for

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Mid-Atlantic

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Prepared by

CH2MHILL

Virginia Beach, Virginia

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Acronyms and Abbreviations

µg/L	micrograms per liter
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
BERA	baseline ecological risk assessment
BTAG	biological technical assistance group
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
COCs	chemicals of concern
COPCs	chemicals of potential concern
CSF	carcinogenic slope factor
CSM	conceptual site model
CTE	central tendency exposure
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
FFA	Federal Facilities Agreement
FS	Feasibility Study
ft	feet
gpm	gallons per minute
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IRA	Interim Remedial Action
IRP	Installation Restoration Program
ISCO	*in situ* chemical oxidation
LUC	land use control
MCL	maximum contaminant level
MIP	membrane interface probe
MNA	monitored natural attenuation
mg/kg	milligrams per kilogram
NAB	Naval Amphibious Base
NAPL	non-aqueous phase liquid

Navy	Department of the Navy
NCP	National Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
OWS	oil-water separator
PAH	polycyclic aromatic hydrocarbon
PCE	tetrachloroethene
PCP	pentachlorophenol
PP	Proposed Plan
PWC	Public Works Center
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
RD	Remedial Design
RfD	reference dose
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SERA	Screening Ecological Risk Assessment
SMP	Site Management Plan
SRI	Supplemental Remedial Investigation
SVOC	semivolatile organic compound
TCE	trichloroethene
U.S.	United States
VC	vinyl chloride
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound

SECTION 1

Declaration

1.1 Site Name and Location

Site 13 Public Works Pentachlorophenol Dip Tank and Wash Rack
Naval Amphibious Base (NAB) Little Creek
Virginia Beach, Virginia
EPA ID # VA5170022482

1.2 Statement of Basis and Purpose

This Record of Decision (ROD) presents the Selected Remedy at Site 13, Public Works Former Pentachlorophenol (PCP) Dip Tank and Wash Rack, at NAB Little Creek, Virginia Beach, Virginia. This determination has been made in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on information contained in the Administrative Record file for the site.

The United States (U.S.) Department of the Navy (Navy) is the lead agency and provides funding for site cleanups at NAB Little Creek. The Navy and U.S. Environmental Protection Agency (EPA) Region III issue this ROD jointly. The Commonwealth of Virginia, Virginia Department of Environmental Quality (VDEQ), concurs with the Selected Remedy.

1.3 Assessment of the Site

Previous investigations have identified the presence of PCP and volatile organic compounds (VOCs) in groundwater at concentrations that pose a potential threat to human health if used as a potable water supply. The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances in the environment.

1.4 Description of the Selected Remedy

The selected remedy for Site 13 is groundwater treatment through enhanced anaerobic bioremediation. Land use controls (LUCs) will be maintained on groundwater and associated property use within the boundaries of Site 13 until the concentrations of hazardous substances in the groundwater have been reduced to levels that allow for unlimited use and unrestricted exposure.

Site 13 is one of eleven Installation Restoration Program (IRP) sites that are subject to the requirements of CERCLA at NAB Little Creek. The status of all the IRP sites at NAB Little

Creek can be found in the current version of the Site Management Plan (SMP), which is located in the Administrative Record.

Under current and reasonably anticipated future land use scenarios, where groundwater is restricted from use as a potable water supply, there are no realistic exposure scenarios, and all available data suggest that mobility and migration of contaminated groundwater are limited at Site 13. No principal threat waste has been identified at Site 13. The components of the selected remedy include the following:

- Enhanced anaerobic bioremediation of the groundwater plume through:
  - Construction of injection wells of sufficient number and spacing for effective *in situ* groundwater treatment
  - Construction of monitoring wells of sufficient number and spacing for effective monitoring of *in situ* groundwater treatment
  - Injection of substrate for enhanced anaerobic bioremediation of PCP and VOCs
- LUCs, as described in Section 2.12.2 of this ROD, to:
  - Prohibit the withdrawal of groundwater except for environmental monitoring and testing
  - Prohibit use of the site for residential child care, elementary or secondary school, or playground facilities
  - Maintain the integrity of any current or future remedial or monitoring system
- Groundwater monitoring and reporting to assess the progress of the remediation over time.

1.5 Statutory Determinations

The Selected Remedy is protective of human health and the environment, complies with federal and state requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, uses permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable, and satisfies the preference for treatment as a principal element of the remedy.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

1.6 ROD Data Certification Checklist

The following information is included in the Decision Summary (Section 2) of this ROD. This decision is based on information contained in the Administrative Record for the site.

Information not specifically summarized in this ROD but contained in the Administrative Record has been considered and is relevant to the selection of the remedy.

- Chemicals of concern (COCs) and their respective concentrations (Tables 2-2 and 2-3)
- Baseline risk represented by the COCs (Section 2.7)
- Cleanup levels established for COCs and the basis for these levels (Section 2.12.4 and Table 2-8)
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the baseline risk assessment and ROD (Section 2.6)
- Potential land and groundwater use that will be available at the site as a result of the Selected Remedy (Section 2.12.4)
- Estimated capital, annual operation and maintenance (O&M), and total present-worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 2.12.3 and Table 2-9)
- Key factors that lead to selecting the remedy (i.e., a description of how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing in and modifying criteria, with emphasis on the criteria key to the decision) (Section 2.10, 2.12.1, and 2.13)

1.7 Authorizing Signatures

W. W. Crow, CAPT, USN
By direction of the Commander
Navy Region Mid-Atlantic

9/12/07
Date

James J. Burke, Director
Hazardous Site Cleanup Division
EPA (Region III)

9/21/07
Date

SECTION 2

Decision Summary

The Navy is the lead agency and provides funding for site cleanups at NAB Little Creek. This ROD describes the Navy and EPA's selected remedial action for Site 13—Public Works Former PCP Dip Tank and Wash Rack at the NAB Little Creek, Virginia Beach, Virginia. VDEQ concurs with the Selected Remedy.

2.1 Site Name, Location, and Description

NAB Little Creek encompasses 2,215 acres in the northwest corner of Virginia Beach, Virginia, adjacent to the Chesapeake Bay (Figure 2-1). The facility is primarily industrial, and its personnel provide logistic facilities and support services for local commands, organizations, homeported ships, and other U.S. and allied units to meet amphibious warfare training requirements of the U.S. Armed Forces. NAB Little Creek is also used for recreational, commercial, and residential purposes. Land development surrounding the base is residential, commercial, and industrial.

Site 13 is located in the eastern portion of the base, near the intersection of 7th and F Streets (Figure 2-2). The site consisted of a dip tank, associated washing/drying racks, and an unpaved storage area. The dip tank consisted of an in-ground metal tank containing approximately 1,500 gallons of PCP, diesel fuel, and kerosene. Use of the dip tank and associated drying racks took place between the early 1960s and 1974. The wash rack consisted of a concrete pad surrounded by a concrete curb with a centrally located drain. The wash rack was installed in 1945 and used to clean vehicles and equipment with steam and biodegradable chemicals. The wash water and runoff drains into an oil-water separator (OWS). An unpaved storage area located adjacent to the wash rack was used to store various materials and equipment. The dip tank and associated drying racks were dismantled in 1982. Releases from the site resulted in PCP and VOCs in the soil and shallow groundwater i.e., Columbia Aquifer. The dip tank and contaminated soil were excavated as part of an Interim Removal Action (IRA) completed in 1999. PCP and VOC concentrations in shallow groundwater remain above levels that allow for unlimited use and unrestricted exposure.

2.2 Site History

NAB Little Creek was placed on the National Priorities List (NPL) in May 1999, and the Federal Facilities Agreement (FFA) for NAB Little Creek was signed in November 2003 (Department of Defense, 2003). The FFA provides for CERCLA directed enforcement activities. No enforcement activities have been recorded at Site 13.

NAB Little Creek initiated environmental investigation efforts under the Navy Assessment and Control of Installation Pollutants Program by conducting an Initial Assessment Study in 1984 (Rogers, Golden, and Halpern, 1984) followed by a Round 1 Verification Study in 1986

(CH2M HILL, 1986). An Interim Remedial Investigation was completed in 1991 (Ebasco, 1991), and a Remedial Investigation/Feasibility Study (RI/FS) report was completed in 1994 (FWES, 1994). An Engineering Evaluation/Cost Analysis (EE/CA) was prepared in 1999 to further evaluate remedial alternatives (CH2M HILL, 1999). The dip tank and surrounding soil were excavated in 1999. A Removal Action closeout report was completed in 1999 (IT-OHM Corporation, July 1999).

2.2.1 Screening Ecological Risk Assessment 2000

A screening ecological risk assessment (SERA) for Site 13 was completed in June 2000 (CH2M HILL, 2000). The SERA concluded there were no unacceptable risks to ecological receptors under current site conditions.

2.2.2 Baseline Ecological Risk Assessment 2001

A baseline ecological risk assessment (BERA) was completed for the soil in the drainage ditch receiving runoff from the site at the request of EPA in October 2001 (CH2M HILL, 2001). The BERA included data collected as part of the SERA and additional data collected in August 2001. The BERA concluded that there were no unacceptable risks to ecological receptors from exposure to soil in the drainage ditch.

2.2.3 Supplemental Remedial Investigation 2002

A Supplemental Remedial Investigation (SRI) to the 1994 RI was conducted in 2000. The report incorporated data from 1993 through 2000 (CH2M HILL, 2002). The SRI identified metals, semivolatile organic compounds (SVOCs), and VOCs as chemicals of potential concern (COPCs) in soil and groundwater. Additionally, a sanitary sewer survey was conducted and indicated a leaking sewer line was located along F Street potentially influencing groundwater flow direction to the west. The human health risk assessment (HHRA) was completed as part of the SRI for Site 13 based on data collected in 1994, 1995, and 1998. Based on the results of the HHRA, the Navy in partnership with the VDEQ and EPA determined the only unacceptable human health risks were associated with exposure to VOCs and PCP in shallow groundwater.

2.2.4 Pilot Study 2000–2002

A groundwater pilot study was implemented to evaluate the effects of enhanced aerobic bioremediation on PCP in groundwater using a compound that releases oxygen in the soil and groundwater. Post injection groundwater sampling indicated an average of a 90 percent reduction in the concentrations of PCP within the pilot study area (CH2M HILL, 2003a).

2.2.5 Additional Groundwater Investigations 2003

Additional groundwater investigations were conducted to refine the extent of the VOC groundwater plume at Site 13 (CH2M HILL, 2003b). These investigations included grab groundwater sampling and a membrane interface probe (MIP) survey. Additionally, a survey of the sanitary sewer line was conducted and no leaks were detected, concluding the sanitary sewer line discovered during the SRI had been repaired.

2.2.6 Feasibility Study 2004

Based on data collected during the previous investigations, an FS was completed to evaluate remedial action alternatives for Site 13 groundwater (CH2M HILL, 2004a). The FS evaluated the following alternatives:

1. No Action
2. Long-Term Monitored Natural Attenuation (MNA)
3. Pump and Treat
4. Enhanced Anaerobic/Aerobic Bioremediation with Reactive Zones
5. Enhanced Anaerobic Bioremediation
6. Enhanced Aerobic Bioremediation for PCP and MNA for VOCs

Alternatives 5 and 6 ranked highest in the FS. A treatability study was recommended to identify the most effective alternative for groundwater treatment.

2.2.7 Treatability Study 2004–2005

A treatability study was conducted in 2004 to assess the effectiveness of a combined treatment utilizing *in situ* chemical oxidation (ISCO) and enhanced anaerobic bioremediation (CH2M HILL/AGVIQ, 2006). The study utilized ISCO in the northern portion of the plume where VOC and PCP concentrations were highest and enhanced anaerobic bioremediation in the southern portion of the plume where groundwater concentrations were substantially lower. The results of the study indicated ISCO was effective in reducing the PCP concentrations. In addition, the treatability study compared the results of the enhanced anaerobic bioremediation to the results of the enhanced aerobic bioremediation from the 2000 pilot study. The comparison indicated that both alternatives were somewhat effective in reducing PCP and VOC concentrations in groundwater. Enhanced anaerobic bioremediation was identified as the preferred alternative because PCP and VOCs degrade under anaerobic conditions, while only some of the VOCs degrade under aerobic conditions and the aquifer is naturally anaerobic.

2.2.8 Vapor Intrusion Assessment 2007

To investigate potential vapor intrusion of VOCs from groundwater into buildings in the vicinity of Site 13, a site visit was conducted and groundwater samples from the top of the aquifer adjacent to the buildings were collected. The results indicated that there are no unacceptable risks for vapor intrusion of VOCs because there are limited exposure pathways based on the design and construction of the buildings and the VOC concentrations at the top of the aquifer were not high enough to result in a vapor intrusion risk (CH2M HILL, 2007).

2.3 Community Participation

The Navy and EPA provide information regarding the cleanup of NAB Little Creek to the public through the community relations program, which includes a Restoration Advisory Board (RAB) that was formed in 1994, public meetings, the Administrative Record file for the site, the information repository, and announcements published in the local newspapers.

During the course of investigations at Site 13, the RAB has been apprised of all environmental activities related to the site.

In accordance with Section 117(a) of CERCLA, the Navy provided a public comment period from June 5, 2007 through July 5, 2007, for the Proposed Plan (PP) for Site 13. A public meeting to present the PP was held on June 11, 2007 at Shelton Park Elementary School. Public notice of the meeting and availability of documents was placed in *The Virginian-Pilot* newspaper on June 3, 2007.

The PP and previous investigation reports for Site 13 are available to the public in the information repository for the Administrative Record maintained at:

Public Affairs Office, NAVFAC Mid-Atlantic
9742 Maryland Ave, Bldg A-81
Norfolk, Virginia 23511
Phone: (757) 445-8732 ext. 3096
Robin.Willis@navy.mil

Or online at:

http://public.lantops-ir.org/sites/public/nablc/Site%20Files/AdminRecords.aspx)

2.4 Scope and Role of Response Actions

Site 13 is one of five IRP sites currently being addressed under CERCLA at NAB Little Creek. The response action for Site 13 does not include or affect any other sites at the facility. Information on the status of all the IRP sites at NAB Little Creek can be found in the current version of the SMP in the Administrative Record.

The Selected Remedy in this ROD, groundwater treatment through enhanced anaerobic bioremediation with LUCs, addresses all potential risks from PCP and VOCs in groundwater and eliminates current/all exposure pathways (Figure 2-2). Throughout implementation of the remedy, LUCs will be maintained within the boundaries of Site 13 until the concentrations in groundwater have been reduced to Safe Drinking Water Act Maximum Contaminant Levels (MCLs) to allow for unlimited use and unrestricted exposure. LUCs will be implemented by the Navy to meet the following objectives:

- Prohibit the withdrawal of groundwater except for environmental monitoring and testing
- Prohibit the use of the site for residential, child care, elementary or secondary school, or playground facilities
- Maintain the integrity of any current or future remedial or monitoring system

The Selected Remedy will be designed and implemented to meet federal and state requirements.

2.5 Site Characteristics

NAB Little Creek and the surrounding area contain industrial, commercial, recreational, and residential land uses. The area surrounding this 2,215-acre base is low lying and relatively flat, with several freshwater lakes (Chubb Lake, Lake Bradford, Little Creek Reservoir/Lake Smith, and Lake Whitehurst) located on or adjacent to the base. Little Creek Reservoir/Lake Smith, upgradient of the base, serves as a secondary drinking water supply for parts of the City of Norfolk. NAB Little Creek is centered about three saltwater bodies: Little Creek Cove, Desert Cove, and Little Creek Channel, which connects the coves with the Chesapeake Bay (Figure 2-1).

Site 13 is located in the eastern portion of the Base, near the intersection of 7th and F Streets (Figure 2-2). Several buildings (Buildings 3165, 3165B, 3165D, 3165E, 3174, 3520, 3521, and 3660) are located within the site boundary. The ground surface is generally level and includes areas of exposed gravel and/or grass covered ground surface between buildings and a concrete and asphalt parking lot for the Base Public Works Center (PWC) (Figure 2-2). A grass drainage ditch located along 7th Street conveys runoff from the site to the southeast within the Base stormwater system. There are no areas of archeological or historical significance at Site 13.

The water table (Columbia Aquifer) at the site ranges seasonally from 4 to 7 feet (ft) below ground surface (bgs). The average shallow groundwater flow velocity in the Columbia Aquifer has been calculated to be 110 ft per year. A 30- to 40-ft-thick clay confining unit (Yorktown Confining Unit) at a depth of approximately 22 ft separates the Columbia Aquifer from the underlying Yorktown Aquifer which has not been impacted by Site 13 based on similar chemical concentrations and hydrogeologic characteristics at IR Site 11 located less than 100 ft east (LS11-MW20Y) (CH2M HILL, 2004b). The vertical hydraulic conductivity of the confining clay is very low (3×10^{-8} centimeters per second). Groundwater in the Columbia Aquifer generally flows toward the south-southwest. Formerly, local groundwater flow was influenced by a leaking sanitary sewer line (approximately 10 gallons per minute [gpm]) that runs north-south along F Street. The sewer survey conducted as part of the treatability study determined the sewer line had been repaired.

Currently, groundwater at NAB Little Creek is not used as a potable water source. Potable water is supplied to NAB Little Creek and the surrounding community by the City of Virginia Beach. The nearest location of groundwater withdrawal is wells at NAB Little Creek golf course located approximately 4,000 ft northwest of Site 13. These wells provide water from the Yorktown Aquifer for irrigation of the golf course. Groundwater flow in the Yorktown Aquifer is north toward the Chesapeake Bay.

2.5.1 Conceptual Site Model

The source of PCP and VOCs in groundwater was the former PCP dip tank, which was removed (along with contaminated soil) in 1999. The conceptual site models (CSMs) for human health (Figure 2-3) and ecological receptors (Figure 2-4) show transport pathways/ mechanisms, exposure media, and exposure routes. Surface water and sediment are not present at Site 13 and groundwater does not discharge within or adjacent to the site.

Direct releases of PCP may have occurred from the former dip tank to subsurface soil and groundwater. The source of chlorinated VOCs, tetrachloroethene (PCE) and its degradation products trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride (VC), has not been identified but appears to have been within the PWC at a location west or southwest of the dip tank. VOCs and PCP present in groundwater may be further transported through the groundwater system via dissolution, advection, and dispersion. Microbial analysis has verified the presence of healthy microbial populations capable of biodegradation and site data indicate anaerobic biodegradation of VOCs is occurring based on the presence of VOC degradation compounds. The clay confining unit underlying the Columbia Aquifer prohibits downward migration of VOCs and PCP to the Yorktown Aquifer.

2.5.2 Sampling Strategy

A total of 44 soil and 214 groundwater samples were collected and analyzed to characterize the nature and extent of contamination and evaluate potential risks to human health and the environment as part of prior investigations. The field activities included soil and groundwater sampling using a variety of sampling technologies, including hollow stem auger, direct push, and MIP. A summary of the samples collected is provided on Table 2-1 and sample locations are shown on Figure 2-5.

2.5.3 Nature of Contamination

Site 13 shallow groundwater contamination covers an estimated 2.9 acres underlying the parking lot for the Base PWC. The maximum concentrations of the COCs for Site 13 groundwater are identified on Table 2-2. The lateral extent of the shallow groundwater PCP and VOC plumes are illustrated on Figure 2-2.

PCP concentrations are highest in the area of the former dip tank in the upper portion of the Columbia Aquifer, at approximately 3 to 12 ft bgs. VOC concentrations are highest in the central portion of the parking area at approximately 4 to 13 ft bgs. Residual dense non-aqueous phase liquid (DNAPL) may be present if dissolved phase concentrations are equal to 1 percent of the constituents' maximum aqueous solubility. Parent VOC compounds have not been detected in groundwater samples at concentrations above 1 percent of their maximum aqueous solubility. PCP has been detected in groundwater at concentrations above 1 percent of the maximum aqueous solubility for PCP, which is consistent with the high PCP concentrations in soils at Site 13. The higher dissolved PCP concentrations were found in the upper part of the aquifer at the former tank area, indicating that the non-aqueous phase liquid (NAPL) PCP was concentrated in the soil above the water table, or in the top few feet of the aquifer, and was unable to migrate down through the water column. The NAPL was excavated in 1999 when the soil in the area of the former tank was excavated down to a depth of just below the water table during the 1999 removal action.

The source of PCP was removed with excavation of the dip tank and associated soils in 1999. The source of VOCs was likely the wash rack and/or leaking sewer lines beneath Building 3165. The PWC has discontinued use of the wash rack at Building 3165. Decreasing VOC concentrations observed during the initial investigations indicate that this source is depleting naturally.

2.6 Current and Potential Future Land and Resource Uses

Currently, Site 13 consists of a PWC storage area and wash rack. Enlisted quarters, industrial activities, and administrative offices surround the site. Current land uses are expected to continue at Site 13, and there is no other planned future land use. LUCs will be implemented within the boundaries of the site to eliminate exposure to shallow groundwater until the remedial action reduces concentrations of VOCs and PCP to levels that allow unlimited use and unrestricted exposure. Because the Commonwealth of Virginia considers all aquifer groundwater of potential beneficial use (potable), remedial action objectives for unlimited use and unrestricted exposure will be measured by MCLs.

Groundwater is not currently used as a potable water supply at or in the vicinity of NAB Little Creek because of its general poor quality (iron and manganese above secondary MCLs), and low yield (generally less than 3 to 5 gpm). Potable water is supplied to the Base by the City of Virginia Beach. The Navy acknowledges the State of Virginia's anti-degradation policy for future beneficial use of groundwater.

2.7 Summary of Site Risks

An HHRA and ERA were completed to identify and characterize the current and potential future risks associated with exposure to soil and groundwater at Site 13 if no remediation is implemented. Risk assessments provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the remedial action. Detailed discussions of potential risks are provided in the SRI (CH2M HILL, 2002) and ERA (CH2M HILL, 2001). Potable use of shallow groundwater poses the only potential unacceptable risk to human health. Based on a limited viable ecological habitat and results of the BERA conducted on soil from a drainage swale that received runoff from the site, the Navy, in consultation with the EPA and VDEQ agree there is no unacceptable ecological risk. Additionally, there are no surface water or sediment features and thus no risk associated with these media. The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

2.7.1 Human Health Risk Summary

Exposure to VOCs and PCP present in shallow groundwater as a result of releases associated with the former dip tank and wash rack pose potential human health risk. The basis for action at Site 13 is based on risk identified in the SRI/HHRA (CH2M HILL, 2002).

Selection of Chemicals of Potential Concern

COPCs are identified based on maximum concentrations exceeding EPA Region III risk-based screening values. Exposure to PCP and VOCs present in shallow groundwater as a result of releases associated with the former dip tank and wash rack pose potential human health risk. Appendix J.2, Tables 2.3 through 2.8 of the SRI provide detailed information for the selection of COPCs for all media. For VOCs and SVOCs in groundwater, the selection of COPCs is detailed in Appendix J.1, Table 1-3 of the SRI. The exposure point concentrations (EPCs) used to estimate the risk for COPCs are provided in Appendix J.2, Tables 3.1 through 3.6 of the SRI. PCP and VOCs in groundwater were the only COPCs retained as COCs at the

conclusion of the risk assessment. For these COCs, summary statistics and EPCs for reasonable maximum exposure (RME) and central tendency exposure (CTE) are identified on Table 2-3.

Exposure Assessment

The human health exposure assessment identifies and evaluates the contaminant sources, release mechanisms, exposure pathways, exposure routes, and receptors. The elements of the exposure assessment for Site 13 are identified in the CSM (Figure 2-3). An estimate of risk is presented in the SRI, evaluating exposure to surface and subsurface soil and groundwater for current/future industrial workers, future residents, and future construction workers. Inhalation of particulate emissions is not a complete exposure pathway and no COPCs were retained for the soil-to-air pathway. A detailed discussion of the exposure pathways for all scenarios is provided in Section 7.3 and Appendix J.2, Table 1 of the SRI. Exposure concentrations and intake parameters for soil and groundwater are detailed in Section 7.3.3 of the SRI.

Toxicity Assessment

The toxicity assessment provides a numerical estimate of the relationship between the extent of exposure and possible severity of adverse effects, and consists of two steps: hazard identification and dose response assessment. Toxicity data used in the HHRA are EPA's published toxicity values (noncarcinogenic reference doses [RfDs] and carcinogenic slope factors [CSFs]) in the Integrated Risk Information System and Health Effects Assessment Summary Tables databases. Where data were not available from either of these sources, EPA's National Center for Environmental Assessment data were used. Toxicity data used in risk evaluations for the COCs are provided on Table 2-4 (non-cancer) and Table 2-5 (cancer).

Risk Characterization

Risk characterization is the final step in an HHRA. For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated using the following equation:

Risk = Chronic daily intake (CDI) × CSF

where:

Risk = a unitless probability (i.e., 2×10^{-5}) of an individual's developing cancer

CDI = chronic daily intake averaged over 70 years (milligrams per kilogram [mg/kg]-day)

CSF = carcinogenic slope factor, expressed as $(mg/kg\text{-}day)^{-1}$

These risks are probabilities that usually are expressed in scientific notation (i.e., $1x10^{-6}$). An excess lifetime cancer risk of $1x10^{-6}$ indicates that an individual experiencing the RME estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been

estimated to be as high as 1 in 3. EPA's generally acceptable risk range for site-related exposures is 10^{-4} to 10^{-6}.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified period (i.e., lifetime) with an RfD derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effects. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The hazard index (HI) is generated by adding the HQs for all COCs that affect the same target organ (e.g., the liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI>1 indicates that site-related exposures may present a risk to human health. The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

CDI and RfD are expressed in the same units and represent the same exposure period (e.g., chronic, subchronic, short-term).

Soil. Risk summary tables for soil at Site 13 are provided in Appendix J.2, Table 9s of the SRI. There are no unacceptable non-cancer hazards associated with exposure to site soils for industrial workers, construction workers, or adult residents. In addition, there are no cancer risks above EPA's acceptable levels for industrial workers, construction workers, or adult/child residents.

A cumulative non-cancer hazard index (HI=1.1), slightly exceeding EPA's target HI of 1.0 was identified for a hypothetical future child resident from exposure to soil based on RME exposure concentrations. However, there are no individual compounds or target organ effects with an HQ greater than 1. In addition, there is no unacceptable soil hazard (HI=0.4) based on CTE (average concentration in soil) exposure concentrations. Therefore, the Navy, in partnership with the EPA and VDEQ, agree that there are no unacceptable risks associated with exposure to site soil, and no further action is necessary for soil at Site 13.

Groundwater. A summary of cancer risks and non-cancer hazards are provided in Appendix J.2, Tables 9s of the SRI. Risk estimates were calculated for future child and adult residents based on potable use of groundwater and for future industrial and construction worker exposure to groundwater in an open excavation. Those exposure scenarios would result in cancer risks and non-cancer hazards primarily associated with PCP and VOCs (PCE, TCE, and VC) above EPA's acceptable levels. The unacceptable risks and hazards associated with the groundwater are summarized on Tables 2-6 and 2-7.

Iron and manganese concentrations in groundwater resulted in HQs above EPA's acceptable threshold of 1 based on RME calculations. However, iron and manganese are essential human nutrients, the concentrations are consistent with background levels and the CTE concentrations are below the EPA's target HI of 1. Therefore, the Navy, in partnership with the EPA and VDEQ, agree the iron and manganese in groundwater do not pose an unacceptable risk, and no further action is necessary for metals in groundwater.

Summary of Total Risks Across Pathways and Media. There are no unacceptable RME risks from exposure to all media across all pathways under current land use (current industrial workers). Additionally, there are no unacceptable RME risks associated with exposure to site soil across all pathways and receptors. Potential future land use may pose an unacceptable risk from exposure via inhalation of, ingestion of, and dermal contact with site groundwater by industrial workers, residents, and construction workers. Detailed risk assessment results for receptors potentially at risk from exposure against all pathways and all media are provided in Table 9s of the SRI Appendix J.2.

Uncertainty

The risk measures used in risk assessments are not fully probabilistic estimates of risk but are conditional estimates, given that a set of assumptions about exposure and toxicity are realized. Thus, it is important to specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective. A detailed discussion of the uncertainties associated with the risk assessment is included in the SRI (CH2M HILL, 2002).

2.7.2 Ecological Risk Summary

The elements of the ecological exposure assessment for Site 13 are identified in the CSM (Figure 2-4). Potential ecological risks associated with Site 13 soil and groundwater were evaluated via a SERA and were found to be negligible. The limited available habitat due to the developed nature (buildings and pavement) of the site reduces the potential exposure to ecological receptors.

Although the site offers limited habitat, runoff from the site enters an adjacent drainage ditch which may be a complete pathway for ecological receptors. A BERA (through step 3a) was conducted to evaluate potential risks associated with soil in the drainage ditch. The results of the BERA indicated polycyclic aromatic hydrocarbons (PAHs) were detected above biological technical assistance group (BTAG) ecological screening values. However, site PAH concentrations were below BTAG approved alternate toxicologically-based screening values. Total PAHs did not exceed BTAG soil screening values for lower trophic level receptors based on mean surface soil concentrations. Furthermore, the onsite concentrations for individual PAHs were generally consistent with urban background concentrations based on ratios of maximum concentrations. None of the HQs for the upper trophic level receptors exceeded the target level of 1. Based on the results of the BERA, the potential risks to terrestrial organisms that may utilize the drainage ditch at Site 13 are expected to be negligible.

The Navy, in consultation with EPA and VDEQ agree that no action is warranted to protect ecological receptors at the site.

2.8 Remedial Action Objectives

It is the current judgment of the Navy and EPA, in consultation with VDEQ, that remedial action is necessary to protect public health, welfare, and the environment from actual or threatened releases of PCP and VOCs in shallow groundwater from Site 13. Although future land use is reasonably anticipated to remain industrial, the VDEQ groundwater anti-

degradation policy was identified as an applicable criterion to be considered. Clean up levels are the MCLs. Clean up levels are identified in Table 2-8. The site-specific Remedial Action Objectives (RAOs) are to:

- Prevent exposure to Site 13 groundwater until concentrations of PCP and VOCs have been reduced to levels that allow unlimited use and unrestricted exposure.
- Reduce concentrations of PCP and VOCs in Site 13 groundwater to the clean up levels in Table 2-8 through treatment to the maximum extent practicable within a reasonable amount of time.

LUCs will be maintained to prevent exposure to groundwater within the boundaries of Site 13 until the concentrations of VOCs and PCP in the groundwater have been reduced to levels that allow for unlimited use and unrestricted exposure (Figure 2-2).

2.9 Description of Alternatives

Remedial alternatives to address VOCs and PCP in groundwater at Site 13 were evaluated and are described in detail in the FS (CH2M HILL, 2004a). Various technologies were considered, but deemed to be unsuitable for the remedial action. This technology screening is summarized on Table 4-1 of the FS. Technologies that were retained for further consideration included those that enhance naturally occurring biodegradation processes and those that remove contaminated groundwater and treat it *ex situ*. Six remedial alternatives were developed from the technologies retained:

1. No Action
2. Long-term MNA
3. Pump and Treat
4. Enhanced Anaerobic/Aerobic Bioremediation with Reactive Zones
5. Enhanced Anaerobic Bioremediation
6. Enhanced Aerobic Bioremediation for PCP and MNA for VOCs

With the exception of Alternative 1 (no action), the remedial alternatives require groundwater monitoring and the implementation of LUCs to prevent exposure to groundwater until concentrations allow for unlimited use and unrestricted exposure.

2.9.1 Alternative 1—No Action

Alternative 1 is a no-action alternative in which no remedial actions are taken at Site 13. The no action alternative serves as a baseline for comparison, in accordance with CERCLA.

2.9.2 Alternative 2—Long-term MNA

This alternative allows the COCs to break down naturally over time via reductive dechlorination. Reductive dechlorination is a naturally occurring, microbially mediated, anaerobic process that degrades VOCs and PCP to less toxic daughter products. Geochemical data and the identification of PCE and TCE degradation daughter products indicate that natural attenuation through reductive dechlorination is occurring at the site.

Natural attenuation is expected to continue under this alternative until the mass of VOCs and PCP in the residual source area is depleted as evidenced by monitoring. This remedy is expected to require a minimum of 57 years to meet RAOs.

Throughout implementation of the remedy, the Navy will implement LUCs to prevent potential unacceptable risks to human receptors from exposure to VOCs and PCP in groundwater. Periodic groundwater monitoring would be needed to verify contaminant concentrations and groundwater quality. Five-year reviews are required until concentrations of COCs in groundwater allow for unlimited use and unrestricted exposure.

2.9.3 Alternative 3—Pump and Treat

This alternative uses extraction wells to remove contaminated groundwater and an onsite treatment system to treat the recovered groundwater to levels that would permit appropriate disposal. Extraction wells would be installed downgradient from the center of the plume to remove and prevent offsite flow of contaminated groundwater. The onsite treatment system would utilize activated carbon absorption. This alternative would provide positive hydraulic control of plume migration; extraction wells could produce inward hydraulic gradients to contain the plume within site boundaries. Extraction wells would increase groundwater flow velocities through contaminated areas resulting in potential increases in contaminant dissolution rates and ultimate removal. This remedy is expected to require a minimum of 57 years to meet RAOs.

Throughout implementation of the remedy, the Navy will implement LUCs to prevent potential unacceptable risks to human receptors from exposure to VOCs and PCP in groundwater. Periodic groundwater monitoring would be needed to verify contaminant concentrations and groundwater quality. Five-year reviews are required until concentrations of COCs in groundwater allow for unlimited use and unrestricted exposure.

2.9.4 Alternative 4—Enhanced Anaerobic/Aerobic Bioremediation with Reactive Zones

This alternative uses a passive *in situ* bioremediation strategy that targets PCP remediation under aerobic conditions and VOC remediation under anaerobic conditions. Geochemical data and the identification of VOC daughter products indicate that natural attenuation through reductive dechlorination is occurring at the site.

The aerobic and anaerobic zones would be established by injecting an oxygen releasing and hydrogen releasing substrate into the groundwater to form a reactive barrier cross-gradient to the direction of groundwater flow. Groundwater is passively treated as it moves through the treatment zones. Treatment effectiveness is expected to be high within the reactive zone due to high concentrations of substrate and low groundwater velocities, but will decrease with distance downgradient of the zone as substrate concentrations decrease. Reapplication of substrate may be necessary to maintain desired subsurface environmental conditions. RAOs are expected to be achieved in less than 45 years. The duration of remedial action is dependent on groundwater velocities and contaminant partitioning to the soil.

Throughout implementation of the remedy, the Navy will implement LUCs to prevent potential unacceptable risks to human receptors from exposure to VOCs and PCP in groundwater. Periodic groundwater monitoring would be needed to verify contaminant

concentrations and groundwater quality. Five-year reviews are required until concentrations of COCs in groundwater allow for unlimited use and unrestricted exposure.

2.9.5 Alternative 5—Enhanced Anaerobic Bioremediation

This alternative uses injection of organic substrate, such as an emulsified vegetable oil or other comparable substrate, to create anaerobic conditions and to serve as an electron donor to enhance the biodegradation of PCP and VOCs. Based on current site conditions, the proposed injection layout for enhanced anaerobic bioremediation treatment consists of a grid of injection wells in the source area and a single line of injection wells perpendicular to the downgradient plume.

It is difficult to estimate the length of time the substrate will serve as an electron donor or the time required to achieve adequate reduction in PCP and VOCs to allow active remediation to cease. However, field application of emulsified oil substrate has shown it can last for several years if applied at a sufficiently high concentration. For cost estimating purposes, it was assumed substrate would remain effective for enhanced anaerobic bioremediation for 3 years after each injection, and a total of three injections would be required. However, as treatment progresses and the concentrations of the COCs and their daughter products change, the type of substrate, the quantity of substrate, the frequency of injection, and the location of injection may be revised to address current site conditions. It was assumed that following the third injection, PCP and VOC concentrations will have decreased such that subsequent injections will no longer be required. During the active injection period, groundwater monitoring would be completed to evaluate the performance of the injections and the overall effectiveness of the treatment. Groundwater monitoring will also be required to continue after active remediation ceases if PCP and VOC concentrations in groundwater continue to exceed MCLs. For cost estimating purposes, PCP and VOCs were estimated to degrade to below MCLs in approximately 45 years.

Throughout implementation of the remedy, the Navy will implement LUCs to prevent potential unacceptable risks to human receptors from exposure to PCP and VOCs in groundwater. Five-year reviews are required until concentrations of COCs in groundwater allow for unlimited use and unrestricted exposure.

2.9.6 Alternative 6—Enhanced Aerobic Bioremediation for PCP and MNA for VOCs

This alternative involves active remediation of the higher concentration PCP plume, followed by MNA of the VOC plume. The creation of an aerobic zone would promote biodegradation of PCP. Geochemical data and the identification of PCE and TCE degradation daughter products indicate that natural attenuation through reductive dechlorination is occurring at the site.

Aerobic conditions would be created by injecting an oxygen releasing compound into the subsurface in a grid pattern. The pattern would provide an even distribution of substrate over the extent of the PCP plume. Residual source areas may receive larger doses of substrate. Treatment effectiveness is expected to be high within the reactive zone due to high concentrations of substrate and low groundwater velocities, but will decrease with distance downgradient of the zone as substrate concentrations decrease. Reapplication of

oxygen releasing compound may be necessary to maintain desired subsurface environmental conditions. The aerobic conditions created by the injection of oxygen releasing compound will initially hinder reductive dechlorination of PCE and TCE. However, the concentration of VOCs is near clean up levels and reductive dechlorination is expected to continue as the aquifer recovers from the aerobic "spike". The duration of remedial action is dependent on aquifer recovery to anaerobic conditions from the aerobic "spike". RAOs are expected to be achieved in approximately 45 years.

Throughout implementation of the remedy, the Navy will implement LUCs to prevent potential unacceptable risks to human receptors from exposure to VOCs and PCP in groundwater. Periodic groundwater monitoring would be needed to verify contaminant concentrations and groundwater quality. Five-year reviews are required until concentrations of COCs in groundwater allow for unlimited use and unrestricted exposure.

2.9.7 Common Elements and Distinguishing Features

Alternative 1 does not protect human health and the environment, but provides a baseline for comparison purposes. With the exception of the no-action alternative, the common elements of the remedial alternatives evaluated are as follows:

- Comply with ARARs
- Require statutory remedy 5-year reviews
- Require groundwater monitoring and reporting
- Require LUCs until PCP and VOC concentrations in groundwater are reduced to levels that allow unlimited use and unrestricted exposure
- The same RAOs and expected outcome of reducing PCP and VOC concentrations to MCLs

Distinguishing features of the remedial alternatives are as follows:

- Estimated remedial action timeframe
- Alternative 2—Involves no active remediation of PCP or VOC plumes
- Alternative 3—Removal of contaminated groundwater and *ex situ* treatment of removed water
- Alternative 4—Creation of both aerobic and anaerobic treatment zones in a down gradient reactive barrier
- Alternative 5—Initial creation of anaerobic treatment zone in source area and downgradient
- Alternative 6—Initial creation of aerobic treatment zone in source area and downgradient

Other distinguishing features are cost and implementation requirements.

2.10 Comparative Analysis of Alternatives

Each remedial alternative for Site 13 was evaluated against the nine criteria listed below. Alternative 1 (no action) was evaluated as a baseline and does not achieve RAOs and is not evaluated in detail against the nine criteria. The Site 13 FS provides a more detailed comparative analysis of alternatives. A comparison of the alternatives is presented in Table 2-9.

- **Protection of Human Health and the Environment**. Addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.
- **Compliance with ARARs**. Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, which are collectively referred to as "ARARs," unless waived under CERCLA §121(d)(4).
- **Long-term Effectiveness and Permanence**. Refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.
- **Reduction of Toxicity, Mobility, or Volume Through Treatment**. Refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.
- **Short-term Effectiveness**. Addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy.
- **Implementability**. Considers the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.
- **Cost**. Refers to the estimated capital and annual O&M costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent.
- **State Acceptance.** Includes the State's position and key concerns related to the preferred alternative and other alternatives in the proposed plan, and State comments on ARARs or proposed ARARs waivers.
- **Community Acceptance**. Includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose.

2.10.1 Threshold Criteria

Protection of Human Health and the Environment

The LUC component of Alternatives 2 through 6 protects human health and the environment until such time as the remedy reduces PCP and VOC to meet RAOs. Alternatives 3 through 6 reduce COC concentrations through active treatment and protect human health and the environment. The no action alternative (Alternative 1) does not meet the threshold criterion of protecting human health and the environment and will not be discussed any further.

Compliance with Applicable or Relevant and Appropriate Requirements

Each was evaluated for chemical-specific, location-specific, and action-specific requirements. With the exception of the no action alternative, all of the alternatives will comply with ARARs.

2.10.2 Primary Balancing Criteria

Long-term Effectiveness and Permanence

Alternatives 2 through 6 prevent exposure to and use of Site 13 groundwater through LUCs and provide long-term permanent restoration of the aquifer. Alternatives 2, 4, and 6 are considered slightly less effective in the long term because they do not target the source zone through treatment and/or do not equally treat PCP and VOCs.

Reduction in Toxicity, Mobility, or Volume

Alternative 2 has no features that would act to reduce toxicity, mobility, or volume of contaminants, except the eventual depletion of the contaminant plume by natural processes. Alternatives 4, 5, and 6 equally reduce toxicity mobility or volume through use of substrate in the source (Alternatives 5 and 6) and/or at the plume boundary (Alternatives 4, 5, and 6) to enhance naturally occurring dechlorination of VOCs and PCP. Although Alternative 3 reduces toxicity, mobility, and volume of the contaminant plume through physical removal of contaminated groundwater, the anticipated time to reach clean up levels is longer than alternatives 4, 5, and 6. Both enhanced Alternatives 5 and 6 will alter the redox potential of the aquifer, and both alternatives may result in the mobilization of select metals inherent to the soils at NAB Little Creek. However, after treatment is concluded, LTM will be conducted to ensure the aquifer re-equilibrates and metals concentrations return to pretreatment conditions.

Short Term Effectiveness

Alternative 2 would result in no short-term change in the level of risk posed by groundwater contamination at Site 13 because no active measures would be taken to treat the groundwater. Alternatives 4, 5, and 6 involve *in situ* treatment of the groundwater and there is the potential for worker exposure to contaminated soil during well installation and to groundwater during groundwater sampling, well installation, and substrate injection. Alternative 3 has the least short term effectiveness as a result of the extraction and management of contaminated groundwater *ex situ* resulting in frequent exposure to the COCs in groundwater.

Implementability

There are no implementability requirements associated with Alternative 2. Alternatives 3 through 6 incorporate active remedial measures:

- Alternative 3 requires installation of a pumping system, increasing the difficulty of implementation. In addition, a small onsite treatment system for removing PCP and VOCs would be constructed, increasing the difficulty of implementation. Periodic maintenance and operational adjustments would be required.
- Alternative 4 requires injection of two different substrates along the boundary of the contaminant plume in specific configurations. This alternative would be more difficult to implement than Alternatives 5 or 6.
- Alternatives 5 and 6 require injection of substrate through permanent or temporary injection wells. The installation of the injection wells will temporarily impede the use of limited areas of the parking lot at Site 13. The parking lot will also be temporarily obstructed during injections and groundwater sampling. However, the extent to which the parking lot is obstructed during injections and groundwater sampling is expected to be less than during well installation.

Cost

Alternative 2 involves no remedial action, so there are no capital or operational costs associated with those alternatives. Alternative 2 includes costs associated with continuing groundwater monitoring, which are common to all of the remedial action alternatives being considered.

Alternatives 3 though 6 incorporate active remedial activities:

- Costs for Alternative 3 include capital and operational costs associated with installation and O&M of the pumping wells and onsite treatment system and costs associated with long-term groundwater monitoring. The total 30-year net present value of this alternative, including monitoring, is $777,713.
- Costs for Alternative 4 include capital and operational costs associated with two different substrate injection materials and mobilization of direct-push equipment for completing the injection and costs associated with long-term groundwater monitoring. Replenishment of substrate materials in the barrier walls may be required at periodic intervals to ensure continued effectiveness. The total estimated net present value for a one-time injection with a 30-year monitoring period is $703,892.
- Costs for Alternative 5 includes capital and operational costs associated with well installation, three substrate injections, and the costs associated with long-term groundwater monitoring. The net present value for the 30-year monitoring period is $787,313.
- Costs for Alternative 6 includes capital and operational costs associated with substrate injection material and mobilization of direct-push equipment to complete the injection and costs associated with long-term groundwater monitoring. The replenishment of the substrate material may be required at periodic intervals to ensure continued

effectiveness. Costs were estimated for a one-time injection with a 45-year monitoring period and a 10-year monitoring period with two substrate replenishments. Alternative 6 has a net present value of $808,946 for the 45-year monitoring period.

These costs are summarized in Table 2-9.

2.10.3 Modifying Criteria

State Acceptance

State involvement has been solicited throughout the CERCLA process and proposed remedy selection. VDEQ, as the designated State support agency in Virginia, has reviewed this ROD and has given concurrence on Alternative 5, the Selected Remedy.

Community Acceptance

The public meeting was held on June 12, 2007 to present the PP and answer community questions regarding the proposed remedial action at Site 13. No members of the community attended the public meeting. No comments were received from the public during the public comment period. Detailed information on the public meeting is provided in the Responsiveness Summary of this ROD.

2.11 Principal Threat Wastes

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site whenever practicable. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur.

The original source for potential principal threat waste was removed with the excavation of the dip tank and associated soils. DNAPL have not been identified at Site 13. Dissolved VOC and PCP concentrations are present in groundwater, but contaminated groundwater is generally not considered principal threat waste.

Under current land use, groundwater is not used as a potable supply. Exposure to groundwater from construction activities is restricted by NAB Little Creek "dig permit" protocols which require personnel to consult with environmental staff prior to any subsurface intrusive activities. For anticipated future land use scenarios, LUCs will prohibit potable groundwater use until concentrations are reduced to levels that allow for unlimited use and unrestricted exposure. All available data suggest that mobility and migration of contaminated groundwater is limited at Site 13.

Based on the absence of identified DNAPL and a lack of exposure, principal threat wastes are not present at Site 13.

2.12 Selected Remedy

Alternative 5, Enhanced Anaerobic Bioremediation with LUCs, is the Selected Remedy to address groundwater contamination at Site 13.

2.12.1 Summary of the Rationale for the Selected Remedy

Alternative 5, Enhanced Anaerobic Bioremediation, is expected to effectively achieve RAOs in about the same time (estimated to be < 45 years) as Alternatives 4 and 6 and in less time than Alternatives 1 through 3. Alternative 5 will achieve RAOs with similar ease of implementation and achieves greater long-term effectiveness and permanence than Alternatives 4 and 6 because it will equally treat the VOCs and PCP. Additionally, Alternative 5 will achieve RAOs with lower cost than Alternative 6.

The Navy and EPA, in consultation with VDEQ, believe enhanced anaerobic bioremedation meets the threshold criteria and provides the best balance of tradeoffs among the alternatives with respect to the balancing and modifying criteria. The Navy expects the Selected Remedy to satisfy the following requirements of CERCLA:

- Protection of human health and the environment
- Compliance with ARARs
- Cost-effectiveness
- Utilization of permanent solutions and alternative treatment technologies to the maximum extent practicable
- The preference for treatment as a principal element

2.12.2 Description of the Selected Remedy

Biological reductive dechlorination is a naturally-occurring, microbially-mediated, anaerobic process in which chlorine atoms on a parent PCP or VOC molecule are sequentially replaced with hydrogen. In the reductive dechlorination process, electrons are transferred from an electron donor to the PCP or VOC compound, which functions as the electron acceptor. Therefore, an external electron donor source is required for the reaction to occur. Potential electron donor sources include biodegradable organic co-contaminants, native organic matter, or substrates intentionally added to the aquifer. Deeply anaerobic (reducing) conditions are required for reductive dechlorination of many compounds, and competing electron acceptors such as dissolved oxygen, nitrate, nitrite, manganese (IV), ferric iron, and sulfate must be depleted. Enhanced Anaerobic Bioremediation is implemented by adding a suitable substrate to the groundwater. The introduced substrate serves multiple purposes: depleting competing electron acceptors, creating strongly reducing conditions, and producing an electron donor source for reductive dechlorination.

The predominant parent COCs at Site 13 are PCP, PCE, and TCE. To complete anaerobic degradation of PCP, the replacement of a chlorine with a hydrogen molecule results in the production of first a tetrachlorophenol, followed by a trichlorophenol, then a dichlorophenol, and finally chlorophenol before the phenol ring is broken relatively late in the process. The sequential degradation pathway for chlorinated ethenes begins with PCE degrading to TCE, dichloroethene (DCE) (predominantly cis-1,2-DCE), VC, and finally to the innocuous end product, ethene. Ethene further degrades to ethane. Reductive dechlorination of phenols may occur at a slower rate than reductive dechlorination of ethenes. However, a microcosm study conducted as part of the FS confirmed anaerobic biodegradation of PCP could take place at Site 13, and the addition of an electron donor

increased the degradation rate. The elevated concentrations of cis-1,2-DCE and VC demonstrate reductive dechlorination of the chlorinated ethenes at Site 13 is already occurring.

Before implementation of this alternative, groundwater samples will be collected to confirm the assumptions made in the proposed treatment design, and to modify as necessary the application locations, substrate, and the corresponding monitoring locations. Based on current site conditions, preliminary design elements for implementation of the Enhanced Anaerobic Bioremediation remedy are presented on Figure 2-6 and Table 2-10. Anaerobic conditions will be established by injecting an emulsified oil substrate (or comparable substrate) into permanent injection wells. Injection wells will be arranged in a grid pattern in the upgradient portion of the site to target the elevated concentrations associated with the source area. To treat the downgradient plume, injection wells will be arranged in a single line perpendicular to groundwater flow where plume concentrations are greatest. It is anticipated that the grid area will have 18 injection wells (three rows of six wells) and the single line in the downgradient plume will have eight injection wells.

For cost estimating purposes it was assumed monitoring wells and injection wells would be installed at the onset of the project, a total of three injections would be completed (one every third year), and groundwater monitoring would be completed for 45 years. The 45-year groundwater monitoring period would consist of a baseline round of samples collected before injections, periodic performance monitoring and annual monitoring throughout the active injection period, and annual monitoring following the active injection period (Table 2-10). Since contaminants will remain in place, 5-year reviews will be required to evaluate remedy effectiveness. If necessary, as treatment progresses and the concentrations of the COCs and their daughter products change, the type of substrate, the quantity of substrate, the frequency of injection, and the location of injection may be revised to address current site conditions.

The Selected Remedy shall attain, to the maximum extent practicable in a reasonable amount of time, the cleanup levels in Table 2-8 in ground water throughout Site 13 and in any portion of the Site 13 VOC or phenol plume that migrates beyond the boundaries of Site 13. Throughout implementation of the remedy, the Navy will implement LUCs to prevent potential unacceptable risks to human receptors from exposure to PCP and VOCs in groundwater. LUCs will be implemented by the Navy within the boundaries of Site 13 (Figure 2-6) until the concentrations of PCP and VOCs in groundwater have been reduced to levels that allow for unlimited use and unrestricted exposure. The LUCs will meet the following objectives:

- Prohibit the withdrawal of groundwater except for environmental monitoring and testing
- Prohibit the use of the site for residential, child care, elementary or secondary school, or playground facilities
- Maintain the integrity of any current or future remedial or monitoring system

The Navy shall develop and submit to EPA and VDEQ, in accordance with the FFA and the schedule in the SMP, a groundwater treatment Remedial Action Work Plan/RD and a LUC RD. The LUC RD will provide for implementation and maintenance actions, including

periodic inspections and reporting. The Navy will implement, maintain, monitor, report on, and enforce the LUCs according to the LUC RD.

2.12.3 Summary of the Estimated Remedy Costs

A complete cost summary for each remedial alternative is provided in Appendix F of the Site 13 FS (CH2M HILL, 2004a). The estimated costs for the selected remedy are summarized in Table 2-11. The information in this cost estimate is based on the best available information regarding the anticipated scope of the Selected Remedy. Changes in the cost estimate are likely to occur as a result of new information and data collected during the remedial design of the Selected Remedy. Major changes will be documented in the form of a memorandum in the Administrative Record file, an explanation of significant differences or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 percent to -30 percent of the actual project cost.

2.12.4 Expected Outcomes of the Selected Remedy

Current land uses (light industrial) are expected to continue at Site 13, and there is no other planned land use in the foreseeable future. If enhanced anaerobic bioremediation is implemented, exposure will be controlled through LUCs until groundwater PCP and VOC concentrations are reduced to acceptable levels for unlimited use and unrestricted exposure. The effectiveness of treatment of PCP and VOCs in groundwater will be measured by comparison to clean up levels (Table 2-8); however, the remedial technologies are not guaranteed to achieve concentrations at or below clean up levels across the site. As required by CERCLA, 5-year reviews will be conducted to assess the effectiveness of the remedy and groundwater quality. If necessary, as treatment progresses and the concentrations of the COCs and their daughter products change, the type of substrate, the quantity of substrate, the frequency of injection, and the location of injection may be revised to address current site conditions.

2.13 Statutory Determinations

Remedial actions undertaken at NPL sites must meet the statutory requirements of Section 121 of CERCLA and thereby achieve adequate protection of human health and the environment; comply with ARARs of both federal and state laws and regulations; be cost-effective; and use, to the maximum extent practicable, permanent solutions and alternative treatment or resource recovery technologies. In addition, CERCLA states a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, and/or mobility of hazardous waste as the principal element. The following discussion summarizes the statutory requirements that are met by the Selected Remedy.

2.13.1 Protection of Human Health and the Environment

The Selected Remedy, enhanced anaerobic bioremediation, will protect human health and the environment by reducing and controlling site risks through groundwater treatment to reduce contaminant mass and toxicity. Furthermore, LUCs will be implemented to eliminate the threat of exposure to the COC via ingestion of, inhalation of, or direct contact with PCP and VOCs in groundwater. Short term risks associated with the implementation of the Selected Remedy are easily managed to prevent unacceptable exposure.

2.13.2 Compliance with Applicable or Relevant and Appropriate Requirements and To-Be-Considered Criteria

The Selected Remedy will meet all identified ARARs. Federal and state ARARs for Site 13, summarized by classification, are presented in Table 2-12 (Federal) and Table 2-13 (State). The classification of ARARs identified include chemical-specific, location-specific, and action-specific requirements and other to-be-considered criteria, as appropriate.

2.13.3 Cost-Effectiveness

The Selected Remedy is cost-effective and represents a reasonable value for the cost of the remedy. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (NCP § 300.430[f][1][ii][D]). This determination was accomplished by evaluating the overall effectiveness of those alternatives that satisfied the threshold criteria. Overall effectiveness was then compared to costs to assess cost-effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to represent a reasonable value for the money to be spent. The estimated present-worth cost of the Selected Remedy is $787, 313.

2.13.4 Use of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

The Navy, EPA, and VDEQ agree that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a practicable manner at Site 13. The Selected Remedy provides treatment through substrate injection that enhances dechlorination through natural microbial degradation processes to reduce contaminant mass. Because long-term effectiveness and permanence, as well as reduced toxicity and volume, are achieved through the Selected Remedy, the Navy, EPA, and VDEQ concur that the Selected Remedy provides the best balance of tradeoffs in terms of the balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against offsite treatment and disposal, and considering state and community acceptance.

2.13.5 Preference for Treatment as a Principal Element

The Selected Remedy uses treatment as a principal element and therefore satisfies the statutory preference for treatment.

2.13.6 Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

2.14 Documentation of Significant Changes

The PP for Site 13 was released for 30 day public comment period on June 5, 2007 and identified enhanced anaerobic bioremediation as the Preferred Alternative for groundwater

remediation. No new information or comments were received during the public comment period to result in a change to the remedy, as originally identified in the Proposed Plan.

SECTION 3

Responsiveness Summary

In accordance with Section 113 and 117 of CERCLA 42 U.S.C. §§9613 and 9617, the Navy provided a public comment period from June 5 through July 5, 2007, for the proposed remedial action described in the FS and PP for Site 13. A public meeting to present the PP was held at Shelton Park Elementary School in Virginia Beach, Virginia, on June 11, 2007. Public notice of the meeting and availability of documents was placed in *The Virginian-Pilot* newspaper on June 3, 2007.

The participants in the public meeting included representatives of the Navy, EPA, and VDEQ. No community members attended the meeting. No questions were received during the public meeting, and no additional written comments, concerns, or questions were received from community members during the public comment period.

SECTION 4

References

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Tables

Table 2-1
Sample Analysis Summary for Investigation Activities
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

	Groundwater							Surface Soils			Subsurface Soils				
						Metals									
Year	VOCs	6 Chlorinated VOCs*	SVOCs	PCP	Pesticides/ PCB	Total	Dissolved	VOCs	SVOCs	Metals	VOCs	6 Chlorinated VOCs*	SVOCs	PCP	Metals
1993	7	NA	6	NA	NA	NA	NA	6	6	NA	2	NA	2	NA	NA
1995	14	NA	12	NA	3	4	4	NA	NA	NA	16	NA	16	NA	3
1998	NA	70	30	33	NA	NA	25	NA	NA	NA	NA	7	NA	NA	NA
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	13	NA
2000	7	NA	17	NA	NA	8	8	NA	NA	NA	NA	NA	NA	NA	NA
2001	38	NA	57	NA	NA	11	11	NA	NA	NA	NA	NA	NA	NA	NA
2002	NA	NA	NA	4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2003	31	NA	27	NA	NA	27	25	NA	NA	NA	NA	NA	NA	NA	NA
2004	15	NA	15	NA	NA	15	15	NA	NA	NA	NA	NA	NA	NA	NA
2005	46	NA	46	NA	3	45	45	NA	NA	NA	NA	NA	NA	NA	NA
2006	15	NA	10	NA	NA	10	10	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

NA - Analytical suite not analyzed

VOCs - Volatile Organic Compounds

SVOCs - Semivolatile Organic Compounds

* 1,1-Dichloroethene, Tetrachloroethene, Trichloroethene, Vinyl chloride, cis-1,2-Dichloroethene, trans-1,2-Dichloroethene

Table 2-2
Maximum Concentration of Chemicals of Concern
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Chemical of Potential Concern	Maximum Concentration (µg/L)
Tetrachloroethene	5.2
Trichloroethene	8.9
Vinyl Chloride	61
Pentachlorophenol	1,500

Table 2-3
Sample Analysis Summary for Investigation Activities
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Chemical of Potential Concern	Average Concentration (µg/L)	Maximum Concentration (µg/L)		Location of Maximum Concentration	Detection Frequency	Screening Toxicity Value (µg/L)		Exposure Point Concentration (Reasonable Maximum Exposure) (µg/L)	Exposure Point Concentration (Central Tendency) (µg/L)
Tetrachloroethene	2.23E+02	3.50E+02	D	LC13-GW106-95C	15/35	1.07E+00		3.50E+02	2.23E+02
Trichloroethene	9.55E+01	1.50E+02		LC13-GW110-95C	17/35	1.55E+00	C	1.50E+02	9.55E+01
Vinyl Chloride	2.20E+01	3.10E+01		LC13-GW110-95C	7/35	1.91E-02	C	3.10E+01	2.20E+01
Pentachlorophenol	NA	3.20E+02	D	LC13-GW108-95C	20/34	5.58E-01		3.20E+02	3.20E+03

Notes:
N - Non Cancer
C - Cancer
J - Concentration is estimated below the detection limit.
D - Result came from a diluted sample.

Table 2-4
Oral Dermal/Inhalation Non-Cancer Data
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Dermal RfD Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfD: Target Organ	Dates or RFD: Target Organ (3) (MM/DD/YYYY)
Pentachlorophenol	Chronic	3.0E-02	mg/kg-day	50%	1.5E-02	mg/kg-day	Fetus	100	IRIS	2/28/2000
	Subchronic	3.0E-02	mg/kg-day	50%	1.5E-02	mg/kg-day	Fetus	100	HEAST	2/28/2000
Tetrachloroethene	Chronic	1.0E-02	mg/kg-day	100%	1.0E-02	mg/kg-day	Liver	1000	IRIS	2/28/2000
	Subchronic	1.0E-01	mg/kg-day	100%	1.0E-01	mg/kg-day	Liver	100	HEAST	2/28/2000
Trichloroethene	Chronic	6.0E-03	mg/kg-day	100%	6.0E-03	mg/kg-day	Liver, Kidney		NCEA	
	Subchronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vinyl chloride	Chronic	3.0E-03	mg/kg-day	100%	3.0E-03	mg/kg-day	Liver	30/1		
	Subchronic	N/A								

Chemical of Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD (2)	Units	Primary Target Organ	Combined Uncertainty/ Modifying Factors	Sources of RfC: RfD: Target Organ	Dates (3) (MM/DD/YYYY)
Pentachlorophenol	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Subchronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tetrachloroethene	Chronic	4.90E-01	mg/m^3	1.40E-01	mg/kg-day	Liver	N/A	NCEA	N/A
	Subchronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Trichloroethene	Chronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Subchronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vinyl chloride	Chronic	1.00E-01	mg/m^3	2.80E-02	mg/kg-day	Liver	30/1	IRIS	3/10/2001
	Subchronic	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A = Not Applicable or Not Available. IRIS indicates that calculations of dermal risks may not be appropriate for this chemical.
(1) Refer to RAGS, Part A. Source is EPA Region III *Oral Absorption Values for Oral-to-Dermal Extrapolation*, April 8, 1999.
For constituents not available in the Region III document the following general values were used: VOCs - 80%, Pesticides/PCBs - 50%, and metals - 20%.
ATSDR = Agency for Toxic Substances and Disease Registry
IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables
NCEA = National Center for Environmental Assessment
(2) Provide equation for derivation in text.
(3) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide the date of the article provided by NCEA.

RESP = Respiratory System
CNS = Central Nervous System
NOAEL = No adverse effect level

Table 2-5
Oral Dermal/Inhalation Cancer Data
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	EPA Carcinogen Group	Source	Date (2) (MM/DD/YYYY)
Pentachlorophenol	1.2E-01	50%	2.4E-01	$(mg/kg\text{-}day)^{-1}$	B2	IRIS	2/28/2000
Tetrachloroethene	5.2E-02	100%	5.2E-02	$(mg/kg\text{-}day)^{-1}$		NCEA	
Trichloroethene	1.1E-02	100%	1.1E-02	$(mg/kg\text{-}day)^{-1}$		NCEA	
Vinyl chloride (lifetime from birth)	1.4E+00	100%	1.4E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	10/31/2000
Vinyl chloride (lifetime from adult)	7.2E-01	100%	7.2E-01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	10/31/2000

Chemical of Potential Concern	Unit Risk	Units	Adjustment (3)	Inhalation Cancer Slope Factor	Units	Weight of Evidence/Cancer Guidance Description	Source	Date (2) (MM/DD/YYYY)
Pentachlorophenol	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tetrachloroethene	5.7E-07	$(\mu g/m^3)^{-1}$	3500	2.0E-03	$(mg/kg\text{-}day)^{-1}$		NCEA	
Trichloroethene	1.7E-06	$(\mu g/m^3)^{-1}$	3500	6.0E-03	$(mg/kg\text{-}day)^{-1}$		NCEA	
Vinyl chloride (lifetime from birth)	4.4E-06	$(\mu g/m^3)^{-1}$	3500	1.5E-02		A	IRIS	10/31/2000
Vinyl chloride (lifetime from adult)	8.8E-06	$(\mu g/m^3)^{-1}$	3500	3.1E-02	$(mg/kg\text{-}day)^{-1}$	A	IRIS	10/31/2000

(1) Refer to RAGS, Part A. Source is EPA Region III *Oral Absorption Values for Oral-to-Dermal Extrapolation* , April 8, 1999.
(2) For IRIS values, provide the date IRIS was searched.
For HEAST values, provide the date of HEAST.
For NCEA values, provide article date provided by NCEA.
(3) Adjustment Factor applied to Unit Risk to calculate Inhalation Slope Factor = 70 kg x 1/20m^3/day x 1000 µg/mg

N/A-Not available
IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables
NCEA = National Center for Environmental Assessment
U = Under review.

EPA Carcinogen Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

Table 2-6
Summary of Unacceptable RME Cancer Risks and Hazard Indices
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Receptor	Media	Exposure Route	Cancer Risk	COCs with Cancer Risks >10^{-4}	Hazard Index	COCs with HQ > 1
Future Resident Adult	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		1.90E+00	Iron (1.9E+00)
		Dermal Contact	NA		9.00E+00	Pentachlorophenol (9.0E+00)
		Total	NA		1.09E+01	
		Receptor Total	NA		1.09E+01	
Future Resident Child	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		1.04E+01	Tetrachloroethene (2.2E+00) Trichloroethene (1.6E+00) Iron (4.3E+00) Manganese (2.3E+00)
		Dermal Contact	NA		2.00E+01	Tetrachloroethene (1.2E+00) Pentachlorophenol (2.0E+01)
		Total	NA		3.04E+01	
		Receptor Total	NA		3.04E+01	
Future Resident Adult/Child	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		NA	
		Dermal Contact	3.48E-02	Trichloroethene (1.7E-02) Pentachlorophenol (1.7E-02)	NA	
		Total	3.48E-02		NA	
		Receptor Total	3.48E-02		NA	
Future Industrial Worker	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		NA	
		Dermal Contact	NA		NA	
		Total	NA		NA	
		Receptor Total	NA		NA	
Future Construction Worker	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		NA	
		Dermal Contact	NA		5.40E+00	Pentachlorophenol (5.4E+00)
		Total	NA		5.40E+00	
		Receptor Total	NA		5.40E+00	

Incremental cancer risks and hazard quotients are identified in parathesis
NA - Not applicable.

Table 2-7
Summary of Unacceptable CTE Cancer Risks and Hazard Indices
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Receptor	Media	Exposure Route	Cancer Risk	COCs with Cancer Risks $>10^{-4}$	Hazard Index	COCs with HQ > 1
Future Resident Adult	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		NA	
		Dermal Contact	NA		5.44E+00	Pentachlorophenol (5.44E+00)
		Total	NA		5.44E+00	
		Receptor Total	NA		5.44E+00	
Future Resident Child	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		NA	
		Dermal Contact	NA		2.35E+01	TrIchloroethene (1.18E+01) Pentachlorophenol (1.18E+01)
		Total	NA		2.35E+01	
		Receptor Total	NA		2.35E+01	
Future Resident Adult/Child	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		NA	
		Dermal Contact	6.15E-03	Pentachlorophenol (6.15E-03)	NA	
		Total	6.15E-03		NA	
		Receptor Total	6.15E-03		NA	
Future Industrial Worker	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		NA	
		Dermal Contact	NA		NA	
		Total	NA		NA	
		Receptor Total	NA		NA	
Future Construction Worker	Groundwater	Inhalation	NA		NA	
		Ingestion	NA		NA	
		Dermal Contact	NA		1.44E+00	Pentachlorophenol (1.44E+00)
		Total	NA		1.44E+00	
		Receptor Total	NA		1.44E+00	

Incremental cancer risks and hazard quotients are identified in parathesis
NA - Not applicable.

Table 2-8
Preliminary Remediation Goals
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Chemical of Concern	Clean up Level (µg/L)
Tetrachloroethene	5
Trichloroethene	5
Vinyl Chloride	2
Pentachlorophenol	1

Table 2-9
Description of Alternatives for Site 13
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Alternative	Components	Details	Cost	Cost Per Year	Cost Total
1--No Action	Existing groundwater plume	N/A	Capital Cost Annual O&M Present Value Time Frame > 70 Years	$0 $0 $0	$0 $0 $0
2--Long-Term Monitored Natural Attenuation (MNA)	MNA LTM LUCs	Allow the COCs to break down naturally over time Conduct LTM to evaluate NA and track changes in concentraiton and potential movement of the plume. Implement LUCs to prevent exposure to groundwater until remediation goals are met.	Capital Cost (YEAR 0) Annual O&M (YEAR 1 -30) Present Value (30 years) Time Frame > 57 Years	$30,000 $25,680	$30,000 $770,400 $414,530
3--Pump and Treat	Extraction wells Onsite treatment system LTM LUCs	Installaiton of 2 extraction wells downstream from the center of the plume to remove and prevent ofsite flow of contaminated groundwater. Installation of an onsite treatment system to treat the extracted groundwater for disposal. Conduct LTM to evaluate treatment and track changes in concentration and potential movement of the plume. Implement LUCs to prevent exposure to groundwater until remediation goals are met.	Capital Cost (YEAR 0) Annual O&M Cost (YEAR 1-30) Pump Rehabilitation (5 Year Intervals) Air Stripper Cleaning/Metals Removal Rehabilitation (3 Year Intervals) Present Value (30 years) Time Frame = 57 Years	$113,055 $42,257 $3,552 $5,000	$113,055 $1,267,710 $21,312 $50,000 $777,713
4--4 Enhanced Anaerobic/Aaerobic Bioremediation with Reactive Zones	Aerobic treatment zone for PCP Anaerobic treatment zone for VOCs LTM LUCs	Injection of compound to create an aerobic treatment zone to enhance biodegradation of PCP. Groundwater is passively treated as it moves through the zone. Injection of a compound to create an anaerobic treatment zone to enhance biodegradation of VOCs. Groundwater is passively treated as it moves through the treatment system. Conduct LTM to evaluate treatment and track changes in concentration and potential movement of the plume. Implement LUCs to prevent exposure to groundwater until remediation goals are met.	Capital Cost (YEAR 0) Annual O&M Cost (YEAR 1-30) Time Frame < 45 years Present Value (30 Years) (1 Treatment Event) Time Frame < 45 Years	$319,326 $25,680	$319,326 $770,400 $703,892 $703,892
5--Enhanced Anaerobic Bioremediation	Direct anaerobic treatment of PCP and VOCs MNA for VOCs LTM LUCs	Injection of a compound to create an anaerobic treatment zone to directly treat the source area and groundwater plume through enhanced bioremediation of the PCP and VOCs. Period of treatment impacted by the number of injection events. Conduct LTM to evaluate treatment and track changes in concentration and potential movement of the plume. Implement LUCs to prevent exposure to groundwater until remediation goals are met.	Capital Cost (YEAR 0) Annual O&M Cost (YEAR 1-30) Present Value (30 Years) (1 Treatment Event) Time Frame < 45 years	$378,987 $32,180	$378,987 $965,400 $787,313
6--Enhanced Aerobic Bioremediation for PCP and Monitored Natural Attenuation for VOCs	Direct aerobic treatment of PCP MNA for VOCs LTM LUCs	Injection of compound to create aerobic conditions to directly treat the source area and groundwater plume through enhanced bioremediatiojn of PCP. Period of treatment impacted by the number of injection events. Conduct LTM to evaluate treatment and track changes in concentration and potential movement of the plume. Implement LUCs to prevent exposure to groundwater until remediation goals are met.	Capital Cost (YEAR 0) Annual O&M Cost (YEAR 1-30) Present Valuate (30 Years) (1 Treatment Event) Time Frame < 45 years	$424,416 $25,680	$424,416 $770,400 $808,946

Table 2-10
Groundwater Monitoring Schedule for Enhanced Anaerobic Bioremediation
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Parameter	Preconstruction	Baseline	Active Injection Period Injection Year	Active Injection Period Non-Injection Year	Post Active Injection Period
Field parameters: (pH, temperature, dissolved oxygen, oxidation-reduction potential, specific conductance)	x	x	Months 1, 3, 6, 9, and 12 following injection	Semi-annually	Annually
volatile organic compounds, semivolatile organic compounds, total organic carbon, methane, ethane, ethene, and alkalinity	x	x	Months 1, 3, 6, 9, and 12 following injection	Semi-annually	Annually
Select natural attenuation parameters	x	x	Months 1, 6, and 12 following injection	Semi-annually	Annually

Samples may be analyzed for microbial parameters if incomplete degradation of contaminants of concern is observed.

Table 2-11
Detailed Cost Estimate for the Selected Remedy
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	TOTAL
PRE-CONSTRUCTION ACTIVITY				
Pre-Construction Meetings	1	LS	$ 2,000.00	$ 2,000.00
Mobilization	1	LS	$ 5,000.00	$ 5,000.00
Supervision & Management	1	LS	$ 2,500.00	$ 2,500.00
Bench Scale Treatability Study	1	LS	$ 25,000.00	$ 25,000.00
SYSTEM INSTALLATION				
"Core Area" HRC Application				
No. of injection points	64			
Mass per ft. of injection (lbs)	4			
Feet of injection per point	16			
Total Mass per injection point	4096	lbs		
Cost per unit mass			$5	$ 20,480.00
"Non-Core Area" HRC Application				
No. of injection points	285			
Mass per ft. of injection (lbs)	4			
Feet of injection per point	16			
Total Mass per injection point	64			
Cost per unit mass	18240	lbs	$ 5.00	$ 91,200.00
Shipping ($1/lb)	22,336	lbs	$ 1.00	$ 22,336.00
HRC Injection Cost				
No. of injection points	349			
Time per injection point (hrs)	0.75			
Productivity Hrs/day (inc. down time)	8			
Days to complete	33	DAY	$ 1,800.00	$ 58,893.75
SITE RESTORATION				
Parking lot asphalt repair	1	LS	$ 5,000.00	$ 5,000.00
POST-CONSTRUCTION ACTIVITIES				
Demobilization	1	LS	$ 3,000.00	$ 3,000.00
Submittals/Reporting	1	LS	$ 10,000.00	$ 10,000.00
Subtotal				$ 245,409.75
General Conditions			7%	$ 5,077.50
Subtotal				**$ 250,487.25**
Location Muliplier				89%
Adjusted Cost				**$ 222,933.65**
Overhead			40%	$ 89,173.46
Profit			10%	$ 22,293.37
Contingency			20%	$ 44,586.73
Total Alternative Cost				**$378,987**
Total Present Value				**$787,313**

Note:
This is an order of magnitude engineering cost estimate that is expected to be within +50% to -30% of the actual project cost.

Table 2-12
Federal Applicable or Relevant and Appropriate Requirements
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Media	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Federal Chemical-Specific ARARs					
Safe Drinking Water Act					
Groundwater	SDWA standards serve to protect public water systems. Primary drinking water standards consist of federally enforceable MCLs. MCLs are the highest level of a contaminant that is allowed in drinking water.	Impact to public water systems that have at least 15 service connections or serve at least 25 year-round residents. May also be cleanup standards for on-site ground or surface waters that are current or potential sources of drinking water.	40 CFR 141.11 to 141.16 and 141.61 to 141.66	Relevant and Appropriate	This remedial action is being implemented with a target goal of achieving MCLs. The aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply.
Groundwater	SDWA standards serve to protect public water systems. The MCLG is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.	Impact to public water systems that have at least 15 service connections or serve at least 25 year-round residents. May also be cleanup standards for on-site ground or surface waters that are current or potential sources of drinking water.	40 CFR 141.50 to 141.55	TBC	Although MCLGs are non-enforceable standards, this remedial action is being implemented with a target goal of achieving MCLs.
USEPA Region III RBC Tables					
Water, air, fish tissue, soil	Chemical concentrations corresponding to fixed levels of human health risk (i.e., a hazard quotient of 1, or lifetime cancer risk of 10^{-6}, whichever occurs at a lower concentration).	Assessment of potential human health risks.	USEPA Region III RBC Tables (October 2006)	TBC	The remedial action is being implemented with a target goal of achieving MCLs.
Location-Specific ARARs					
No Applicable Federal-Location Specific ARARs Idendified					
Action Specific ARARs					
Safe Drinking Water Act					
Underground injection	Regulates the subsurface emplacement of liquids through the Underground Injection Control program, which governs the design and operation of five classes of injection wells in order to prevent contamination of underground sources of drinking water.	Any dug hole or well that is deeper than it's largest surface dimension, where the principal function of the hole is in placement of fluids.	40 CFR 144.1(g)(1),144.3,144.6,144.11,144.12(a),144.24(a),144.80(e), 144.82, 144.83, 146.8, 146.10(c)	Applicable	The Remedy will include substrate injection. The remedy will comply with the substantive requirements of the regulation. This ARAR is applicable because the injections wells are considered class V groundwater wells and fluids will be injected into the ground.

ARAR	Applicable or relevant and appropriate requirement
CFR	Code of Federal Regulations
MCL	Maximum Contaminant Level
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
MCLG	Maximum Contaminant Level Goal
RBC	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
USEPA	United States Environmental Protection Agency

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USEPA, 1998. RCRA, Superfund & EPCRA Hotline Training Manual. Introduction to Applicable or Relevant and Appropriate Requirements. EPA540-R-98-020.

Table 2-13
Virginia Applicable or Relevant and Appropriate Requirements
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

Virginia Location-Specific

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Chesapeake Bay Preservation Area Designation and Management Regulations ~~[VA Code Ann. §§ 10.1-2100 to 2116]~~					
Chesapeake Bay and its tributaries	Criteria that provide for the protection of water quality of the Chesapeake Bay and its tributaries, that will also accommodate economic development in Tidewater Virginia. Under these requirements, certain locally designated tidal and nontidal wetlands,	Location is within a Chesapeake Bay Preservation Area.	*Chesapeake Bay Preservation Area Designation and Management Regulations*, 9 VAC 10-20-120 to 130	Relevant and Appropriate	Site 13 is located within the Chesapeake Bay watershed. However, there are no surface waters within or influenced by Site 13 and the remedy will not involve or effect tributaries of the Chesapeake Bay.

Virginia Chemical-Specific ARARs

Media	Requirement	Prerequisite	Citation	ARAR Determination	Comment
State Water Control Board					
Groundwater	Establishes restoration requirements and groundwater quality standards to protect public health or welfare and enhance the quality of water.	Standards are used when no MCL is available.	*Groundwater Standards*, 9 VAC 25-280-20 to -50	Applicable	This remedial action is being implemented with a target goal of achieving MCLs/Clean Up levels. The aquifer is not currently, nor reasonably anticipated in the future to be used as a potable water supply.
Virginia Waste Management Act					
Waste/Soil/Water	Wastes to be managed must be sampled for TCLP analyses to determine the appropriate waste characterization. TCLP regulatory levels and definition of RCRA hazardous waste.	Management of wastes.	*Hazardous Waste Regulations*, 9 VAC 20-60-261(incorporating 40CFR part 261.3) and 9 VAC 20-60-262 (incorporating 40CFR 262.11)	Applicable	This remedy will generate soil and water IDW which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.
Waste/Soil/Water	Hazardous wastes shall not be disposed or managed in solid waste disposal facilities unless specifically authorized by the facility permit or the director of VDEQ.	Management of solid waste.	Solid Waste Management Regulations, 9 VAC20-80-240 (c)	Relevant and Appropriate	This remedy will generate soil and water IDW which will be characterized for off site disposal.

Action-Specific ARARs

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Virginia Waste Management Act					
Handling, storage, treatment, disposal, and/or transportation of hazardous waste IDW	Provides for the control of all hazardous wastes that are generated within, or transported to, the Commonwealth for the purposes of storage, treatment, or disposal or for the purposes of resource conservation or recovery.	Management of wastes that meet the definition of hazardous waste.	*Hazardous Waste Regulations*, 9 VAC 20-60-261(incorporating 40CFR 261.3) and 9 VAC 20-60-262 (incorporating 40CFR 262.11)	Applicable	This remedy will generate soil and water IDW which will be characterized for off site disposal.
Handling, storage, treatment, disposal, and/or transportation of hazardous waste IDW	Provides for the control of all hazardous wastes that are generated within, or transported to, the Commonwealth for the purposes of storage, treatment, or disposal or for the purposes of resource conservation or recovery. Any disposal facility must be properly permitted and in compliance with all operational and monitoring requirements of the permit and regulations.	Management of wastes that meet the definition of hazardous waste.	*Hazardous Waste Regulations*, 9 VAC 20-60-,262 (incorporating 40CFR 262.11, .12, .20, and .30 -.34)	Relevant and Appropriate	This remedy will generate soil and water IDW which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste. If characterization results indicate this material is hazardous, it will be disposed of accordingly.
Handling, storage, treatment, disposal, and/or transportation of solid waste IDW	Establishes standards and procedures pertaining to the management of solid wastes facilities in this Commonwealth in order to protect the public health, public safety, the environment, and natural resources. Provides the means for identification of open dumping of solid waste and provides the means for prevention or elimination of open dumping of solid waste to protect the public health and safety and enhance the environment.	Management of wastes that meet the definition of solid waste.	*Solid Waste Management Regulations*, 9 VAC 20-80-80,-90,-140 to 160	Relevant and Appropriate	This remedy will generate soil and water IDW which will be characterized for off site disposal. Based on site history, it is not anticipated that IDW will be characterized as hazardous waste.

Acronyms and Abbreviations

ARAR	Applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
IDW	Investigation Derived Waste
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
PMCL	Primary Maximum Contaminant Level
VAC	Virginia Administrative Code
RCRA	Resource Conservation and Recovery Act

References

Commonwealth of Virginia, 2004. Preliminary Identification, Applicable or Relevant and Appropriate Requirements.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Interim Final.* Office of Emergency and Remedial Response. EPA/540/G-89/006.

USEPA, 1998. *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes.* Office of Emergency and Remedial Response.

USEPA, 1998. RCRA, Superfund & EPCRA Hotline Training Manual. Introduction to Applicable or Relevant and Appropriate Requirements. EPA540-R-98-020.

Figures

\\ariadne\groups\gis\USNavFaceNGCom\187222LittleCreek\Projects\Site13_Draft_ROD\Figure 2-1 - Little Creek Location and Vicinity.mxd

Legend

- Installation Boundary
- Area of Investigation

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Feet

Figure 2-1
NAB Little Creek Location and Vicinity
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

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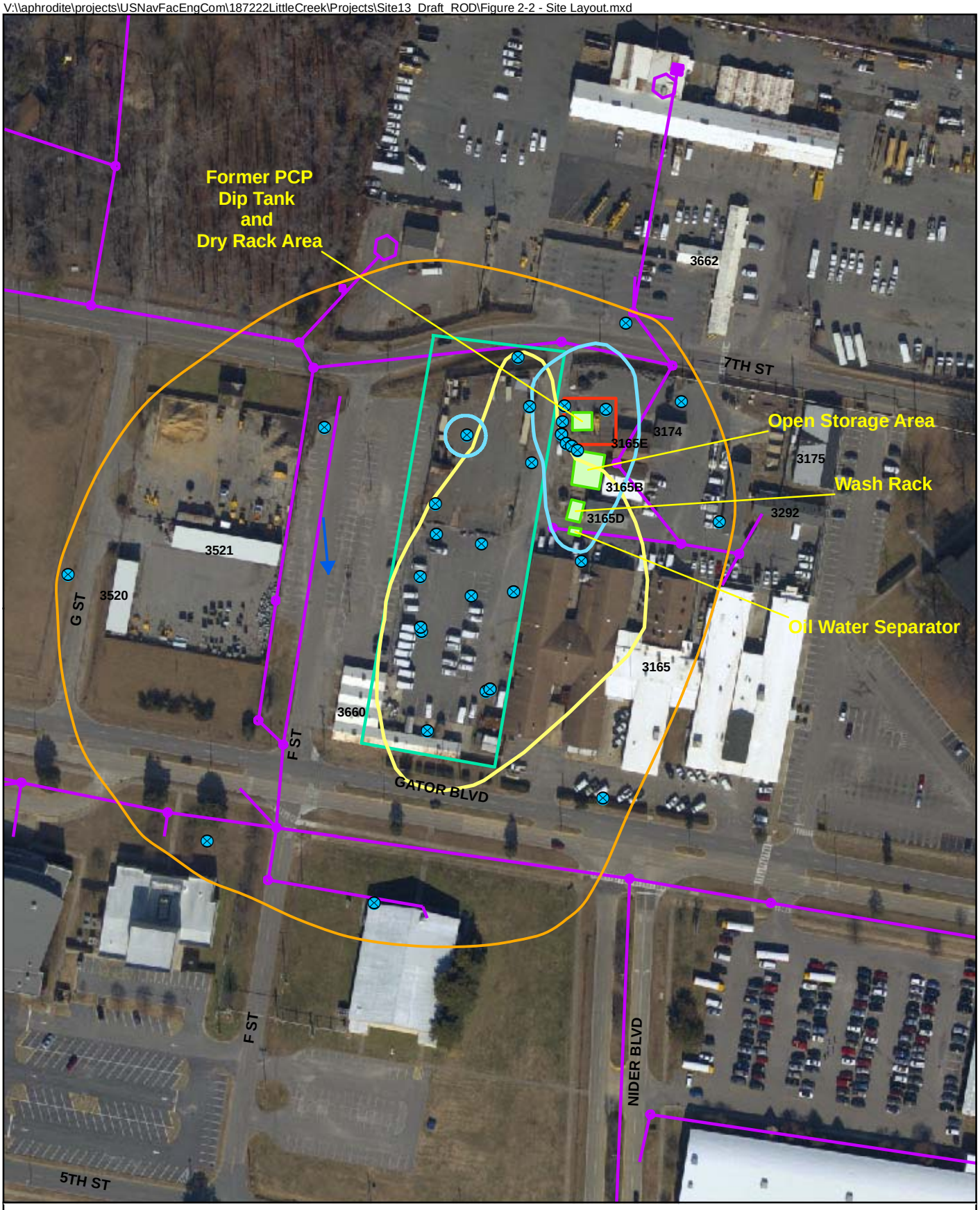
V:\\aphrodite\projects\USNavFacEngCom\187222LittleCreek\Projects\Site13_Draft_ROD\Figure 2-2 - Site Layout.mxd



Legend

- Monitoring Well
- Groundwater Flow Direction (April 2006)
- LUC Boundary
- Pentachlorophenol (PCP) Plume
- Volatile Organic Compound (VOC) Plume
- 2000 Pilot Study Area
- 2004 Treatability Study Area
- Site 13 Structures
- Site Boundary
- Sanitary Sewer System

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Figure 2-2
Site Layout
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

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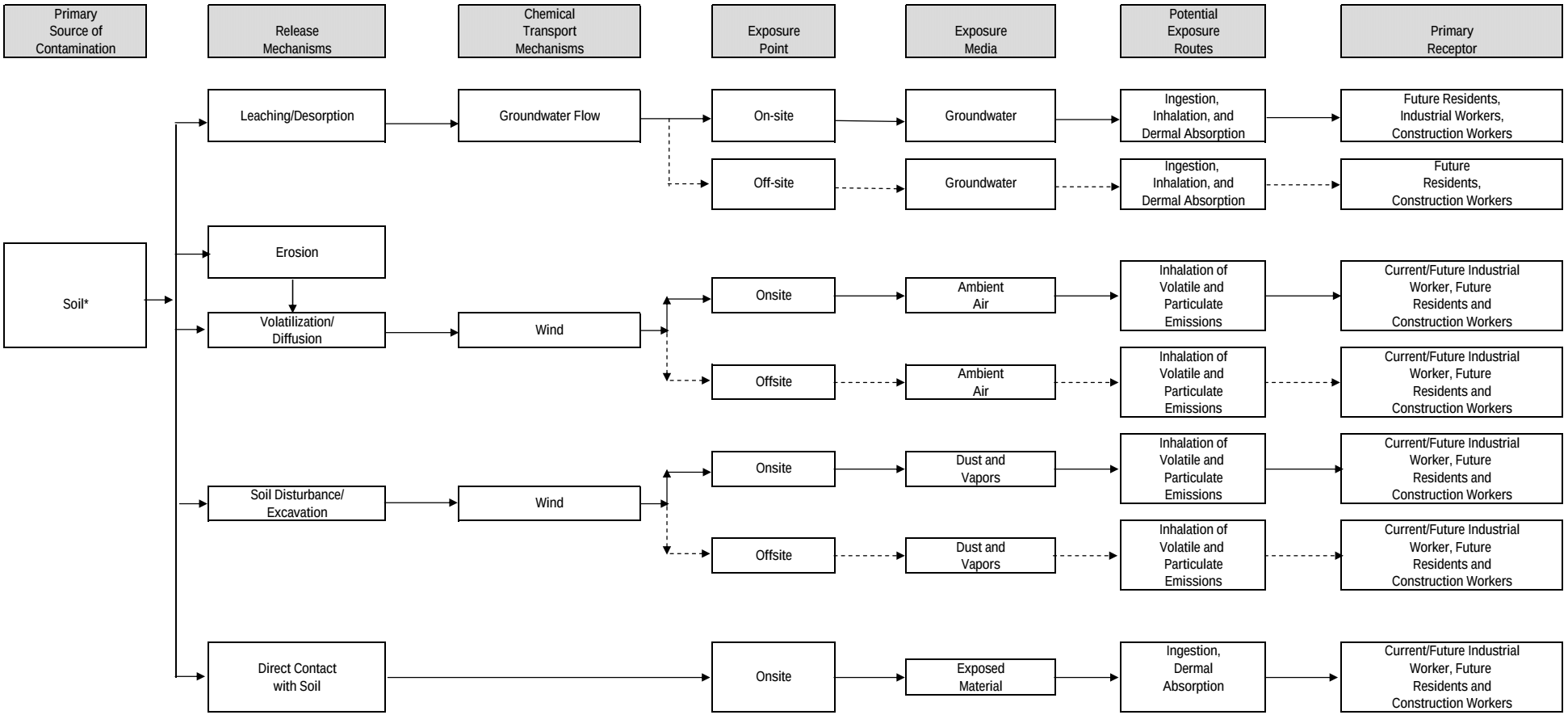

* Current scenario is for surface soil and future scenarios are for surface and subsurface soil combined.

Complete Pathway
Incomplete Pathway

Figure 2-3
Conceptual Exposure Model for Potential Human Exposures
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

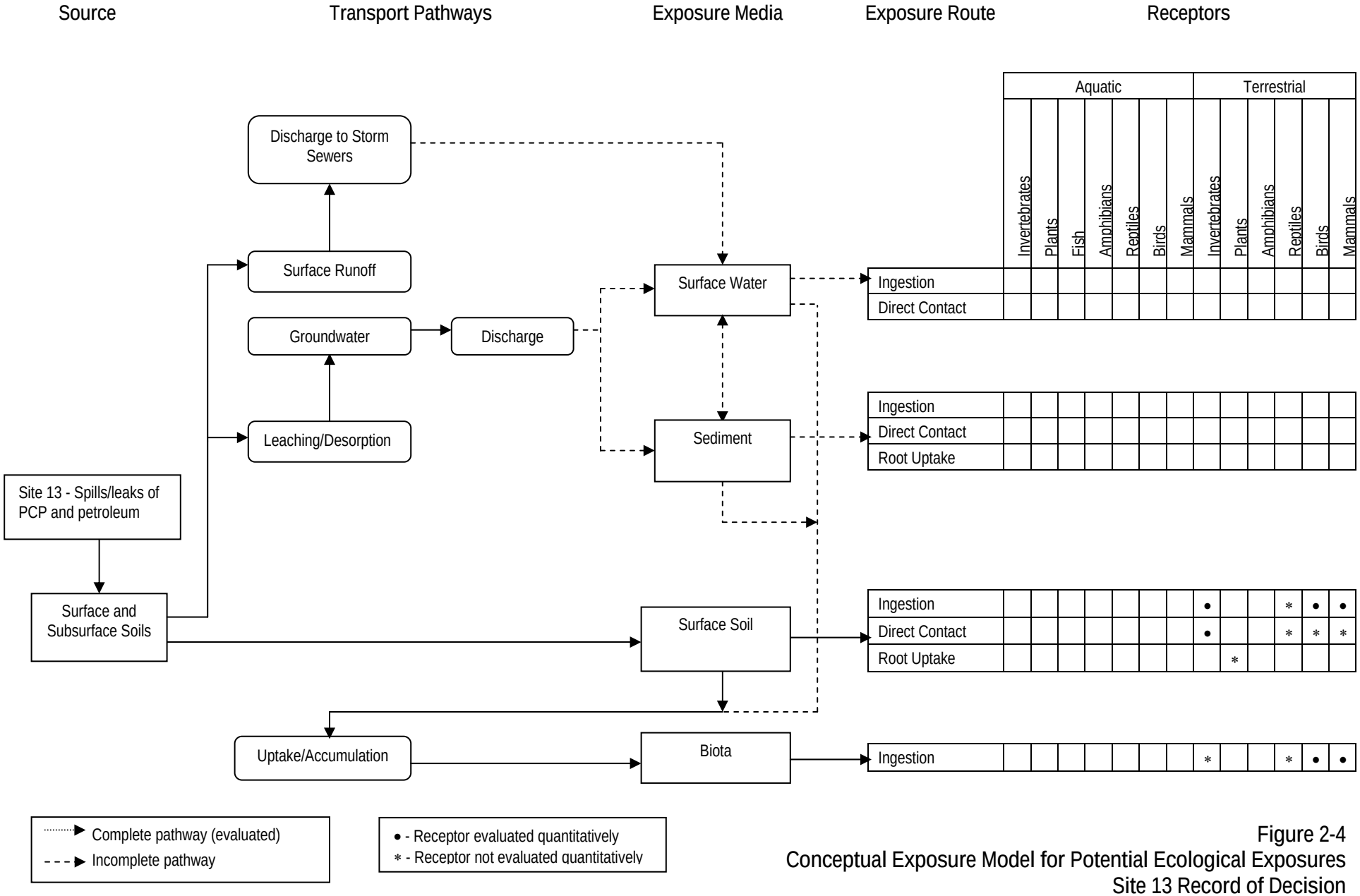

Figure 2-4
Conceptual Exposure Model for Potential Ecological Exposures
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

\\ariadne\groups\gis\USNavFaceNGCom\187222LittleCreek\Projects\Site13_Draft_ROD\Figure 2-5 - Site 13 Sample Locations.mxd

Legend

- Surface Soil Stations
- Subsurface Soil Stations
- Surface Water Stations
- Sediment Stations
- MIP Locations
- GP Locations
- Abandoned Monitoring Well
- Groundwater Grab
- Monitoring Well
- Piezometer
- Sewer Sludge
- Surface Water
- Temporary Well
- Area of Investigation
- Site 13 Structures
- Groundwater Flow Direction (April 2006)

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Figure 2-5
Site 13 Sample Locations
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

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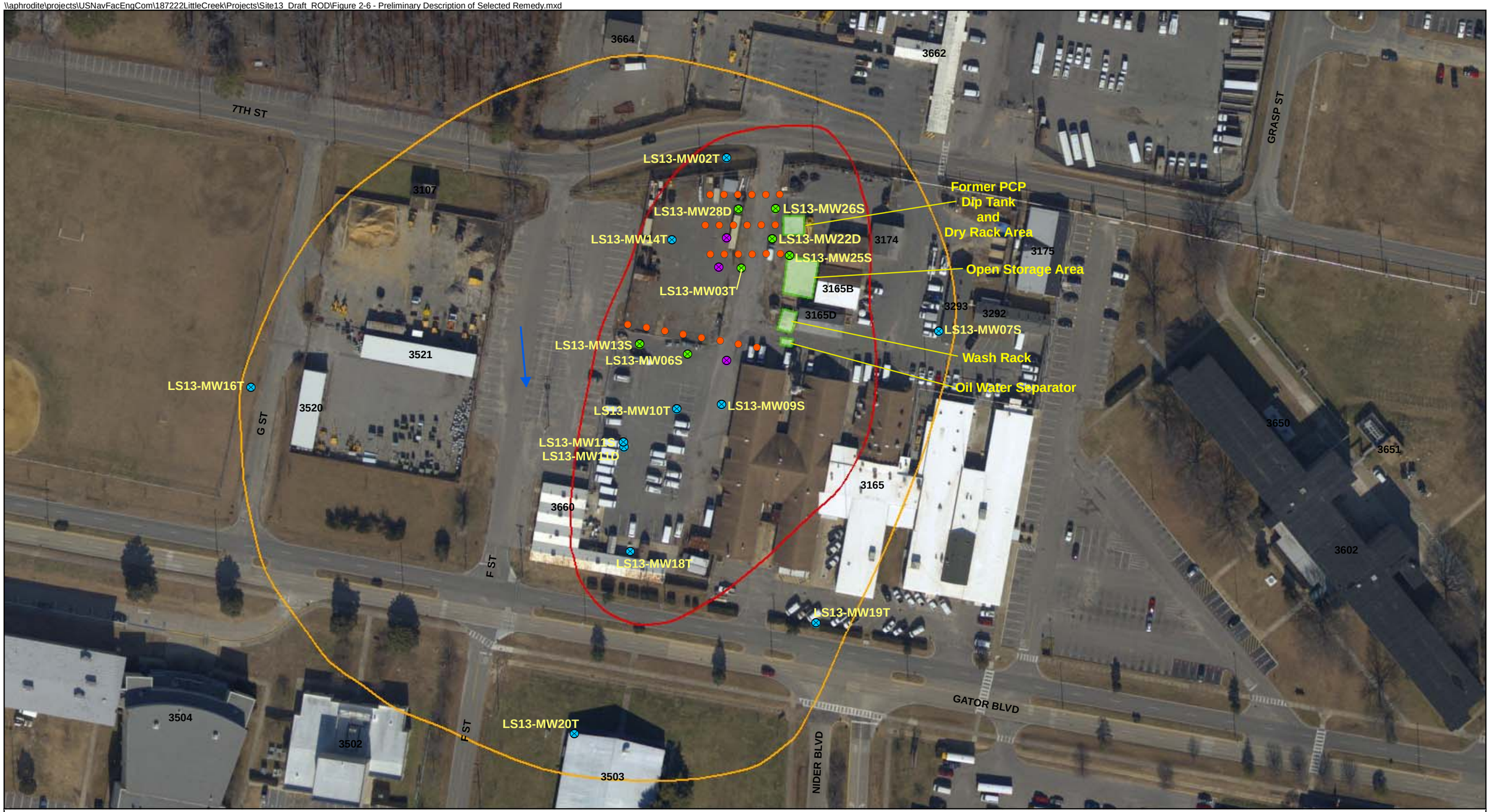
\\aphrodite\projects\USNavFacEngCom\187222LittleCreek\Projects\Site13_Draft_ROD\Figure 2-6 - Preliminary Description of Selected Remedy.mxd



Legend

- Proposed Injection Well
- Proposed Performance Monitoring Well
- Existing Performance Monitoring Well
- Annual Monitoring Well
- LUC Boundary
- Area of Investigation
- Site 13 Structures
- Groundwater Flow Direction (April 2006)

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Figure 2-6
Preliminary Description of Selected Remedy
Site 13 Record of Decision
NAB Little Creek
Virginia Beach, Virginia

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