N61414.AR.002234
JEB LITTLE CREEK
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FINAL RECORD OF DECISION SOLID WASTE MANAGEMENT UNIT 3 (SWMU 3) PIER 10 SANDBLAST YARD JEB LITTLE CREEK VIRGINIA BEACH VA
12/01/2014
CH2M HILL

Final

Record of Decision

SWMU 3 – Pier 10 Sandblast Yard

Joint Expeditionary Base Little Creek
Virginia Beach, Virginia
December 2014

1. Declaration

This Record of Decision (ROD) presents the selected remedy for Solid Waste Management Unit (SWMU) 3 – Pier 10 Sandblast Yard, at Joint Expeditionary Base (JEB) Little Creek, Virginia Beach, Virginia, herein referred to as SWMU 3. The former Naval Amphibious Base (NAB) Little Creek (now referred to as JEB Little Creek) was placed on the United States Environmental Protection Agency (USEPA) National Priorities List effective May 10, 1999 (USEPA ID: VA5170022482). This remedy was selected 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 and others, 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 JEB Little Creek.

On October 1, 2009, Hampton Roads' first Joint Base was established. This new installation comprises the former NAB Little Creek and the former Army post Fort Story; the new name is JEB Little Creek-Fort Story. With the forming of this new command, the Department of the Navy (Navy) assumes responsibility for managing both properties and merged public meetings regarding the ongoing environmental restoration. However, separate records are maintained to ensure the integrity of ongoing efforts at both properties. When required for public notices and distributions, the former bases are jointly identified as JEB Little Creek-Fort Story. For Environmental Restoration Program (ERP) documents, the bases are referred to separately as JEB Little Creek and JEB Fort Story. This ROD contains information associated with the ERP at JEB Little Creek and does not discuss the ERP at JEB Fort Story.

The Navy is the lead agency and provides funding for site cleanups at JEB Little Creek. The Navy and USEPA Region 3, the lead regulatory agency, issue this ROD jointly. The Commonwealth of Virginia, Virginia Department of Environmental Quality (VDEQ) is the support agency and concurs with the decision.

1.1 Description of the Selected Remedy

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. Under current and reasonably anticipated land use scenarios, groundwater is not expected to be used as a potable water supply. Previous investigations have identified the presence of volatile organic compounds (VOCs) trichloroethene (TCE) and vinyl chloride in shallow groundwater at concentrations that pose a potential threat to human health. The selected remedy for SWMU 3 is monitored natural attenuation (MNA) of VOCs and land use controls (LUCs). LUCs will be maintained on groundwater and associated property use within the boundaries of SWMU 3 until concentrations of hazardous substances in the groundwater have been reduced to levels that allow for unlimited use and unrestricted exposure (UU/UE).

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, and utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. The selected remedy does not satisfy the statutory preference for treatment as a principal element; however, MNA is expected to be successful in attaining cleanup levels throughout the plume and no source materials constituting principal threats are present. Data indicate that MNA will be effective and degrade VOCs to attain cleanup levels within a reasonable timeframe, and LUCs will prohibit exposure and restrict groundwater uses until concentrations allow for UU/UE. Because the remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for UU/UE, the Navy will conduct statutory reviews every 5 years after initiation of remedial action to ensure that the remedy is protective of human health and the environment. Because no remedial action is warranted for soil, surface water, and sediment, these media will not be reviewed as part of statutory remedy reviews at SWMU 3. In accordance with current policy, the Naval Facilities Engineering Command (NAVFAC), Mid-Atlantic, will conduct the first statutory remedy review concurrent with the next scheduled review for JEB Little Creek in 2019.

1.2 Data Certification Checklist

The following information is included in the Decision Summary section of this ROD (additional information can be found in the Administrative Record file for JEB Little Creek, SWMU 3):

- Contaminants of concern (COCs) and their respective concentrations (Section 2.8 and Table 3)
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater (Section 2.6)
- Baseline risk represented by the COCs (Section 2.7 and Table 4)
- Cleanup levels established for COCs and the basis for these levels (Section 2.10)
- Estimated capital, annual operation and maintenance, and total present-worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 2.11 and Table 8)
- Key factors that led to selecting the remedy (i.e., describe how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) (Section 2.11 and Table 9)
- Potential land and groundwater use that will be available at the site as a result of the selected remedy (Section 2.12.1 and Table 10)

1.3 Authorizing Signatures

[signature]

F.E. Hughlett
Captain, United States Navy
Commander
Joint Expeditionary Base Little Creek-Fort Story

15 DEC 14
Date

[signature]

Cecil Rodrigues, Director
Hazardous Site Cleanup Division
EPA (Region III)

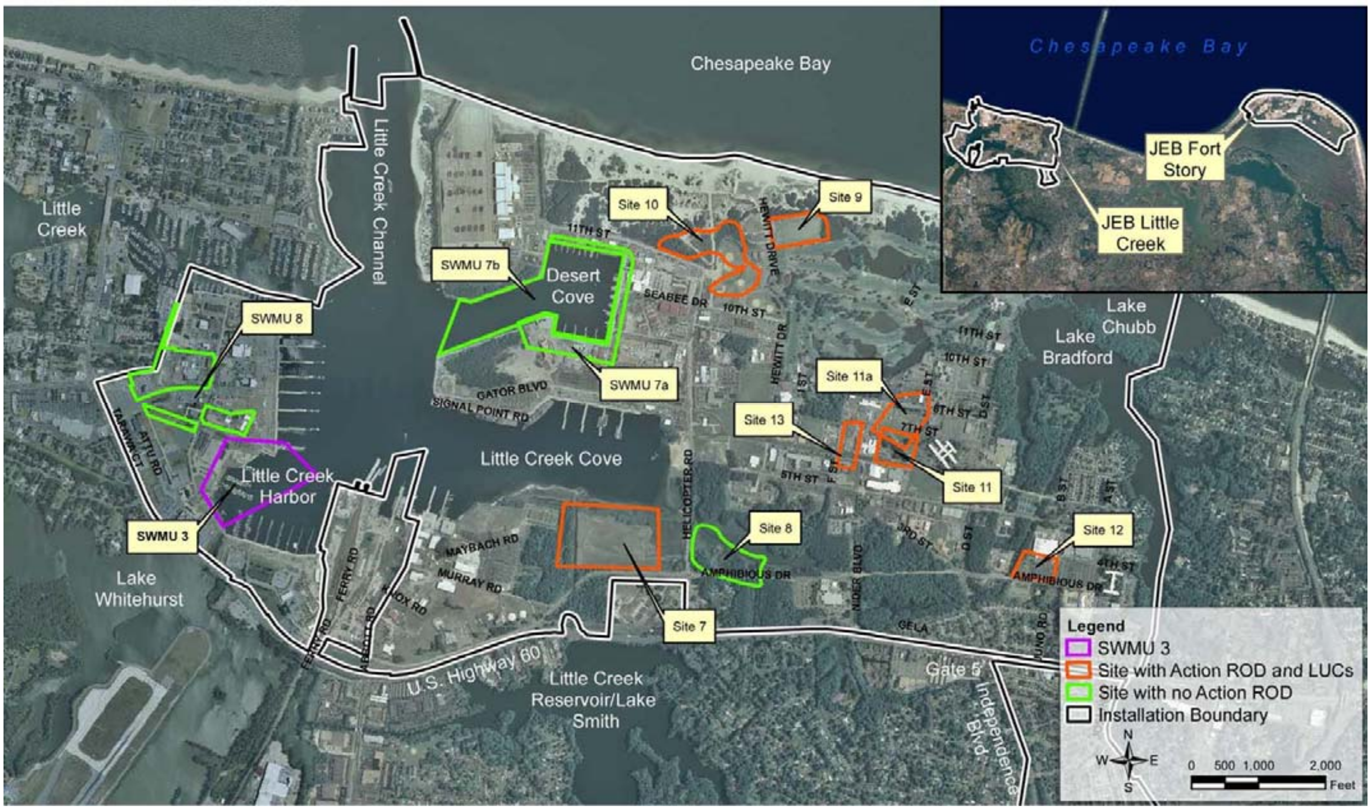
12/23/2014
Date

2. Decision Summary

2.1 Site Description and History

JEB Little Creek consists of 2,215 acres located in the northwestern corner of Virginia Beach, Virginia, adjacent to the Chesapeake Bay (**Figure 1**). The western boundary of JEB Little Creek borders the city of Norfolk, Virginia. JEB Little Creek is primarily an industrial facility that provides logistic and support services to 23 home-ported ships and 155 shore-based resident commands. The area surrounding the facility is low-lying and relatively flat. JEB Little Creek is bounded on the north by the Chesapeake Bay; on the west by residential communities and several marinas; on the south by Shore Drive, Lake Whitehurst, Lake Smith, Norfolk International Airport, and residential development; and on the east by Lake Bradford.

FIGURE 1
SWMU 3 Location Map



SWMU 3, Pier 10 Sandblast Yard, is located in a developed area on Little Creek Harbor's western side (**Figure 2**). SWMU 3 was used for sandblasting boats between 1962 and 1984. Sandblasting activities took place on a 0.04-acre concrete pad located to the west of Building 1263. After 1984, anchors and chains were sandblasted on the concrete pad. The residual, used abrasive blast material (ABM) was periodically sampled, determined to be non-hazardous, and removed from the site. However, some residual ABM, consisting of paint chips and blast grit, covered the unpaved ground south of the pad to the water's edge and the near-shore bottom of Little Creek Harbor. In 1982, a fence was installed around the sandblasting area to limit access to the site and minimize windblown sandblast materials from migrating outside the fenced area. In 1995, the concrete pad was taken out of service, and a new sandblasting area was constructed in the northwestern corner of the site. The new sandblasting area consisted of a 0.4-acre concrete pad surrounded by a 4- to 5-foot-high concrete wall. All sandblasting operations at SWMU 3 ceased in 1996 when a new indoor sandblasting facility, Building CB125, was completed adjacent to SWMU 7b.

FIGURE 2
SWMU 3 Boundary and Immediate Vicinity

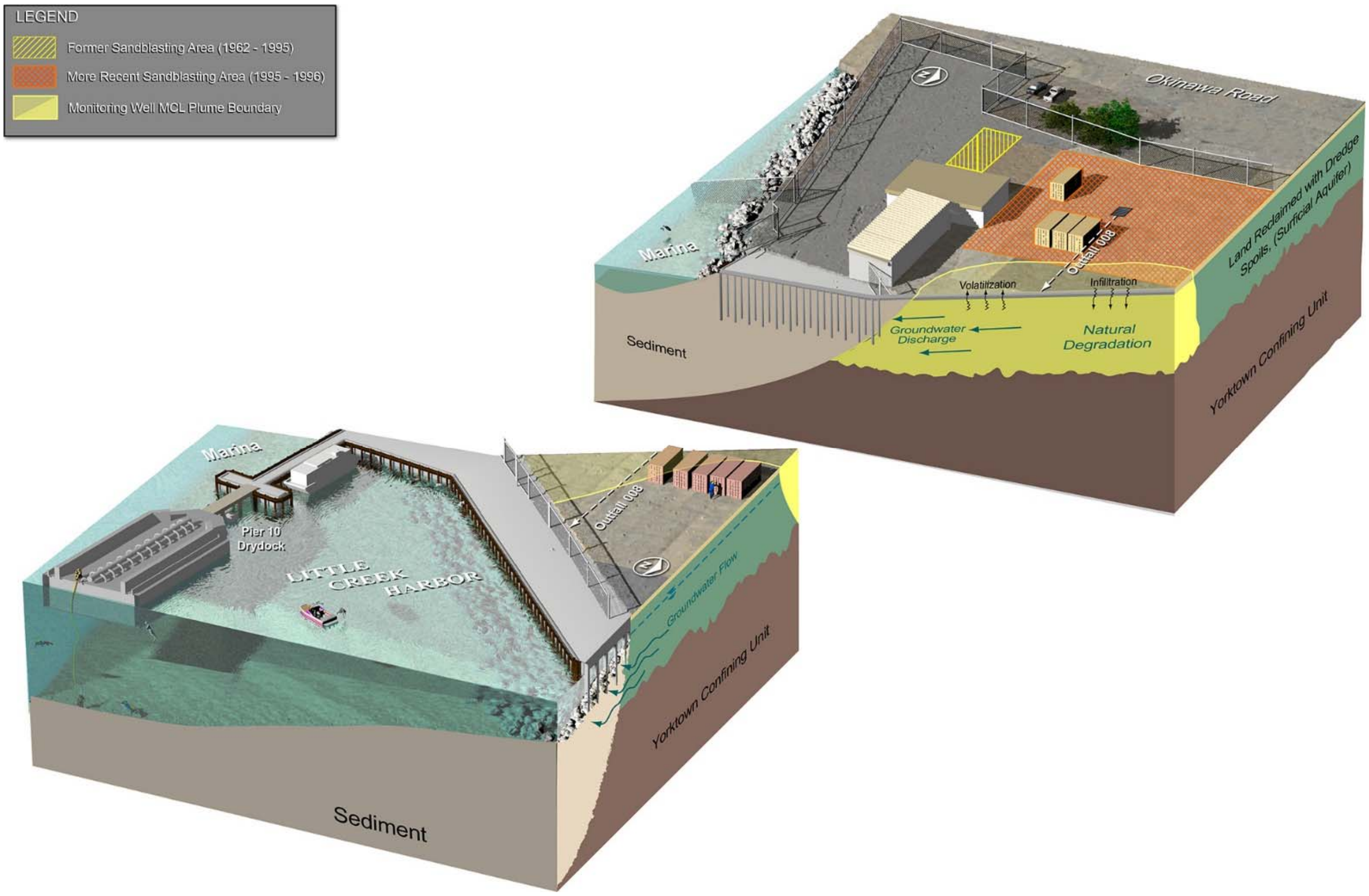
Historical releases from SWMU 3 likely occurred from the accumulation of sandblasting residue on the ground surface. Prior to 1993, runoff from sandblasting operations occurred as sheet flow to Little Creek Harbor. In 1993, a catch basin connected to Virginia Pollution Discharge Elimination System (VPDES)-permitted Outfall 008 (Permit Number VA0079928) was constructed to receive runoff from various areas. Following construction of the new concrete pad surrounding the catch basin, surface runoff from the more recent sandblasting area flowed to this catch basin and emptied into Little Creek Harbor via VPDES-permitted Outfall 008.

2.2 Site Characteristics

Figure 3 presents a conceptual site model of current site conditions. The terrestrial portion of SWMU 3 includes a fenced area containing Buildings 1262 (firefighting equipment storage), 1263 (welding and metal-working shop), and 1268 (wood storage), and two concrete pads formerly used for sandblasting operations. Within the fenced area, the ground surface is generally covered in concrete, asphalt, or gravel. Little to no vegetation covers unpaved areas. Outside of the fenced area are Buildings 1265-1 and 1265-3 (IT support administrative spaces), 1516 (former Morale, Welfare, and Recreation [MWR] marina shop), 1528 (MWR restrooms), and 1604 (United Service Organization administrative and cooking space). A small, grassy area is located outside the fence; otherwise, the ground surface is generally covered in concrete, asphalt, or gravel. The topography at SWMU 3 is relatively flat and gently slopes east/southeast towards Little Creek Harbor.

A catch basin connected to VPDES-permitted Outfall 008 (Permit Number VA0079928), located under Pier 10 approximately 35 feet from its easternmost edge, conveys surface runoff from the site into Little Creek Harbor. Under the current VPDES permit, Outfall 008 is defined as a storm water outfall and has no monitoring requirements. In addition to what is conveyed by the catch basin and outfall, a portion of the stormwater runoff from SWMU 3 flows directly into Little Creek Harbor as sheet flow.

FIGURE 3
Conceptual Site Model



The land where SWMU 3 is located and the surrounding area was created from the placement of dredged material between 1937 and 1954. Dredged fill material was placed overtop the natural fine sand and silt deposits of the Columbia aquifer, beneath which, the low-permeability silt, clay, and sandy clay deposits of the Yorktown confining unit are present at the site. The saturated soil underlying SWMU 3 is referred to as the surficial aquifer, which is generally encountered between 4 and 6 feet below ground surface. The elevation of the water table underlying SWMU 3 varies between high and low tide cycles, with elevation differences of between 1 and 2 feet at low tide and less than half a foot at high tide. Groundwater flows south/southeast towards Little Creek Harbor with some localized reversal in flow direction observed during high tide (**Figure 4**). The average shallow lateral groundwater flow velocity is estimated to be 10.3 feet per year. The groundwater in the surficial aquifer beneath SWMU 3 is generally brackish and is within a transition zone where upgradient fresh water mixes with downgradient seawater.

2.3 Previous Investigations

Environmental investigations were initiated at JEB Little Creek (former NAB Little Creek) under the Navy Assessment and Control of Installation Pollutants Program in 1984. SWMU 3 was characterized as part of several investigations and studies between 1989 and 2014. **Table 1** provides a summary of previous investigations and studies specific to SWMU 3, and previous sample locations are depicted on **Figure 5**. Documents and information produced during the respective investigations form a portion of the Administrative Record file for JEB Little Creek, which can be referenced for further details regarding specific sampling strategies, media investigations, and the dates and locations of sampling.

FIGURE 4
Groundwater Flow

TABLE 1
Studies, Investigations, and Activities Summary

Previous Study / Investigation	AR Document Number	Investigation Activities
Site Investigation (SI) (CH2M HILL, December 1999)	000355	Groundwater, surface soil, subsurface soil, and sediment samples were collected to verify the presence or absence of contamination and to conduct a human health risk screening. VOCs, semi-volatile organic compounds (SVOCs), and metals were detected in groundwater above human health screening criteria. Polycyclic aromatic hydrocarbons (PAHs) and metals were detected in soil and sediment above human health screening criteria. Contaminants of potential concern (COPCs) were identified for each medium. Additionally, ABM was observed on the ground surface and in near-shore sediment. The SI recommended a Screening Ecological Risk Assessment (ERA) to identify potentially complete exposure pathways for ecological receptors and an RI to define the nature and extent of contamination.
Screening ERA (CH2M HILL, June 2000)	000417	A Screening ERA, constituting Steps 1 and 2 of the ERA process, was completed using data collected as part of the SI. Based upon a comparison of groundwater, surface soil, and sediment concentrations to ecological screening criteria and results of aquatic and terrestrial food web modeling, inorganic and organic COPCs were identified for each medium. The Screening ERA concluded that the potential for unacceptable ecological risk was moderate to high based upon the potential exposure to metals in sediment and soil; an additional evaluation of potential ecological risk (Step 3) was recommended.
Baseline ERA (CH2M HILL, January 2001)	001031	A Baseline ERA, constituting Step 3 of the ERA process, was completed using data collected as part of the SI. The Baseline ERA concluded that, although terrestrial habitat size and quality are limited at SWMU 3, concentrations of seven metals and one SVOC in surface soil exceeded ecological screening criteria and/or basewide background concentrations. These chemicals in soil may pose potentially unacceptable risks to plants or animals that are at the lower end of the food chain (lower-trophic level receptors). Only zinc was identified as posing a potential risk above regulatory target levels to animals higher on the food chain (upper-trophic-level receptors) exposed to site soil. Potentially unacceptable risks to lower-trophic-level receptors were identified associated with exposure to eight metals, five PAHs, and one SVOC in sediment; however, potential risks to upper-trophic-level aquatic receptors were negligible.

TABLE 1
Studies, Investigations, and Activities Summary

Previous Study / Investigation	AR Document Number	Investigation Activities
RI/Human Health Risk Assessment (HHRA)/ERA (CH2M HILL, August 2005)	000911	Soil, groundwater, sediment, and surface water samples were collected to define the nature and extent of contamination and evaluate potential human health and ecological risks. No potentially unacceptable human health or ecological risks associated with exposure to soil were identified; however, individual detections of lead in soil exceeded the residential risk screening criteria and were determined to require further action. Potentially unacceptable risks associated with future potable use of groundwater were identified as a result of VOCs and metals. SVOCs and metals were detected in surface water but the concentrations did not pose potentially unacceptable risk to human health or the environment. **No potentially unacceptable human health risk**[1] was identified from exposure to sediment; however, **potentially unacceptable ecological risks**[2] to lower-trophic-level receptors exposed to metals and PAHs in sediment were identified. Additionally, evidence of petroleum impacts to subsurface sediment was noted. The RI recommended additional investigation of groundwater and sediment to identify contaminant sources, delineate the nature and extent of contamination, and further assess potential human health and ecological risks. Additionally, the RI concluded that ABM residues in soil are a potential continuing source of contaminants to Little Creek Harbor and recommended the residues be removed.
Supplemental RI (SRI)/ HHRA/ ERA (CH2M HILL, August 2009a)	000222	Soil, groundwater, and sediment samples were collected to identify the source and extent of VOCs in groundwater and assess associated human health risks, define the extent of ABM in sediment, and assess the correlation between ABM content and metals concentrations in sediment. PAHs in sediment were determined to not be site-related, and therefore were not investigated as part of the SRI. Additional surface sediment samples were collected from Little Creek Cove for establishment of urban background sediment values for comparison to site-specific sediment samples. No soil source for VOCs in groundwater was identified. The HHRA identified **potentially unacceptable risks to human health**[3] associated with exposure to tetrachloroethene (PCE), TCE, vinyl chloride, benzene, cis-1,2-dichloroethene (DCE), 1,2-dichloroethane, dibenzofuran, antimony, arsenic, iron, manganese, and thallium in groundwater. However, based upon risk management considerations, the Navy and USEPA, in consultation with VDEQ, agree the risks and/or hazards associated with dibenzofuran, antimony, arsenic, iron, manganese, and thallium are not unacceptable; therefore no further action to address these constituents in groundwater is warranted. The HHRA indicated that currently, there is no route for human exposure to vapors in building indoor air resulting from the volatilization of VOCs in groundwater (vapor intrusion). However, due to the presence of VOCs in groundwater, and the uncertainties associated with quantifying risks associated with potential future vapor intrusion, it was assumed that vapor intrusion from shallow groundwater into indoor air could pose unacceptable risks to future building occupants. The eastern extent of ABM in sediment was defined; however, uncertainty in the extent to the north and along the bulkhead by the marina was identified. Additionally, the presence of petroleum in subsurface sediment was noted. The SRI concluded that ABM tends to be present in sediment where elevated metal concentrations are detected and is a **good indicator of impacts from former sandblasting**[4]. The SRI recommended an evaluation of remedial alternatives to address COCs in groundwater (VOCs) and sediment (copper, lead, nickel, tin, and zinc). Additionally, it recommended addressing ABM and lead in soil. The SRI concluded no further action for surface water was warranted.
Pre-FS Groundwater Sampling (CH2M HILL, 2007)	Work Plan (001384)	In January and September 2008, groundwater samples were collected to support risk management considerations and identification of COCs at SWMU 3. Samples were analyzed for VOCs, dibenzofuran, and total/ and dissolved thallium. Concentrations of VOCs were similar to those detected during the SRI in 2007. TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride were detected above federal maximum contaminant levels (MCLs). Dibenzofuran and total and dissolved thallium were not detected in groundwater. Results of this investigation are documented in the 2014 Focused FS.
Pre-FS Sediment Investigations (Remediation Boundary Delineation) (CH2M HILL, February 2009b and CH2M HILL, December 2009c)	001517 (Pre-FS Sampling Work Plan) 001074 (Vertical Delineation, Sampling and Analysis Plan)	Surface and subsurface sediment sampling was conducted to delineate the sediment remediation area boundary and define dewatering and disposal characteristics. The correlations between ABM content in sediment and the concentrations of copper, lead, nickel, tin, and zinc were used to calculate associated sediment concentrations for each metal using 1 percent ABM (the lowest possible integer). These calculated concentrations, along with site-specific background concentrations and literature-based sediment effect levels (effects range-low, effects range-median, threshold effects level, and probable effects level), were used to define the **sediment preliminary remediation goals**[5] (PRGs) (**Table 7**). To define the area requiring remedial action under CERCLA, the site was broken down into 100-by-100-foot grid cells. A grid cell was identified as requiring remedial action through the calculation of the ratio of the individual sediment COC concentration in surface sediment to its chemical-specific PRG. If surface sediment in a grid cell contained greater than 1 percent ABM, individual COC ratios greater than 1.5, or an average ratio for the COCs greater than 1, it was included in the area requiring remedial action. This approach was selected giving consideration to the size of the grid cells, the spatial distribution of the surface sediment data, and the recognition of the combined impacts caused by multiple contaminants. The lateral and vertical extents of CERCLA-regulated contamination requiring remedial action were defined using the PRGs. In addition, the extent of petroleum-contaminated sediment within the remediation area was delineated. Sediment dewatering and disposal characterization testing indicated the sediment is non-hazardous and that both passive (geotextile tube) and mechanical (belt filter) dewatering technologies would be effective.

TABLE 1
Studies, Investigations, and Activities Summary

Previous Study / Investigation	AR Document Number	Investigation Activities
Risk Assessment Update (Groundwater to Surface Water) (CH2M HILL, July 2012a)	001542	As a result of updates made to the conceptual site model, the future use of groundwater at the site as a potable water source and the human health and ecological risks associated with groundwater discharge to surface water were evaluated as part of the risk assessment update. Based on site-specific determinations on aquifer characteristics (groundwater is located within land made through the placement of dredge spoils and mixes with the adjacent surface water) and the inability to install a potable well between the waste mass (VOCs in groundwater) and the adjacent surface water body (Little Creek Harbor), the Navy and USEPA, in consultation with VDEQ, agreed that future potable use of groundwater is not a viable exposure pathway for human health risk evaluation at SWMU 3. Although potable use is not considered an applicable exposure pathway at SWMU 3, VDEQ considers all groundwater a potential potable resource and requires that all groundwater be restored to beneficial (potable) use. Revisions to the human health and ecological risk evaluations for human and ecological exposure to surface water (and ecological exposure to sediment pore water) **did not identify potentially unacceptable risks**[6] resulting from the discharge of groundwater to Little Creek Harbor. Therefore, the Navy and USEPA, in consultation with VDEQ, agreed that no further evaluation of risks associated with groundwater discharging to Little Creek Harbor was warranted.
Benthic Invertebrate Evaluation (CH2M HILL, December 2012b)	001662	Surface sediment sampling was conducted to evaluate the current health of the benthic invertebrate community within the area requiring remedial action and assess the relationship of the health of the benthic community with concentrations of COCs and ABM in sediment. Data indicated that a larger benthic community was present in areas of higher COC and ABM concentrations. Additionally, data indicated that physical conditions at the site unrelated to former sandblasting (such as low dissolved oxygen in the surface water column just above the sediment surface, water depth, and a high percentage of fine-grained sediment) may have a greater negative impact on the health of the benthic invertebrate community than concentrations of COCs and ABM in sediment. The evaluation concluded that although factors unrelated to former sandblasting may be working in combination with site-related contamination to impact the health of the benthic invertebrate community, the magnitude of **metals concentrations in sediment may potentially result in unacceptable risks to ecological receptors**[7] should these factors change over time; therefore, remedial action at SWMU 3 was determined to be warranted. The evaluation recommended that remedial action objectives (RAOs) to reduce the concentrations of metals in sediment be established for the site.
NTCRA (CH2M HILL, December 2012c, CH2M HILL, December 2012d, and CH2M HILL, September 2013a)	001723 (EE/CA) 001716 (AM) 001786 (Summary Memorandum)	In December 2012, an Engineering Evaluation/Cost Analysis (EE/CA) was finalized to **evaluate non-time-critical removal action (NTCRA) alternatives**[8] to reduce potential unacceptable ecological risks in sediment surrounding the dry dock and its anchoring system. The alternative selected included dredging of contaminated sediment, disposal of dredged materials in a Subtitle D landfill, and replacement with clean fill. A public notice was issued in *The Virginian-Pilot* on November 1, 2012, and the EE/CA was made available to the public from November 1, 2012, to December 15, 2012. No comments were received and an Action Memorandum (AM) was signed by the Navy on December 17, 2012 to implement the recommended alternative presented in the EE/CA. As previously discussed, site-specific sediment cleanup goals were established for the site COCs (copper, lead, nickel, tin, and zinc) by considering metals concentrations, ABM content, and urban background values (**Table 7**). Because ABM was classified as non-hazardous, the Navy and USEPA, in consultation with VDEQ, agreed that the presence of ABM in sediment does not drive the need for action at SWMU 3. The Navy and USEPA, in consultation with VDEQ, agreed that a grid cell required remedial action if the calculated ratio (as previously described) for one or more individual COCs exceeded 1.5 and the average ratio for the five COCs exceeded 1. All available surface sediment data were used to define the revised lateral area requiring remedial action as depicted on **Figure 8**. In December 2012, prior to implementation of the NTCRA, delineation sampling was conducted to determine the vertical extent of the area requiring CERCLA remedial action and the depth of removal required to reduce ecological risk from sediment surrounding the dry dock and its anchoring system (**Figure 8**). Sediment samples were collected from each grid cell located within the area requiring remedial action, in 1-foot intervals to determine the depth at which COC concentrations met ratio requirements as discussed above. With the exception of grid SD609A, the vertical extent of the sediment requiring remedial action was defined. For grid SD609A, ratio requirements were not met within the deepest sample collected from 5 to 5.5 feet below the sediment surface. Beginning in February 2013, **12,600 cubic yards of sediment was dredged**[9] from within a portion of the area requiring remedial action in Little Creek Harbor (**Figure 9**). As a result of engineering constraints, sediment within 50 feet of the bulkhead shoreline, 10 feet of piers, and 20 feet of the shoreline revetment were inaccessible via dredging and left in place. Additionally, the dredge barge could not reach grid cell 01; therefore, this grid cell was not dredged. Dredged materials were transported via barge to Port Weanack located in James City County, Virginia, where they were solidified and offloaded for transport and disposal. Following dredging activities, the site was restored by placing a clean sand layer. Grid cells where previous subsurface sediment sampling results indicated petroleum-like material may have been exposed during dredging activities received approximately 2 feet of sand; the remaining portion of the site received a minimum of 6 inches of sand. In September 2013, a Construction Summary Memorandum was prepared to document completion of removal activities and mitigation of ecological risks associated with SWMU 3 sediment within the NTCRA area, with the exception of grid cell 01.

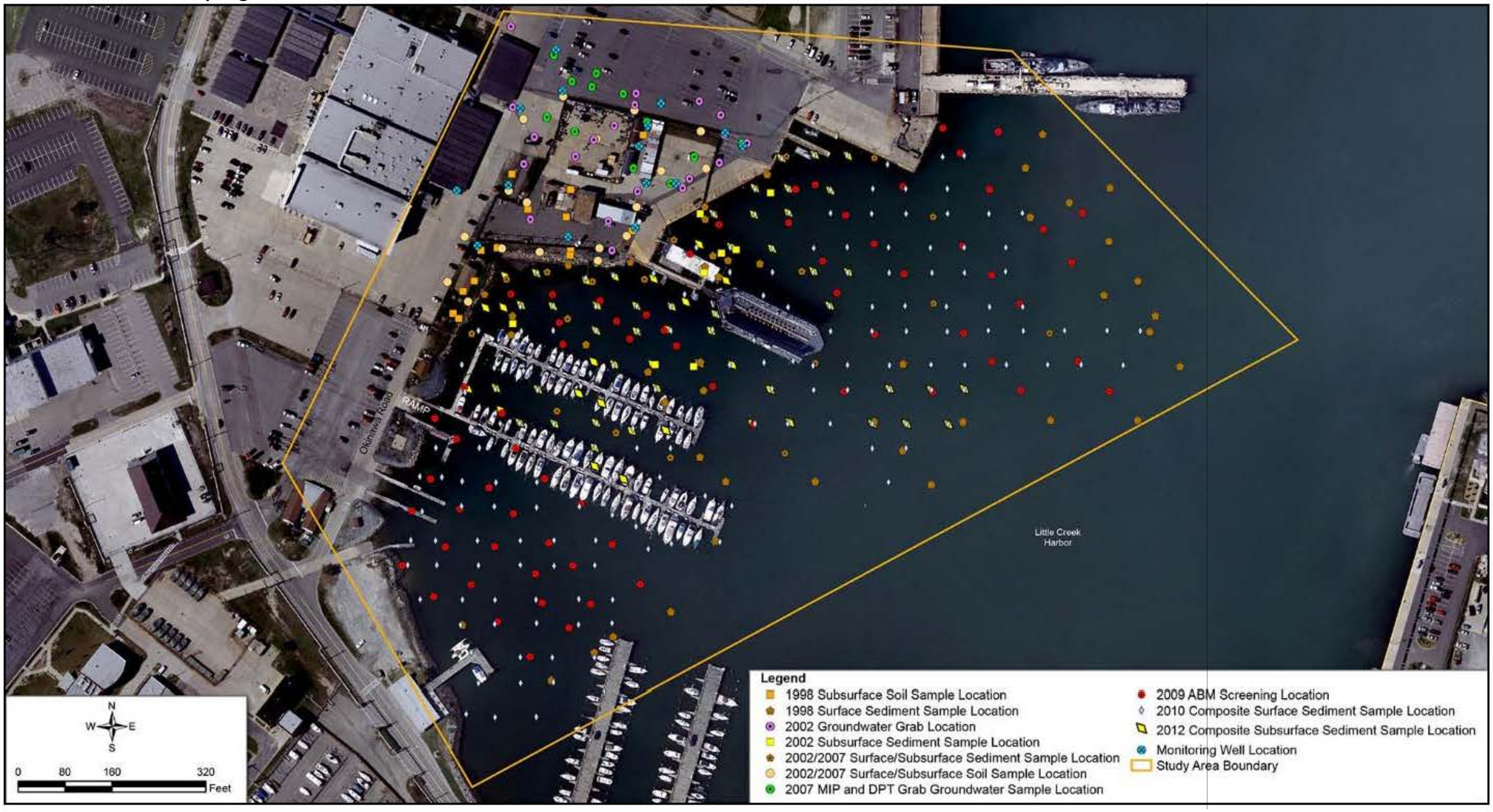
TABLE 1
Studies, Investigations, and Activities Summary

Previous Study / Investigation	AR Document Number	Investigation Activities
Risk Assessment Update (Vapor Intrusion) (CH2M HILL, June 2013b)	001750	Currently at SWMU 3, there is no route for human exposure to vapors in building indoor air resulting from the volatilization of VOCs in groundwater (vapor intrusion); therefore, risk associated with vapor intrusion was not evaluated as part of the HHRAs in the RI and SRI. However, due to the presence of VOCs in groundwater, and the uncertainties associated with quantifying risks from potential future building occupant exposure to vapors in indoor air, it was assumed that vapor intrusion from shallow groundwater into indoor air could pose unacceptable risks to future buildings occupants. As part of a risk assessment update, potential risks associated with future exposure to indoor air were quantified for potential future residents at SWMU 3 using groundwater VOC data collected in January and September 2007 during the SRI. Potentially unacceptable risks associated with TCE and vinyl chloride were identified based on maximum detected concentrations of VOCs in groundwater. However, calculated risks are representative of site conditions in 2007. Based upon natural processes working to reduce chemical concentrations in groundwater (natural degradation) , and proximity of elevated TCE and vinyl chloride concentrations to the adjacent shoreline, concentrations of these chemicals are expected to be lower or to have migrated with groundwater flow and discharged to Little Creek Harbor. As a result, calculated risks are likely an overestimation of actual potential risks; therefore, the Navy and USEPA, in consultation with VDEQ, agreed that no current or future action is warranted to address vapor intrusion at SWMU 3.
Time-Critical Removal Action (TCRA) (CH2M HILL, June 2013d, CH2M HILL, December 2013, and Tetra Tech, October 2014)	001748 (AM) 001900 (Scope Change AM) 001913 (Lead Sampling Work Plan) 001724 (TCRA Work Plan) 002209 (CCR)	An AM was signed by the Navy on June 17, 2013 for completion of a TCRA at SWMU 3 to prevent remaining sediment from re-contaminating areas cleaned up during the NTCRA, address localized areas of elevated lead concentrations (> 400 milligrams per kilogram [mg/kg]) in soil, and reduce potential ecological risks associated with exposure to site COCs in remaining sediment. Performing an action other than a TCRA would have required a planning period of at least six months, which could have allowed storm events to move contaminated sediment into areas dredged and backfilled during the NTCRA. A second AM to document a partial change in scope of the response action was signed on December 16, 2013. The final scope of the TCRA included sediment dredging where feasible, soil excavation, and offsite disposal of soil and sediment, followed by site restoration including backfill and construction of a stormwater management retention feature. In those areas inaccessible for dredging, the TCRA scope included the placement of powdered activated carbon on the sediment surface to reduce benthic invertebrate exposure to metals in sediment. A public notice was issued in *The Virginian Pilot* on November 30, 2013, and the TCRA was made available for public comment from November 30, 2013 to December 31, 2013. No comments were received. Areas addressed as part of the TCRA are depicted on **Figures 7 and 9**. Beginning in November 2013, approximately **1,300 cubic yards of sediment and 320 cubic yards of soil were removed**[10], transported, and disposed of offsite. Sediment was removed from the area depicted on **Figure 9**. The vertical depth of sediment removal required to reduce potential ecological risks associated with site COCs in sediment was previously delineated as part of the NTCRA delineation sampling event conducted in December 2012. Successful removal of elevated concentrations of lead in soil (> 400 mg/kg) was confirmed through pre-excavation confirmation soil sampling and post-excavation confirmation sampling. Soil was removed from the area depicted on **Figure 7**. Following completion of removal activities, a minimum of 6 inches of clean sand were placed in the sediment removal area; a stormwater retention feature was constructed to retain and filter runoff from the adjacent parking lot and remaining areas were backfilled with clean fill to match surrounding grade. In remaining areas, as depicted on **Figure 9**, 2 inches of powdered activated carbon delivered as part of a pebble-like aggregate (also known as a “reactive amendment”) was distributed across the sediment surface. Sediment cores were collected to verify successful achievement of desired amendment thickness and no post-action monitoring of sediment was required. In September 2014, a Construction Completion Report (CCR) was finalized to document TCRA activities.
Focused FS (CH2M HILL, October, 2014)	002184 (Sampling and Analysis Plan) 002199 (Focused FS)	Although potable use was previously concluded to not be an applicable exposure pathway at SWMU 3, VDEQ considers all groundwater a potential potable resource and requires that all groundwater be restored to beneficial (potable) use. Therefore, a Focused FS was completed to develop and **evaluate remedial alternatives**[11] to prevent unacceptable risk from future exposure through potable use of groundwater. As part of the Focused FS, groundwater sampling was conducted to evaluate current site conditions and collect groundwater geochemistry data to aid in the evaluation of remedial alternatives to address VOCs in groundwater. Samples were collected from existing site monitoring wells and analyzed for COPCs identified in the HHRA conducted as part of the SRI as well as those VOCs detected above federal drinking water standards. Data indicated that COPC concentrations in groundwater have decreased as a result of naturally occurring physical and chemical processes since completion of the RI and SRI (**Table 3**). A revised HHRA was completed to assess potential risks posed by the COPCs under current site conditions. Results identified **potentially unacceptable risks to future residents**[12] from potable use of groundwater; however risks are limited to exposure to vinyl chloride and TCE in groundwater. As part of the Focused FS, two remedial alternatives were selected for detailed comparative analysis: (1) no action and (2) MNA and LUCs.

Notes:
*The documents listed are available in the AR and provide detailed information used to support remedy selection at SWMU 3.

FIGURE 5

SWMU 3 Previous Sampling Locations



2.4 Scope and Role of Response Action

The former NAB Little Creek, now referred to as JEB Little Creek, was placed on the National Priorities List in May 1999. The Navy, USEPA, and VDEQ entered into a Federal Facility Agreement (FFA) in 2003. The FFA identified 10 sites for Remedial Investigation (RI)/Feasibility Study (FS) activities requiring closure through a ROD. SWMU 7, identified in the FFA for investigation under an RI/FS, was later divided into SWMU 7a and SWMU 7b. Seventeen sites were identified in the FFA as requiring further evaluation through desktop audits or site screening process investigations. Sixteen of the sites were evaluated, and closeout documentation was prepared (**Table 2**). Site 11a was recommended for further investigation under RI/FS activities and closure through a ROD.

SWMU 3 is the last of 12 ERP sites addressed under CERCLA at JEB Little Creek (**Figure 1**). A summary of the remedy selection decision for the remaining sites is provided below:

- SWMU 7a: No Action ROD
- SWMU 7b: No Action ROD
- SWMU 8: No Action ROD
- Site 7: Action ROD for maintenance of the existing soil cover, LUCs, and groundwater monitoring
- Site 8: No Action ROD
- Sites 9 and 10: Action ROD for LUCs and groundwater monitoring
- Site 11: Action ROD for enhanced reductive dechlorination with LUCs and post-treatment groundwater monitoring
- Site 11a: Action ROD for enhanced reductive dechlorination with LUCs and post-treatment groundwater monitoring
- Site 12: Action ROD for bio-augmentation with LUCs and post-treatment groundwater monitoring
- Site 13: Action ROD for enhanced anaerobic bioremediation with LUCs and post-treatment groundwater monitoring

The FFA also identified 105 sites for which no action under CERCLA is required due to the determination that the site poses no threat or potential threat to public health, welfare, or the environment, or the site is addressed by other environmental programs.

Seven Military Munitions Response Program sites were identified for Preliminary Assessment. Of the seven sites, two were determined to require no action under CERCLA following completion of the Preliminary Assessment (**Table 2**). The five remaining sites were identified for further evaluation through desktop audits or site screening process investigations. Each site was evaluated, and closeout documentation was prepared (**Table 2**). Details of these investigations are presented in the **Site Management Plan**[13] for JEB Little Creek, which is updated annually and available in the Administrative Record file.

2.5 Nature and Extent and Fate and Transport of Contamination

The following section summarizes current site conditions at SWMU 3, including nature and extent, fate and transport, and natural attenuation processes.

Nature and Extent of Contamination

The chlorinated VOC tetrachloroethene (PCE) and several "breakdown product" compounds formed from the biological and chemical degradation of PCE – namely TCE, cis-1,2-dichloroethene (DCE), and vinyl chloride – have been detected in groundwater above federal maximum contaminant levels (MCLs). However, based upon data collected in August 2014, TCE and vinyl chloride are the only chlorinated VOCs remaining in groundwater above MCLs (**Table 3**). The groundwater plume is located east of the more recent (1992 to 1996) sandblasting area extending south to Little Creek Harbor (**Figure 6**). No release of chlorinated solvents to soil has been documented at the site. Additionally, detected concentrations of VOCs in soil do not indicate that any continuing source of contamination is present in soil.

TABLE 2
Site and Preliminary Screening Area Closeout Summary

Site/Preliminary Screening Area	Investigation Activity	Determination	Closeout Documentation
FFA Sites			
SWMU 30 – Leaking Above Ground Diesel Tank	Desktop audit and site visit.	Aboveground storage tank and surrounding berm is in good condition. Further assessment will be conducted under Spill Prevention, Control, and Countermeasures Plan/Aboveground Storage Tank Program.	Final June 2003 Tier I Partnering Team Meeting Minutes, Consensus Statement.
SWMU 96 – Scrap Metal Storage Area	Desktop audit and site visit.	Currently an active equipment storage area operated under facility protocols for maintaining best management practices. No evidence of a CERCLA release. No further action required.	Final Closeout Report Appendix B Sites SWMUs 96, 97, 98, and 119, NAB Little Creek, Virginia Beach, Virginia. September 2004.
SWMU 97 – Vehicle Maintenance Facility Storm Drain		Active storm drain operated under the facility VPDES permit. No evidence of a CERCLA release. No further action required.	
SWMU 98 – Elevated Causeways Mechanic Shop Material Dispensing Area		No evidence of a CERCLA release. No further action required.	
SWMU 119 – Former Special Warfare Group 2 Electronics Shop	Groundwater samples collected.	No evidence of a CERCLA release or potential unacceptable risks. No further action required.	
Area of Concern (AOC) H – Buildings 3109 and 3360 at Golf Course (Pesticide Mixing Area)	Soil samples collected.	Potential risks to human health and ecological receptors minimal and no further action is required.	Final Close-Out Report Appendix B Sites AOCs – H, I, J, and Site 14, NAB Little Creek, Virginia Beach, Virginia. March 2004
AOC I – Eagle Haven Golf Course Pond	Soil and sediment samples collected.		
AOC J – Former "Burn Area" between IF Sites 9 and 10	Soil and groundwater samples collected.		
Installation Restoration Site 14 – Old Pole Yard and Transformer Storage Area	Soil samples collected.		
SWMU 18 – Personal Watercraft Transmission Garage Spent Battery Shop, Collection Area	Desktop audit and site visit.	No evidence of a CERCLA release. No further action required.	Final April 2005 Tier I Partnering Team Meeting Minutes, Consensus Statement.
SWMU 116 – Morale, Welfare, and Recreation Boat Maintenance Facility			
AOC D – Polychlorinated Biphenyl Transformer Leak			
SWMU 5 – Port Ops Boat Painting Area	Soil and groundwater samples collected.	No evidence of a CERCLA release or potential unacceptable risks. No further action required.	Final Site Screening Assessment Closeout Report SWMUs 5, 6, 13, and Site 6, NAB Little Creek, Virginia Beach, Virginia. January 2006.
SWMU 6 – Seabee Area – CB-124	Soil and groundwater samples collected.		
SWMU 13 – Former Pesticide Shop	Soil and groundwater samples collected.		
Installation Restoration Site 6 – Special Boat Unit Battery Storage Yard	Soil and groundwater samples collected.		

TABLE 2
Site and Preliminary Screening Area Closeout Summary

Site/Preliminary Screening Area	Investigation Activity	Determination	Closeout Documentation
Military Munitions Response Program Sites			
Chemical Defense Area	Desktop evaluation.	No evidence of a CERCLA release or potential unacceptable risks were identified during the archive search. Additionally, significant redevelopment and fill of the area has occurred. Area removed from further study.	Final Preliminary Assessment, NAB Little Creek. September 2007.
1942 Pistol Range	Desktop evaluation.	No evidence of a CERCLA release or potential unacceptable risks. The site is currently under several feet of concrete that makes up the landing craft air cushion pad. Area removed from further study.	
Anti-Aircraft Target Rifle Range	Desktop evaluation and site visit.	Site screening area does not pose a threat or potential threat to public health, welfare, or the environment. Area removed from further study.	Final Site Screening Process Closeout Report, Anti-Aircraft Target Rifle Range, 1944 Pistol Range, and 1953 Pistol Range, NAB Little Creek, JEB Little Creek-Fort Story, Virginia Beach, Virginia. September 2010.
1944 Pistol Range			
1953 Pistol Range			
Depth Charge Testing Area	Desktop evaluation.	Site screening area does not pose a threat or potential threat to public health, welfare, or the environment. Area removed from further study.	Final Site Screening Process Closeout Report, Depth Charge Testing Area, NAB Little Creek, JEB Little Creek-Fort Story, Virginia Beach, Virginia. September 2010.
Former Morale, Welfare, and Recreation Skeet Range	Soil and groundwater samples collected.	Site screening area does not pose a threat or potential threat to public health, welfare, or the environment. Area removed from further study.	Final Site Screening Process Report, Former Morale, Welfare, and Recreation Skeet Range, NAB Little Creek, JEB Little Creek-Fort Story, Virginia Beach, Virginia. January 2011.

TABLE 3
Maximum Concentrations of COPCs

COPC	MCL	Maximum Concentration					
		8/2002	2/2007	9/2007	2/2008	9/2008	8/2014
Benzene	5	1.3	ND	ND	ND	ND	ND
1,1-DCA	--	87	9	6.2	8	11	3.01
1,2-DCA	5	1.5	ND	ND	ND	ND	ND
PCE	5	210	ND	0.1	0.3	ND	ND
TCE	5	180	17	16	19	19	6.01
cis-1,2-DCE	70	47	260	140	210	310	28
trans-1,2-DCE	100	14	79	64	83	130	12.2
Vinyl chloride	2	21	56	35	55	85	15.9

Concentrations reported in micrograms per liter (µg/L).
DCA – dichloroethane
ND – not detected

FIGURE 6
2014 Groundwater COC Plume Boundary

Fate and Transport of Contamination

Constituent fate and transport of dissolved VOCs in groundwater at SWMU 3 are natural attenuation processes. Natural attenuation occurs through a combination of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes consist of biodegradation, advection, dispersion, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants. An evaluation of natural attenuation at SWMU 3 is detailed in the Focused FS and summarized below.

Natural Attenuation Evaluation

Physical processes of advection with groundwater flow and dispersion through tidal influx are the primary mechanism for natural attenuation at SWMU 3. During low-tide, VOCs are transported through downgradient migration of groundwater and subsequently discharged to Little Creek Harbor (**Figure 4**). Contaminant concentrations are also dispersed through tidal influx as a result of localized reversal in groundwater flow during high-tide cycles (**Figure 4**). As noted in the risk assessment summaries below, discharge of groundwater to surface water does not pose an unacceptable incremental increase in human health or ecological risks in Little Creek Harbor.

A secondary mechanism for natural attenuation of VOCs at SWMU 3 is biodegradation. Although historical **data trends**[14] within individual monitoring wells do not indicate significantly decreasing trends, an assessment of chlorinated VOC concentrations across the entire site indicate overall decreasing trends for all constituents evaluated (**Table 3**) indicating overall degradation of VOCs. Additionally, the presence of daughter products (TCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride) and innocuous end products (methane, ethane, ethane, and chloride) in groundwater at SWMU 3 are strong indicators of degradation.

Groundwater geochemical data[15] indicate that conditions within the plume area are somewhat favorable for reductive dechlorination. In 2007, 2008, and 2014, dissolved oxygen has been measured below 1 milligram per liter (mg/L) and negative oxidation reduction potential values are indicative of reducing conditions conducive for the reductive dechlorination of VOCs. Nitrate was detected at low levels (< 1 mg/L) and nitrite was not detected. This indicates that nitrate and nitrite are not available as electron acceptors competing with chlorinated VOCs in groundwater for available electron donors, inhibiting reductive dechlorination at the site. Ferrous iron has been detected above 1 mg/L in both 2007 and 2014 indicting that iron reduction has been and continues to be occurring at the site. Because ferric iron acts as a competing electron acceptor, its reduction to ferrous iron is a positive indicator of conditions conducive for reductive dechlorination at SWMU 3. Sulfate has been detected at concentrations > 20 mg/L both in 2007 and 2014 indicative of potentially competitive conditions that may inhibit reductive dechlorination; however sulfate concentrations have decreased from 2007 (average of 118 mg/L) to 2014 (average of 77.8 mg/L). Sulfide was detected at 4.8 mg/L at LW03-MW07 and at 1 mg/L at LW03-MW12 in 2007; however was not detected in August 2014. Overall data trends are indicative of some sulfate reduction at SWMU 3. Methane was detected at low concentrations in plume area wells in both 2007 and 2014 (maximum concentration of 1.3 mg/L), indicating some methanogenesis may be occurring. Alkalinity concentrations within the plume were elevated in comparison to background conditions, indicative of increased biological activity. Although carbon dioxide was detected at > 100 mg/L, it was not elevated above background conditions. The pH levels have historically been and are currently within the optimal range (between 5 and 9 units) for biodegradation. Although present slightly below the recommended level of 20 mg/L for reductive dechlorination and at decreased levels from 2007 to 2014, TOC is present in groundwater as an available electron donor source.

2.6 Current and Potential Future Land and Water Uses

The terrestrial portion of SWMU 3 includes a fenced area containing Buildings 1262 (firefighting equipment storage), 1263 (welding and metal-working shop), and 1268 (wood storage), and two concrete pads formerly used for sandblasting operations. Outside of the fenced area are Buildings 1265-1 and 1265-3 (IT support administrative spaces), 1516 (former MWR marina shop), 1528 (MWR restrooms), and 1604 (United Service Organization administrative and cooking space).

The aquatic portion of the site, located in Little Creek Harbor, consists of the Pier 10 floating dry dock and its associated anchoring system, as well as a recreational marina used by military dependents and former active duty service members. In addition to floating dry dock activities, Little Creek Harbor is currently used for dive team training. The facility currently allows recreational fishing from the pier located behind Building 1604. A public health restriction on shellfish consumption in Virginia Beach and Norfolk and a fish consumption advisory for the entire Chesapeake Bay are currently in place; JEB Little Creek falls under those restrictions and advisories.

Surficial aquifer groundwater is not currently used as a potable water supply at or near JEB Little Creek because of its generally poor quality (naturally present iron and manganese frequently exceeds secondary drinking water standards) and low yields from wells installed in the aquifer (generally less than 3 to 5 gallons per minute). Additionally, surficial aquifer groundwater underlying SWMU 3 is generally brackish, and is within a transition zone where upgradient freshwater mixes with downgradient seawater. Potable water is supplied to the base and surrounding communities by the City of Virginia Beach. However, the Navy acknowledges the Commonwealth of Virginia's and USEPA's expectation to return usable groundwaters to their **beneficial uses**[16] wherever practicable. Groundwater wells at the base golf course located approximately 9,400 feet northeast of SWMU 3 provide water from the deeper Yorktown aquifer for irrigation of the golf course. The current and reasonably anticipated future land use of the SWMU 3 area is not expected to change.

2.7 Summary of Site Risks

Detailed results of the Human Health Risk Assessments (HHRAs) and Ecological Risk Assessments (ERAs) conducted at SWMU 3 are presented in the RI/HHRA/ERA, Supplemental Remedial Investigation (SRI)/HHRA/ERA, Groundwater to Surface Water Risk Assessment Update, Benthic Invertebrate Evaluation, Vapor Intrusion Risk Assessment Update, and Focused FS available in the AR file. The following subsections summarize the findings of these risk assessments.

2.7.1 Human Health Risk Summary

The HHRAs were completed to evaluate the potential impact from exposure to surface soil, subsurface soil, surface water, sediment, groundwater, and indoor air at SWMU 3 using reasonable maximum exposure (RME) and central tendency exposure (CTE) point concentrations. The RME scenario assumes the highest level of human exposure that could reasonably be expected to occur, whereas the CTE scenario reflects human exposure to average concentrations across the site.

The **potential receptor pathways**[17] evaluated included: current adult/adolescent recreational user and other worker (e.g., scuba diver) exposure to surface water and sediment; current adult/adolescent trespasser/visitor and maintenance worker exposure to surface soil; hypothetical future adult/adolescent recreational user, other worker, and maintenance worker exposure to surface water and sediment; hypothetical future adult/child resident, industrial worker, and construction worker exposure to soil and groundwater; and hypothetical future adult/child resident exposure to indoor air. The **potential exposure pathways**[18] evaluated included: ingestion of and dermal contact with surface water and sediment and ingestion of, dermal contact with, and inhalation of emissions (volatile and/or particulate) from soil and groundwater.

The potential for non-cancer hazards, referred to as the hazard quotient (HQ), is evaluated by calculating the ratio of exposure to toxicity. An HQ greater than 1 indicates that a receptor's exposure to a particular chemical may present an unacceptable non-cancer hazard. In addition, hazard indices (HIs) are generated by adding the HQs for all chemicals that affect the same target organ or cause the same types of adverse health effects within a medium or across all media to which an individual may reasonably be exposed. HI values greater than 1 indicate the potential for unacceptable non-cancer hazards due to site exposure.

For known or suspected carcinogens, the likelihood of any type of cancer resulting from exposure to contamination is generally expressed as an upper bound probability of 10^{-4} (a 1 in 10,000 chance of one extra case of cancer occurring because of exposure) using information on the relationship between dose and response. Acceptable exposure levels are generally considered as concentrations that represent a lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} (a 1 in 1,000,000 chance of one extra case of cancer occurring because of exposure).

The risk drivers contributing to non-cancer hazards and cancer risks exceeding USEPA threshold levels are summarized in **Table 4.** Risk drivers are those chemicals that contribute an HI above 0.1 to a target organ HI above 1, or a carcinogenic risk above 1×10^{-6} to a cumulative carcinogenic risk above 1×10^{-4}. Site-specific COCs are those risk drivers identified during the August 2014 risk assessment update.

Sediment and Surface Water

Calculated RME cancer risks and non-cancer hazards associated with human exposure to surface water and sediment were below USEPA's target risk levels. Additionally, an evaluation of human health risks associated with groundwater discharge to surface water does not pose an unacceptable incremental increase in risks from exposure to surface water in Little Creek Harbor. Therefore, the Navy and USEPA, in consultation with VDEQ, agree no action is required for sediment and surface water to ensure protection of human health.

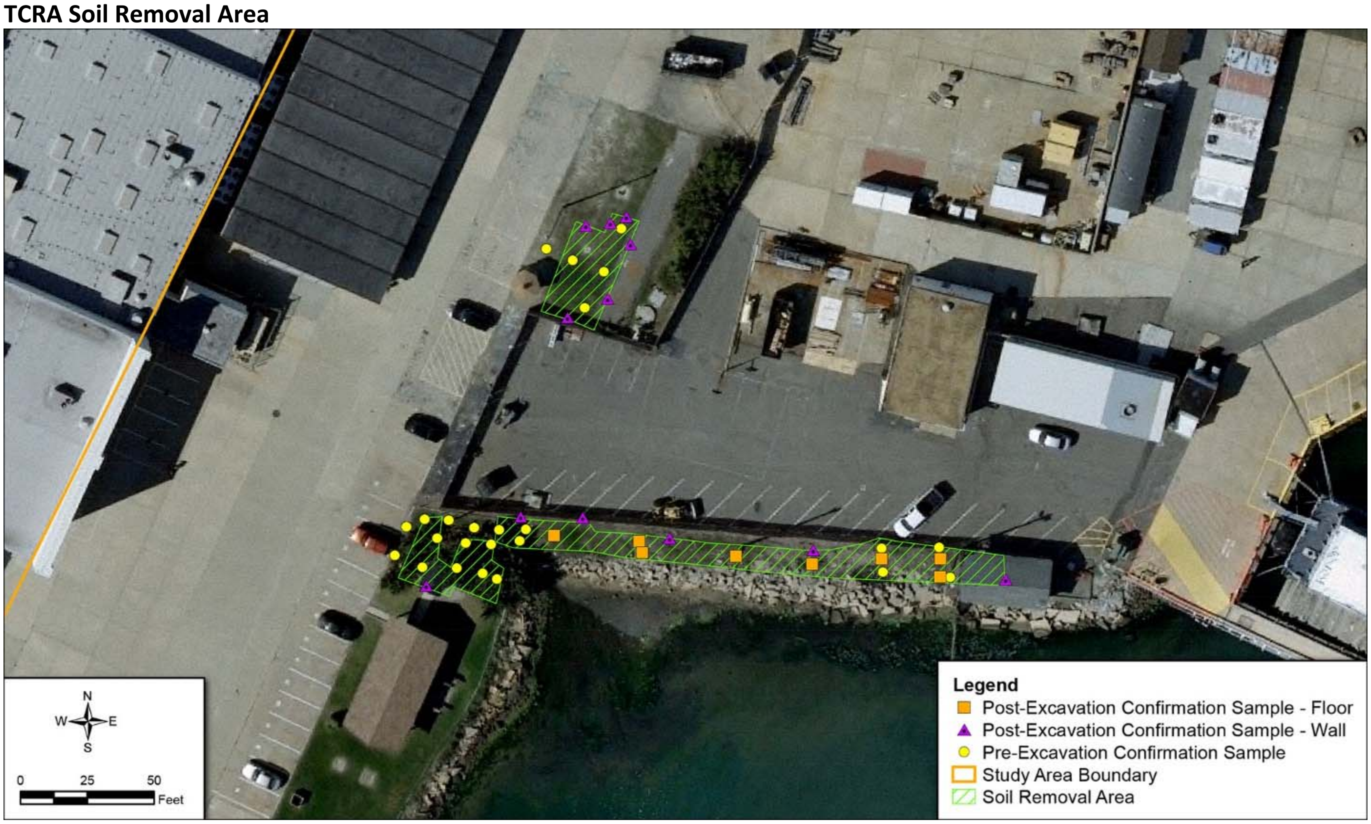
Soil

Under current land use, RME cancer risks and non-cancer hazards associated with exposure to surface and subsurface soil were below USEPA's target risk levels. Under future land use, the child resident cumulative RME non-cancer hazard (HI=3.0) from exposure to combined surface and subsurface soil exceeded USEPA's target risk level of 1. However, there were no target organ effect HIs greater than 1. RME cancer risks and non-cancer hazards were below or within USEPA's target risk levels for future adult and lifetime residents, industrial workers, and construction workers. There were no CTE non-cancer hazards above USEPA's target risk levels.

Exposure to lead is regulated by the USEPA based on the concentration of lead in blood. The Integrated Exposure Uptake Biokinetic model was used to evaluate future child resident exposure to lead in surface and subsurface soil across the site and the Adult Lead Methodology Model was used to evaluate current maintenance worker and future industrial worker exposure to lead in soil across the site. Concentrations of lead in surface and subsurface soil at individual sample locations exceeded the child residential screening criteria, the Integrated Exposure Uptake Biokinetic and Adult Lead Methodology models demonstrated that exposure to lead in soil across the site would not be a potential health concern. While there are no potentially unacceptable human health risks from exposure to lead in soil, the Navy proactively addressed localized areas of elevated levels of lead concentrations (> 400 milligrams per kilogram [mg/kg]) as part of the TCRA. Pre-excavation confirmation soil samples were collected as part of TCRA activities to define the extent of removal (**Figure 7**). Following excavation activities, a field survey was conducted to ensure that required excavation depths were achieved and localized post-excavation **confirmation sampling**[19] was conducted in areas where clean boundaries were not previously defined. Following completion of excavation, field surveying, and post-confirmation sampling activities, the soil removal areas were restored by backfilling with imported clean fill material or by the construction of a stormwater management retention feature. Successful removal of soil is documented in the TCRA Construction Completion Report (CCR).

Based on the results of the HHRA and completion of the TCRA, which removed localized areas of lead contamination attributable to SWMU 3, the Navy and USEPA, in consultation with VDEQ, agree no further action is required for soil to ensure the protection of human health.

FIGURE 7
TCRA Soil Removal Area



Groundwater

As part of the 2009 SRI HHRA, risk estimates were calculated for future residents and industrial workers based on potable use of groundwater and for future construction worker exposure to groundwater in an open excavation. Calculated cumulative RME cancer risks and non-cancer hazards associated with future construction worker exposure to groundwater were below USEPA's target levels. Exposure to groundwater by future adult and child residents resulted in cumulative RME non-cancer hazards (adult HI = 6.6, cumulative child HI = 15) above USEPA's target levels. Adult and child resident exposure to groundwater would also result in cumulative CTE non-cancer hazards (adult HI = 1.3, child HI = 4.0) above USEPA's target levels. Future lifetime resident exposure to groundwater would result in cumulative RME cancer risks (cancer risk = 8.6 x 10^{-4}) and cumulative CTE cancer risks (cancer risk = 1.1 x 10^{-4}) above USEPA's acceptable levels. Future industrial worker exposure to groundwater would result in cumulative RME cancer risks (cancer risk = 1.3 x 10^{-4}) and non-cancer hazards (HI = 1.9) above USEPA's target risk levels. However, cumulative CTE cancer risks (cancer risk = 1.2 x 10^{-5}) and non-cancer hazards (cumulative HI = 0.73) were within or below USEPA's target risk levels. Unacceptable risks and hazards from exposure to groundwater were associated with VOCs, one SVOC (dibenzofuran) and metals in groundwater (**Table 4**).

Although dibenzofuran and metals concentrations in groundwater resulted in cancer risks or non-cancer hazards above USEPA's acceptable levels based on RME calculations, the Navy and USEPA, in consultation with VDEQ agree dibenzofuran, antimony, arsenic, iron, manganese, and thallium in groundwater do not pose an unacceptable risk based upon the risk management considerations presented in **Table 5**. Therefore, no further action for these constituents in groundwater is required to ensure protection of human health.

As part of development of the Focused FS, groundwater data collected during the SI, RI, and SRI were reviewed against updated risk-based screening values, MCLs, and toxicity values to identify any potentially new contaminants of potential concern (COPCs) in groundwater, in addition to those previously identified in the 2009 SRI HHRA. As a result, 1,1-dichloroethane (DCA), chromium, and cobalt were identified as new COPCs that may potentially contribute to an unacceptable risk or hazard in groundwater and may potentially be identified as site-specific COCs. However, based upon the risk management considerations presented in **Table 5** the Navy and USEPA, in consultation with VDEQ agree the potential risks and hazards associated with chromium and cobalt are acceptable and no further action is warranted to address these constituents in groundwater to ensure protection of human health.

In August 2014 additional groundwater sampling was conducted to evaluate the current concentrations of the VOC COPCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, benzene, 1,1-DCA, and 1,2-DCA) and assess potential human health risks associated with future adult and child residential and future industrial worker potable use of groundwater under current site conditions. No RME risks or hazards above USEPA's target levels associated with future industrial worker exposure to groundwater were identified. Calculated cumulative RME cancer risks and non-cancer hazards associated with future industrial worker exposure to groundwater were below USEPA's target levels. Calculated cumulative RME non-cancer hazards associated with future adult resident (1.3) and future child resident (HI = 1.7) exposure to groundwater were slightly above USEPA's target threshold of 1; however there were no target organ effects above 1 and calculated cumulative CTE risks were below USEPA's threshold of 1. Future lifetime resident exposure to groundwater would result in cumulative RME cancer risks (cancer risk = 2.2 x 10^{-4}) above USEPA's acceptable levels. Calculated cumulative CTE risks are below USEPA's target levels of 10^{-6}. Unacceptable risks to the lifetime resident are associated with TCE and vinyl chloride (**Table 4**).

Indoor Air Vapor

Vapor intrusion is not considered a current exposure pathway at SWMU 3. Risks associated with future resident exposure to indoor air via vapor intrusion from groundwater were calculated using groundwater data collected as part of the SRI in 2007. Calculated cumulative cancer risk and non-cancer hazard estimates (cancer risk = 9.0 x 10^{-4}, cumulative HI = 5) were above USEPA's target levels based upon maximum detected concentrations of VOCs in groundwater, primarily associated with TCE and vinyl chloride (**Table 4**). However, calculated cumulative cancer risks and non-cancer hazards based upon the 95 percent upper confidence limit (UCL) of the mean groundwater concentrations were below USEPA's acceptable levels. Additionally, maximum detected chemical concentrations and calculated 95 percent UCL of the mean concentrations were representative of site conditions in 2007. Based

TABLE 4

Summary of Unacceptable Human Health Risks Identified in the Supplemental Remedial Investigation

Receptor	COPC	RME EPC[1]	Total RME		Total CTE		Cancer Toxicity Factor (CSF)[2]	Non-Cancer Toxicity Factor (RfD)[2]
			Cancer Risk	Non-Cancer Hazard	Cancer Risk	Non-Cancer Hazard		
Groundwater (exposure pathways evaluated are ingestion, dermal contact and inhalation)								
2009 SRI HHRA[3]								
Future Resident Adult	PCE	34 µg/L	N/A	0.16	N/A	0.016	N/A	1 x 10^{-2}
	TCE	30 µg/L	N/A	0.16	N/A	0.018	N/A	6 x 10^{-3}
	VC	12 µg/L	N/A	0.13	N/A	0.022	N/A	3 x 10^{-3}
	cis-1,2-DCE	60 µg/L	N/A	0.18	N/A	0.019	N/A	1 x 10^{-2}
	Dibenzofuran	28 µg/L	N/A	1.7	N/A	0.27	N/A	1 x 10^{-3}
	Antimony	2.2 µg/L	N/A	0.15	N/A	0.047	N/A	4 x 10^{-4}
	Thallium	5.0 µg/L	N/A	2.0	N/A	0.33	N/A	7 x 10^{-5}
	Receptor Total	*N/A*	*N/A*	*6.6*	*N/A*	*1.3*	*N/A*	*N/A*
Future Resident Child	PCE	34 µg/L	N/A	0.34	N/A	0.043	N/A	1 x 10^{-2}
	TCE	30 µg/L	N/A	0.37	N/A	0.058	N/A	6 x 10^{-3}
	VC	12 µg/L	N/A	0.27	N/A	0.068	N/A	3 x 10^{-3}
	cis-1,2-DCE	60 µg/L	N/A	0.42	N/A	0.06	N/A	1 x 10^{-2}
	Dibenzofuran	28 µg/L	N/A	4.0	N/A	0.69	N/A	1 x 10^{-3}
	Antimony	2.2 µg/L	N/A	0.36	N/A	0.16	N/A	4 x 10^{-4}
	Arsenic	7.1 µg/L	N/A	1.5	N/A	0.69	N/A	3 x 10^{-4}
	Iron	15,000 µg/L	N/A	1.4	N/A	0.33	N/A	7 x 10^{-1}
	Manganese	460 µg/L	N/A	1.7	N/A	0.69	N/A	2 x 10^{-2}
	Thallium	5.0 µg/L	N/A	4.6	N/A	1.1	N/A	7 x 10^{-5}
	Receptor Total	*N/A*	*N/A*	*15*	*N/A*	*4.0*	*N/A*	*N/A*
Future Resident Adult/Child	1,2-DCA	1.5 µg/L	3.1 x 10^{-6}	N/A	8.5 x 10^{-7}	N/A	9.1 x 10^{-2}	N/A
	Benzene	1.3 µg/L	1.5 x 10^{-6}	N/A	4.6 x 10^{-7}	N/A	5.5 x 10^{-2}	N/A
	PCE	34 µg/L	4.4 x 10^{-4}	N/A	3.1 x 10^{-5}	N/A	5.4 x 10^{-1}	N/A
	TCE	30 µg/L	6.9 x 10^{-6}	N/A	5.2 x 10^{-7}	N/A	1.1 x 10^{-2}	N/A
	VC	12 µg/L	2.6 x 10^{-4}	N/A	3.6 x 10^{-5}	N/A	1.4	N/A
	Arsenic	7.1 µg/L	1.6 x 10^{-4}	N/A	3.9 x 10^{-5}	N/A	1.5	N/A
	Receptor Total	*N/A*	*8.6 x 10^{-4}*	*N/A*	*1.1 x 10^{-4}*	*N/A*	*N/A*	*N/A*

TABLE 4

Summary of Unacceptable Human Health Risks Identified in the Supplemental Remedial Investigation

Receptor	COPC	RME EPC[1]	Total RME		Total CTE		Cancer Toxicity Factor (CSF)[2]	Non-Cancer Toxicity Factor (RfD)[2]
			Cancer Risk	Non-Cancer Hazard	Cancer Risk	Non-Cancer Hazard		
Future Industrial Worker	PCE	34 µg/L	6.3×10^{-5}	0.033	3.3×10^{-6}	0.0065	5.4×10^{-1}	1×10^{-2}
	TCE	30 µg/L	1.2×10^{-6}	0.049	6.6×10^{-8}	0.011	1.1×10^{-2}	6×10^{-3}
	VC	12 µg/L	3.0×10^{-5}	0.039	2.7×10^{-6}	0.013	7.2×10^{-1}	3×10^{-3}
	Arsenic	7.1 µg/L	3.7×10^{-5}	0.23	5.9×10^{-6}	0.14	1.5	3×10^{-4}
	Receptor Total	*N/A*	*1.3×10^{-4}*	*1.9*	*1.2×10^{-5}*	*0.73*	*N/A*	*N/A*
August 2014 HHRA Update								
Future Resident Adult/Child	TCE[4]	6.0	6.5×10^{-6}	N/A	1.7×10^{-6}	N/A	9.3×10^{-3}/ 3.7×10^{-2}	N/A
	VC	16	2.1×10^{-4}	N/A	6.4×10^{-5}	N/A	1.5	N/A
	Receptor Total	*N/A*	*2.2×10^{-4}*	*N/A*	*6.5×10^{-5}*	*N/A*	*N/A*	*N/A*
Indoor Air								
Future Resident	TCE[5]	5.61 µg/m³	1.0×10^{-5}	2.7	3.0×10^{-6}	0.6	1.0×10^{-6}/ 3.1×10^{-6}	2.0×10^{-3}
	VC	142 µg/m³	9.0×10^{-4}	1.4	7.0×10^{-5}	0.11	4.4×10^{-6}	1.0×10^{-1}
	Receptor Total	*N/A*	*9.0×10^{-4}*	*5.0*	*7.5×10^{-5}*	*0.9*	*N/A*	*N/A*

µg/L – microgram per liter
µg/m³ – microgram per cubic meter
COPC – constituent of potential concern
CSF – cancer slope factor; expressed in mg/kg-day-1 for groundwater.
CTE – central tendency exposure
DCA – dichlorothane
DCE – dichloroethene
EPC – exposure point concentration
IUR – inhalation unit risk factor; expressed in units of µm/m³-1 for indoor air.
N/A – not applicable
PCE – tetrachloroethene
RfD – reference dose; expressed in mg/kg-day for groundwater.
RfC – reference concentration; expressed in mg/m³ for indoor air.
RME – reasonable maximum exposure
TCE – trichloroethene
VC – vinyl chloride

Notes:

1 For completion of the SRI HHRA the RME EPC for groundwater was calculated as the 95% upper confidence limit (UCL) of the arithmetic mean. In cases where there were less than five samples in the data set, or the recommended UCL exceeded the maximum detected concentration, the maximum concentration was used as the RME EPC. The arithmetic mean concentration was used as the CTE EPC for groundwater. For completion of the August 2014 HHRA update the RME and CTE EPC was the maximum detected concentration. The RME EPC for indoor air was calculated using the maximum detected concentration in groundwater. The CTE EPC for indoor was calculated using the 95% UCL of the mean concentration in groundwater.

2 Sources: Integrated Risk Information system (IRIS), Health Effects Assessment Summary Tables (HEAST), National Center for Environmental Assessment (NCEA), California Environmental Protection Agency (CalEPA), current at time SRI conducted (2008) for the SRI HHRA and current at the time the 2014 HHRA Update was performed for the 2014 HHRA Update calculations.

3 Site data for VOCs listed in this section of the table were resampled and the risk assessment subsequently updated in 2014.

4 Risk estimates for TCE take into account mutagenic mode of action on the kidney (CSF = 9.3×10^{-3}) and are added to the risk estimates for liver and non-Hodgkin's Lymphoma (CSF = 3.7×10^{-2}).

5 Risk estimates for TCE take into account mutagenic mode of action on the kidney (IUR = 1.110^{-6}) and are added to the risk estimates for liver and non-Hodgkin's Lymphoma (IUR = 3.1×10^{-6}).

Potential unacceptable risks or hazards are shaded yellow. Although the cancer risk from an individual constituent may be within USEPA acceptable risk range of 10-4 to 10-6, the constituent contributes a cancer risk greater than 10-6 to a cumulative cancer risk above 10-4. Although the HI from an individual constituent may not exceed 1, the constituent contributes a HI >0.1 to a target organ HI above 1.

TABLE 5
Risk Management Considerations

Risk Driver	Risk Management Consideration		Detection[1]			MCL	Frequency of Exceedance	Background			
			Frequency	Min	Max			UTL	Frequency of Exceedance	Min	Max
Dibenzofuran	– No CTE risks or hazards above USEPA's acceptable levels (Table 4). – Dibenzofuran was detected in one of five samples collected during the 1998 SI. – Dibenzofuran was not analyzed for during the RI and SRI; however was not detected in 62 groundwater samples collected in January and September 2008.		1/5	28	28	NE	--	NE	--	--	--
Antimony	– RME and CTE HIs for antimony are below 1 (Table 4). Although antimony contributes a CTE HI slightly above 0.1 (HI = 0.16) to a target organ effect above 1 (blood HI = 1.3); thallium contributes an individual HI above 1 (HI = 1.1) to the total target organ effect. – Concentrations of total and dissolved antimony are below the MCL. – Concentrations of dissolved antimony are below background.	Total	5/36	4.9	5.1	6	0/5	ND	5/5	ND	ND
		Dissolved	1/36	4.9	4.9	6	0/1	49	0/1	2.7	31.6
Arsenic	– No discernable plume of arsenic concentrations above the MCL. – Concentrations are within range of detected background concentrations. – Reducing conditions indicated by low dissolved oxygen and negative oxidation reduction potential may have increased the mobility of naturally occurring arsenic.	Total	23/36	1.4 K	27.6	10	6/23	4	12/23	3.9	105
		Dissolved	27/36	1.4 J	25.2	10	4/27	4	11/27	5.4	78
Chromium[2]	– Concentrations are generally similar to or below background. – Concentrations of total and dissolved chromium are below the MCL. – Chromium identified as a potential COC based on comparison of measured total chromium concentrations to hexavalent chromium, the more toxic form of chromium, screening levels. – When calculated, carcinogenic risks for chromium assume all of the detected chromium (measured as total chromium) is in the more toxic hexavalent form of chromium.	Total	9/36	0.7 J	29.9	100	0/9	4.1	3/9	1.1	18.9
		Dissolved	12/36	0.47 J	11.7	100	0/12	2.1	3/12	1.3	2.2
Cobalt[2]	– Concentrations are generally similar to or below background. – The non-cancer hazard and risk-based screening level for cobalt is based on a 2008 non-cancer reference dose (RfD) from the Provisional Peer Reviewed Toxicity Value (PPRTV) database. Confidence in the study used to drive the PPRTV RfD was low to medium, and confidence in the provisional RfD was low (Provisional Peer Reviewed Toxicity Values for Cobalt, Superfund Health Risk Technical Support Center, National Center for Environmental Assessment, Office of Research and Development, USEPA, August 25, 2008).	Total	23/36	0.19 J	23.1	NE	--	2.6	5/23	0.95	21.5
		Dissolved	22/36	0.14 J	22.8	NE	--	1.9	6/21	1.2	55.9

TABLE 5
Risk Management Considerations

Risk Driver	Risk Management Consideration		Detection[1]			MCL	Frequency of Exceedance	Background			
			Frequency	Min	Max			UTL	Frequency of Exceedance	Min	Max
Iron	– No CTE risks or hazards above USEPA's acceptable levels (Table 4). – Concentrations are generally similar to background. – Iron is an essential human nutrient. – The estimated RME intake of iron via incidental ingestion of groundwater (0.98 milligrams per kilogram-day) falls within the recommended daily allowance (RDA) range for children ages 6 months to 10 years (0.36–1.11 mg/kg-day) (USEPA, 1999).	Total	34/36	248	35,500	NE	--	11,200	5/34	303	70,800
		Dissolved	30/36	120 J	30,400	NE	--	17,100	3/30	24.9	43,600
Manganese	– No CTE risks or hazards above USEPA's acceptable levels (Table 4). – Concentrations are below background. – Manganese is an essential human nutrient. – The estimated RME child resident daily intake rate is 0.029 mg/kg-day, which corresponds to an intake of 0.44 mg/day lower than the recommended daily allowance for a child 1 to 3 years [1.2 mg/day (Institute of Medicine, 2005)].	Total	31/36	26	1,020	NE	--	1,500	0/31	16.3	1,910
		Dissolved	32/36	23 J	1,200 J	NE	--	1,510	0/32	17.2	1,930
Thallium	– The RME non-cancer HIs are 1.9 and 4.5 for ingestion by future adult and child residents, respectively. There are no CTE hazards for future adult residents. The CTE non-cancer HI of 1.1 for the future child resident is only slightly above USEPA's target HI of 1. – Thallium has not been detected in 46 groundwater samples collected in January 2007, September 2007, January 2008, and September 2008.	Total	6/36	2.5 J	5.5 J	2	6/6	2.5	3/6	4.4	18.4
		Dissolved	6/36	2.5	9 J	2	6/6	4	3/6	3	9.7

Notes:

All concentrations shown in µg/L.

J – Analyte present. Reported value is estimated.

K – Analyte present. Reported value may be biased high.

ND – not detected

NE – not established

[1] Samples collected as part of SI, RI, and SRI.

[2] Constituents identified as COPCs based upon comparison of maximum detected concentrations from SI, RI, and SRI groundwater samples to May 2014 tap-water RSLs. Associated risks were not calculated.

upon groundwater VOC data collected in August 2014, maximum detected concentrations of TCE and vinyl chloride (**Table 3**) have decreased to concentrations generally similar to the calculated 95 percent UCL values (TCE = 3.8 μg/L; vinyl chloride = 11 μg/L) used in the risk assessment.

2.7.2 Ecological Risk Summary

An ERA (Steps 1 through 7 of the ERA process) was completed to evaluate **potential risks**[20] to **plants and animals ("ecological receptors")**[21] through direct exposure to surface soil, groundwater (discharged to surface water), sediment, and surface water; and exposure via the food web. Potential risks to aquatic and wildlife receptors were evaluated using maximum exposure scenarios, and subsequently refined using average media concentrations. The average concentration estimates provide a representative estimate of exposures and risks to receptor populations (the focus of the assessment endpoints) rather than individual organisms. Facility-specific sediment reference samples were also considered, as was bioavailability, or the degree to which a chemical in an environmental medium can be assimilated by an organism, and existing benthic invertebrate [organisms without a backbone living on or in the bottom sediments of a water body (i.e., clams and polychaete worms)] community conditions.

Potential unacceptable ecological risks are identified as HQs greater than or equal to 1. HQs are calculated by dividing the estimated exposure concentration by the corresponding medium-specific screening toxicity value (direct exposure) or by dividing the exposure dose by the corresponding ingestion toxicity value (food web exposure). Based on the ERA, potential risks were identified for aquatic receptors (benthic invertebrate community) exposed to surface sediments at SWMU 3.

Food Web Exposure

Wildlife Receptors

As part of the 2004 RI, food web modeling was conducted to evaluate potential risks to wildlife. Modeled food web exposure estimates (dietary doses) were compared to No Observed Adverse Effects Level (the highest level that did not result in toxic effects) and Lowest Observed Adverse Effects Level (LOAEL, the lowest concentration that resulted in toxic effects) ingestion toxicity values. Terrestrial and semi-aquatic mammalian and avian species were evaluated as potential receptors for this pathway. Potentially unacceptable risks to avian terrestrial omnivores (American robin) and avian terrestrial carnivores (American kestrel) were identified due to zinc in surface soil (LOAEL-based HQs of 1.16 and 1.21, respectively). Potentially unacceptable risks to avian piscivores (great blue heron) due to mercury in surface sediments were also identified (LOAEL-based HQ of 2.85).

Although risks above regulatory target levels were identified for soil, the terrestrial portions of SWMU 3 are highly developed, resulting in low habitat quality (pavement, asphalt, or hard-packed dirt with sparse herbaceous plants) and a lack of significant exposure pathways for terrestrial ecological receptors. Therefore, the Navy and USEPA, in consultation with VDEQ, agreed that no action is warranted to address terrestrial food-web exposures.

Although risks above regulatory target levels were identified for sediment, the shoreline at SWMU 3 consists of bulkheads and rip-rap, resulting in little, if any, available foraging habitat for species like the great blue heron, which forages in shallow water areas such as vegetated wetlands. Potential risks for the other evaluated semi-aquatic avian receptor (osprey, which forages in deeper waters) were not above regulatory target levels. Therefore, the Navy and USEPA, in consultation with VDEQ, agreed that no action is warranted to address aquatic food-web exposures.

Direct Exposure Assessment

Terrestrial Receptors

Terrestrial plants, small mammals, and soil invertebrates (i.e., earthworms) could potentially be exposed to constituents in SWMU 3 surface soil under a worst-case scenario. Based on a comparison to literature-based soil screening values and facility-specific background concentrations, potential risks (HQs > 1) were identified for seven metals (chromium, copper, iron, lead, mercury, nickel, and zinc) from exposure to surface soils at the site.

Although risks above regulatory target levels were identified for soil, the terrestrial portions of SWMU 3 are highly developed, resulting in low habitat quality (pavement, asphalt, or hard-packed dirt with sparse herbaceous plants) and a lack of significant exposure pathways for terrestrial ecological receptors. Therefore, the Navy and USEPA, in consultation with VDEQ, agreed that no action is warranted to address terrestrial receptor exposures to soil.

Aquatic Receptors

Several pathways were identified by which aquatic life could be exposed to contaminants in Little Creek Harbor. Water-column-dwelling aquatic life could be exposed to constituents in surface water from surface runoff and following the discharge of contaminated groundwater to surface water. Benthic invertebrates can be exposed to contaminants in bulk sediment and/or sediment pore water through direct contact and/or ingestion. Pore water data were not collected as part of SWMU 3 investigation activities; therefore, only direct contact with sediment was evaluated. Based on habitat and salinity, amphibians and reptiles are not expected to be significant receptors at the site; therefore, this exposure pathway was not evaluated.

The benthic invertebrate community found in Little Creek Harbor is generally typical of what is expected for this geographical area and type of habitat (urban harbor). The dominant organisms (polychaete worms) are generally characterized as tolerant of pollutants and low dissolved oxygen, and are surface dwellers, inhabiting the sediment/water interface. Deeper-dwelling organisms are generally rare to absent, likely the result of low oxygen conditions observed at depths more than a few centimeters below the sediment surface.

Potentially unacceptable risks (defined as a mean HQ greater than or equal to 1) to benthic invertebrates from direct exposure to surface sediment in Little Creek Harbor were identified for copper, lead, mercury, nickel, tin, zinc, and polycyclic aromatic hydrocarbons (PAHs) (**Table 6**). In general, sediment concentrations and, subsequently, potential risks, were highest in the near shore areas**.** With the exception of mercury, ABM content in sediment was significantly correlated with concentrations of the metal COPCs in surface sediment and was a good indicator of impacts from historic sandblasting activities.

Although mercury is commonly used as an anti-fouling agent in marine paints, mercury concentrations detected in sediment do not correlate with ABM content, and concentrations potentially posing risk were spatially limited (detected in exceedance of 1 part per million in 2 of 46 samples). Additionally, PAHs were detected in sediment across the site at concentrations potentially contributing to risk above regulatory target levels; however, these are not associated with historical sandblasting activities and are not considered to be a result of a SWMU 3 CERCLA-regulated release. Therefore, the Navy and USEPA, in consultation with VDEQ, agreed that potential ecological risks associated with mercury and PAHs in sediment were not unacceptable and no action is warranted to address mercury and PAHs in sediment under CERCLA.

Sediment Removal Actions

A NTCRA and a TCRA were completed to mitigate potential ecological risks associated with benthic invertebrate exposure to site COCs (copper, lead, nickel, tin, and zinc) in sediment at SWMU 3. Surface sediment data collected as part of the 2010 benthic invertebrate investigation were used to define the lateral extent of remediation required to mitigate potentially unacceptable ecological risks at SWMU 3. Prior to conducting the removal actions, pre-removal action sediment sampling was conducted to define the final vertical extent of remediation required to mitigate potentially unacceptable ecological risks at SWMU 3. Sediment data were compared to site-specific PRGs (**Table 7**) and the remediation area was defined as described in **Table 1** and presented on **Figure 8**.

Non-Time Critical Removal Action

A NTCRA was completed from February 2013 to May 2013 to address sediment surrounding the dry dock and anchoring system. Approximately 12,600 cubic yards of sediment were dredged from the NTCRA area, as presented on **Figure 9**. Dredged material was transported via barge to Port Weanack, where it was solidified and

TABLE 6
Summary Statistics - SWMU 3 Surface Sediment - Pre-2010 Samples

Chemical	Frequency of Detection	Maximum Concentration Detected	Arithmetic Mean	95% UCL (Normal)	Sediment Screening Value	Frequency of Exceedance	Maximum Hazard Quotient	95% UCL Hazard Quotient	Mean Hazard Quotient
All Samples									
Metals (mg/kg)									
Copper	46 / 46	3,310	491	652	34.0	44 / 46	97.4	19.2	14.5
Lead	46 / 46	2,430	315	434	46.7	42 / 46	52.0	9.29	6.75
Mercury	41 / 46	1.80	0.42	0.51	0.15	36 / 46	12.0	3.38	2.82
Nickel	46 / 46	866	87.1	132	20.9	39 / 46	41.4	6.30	4.17
Tin	37 / 42	642	56.1	86.0	3.40	35 / 42	189	25.3	16.5
Zinc	46 / 46	19,200	1,447	2,215	150	44 / 46	128	14.8	9.65
PAHs (µg/kg)									
Total PAHs	28 / 30	48,319	9,190	--	4,022	22 / 30	12.0	--	2.29
Near-Shore									
Metals (mg/kg)									
Copper	13 / 13	3,310	1,099	1,580	34.0	12 / 13	97.4	46.5	32.3
Lead	13 / 13	2,430	783	1,134	46.7	11 / 13	52.0	24.3	16.8
Mercury	9 / 13	0.55	0.23	0.32	0.15	6 / 13	3.67	2.17	1.55
Nickel	13 / 13	866	235	381	20.9	11 / 13	41.4	18.2	11.2
Tin	8 / 9	642	197	318	3.40	8 / 9	189	93.6	58.1
Zinc	13 / 13	19,200	3,788	6,381	150	12 / 13	128	42.5	25.3
PAHs (µg/kg)									
Total PAHs	9 / 11	48,319	9,620	--	4,022	6 / 11	12.0	--	2.39
Off-Shore									
Metals (mg/kg)									
Copper	25 / 25	776	264	320	34.0	25 / 25	22.8	9.41	7.77
Lead	25 / 25	499	138	173	46.7	24 / 25	10.7	3.71	2.96
Mercury	25 / 25	1.80	0.55	0.67	0.15	24 / 25	12.0	4.49	3.64
Nickel	25 / 25	82.9	30.2	35.2	20.9	23 / 25	3.97	1.68	1.44
Tin	21 / 25	99.5	18.4	25.6	3.40	20 / 25	29.3	7.53	5.42
Zinc	25 / 25	1,710	551	678	150	25 / 25	11.4	4.52	3.67
PAHs (µg/kg)									
Total PAHs	13 / 13	16,319	9,443	--	4,022	12 / 13	4.06	--	2.35
Marina									
Metals (mg/kg)									
Copper	8 / 8	362	215	298	34.0	7 / 8	10.6	8.76	6.32
Lead	8 / 8	226	108	161	46.7	7 / 8	4.84	3.44	2.32
Mercury	7 / 8	0.77	0.35	0.53	0.15	6 / 8	5.13	3.51	2.30
Nickel	8 / 8	61.8	24.8	36.5	20.9	5 / 8	2.96	1.75	1.19
Tin	8 / 8	46.0	14.6	23.5	3.40	7 / 8	13.5	6.91	4.30
Zinc	8 / 8	952	443	615	150	7 / 8	6.35	4.10	2.95
PAHs (µg/kg)									
Total PAHs	6 / 6	13,817	7,855	--	4,022	4 / 6	3.44	--	1.95

µg/kg – micrograms per kilogram

offloaded for transport and disposal in Waste Management's Charles City Landfill. Prior to and immediately following NTCRA dredging activities, **surveys**[22] of the sediment surface elevation were conducted to confirm that required dredge depths were achieved. Following successful completion of dredging, a minimum of 6 inches of clean sand was placed across the removal action area to address any residual contamination that may remain. Post-sand placement sediment cores were collected and a final survey of the sediment surface elevation was conducted to ensure adequate sand placement. Because pre-removal action sampling defined the area requiring action to mitigate potential ecological risk at SWMU 3 and pre- and post-dredge bathymetric surveys confirmed successful removal of all contaminated sediment, no post-dredge confirmation sampling was required.

TABLE 7
Sediment Preliminary Remediation Goals

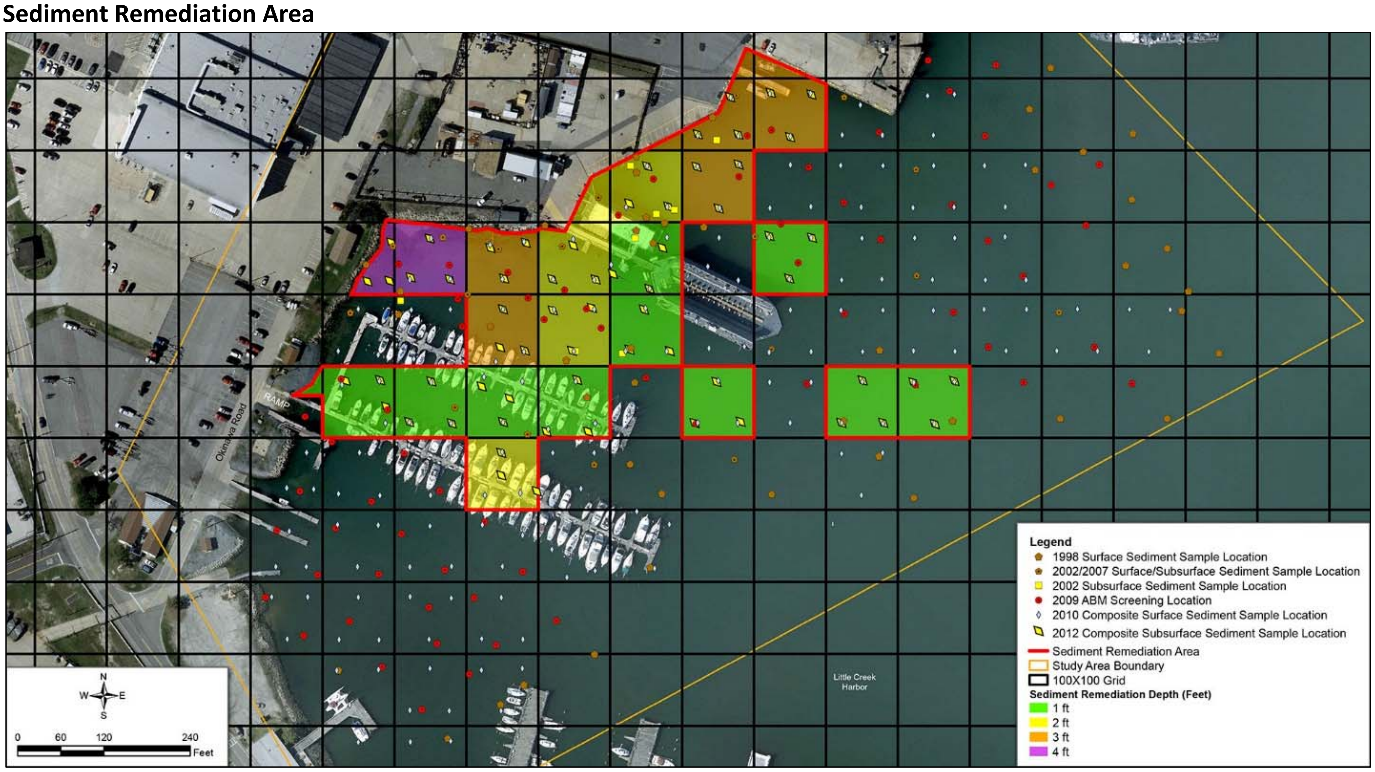
	Copper	Lead	Nickel	Tin	Zinc
Threshold Effects Level	18.7	30.2	15.9	NA	124
Effects Range-Low	34.0	46.7	20.9	NA	150
Probable Effects Level	108	112	42.8	NA	271
Mean Background	155	45.2	23.2	8.61	290
Max. Background	184	67.6	26.5	9.80	421
1% ABM	232	107	26.2	11.2	454
Effects Range-Median	270	218	51.6	NA	410

Shaded cells indicate the selected cleanup goal. All values in mg/kg.
NA – Not Applicable

Time-Critical Removal Action

A TCRA was completed from November 2013 to March 2014 to address remaining sediment within the SWMU 3 remediation area. As part of the TCRA, the near-shore sediments adjacent to the rip-rap shoreline were dredged (**Figure 9**). Excavated material was dewatered, solidified and transported to Southeastern Public Service Authority Landfill for disposal. Immediately following sediment excavation activities, **post-excavation field surveys**[23] were completed to confirm that the required removal depths were achieved. Following successful completion of dredging, the site was restored through placement of a minimum of 2 feet of clean sand and reconstruction of the shoreline embankment. Following sand placement a final field survey was completed to ensure adequate sand

FIGURE 8
Sediment Remediation Area

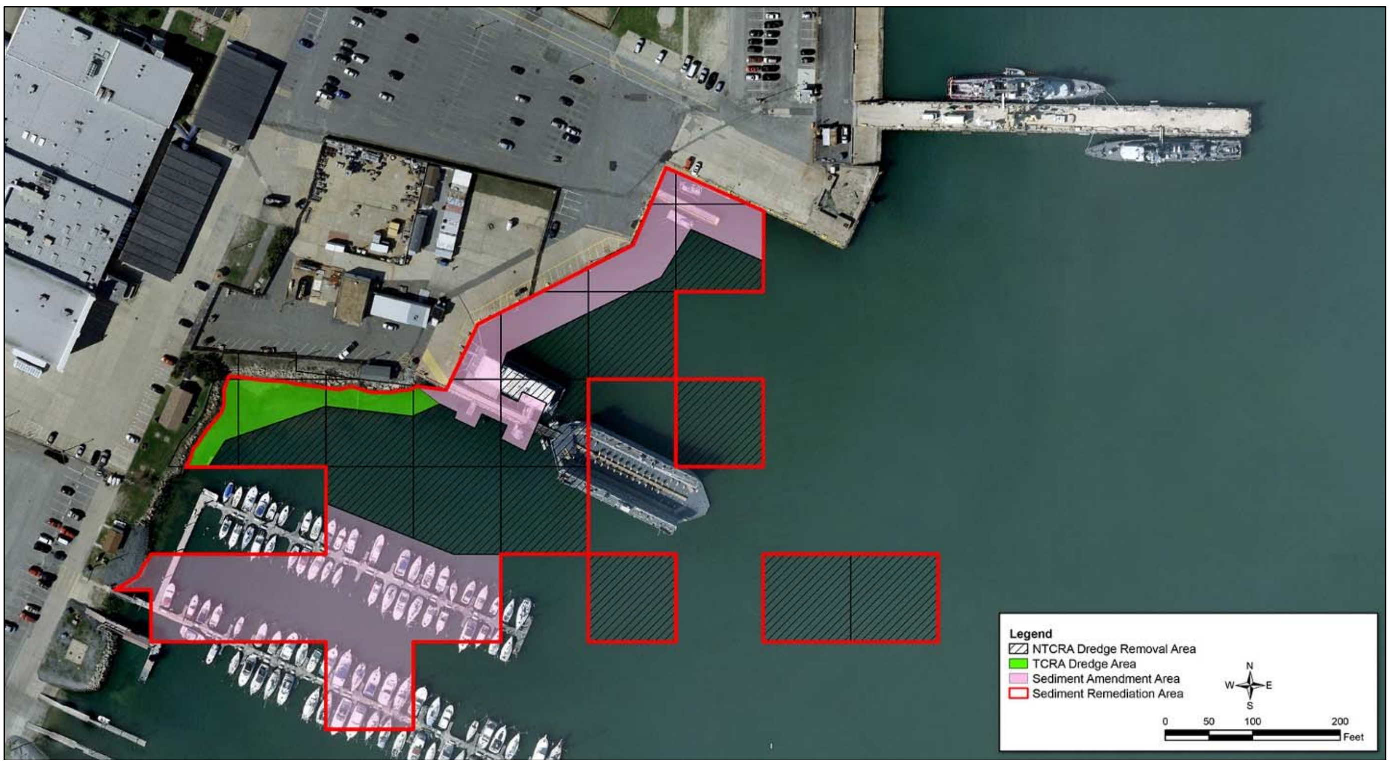


placement. Because pre-removal action sampling defined the area requiring action to mitigate potential ecological risk at SWMU 3 and post-excavation field surveys confirmed successful removal of all contaminated sediment, no post-excavation confirmation sampling was required.

Within the remaining sediment remedial action area, a reactive amendment (AquaGate+PAC) was placed to address potential risks associated with metal COCs in sediment. Post-reactive amendment placement **sediment core collection**[24] was completed to ensure adequate placement. The Navy and USEPA, in consultation with VDEQ, agreed that the ecological value associated with excavation by dredging of contaminated sediment to the extent feasible during the NTCRA and TCRA, coupled with the placement of the reactive amendment, compensate for and effectively mitigate any potential ecological risks remaining at the site. Therefore, no post-amendment monitoring is required. Successful removal of contaminated sediment, placement of reactive amendment, and risk mitigation is documented in the NTCRA Construction Summary memorandum and TCRA CCR.

Based on the results of the ERA and completion of the NTCRA and TRCA, which reduced potentially unacceptable ecological risks attributable to SWMU 3, the Navy and USEPA, in consultation with VDEQ, agreed no further action is required for sediment to ensure protection of the environment.

FIGURE 9
Sediment Removal Action Areas



2.8 Basis for Response Action

Based on the results of the August 2014 revised HHRA, exposure to TCE and vinyl chloride in shallow aquifer groundwater at SWMU 3 poses an unacceptable risk to human health (**Table 4**). Maximum concentrations of COCs are presented in **Table 3**. The selected remedy identified in this ROD is necessary to protect public health, welfare, or the environment from actual or threatened releases of hazardous substances into the environment.

2.9 Principal Threat Wastes

Principal threat wastes are source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should they be exposed. Although no "threshold level" of risk has been established to identify principal threat wastes, a general guideline is to consider principal threats to be those source materials with toxicity and mobility characteristics that combine to pose a potential risk several orders of magnitude greater than the risk level acceptable for the current or reasonably anticipated future land use, given realistic exposure scenarios. There is no principal threat waste at SWMU 3. Dissolved VOC concentrations are present in groundwater; however, contaminated groundwater is generally not considered a source material. The presence of dense non-aqueous phase liquids (DNAPLs) could represent a principal threat waste if present; however DNAPLs have not been identified at SWMU 3. Additionally, no soil source of VOCs to groundwater has been identified at the site. Currently groundwater is not used as a potable water supply. Exposure to groundwater from construction activities does not pose potentially unacceptable risk to human health. Based upon the absence of identified DNAPL and a lack of exposure, principal threat wastes are not present at SWMU 3. Previous removal actions resulted in the removal of low-level threat waste from soil and sediment.

2.10 Remedial Action Objectives

The site-specific RAOs have been established as:

- Prevent potable use of groundwater and exposure to groundwater emissions via vapor intrusion until concentrations of COCs allow for unlimited use and unrestricted exposure.
- Monitor the natural attenuation of groundwater COCs until concentrations allow for unlimited use and unrestricted exposure.

Cleanup levels have been established for constituents with concentrations contributing to unacceptable risks and hazards from exposure to shallow aquifer groundwater within SWMU 3. The cleanup levels were developed from the **PRGs**[25], which were established in the Focused FS as the MCLs after consideration of the total risks/hazards associated with their use. Cleanup levels for the SWMU 3 COCs are as follows:

- TCE: 5 µg/L
- Vinyl chloride: 2 µg/L

The Navy acknowledges the Commonwealth of Virginia's and USEPA's expectation to return groundwaters to their beneficial uses wherever practicable. Therefore, although not identified as site-specific COCs requiring action, the degradation of TCE may result in temporary increases to the concentrations of daughter products cis-1,2-DCE and trans-1,2-DCE above their respective MCLs. RAOs cannot be met if these constituents are above their MCLs. As a result, cis-1,2-DCE and trans-1,2-DCE will be monitored during remedy implementation to ensure concentrations remain below their respective MCLs. The breakdown product MCLs are as follows:

- cis-1,2-DCE: 70 µg/L
- trans-1,2-DCE: 100 µg/L

2.11 Description and Comparative Analysis of Remedial Alternatives

The Focused FS details the development and evaluation of the following remedial alternatives for SWMU 3:

- Alternative 1 – No Action
- Alternative 2 – MNA and LUCs

Table 8 provides the major components, details, and **cost**[26] of each remedial alternative identified for SWMU 3. Alternative 1 is the No Action alternative and serves as the baseline for comparison of other alternatives. Under this alternative, no additional effort or resources would be utilized at SWMU 3. The NCP identifies nine evaluation criteria for use in a comparative analysis of the remedial alternatives. Each remedial alternative for SWMU 3 was evaluated against these criteria in the Focused FS. Definition of the nine evaluation criteria and a comparative analysis of each alternative are summarized in **Table 9**.

TABLE 8
Description of Remedial Alternatives

Alternative	Components	Details	Cost[1]	
1 – No Action	None	None	Capital Cost	$0
			Annual O&M	$0
			Total O&M	$0
			Present-Worth	$0
			Time Frame	Indefinite
			Discount Rate	N/A
2 – MNA and LUCs	MNA	Natural attenuation processes to reduce sitewide concentrations of VOCs in groundwater. Annual groundwater monitoring for select VOCs and natural attenuation indicator parameters to evaluate trends over time and progress towards meeting the cleanup levels.	Capital Cost	$48,800
			Annual O&M	$26,900
			Total O&M	$321,130
			Present-Worth	$370,000 (-30%/+50%: $259,000/$555,000)
	LUCs	LUCs to prohibit aquifer use and to require evaluation of vapor intrusion if future changes in building or land use occur or for new construction. Annual site inspections to ensure compliance with LUCs.	Time Frame	15 years
			Discount Rate	3.0%

[1] The cost information provided is based on best available information regarding the scope of the remedial alternative. Changes in the cost elements may occur as a result of new information and data collected during the remedial design and/or changes in uncertain market conditions such as, but not limited to: local labor or contractor availability, wages, other work, material market fluctuations, price escalations, force majeure events, and developing bidding conditions. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Difference, or a ROD Amendment. The Present-Worth cost is an order of magnitude cost estimate and is expected to be within -30%/+50% of the final remedy cost.

2.12 Selected Remedy

Based on the comparative analysis, the selected remedy to address VOCs in groundwater is Alternative 2, MNA and LUCs. Based on the evaluation of the data and information currently available, the Navy and USEPA, in consultation with VDEQ, has concluded the selected remedy meets the threshold criteria and provides the best balance of tradeoffs with respect to the balancing and modifying criteria. Alternative 1, No Action does not meet the RAOs, as it does not provide for future protection against exposure to groundwater.

Alternative 2 consists of MNA of COCs in groundwater and the implementation of LUCs to prevent unlimited use and unrestricted exposure to groundwater while concentrations remain above cleanup levels. Natural attenuation refers to the reliance on natural processes to achieve cleanup levels. Natural attenuation processes include a combination of physical, chemical, or biological processes that under favorable conditions act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater.

The primary natural attenuation mechanisms at SWMU 3 are advection with groundwater flow and discharge to Little Creek Harbor and dispersion through tidal influx. A secondary natural attenuation mechanism at SWMU 3 is degradation through natural processes. As discussed in Section 2.7.1 and 2.7.2, an evaluation of human health and ecological risks associated with groundwater discharge to surface water concluded that the discharge of groundwater to surface water does not pose an unacceptable incremental increase in risks from exposure to surface water in Little Creek Harbor. A discussion of natural attenuation processes taking place at SWMU 3 is presented in Section 2.5. COCs are expected to reach cleanup levels in **approximately 15 years**[27].

Long-term reduction in COC concentrations will be monitored as part of a long-term monitoring plan designed to evaluate the achievement of RAOs over time, determine continued remedy effectiveness and protectiveness, and assess site exit strategies. Based on current site conditions it is assumed that no new monitoring wells are required. Eight existing monitoring wells will be included in the long-term monitoring plans. It is assumed annual monitoring for select VOCs and groundwater geochemistry will be conducted. The final long-term monitoring plan will be developed following signature of the ROD. Because contaminants will remain onsite following remedy implementation, the need for additional action to achieve the cleanup levels will be evaluated and documented during CERCLA Five-Year Reviews.

Throughout operation of the remedy, the Navy will implement LUCs to prevent exposure to groundwater and groundwater emissions that may result in unacceptable risks to human health. LUCs will be implemented within the LUC boundary (**Figure 10**) until site conditions allow for unlimited use and unrestricted exposure.

The surficial aquifer groundwater LUCs will meet the following objectives:

- Prohibit the withdrawal of groundwater for anything other than environmental monitoring.
- Prohibit changes from current building uses or construction of new buildings without further evaluation of potential vapor intrusion risks and/or implementation of mitigation measures
- Prohibit the use of the site for child care, elementary or secondary school, or playground facilities; and
- Maintain the integrity of any current or future remedial or monitoring system.

The Navy will develop and submit to USEPA and VDEQ, in accordance with the FFA and the schedule in the Site Management Plan, a LUC Remedial Design. The LUC Remedial Design 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 Remedial Design.

Although the Navy may transfer these responsibilities to another party by contract, property transfer agreement, or through other means, the Navy shall remain ultimately responsible for remedy integrity. The Navy shall: 1) perform CERCLA Section 121(c) Five-Year Reviews; 2) notify the appropriate regulators and/or local government representatives of any known LUC deficiencies or violations; 3) provide access to the property to conduct any necessary response; 4) retain the ability to change, modify, or terminate LUCs and any related deed or lease provisions; and, 5) ensure that the LUC objectives are met to maintain remedy protectiveness.

FIGURE 10
Conceptual Remedy Layout

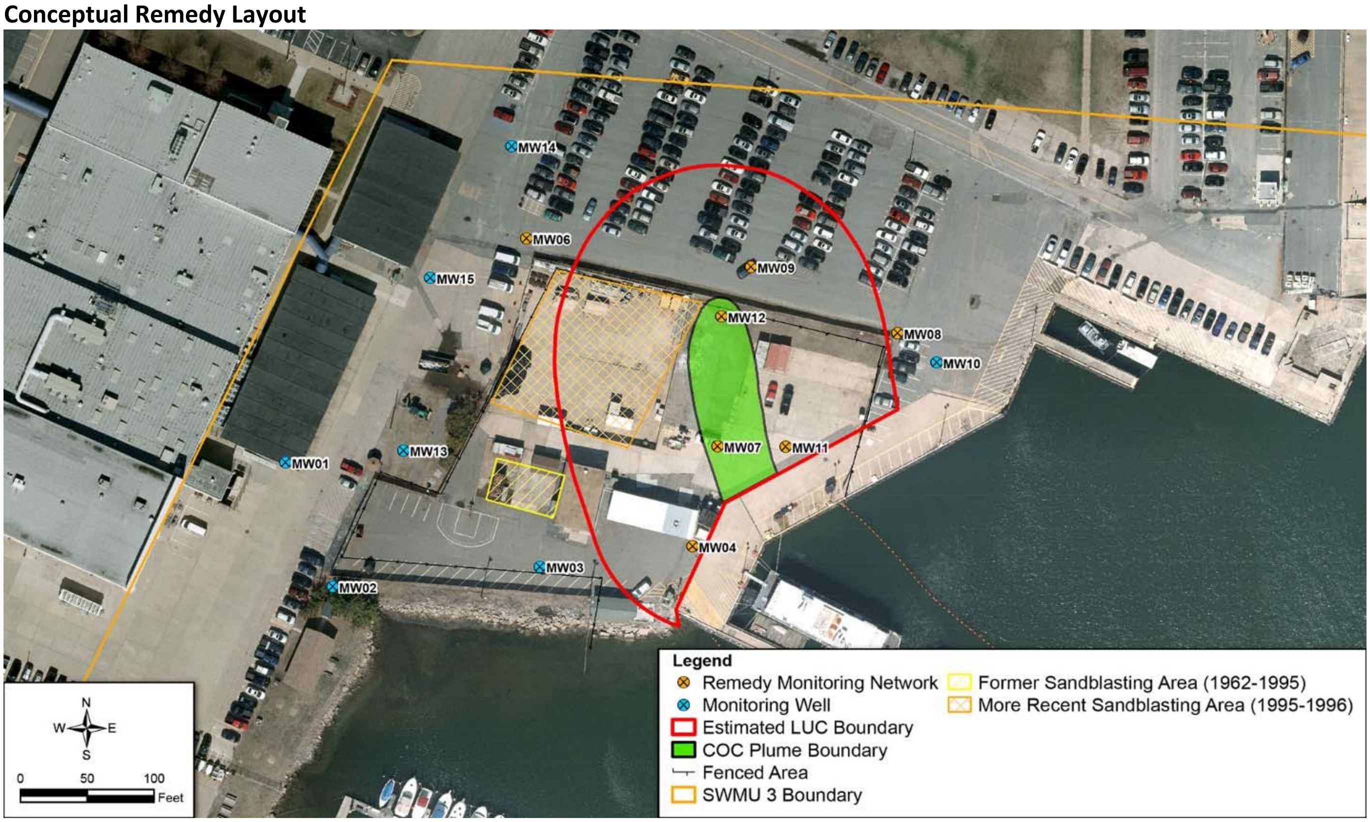


TABLE 9
Comparative Analysis of Alternatives

NCP Criteria	Definition	Comparative Analysis	
		Alternative 1 – No Action	Alternative 2 – Land Use Controls
Threshold Criteria			
Protection of Human Health and the Environment	Addresses whether a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through mitigation, engineering controls, or institutional controls.	*Not Effective* - Does not meet the RAOs and does not provide protection against future human exposure to VOCs in groundwater.	*Effective* - Meets the RAOs and is protective of human health and the environment. Site COCs naturally attenuate over time from natural processes and LUCs prevent potential unacceptable risk to human health from exposure to VOCs in groundwater until concentrations allow for unlimited use and unrestricted exposure.
Compliance with applicable and relevant and appropriate requirements (ARARs)	Addresses whether a remedy will meet all of the ARARs of other Federal and State environmental laws and/or justifies a waiver of the requirements.	*Does not comply* – No monitoring will be conducted to evaluate whether chemical-specific ARARs are met.	*Complies* – Site COCs will naturally attenuate to below chemical-specific ARARs; LUCs will be in place until the RAOs are achieved, and periodic monitoring will be conducted to evaluate whether chemical-specific ARARs are met.
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Addresses the expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up goals have been met.	*Not Effective* - All future risks would remain.	*Effective* - Prevents unacceptable exposures over the long-term through site use restrictions and achieves long-term effectiveness and permanence through the natural attenuation of site COCs.
Reduction in Toxicity, Mobility, and Volume Through Treatment	Discusses the anticipated performance of the treatment technologies a remedy may employ.	*Not Effective* - No Reduction in toxicity, mobility, or volume through treatment because no treatment technologies would be employed.	*Not Effective* - No Reduction in toxicity, mobility, or volume through treatment because no treatment technologies would be employed, relying instead on natural attenuation processes to remediate groundwater.
Short-Term Effectiveness	Considers the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until clean-up goals are achieved.	*Effective* - No short-term risks to the community or to workers would occur as a result of implementing the action.	*Effective* – Limited short-term risks to the community or to workers resulting from travel to and from the site to conduct periodic groundwater monitoring.
Implementability	Evaluates the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement an option.	*Easy* – Implementable but agency and community acceptance are unlikely.	*Easy* - Readily implementable; requires implementation, monitoring, and communication of land use controls.
Cost	Compares the estimated initial, operations and maintenance, and present-worth costs.	$0	$370,000 (-30 percent = $259,000; +50 percent = $555,000)
Modifying Criteria			
State Acceptance	State involvement has been solicited throughout the CERCLA and remedy selection process. VDEQ, as the designated State support agency in Virginia, has reviewed this ROD and has given concurrence on the selected remedy.		
Community Acceptance	A public meeting was held on November 18, 2014 at 7:00 pm to present the Proposed Plan and answer community questions regarding the proposed remedial action at SWMU 3. Detailed information regarding the public meeting is provided in the Responsiveness Summary (Section 3) of this ROD.		

2.12.1 Expected Outcome of the Selected Remedy

Current land uses at SWMU 3 are expected to continue, and there are no other planned land uses in the foreseeable future. Exposure to groundwater will be controlled through LUCs until it is demonstrated that site conditions are suitable for unlimited use and unrestricted exposure. **Table 10** identifies the unacceptable human health risks for groundwater, the RAOs established to address the unacceptable risks, the remedy component that will be implemented to achieve the RAO, what metrics will be used to confirm the RAOs are met, and the expected outcome from implementation of the remedy components.

TABLE 10
Expected Outcome

Risk	RAO	Remedy Component	Metric	Expected Outcome
Future resident exposure to COCs in groundwater	Monitor the natural attenuation of groundwater COCs until concentrations allow for unlimited use and unrestricted exposure.	MNA	Implement until each groundwater COC is at or below its respective cleanup level for three consecutive monitoring events.	UU/UE
	Prevent potable use of groundwater and exposure to groundwater emissions until concentrations of COCs allow for unlimited use and unrestricted exposure.	LUCs	Maintain until each groundwater COC is at or below its respective cleanup level for three consecutive monitoring events.	

2.12.2 Statutory Determinations

In accordance with the NCP, the selected remedy, if implemented, meets the following statutory requirements:

Protection of Human Health and the Environment—The selected remedy will protect human health and the environment from exposure to VOCs in groundwater through LUCs restricting the use of and exposure to shallow groundwater and groundwater emissions until natural attenuation reduces concentrations of COCs to levels that allow for unrestricted use and unlimited exposure.

Compliance with ARARs—The selected remedy will meet all identified federal and state **ARARs**[28] for SWMU 3, presented in **Appendix A**. The classification of ARARs identified includes chemical-specific, location-specific, and action-specific requirements.

Cost-Effectiveness—The selected remedy provides the most reasonable value relative to the cost. The costs are proportional to overall effectiveness in comparison to other alternatives (e.g., similar benefit at lower cost).

Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable—The Navy and USEPA in consultation with VDEQ, determined the Selected Remedy for SWMU 3 represents the maximum extent to which permanent solutions and treatment technologies can be used in a practicable manner.

Preference for Treatment as a Principal Element—While the Selected Remedy does not satisfy the statutory preference for treatment as a principal element, MNA is expected to be successful in attaining cleanup levels throughout the plume and the RAOs for groundwater-based contaminant trends over time. Additionally, DNAPL has not been observed during groundwater sampling, concentrations of COCs indicating DNAPL have not been detected, and no source materials constituting principal threats are present.

Five-Year Review Requirements— The Selected Remedy will result in hazardous substances, pollutants, or contaminants remaining in site groundwater above levels that allow for unlimited use and unrestricted exposure. The Navy will maintain LUCs and conduct a statutory remedy review every 5 years after initiating remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. If the remedy is found not to be protective of human health and the environment because, for example, LUCs have failed, the Navy, USEPA, and VDEQ would evaluate additional remedial actions and the Navy may be required to undertake additional remedial action. Because no hazardous substances, pollutants, or contaminants remain in site soil, surface water, and sediment and no action is warranted for these media they will not be evaluated as part of SWMU 3 statutory remedy reviews.

2.13 Community Participation

The Navy and USEPA provide information regarding the environmental cleanup at JEB Little Creek to the public through the community relations program, which includes a Restoration Advisory Board, public meetings, the Administrative Record file for SWMU 3, and announcements published in *The Virginian-Pilot* newspaper. During the course of investigations at SWMU 3, the Restoration Advisory Board has been apprised of all environmental activities related to the site. To date, public participation activities for SWMU 3 have included public comment periods associated with completion of the NTCRA and TCRA.

In accordance with Sections 113 and 117(a) of CERCLA, the Navy provided a public comment period between October 25, 2014 and December 8, 2014, for the SWMU 3 Proposed Plan. A public meeting to present the Proposed Plan was held November 18, 2014. Public notice of the meeting and availability of documents was placed in *The Virginian-Pilot* newspaper on October 25, 2014.

The Proposed Plan was available during the public comment period at the Virginia Beach Central Library. The final Proposed Plan and other documents associated with the environmental activities conducted at SWMU 3 are available to the public in the Administrative Record file for JEB Little Creek. Appointments to review the Administrative Record file can be made by contacting:

NAVFAC Atlantic
6506 Hampton Boulevard, Norfolk, VA 23508
Phone: 757.322.4785

Access to the Administrative Record file for the JEB Little Creek ERP is also available online at:

http://www.navfac.navy.mil/products_and_services/ev/products_and_services/env_restoration.html

3. Responsiveness Summary

The participants in the public meeting held on November 18, 2014 included representatives of the Navy, USEPA, and the VDEQ. Navy, USEPA, and VDEQ representatives were available at the public meeting to present the Proposed Plan for SWMU 3 and answer any questions regarding the Proposed Plan as well as any other documents in the Administrative Record file for JEB Little Creek. The Navy, USEPA, and VDEQ received no written comments, concerns, or questions during the public comment period. No one from the public attended the public meeting.

Appendix A
ARARs

Acronyms and Abbreviations

ARAR	Applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
PCE	Tetrachloroethene
SWMU	Solid Waste Management Unit
TBC	To Be considered
TCE	Trichloroethene
trans-1,2-DCE	trans-1,2-dichloroethene
USC	United States Code
VC	vinyl chloride

References

Commonwealth of Virginia, 2013. 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. EPA/540/G-89/009.

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

TABLE A-1
Federal Chemical-Specific ARARs
SWMU 3 ROD
Joint Expeditionary Base Little Creek
Virginia Beach, Virginia

Media	Requirement	Prerequisite	Citation	ARAR/TBC Determination	Comment
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 141.61(a)(1), (5), and (9)	Relevant and appropriate	The cleanup standard for each site-specific COC is as follows: TCE in groundwater is 5 µg/L cis-1,2-DCE in groundwater is 70 µg/L VC in groundwater is 2 µg/L

TABLE A-2

Virginia Chemical-Specific ARARs

SWMU 3 ROD
Joint Expeditionary Base Little Creek
Virginia Beach, Virginia

Media	Requirement	Prerequisite	Citation	ARAR/TBC Determination	Comment
No Virginia Chemical-Specific ARARs apply.					

TABLE A-3
Federal Location-Specific ARARs
SWMU 3 ROD
Joint Expeditionary Base Little Creek
Virginia Beach, Virginia

Location	Requirement	Prerequisite	Citation	ARAR/TBC Determination	Comment
Migratory Flyway					
Migratory bird area	Protects almost all species of native birds in the United States from unregulated taking.	Presence of migratory birds.	Migratory Bird Treaty Act;16 USC 703	Applicable	SWMU 3 is located in the Atlantic Migratory Flyway. If migratory birds, or their nests or eggs, are identified at SWMU 3, operations will not destroy the birds, nests or eggs.
Coastal Zone					
Coastal zone or area that will affect the coastal zone	Federal activities must be consistent with, to the maximum extent practicable, State coastal zone management programs. Federal agencies must comply with the consistency requirements of 15 CFR § 930.	Actions that may affect identified coastal zone resources or uses	15 CFR 930.33(a)(1), (a)(2), (b); .35(b); .36(a); 39(a), (b), and (d)	Applicable	Activities at SWMU 3 that will affect Virginia's coastal zone will be consistent to the maximum extent practicable with Virginia's enforceable policies. Activities performed on-site and in compliance with CERCLA are not subject to administrative review; however, the substantive requirements of making a consistency determination will be met.

TABLE A-4
Virginia Location-Specific ARARs
SWMU 3 ROD
Joint Expeditionary Base Little Creek
Virginia Beach, Virginia

Location	Requirement	Prerequisite	Citation	ARAR/TBC Determination	Comment
No Virginia Location-Specific ARARs apply.					

TABLE A-5
Federal Action-Specific ARARs
SWMU 3 ROD
Joint Expeditionary Base Little Creek
Virginia Beach, Virginia

Action	Requirement	Prerequisite	Citation	ARAR/TBC Determination	Comment
No Federal Action-Specific ARARs apply.					

TABLE A-6
Virginia Action-Specific ARARs
SWMU 3 ROD
Joint Expeditionary Base Little Creek
Virginia Beach, Virginia

Action	Requirement	Prerequisite	Citation	ARAR/TBC Determination	Comment
Waste Management					
Management of non-hazardous solid waste in containers	Establishes standards and procedures pertaining to the management of non-hazardous solid wastes in containers. Nonputrescible wastes must be stored in appropriate containers and not staged for more than 90 days.	Generation of non-hazardous solid waste that is managed onsite in containers.	9 VAC 20-81-95(D)(10)(b)	Applicable	It is anticipated that some wastes (such as purge water and decontamination fluids) may be generated and managed onsite in containers. Based on the analytical results from previous investigations, it is expected that these wastes will be non-hazardous solid waste. Wastes will be characterized prior to offsite disposal.
Accumulation of hazardous waste in containers onsite for less than 90 days	Hazardous waste may be accumulated on site in containers for up to 90 days so long as the containers are in good condition, compatible with the waste being stored, and labeled with the words “Hazardous Waste” and the date that accumulation began. The containers must also be kept closed unless adding or removing waste and inspected weekly.	Accumulation of hazardous waste in containers onsite.	9 VAC 20-60-262 only as it incorporates 40 CFR 262.34 (a)(1)(i), (2), (3), and 40 CFR 265.171 through 174	Applicable	It is possible that hazardous waste will be generated and staged onsite in containers for less than 90 days
Monitoring Well Construction and Maintenance					
Monitoring Well Installation and Abandonment	Establishes requirements for the installation and abandonment of observation and monitoring wells, governed jointly by the State Board of Health and Department of Environmental Quality.	Observation and monitoring wells must be properly installed and abandoned in accordance with Virginia regulations to prevent contamination from reaching groundwater resources via the well.	12 VAC 5-630-420(B) and (C); and 450(C)(1),(2),(4),(5), (7), (8), and (9)	Applicable	Monitoring wells will be installed and abandoned in accordance with the Virginia regulations.

Appendix B
Acronyms and Abbreviations

Acronyms and Abbreviations

µg/L	micrograms per liter
ABM	abrasive blast material
AM	Action Memorandum
AOC	area of concern
CCR	Construction Completion Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	contaminant of concern
COPC	contaminant of potential concern
CTE	central tendency exposure
DCA	dichloroethane
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
EE/CA	Engineering Evaluation and Cost Analysis
ERA	Ecological Risk Assessment
ERP	Environmental Restoration Program
FFA	Federal Facility Agreement
FS	Feasibility Study
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
JEB	Joint Expeditionary Base
LOAEL	Lowest Observed Adverse Effects Level
LUC	Land Use Control
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
MWR	morale, welfare, and recreation
NA	not applicable
NAB	Naval Amphibious Base
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NTCRA	Non-Time-Critical Removal Action
PAH	polycyclic aromatic hydrocarbon
PCE	tetrachloroethene
PRG	preliminary remediation goal
RAO	remedial action objective
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision

SI	Site Investigation
SRI	Supplemental Remedial Investigation
SVOC	semi-volatile organic compound
SWMU	Solid Waste Management Unit
TCE	trichloroethene
TCRA	Time-Critical Removal Action
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound
VPDES	Virginia Pollutant Discharge Elimination System

References

Item	Reference Phrase in ROD	Location in ROD	Identification of Referenced Document Available in the Administrative Record file
1	No potentially unacceptable human health risk	Table 1	CH2M HILL. 2005. Final Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 7, Table 7-4)
2	Potentially unacceptable ecological risks	Table 1	CH2M HILL. 2005. Final Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 8)
3	potentially unacceptable risks to human health	Table 1	CH2M HILL. 2009a. Final Supplemental Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 7, Tables 7-4 and 7-5)
4	good indicator of impacts from former sandblasting	Table 1	CH2M HILL. 2009a. Final Supplemental Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 8)
5	sediment preliminary remediation goals	Table 1	CH2M HILL, 2009b. Final Technical Memorandum Work Plan for Pre-Feasibility Study Sediment Sampling, SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. February.
6	did not identify potentially unacceptable risks	Table 1	CH2M HILL. 2012a. Final Technical Memorandum Risk Assessment Update – Evaluation of Future Potable Use of Groundwater and Groundwater Discharge to Surface Water at SWMU 3-Pier 10 Sandblast Yard. July.
7	metals concentrations in sediment may potentially result in unacceptable risks to ecological receptors	Table 1	CH2M HILL. 2012b. Final Technical Memorandum Benthic Invertebrate Evaluation, SWMU 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. December. (Sections 5 and 6)
8	evaluate non-time-critical removal action (NTCRA) alternatives	Table 1	CH2M HILL. 2012c. Final Engineering Evaluation/Cost Analysis for SWMU 3 – Pier 10 Sandblast Yard. December. (Table 4-1)
9	12,600 cubic yards of sediment was dredged	Table 1	CH2M HILL. 2013a. Final NTCRA Construction Summary Memorandum for SWMU 3 – Pier 10 Sandblast Yard and SWMU 7b – Small Boats Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. December.
10	1,300 cubic yards of sediment and 320 cubic yards of soil were removed	Table 1	TetraTeach. 2014. Final Construction Completion Report, Time-Critical Removal Action, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October.
11	evaluate remedial alternatives	Table 1	CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October.
12	potentially unacceptable risks to future residents	Table 1	CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Table 2, Appendix C)

Item	Reference Phrase in ROD	Location in ROD	Identification of Referenced Document Available in the Administrative Record file
13	Site Management Plan	Section 2.4	CH2M HILL. 2012e. Site Management Plan for Fiscal Years 2013 through 2017, Joint Expeditionary Base Little Creek –Fort Story, Little Creek, Virginia Beach, Virginia. October.
14	data trends	Section 2.5	CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Section 1.6.2, Appendix D)
15	groundwater geochemical data	Section 2.5	CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Section 1.6.2, Appendix A)
16	beneficial uses	Section 2.6	USEPA. 1994. *National Oil and Hazardous Substances Pollution Contingency Plan.* 40 CFR 300.430 (a) (1)(iii)(f). VA. Code § 62.1-44.2.
17	potential receptor pathways	Section 2.7.1	CH2M HILL. 2005. Final Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 7, Table 7-4) CH2M HILL. 2009a. Final Supplemental Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 7, Tables 7-4 and 7-5) CH2M HILL. 2012a. Final Technical Memorandum Risk Assessment Update – Evaluation of Future Potable Use of Groundwater and Groundwater Discharge to Surface Water at SWMU 3-Pier 10 Sandblast Yard. July. CH2M HILL. 2013b. Final Technical Memorandum Risk Assessment Update - Vapor Intrusion Evaluation, SWMU 3, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. June. CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Table 2, Appendix C)
18	potential exposure pathways	Section 2.7.1	CH2M HILL. 2005. Final Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 7, Table 7-4) CH2M HILL. 2009a. Final Supplemental Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 7, Tables 7-4 and 7-5) CH2M HILL. 2012a. Final Technical Memorandum Risk Assessment Update – Evaluation of Future Potable Use of Groundwater and Groundwater Discharge to Surface Water at SWMU 3-Pier 10 Sandblast Yard. July. CH2M HILL. 2013b. Final Technical Memorandum Risk Assessment Update - Vapor Intrusion Evaluation, SWMU 3, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. June. CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Table 2, Appendix C)
19	confirmation sampling	Section 2.7.1	TetraTeach. 2014. Final Construction Completion Report, Time-Critical Removal Action, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Appendix D)

Item	Reference Phrase in ROD	Location in ROD	Identification of Referenced Document Available in the Administrative Record file
20	potential risks	Section 2.7.2	CH2M HILL. 2005. Final Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 8) CH2M HILL. 2009a. Final Supplemental Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 8) CH2M HILL. 2012b. Final Technical Memorandum Benthic Invertebrate Evaluation, SWMU 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. December.
21	plants and animals (”ecological receptors”)	Section 2.7.2	CH2M HILL. 2005. Final Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 8) CH2M HILL. 2009a. Final Supplemental Remedial Investigation, Human Health Risk Assessment, and Ecological Risk Assessment for SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia. August. (Section 8) CH2M HILL. 2012b. Final Technical Memorandum Benthic Invertebrate Evaluation, SWMU 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. December.
22	surveys	Section 2.7.2	CH2M HILL. 2013a. Final NTCRA Construction Summary Memorandum for SWMU 3 – Pier 10 Sandblast Yard and SWMU 7b – Small Boats Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. December. (Attachment J)
23	post-excavation field surveys	Section 2.7.2	TetraTeach. 2014. Final Construction Completion Report, Time-Critical Removal Action, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Appendix C)
24	sediment core collection	Section 2.7.1	TetraTeach. 2014. Final Construction Completion Report, Time-Critical Removal Action, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Appendix F)
25	PRGs	Section 2.10	CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Section 2.4)
26	cost	Section 2.11	CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Appendix F)
27	approximately 15 years	Section 2.12	CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Section 3.2, Appendix D)
28	applicable and relevant and appropriate requirements (ARARs)	Table 9	CH2M HILL. 2014. Final Focused Feasibility Study for Groundwater, Solid Waste Management Unit 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia. October. (Appendix E)

Detailed site information referenced in this ROD in bold blue text is contained in the Administrative Record file.

For access to information contained in the Administrative Record file for JEB Little Creek, please contact:

NAVFAC Atlantic
6506 Hampton Boulevard, Norfolk, VA 23508
Phone: 757.322.4785