N61414.AR.002199
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FINAL FOCUSED FEASIBILITY STUDY FOR GROUNDWATER SOLID WASTE MANAGEMENT UNIT 3 (SWMU 3) PIER 10 SANDBLAST YARD JEB LITTLE CREEK VIRGINIA BEACH VA
10/01/2014
CH2M HILL

Final

Focused Feasibility Study for Groundwater Solid Waste Management Unit 3— Pier 10 Sandblast Yard

Joint Expeditionary Base Little Creek Virginia Beach, Virginia

Contract Task Order WE61

October 2014

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic

Under the

NAVFAC CLEAN 8012 Program
Contract N62470-11-D-8012

Prepared by

CH2MHILL

Virginia Beach, Virginia

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Acronyms and Abbreviations

µg/L	microgram per liter
ABM	abrasive blast material
ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-term Environmental Action – Navy
COC	constituent of concern
COPC	constituent of potential concern
CSF	cancer slope factor
CSM	conceptual site model
CTE	central tendency exposure
DCA	dichloroethane
DCE	dichloroethene
DO	dissolved oxygen
EE/CA	Engineering Evaluation/Cost Analysis
EPC	exposure point concentration
ERA	ecological risk assessment
ERP	Environmental Restoration Program
FS	Feasibility Study
HHRA	human health risk assessment
JEB	Joint Expeditionary Base
LUC	land use control
MCL	maximum contaminant level
mg/kg	milligram per kilogram
MWR	morale, welfare, and recreation
NAB	Naval Amphibious Base
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NTCRA	non-time-critical removal action
PCE	tetrachloroethene
ppt	parts per thousand
PPRTV	Provisional Peer Reviewed Toxicity Value
PRG	preliminary remediation goal
RAO	remedial action objective
RfD	reference dose
RI	Remedial Investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RQ	remediation quotient
SARA	Superfund Amendments and Reauthorization Act
SERA	screening ecological risk assessment

SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TBC	to-be-considered
TCE	trichloroethene
TCRA	time-critical removal action
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
VAC	Virginia Administrative Code
VC	vinyl chloride
VDEQ	Virginia Department of Environmental Quality
VOC	volatile organic compound
VPDES	Virginia Pollution Discharge Elimination System

1 Introduction

This report presents the results of a Focused Feasibility Study (FS) for Solid Waste Management Unit (SWMU) 3, Pier 10 Sandblast Yard, at Joint Expeditionary Base (JEB) Little Creek, Virginia Beach, Virginia. This Focused FS was prepared for Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic under the NAVFAC Comprehensive Long-term Environmental Action – Navy (CLEAN) Contract No. N62470-11-D-8012, Contract Task Order WE61, for submittal to the JEB Little Creek Environmental Restoration Partnering Team, which consists of representatives from NAVFAC Mid-Atlantic, United States Environmental Protection Agency (USEPA) Region 3, and Virginia Department of Environmental Quality (VDEQ).

1.1 Objective and Approach

The FS was prepared in accordance with the process outlined in the Department of the Navy's (Navy's) Environmental Restoration Program (ERP), which is consistent with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP), Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and the 1988 USEPA guidance titled *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988).

The remedial alternatives described in this Focused FS report are consistent with the requirements of the NCP and are designed to prevent potential future risks to human health from constituents present in groundwater at SWMU 3. The Focused FS consisted of the following tasks:

- Developing remedial action objectives (RAOs) and preliminary remediation goals (PRGs)
- Identifying applicable or relevant and appropriate requirements (ARARs)
- Screening of potentially applicable remedial technologies based on effectiveness, implementability, and cost criteria
- Assembling remedial alternatives that, to the maximum extent practicable, provide permanent solutions and use alternative technologies
- Analyzing the remedial alternatives in detail using the nine NCP evaluation criteria

Following completion of the Focused FS, a preferred alternative that best satisfies the RAOs will be presented in a Proposed Plan that will be submitted for public comment. The resulting comments will be reviewed and a responsiveness summary will be prepared to address the public comments. Incorporating any changes resulting from public comments, a remedy will be subsequently selected and formally documented in a Record of Decision (ROD).

The results of the Focused FS are presented in the following sections:

- Section 1 – Introduction
- Section 2 – Development and Screening of Alternatives
- Section 3 – Detailed Evaluation of Remedial Alternatives

References are provided in Section 4.

1.2 Facility Description

Hampton Roads' first Department of Defense Joint Base was established on October 1, 2009. This new installation comprises the former Naval Amphibious Base (NAB) Little Creek and the former Army Post Fort Story; the new name for the combined installation is JEB Little Creek-Fort Story. With the formation of this new command, the Navy assumes responsibility for managing both properties and merged public meetings regarding the ongoing ERPs. 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 identified jointly as JEB Little Creek-Fort Story. For ERP documents, the Bases are referred to separately as JEB Little Creek and JEB Fort Story.

The former NAB Little Creek was placed on the USEPA National Priorities List on May 10, 1999 (USEPA Identification: VA5170022482).

JEB Little Creek consists of 2,215 acres located in the northwest 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 for local commands, organizations, home-ported ships, and other United States and allied units to meet amphibious warfare-training requirements of the United States armed forces. The area surrounding the facility is low-lying and relatively flat. Land development surrounding the Base is residential, commercial, and industrial.

1.3 Site Description and History

SWMU 3, the Pier 10 Sandblast Yard, is located in a developed area on Little Creek Harbor's western side (**Figure 2**). The area was used for sandblasting boats between 1962 and 1984, with sandblasting activities taking place on a 0.04-acre concrete pad located to the west of Building 1263 (RGH, 1984). After 1984, anchors and chains were sandblasted on the concrete pad. The residual, used abrasive blast material (ABM) consisting of paint chips and blast grit was periodically sampled, determined to be non-hazardous, and removed from the site. However, some residual ABM 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 to 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.

1.4 Previous Investigations and Actions

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 has been characterized under several investigations and studies between 1989 and 2013. **Table 1** provides a summary of previous investigations and studies specific to SWMU 3 and **Figure 3** depicts terrestrial sample locations. The respective investigations are a part of the Administrative Record file for JEB Little Creek and can be referenced for further details regarding specific sampling strategies, media investigations, and when and where the sampling was performed. Additional groundwater sampling and analysis, discussed below, was conducted in 2008 and 2014 to aid in development of remedial alternatives to address groundwater at SWMU 3 and are documented herein.

1.4.1 Pre-Feasibility Study Groundwater Sampling

Groundwater sampling was conducted at SWMU 3 in January and September 2008 and August 2014 in accordance with the *Project Instructions for Navy CLEAN CTO-0048 Groundwater Investigation, SWMU 3* (CH2M HILL, 2008) and *Draft Sampling and Analysis Plan for Pre-Feasibility Study Groundwater Sampling at SWMU 3* (CH2M HILL, 2014). Raw analytical data are provided in **Appendix A** and data validation reports are provided in **Appendix B**.

In January and September 2008, groundwater samples were collected from 15 existing site monitoring wells at varying depths and analyzed for TCL volatile organic compounds (VOCs), dibenzofuran, and total and dissolved thallium (**Appendix A, Table A-1**). Field measurements of dissolved oxygen (DO), oxidation reduction potential (ORP), salinity, pH, specific conductivity, turbidity, and temperature were also collected. Dibenzofuran and total/dissolved thallium were not detected in groundwater during each event (**Appendix A, Table A-2**). Thirteen VOCs were detected in groundwater in January 2008 and nine VOCs were detected in groundwater in September 2008. Of the VOCs detected, trichloroethene (TCE), cis-1,2-dichlorothene (DCE), trans-1,2-DCE, and vinyl chloride (VC) were detected above their respective maximum contaminant levels (MCLs) (**Figure 4**).

In August 2014, groundwater samples were collected from 14 existing monitoring wells (LW03-MW05 was not located) and analyzed for VOCs identified as site COPCs or previously detected above the MCL [tetrachloroethene (PCE), TCE, cis-1,2-DCE, trans-1,2-DCE, VC, 1,2-dichloroethane (DCA), 1,1-DCA, and benzene] (**Appendix A, Table A-1**). Additionally, groundwater samples were analyzed for geochemical parameters total organic carbon (TOC), total dissolved solids (TDS), dissolved manganese, volatile fatty acids (VFAs), methane, ethane, ethene, chloride, nitrate, sulfate, sulfide, and alkalinity. Field measurements of DO, ORP, salinity, pH, specific conductivity, turbidity, temperature, ferrous iron, and carbon dioxide were also collected. VOCs were detected in 4 monitoring wells (**Appendix A, Table A-2**) with only TCE and VC detected above the MCL in 2 of the 4 monitoring wells (**Figure 4**). Concentrations of VOCs have decreased from those observed in 2007 SRI sampling and 2008 Pre-FS groundwater sampling. A discussion of the geochemical results is provided in Section 1.6.2. VOC data collected in August 2014 were used to re-evaluate the potentially unacceptable risks to human health from exposure to groundwater identified in the 2008 SRI (CH2M HILL, 2009b). Results of the risk assessment are presented in Section 1.6.4.

1.5 Conceptual Site Model

A conceptual site model (CSM) (**Figure 5**) has been developed to summarize the site conditions, contaminant distribution, transport pathways, potential receptors and exposure pathways, and land use data collected during site investigations. **Figure 5** presents the CSM of site conditions following completion of the non-time-critical removal action (NTCRA) and time-critical removal action (TCRA) discussed in **Table 1.** Because risks associated with exposure to soil and sediment were mitigated as part of the removal actions, these media will require no further action and are not discussed in the forthcoming sections.

1.6 Site Characteristics

The terrestrial portion of SWMU 3 includes a fenced area containing Buildings 1262 (firefighting equipment), 1263 (welding and metal-working shop), and 1268 (wood storage), as well as 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 (Information Technology support administrative spaces), 1516 (former morale, welfare, and recreation [MWR] marina shop), 1528 (MWR restrooms), and 1604 (United Service Organizations administrative and cooking space). A small, grassy picnic area (Building 1269) 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 Virginia Pollution Discharge Elimination System (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 stormwater outfall and has no monitoring requirements. In addition to what is conveyed by the catch basin and outfall, a portion of stormwater runoff from SWMU 3 flows directly into Little Creek Harbor as sheet flow.

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 the 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. A public health restriction on shellfish consumption and a fish consumption advisory are currently in place for Little Creek. For safety and security purposes, recreational swimming is not permitted in Little Creek Harbor; however, the facility currently allows recreational fishing from the pier located behind Building 1604.

The land where SWMU 3 is located and the surrounding area were created from the placement of dredged material between 1937 and 1954; thus, the shallow aquifer geology is likely a mix of dredge spoil and pre-1937 land formation and not representative of the upper Holocene and Pleistocene unconsolidated fine sand and silt deposits of the Columbia aquifer. Beneath this dredged fill material, 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 at 5 feet below ground surface. Groundwater flows south-southeast towards Little Creek Harbor with some localized reversal in groundwater flow direction during high tide (**Figures 6 and 7**). The elevation of the water table underlying SWMU 3 varies by less than 1 foot across the site. The average shallow groundwater flow velocity is estimated to be 10.3 feet per year. The groundwater in the surficial aquifer beneath SWMU 3 is generally brackish [salinity ranging from 0.5 to 30 parts per thousand (ppt)]. Salinity measurements collected during August 2014 groundwater sampling indicated salinity across the site ranging from 0.42 ppt in MW08 located behind a bulkhead wall to 17.14 ppt in MW02 located adjacent to the rip-rap shoreline (**Appendix A, Table A-2**). The brackish nature of the groundwater underlying SWMU 3 is indicative of a transition zone where upgradient fresh water mixes with downgradient seawater. The shallow groundwater is not currently used and is not expected to be used as a potable water supply. Potable water is provided to the Base and surrounding communities by the City of Virginia Beach.

1.6.1 Nature and Extent of Groundwater Contamination

VOCs, semivolatile organic compounds (SVOCs), and metals have been detected in groundwater. The chlorinated VOCs, PCE and several “daughter product” compounds formed from the biological and chemical degradation of PCE, – namely TCE, cis-1,2- DCE, and VC – were historically detected in groundwater above MCLs. The maximum concentration of parent product PCE (210 micrograms per liter) was detected in upgradient monitoring well LW03-MW06 in 2002 (**Figure 4**); however, PCE was not detected above the MCL during five rounds of subsequent sampling in January/September 2007, January/September 2008, and August 2014. Maximum concentrations of daughter products TCE, cis-1,2-DCE, and VC were detected at monitoring well LW03-MW12, downgradient of LW03-MW06, in 2007. While detected in upgradient well LW03-MW06 in 2002, breakdown products TCE, cis-1,2-DCE, and VC were not detected in this monitoring well during the subsequent 2007, 2008, and 2014 sampling events. Based upon the results of the August 2014 groundwater sampling, only TCE and vinyl chloride remain in groundwater at concentrations exceeding their respective MCLs (**Figure 4**). Groundwater contamination is limited to the downgradient edge of the site and discharges to Little Creek Harbor. Contaminant distribution over time is likely the result of the degradation of chlorinated VOCs and downgradient advection of daughter products. In addition to the chlorinated ethenes discussed above, chlorinated ethanes 1,1- DCA and 1,2-DCA as well as benzene were detected in groundwater. 1,1-DCA was detected in groundwater in 1998, 2002, 2007, 2008, and 2014. Concentrations have generally decreased over time. No MCL has been established for 1,1-DCA. 1,2-DCA and benzene were detected in groundwater in 2002 at concentrations below their respective MCLs; however they were not detected during 2007, 2008, and 2014 sampling activities. Based upon the results of soil, groundwater and membrane interface probe sampling conducted as part of the SI, RI, and SRI, no specific source for the VOCs has been identified at the site.

SVOCs were detected in one monitoring well (LW03-MW04) in 1998. Dibenzofuran was the only SVOC that was detected above screening values. Although identified as a contaminant of potential concern, the SI concluded dibenzofuran was not site-related and therefore SVOCs were not analyzed in groundwater samples during the RI and SRI. Dibenzofuran was analyzed in groundwater samples during pre-FS groundwater sampling conducted in January and September 2008 to confirm its presence or absence in groundwater. Dibenzofuran was not detected in groundwater (**Appendix A, Table A-1**). Total and dissolved metals have been detected in groundwater above background values across the site during each site investigation. Detected soil concentrations of VOCs, SVOCs, and metals do not indicate that any continuing source of contamination is present in the site soil.

1.6.2 Fate and Transport of Groundwater Contamination

Constituent fate and transport of dissolved VOCs in groundwater at SWMU 3 are natural attenuation processes. Conditions at SWMU 3 were evaluated for their suitability for natural attenuation of chlorinated VOCs detected in groundwater at the site. Natural attenuation occurs though 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.

1.6.2.1 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 7**). Contaminant concentrations are also dispersed through tidal influx as a result of localized reversal in groundwater flow during high-tide cycles (**Figure 6**). 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 at SWMU 3 is biodegradation. Chlorinated VOCs in groundwater can be subject to degradation via biological and abiotic processes. The abiotic pathway results in degradation of chlorinated VOCs to acetylene and occurs under highly reducing conditions. This is not anticipated to be the primary pathway at SWMU 3. Biodegradation typically occurs via reductive dechlorination, which is a naturally occurring, microbially mediated, anaerobic process in which chlorine atoms on a parent molecule are sequentially replaced with hydrogen. For chlorinated ethenes (PCE, TCE, cis-1,2-DCE, and vinyl chloride), electrons are transferred from an electron donor source to the chlorinated VOC compound, which functions as the electron acceptor. Therefore, an external electron donor source (such as native organic matter) is required for the reaction to occur. The following biogeochemical conditions can also influence the rate of reductive dechlorination: pH, oxidation-reduction (redox) conditions, abundance of functional microorganisms, absence of inhibitory compounds (such as chloroform), and nutrient availability. Although reductive dechlorination of chlorinated VOCs favors deeply reducing conditions (between sulfate-reducing and methanogenic conditions), there is also evidence of reductive dechlorination of chlorinated ethenes under iron-reducing and denitrifying conditions.

The reductive dechlorination pathways for the chlorinated VOCs at SWMU 3 are as follows:

PCE → TCE → cis-1,2-DCE → vinyl chloride → ethene

The transformation rate for each step varies but tends to become slower with progress along the breakdown sequence and may result in accumulation of daughter products. However, these less-chlorinated daughter products may be degraded by other processes. Chlorinated ethenes (TCE, cis-1,2-DCE, and vinyl chloride) are subject to aerobic biodegradation and mineralization to carbon dioxide. Abiotic degradation of chlorinated VOCs by iron-bearing minerals (such as iron monosulfide) in the subsurface has also been widely reported in literature (He et al., 2010; Lee, et al., 2009).

Multiple lines of evidence are required to evaluate the level of activity and effectiveness of biodegradation. One primary line of evidence that biodegradation is occurring at a site is the reduction in contaminant concentrations. To assess this decrease, the non-parametric Mann-Kendall methodology (Gilbert, 1987; Gibbons, 1994) was used to evaluate select VOC (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC) groundwater concentration data in monitoring wells LW03-MW05, LW03-MW06, LW03-MW07, and LW03-MW12 and determine whether statistically significant increasing or decreasing concentration trends could be observed. The Mann-Kendall nonparametric test is well suited for evaluation of environmental data because the sample size can be small (as few as four data points), no assumptions are made regarding the underlying statistical distribution of the data, missing data values (nondetects) are easily handled, and irregularly spaced sampling intervals are permitted. This technique can be viewed as a nonparametric test for a zero slope in the linear regression of time-ordered data versus time. No significant changes were observed (**Appendix D, Table D-1**). This may be a result of the low concentrations observed and historical nondetects with higher reporting limits as well as the downgradient migration of VOCs resulting from advection and tidal flux. Scatter plots and linear regression was used to assess overall decreasing trends in chlorinated VOC concentrations across the site, using maximum detected concentrations from each sampling event between 1998 and 2014 for PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC (**Appendix D**). Decreasing trends in contaminant concentrations were observed for each constituent.

Another primary line of evidence is the presence of daughter products (**Appendix D, Table D-2**). Samples for innocuous end products methane, ethane, and ethene were collected as part of site investigations in February 2007 (SRI, Table 5-3)and August 2014 (**Appendix A, Table A-1**). Groundwater samples were also analyzed in August 2014 for chloride (**Appendix A, Table A-1**), which may be an indirect line of evidence that reductive dechlorination has occurred if it is present at concentrations above background.

A third line of evidence is the use of geochemical to show that conditions are favorable for biodegradation of contaminants. The key indicator parameters used to assess reductive dechlorination are consumption of the electron donors (TOC and petroleum hydrocarbons), footprints of normal metabolic reactions, and an increase in dissolved inorganic carbon. As previously stated, reductive dechlorination most favorably occurs under deeply reducing conditions (between sulfate-reducing and methanogenic conditions). Footprints of normal metabolic reactions can be used as an indicator of the dominant redox conditions of the aquifer. Microorganisms preferentially use electron acceptors that will provide the most energy. DO is consumed first as the prime electron acceptor; nitrate is the next preferred electron acceptor, followed by manganese, ferric iron, sulfate, and carbon dioxide. As each preferential electron acceptor is used and depleted, the ORP of the groundwater system is driven toward more reducing conditions (that is, more negative). Metabolically, DHC bacteria are known to reductively degrade chlorinated ethenes (such as PCE and TCE); however, they may not be able to effectively reduce contaminants all the way to ethene, resulting in a stall or accumulation of daughter products. Therefore, the DHC functional genes evaluate the presence of specific DHC strains that are known to be capable of reductively degrading TCE to cis-1,2-DCE and cis-1,2-DCE and vinyl chloride to ethene.

To evaluate whether conditions are favorable for reductive dechlorination, groundwater geochemistry was evaluated as part of the 2007 and 2014 sampling events. Geochemical parameter data suggest that variable redox conditions are present within the historic and current groundwater plume area (LW03-MW05, LW03-MW06, LW03-MW07, and LW03-MW12). In 2007, 2008, and 2014 DO has been measured as below 1 mg/L and negative ORP values 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 denitrification is not a competitive process 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. The inconsistencies between the 2007 and 2014 sulfide results may be attributed to the propensity of sulfide to precipitate from solution as ferrous sulfide. 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 (LW03-MW07 and LW03-MW12) during the 2014 sampling were elevated in comparison to background conditions (LW03-MW14), indicative of increased biological activity. Although carbon dioxide was detected at > 100mg/L, it was not elevated above background conditions. Carbon dioxide is the ultimate oxidative daughter product. Its presence at levels greater than background is supportive of biodegradation, but concentrations comparable to background do not necessarily indicate no biodegradation is occurring. Rather, comparable results may indicate biodegradation is occurring slowly or may indicate that infiltration or groundwater mixing are occurring in the contaminated area at a rate that outpaces the accumulation of carbon dioxide. 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.

Overall, VOC and geochemical data collected in 2007 and 2014 indicate that conditions are conducive for reductive dechlorination at SWMU 3 (evidence of iron reduction, sulfate reduction, and methanogenesis). However, as concentrations of VOCs decrease in groundwater and VOCs progress along the breakdown sequence, as is evidenced by trend analyses discussed above, the transformation rate tends to become slower and is coupled with an increase in the mobility of each subsequent breakdown product. As a result of the predominant mechanism of natural attenuation at SWMU 3 of the physical migration of VOCs through natural groundwater flow (advection), tidal flux (dispersion), and subsequent discharge to Little Creek Harbor, it is assumed that the processes of reductive dechlorination would become less prominent as VOCs are transformed and parent product concentrations decrease. Vinyl chloride, the predominant VOC remaining in groundwater at SWMU 3, is likely to discharge to Little Harbor prior to its end product degradation.

1.6.3 Summary of Site Groundwater and Surface Water Risks

Detailed results of the human health risk assessment (HHRA) and ecological risk assessment (ERA) conducted at SWMU 3 are presented in the Remedial Investigation (RI)/HHRA/ERA, Supplemental RI/HHRA/ERA, and subsequent risk assessment updates. The following subsections summarize the findings of the risk assessments for groundwater and surface water.

1.6.3.1 Human Health Risk Assessment Summary

A human health risk assessment was conducted as part of the 2002 RI. Current exposure scenarios evaluated as part of the 2002 RI HHRA consisted of adult/adolescent recreational user (those swimming and boating in the harbor) and other worker (for example, scuba diver engaging in training activities in the harbor) exposure to surface water. Hypothetical future exposure scenarios that were evaluated consisted of adult/adolescent recreational user, other worker, and maintenance worker exposure to surface water; and adult/child resident, industrial worker, and construction worker exposure to groundwater. The exposure pathways that were evaluated were ingestion of, dermal contact with, and inhalation of volatile emissions from groundwater, and ingestion of and dermal contact with surface water. Exposures to surface and subsurface soil were also evaluated as part of the 2002 RI HHRA, but as discussed above, risks associated with exposure to soil and sediment were mitigated as part of the removal actions, these media will require no further action, and are therefore not discussed further in the Focused FS. The 2002 RI HHRA indicated potential unacceptable risks associated with potable use of groundwater for future residents and industrial workers if the groundwater is used as a potable water supply. These potential unacceptable risks were associated with VOCs detected in the groundwater. No unacceptable human health carcinogenic risks or non-cancer hazards associated with exposure to surface water at SWMU 3 were identified.

The HHRA included in the 2009 SRI evaluated future adult/child resident, industrial worker, and construction worker exposure to groundwater. A summary of the 2009 SRI risk calculations above USEPA's target thresholds is provided in **Table 2**. No potentially unacceptable human health carcinogenic risks or non-cancer hazards associated with construction worker exposure to groundwater were identified. Future potable use of shallow groundwater may result in unacceptable cancer risks and non-cancer hazards for future industrial workers and hypothetical future residents. Unacceptable carcinogenic risks and non-cancer hazards are associated with exposure to 1,2-DCA, PCE, TCE, cis-1,2-DCE, vinyl chloride, benzene, dibenzofuran, antimony, arsenic, iron, manganese, and thallium in groundwater (**Table 2**). Based upon the risk management considerations presented in **Table 3**, the Navy and USEPA, in consultation with VDEQ, agree the risks and/or hazards associated with dibenzofuran, antimony, arsenic, iron, manganese, and thallium are acceptable; therefore no further action to address these constituents in groundwater is warranted.

Following completion of the SRI a risk assessment update to evaluate human health risks associated with groundwater discharge to Little Creek Harbor was conducted and concluded that discharge of groundwater to surface water does not pose an unacceptable incremental increase in carcinogenic risks or non-cancer hazards from exposure to surface water in Little Creek Harbor (CH2M HILL, 2012a).

As part of development of this Focused FS, groundwater data collected during the SI, RI, and SRI were compared to updated risk-based screening values (November 2013 tap-water RSLs), MCLs, and toxicity values. As a result, in addition to previously identified COCs, 1,1-DCA, chromium, and cobalt were identified as new COPCs that may contribute to an unacceptable risk or hazard in groundwater and may be COCs. However, based upon the risk management considerations presented in **Table 3**, the Navy and USEPA, in consultation with VDEQ, agree potential risks and hazards associated with chromium and cobalt are acceptable and no further action is warranted to address these constituents in groundwater.

The human health risks associated with exposure to groundwater were re-evaluated using the most recent round of groundwater sample data (August 2014). The risk calculations are presented in Appendix C and the COCs are summarized on Table 2. The methodology used to calculate the risks is generally the same as that used in the 2009 SRI HHRA, however the screening levels to identify the COPCs, the exposure factors used to calculate intake of the COPCs, and the toxicity values used to calculate the hazards and risks have been updated to current values, as included in Appendix C. The risk calculations indicate that future potable use of shallow groundwater by industrial workers and exposure to groundwater by construction workers would not results in any unacceptable non-cancer hazards or carcinogenic risks. Additionally, the non-cancer hazards to future residents who use groundwater as a potable water supply would also be within acceptable levels. However potable use of groundwater by future residents may result in unacceptable cancer risks associated with TCE and vinyl chloride (**Table 2**).

There are no existing pathways for vapor intrusion (i.e. no occupied buildings within 100 feet of an MCL exceedance) at SWMU 3. Risks and hazards associated with hypothetical future adult resident exposure to indoor air via vapor intrusion from groundwater were calculated in 2013 using groundwater data collected in 2007. Results are documented in the technical memorandum Risk Assessment Update – Vapor Intrusion Evaluation, SWMU 3, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia, (CH2M HILL, 2013). Based upon predicted indoor air concentrations calculated using the maximum-detected concentrations of VOCs in groundwater, potentially unacceptable risks to human health were identified. However, no potentially unacceptable risks were identified when calculated using the 95 percent upper confidence limit (UCL) of the mean groundwater concentrations. Additionally, maximum-detected constituent concentrations and calculated 95 percent UCL of the mean concentrations were representative of site conditions in 2007. Based upon groundwater VOC data collected in August 2014, concentrations of VOCs have decreased to concentrations more indicative of conditions representative of the calculated 95 percent UCL values used in the risk assessment.

1.6.3.2 Ecological Risk Assessment Summary

An ERA was completed to evaluate the potential risks to ecological receptors through direct exposure to groundwater (discharged to surface water) and surface water, as well as food web exposures. No potentially unacceptable risks from direct exposure to surface water or from aquatic food web exposure were identified. Additionally, an evaluation of ecological risks associated with groundwater discharge to Little Creek Harbor concluded that discharge of groundwater to surface water does not pose an unacceptable incremental increase in risks to aquatic receptors in Little Creek Harbor.

2 Development and Screening of Alternatives

This section presents general and site-specific RAOs and identification of ARARs for SWMU 3.

2.1 National Oil and Hazardous Substance Pollution Contingency Plan and Comprehensive Environmental Response, Compensation, and Liability Act Objectives

General RAOs are defined by the NCP and CERCLA, as amended by SARA, which is applicable to all CERCLA sites. CERCLA defines the statutory requirements for developing remedies. The NCP requires that the selected remedy meet the following:

- Each remedial action selected shall be protective of human health and the environment (40 Code of Federal Regulations [CFR] 300.430 [f][ii][A]).
- Onsite remedial actions that are selected must attain those ARARs that are identified at the time of the ROD signature (40 CFR 300.430 [f][ii][B]).
- Each remedial action selected shall be cost-effective, provided that it first satisfies the threshold criteria set forth in §300.430(f)(1)(i)(A). A remedy shall be cost-effective if its costs are proportional to its overall effectiveness.
- Each remedial action shall use permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable (40 CFR 300.430 [f][ii][E]).

The statutory scope of CERCLA was amended by SARA to include the following general objectives for remedial action at all CERCLA sites:

- Remedial actions "shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further releases at a minimum which assures protection of human health and the environment" (Section 121[d][1]).
- Remedial actions in which treatment that "permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants is a principal element are to be preferred" (Section 121[b][1]). If the treatment or recovery technologies selected are not a permanent solution, an explanation must be published (Section 121 [b][1][G]).
- The least-favored remedial actions are those that include "offsite transport and disposal of hazardous substances or contaminated materials without treatment" where practicable treatment technologies are available (Section 121[b][1]).
- The selected remedy must comply with or attain the level of any standard, requirement, criteria, or limitation under federal environmental law or any promulgated standard, requirement, criteria, or limitation under a state environmental or facility siting law that is more stringent than any federal standard, requirement, criteria, or limitation [Section 121[d][2][A]).

2.2 Remedial Action Objectives

RAOs consist of media-specific goals for protecting human health and the environment. The only media of concern being addressed by this Focused FS is shallow groundwater based on potential future unacceptable carcinogenic risks and non-cancer hazards to human health. The RAOs are as follows:

- Prevent potable use of groundwater and exposure to groundwater emissions 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 unlimited exposure.

2.3 Applicable or Relevant and Appropriate Requirements

As required by CERCLA Section 121, remedial actions carried out under Section 104 or secured under Section 106 must attain the levels of standards of control for hazardous substances, pollutants, or contaminants specified by the ARARs of federal and state environmental laws and state facility-siting laws, unless waivers are obtained. According to USEPA guidance, remedial actions should also be based on non-promulgated, to-be-considered (TBC) criteria or guidelines if the ARARs do not address a particular situation.

ARARs are identified by the USEPA as either being applicable to a situation or relevant and appropriate to it.

"Applicable" requirements are standards and other environmental protection requirements of federal or state law dealing with a hazardous substance, pollutant, contaminant, action being taken, location, or other circumstance at a CERCLA site.

"Relevant and appropriate" requirements are standards and environmental protection criteria of federal or state law that, although not "applicable" to a hazardous substance, pollutant, contaminant, action being taken, location, or other circumstance, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. A requirement that is relevant and appropriate must be met as if it were applicable. TBC criteria are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. TBC criteria are evaluated along with ARARs and may be implemented by the USEPA when ARARs are not fully protective of human health and the environment.

Onsite CERCLA response actions must meet substantive requirements, but not administrative requirements. Substantive requirements are those dealing directly with actions or with conditions in the environment.

Administrative requirements implement the substantive requirements by prescribing procedures, such as fees, permitting, and inspection that make substantive requirements effective. This distinction applies to onsite actions only; offsite response actions are subject to all applicable standards and regulations, including administrative requirements, such as permits.

Three classifications of requirements are defined by the USEPA in the ARAR determination process: chemical-specific, location-specific, and action-specific. These classifications are described as follows. The remedial action alternatives developed in this FS were analyzed for compliance with the potential federal and state ARARs, which are provided in **Appendix E**.

Chemical-specific ARARs are health or risk management-based numbers or methodologies that result in the establishment of numerical values for a given medium that would meet the NCP "threshold criterion" of overall protection of human health and the environment. These requirements generally set protective cleanup concentrations for the constituent of concerns in the designated media, or set safe concentrations of discharge for response activity. Federal and Commonwealth of Virginia chemical-specific regulations that have been reviewed are summarized in **Appendix E**.

Location-specific ARARs restrict response activities and media concentrations based on the characteristics of the surrounding environments. Location-specific ARARs may include restrictions on response actions within wetlands or floodplains, near locations of known endangered species, or on protected waterways. Federal and Commonwealth of Virginia location-specific regulations that have been reviewed are summarized in **Appendix E**.

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous substances. Federal and Commonwealth of Virginia action-specific ARARs that may affect the development and conceptual arrangement of response alternatives are summarized in **Appendix E**.

2.4 Development of Preliminary Remediation Goals

No unacceptable risks to human health and the environment were identified from exposure to surface water or indoor air. Potentially unacceptable risks associated with exposure to soil and sediment were mitigated through completion of the NTCRA and TCRA. Based upon the COCs identified in the August 2014 updated HHRA, and the risk management considerations agreed upon by the Navy, USEPA, and VDEQ (Section 1.6.4), the COCs for SWMU 3 groundwater are TCE and vinyl chloride. To achieve the RAO for unlimited use and unrestricted exposure, PRGs are established as the MCL. The PRGs for SWMU 3 groundwater are listed on **Table 4**.

Although not identified as site-specific COCs requiring PRGs, the degradation of TCE may result in temporary increases to the concentrations of daughter products cis-1,2-DCE and trans-1,2-DCE. Even if the site-specific COC concentrations reach cleanup levels (MCLs), SWMU 3 cannot reach unlimited use and unrestricted exposure until cis-1,2-DCE and trans-1,2-DCE are below the MCL. As a result, these constituents will be monitored during remedy implementation to ensure concentrations remain below their respective MCLs. The daughter product MCLs are as follows:

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

2.5 Development of General Response Actions and Remedial Alternatives

General response actions are broad classes of responses, remedies, or technologies developed to meet the site-specific RAO. After the RAO was developed, three general response actions consistent with the site-specific objective were identified, including the CERCLA requirement of no action, which will serve as a baseline for comparison. The general response actions for SWMU 3 are:

- No Action – No Action involves no remedial action, and is included as a baseline for comparison.
- Natural Attenuation - Relies on natural attenuation to reduce contaminant concentrations without performing any other measures.

- Land Use Controls (LUCs) – LUCs reduce the potential for receptor contact with contaminated media. These may include, but are not limited to: 1) LUCs to limit the future use of the site or activities that may occur and 2) public education.

The general response actions were used to develop the remedial alternatives as follows: 1) No Action and 2) Monitored Natural Attenuation (MNA) and LUCs.

3 Detailed Evaluation of Remedial Alternatives

This section identifies, describes, and evaluates in detail the two remedial alternatives for SWMU 3. The purpose of the evaluation is to assess the strengths and weaknesses of the alternatives with respect to the evaluation criteria set forth in the NCP.

3.1 Evaluation Criteria

The detailed analysis of alternatives was conducted in accordance with the Guidance for Conducting RIs and FSs under CERCLA (USEPA, 1988) and the NCP (Part 300.430[e]), including the February 1990 revisions. In conformance with the NCP, seven of the following nine criteria were evaluated in the detailed analysis:

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

State acceptance and community acceptance criteria will be evaluated by addressing comments received after the public comment period for the Proposed Plan. This evaluation will be presented in the Responsiveness Summary of the ROD for SWMU 3. A detailed description of each criterion is provided on **Table 5**.

3.2 Description of Remedial Alternatives

A description of each remedial alternative was developed from the general response actions retained following the screening process:

3.2.1 Alternative 1: No Action

Alternative 1 is the No Action alternative as required by the NCP and serves as the baseline for comparison of other alternatives. Under this alternative, no additional effort or resources would be expended at SWMU 3.

3.2.2 Alternative 2: Monitored Natural Attenuation and Land Use Controls

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 PRGs. Natural attenuation refers to the reliance on natural processes to achieve PRGs. As discussed in Section 1.6.2.1, 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 SWMNU 3 is degradation through natural processes. As discussed in Section 1.6.3.1 and 1.6.3.2, 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 1.6.2.1.

Using the same statistical method as presented in Section 1.6.2.1, an intra-well trend analysis for vinyl chloride at LW03-MW12, where this COC is at its maximum concentration was conducted to estimate the timeframe in which COCs can be expected to reach PRGs. Because parent compound PCE is no longer present at the site, and TCE is remains only slightly above the PRG at 6.01 ug/L, only VC was assessed. Because vinyl chloride is the final chlorinated ethene in the reductive dechlorination sequence, the projected date at which the maximum detected concentration of this constituent would reach its PRG (MCL) represents the most conservative estimate at which TCE and VC would be expected to reach PRGs. With the lack of parent product and low concentrations of TCE remaining it is not expected that cis-1,2-DCE or trans-1,2-DCE would increases to levels above their respective MCLs. The estimated timeframe for vinyl chloride to reach the PRG in LW03-MW12 is approximately 15 years (**Appendix D**). LUCs will be maintained until the RAO is achieved, with 5-year statutory reviews to ensure protection of human health and the environment. The proposed LUC boundary would be established surrounding the groundwater COC plume, as defined by exceedances of MCLs, and is shown on **Figure 8**. Long-term reduction in COC concentrations will be monitored as part of a LTM plan designed to evaluate the achievement of RAOs over time, determine continued remedy protectiveness, and assess site exit strategies. The monitoring assumptions, including frequency, duration, and analytical parameters, are included in the cost estimate (**Appendix F**). The final LTM plan will be developed following remedy selection.

3.3 Evaluation of Remedial Alternatives

The detailed analysis of remedial alternatives comprises individual and comparative evaluation of the remedial alternatives. During the individual evaluation, each alternative is assessed against the NCP criteria described in Section 3.1. The results are then arrayed to compare the alternatives and identify the key trade-offs among them. This approach provides decision-makers with sufficient information to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the remedy selection requirements in the ROD. The comparative evaluation is summarized in the following subsections and in **Table 6**.

3.3.1 Overall Protection of Human Health and the Environment

Alternative 1 does not meet the RAO and does not provide protection for future human exposure to VOCs in groundwater. Alternative 2 meets the RAO and is protective of human health and the environment. Site related COCs would naturally attenuate over time from natural processes, and LUCs would mitigate potential risk to human health by preventing unacceptable exposure to VOCs in groundwater.

3.3.2 Compliance with ARARs

Alternative 1 does not comply with ARARs. Alternative 2 complies with the identified chemical-, location-, and action-specific ARARs (**Appendix E**). Site-related COCs would eventually attenuate below chemical-specific ARARs. LUCs would be in place until the RAO is achieved, and groundwater sampling would be conducted to monitor the concentrations of COCs in groundwater until PRGs have been met.

3.3.3 Long-term Effectiveness and Permanence

Alternative 1 is not effective in the long term. Alternative 2 would prevent unacceptable exposures over the long-term through the implementation of LUCs. Alternative 2 is expected to achieve long-term effectiveness and permanence through the natural attenuation of site-related COCs to below PRGs in approximately 15 years allowing for unlimited use and unrestricted exposure.

3.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 1 does not reduce toxicity, mobility, or volume through treatment. Alternative 2 does not employ an active treatment process for the site-related COCs, relying instead on natural attenuation processes to remediate the groundwater. Therefore, the expected overall reduction of toxicity, mobility, and volume of the site-related COCs is acceptable, but assumed to be slow.

3.3.5 Short-term Effectiveness

Although there is no current or reasonably anticipated exposure to groundwater, Alternatives 1 is not effective in the short-term because it is not protective (Threshold Criteria). Alternative 2 has no initial concerns regarding short-term effectiveness, as it does not employ initial construction activities that would endanger public communities or remedial workers, or adversely impact the environment. However, as part of Alternative 2, transportation of personnel to and from the site for groundwater monitoring, and transportation and disposal of investigation derived waste generated during sampling events will contribute to environmental and worker safety impacts throughout the life of the remedy.

3.3.6 Implementability

Alternative 1 would be easiest to implement, as there is no effort associated with this alternative. Alternative 2 would require the preparation of a LUC Remedial Design, filing of a survey plat with the City of Virginia Beach providing notice of LUCs, development of a groundwater sampling plan, completion of annual site inspections to ensure the integrity of the LUCs, completion of statutory Five-year Reviews including the completion of groundwater monitoring, and coordination between NAVFAC, JEB Little Creek, USEPA, and VDEQ to ensure LUCs are enforced.

3.3.7 Cost

There are no costs associated with Alternative 1. The estimated present-value cost for implementation of Alternative 2, factoring in a 15-year operations and maintenance period, is $370,000 (-30 percent = $259,000; +50 percent = $555,000). The detailed cost estimate is provided in **Appendix F.**

4 References

CH2M HILL. 1999. *Final Site Investigation Report, SWMU 3 and IR Site 8,* NAB Little Creek, Virginia Beach, Virginia. December.

CH2M HILL. 2000. *Final Screening Ecological Risk Assessment, IR Sites 5, 7, 8, 9, 10, 11, 12, 13, and 16 and SWMU 3, NAB Little Creek, Virginia Beach, Virginia.* June.

CH2M HILL. 2001. *Draft Baseline (Step 3) Ecological Risk Assessment for IR Sites 7, 8 and SWMU 3, NAB Little Creek, Virginia Beach, Virginia.* January.

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.

CH2M HILL. 2009a. *Work Plan for Pre-Feasibility Study Sediment Sampling SWMU 3, Pier 10 Sandblast Yard, Naval Amphibious Base Little Creek, Virginia Beach, Virginia.* February.

CH2M HILL. 2009b. *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.

CH2M HILL. 2009c. *Final SWMU 3 – Pier 10 Sandblast Yard Vertical Removal Boundary Delineation and Waste Characterization Sediment Sampling Work Plan and Sampling and Analysis Plan, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia.* December.

CH2M HILL. 2012a. *Final 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. 2012b*. Benthic Invertebrate Evaluation, SWMU 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia*. December.

CH2M HILL. 2012c. *Final Engineering Evaluation/Cost Analysis and Action Memorandum for SWMU 3 – Pier 10 Sandblast Yard*. December.

CH2M HILL. 2013a. *Final Technical Memorandum Risk Assessment Update - Vapor Intrusion Evaluation, SWMU 3, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia.* June.

CH2M HILL. 2013b. *Final Action Memorandum for Completion of Time-Critical Removal Action at SWMU 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia.* June.

CH2M HILL. 2013c. *Final Technical Memorandum Non-Time-Critical Removal Action Summary, SWMU 3 –Pier 10 Sandblast Yard and SWMU 7b – Small Boats Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia.* September.

CH2M HILL. 2013d. *Final Action Memorandum (Partial Change in Approach of the Response) for Completion of Time-Critical Removal Action at SWMU 3 – Pier 10 Sandblast Yard, Joint Expeditionary Base Little Creek, Virginia Beach, Virginia.* December.

Gibbons, Robert D. 1994. *Statistical Methods for Groundwater Monitoring.* John Wiley & Sons, New York.

Gilbert, Richard O. 1987. *Statistical Methods for Environmental Pollution Monitoring.* New York: Van Nostrand Reinhold Company, New York.

He, Y.T., J.T. Wilson, and R.T. Wilkin. 2010. “Impact of iron sulfide transformation on trichloroethylene degradation.” *Geochimica Et Cosmochimica Acta* 74(7), 2025-2039.

Lee, H.K., S.H. Do, B. Batchelor, Y.H. Jo, and S.H. Kong. 2009. “PCE DNAPL degradation using ferrous iron solid mixture (ISM).” *Chemosphere* 76(8), 1082-1087.

Rogers, Golden, and Halpern (RGH). 1984. *Initial Assessment Study of Naval Amphibious Base Little Creek, Norfolk, Virginia.* December.

United States Environmental Protection Agency (USEPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.*

USEPA. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study.* EPA 540-R-00-002. OSWER 9355.0-75. July.

Tables

TABLE 1

Studies, Investigations, and Actions Summary

SMWU 3 Focused Feasibility Study Report

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

Previous Study / Investigation	Date	Investigation Activities
Site Investigation (CH2M HILL, 1999)	1998	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. Volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals were detected in groundwater above human health screening criteria. Polycyclic aromatic hydrocarbons and metals were detected in soil and sediment above human health screening criteria. Constituents of potential concern (COPCs) were identified for each medium. Additionally, abrasive blast material (ABM) was observed on the ground surface and in near-shore sediment. The Site Investigation recommended a screening ecological risk assessment (SERA) to identify potentially complete exposure pathways for ecological receptors and a Remedial Investigation (RI) to define the nature and extent of contamination.
SERA (CH2M HILL, 2000)	2000	A SERA, constituting Steps 1 and 2 of the ecological risk assessment (ERA) process, was completed using data collected as part of the Site Investigation. Based upon a comparison of groundwater, surface soil, and sediment concentrations to ecological screening criteria, inorganic and organic COPCs were identified for each medium. The SERA concluded that the potential for 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 Ecological Risk Assessment (BERA) (CH2M HILL, 2001)	2001	A BERA, constituting Step 3 of the ERA process, was completed using data collected as part of the Site Investigation. The BERA concluded that, although terrestrial habitat size and quality are limited at Solid Waste Management Unit (SWMU) 3, concentrations of select metals and one SVOC in 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 low on the food chain (lower-trophic-level receptors). Only zinc was identified as posing a potential unacceptable risk 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 select metals, polycyclic aromatic hydrocarbons, and one SVOC in sediment; however, potential risks to upper-trophic-level aquatic receptors were negligible.
RI/Human Health Risk Assessment (HHRA)/ERA (CH2M HILL, 2005)	2002	Soil, groundwater, sediment, and surface water samples were collected to define the nature and extent of contamination and to evaluate potential human health and ecological risks. No potentially unacceptable human health or ecological risks associated with exposure to site 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, SVOCs, and metals. SVOCs and metals were detected in surface water, but the concentrations did not pose potentially unacceptable risks to human health or the environment. No potentially unacceptable human health risk was identified from exposure to sediment; however, potentially unacceptable ecological risks to lower-trophic-level receptors exposed to metals and polycyclic aromatic hydrocarbons 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 that the residues be removed.
Supplemental RI/ HHRA/ERA (CH2M HILL, 2009b)	2007/2008	Soil, groundwater, and sediment samples were collected to identify the source and extent of VOCs in groundwater and associated human health risks, define the extent of ABM in sediment, and assess the correlation between ABM content and metals concentrations in sediment. polycyclic aromatic hydrocarbons in sediment were determined to not be related to sandblasting at SWMU 3 and, therefore, were not investigated as part of the Supplemental RI. 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 associated with exposure to tetrachloroethene (PCE), vinyl chloride (VC), dibenzofuran, arsenic, iron, manganese, and thallium in groundwater. However, based upon calculated risk levels, frequency and magnitude of detected concentrations in groundwater, and/or a comparison of chemical concentrations to background concentrations (metals only), the risks associated with PCE, dibenzofuran, arsenic, iron, manganese, and thallium were considered acceptable and the Supplemental RI recommended no further action for these chemicals. There is no current vapor intrusion exposure pathway. However, due to the presence of VOCs in groundwater, and the uncertainties associated with quantifying risks associated with the potential future vapor intrusion pathway, it is assumed that vapor intrusion from shallow groundwater into

Previous Study / Investigation	Date	Investigation Activities
		indoor air could pose unacceptable risks to people occupying future buildings at SWMU 3. 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 Supplemental RI concluded that ABM tends to lie in the same places as elevated metal concentrations and is a good indicator of impacts from past sandblasting. The Supplemental RI recommended an evaluation of remedial alternatives to address constituents of concern (COCs) in groundwater (VC) and sediment (copper, lead, nickel, tin, and zinc). Additionally, it recommended addressing ABM and lead in soil. The Supplemental RI concluded no further action for surface water was warranted.
Pre-Feasibility Study (FS) Sediment Investigations (Remediation Boundary Delineation) (CH2M HILL, 2009a, and CH2M HILL, 2009c)	2009	Surface and subsurface sediment sampling was conducted to delineate the sediment remediation area boundary and define sediment dewatering and disposal characteristics for evaluation of remedial alternatives in an FS. As part of the Supplemental RI, the relationship between the metals COPC concentrations in surface sediment and the corresponding amount of ABM present was evaluated. The 2002 and 2007 surface sediment data indicated that as ABM content increased, concentrations of site COPCs (copper, lead, nickel, tin, and zinc) in surface sediment also increased. These correlations were used to calculate the COPC concentrations expected when ABM content is set at 1 percent (the lowest possible whole number; also, percent ABM in sediment was only estimated to the nearest whole number). These calculated COPC values, along with consideration of 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 (PRGs). The PRGs for copper, lead, and tin were established as the calculated value at 1 percent ABM; none of these PRGs exceeded the effects range-median (where available) and all were comparable to the maximum background concentration. The PRG for nickel was established as the maximum background concentration because maximum background exceeded the calculated value at 1 percent ABM and was below the effects range-median. For zinc, the effects range-median screening value was established as the PRG because the calculated value at 1 percent ABM exceeded all effects-based criteria. It should be noted, however, that the maximum background value for zinc also exceeded the effects range-median. To define the area requiring remedial action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the site was broken down into 100-by-100-foot grid cells and remediation quotients (RQs) were calculated as the ratio of the sediment concentration to the chemical-specific PRG. A grid cell was defined as requiring action and included in the preliminary remedial action area if ABM content was greater than 1 percent, the RQ for one or more individual COCs exceeded 1.5, or the average RQ for the five COCs exceeded 1. 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 cumulative impacts caused by multiple contaminants. The use of a threshold value of 1.5 for an individual contaminant was deemed appropriate based on the potential impacts of each contaminant at these levels and the spatial distribution of the contaminants. The threshold value of 1 for the mean of the five COCs acknowledges the distribution of all of the contaminants across the grid cell and cumulative impacts posed by multiple contaminants, particularly those exceeding ecological threshold values. The lateral and vertical extents of CERCLA-regulated contamination warranting remediation were adequately delineated in accordance with the established PRGs. In addition to breaking down the site into 100-by-100-foot grid cells, the extent of the petroleum-impacted sediment within the remediation area was delineated for consideration during remedial alternative development. Sediment dewatering and disposal characterization testing indicated sediment is non-hazardous and that both passive (geotextile tube) and mechanical (belt filter) dewatering technologies would be effective.

TABLE 1

Studies, Investigations, and Actions Summary

SMWU 3 Focused Feasibility Study Report

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

Previous Study / Investigation	Date	Investigation Activities
Risk Assessment Update (Groundwater to Surface Water) (CH2M HILL, 2012a)	2012	As a result of updates made to the conceptual site model, the viability of the future potable use scenario as an applicable human health exposure pathway for groundwater at the site and the human health and ecological risks associated with groundwater discharge to surface water were evaluated. Based on site-specific determinations on aquifer characteristics (groundwater is located within land made through the placement of dredge spoils and mixing of groundwater 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 Department of the Navy (Navy) and United States Environmental Protection Agency (USEPA), in consultation with the Virginia Department of Environmental Quality (VDEQ), agreed that potable use of groundwater is not a viable exposure scenario for human health risk evaluation at SWMU 3 under the current conceptual site model. Revision to the human health and ecological risk evaluations did not identify risk above regulatory target levels associated with the discharge of groundwater to surface water. Therefore, the Navy and USEPA, in consultation with VDEQ, agreed that no further evaluation of the groundwater to surface water transport pathway at SWMU 3 was warranted.
Benthic Invertebrate Evaluation (CH2M HILL, 2012b)	2012	Surface sediment sampling was conducted to evaluate the current condition of the benthic invertebrate community within the remediation boundary and determine if the condition of the benthic community is correlated with the concentrations of COCs and ABM content in sediment. Data indicated that the condition of the benthic community was positively correlated to COC concentrations and ABM content, with the portion of the site with the highest concentrations of metals and ABM content (Near Shore Area and portions of the Marina) typically having the most developed benthic invertebrate community relative to other areas of the site (Dry Dock and Offshore Areas), where metals concentrations and ABM content are typically lower. Additionally, data indicated low bioavailability of metals in sediment. Physical conditions at the site not related to impacts from CERCLA-regulated contamination (low dissolved oxygen [DO] and high percentage of fine-grained sediment) were generally better predictors of the condition of the benthic community, indicating that these conditions may have a stronger impact on the survival of the benthic invertebrate community than CERCLA-regulated contamination. 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 should these factors change over time; therefore, remedial action at SWMU 3 was determined to be warranted. The evaluation recommended that, given the current physical characteristics in the Dry Dock and Offshore Areas (primarily low bottom DO concentrations), it is unlikely that a benthic invertebrate community that would approach that in a similar urban reference area would be established following remedial action. Therefore, it was determined that the remedial action objective established for the site should focus on the reduction of metals concentrations and not the establishment of a benthic invertebrate community.
Non-time-critical Removal Action (NTCRA) (CH2M HILL, 2012c, and CH2M HILL, 2013c)	2012/2013	In December 2012, an Engineering Evaluation/Cost Analysis (EE/CA) was finalized to evaluate NTCRA alternatives to mitigate potential unacceptable ecological risks in sediment surrounding the dry dock and its anchoring system. The alternative selected included mechanical dredging of impacted sediment, disposal of dredged materials in a Subtitle D landfill, and replacement with clean fill. A public notice was published 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 the Navy signed an Action Memorandum 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. As documented in the EE/CA, because ABM itself is not toxic and does not pose risk to the environment, the Navy and USEPA, in consultation with VDEQ, agreed that the presence of ABM in sediment does not itself drive the need for action at SWMU 3. Additionally, the Navy and USEPA, in consultation with VDEQ, agreed that within the previously established 100-by-100-foot grid pattern, a grid cell was defined as requiring action if the RQ for one or more individual COCs exceeded 1.5 *and* the average RQ for the five COCs exceeded 1. All available surface sediment data were used to refine the lateral remediation area boundary. In December 2012, prior to implementation of the NTCRA, removal area delineation sampling was conducted to determine the vertical extent of the remediation area and depth of removal required for mitigation of ecological risk in sediment. Sediment samples were collected from each grid cell located within the CERCLA remediation area, in 1-foot depth intervals, to determine the depth at which COC concentrations were below cleanup criteria. All samples were analyzed for the site COCs (copper, lead, nickel, tin, and zinc) and RQs were calculated. With the exception of grid cell SD609A, the vertical extent of the remediation area was defined. For grid cell SD609A, the COC concentrations did not meet the cleanup criteria in the deepest sample, collected from 5 to 5.5 feet

Previous Study / Investigation	Date	Investigation Activities
		below the sediment surface. Beginning in February 2013, 12,600 cubic yards of sediment were dredged from the removal action area in Little Creek Harbor. As a result of engineering constraints, sediment within 50 feet of the bulk-head shoreline, 10 feet of piers, and 20 feet of the shoreline revetment were inaccessible via dredging and left in place. Also, although initially included in the removal action area, grid cell 01 was not dredged as a result of dredge barge inaccessibility. Dredged materials were transported via barge to Port Weanack, James City County, Virginia, where they were solidified and offloaded for transport and disposal in a Subtitle D landfill. Following dredging activities, the site was restored through placement of a clean sand layer. Grid cells where previous subsurface sediment sampling results indicated petroleum-like material that 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 finalized to document completion of removal activities and mitigation of ecological risks associated with SWMU 3 sediment within the final NTCRA area, with the exception of grid cell 01.
Risk Assessment Update (Vapor Intrusion) (CH2M HILL, 2013a)	2013	Vapor intrusion is not considered a current exposure pathway at SWMU 3, and therefore was not evaluated as part of the HHRA in the RI and Supplemental RI. However, due to the presence of VOCs in groundwater, and the uncertainties associated with quantifying risks from the potential future vapor intrusion pathway, it was assumed that vapor intrusion from shallow groundwater into indoor air could pose unacceptable risks to people occupying buildings at SWMU 3 in the future. 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 Supplemental RI. Potentially unacceptable risks associated with trichloroethene (TCE) and VC were identified based on maximum detected concentrations of VOCs in groundwater. However, calculated risks are representative of site conditions in 2007. Based upon current site conditions, and proximity of elevated TCE and VC concentrations to the adjacent shoreline, concentrations of these chemicals are expected to have undergone natural degradation as well as transport via 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 2013c, CH2M HILL, December 2013d, and Tetra Tech, September 2014)	2013/2014	An Action Memorandum 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 (greater than 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 6 months, which could have allowed storm events to move contaminated sediment into areas dredged and backfilled during the NTCRA. A second Action Memorandum 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, 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. Beginning in November 2013, approximately 1,300 cubic yards of sediment and 320 cubic yards of soil were removed, transported, and disposed of offsite. The lateral and 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 (greater than 400 mg/kg) was confirmed through pre-excavation confirmation soil sampling and post-excavation confirmation sampling. 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 areas where dredging was determined to be infeasible, 2 inches of powdered activated carbon delivered as part of a pebble-like aggregate 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.

Notes:

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

TABLE 2

Summary of Groundwater and Indoor Air Human Health Risks Above USEPA Target Risk Levels

SMWU 3 Focused Feasibility Study Report

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

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								
2009 SRI HHRA								
Future Resident Adult	PCE	34 µg/L	N/A	0.16	N/A	0.016	N/A	1×10^{-2}
	TCE	30 µg/L	N/A	0.16	N/A	0.018	N/A	6×10^{-3}
	VC	12 µg/L	N/A	0.13	N/A	0.022	N/A	3×10^{-3}
	cis-1,2-DCE	60 µg/L	N/A	0.18	N/A	0.019	N/A	1×10^{-2}
	Dibenzofuran	28 µg/L	N/A	1.7	N/A	0.27	N/A	1×10^{-3}
	Antimony	2.2 µg/L	N/A	0.15	N/A	0.047	N/A	4×10^{-4}
	Thallium	5.0 µg/L	N/A	2.0	N/A	0.33	N/A	7×10^{-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	1×10^{-2}
	TCE	30 µg/L	N/A	0.37	N/A	0.058	N/A	6×10^{-3}
	VC	12 µg/L	N/A	0.27	N/A	0.068	N/A	3×10^{-3}
	cis-1,2-DCE	60 µg/L	N/A	0.42	N/A	0.06	N/A	1×10^{-2}
	Dibenzofuran	28 µg/L	N/A	4.0	N/A	0.69	N/A	1×10^{-3}
	Antimony	2.2 µg/L	N/A	0.36	N/A	0.16	N/A	4×10^{-4}
	Arsenic	7.1 µg/L	N/A	1.5	N/A	0.69	N/A	3×10^{-4}
	Iron	15,000 µg/L	N/A	1.4	N/A	0.33	N/A	7×10^{-1}
	Manganese	460 µg/L	N/A	1.7	N/A	0.69	N/A	2×10^{-2}
	Thallium	5.0 µg/L	N/A	4.6	N/A	1.1	N/A	7×10^{-5}
	Receptor Total	*N/A*	*N/A*	*15*	*N/A*	*4.0*	*N/A*	*N/A*

TABLE 2

Summary of Groundwater and Indoor Air Human Health Risks Above USEPA Target Risk Levels

SMWU 3 Focused Feasibility Study Report

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

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 Resident Adult/Child	1,2-DCA	1.5 µg/L	3.1×10^{-6}	N/A	8.5×10^{-7}	N/A	9.1×10^{-2}	N/A
	Benzene	1.3 µg/L	1.5×10^{-6}	N/A	4.6×10^{-7}	N/A	5.5×10^{-2}	N/A
	PCE	34 µg/L	4.4×10^{-4}	N/A	3.1×10^{-5}	N/A	5.4×10^{-1}	N/A
	TCE	30 µg/L	6.9×10^{-6}	N/A	5.2×10^{-7}	N/A	1.1×10^{-2}	N/A
	VC	12 µg/L	2.6×10^{-4}	N/A	3.6×10^{-5}	N/A	1.4	N/A
	Arsenic	7.1 µg/L	1.6×10^{-4}	N/A	3.9×10^{-5}	N/A	1.5	N/A
	Receptor Total	*N/A*	*8.6×10^{-4}*	*N/A*	*1.1×10^{-4}*	*N/A*	*N/A*	*N/A*
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[3]	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*

TABLE 2

Summary of Groundwater and Indoor Air Human Health Risks Above USEPA Target Risk Levels

SMWU 3 Focused Feasibility Study Report

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

Receptor	COPC	RME EPC[1]	Total RME		Total CTE		Inhalation Unit Risk Factor (IUR)[2]	Inhalation Reference Concentration (RfC)[2]
			Cancer Risk	Non-Cancer Hazard	Cancer Risk	Non-Cancer Hazard		
Indoor Air								
Future Adult Resident	TCE[4]	5.61 µg/m^3	1.0 x 10^{-5}	2.7	3.0 x 10^{-6}	0.6	1.0 x 10^{-6}/ 3.1x10^{-6}	2.0 x 10^{-3}
	VC	142 µg/m^3	9.0 x 10^{-4}	1.4	7.0 x 10^{-5}	0.11	4.4 x 10^{-6}	1.0 x 10^{-1}
	Receptor Total	*N/A*	*9.0 x 10^{-4}*	*5.0*	*7.5 x 10^{-5}*	*0.9*	*N/A*	*N/A*

µg/L – microgram per liter

µg/m^3 – 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/m^3-1 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/m^3 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% 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 indoor air EPCs were calculated using 2007 groundwater data and EPA's Vapor Intrusion Screening Level calculator, current at the time the VI assessment was conducted (2013). USEPA's default attenuation factor of 0.001 was utilized. The RME EPC for indoor air was calculated using the maximum detected groundwater concentration. The CTE EPC for indoor was calculated using the 95% UCL of the mean groundwater concentration.

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 Risk estimates for TCE take into account mutagenic mode of action on the kidney (CSF = 9.3x10^{-3}) and are added to the risk estimates for liver and non-Hodgkin's Lymphoma (CSF = 3.7x10^{-2}).

4 Risk estimates for TCE take into account mutagenic mode of action on the kidney (IUR = 1.1$10^{-6}$) and are added to the risk estimates for liver and non-Hodgkin's Lymphoma (IUR = 3.1x10^{-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 3

Risk Management Considerations

SWMU 3 Focused Feasibility Study

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

Risk Driver	Risk Management Consideration
Dibenzofuran	- No CTE risks or hazards above USEPA's acceptable levels (Table 2). - 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.
Antimony	- RME and CTE HIs for antimony are below 1 (Table 2). 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 blood HI. - Concentrations of total and dissolved antimony are below the MCL. - Concentrations of dissolved antimony are below background.
Arsenic	- No discernable plume of arsenic concentrations above the MCL. - Concentrations are within range of detected background concentrations. - Reducing conditions indicated by low DO and negative ORP may have increased the mobility of naturally occurring arsenic.
Chromium*	- 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.
Cobalt*	- 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).

TABLE 3

Risk Management Considerations

SWMU 3 Focused Feasibility Study

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

Iron	- No CTE risks or hazards above USEPA's acceptable levels (Table 2). - 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).
Manganese	- No CTE risks or hazards above USEPA's acceptable levels (Table 2). - 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)].
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 detected been detected in 46 groundwater samples collected in January 2007, September 2007, Janury 2008, and September 2008.

* 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.

TABLE 4

Groundwater Preliminary Remediation Goals

SMWU 3 Focused Feasibility Study Report

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

Constituent of Concern	2014 Maximum Detected Concentration (µg/L)	Preliminary Remediation Goal (µg/L)
TCE	6.01	5
VC	15.9	2

TABLE 5

Evaluation Criteria

SWMU 3 Focused Feasibility Study Report

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

Evaluation Criteria	Description
Overall Protection of Human Health and the Environment	This criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence and short-term effectiveness. This evaluation focuses on whether each alternative achieves adequate protection and describes how site risks are being eliminated, reduced, or controlled. This criterion allows for consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.
Compliance with Applicable or Relevant and Appropriate requirements (ARARs)	This criterion is used to determine whether each alternative will meet all of the federal and state ARARs that have been identified. ARARs are discussed in Section 3.3. The following factors will be considered as each alternative is evaluated for this criterion on federal and state levels: • Compliance with location-specific ARARs • Compliance with chemical-specific ARARs • Compliance with action-specific ARARs • Compliance with other criteria, advisories, or guidelines
Long-term Effectiveness and Permanence	This criterion addresses the results of the remedial action in terms of risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following factors will be considered as each alternative is evaluated for this criterion: • Magnitude of estimated residual risk • Adequacy and reliability of controls
Reduction of Toxicity, Mobility, and Volume Through Treatment	This criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of hazardous substances, and thereby reduce the principal threats at a site. The following factors will be considered as each alternative is evaluated for this criterion: • Treatment processes used and materials treated • Amount of hazardous material destroyed or treated • Degree of expected reduction in toxicity, mobility, or volume • Degree to which treatment is irreversible • Type and quantity of residuals remaining after treatment • Satisfaction of the statutory preference for treatment as a principal element
Short-term Effectiveness	This criterion addresses the effects of the alternative on human health and the environment during the construction and implementation phases until remedial action objectives (RAOs) are met. The following factors will be considered as each alternative is evaluated for this criterion: • Protection of community during remedial actions • Protection of workers during remedial actions • Environmental impacts • Time to achieve the RAOs
Implementability	This criterion addresses the technical and administrative feasibility of implementing each alternative, as well as the availability of services and materials required for implementation. The following factors will be considered as each alternative is evaluated for this criterion: • Technical feasibility - Ability to construct, operate, and monitor the technology - Reliability of the technology - Ease of undertaking additional remedial action, if necessary - Ability to monitor the effectiveness • Administrative feasibility - Ability to coordinate with and obtain approvals from other agencies - Availability of equipment, specialists, technologies, off-property treatment, storage or disposal services, and capacity
Cost	This criterion evaluates alternatives based on the associated capital cost and operations and maintenance cost to achieve the RAOs. The estimated cost of each remedial option is expressed as present value based on an assumed discount rate of 3.0 percent over a 30-year operation period. The discount rate was selected based on information from the Federal Office of Management and Budget (http://www.whitehouse.gov/omb/circulars_a094_a94_appx-c/). Note that the 30-year operations and maintenance period is assumed for evaluation purposes only; the actual operations and maintenance period could be much longer in some cases. Cost estimates have been prepared in accordance with United States Environmental Protection Agency guidance (USEPA, 2000) and represent a plus 50 to minus 30 percent range of accuracy.
State Acceptance	This criterion evaluates the technical and administrative issues and concerns the state may have regarding each of the alternatives. This criterion is not discussed in this report, but will be addressed in the Record of Decision (ROD).
Community Acceptance	This criterion evaluates the technical and administrative issues and concerns the public may have regarding each of the alternatives. This criterion is not discussed in this report, but will be addressed in the Proposed Plan and ROD.

TABLE 6

Comparative Analysis of Remedial Alternatives

SWMU 3 Focused Feasibility Study Report

Joint Expeditionary Base Little Creek

Virginia Beach, Virginia

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Monitored Natural Attenuation and Land Use Controls
Overall Protection of Human Health and the Environment	Not Protective	Protective
Compliance with Applicable or Relevant and Appropriate Requirements	Does Not Comply	Complies
Long-term Effectiveness and Permanence	Ineffective	Effective
Reduction of Toxicity, Mobility, and Volume Through Treatment	Ineffective	Effective
Short-term Effectiveness	Ineffective	Effective
Implementability	Easy	Easy
Cost	No Cost	$370,000

Figures

R:\USNAVFACENGCOM405450\LITTLECREEK\MAPFILES\379837_SWMU3_FOCUSED_FS\FIGURE 1 - BASE LOCATION MAP.MXD CBOWMAN 1/20/2014 7:47:09 AM

Legend

Installation Boundary

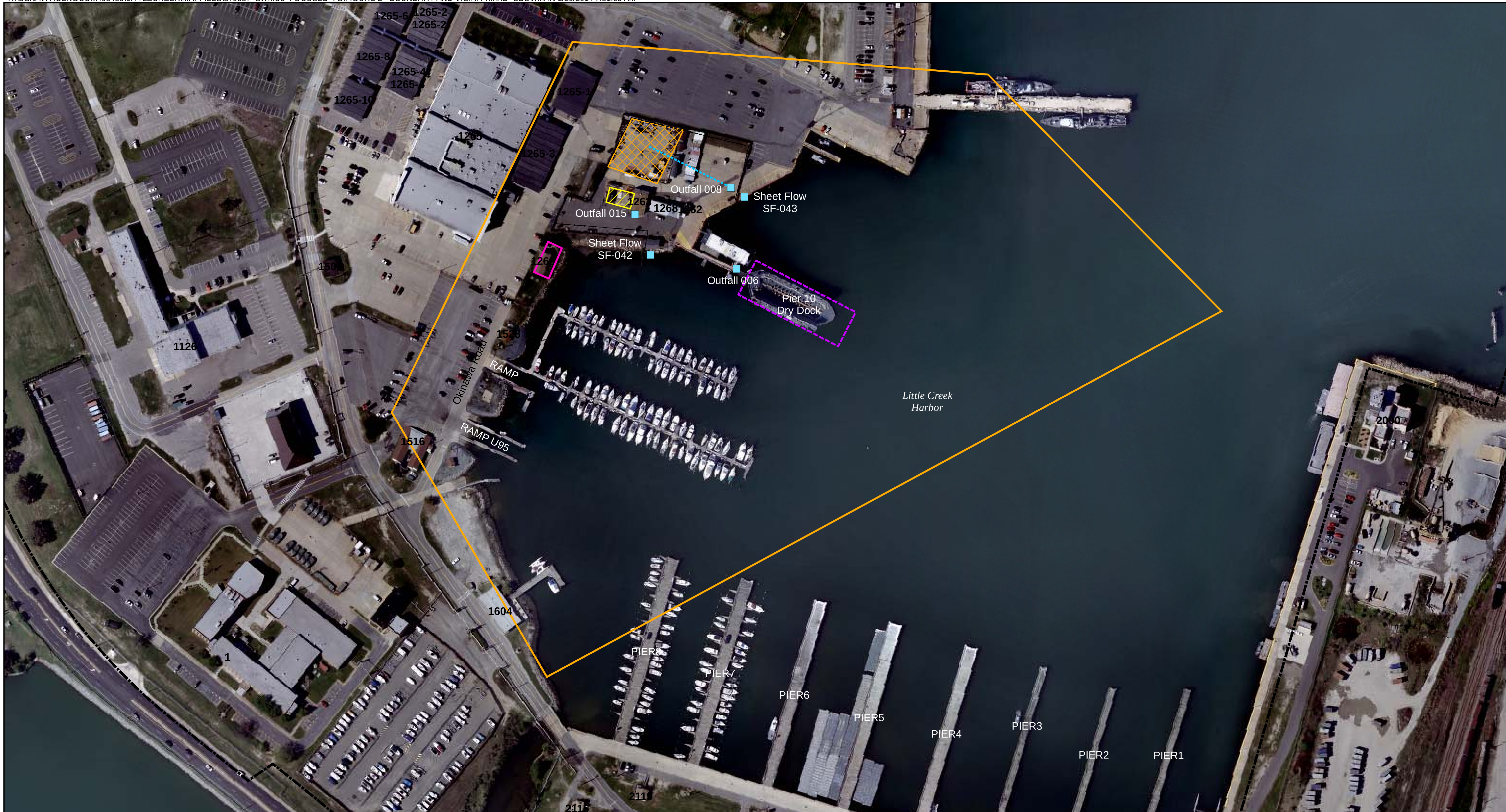
SWMU 3 Study Area Boundary

N W E S

0 1,500 3,000 Feet

Figure 1
SWMU 3 Location Map
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

CH2MHILL



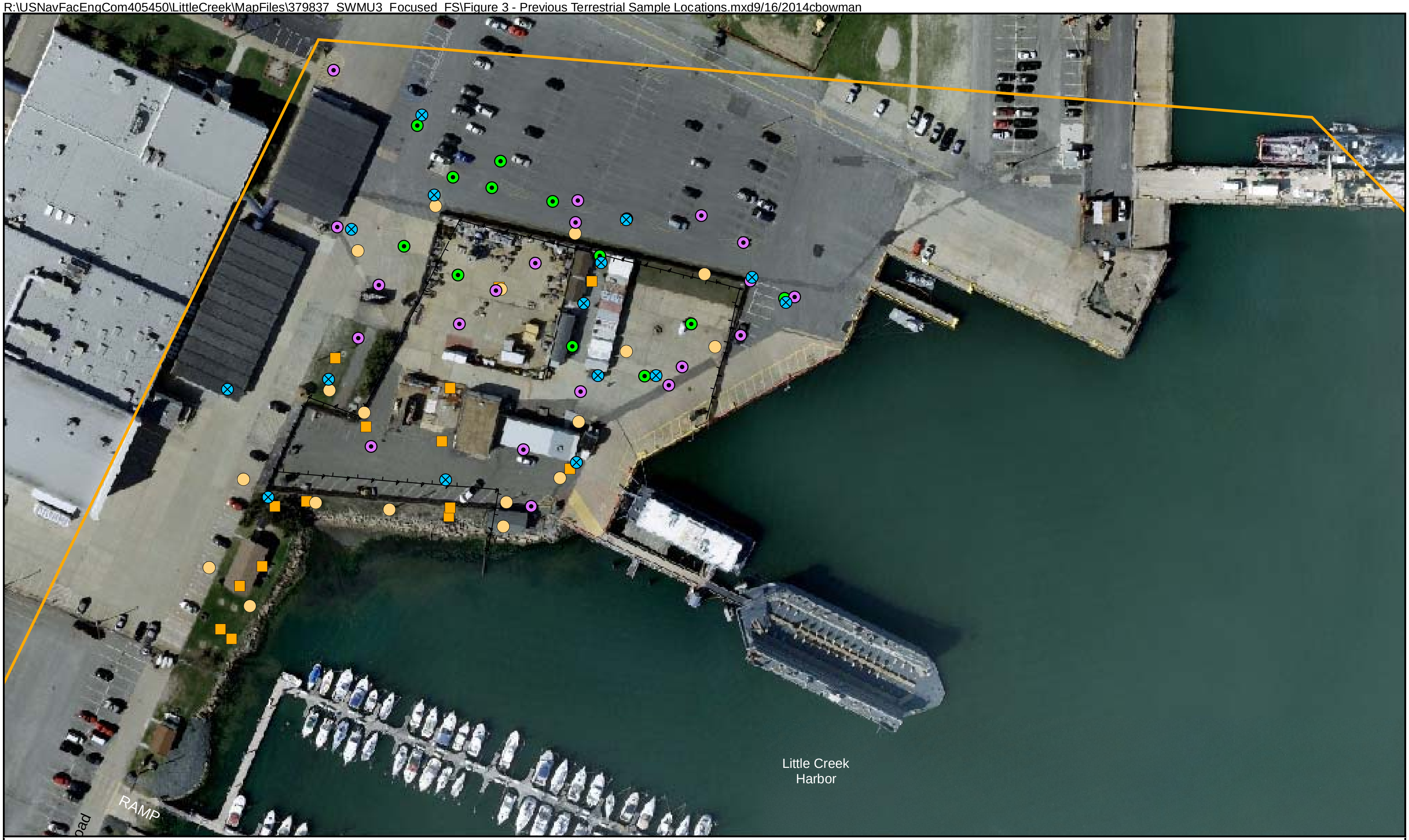
Legend

- Outfall Locations
- Underground Drain Pipe
- Picnic Area
- Fenced Area
- 1999 Dredging Limits
- SWMU 3 Study Area Boundary
- Former Sandblasting Area (1962-1995)
- More Recent Sandblasting Area (1995-1996)

Figure 2
SWMU 3 Boundary and Immediate Vicinity
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

CH2MHILL

R:\USNavFacEngCom405450\LittleCreek\MapFiles\379837_SWMU3_Focused_FS\Figure 3 - Previous Terrestrial Sample Locations.mxd9/16/2014cbowman



Legend

- 1998 Subsurface Soil Sample Location
- 2002/2007 Surface/Subsurface Soil Sample Location
- 2002 Groundwater Grab Location
- 2007 MIP and DPT Grab Groundwater Sample Location
- Monitoring Well Location
- Study Area Boundary

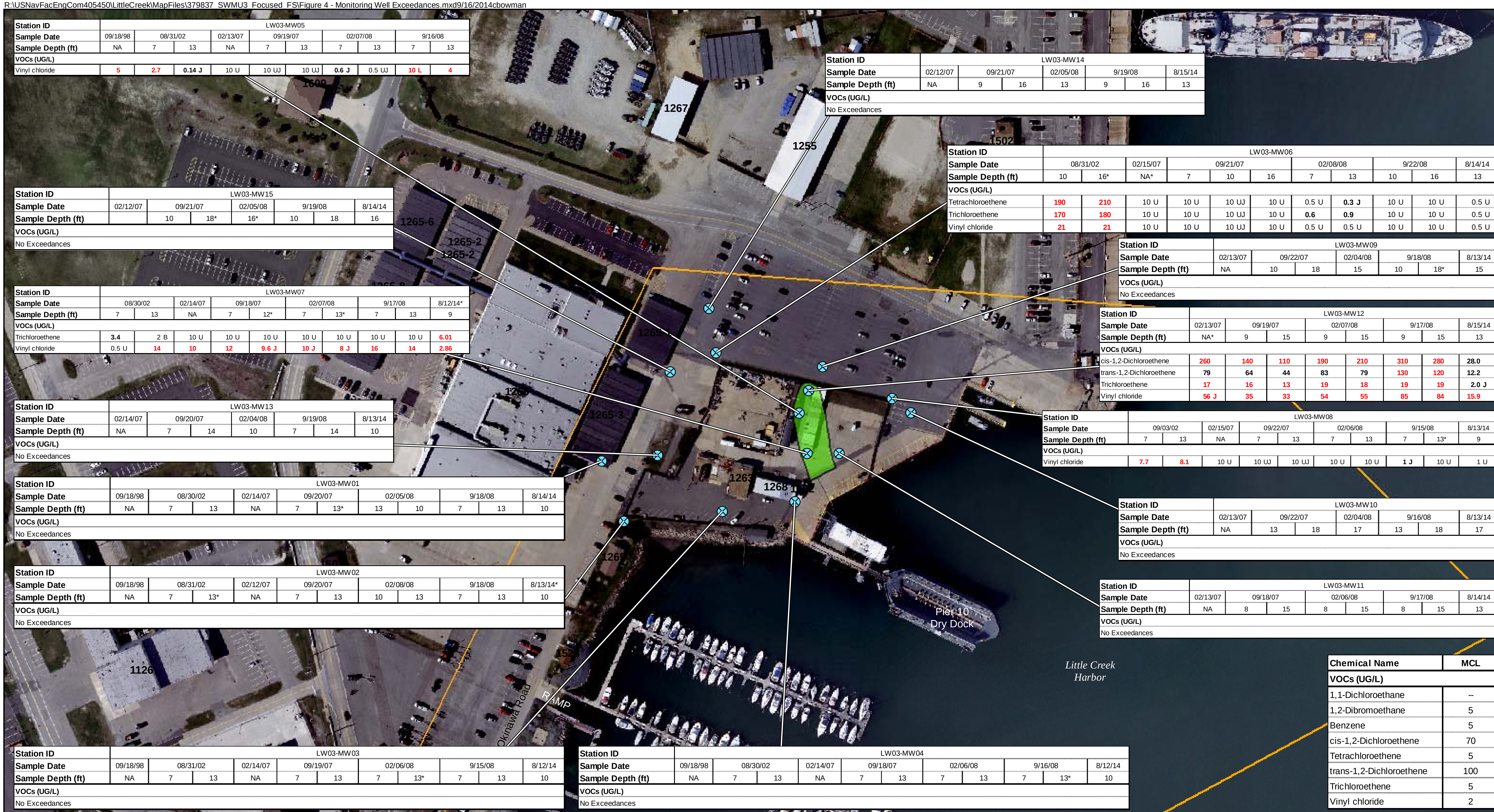
N W E S

0 60 120 Feet

Figure 3
Previous Terrestrial Sample Locations
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

CH2MHILL

R:\USNavFacEngCom405450\LittleCreek\MapFiles\379837_SWMU3_Focused_FS\Figure 4 - Monitoring Well Exceedances.mxd9/16/2014cbowman



Station ID	LW03-MW05									
Sample Date	09/18/98	08/31/02		02/13/07	09/19/07		02/07/08		9/16/08	
Sample Depth (ft)	NA	7	13	NA	7	13	7	13	7	13
VOCs (UG/L)										
Vinyl chloride	**5**	**2.7**	**0.14 J**	10 U	10 UJ	10 UJ	**0.6 J**	0.5 UJ	**10 L**	**4**

Station ID	LW03-MW14						
Sample Date	02/12/07	09/21/07		02/05/08	9/19/08		8/15/14
Sample Depth (ft)	NA	9	16	13	9	16	13
VOCs (UG/L)							
No Exceedances							

Station ID	LW03-MW06										
Sample Date	08/31/02		02/15/07	09/21/07			02/08/08		9/22/08		8/14/14
Sample Depth (ft)	10	16*	NA*	7	10	16	7	13	10	16	13
VOCs (UG/L)											
Tetrachloroethene	**190**	**210**	10 U	10 U	10 UJ	10 U	0.5 U	**0.3 J**	10 U	10 U	0.5 U
Trichloroethene	**170**	**180**	10 U	10 U	10 UJ	10 U	**0.6**	**0.9**	10 U	10 U	0.5 U
Vinyl chloride	**21**	**21**	10 U	10 U	10 UJ	10 U	0.5 U	0.5 U	10 U	10 U	0.5 U

Station ID	LW03-MW15						
Sample Date	02/12/07	09/21/07		02/05/08	9/19/08		8/14/14
Sample Depth (ft)		10	18*	16*	10	18	16
VOCs (UG/L)							
No Exceedances							

Station ID	LW03-MW09						
Sample Date	02/13/07	09/22/07		02/04/08	9/18/08		8/13/14
Sample Depth (ft)	NA	10	18	15	10	18*	15
VOCs (UG/L)							
No Exceedances							

Station ID	LW03-MW07									
Sample Date	08/30/02		02/14/07	09/18/07		02/07/08		9/17/08		8/12/14*
Sample Depth (ft)	7	13	NA	7	12*	7	13*	7	13	9
VOCs (UG/L)										
Trichloroethene	**3.4**	2 B	10 U	10 U	10 U	10 U	10 U	10 U	10 U	**6.01**
Vinyl chloride	0.5 U	**14**	**10**	**12**	**9.6 J**	**10 J**	**8 J**	**16**	**14**	**2.86**

Station ID	LW03-MW12							
Sample Date	02/13/07	09/19/07		02/07/08		9/17/08		8/15/14
Sample Depth (ft)	NA*	9	15	9	15	9	15	13
VOCs (UG/L)								
cis-1,2-Dichloroethene	**260**	**140**	**110**	**190**	**210**	**310**	**280**	**28.0**
trans-1,2-Dichloroethene	**79**	**64**	**44**	**83**	**79**	**130**	**120**	**12.2**
Trichloroethene	**17**	**16**	**13**	**19**	**18**	**19**	**19**	**2.0 J**
Vinyl chloride	**56 J**	**35**	**33**	**54**	**55**	**85**	**84**	**15.9**

Station ID	LW03-MW13						
Sample Date	02/14/07	09/20/07		02/04/08	9/19/08		8/13/14
Sample Depth (ft)	NA	7	14	10	7	14	10
VOCs (UG/L)							
No Exceedances							

Station ID	LW03-MW08									
Sample Date	09/03/02		02/15/07	09/22/07		02/06/08		9/15/08		8/13/14
Sample Depth (ft)	7	13	NA	7	13	7	13	7	13*	9
VOCs (UG/L)										
Vinyl chloride	**7.7**	**8.1**	10 U	10 UJ	10 UJ	10 U	10 U	**1 J**	10 U	1 U

Station ID	LW03-MW01										
Sample Date	09/18/98	08/30/02		02/14/07	09/20/07		02/05/08		9/18/08		8/14/14
Sample Depth (ft)	NA	7	13	NA	7	13*	13	10	7	13	10
VOCs (UG/L)											
No Exceedances											

Station ID	LW03-MW10						
Sample Date	02/13/07	09/22/07		02/04/08	9/16/08		8/13/14
Sample Depth (ft)	NA	13	18	17	13	18	17
VOCs (UG/L)							
No Exceedances							

Station ID	LW03-MW02										
Sample Date	09/18/98	08/31/02		02/12/07	09/20/07		02/08/08		9/18/08		8/13/14*
Sample Depth (ft)	NA	7	13*	NA	7	13	10	13	7	13	10
VOCs (UG/L)											
No Exceedances											

Station ID	LW03-MW11							
Sample Date	02/13/07	09/18/07		02/06/08		9/17/08		8/14/14
Sample Depth (ft)	NA	8	15	8	15	8	15	13
VOCs (UG/L)								
No Exceedances								

Chemical Name	MCL
VOCs (UG/L)	
1,1-Dichloroethane	--
1,2-Dibromoethane	5
Benzene	5
cis-1,2-Dichloroethene	70
Tetrachloroethene	5
trans-1,2-Dichloroethene	100
Trichloroethene	5
Vinyl chloride	2

Station ID	LW03-MW03										
Sample Date	09/18/98	08/31/02		02/14/07	09/19/07		02/06/08		9/15/08		8/12/14
Sample Depth (ft)	NA	7	13	NA	7	13	7	13*	7	13	10
VOCs (UG/L)											
No Exceedances											

Station ID	LW03-MW04										
Sample Date	09/18/98	08/30/02		02/14/07	09/18/07		02/06/08		9/16/08		8/12/14
Sample Depth (ft)	NA	7	13	NA	7	13	7	13	7	13*	10
VOCs (UG/L)											
No Exceedances											

Legend

- Monitoring Well Location
- COC Plume Boundary
- SWMU 3 Study Area Boundary
- Installation Boundary

Notes:
Bold text indicates detection
Bold red text indicates exceedance of MCL
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
L - Analyte present, value may be biased low, actual value may be higher
UJ - Analyte not detected, quantitation limit may be inaccurate
UL - Analyte not detected, quantitation limit is probably higher
UG/L - Micrograms per liter
*-A duplicate sample was collected and the higher of the two results is shown.
VOC - Volatile Organic Compound

N
W E
S

0 150 300 Feet

Figure 4
Monitoring Well Exceedances
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

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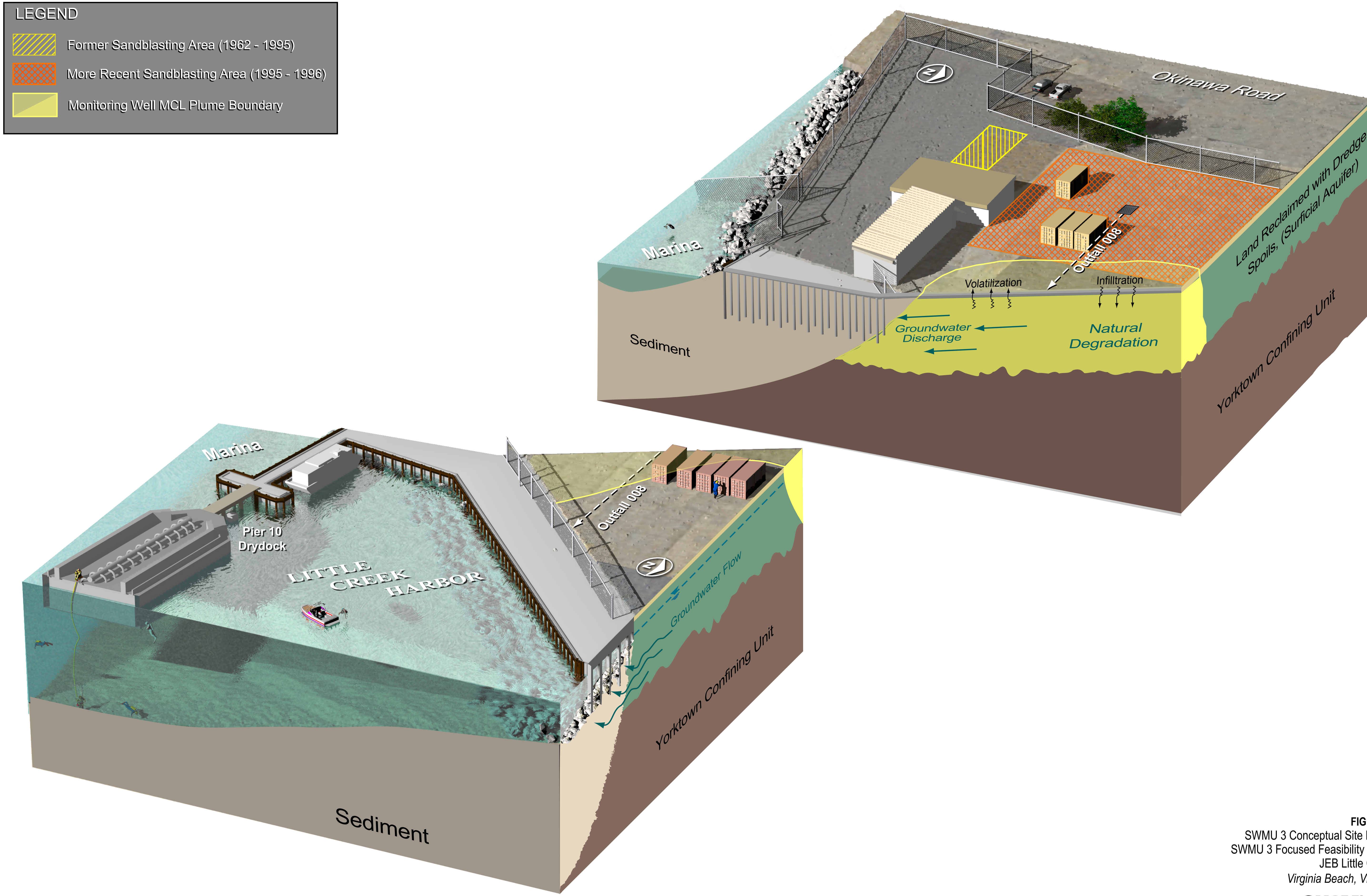


FIGURE 5
SWMU 3 Conceptual Site Model
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

CH2MHILL

Legend

- Former Monitoring Well
- Monitoring Well Location
- Contour
- Groundwater Flow Direction
- SWMU 3 Study Area Boundary
- Installation Boundary

Note:
* - Groundwater elevation data not used. Monitoring well was previously located underneath a portable building and was not able to be re-surveyed in 2007 with all other site monitoring wells. Survey data is presumed to be outdated.

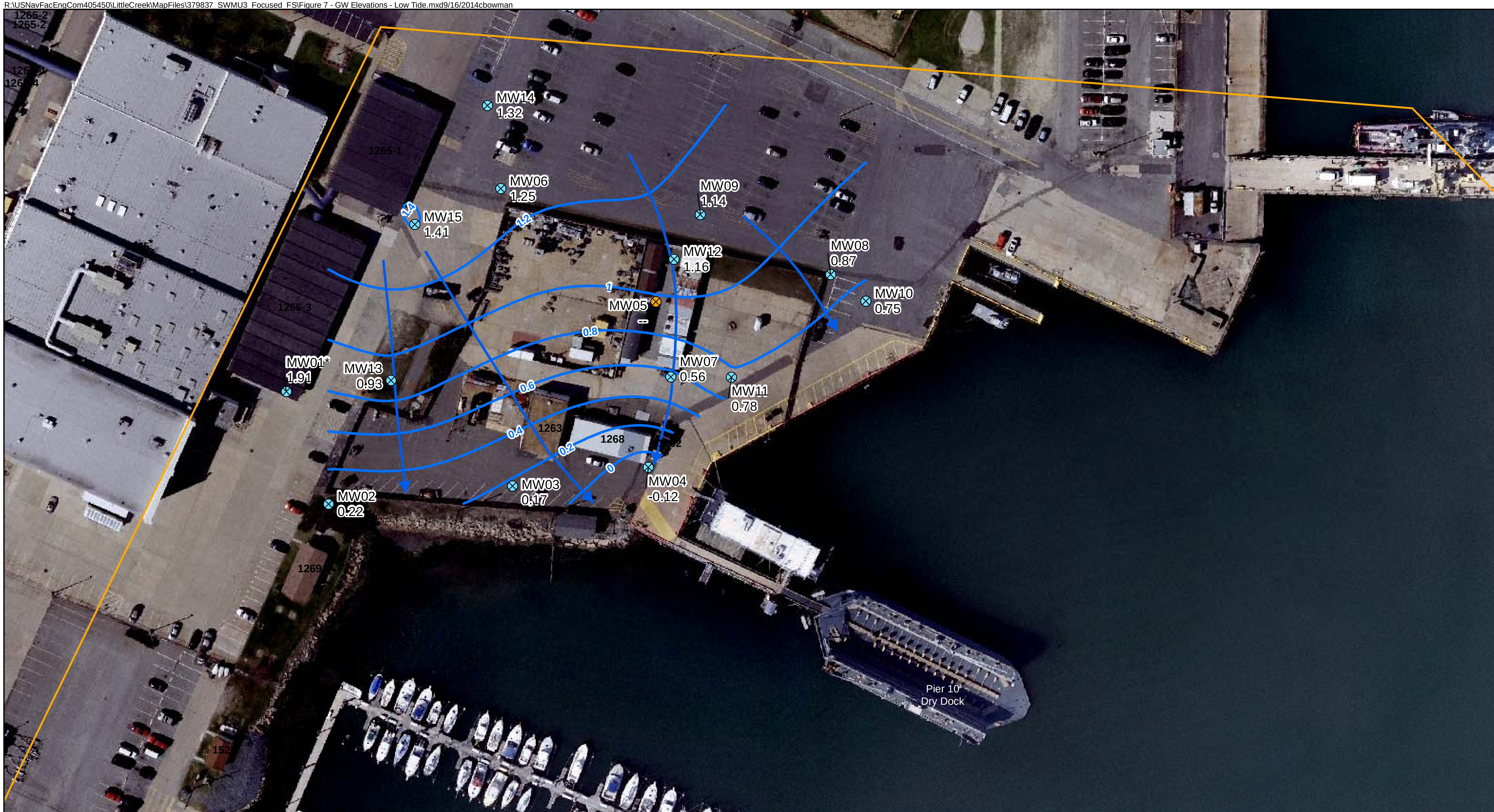
N W E S

0 80 160 Feet

Figure 6
Groundwater Flow – August 2014 High-Tide
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

CH2MHILL

R:\USNavFacEngCom405450\LittleCreek\MapFiles\379837_SWMU3_Focused_FS\Figure 7 - GW Elevations - Low Tide.mxd9/16/2014cbowman



Legend

- Former Monitoring Well
- Monitoring Well Location
- Contour
- Groundwater Flow Direction
- SWMU 3 Study Area Boundary
- Installation Boundary

Note:
* - Groundwater elevation data not used. Monitoring well was previously located underneath a portable building and was not able to be re-surveyed in 2007 with all other site monitoring wells. Survey data is presumed to be outdated.

N W E S

0 80 160 Feet

Figure 7
Groundwater Flow – August 2014 Low-Tide
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

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R:\USNavFacEngCom405450\LittleCreek\MapFiles\379837_SWMU3_Focused_FS\Figure 8 - Conceptual Remedy Layout.mxd9/23/2014cbowman

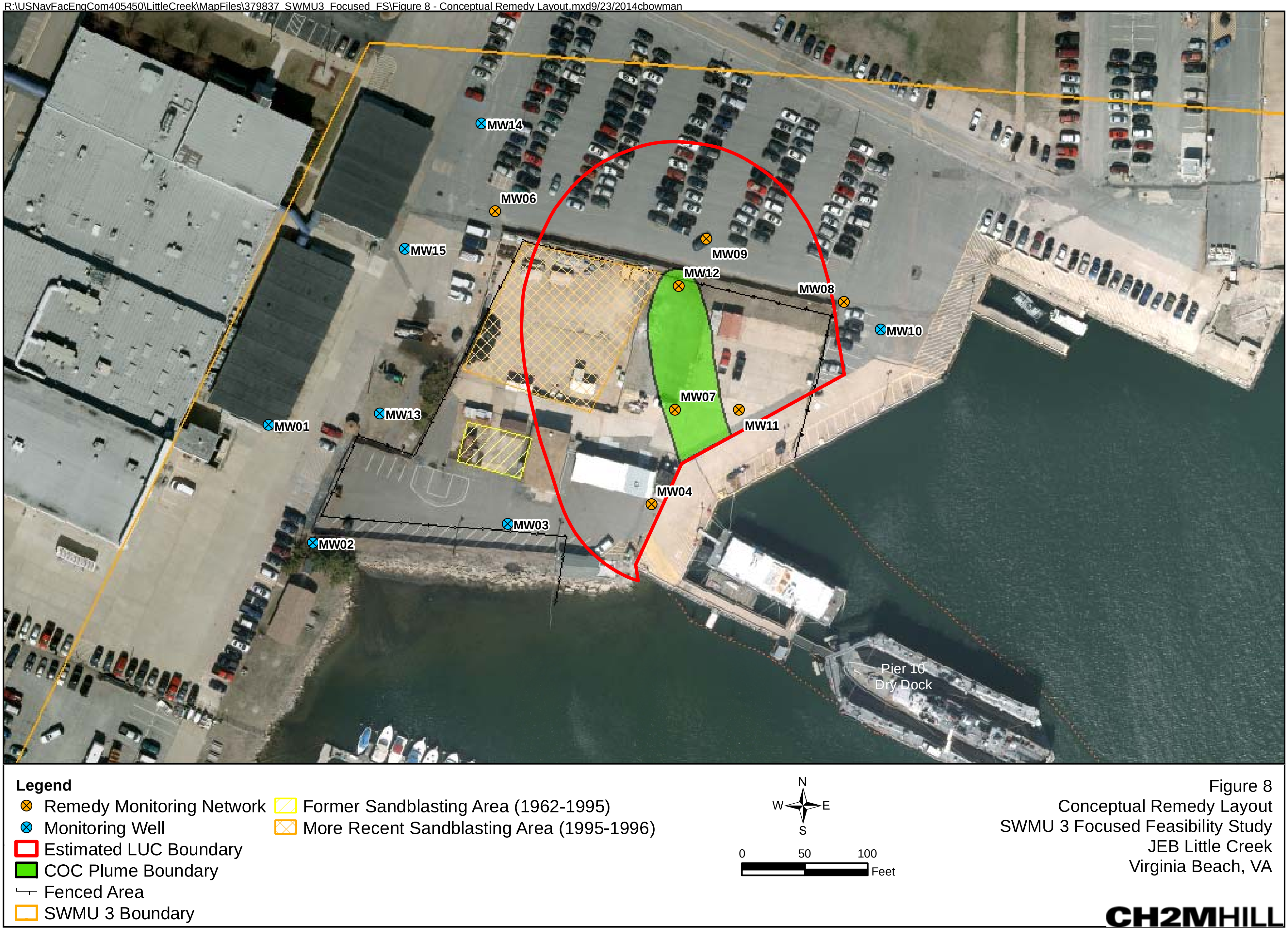

Figure 8
Conceptual Remedy Layout
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, VA

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Appendix A
Raw Analytical Data

Station ID	LW03-MW01					LW03-MW02					
Sample ID	LW03-MW01-07-08A	LW03-MW01-13-08A	LW03-MW01-07-08C	LW03-MW01-13-08C	LW03-MW01-14C	LW03-MW02-10-08A	LW03-MW02-13-08A	LW03-MW02-07-08C	LW03-MW02-13-08C	LW03-MW02-14C	LW03-MW02P-14C
Sample Date	02/05/08	02/05/08	09/18/08	09/18/08	08/14/14	02/08/08	02/08/08	09/18/08	09/18/08	08/13/14	08/13/14
Chemical Name											
Volatile Organic Compounds (UG/L)											
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 UJ	0.5 UJ	0.5 U	0.5 U	NA	NA
1,1,2-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,1-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2,4-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2-Dibromoethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
1,2-Dichloroethene (total)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,3-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,4-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
2-Butanone	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	NA	NA
2-Hexanone	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	NA	NA
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	NA	NA
Acetone	5 U	5 U	5 U	5 U	NA	5 U	5	5 U	5 U	NA	NA
Benzene	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
Bromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Bromodichloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Bromoform	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Bromomethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Carbon disulfide	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Carbon tetrachloride	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Chlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Chloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 UJ	0.5 UJ	0.5 U	0.5 U	NA	NA
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Chloromethane	0.5 U	0.5 U	0.5 U	0.3 B	NA	0.5 U	0.5 U	0.3 B	0.3 B	NA	NA
cis-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 UJ	0.5 U	0.5 U	0.5 U	1 U	1 U
cis-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Cyclohexane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Dichlorodifluoromethane (Freon-12)	0.5 U	0.5 U	0.5 UJ	0.5 UJ	NA	0.5 U	0.5 U	0.5 UJ	0.5 UJ	NA	NA
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Isopropylbenzene	0.2 J	0.2 J	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
m- and p-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl acetate	0.5 UJ	0.5 UJ	0.5 R	0.5 R	NA	0.5 UJ	0.5 UJ	0.5 R	0.5 R	NA	NA
Methylcyclohexane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Methylene chloride	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.8	0.5 U	0.5 U	NA	NA
Methyl-tert-butyl ether (MTBE)	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
Toluene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
trans-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 UJ	0.5 U	0.5 U	0.5 U	1 U	1 U
trans-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Trichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
Trichlorofluoromethane (Freon-11)	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	NA	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	NA	NA
Vinyl chloride	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	1 U
Xylene, total	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA

Table A-1
Pre-Feasibility Study Raw Analytical Data
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	LW03-MW01					LW03-MW02					
Sample ID	LW03-MW01-07-08A	LW03-MW01-13-08A	LW03-MW01-07-08C	LW03-MW01-13-08C	LW03-MW01-14C	LW03-MW02-10-08A	LW03-MW02-13-08A	LW03-MW02-07-08C	LW03-MW02-13-08C	LW03-MW02-14C	LW03-MW02P-14C
Sample Date	02/05/08	02/05/08	09/18/08	09/18/08	08/14/14	02/08/08	02/08/08	09/18/08	09/18/08	08/13/14	08/13/14
Chemical Name											
Semivolatile Organic Compounds (UG/L)											
Dibenzofuran	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	NA	NA
Total Metals (UG/L)											
Thallium	1 U	1 U	2 U	2 U	NA	5 U	5 U	5 U	5 U	NA	NA
Dissolved Metals (UG/L)											
Thallium, Dissolved	1 U	1 U	2 U	2 U	NA	5 U	5 U	5 U	5 U	NA	NA
Wet Chemistry											
Acetate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	NA	1 U	NA
Alkalinity (mg/l)	NA	NA	NA	NA	302	NA	NA	NA	NA	95.5	NA
Butyrate (mg/l)	NA	NA	NA	NA	2 U	NA	NA	NA	NA	2 U	NA
Chloride (mg/l)	NA	NA	NA	NA	450 D	NA	NA	NA	NA	11,000 D	NA
Ethane (mg/l)	NA	NA	NA	NA	0.002 U	NA	NA	NA	NA	0.002 U	NA
Ethene (mg/l)	NA	NA	NA	NA	0.002 U	NA	NA	NA	NA	0.002 U	NA
Ferrous iron (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lactate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	NA	1 U	NA
Methane (mg/l)	NA	NA	NA	NA	2.34 D	NA	NA	NA	NA	0.42	NA
Nitrate (mg/l)	NA	NA	NA	NA	0.1 U	NA	NA	NA	NA	0.1 U	NA
Nitrite (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propionate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	NA	1 U	NA
Pyruvate (mg/l)	NA	NA	NA	NA	0.5 U	NA	NA	NA	NA	0.5 U	NA
Sulfate (mg/l)	NA	NA	NA	NA	5.87	NA	NA	NA	NA	1,520 D	NA
Sulfide (mg/l)	NA	NA	NA	NA	1.82 U	NA	NA	NA	NA	1.33 J	NA
Total dissolved solids (TDS) (mg/l)	NA	NA	NA	NA	1,050	NA	NA	NA	NA	20,500	NA
Total organic carbon (TOC) (mg/l)	NA	NA	NA	NA	4.17	NA	NA	NA	NA	2.22 J	NA

Notes:
Shading indicates detections
NA - Not analyzed
* - Duplicate analysis was not within control limits
B - Analyte not detected above the level reported in blanks
D - Compound identified in an analysis at a secondary dilution factor
J - Analyte present, value may or may not be accurate or precise
K - Analyte present, value may be biased high, actual value may be lower
L - Analyte present, value may be biased low, actual value may be higher
R - Unreliable Result
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccurate
UL - Analyte not detected, quantitation limit is probably higher
MG/L - Milligrams per liter
UG/L - Micrograms per liter

Station ID	LW03-MW03						LW03-MW04					
Sample ID	LW03-MW03-07-08A	LW03-MW03-13-08A	LW03-MW03P-13-08A	LW03-MW03-07-08C	LW03-MW03-13-08C	LW03-MW03-14C	LW03-MW04-07-08A	LW03-MW04-13-08A	LW03-MW04-07-08C	LW03-MW04-13-08C	LW03-MW04P-07-08C	LW03-MW04-14C
Sample Date	02/06/08	02/06/08	02/06/08	09/15/08	09/15/08	08/12/14	02/06/08	02/06/08	09/16/08	09/16/08	09/16/08	08/12/14
Chemical Name												
Volatile Organic Compounds (UG/L)												
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,1,2-Trichloroethane	0.5 U	0.5 UJ	0.5 UJ	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,1-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.4 J	0.6	0.4 J	0.6	0.4 J	1 U
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dibromoethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U
1,2-Dichloroethene (total)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U	NA	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,3-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,4-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
2-Butanone	5 U	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	5 U	NA
2-Hexanone	5 U	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	5 U	NA
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	5 U	NA
Acetone	5 U	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	5 U	NA
Benzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U
Bromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Bromodichloromethane	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U	NA	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA
Bromoform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Bromomethane	0.5 UJ	0.5 UJ	0.5 UJ	0.5 U	0.5 U	NA	0.5 UJ	0.5 UJ	0.5 U	0.5 U	0.5 U	NA
Carbon disulfide	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Carbon tetrachloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Chlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Chloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Chloromethane	0.5 U	0.5 U	0.5 U	0.2 B	0.5 U	NA	0.5 U	0.5 U	0.1 B	0.2 B	0.2 B	NA
cis-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.2 J	1 U	2	2	2	4	3	2.48
cis-1,3-Dichloropropene	0.5 U	0.5 UJ	0.5 UJ	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Cyclohexane	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U	NA	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Dichlorodifluoromethane (Freon-12)	0.5 U	0.5 U	0.5 U	0.5 UJ	0.5 UJ	NA	0.5 U	0.5 U	0.5 UJ	0.5 UJ	0.5 UJ	NA
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Isopropylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
m- and p-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl acetate	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Methylcyclohexane	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U	NA	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA
Methylene chloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Methyl-tert-butyl ether (MTBE)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U
Toluene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
trans-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.6	0.9	0.6	1	0.6	1 U
trans-1,3-Dichloropropene	0.5 U	0.5 UJ	0.5 UJ	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Trichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.2 J	0.3 J	0.5 U	0.5 U	0.5 U	1 U
Trichlorofluoromethane (Freon-11)	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	NA	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	NA
Vinyl chloride	0.5 UJ	0.5 UJ	0.5 UJ	0.5 U	0.5 U	1 U	0.5 UJ	0.5 UJ	0.5 U	0.5 U	0.5 U	1 U
Xylene, total	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA

Table A-1
Pre-Feasibility Study Raw Analytical Data
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	LW03-MW03						LW03-MW04					
Sample ID	LW03-MW03-07-08A	LW03-MW03-13-08A	LW03-MW03P-13-08A	LW03-MW03-07-08C	LW03-MW03-13-08C	LW03-MW03-14C	LW03-MW04-07-08A	LW03-MW04-13-08A	LW03-MW04-07-08C	LW03-MW04-13-08C	LW03-MW04P-07-08C	LW03-MW04-14C
Sample Date	02/06/08	02/06/08	02/06/08	09/15/08	09/15/08	08/12/14	02/06/08	02/06/08	09/16/08	09/16/08	09/16/08	08/12/14
Chemical Name												
Semivolatile Organic Compounds (UG/L)												
Dibenzofuran	10 U	10 U	10 U	11 U	11 U	NA	10 U	10 U	10 U	10 U	10 U	NA
Total Metals (UG/L)												
Thallium	5 U	5 U	1 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	5 U	NA
Dissolved Metals (UG/L)												
Thallium, Dissolved	5 U	5 U	1 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	5 U	NA
Wet Chemistry												
Acetate (mg/l)	NA	NA	NA	NA	NA	1 U	NA	NA	NA	NA	NA	1 U
Alkalinity (mg/l)	NA	NA	NA	NA	NA	178	NA	NA	NA	NA	NA	115
Butyrate (mg/l)	NA	NA	NA	NA	NA	2 U	NA	NA	NA	NA	NA	2 U
Chloride (mg/l)	NA	NA	NA	NA	NA	1,080 D	NA	NA	NA	NA	NA	4,150 D
Ethane (mg/l)	NA	NA	NA	NA	NA	0.002 U	NA	NA	NA	NA	NA	0.002 U
Ethene (mg/l)	NA	NA	NA	NA	NA	0.002 U	NA	NA	NA	NA	NA	0.002 U
Ferrous iron (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lactate (mg/l)	NA	NA	NA	NA	NA	1 U	NA	NA	NA	NA	NA	1 U
Methane (mg/l)	NA	NA	NA	NA	NA	0.0584	NA	NA	NA	NA	NA	0.0377
Nitrate (mg/l)	NA	NA	NA	NA	NA	0.1 U	NA	NA	NA	NA	NA	0.07 J
Nitrite (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propionate (mg/l)	NA	NA	NA	NA	NA	1 U	NA	NA	NA	NA	NA	1 U
Pyruvate (mg/l)	NA	NA	NA	NA	NA	0.5 U	NA	NA	NA	NA	NA	0.5 U
Sulfate (mg/l)	NA	NA	NA	NA	NA	132	NA	NA	NA	NA	NA	585 D
Sulfide (mg/l)	NA	NA	NA	NA	NA	1.79 U	NA	NA	NA	NA	NA	0.873 J
Total dissolved solids (TDS) (mg/l)	NA	NA	NA	NA	NA	2,110	NA	NA	NA	NA	NA	7,840
Total organic carbon (TOC) (mg/l)	NA	NA	NA	NA	NA	4.31	NA	NA	NA	NA	NA	2.32 J

Notes:

Shading indicates detections
NA - Not analyzed
* - Duplicate analysis was not within control limits
B - Analyte not detected above the level reported in blanks
D - Compound identified in an analysis at a secondary dilutic
J - Analyte present, value may or may not be accurate or pre
K - Analyte present, value may be biased high, actual value
L - Analyte present, value may be biased low, actual value n
R - Unreliable Result
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccura
UL - Analyte not detected, quantitation limit is probably highe
MG/L - Milligrams per liter
UG/L - Micrograms per liter

Station ID	LW03-MW05				LW03-MW06						
Sample ID	LW03-MW05-07-08A	LW03-MW05-13-08A	LW03-MW05-07-08C	LW03-MW05-13-08C	LW03-MW06-07-08A	LW03-MW06-13-08A	LW03-MW06-10-08C	LW03-MW06-16-08C	LW03-MW06P-16-08C	LW03-MW06-07-08C	LW03-MW06-14C
Sample Date	02/07/08	02/07/08	09/16/08	09/16/08	02/08/08	02/08/08	09/22/08	09/22/08	09/22/08	09/22/09	08/14/14
Chemical Name											
Volatile Organic Compounds (UG/L)											
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	0.5 UJ	10 U	10 U	10 U	10 U	NA
1,1,2-Trichloroethane	0.5 UJ	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 U	10 U	10 U	10 U	10 U	NA
1,1-Dichloroethane	0.5 J	0.3 J	4 L	2	0.5 U	0.5 U	10 U	10 U	10 U	10 U	0.5 U
1,1-Dichloroethene	0.5 U	0.5 U	0.5 L	0.2 J	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 R	10 R	10 R	10 R	NA
1,2-Dibromoethane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
1,2-Dichlorobenzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
1,2-Dichloroethane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	0.5 U
1,2-Dichloroethene (total)	NA	NA	NA	NA	NA	NA	10 U	10 U	10 U	10 U	NA
1,2-Dichloropropane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 UJ	10 U	10 U	10 U	10 U	NA
1,3-Dichlorobenzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
1,4-Dichlorobenzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
2-Butanone	5 U	5 U	5 UL	5 U	5 U	5 U	10 U	10 U	10 U	10 U	NA
2-Hexanone	5 U	5 U	5 UL	5 U	5 U	5 U	10 U	10 U	10 U	10 U	NA
4-Methyl-2-pentanone	5 U	5 U	5 UL	5 U	5 U	5 U	10 U	10 U	10 U	10 U	NA
Acetone	5 U	5 U	5 UL	5 U	5 U	5 U	10 U	10 U	10 U	10 U	NA
Benzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	0.5 U
Bromochloromethane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	NA	NA	NA	NA	NA
Bromodichloromethane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 UJ	10 U	10 U	10 U	10 U	NA
Bromoform	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Bromomethane	0.5 UJ	0.5 UJ	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Carbon disulfide	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Carbon tetrachloride	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Chlorobenzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Chloroethane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 UJ	10 U	10 U	10 U	10 U	NA
Chloroform	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Chloromethane	0.5 U	0.5 U	0.5 UL	0.3 B	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
cis-1,2-Dichloroethene	1	0.4 J	27	11	0.2 J	0.3 J	10 U	10 U	10 U	10 U	0.5 U
cis-1,3-Dichloropropene	0.5 UJ	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 U	10 U	10 U	10 U	10 U	NA
Cyclohexane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 UJ	10 U	10 U	10 U	10 U	NA
Dibromochloromethane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Dichlorodifluoromethane (Freon-12)	0.5 U	0.5 U	0.5 UL	0.5 UJ	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Ethylbenzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Isopropylbenzene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
m- and p-Xylene	NA	NA	NA	NA	NA	NA	10 U	10 U	10 U	10 U	NA
Methyl acetate	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 UJ	10 U	10 U	10 U	10 U	NA
Methylcyclohexane	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 UJ	10 U	10 U	10 U	10 U	NA
Methylene chloride	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Methyl-tert-butyl ether (MTBE)	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
o-Xylene	NA	NA	NA	NA	NA	NA	10 U	10 U	10 U	10 U	NA
Styrene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
Tetrachloroethene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.3 J	10 U	10 U	10 U	10 U	0.5 U
Toluene	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA
trans-1,2-Dichloroethene	0.5 U	0.5 U	9 L	4	0.5 U	0.5 U	10 U	10 U	10 U	10 U	0.5 U
trans-1,3-Dichloropropene	0.5 UJ	0.5 U	0.5 UL	0.5 U	0.5 UJ	0.5 U	10 U	10 U	10 U	10 U	NA
Trichloroethene	0.5 U	0.5 U	2 L	0.8	0.6	0.9	10 U	10 U	10 U	10 U	0.5 U
Trichlorofluoromethane (Freon-11)	0.5 UJ	0.5 UJ	0.5 UL	0.5 UJ	0.5 UJ	0.5 UJ	10 U	10 U	10 U	10 U	NA
Vinyl chloride	0.6 J	0.5 UJ	10 L	4	0.5 U	0.5 U	10 U	10 U	10 U	10 U	0.5 U
Xylene, total	0.5 U	0.5 U	0.5 UL	0.5 U	0.5 U	0.5 U	10 U	10 U	10 U	10 U	NA

Station ID	LW03-MW05				LW03-MW06						
Sample ID	LW03-MW05-07-08A	LW03-MW05-13-08A	LW03-MW05-07-08C	LW03-MW05-13-08C	LW03-MW06-07-08A	LW03-MW06-13-08A	LW03-MW06-10-08C	LW03-MW06-16-08C	LW03-MW06P-16-08C	LW03-MW06-07-08C	LW03-MW06-14C
Sample Date	02/07/08	02/07/08	09/16/08	09/16/08	02/08/08	02/08/08	09/22/08	09/22/08	09/22/08	09/22/09	08/14/14
Chemical Name											
Semivolatile Organic Compounds (UG/L)											
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	NA
Total Metals (UG/L)											
Thallium	1 U	1 U	5 U	5 U	1 U	1 U	5 U	5 U	5 U	5 U	NA
Dissolved Metals (UG/L)											
Thallium, Dissolved	5 U	1 U	5 U	5 U	1 U	1 U	5 U	5 U	5 U	5 U	NA
Wet Chemistry											
Acetate (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1 U
Alkalinity (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	189
Butyrate (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2 U
Chloride (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	688 D
Ethane (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.002 U
Ethene (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.002 U
Ferrous iron (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lactate (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1 U
Methane (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.33
Nitrate (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.1 U
Nitrite (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propionate (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1 U
Pyruvate (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.5 U
Sulfate (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	97.7
Sulfide (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.82 U
Total dissolved solids (TDS) (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,470
Total organic carbon (TOC) (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.6 J

Notes:

Shading indicates detections
NA - Not analyzed
* - Duplicate analysis was not within control limits
B - Analyte not detected above the level reported in blanks
D - Compound identified in an analysis at a secondary dilutio
J - Analyte present, value may or may not be accurate or pre
K - Analyte present, value may be biased high, actual value
L - Analyte present, value may be biased low, actual value n
R - Unreliable Result
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccura
UL - Analyte not detected, quantitation limit is probably highe
MG/L - Milligrams per liter
UG/L - Micrograms per liter

Station ID	LW03-MW07							LW03-MW08					
Sample ID	LW03-MW07-07-08A	LW03-MW07-13-08A	LW03-MW07P-07-08A	LW03-MW07-07-08C	LW03-MW07-13-08C	LW03-MW07-14C	LW03-MW07P-14C	LW03-MW08-07-08A	LW03-MW08-13-08A	LW03-MW08-07-08C	LW03-MW08-13-08C	LW03-MW08P-07-08C	LW03-MW08-14C
Sample Date	02/07/08	02/07/08	02/07/08	09/17/08	09/17/08	08/12/14	08/12/14	02/06/08	02/06/08	09/15/08	09/15/08	09/15/08	08/13/14
Chemical Name													
Volatile Organic Compounds (UG/L)													
1,1,1-Trichloroethane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,1,2-Trichloroethane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,1-Dichloroethane	7 J	7 J	7 J	6 J	5 J	2.95	3.01	6 J	4 J	2 J	2 J	2 J	1.06 J
1,1-Dichloroethene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,2-Dibromo-3-chloropropane	10 U	10 U	10 U	10 R	10 R	NA	NA	10 U	10 U	10 R	10 R	10 R	NA
1,2-Dibromoethane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,2-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,2-Dichloroethane	10 U	10 U	10 U	10 U	10 U	1 U	1 U	10 U	10 U	10 U	10 U	10 U	1 U
1,2-Dichloroethene (total)	29	24	31	41	37	NA	NA	2 J	2 J	2 J	2 J	2 J	NA
1,2-Dichloropropane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,3-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
1,4-Dichlorobenzene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
2-Butanone	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
2-Hexanone	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
4-Methyl-2-pentanone	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Acetone	10 U	10 UJ	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	2 B	10 U	NA
Benzene	10 U	10 U	10 U	10 U	10 U	1 U	1 U	10 U	10 U	10 U	10 U	10 U	1 U
Bromochloromethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromodichloromethane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Bromoform	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Bromomethane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Carbon disulfide	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Carbon tetrachloride	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Chlorobenzene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Chloroethane	10 U	10 U	10 U	10 U	10 U	NA	NA	38	23	33	25	36	NA
Chloroform	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Chloromethane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
cis-1,2-Dichloroethene	22	18	24	30	27	12.4	12.9	2 J	2 J	2 J	2 J	2 J	1 U
cis-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Cyclohexane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Dibromochloromethane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Dichlorodifluoromethane (Freon-12)	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Ethylbenzene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Isopropylbenzene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
m- and p-Xylene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Methyl acetate	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Methylcyclohexane	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Methylene chloride	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Methyl-tert-butyl ether (MTBE)	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
o-Xylene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Styrene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Tetrachloroethene	10 U	10 U	10 U	10 U	10 U	1 U	1 U	10 U	10 U	10 U	10 U	10 U	1 U
Toluene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
trans-1,2-Dichloroethene	7 J	6 J	7 J	11	10 J	2.69	2.68	10 U	10 U	10 U	10 U	10 U	1 U
trans-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Trichloroethene	10 U	10 U	10 U	10 U	10 U	5.79	6.01	10 U	10 U	10 U	10 U	10 U	1 U
Trichlorofluoromethane (Freon-11)	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Vinyl chloride	10 J	8 J	10 J	16	14	2.86	2.86	10 U	10 U	1 J	10 U	1 J	1 U
Xylene, total	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA

Table A-1
Pre-Feasibility Study Raw Analytical Data
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	LW03-MW07							LW03-MW08					
Sample ID	LW03-MW07-07-08A	LW03-MW07-13-08A	LW03-MW07P-07-08A	LW03-MW07-07-08C	LW03-MW07-13-08C	LW03-MW07-14C	LW03-MW07P-14C	LW03-MW08-07-08A	LW03-MW08-13-08A	LW03-MW08-07-08C	LW03-MW08-13-08C	LW03-MW08P-07-08C	LW03-MW08-14C
Sample Date	02/07/08	02/07/08	02/07/08	09/17/08	09/17/08	08/12/14	08/12/14	02/06/08	02/06/08	09/15/08	09/15/08	09/15/08	08/13/14
Chemical Name													
Semivolatile Organic Compounds (UG/L)													
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10 U	NA
Total Metals (UG/L)													
Thallium	1 U	0.3 B	1 U	1 U	1 U	NA	NA	1 U	1 U	1 U	1 U	1 U	NA
Dissolved Metals (UG/L)													
Thallium, Dissolved	1 U	1 U	1 U	1 U	1 U	NA	NA	1 U	1 U	1 U	1 U	1 U	NA
Wet Chemistry													
Acetate (mg/l)	NA	NA	NA	NA	NA	1 U	NA	NA	NA	NA	NA	NA	1 U
Alkalinity (mg/l)	NA	NA	NA	NA	NA	313	NA	NA	NA	NA	NA	NA	275
Butyrate (mg/l)	NA	NA	NA	NA	NA	2 U	NA	NA	NA	NA	NA	NA	2 U
Chloride (mg/l)	NA	NA	NA	NA	NA	151	NA	NA	NA	NA	NA	NA	129
Ethane (mg/l)	NA	NA	NA	NA	NA	0.002 U	NA	NA	NA	NA	NA	NA	0.002 U
Ethene (mg/l)	NA	NA	NA	NA	NA	0.002 U	NA	NA	NA	NA	NA	NA	0.002 U
Ferrous iron (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lactate (mg/l)	NA	NA	NA	NA	NA	1 U	NA	NA	NA	NA	NA	NA	1 U
Methane (mg/l)	NA	NA	NA	NA	NA	0.345 D	NA	NA	NA	NA	NA	NA	0.476 D
Nitrate (mg/l)	NA	NA	NA	NA	NA	0.085 J	NA	NA	NA	NA	NA	NA	0.1 U
Nitrite (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propionate (mg/l)	NA	NA	NA	NA	NA	1 U	NA	NA	NA	NA	NA	NA	1 U
Pyruvate (mg/l)	NA	NA	NA	NA	NA	0.5 U	NA	NA	NA	NA	NA	NA	0.5 U
Sulfate (mg/l)	NA	NA	NA	NA	NA	89.5	NA	NA	NA	NA	NA	NA	30.8
Sulfide (mg/l)	NA	NA	NA	NA	NA	1.82 U	NA	NA	NA	NA	NA	NA	1.92 U
Total dissolved solids (TDS) (mg/l)	NA	NA	NA	NA	NA	696	NA	NA	NA	NA	NA	NA	575
Total organic carbon (TOC) (mg/l)	NA	NA	NA	NA	NA	5.92	NA	NA	NA	NA	NA	NA	7.77

Notes:

Shading indicates detections
NA - Not analyzed
* - Duplicate analysis was not within control limits
B - Analyte not detected above the level reported in blanks
D - Compound identified in an analysis at a secondary dilutic
J - Analyte present, value may or may not be accurate or pre
K - Analyte present, value may be biased high, actual value
L - Analyte present, value may be biased low, actual value n
R - Unreliable Result
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccura
UL - Analyte not detected, quantitation limit is probably highe
MG/L - Milligrams per liter
UG/L - Micrograms per liter

Station ID	LW03-MW09					LW03-MW10				LW03-MW11				
Sample ID	LW03-MW09-15-08A	LW03-MW09-10-08C	LW03-MW09-18-08C	LW03-MW09P-18-08C	LW03-MW09-14C	LW03-MW10-17-08A	LW03-MW10-13-08C	LW03-MW10-18-08C	LW03-MW10-14C	LW03-MW11-08-08A	LW03-MW11-15-08A	LW03-MW11-08-08C	LW03-MW11-15-08C	LW03-MW11-14C
Sample Date	02/04/08	09/18/08	09/18/08	09/18/08	08/13/14	02/04/08	09/16/08	09/16/08	08/13/14	02/06/08	02/06/08	09/17/08	09/17/08	08/14/14
Chemical Name														
Volatile Organic Compounds (UG/L)														
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,1,2-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 UJ	0.5 U	0.5 U	NA
1,1-Dichloroethane	0.2 J	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dibromoethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dichlorobenzene	0.5 U	0.5 U	0.3 J	0.3 J	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethene (total)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 UJ	0.5 U	0.5 U	NA
1,3-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,4-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
2-Butanone	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	NA
2-Hexanone	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	NA
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	NA
Acetone	5 U	5 U	5 U	5 U	NA	5 U	5 U	5 U	NA	5 U	5 U	5 U	5 U	NA
Benzene	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Bromodichloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 UJ	0.5 U	0.5 U	NA
Bromoform	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Bromomethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 UJ	0.5 UJ	0.5 U	0.5 U	NA
Carbon disulfide	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Carbon tetrachloride	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Chlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Chloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Chloromethane	0.5 U	0.2 B	0.2 B	0.2 B	NA	0.5 U	0.2 B	0.2 B	NA	0.5 U	0.5 U	0.5 U	0.2 B	NA
cis-1,2-Dichloroethene	4	3	2	2	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 UJ	0.5 U	0.5 U	NA
Cyclohexane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 UJ	0.5 U	0.5 U	NA
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Dichlorodifluoromethane (Freon-12)	0.5 U	0.5 UJ	0.5 UJ	0.5 UJ	NA	0.5 U	0.5 UJ	0.5 UJ	NA	0.5 U	0.5 U	0.5 UJ	0.5 UJ	NA
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Isopropylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
m- and p-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl acetate	0.5 UJ	0.5 R	0.5 R	0.5 R	NA	0.5 UJ	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 R	0.5 R	NA
Methylcyclohexane	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 UJ	0.5 U	0.5 U	NA
Methylene chloride	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Methyl-tert-butyl ether (MTBE)	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
o-Xylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA
trans-1,2-Dichloroethene	0.2 J	0.2 J	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 UJ	0.5 U	0.5 U	NA
Trichloroethene	0.6	0.4 J	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane (Freon-11)	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	NA	0.5 UJ	0.5 UJ	0.5 UJ	NA	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	NA
Vinyl chloride	0.8	0.6	0.5	0.5	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 UJ	0.5 UJ	0.5 U	0.5 U	0.5 U
Xylene, total	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	NA

Station ID	LW03-MW09					LW03-MW10				LW03-MW11				
Sample ID	LW03-MW09-15-08A	LW03-MW09-10-08C	LW03-MW09-18-08C	LW03-MW09P-18-08C	LW03-MW09-14C	LW03-MW10-17-08A	LW03-MW10-13-08C	LW03-MW10-18-08C	LW03-MW10-14C	LW03-MW11-08-08A	LW03-MW11-15-08A	LW03-MW11-08-08C	LW03-MW11-15-08C	LW03-MW11-14C
Sample Date	02/04/08	09/18/08	09/18/08	09/18/08	08/13/14	02/04/08	09/16/08	09/16/08	08/13/14	02/06/08	02/06/08	09/17/08	09/17/08	08/14/14
Chemical Name														
Semivolatile Organic Compounds (UG/L)														
Dibenzofuran	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	NA
Total Metals (UG/L)														
Thallium	1 U	1 U	1 U	1 U	NA	1 U	2 U	5 U	NA	1 U	1 U	5 U	5 U	NA
Dissolved Metals (UG/L)														
Thallium, Dissolved	1 U	1 U	1 U	1 U	NA	1 U	2 U	5 U	NA	1 U	0.14 B	5 U	5 U	NA
Wet Chemistry														
Acetate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	1 U	NA	NA	NA	NA	1 U
Alkalinity (mg/l)	NA	NA	NA	NA	197	NA	NA	NA	110	NA	NA	NA	NA	170
Butyrate (mg/l)	NA	NA	NA	NA	2 U	NA	NA	NA	2 U	NA	NA	NA	NA	2 U
Chloride (mg/l)	NA	NA	NA	NA	277 D	NA	NA	NA	537 D	NA	NA	NA	NA	877 D
Ethane (mg/l)	NA	NA	NA	NA	0.002 U	NA	NA	NA	0.002 U	NA	NA	NA	NA	0.00249 J
Ethene (mg/l)	NA	NA	NA	NA	0.002 U	NA	NA	NA	0.002 U	NA	NA	NA	NA	0.002 U
Ferrous iron (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lactate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	1 U	NA	NA	NA	NA	1 U
Methane (mg/l)	NA	NA	NA	NA	0.0997	NA	NA	NA	0.0454	NA	NA	NA	NA	0.163
Nitrate (mg/l)	NA	NA	NA	NA	0.1 U	NA	NA	NA	0.1 U	NA	NA	NA	NA	0.1 U
Nitrite (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propionate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	1 U	NA	NA	NA	NA	1 U
Pyruvate (mg/l)	NA	NA	NA	NA	0.5 U	NA	NA	NA	0.5 U	NA	NA	NA	NA	0.5 U
Sulfate (mg/l)	NA	NA	NA	NA	29.3	NA	NA	NA	119	NA	NA	NA	NA	70.9
Sulfide (mg/l)	NA	NA	NA	NA	1.82 U	NA	NA	NA	1.75 U	NA	NA	NA	NA	1.79 U
Total dissolved solids (TDS) (mg/l)	NA	NA	NA	NA	767	NA	NA	NA	1,190	NA	NA	NA	NA	1,740
Total organic carbon (TOC) (mg/l)	NA	NA	NA	NA	6.46	NA	NA	NA	2.52 J	NA	NA	NA	NA	1.78 J

Notes:
Shading indicates detections
NA - Not analyzed
* - Duplicate analysis was not within control limits
B - Analyte not detected above the level reported in blanks
D - Compound identified in an analysis at a secondary dilutic
J - Analyte present, value may or may not be accurate or pre
K - Analyte present, value may be biased high, actual value
L - Analyte present, value may be biased low, actual value n
R - Unreliable Result
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccura
UL - Analyte not detected, quantitation limit is probably highe
MG/L - Milligrams per liter
UG/L - Micrograms per liter

Station ID	LW03-MW12					LW03-MW13				LW03-MW14			
Sample ID	LW03-MW12-09-08A	LW03-MW12-15-08A	LW03-MW12-09-08C	LW03-MW12-15-08C	LW03-MW12-14C	LW03-MW13-10-08A	LW03-MW13-07-08C	LW03-MW13-14-08C	LW03-MW13-14C	LW03-MW14-13-08A	LW03-MW14-09-08C	LW03-MW14-16-08C	LW03-MW14-14C
Sample Date	02/07/08	02/07/08	09/17/08	09/17/08	08/15/14	02/04/08	09/19/08	09/22/08	08/13/14	02/05/08	09/19/08	09/19/08	08/15/14
Chemical Name													
Volatile Organic Compounds (UG/L)													
1,1,1-Trichloroethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,1,2-Trichloroethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,1-Dichloroethane	8 J	8 J	11	11	1.3 J	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U
1,1-Dichloroethene	2 J	2 J	3 J	3 J	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,2,3-Trichlorobenzene	NA	NA	NA	NA	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,2-Dibromo-3-chloropropane	10 U	10 U	10 R	10 R	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,2-Dibromoethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,2-Dichlorobenzene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,2-Dichloroethane	10 U	10 U	10 U	10 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U
1,2-Dichloroethene (total)	300	300	450	410	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,3-Dichlorobenzene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
1,4-Dichlorobenzene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
2-Butanone	10 U	10 U	10 U	10 U	NA	5 U	5 U	5 U	NA	5 U	5 U	5 U	NA
2-Hexanone	10 U	10 U	10 U	10 U	NA	5 U	5 U	5 U	NA	5 U	5 U	5 U	NA
4-Methyl-2-pentanone	10 U	10 U	10 U	10 U	NA	5 U	5 U	5 U	NA	5 U	5 U	5 U	NA
Acetone	10 U	10 U	10 U	10 U	NA	5 U	5 U	4 B	NA	7	5 U	5 U	NA
Benzene	10 U	10 U	10 U	10 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U
Bromochloromethane	NA	NA	NA	NA	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Bromodichloromethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Bromoform	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Bromomethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Carbon disulfide	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Carbon tetrachloride	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Chlorobenzene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Chloroethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Chloroform	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Chloromethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.2 B	NA	0.5 U	0.5 U	0.5 U	NA
cis-1,2-Dichloroethene	190	210	310	280	28	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U
cis-1,3-Dichloropropene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Cyclohexane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Dibromochloromethane	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Dichlorodifluoromethane (Freon-12)	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 UJ	0.5 UJ	NA	0.5 U	0.5 UJ	0.5 UJ	NA
Ethylbenzene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Isopropylbenzene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
m- and p-Xylene	10 U	10 U	10 U	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methyl acetate	10 U	10 U	10 U	10 U	NA	0.5 UJ	0.5 U	0.5 U	NA	0.5 UJ	0.5 R	0.5 U	NA
Methylcyclohexane	2 J	2 J	2 J	2 J	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Methylene chloride	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Methyl-tert-butyl ether (MTBE)	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
o-Xylene	10 U	10 U	10 U	10 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Tetrachloroethene	10 U	10 U	10 U	10 U	1 U	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U
Toluene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.1 J	0.5 U	0.5 U	NA
trans-1,2-Dichloroethene	83	79	130	120	12.2	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U
trans-1,3-Dichloropropene	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA
Trichloroethene	19	18	19	19	2 J	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U
Trichlorofluoromethane (Freon-11)	10 U	10 U	10 U	10 U	NA	0.5 UJ	0.5 UJ	0.5 UJ	NA	0.5 UJ	0.5 UJ	0.5 UJ	NA
Vinyl chloride	54	55	85	84	15.9	0.5 U	0.5 U	0.5 U	1 U	0.5 U	0.5 U	0.5 U	1 U
Xylene, total	10 U	10 U	10 U	10 U	NA	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA

Table A-1
Pre-Feasibility Study Raw Analytical Data
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	LW03-MW12					LW03-MW13				LW03-MW14			
Sample ID	LW03-MW12-09-08A	LW03-MW12-15-08A	LW03-MW12-09-08C	LW03-MW12-15-08C	LW03-MW12-14C	LW03-MW13-10-08A	LW03-MW13-07-08C	LW03-MW13-14-08C	LW03-MW13-14C	LW03-MW14-13-08A	LW03-MW14-09-08C	LW03-MW14-16-08C	LW03-MW14-14C
Sample Date	02/07/08	02/07/08	09/17/08	09/17/08	08/15/14	02/04/08	09/19/08	09/22/08	08/13/14	02/05/08	09/19/08	09/19/08	08/15/14
Chemical Name													
Semivolatile Organic Compounds (UG/L)													
Dibenzofuran	10 U	10 U	12 U	10 U	NA	10 U	10 U	11 U	NA	10 U	10 U	10 U	NA
Total Metals (UG/L)													
Thallium	1 U	1 U	1 U	1 U	NA	1 U	2 U	5 U	NA	0.25 B	2 U	2 U	NA
Dissolved Metals (UG/L)													
Thallium, Dissolved	1 U	1 U	1 U	1 U	NA	1 U	2 U	5 U	NA	0.18 B	2 U	2 U	NA
Wet Chemistry													
Acetate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	1 U	NA	NA	NA	1 U
Alkalinity (mg/l)	NA	NA	NA	NA	269	NA	NA	NA	186	NA	NA	NA	168
Butyrate (mg/l)	NA	NA	NA	NA	2 U	NA	NA	NA	2 U	NA	NA	NA	2 U
Chloride (mg/l)	NA	NA	NA	NA	196	NA	NA	NA	174	NA	NA	NA	594 D
Ethane (mg/l)	NA	NA	NA	NA	0.002 U	NA	NA	NA	0.002 U	NA	NA	NA	0.002 U
Ethene (mg/l)	NA	NA	NA	NA	0.002 U	NA	NA	NA	0.002 U	NA	NA	NA	0.002 U
Ferrous iron (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lactate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	1 U	NA	NA	NA	1 U
Methane (mg/l)	NA	NA	NA	NA	0.289	NA	NA	NA	2.52 D	NA	NA	NA	0.0477
Nitrate (mg/l)	NA	NA	NA	NA	0.1 U	NA	NA	NA	3.01	NA	NA	NA	0.1 U
Nitrite (mg/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Propionate (mg/l)	NA	NA	NA	NA	1 U	NA	NA	NA	1 U	NA	NA	NA	1 U
Pyruvate (mg/l)	NA	NA	NA	NA	0.5 U	NA	NA	NA	0.5 U	NA	NA	NA	0.5 U
Sulfate (mg/l)	NA	NA	NA	NA	46.2	NA	NA	NA	52.7	NA	NA	NA	53.6
Sulfide (mg/l)	NA	NA	NA	NA	1.85 U	NA	NA	NA	1.79 U	NA	NA	NA	1.85 U
Total dissolved solids (TDS) (mg/l)	NA	NA	NA	NA	763 *	NA	NA	NA	641	NA	NA	NA	1,200
Total organic carbon (TOC) (mg/l)	NA	NA	NA	NA	8.25	NA	NA	NA	2.57 J	NA	NA	NA	3.31

Notes:

Shading indicates detections
NA - Not analyzed
* - Duplicate analysis was not within control limits
B - Analyte not detected above the level reported in blanks
D - Compound identified in an analysis at a secondary dilutic
J - Analyte present, value may or may not be accurate or pre
K - Analyte present, value may be biased high, actual value
L - Analyte present, value may be biased low, actual value n
R - Unreliable Result
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccura
UL - Analyte not detected, quantitation limit is probably highe
MG/L - Milligrams per liter
UG/L - Micrograms per liter

Station ID	LW03-MW15					
Sample ID	LW03-MW15-16-08A	LW03-MW15P-16-08A	LW03-MW15-10-08C	LW03-MW15-18-08C	LW03-MW15-14C	LW03-MW15-14C-1
Sample Date	02/05/08	02/05/08	09/19/08	09/19/08	08/14/14	08/15/14
Chemical Name						
Volatile Organic Compounds (UG/L)						
1,1,1-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,1,2-Trichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,1-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,1-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2,3-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2,4-Trichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2-Dibromo-3-chloropropane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2-Dibromoethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
1,2-Dichloroethene (total)	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,3-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
1,4-Dichlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
2-Butanone	5 U	5 U	5 U	5 U	NA	NA
2-Hexanone	5 U	5 U	5 U	5 U	NA	NA
4-Methyl-2-pentanone	5 U	5 U	5 U	5 U	NA	NA
Acetone	5 U	4 J	5 U	5 U	NA	NA
Benzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Bromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Bromodichloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Bromoform	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Bromomethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Carbon disulfide	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Carbon tetrachloride	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Chlorobenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Chloroethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Chloroform	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Chloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
cis-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
cis-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Cyclohexane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Dichlorodifluoromethane (Freon-12)	0.5 U	0.5 U	0.5 UJ	0.5 UJ	NA	NA
Ethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Isopropylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
m- and p-Xylene	NA	NA	NA	NA	NA	NA
Methyl acetate	0.5 UJ	0.5 UJ	0.5 U	0.5 U	NA	NA
Methylcyclohexane	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Methylene chloride	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Methyl-tert-butyl ether (MTBE)	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
o-Xylene	NA	NA	NA	NA	NA	NA
Styrene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Toluene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
trans-1,2-Dichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
trans-1,3-Dichloropropene	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA
Trichloroethene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Trichlorofluoromethane (Freon-11)	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	NA	NA
Vinyl chloride	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	NA
Xylene, total	0.5 U	0.5 U	0.5 U	0.5 U	NA	NA

Station ID	LW03-MW15					
Sample ID	LW03-MW15-16-08A	LW03-MW15P-16-08A	LW03-MW15-10-08C	LW03-MW15-18-08C	LW03-MW15-14C	LW03-MW15-14C-1
Sample Date	02/05/08	02/05/08	09/19/08	09/19/08	08/14/14	08/15/14
Chemical Name						
Semivolatile Organic Compounds (UG/L)						
Dibenzofuran	10 U	10 U	10 U	10 U	NA	NA
Total Metals (UG/L)						
Thallium	5 U	5 U	5 U	5 U	NA	NA
Dissolved Metals (UG/L)						
Thallium, Dissolved	5 U	5 U	5 U	5 U	NA	NA
Wet Chemistry						
Acetate (mg/l)	NA	NA	NA	NA	NA	1 U
Alkalinity (mg/l)	NA	NA	NA	NA	140	NA
Butyrate (mg/l)	NA	NA	NA	NA	NA	2 U
Chloride (mg/l)	NA	NA	NA	NA	1,010 D	NA
Ethane (mg/l)	NA	NA	NA	NA	0.002 U	NA
Ethene (mg/l)	NA	NA	NA	NA	0.002 U	NA
Ferrous iron (mg/l)	NA	NA	NA	NA	NA	NA
Lactate (mg/l)	NA	NA	NA	NA	NA	1 U
Methane (mg/l)	NA	NA	NA	NA	0.188	NA
Nitrate (mg/l)	NA	NA	NA	NA	0.1 U	NA
Nitrite (mg/l)	NA	NA	NA	NA	NA	NA
Propionate (mg/l)	NA	NA	NA	NA	NA	1 U
Pyruvate (mg/l)	NA	NA	NA	NA	NA	0.5 U
Sulfate (mg/l)	NA	NA	NA	NA	85.2	NA
Sulfide (mg/l)	NA	NA	NA	NA	1.82 U	NA
Total dissolved solids (TDS) (mg/l)	NA	NA	NA	NA	1,910	NA
Total organic carbon (TOC) (mg/l)	NA	NA	NA	NA	1.44 J	NA

Notes:
Shading indicates detections
NA - Not analyzed
* - Duplicate analysis was not within control limits
B - Analyte not detected above the level reported in blanks
D - Compound identified in an analysis at a secondary dilutic
J - Analyte present, value may or may not be accurate or pre
K - Analyte present, value may be biased high, actual value
L - Analyte present, value may be biased low, actual value n
R - Unreliable Result
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccura
UL - Analyte not detected, quantitation limit is probably highe
MG/L - Milligrams per liter
UG/L - Micrograms per liter

Table A-2
Pre-Feasibility Study Sampling Water Quality Data
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	LW03-MW01					LW03-MW02				
Sample ID	LW03-MW01-07-08A	LW03-MW01-13-08A	LW03-MW01-07-08C	LW03-MW01-13-08C	LW03-MW01-14C	LW03-MW02-10-08A	LW03-MW02-13-08A	LW03-MW02-07-08C	LW03-MW02-13-08C	LW03-MW02-14C
Sample Date	2/5/08	2/5/08	9/18/08	9/18/08	8/14/14	2/8/08	2/8/08	9/18/08	9/18/08	8/13/14
Chemical Name										
Water Quality Parameters										
Carbon dioxide (mg/L)	NS	NS	NS	NS	80	NS	NS	NS	NS	17
Dissolved Oxygen (mg/L)	1.77	1.7	0.31	0.22	0.67	1.69	1.67	2.11	NS	0.09
Dissolved Oxygen (Hach test) (mg/L)	NS	NS	NS	NS	1.5	NS	NS	NS	NS	1
Depth to Water (ft)	6.12	6.08	5.5	NS	5.36	9.4	9.14	7.03	NS	7.2
Ferrous Iron (mg/L)	NS	NS	NS	NS	1	NS	NS	NS	NS	0.15
Flow (gal/min)	0.044	0.044	NS	NS	0.086	0.044	0.044	NS	NS	0.066
Gallons purged (gal)	4.5	4.5	3.5	4.5	2.2	3	4.5	4	NS	2.5
Oxidation-Reduction Potential (mV)	-164	-257	-165	-164	-88.7	-170	-78	-183	-125	-284.2
pH (pH)	7.35	7.36	7.18	7.17	7.24	7.23	7.28	7.28	7.42	7.12
Salinity (pct)	0.17	0.18	0.1	0.1	0.95	2.89	3.33	2.3	NS	17.14
Specific Conductivity (mS/cm)	3.38	3.7	2.87	2.7	1.865	45.3	51.5	36.8	NS	27.92
Temperature (deg C)	15.79	15.78	26.1	24.6	24.09	11.93	11.48	24.4	NS	26.32
Total Dissolved Solids (g/L)	NS	NS	NS	NS	1.212	NS	NS	NS	NS	18.15
Turbidity (NTU)	1.6	7.4	34.4	93.3	1.07	4.1	1.1	2.5	NS	0.06

Notes:
> - Exceeding calibration range of instrument
deg C - degrees Celsius
ft - feet
gal - gallons
gal/min - gallons per minute
g/L - grams per liter
mg/L - Milligrams per liter
mS/cm - microsiemens per centimeter
mV - millivolts
NS - Not sampled
NTU - Nephelometric Turbidity Unit
pct - percent
pH - pH standard units

Table A-2
Pre-Feasibility Study Sampling Water Quality Data
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	LW03-MW03					LW03-MW04				
Sample ID	LW03-MW03-07-08A	LW03-MW03-13-08A	LW03-MW03-07-08C	LW03-MW03-13-08C	LW03-MW03-14C	LW03-MW04-07-08A	LW03-MW04-13-08A	LW03-MW04-07-08C	LW03-MW04-13-08C	LW03-MW04-14C
Sample Date	2/5/08	2/5/08	9/15/08	9/15/08	8/12/14	2/6/08	2/6/08	9/16/08	9/16/08	8/12/14
Chemical Name										
Water Quality Parameters										
Carbon dioxide (mg/L)	NS	NS	NS	NS	60	NS	NS	NS	NS	34
Dissolved Oxygen (mg/L)	1.87	1.88	0.22	0.25	0.84	1.84	1.76	0.23	0.24	0.34
Dissolved Oxygen (Hach test) (mg/L)	NS	NS	NS	NS	0.3	NS	NS	NS	NS	1
Depth to Water (ft)	4.71	4.73	4.35	NS	4.67	6.65	6.94	4.78	4.46	6.34
Ferrous Iron (mg/L)	NS	NS	NS	NS	10	NS	NS	NS	NS	1
Flow (gal/min)	0.055	0.055	NS	NS	0.079	0.055	0.055	NS	NS	0.066
Gallons purged (gal)	4.5	3.5	5	5	NS	4	2.5	3	3	NS
Oxidation-Reduction Potential (mV)	-78	-90	-93	-125	-56.4	-183	-201	-271	-249	-134.4
pH (pH)	6.78	6.86	6.65	6.75	6.73	6.43	6.47	6.36	6.53	6.61
Salinity (pct)	0.3	0.34	0.4	0.3	1.83	1.87	2.2	1.2	1.4	7
Specific Conductivity (mS/cm)	5.65	6.38	6.69	6.3	3.489	30.1	34.9	19.7	23.2	12.24
Temperature (deg C)	18.46	19.35	27.7	27.3	25.99	17.19	18.03	26.1	25.2	24.92
Total Dissolved Solids (g/L)	NS	NS	NS	NS	2.268	NS	NS	NS	NS	7.958
Turbidity (NTU)	0	0	19.2	30.1	0.98	24.5	0	3.3	24	1.82

Notes:
> - Exceeding calibration range of instrument
deg C - degrees Celsius
ft - feet
gal - gallons
gal/min - gallons per minute
g/L - grams per liter
mg/L - Milligrams per liter
mS/cm - microsiemens per centimeter
mV - millivolts
NS - Not sampled
NTU - Nephelometric Turbidity Unit
pct - percent
pH - pH standard units

Station ID	LW03-MW05				LW03-MW06					
Sample ID	LW03-MW05-07-08A	LW03-MW05-13-08A	LW03-MW05-07-08C	LW03-MW05-13-08C	LW03-MW06-07-08A	LW03-MW06-13-08A	LW03-MW06-07-08C	LW03-MW06-10-08C	LW03-MW06-16-08C	LW03-MW06-14C
Sample Date	2/7/08	2/7/08	9/16/08	9/16/08	2/8/08	2/8/08	9/22/08	9/22/08	9/22/08	8/14/14
Chemical Name										
Water Quality Parameters										
Carbon dioxide (mg/L)	NS	NS	NS	NS	NS	NS	NS	NS	NS	>100
Dissolved Oxygen (mg/L)	1.97	1.96	0.27	0.13	1.79	1.73	NS	0.32	0.33	1.33
Dissolved Oxygen (Hach test) (mg/L)	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.9
Depth to Water (ft)	5.61	5.52	5.12	5.12	5.51	5.5	5.21	5.22	5.21	4.98
Ferrous Iron (mg/L)	NS	NS	NS	NS	NS	NS	NS	NS	NS	5
Flow (gal/min)	0.055	0.044	NS	NS	0.05	0.05	NS	NS	NS	NS
Gallons purged (gal)	3	2.5	3	3.5	3.5	4	NS	3.5	3	3.9
Oxidation-Reduction Potential (mV)	-27	-19	-196	-162	-52	-17	-84	-74	-74	-36.7
pH (pH)	6.55	6.52	6.64	6.56	6.4	6.31	6.33	6.38	6.4	6.37
Salinity (pct)	0.22	0.23	0.2	0.2	0.17	0.19	0.2	0.2	0.2	1.33
Specific Conductivity (mS/cm)	4.35	4.4	3.31	3.95	3.42	3.69	NS	3.75	3.62	2.589
Temperature (deg C)	16.45	16.6	21.7	21.5	18.23	18.17	NS	26	26	25.14
Total Dissolved Solids (g/L)	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.683
Turbidity (NTU)	0	0	6	14.2	3.6	9.7	0	18.4	28.7	2.47

Notes:
> - Exceeding calibration range of instrument
deg C - degrees Celsius
ft - feet
gal - gallons
gal/min - gallons per minute
g/L - grams per liter
mg/L - Milligrams per liter
mS/cm - microsiemens per centimeter
mV - millivolts
NS - Not sampled
NTU - Nephelometric Turbidity Unit
pct - percent
pH - pH standard units

Station ID	LW03-MW07					LW03-MW08				
Sample ID	LW03-MW07-07-08A	LW03-MW07-13-08A	LW03-MW07-07-08C	LW03-MW07-13-08C	LW03-MW07-14C	LW03-MW08-07-08A	LW03-MW08-13-08A	LW03-MW08-07-08C	LW03-MW08-13-08C	LW03-MW08-14C
Sample Date	2/7/08	2/7/08	9/17/08	9/17/08	8/12/14	2/6/08	2/6/08	9/15/08	9/15/08	8/13/14
Chemical Name										
Water Quality Parameters										
Carbon dioxide (mg/L)	NS	NS	NS	NS	55	NS	NS	NS	NS	>100
Dissolved Oxygen (mg/L)	1.96	2.05	0.12	0.13	0.7	1.89	2.05	0.24	0.34	1.03
Dissolved Oxygen (Hach test) (mg/L)	NS	NS	NS	NS	1	NS	NS	NS	NS	1
Depth to Water (ft)	5.61	5.61	4.29	4.33	4.75	5.3	5.35	5.05	5.03	4.54
Ferrous Iron (mg/L)	NS	NS	NS	NS	0.2	NS	NS	NS	NS	20
Flow (gal/min)	0.055	0.055	NS	NS	NS	0.05	0.06	NS	NS	0.079
Gallons purged (gal)	2	3	4	3.5	2.2	NS	NS	3	NS	4
Oxidation-Reduction Potential (mV)	-189	-191	-260	-266	-152.6	-106	-92	-145	-132	-59.9
pH (pH)	7.08	7.24	6.98	7	6.88	6.33	6.3	6.32	6.29	6.37
Salinity (pct)	0.05	0.07	0	0.1	0.58	0.05	0.05	0	0	0.42
Specific Conductivity (mS/cm)	1.19	1.51	1	1.18	1.179	1.15	1.19	0.728	0.73	0.866
Temperature (deg C)	14.78	15.91	26.9	26.8	27.22	17.15	17.43	26.6	26.3	25
Total Dissolved Solids (g/L)	NS	NS	NS	NS	0.766	NS	NS	NS	NS	0.563
Turbidity (NTU)	0	0	31.7	34	2.06	0	0	12.5	10.1	1.13

Notes:
> - Exceeding calibration range of instrument
deg C - degrees Celsius
ft - feet
gal - gallons
gal/min - gallons per minute
g/L - grams per liter
mg/L - Milligrams per liter
mS/cm - microsiemens per centimeter
mV - millivolts
NS - Not sampled
NTU - Nephelometric Turbidity Unit
pct - percent
pH - pH standard units

Station ID	LW03-MW09				LW03-MW10			
Sample ID	LW03-MW09-15-08A	LW03-MW09-10-08C	LW03-MW09-18-08C	LW03-MW09-14C	LW03-MW10-17-08A	LW03-MW10-13-08C	LW03-MW10-18-08C	LW03-MW10-14C
Sample Date	2/4/08	9/18/08	9/18/08	8/13/14	2/4/08	9/16/08	9/16/08	8/13/14
Chemical Name								
Water Quality Parameters								
Carbon dioxide (mg/L)	NS	NS	NS	100	NS	NS	NS	>100
Dissolved Oxygen (mg/L)	1.69	0.21	0.23	0.74	1.75	0.13	0.63	1.38
Dissolved Oxygen (Hach test) (mg/L)	NS	NS	NS	0	NS	NS	NS	1
Depth to Water (ft)	6.27	5.88	NS	5.65	5.81	5.29	5.34	4.95
Ferrous Iron (mg/L)	NS	NS	NS	45	NS	NS	NS	7.5
Flow (gal/min)	0.044	NS	NS	0.066	0.055	NS	NS	NS
Gallons purged (gal)	2.6	3	3	2.7	2.6	NS	4	2
Oxidation-Reduction Potential (mV)	-63	-114	-77	-62.6	56	-81	-112	-115.6
pH (pH)	6.36	6.44	6.32	6.42	5.62	5.62	5.65	5.79
Salinity (pct)	0.07	0.1	0.1	0.59	0.17	0.1	0.1	0.99
Specific Conductivity (mS/cm)	1.47	1.13	1.64	1.198	3.43	2.37	2.67	1.944
Temperature (deg C)	19.91	27.4	26.2	25.82	19.34	25.2	24.9	24.56
Total Dissolved Solids (g/L)	NS	NS	NS	0.779	NS	NS	NS	1.264
Turbidity (NTU)	33.6	10.4	24.5	8.23	0	10	5.7	3.01

Notes:
> - Exceeding calibration range of instrument
deg C - degrees Celsius
ft - feet
gal - gallons
gal/min - gallons per minute
g/L - grams per liter
mg/L - Milligrams per liter
mS/cm - microsiemens per centimeter
mV - millivolts
NS - Not sampled
NTU - Nephelometric Turbidity Unit
pct - percent
pH - pH standard units

Station ID	LW03-MW11					LW03-MW12				
Sample ID	LW03-MW11-08-08A	LW03-MW11-15-08A	LW03-MW11-08-08C	LW03-MW11-15-08C	LW03-MW11-14C	LW03-MW12-09-08A	LW03-MW12-15-08A	LW03-MW12-09-08C	LW03-MW12-15-08C	LW03-MW12-14C
Sample Date	2/6/08	2/6/08	9/17/08	9/17/08	8/14/14	2/7/08	2/7/08	9/17/08	9/17/08	8/15/14
Chemical Name										
Water Quality Parameters										
Carbon dioxide (mg/L)	NS	NS	NS	NS	100	NS	NS	NS	NS	>100
Dissolved Oxygen (mg/L)	1.98	1.9	0.15	0.16	0.41	2.09	2	0.47	0.25	1
Dissolved Oxygen (Hach test) (mg/L)	NS	NS	NS	NS	1	NS	NS	NS	NS	1
Depth to Water (ft)	5.4	5.45	4.77	4.9	4.42	5.61	5.62	5.25	5.26	5.02
Ferrous Iron (mg/L)	NS	NS	NS	NS	2.5	NS	NS	NS	NS	12.5
Flow (gal/min)	0.06	0.055	NS	NS	0.079	0.044	0.055	NS	NS	0.079
Gallons purged (gal)	2.3	2.2	2.5	4	2.1	3	3	3.5	3	2.4
Oxidation-Reduction Potential (mV)	-121	-106	-129	-105	-53.8	-73	-72	-110	-95	-71.6
pH (pH)	6.84	6.82	6.88	6.83	6.76	6.41	6.4	6.44	6.45	6.46
Salinity (pct)	0.19	0.19	0.2	0.2	1.54	0.05	0.05	0	0	0.59
Specific Conductivity (mS/cm)	3.78	3.81	3.72	3.84	2.963	1.17	1.16	0.963	1.12	1.19
Temperature (deg C)	19.5	19.46	23.8	23.2	23	16.15	16.55	22.1	21.8	22.44
Total Dissolved Solids (g/L)	NS	NS	NS	NS	1.925	NS	NS	NS	NS	0.773
Turbidity (NTU)	0	0	38	32.8	16.8	0	0	6.7	4.3	13

Notes:
> - Exceeding calibration range of instrument
deg C - degrees Celsius
ft - feet
gal - gallons
gal/min - gallons per minute
g/L - grams per liter
mg/L - Milligrams per liter
mS/cm - microsiemens per centimeter
mV - millivolts
NS - Not sampled
NTU - Nephelometric Turbidity Unit
pct - percent
pH - pH standard units

Table A-2
Pre-Feasibility Study Sampling Water Quality Data
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	LW03-MW13				LW03-MW14				LW03-MW15			
Sample ID	LW03-MW13-10-08A	LW03-MW13-07-08C	LW03-MW13-14-08C	LW03-MW13-14C	LW03-MW14-13-08A	LW03-MW14-09-08C	LW03-MW14-16-08C	LW03-MW14-14C	LW03-MW15-16-08A	LW03-MW15-10-08C	LW03-MW15-18-08C	LW03-MW15-14C
Sample Date	2/4/08	9/19/2008	9/22/08	8/13/14	2/5/08	9/19/08	9/19/08	8/15/14	2/5/08	9/19/08	9/19/08	8/14/14
Chemical Name												
Water Quality Parameters												
Carbon dioxide (mg/L)	NS	NS	NS	90	NS	NS	NS	>100	NS	NS	NS	>100
Dissolved Oxygen (mg/L)	1.7	0.23	0.29	0.81	1.9	0.28	0.24	1.51	1.9	0.22	0.3	1.26
Dissolved Oxygen (Hach test) (mg/L)	NS	NS	NS	2	NS	NS	NS	1	NS	NS	NS	1
Depth to Water (ft)	5.66	5.15	6.02	5.06	5.56	5.31	5.33	5.08	4.69	4.4	4.4	4.18
Ferrous Iron (mg/L)	NS	NS	NS	0.2	NS	NS	NS	10	NS	NS	NS	5
Flow (gal/min)	0.044	NS	NS	0.079	0.044	NS	NS	0.079	0.044	NS	NS	0.079
Gallons purged (gal)	1.6	2	NS	1.5	3.2	3	3	2	4.5	5	4	3
Oxidation-Reduction Potential (mV)	-332	-356	-365	-220.5	5	-20	-4	1.5	-47	-70	-37	22.2
pH (pH)	7.44	7.44	7.29	7.15	6.49	6.14	6.09	6.2	6.31	6.3	6.26	6.11
Salinity (pct)	0.17	0.1	0.2	0.46	0.09	0.1	0.1	1.1	0.29	0.3	0.3	1.69
Specific Conductivity (mS/cm)	3.39	2.54	4.2	0.425	1.88	2.09	2.3	2.16	5.5	5.01	5.07	3.235
Temperature (deg C)	16.81	24.7	24.5	23.5	19	26.2	25.6	24.76	20.38	24.5	23.8	22.61
Total Dissolved Solids (g/L)	NS	NS	NS	0.601	NS	NS	NS	1.405	NS	NS	NS	2.103
Turbidity (NTU)	24.7	0	13.5	1.24	1.1	2.3	5.5	4.87	2.1	56.3	35.3	2.86

Notes:
> - Exceeding calibration range of instrument
deg C - degrees Celsius
ft - feet
gal - gallons
gal/min - gallons per minute
g/L - grams per liter
mg/L - Milligrams per liter
mS/cm - microsiemens per centimeter
mV - millivolts
NS - Not sampled
NTU - Nephelometric Turbidity Unit
pct - percent
pH - pH standard units

Appendix B
Data Validation Reports

CH2M HILL
5700 Cleveland Street
Suite 101
Virginia Beach, Virginia 23462

March 27, 2008
SDG# CTO48-2, Katahdin Analytical Services
NAB Little Creek- SWMU 3

Dear Ms. Moore,

The following Data Validation report is provided as requested for the parameters noted in the table below for SDG # CTO48-2. The data validation was performed in accordance with the CLP statements of work OLC03.2 for low concentration volatiles, OLM04.3 for semivolatiles and ILM05.4 for total and dissolved thallium. Also used in the validation of these samples were the Region III Modifications to the National Functional Guidelines for Organic Data Review, 9/94, and to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Data Review, 4/93, (as referred by the Region III document Innovative Approaches to Data Validation, 6/95, for Level M3/IM-2 review), as applicable, as well as the National Functional Guidelines for Low Concentration Organic Data Review (June 2001).

Sample ID	Lab ID	Matrix	LCV	SV	Total Thallium	Dissolved Thallium
LW03-MW09-15-08A	SB0602-1/2	water	X	X	X	X
LW03-MW10-17-08A	SB0602-3/4	water	X	X	X	X
LW03-FB020408	SB0602-5/6	water	X	X	X	X
LW03-TB020408	SB0602-7	water	X			
LW03-MW13-10-08A	SB0602-8/9	water	X	X	X	X
LW03-EB020408	SB0602-10/11	water	X	X	X	X
LW03-TB020508	SB0631-1	water	X			
LW03-MW14-11-08A	SB06031-2/3	water	X	X	X	X
LW03-MW15-16-08A	SB0631-4/5	water	X	X	X	X
LW03-MW15P-16-08A	SB0631-6/7	water	X	X	X	X
LW03-MW01-07-08A	SB0631-8/9	water	X	X	X	X
LW03-MW01-13-08A	SB0631-10/11	water	X	X	X	X
LW03-MW03-07-08A	SB0656-1/2	water	X	X	X	X
LW03-MW03-13-08A	SB0656-3/4	water	X	X	X	X
LW03-MW03P-13-08A	SB0656-5/6	water	X	X	X	X
LW03-TB020608	SB0656-7	water	X			
LW03-MW04-07-08A	SB0656-8/9	water	X	X	X	X
LW03-MW04-13-08A	SB0656-10/11	water	X	X	X	X
LW03-MW11-08-08A	SB0656-12/13	water	X	X	X	X
LW03-MW11-15-08A	SB0656-14/15	water	X	X	X	X
LW03-MW01-13-08A MS	SB0631-10/11MS	water	X	X	X	X
LW03-MW01-13-08A MSD	SB0631-10/11MSD	water	X	X	X	X

The following quality control samples were provided with this SDG: sample LW03-MW15P-16-08A-field duplicate of sample LW03-MW15-16-08A; sample LW03-MW03P-13-08A-field duplicate of sample LW03-MW03-13-08A; samples LW03-TB020408, LW03-TB020508 and LW03-TB020608-trip blanks; sample LW03-EB020408-equipment blank; and sample LW03-FB020408-field blank. All areas of concern are discussed in the body of the report and a summary of data qualification is provided. The samples were evaluated based on the following criteria:

- Data Completeness *
- Technical Holding Times *
- Initial/Continuing Calibrations
- CRI Standards *
- Interference Check Sample *
- Blanks
- Internal Standards *
- Surrogates/DMCs
- Laboratory Control Samples *
- Matrix Spike Recoveries *
- Matrix Duplicate RPDs *
- Post Digestion Spike Recoveries *
- Serial Dilutions *
- Field Duplicates *
- Identification/Quantitation *
- Reporting Limits *
- Tentatively Identified Compounds

*- indicates that no qualifications were required based on this criteria

Overall Evaluation of Data/Potential Usability Issues

Specific details regarding qualification of the data are addressed in the Specific Evaluation section of this narrative. If an issue is not addressed there were no actions required based on unmet quality criteria.

Major Problems

No issues requiring rejection of the data were found in this SDG.

Minor Problems

Issues requiring qualification of the analytical data were found in the validation of this SDG. A summary of these issues for each fraction is presented in the following paragraphs. All results qualified as estimated J/UJ or biased high, K or biased low, L/UL, should be considered usable but estimated. When more than one qualifier is associated with a compound/analyte the validator has chosen the qualifier that best indicates possible bias in the results and flagged the data accordingly. However, information regarding all quality control issues is provided in the body of the report and on the qualification summary page.

LC-VOA

The continuing calibrations exhibited high %Ds result that required qualifications to be added to the data.

Blank contamination was noted in method and QC blanks associated with samples in this batch. Qualifications were added to the data.

Several samples exhibited low Deuterated Monitoring Compounds that resulted in qualifications to the associated compounds.

SVOA

No qualifications to the data were required.

ICP MS Total & Dissolved Metals

Blank contamination was noted in the laboratory and field QC blanks associated with the samples in this SDG. Qualifications were added to the data. Specific information is provided below. Please note that field QC blanks were not flagged for laboratory blank contamination per CH2M HILL.

Specific Evaluation of Data

Data Completeness

The SDG was received complete and intact. Resubmissions were not required.

Technical Holding Times

According to chain of custody records, sampling was performed on 02/04-06/08 and samples were received at the laboratory 02/05-07/08. All sample preparation and analysis was performed within Region III and/or method holding time requirements.

Initial/Continuing Calibration

LC-VOA

Calibration standards exhibited %Ds that were non-compliant. A summary of these non-compliances and affected samples are noted in the following table. Sample results are qualified as indicated.

Standard ID	Compound(s)	RRF, %RSD, %D	Samples	Q Flag	Q Code
CC 02/11/08	trichlorofluoromethane methyl acetate	38.8% 30.5%	LW03-TB020408, LW03-FB020408, LW03-EB020408	J/UJ	CCH
CC 02/12/08	trichlorofluoromethane methyl acetate	36.1% 46.1%	LW03-TB020508, LW03-MW09-15-08A, LW03-MW10-17-08A, LW03-MW13-10-08A, LW03-MW14-13-08A, LW03-MW15-16-08A, LW03-MW15P-16-08A LW03-MW01-07-08A, LW03-MW01-13-08A	J/UJ	CCH
CC 02/13/08	vinyl chloride bromomethane trichlorofluoromethane	35.3% 35.2% 70.3%	LW03-TB020608, LW03-MW03-07-08A, LW03-MW03-13-08A, LW03-MW03P-13-08A LW03-MW04-07-08A, LW03-MW04-13-08A, LW03-MW11-08-08A, LW03-MW11-15-08A	J/UJ	CCH

Blanks

LC-VOA

The associated method and QC blanks exhibited contamination for TICs. All B flagged TICs in the field samples are flagged B and crossed out in accordance with the Region III modifications to the National Functional Guidelines.

ICP MS Total & Dissolved Metals

Calibration blank contamination was noted for which qualification of the sample data was required. Contamination and sample results qualifications are indicated in the following tables. The field blank samples were not qualified for laboratory blank contamination as requested by CH2M HILL.

Blank ID	Analyte	Concentration	Action Level	Q Flag
CCB	thallium	0.34J ug/L	1.7 ug/L	B

Sample ID	analyte	Q Flag	Q Code
LW03-MW14-13-08A total, LW03-MW14-13-08A dissolved, LOW03-MW11-15-08A dissolved	thallium	B	BL

Deuterated Monitoring Compounds

LC-VOA

The following samples exhibited low DMC recovery results that required qualifications, see table below.

Sample ID	Non-compliant DMC	% Rec	QC Limits	Q Flag	Q Code
LW03-MW03-13-08A	1,2-dichloropropane-d6 trans-1,3-dichloropropane-d4	77 77	84-123% 80-128%	J/UJ	SSL
LW03-MW03P-13-08A	trans-1,3-dichloropropane-d4	72	80-128%	J/UJ	SSL
LW03-MW04-07-08A	1,2-dichloropropane-d6	80	84-123%	J/UJ	SSL
LW03-MW11-15-08A	1,2-dichloropropane-d6 trans-1,3-dichloropropane-d4	78 75	84-123% 80-128%	J/UJ	SSL

A summary of qualifications required is provided on the following page. Please do not hesitate to contact DataQual ES with any questions regarding this validation report.

Sincerely,

Jacqueline A. Cleveland

Digitally signed by Jacqueline A. Cleveland
DN: CN = Jacqueline A. Cleveland, C = US, O = DataQual Environmental Services, LLC
Date: 2008.03.28 16:45:15 -05'00'

Jacqueline Cleveland
Vice-President

Summary of Data Qualifications

LC-VOA

Sample ID	Compound	Results	Q Flag	Q code
LW03-TB020408, LW03-FB020408, LW03-EB020408	trichlorofluoromethane methyl acetate	+/-	J/UJ	CCH
LW03-TB020508, LW03-MW09-15-08A, LW03-MW10-17-08A, LW03-MW13-10-08A, LW03-MW14-13-08A, LW03-MW15-16-08A, LW03-MW15P-16-08A, LW03-MW01-07-08A, LW03-MW01-13-08A	trichlorofluoromethane methyl acetate	+/-	J/UJ	CCH
LW03-TB020608, LW03-MW03-07-08A, LW03-MW03-13-08A, LW03-MW03P-13-08A, LW03-MW04-07-08A, LW03-MW04-13-08A, LW03-MW11-08-08A, LW03-MW11-15-08A	vinyl chloride bromomethane trichlorofluoromethane	+/-	J/UJ	CCH
all samples	"B" flagged TICs	+	B	BL
LW03-MW03-13-08A	1,2-dichloropropane-d6 trans-1,3-dichloropropane-d4	+	J/UJ	SSL
LW03-MW03P-13-08A	trans-1,3-dichloropropane-d4	+	J/UJ	SSL
LW03-MW04-07-08A	1,2-dichloropropane-d6	+	J/UJ	SSL
LW03-MW11-15-08A	1,2-dichloropropane-d6 trans-1,3-dichloropropane-d4	+	J/UJ	SSL

SVOA

Sample ID	Compound	Results	Q Flag	Qual code
No qualifications required.				

ICP-MS Total and Dissolved Metals

Sample ID	Analyte	Results	Q Flag	Q code
LW03-MW14-13-08A total, LW03-MW14-13-08A dissolved, LOW03-MW11-15-08A dissolved	thallium	+ up to action limit	B	BL

Glossary of Qualification Flags and Abbreviations

Qualification Flags (Q-Flags)

U	not detected above the reported sample quantitation limit
J	estimated value
UJ	reported quantitation limit is qualified as estimated
R	result is rejected; the presence or absence of the analyte cannot be verified
D	result value is based on dilution analysis result
NJ	analyte has been tentatively identified, estimated value
L	analyte present, biased low
UL	not detected, quantitation limit is probably higher
K	analyte present, biased high
Q	estimated dioxin/furan concentration
I	interferences present which may cause the results to be biased high

Method Blank Qualification Flags (Q-Flags)

NA	The sample result for the blank contaminant is greater than the sample RL and is greater than 5X the blank value. The sample result for the blank contaminant is not qualified with any blank qualifiers.
B	The sample result for the blank contaminant is less than or greater than the sample RL and is less than 5X the blank value. The sample result for the blank contaminant is qualified as B at the compound value reported.

General Abbreviations

IDL	Instrument Detection Limit
MDL	Method Detection Limit
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
Q Code	Qualifier Code
Q Flag	Qualifier Flag
+	positive result
-	non-detect result

QUALIFIER CODE REFERENCE

Qualifier	Description
TN	Tune
BSL	Blank Spike/LCS - Low Recovery
BSH	Blank Spike/LCS - High Recovery
BD	Blank Spike/Blank Spike Duplicate (LCS/LCSD) Precision
BRL	Below Reporting Limit
EMPC	Estimated Possible Maximum Concentration
ISL	Internal Standard - Low Recovery
ISH	Internal Standard - High Recovery
MSL	Matrix Spike and/or Matrix Spike Duplicate - Low Recovery
MSH	Matrix Spike and/or Matrix Spike Duplicate - High Recovery
MI	Matrix interference obscuring the raw data
MDP	Matrix Spike/Matrix Spike Duplicate Precision
2S	Second Source - Bad reproducibility between tandem detectors
SSL	Spiked Surrogate - Low Recovery
SSH	Spiked Surrogate - High Recovery
SD	Serial Dilution Reproducibility
ICL	Initial Calibration - Low Relative Response Factors (RRF)
ICH	Initial Calibration - High Relative Response Factors (RRF)
ICB	Initial Calibration - Bad Linearity or Curve Function
CCL	Continuing Calibration - Low Recovery or %Difference
CCH	Continuing Calibration - High Recovery or %Difference
LD	Lab Duplicate Reproducibility
HT	Holding Time
PD	Pesticide Degradation
2C	Second Column - Poor Dual Column Reproducibility
LR	Concentration Exceeds Linear Range
BL	Blank Contamination- MBL, EBL, FBL, TBL
RE	Redundant Result - due to Re-analysis or Re-extraction
DL	Redundant Result - due to Dilution
FD	Field Duplicate
OT	Other - explained in data validation report
%Sol	High percent moisture

CH2M HILL
5700 Cleveland Street
Suite 101
Virginia Beach, Virginia 23462

March 27, 2008
SDG# CTO48-3, Katahdin Analytical Services
NAB Little Creek- SWMU 3

Dear Ms. Moore,

The following Data Validation report is provided as requested for the parameters noted in the table below for SDG # CTO48-3. The data validation was performed in accordance with the CLP statements of work OLC03.2 for low concentration volatiles, OLM04.3 for volatiles and semivolatiles and ILM05.3 for total and dissolved thallium. Also used in the validation of these samples were the Region III Modifications to the National Functional Guidelines for Organic Data Review, 9/94, and to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Data Review, 4/93, (as referred by the Region III document Innovative Approaches to Data Validation, 6/95, for Level M3/IM-2 review), as applicable, as well as the National Functional Guidelines for Low Concentration Organic Data Review (June 2001).

Sample ID	Lab ID	Matrix	LCV	VOA	SV	Total Thallium	Dissolved Thallium
LW03-MW05-13-08A	SB0694-5/6	water	X		X	X	X
LW03-MW05-07-08A	SB0694-7/8	water	X		X	X	X
LW03-TB020708	SB0694-15	water	X				
LW03-MW06-13-08A	SB0707-1/2	water	X		X	X	X
LW03-MW06-07-08A	SB0707-3/4	water	X		X	X	X
LW03-MW02-13-08A	SB0707-5/6	water	X		X	X	X
LW03-MW02-10-08A	SB0707-7/8	water	X		X	X	X
LW03-TB020808	SB0707-9	water	X				
LW03-MW08-07-08A	SB0657-1/2	water		X	X	X	X
LW03-MW08-13-08A	SB0657-3/4	water		X	X	X	X
LW03-MW12-15-08A	SB0694-1/2	water		X	X	X	X
LW03-MW12-09-08A	SB0694-3/4	water		X	X	X	X
LW03-MW07-13-08A	SB0694-9/10	water		X	X	X	X
LW03-MW07-07-08A	SB0694-11/12	water		X	X	X	X
LW03-MW07P-07-08A	SB0694-13/14	water		X	X	X	X
LW03-MW07-13-08A MS	SB0694-9/10MS	water		X	X	X	X
LW03-MW07-13-08A MSD	SB0694-9/10MSD	water		X	X	X	X

The following quality control samples were provided with this SDG: sample LW03-MW07P-07-08A-field duplicate of sample LW03-MW07-07-08A; and samples LW03-TB020708 and LW03-TB020808-trip blanks. All areas of concern are discussed in the body of the report and a summary of data qualification is provided.

The samples were evaluated based on the following criteria:

- Data Completeness *
- Technical Holding Times *
- Initial/Continuing Calibrations
- CRI Standards *
- Interference Check Sample *
- Blanks
- Internal Standards *
- Surrogates/DMCs
- Laboratory Control Samples *
- Matrix Spike Recoveries *
- Matrix Duplicate RPDs *
- Post Digestion Spike Recoveries *
- Serial Dilutions *
- Field Duplicates *
- Identification/Quantitation *
- Reporting Limits *
- Tentatively Identified Compounds

*- indicates that no qualifications were required based on this criteria

Overall Evaluation of Data/Potential Usability Issues

Specific details regarding qualification of the data are addressed in the Specific Evaluation section of this narrative. If an issue is not addressed there were no actions required based on unmet quality criteria.

Major Problems

No issues requiring rejection of the data were found in this SDG.

Minor Problems

Issues requiring qualification of the analytical data were found in the validation of this SDG. A summary of these issues for each fraction is presented in the following paragraphs. All results qualified as estimated J/UJ or biased high, K or biased low, L/UL, should be considered usable but estimated. When more than one qualifier is associated with a compound/analyte the validator has chosen the qualifier that best indicates possible bias in the results and flagged the data accordingly. However, information regarding all quality control issues is provided in the body of the report and on the qualification summary page.

LC-VOA

The continuing calibrations exhibited high %Ds result that required qualifications to be added to the data.

Blank contamination was noted in method and QC blanks associated with samples in this batch. Qualifications were added to the data.

Several samples exhibited low Deuterated Monitoring Compounds that resulted in qualifications to the associated compounds.

VOA

The continuing calibrations exhibited high %Ds result that required qualifications to be added to the data.

Dilutions were required for two samples to obtain results within the calibration range.

SVOA

No qualifications to the data were required.

ICP MS Total & Dissolved Metals

Blank contamination was noted in the laboratory and field QC blanks associated with the samples in this SDG. Qualifications were added to the data. Specific information is provided below. Please note that field QC blanks were not flagged for laboratory blank contamination per CH2M HILL.

Specific Evaluation of Data

Data Completeness

The SDG was received complete and intact. Resubmissions were not required.

Technical Holding Times

According to chain of custody records, sampling was performed on 02/06-08/08 and samples were received at the laboratory 02/07-09/08. All sample preparation and analysis was performed within Region III and/or method holding time requirements.

Initial/Continuing Calibration

LC-VOA

Calibration standards exhibited %Ds that were non-compliant. A summary of these non-compliances and affected samples are noted in the following table. Sample results are qualified as indicated.

Standard ID	Compound(s)	RRF, %RSD, %D	Samples	Q Flag	Q Code
CC 02/13/08	vinyl chloride bromomethane trichlorofluoromethane	35.3% 35.2% 70.3%	LW03-TB020708, LW03-MW05-13-08A, LW03-MW05-07-08A	J/UJ	CCH
CC 02/14/08	chloroethane trichlorofluoromethane freon-113 methyl acetate	62.1% 78.9% 30.2% 32.8%	LW03-TB020808, LW03-MW06-13-08A, LW03-MW06-07-08A, LW03-MW02-13-08A, LW03-MW02-10-08A	J/UJ	CCH

VOA

Calibration standards exhibited %Ds that were non-compliant. A summary of these non-compliances and affected samples are noted in the following table. Sample results are qualified as indicated.

Standard ID	Compound(s)	RRF, %RSD, %D	Samples	Q Flag	Q Code
CC 02/12/08	acetone	50.6%	LW03-MW07-13-08A	J/UJ	CCH

Blanks

LC-VOA

The associated method and QC blanks exhibited contamination for TICs. All B flagged TICs in the field samples are flagged B and crossed out in accordance with the Region III modifications to the National Functional Guidelines.

ICP MS Total Metals

Preparation, calibration and field QC blank contamination was noted. Qualification for several analytes was required. Contamination and sample results qualifications are indicated in the following tables. The field blank samples were not qualified for laboratory blank contamination as requested by CH2M HILL.

Blank ID	Analyte	Concentration	Action Level	Q Flag
CCB	thallium	0.66J ug/L	3.3 ug/L	B

Sample ID	analyte	Q Flag	Q Code
LW03-MW07-13-08A total	thallium	B	BL

Deuterated Monitoring Compounds

LC-VOA

The following samples exhibited low DMC recovery results that required qualifications, see table below.

Sample ID	Non-compliant DMC	% Rec	QC Limits	Qual	Q Code
LW03-MW05-07-08A	trans-1,3-dichloropropane-d4	73	80-128%	J/UJ	SSL
LW03-MW06-13-08A	1,2-dichloropropane-d6	76	84-123%	J/UJ	SSL
LW03-MW06-07-08A	1,2-dichloropropane-d6 trans-1,3-dichloropropane-d4	82 76	84-123% 80-128%	J/UJ	SSL
LW03-MW02-10-08A	1,1-dichloroethene-d2	54	65-130%	J/UJ	SSL

Identification/Quantitation

VOA

Dilutions were required for samples LW03-MW12-15-08A and LW03-MW12-09-08A to obtain results within the calibration range. Therefore, E-flagged compound results were not used in the initial analysis of these samples in favor of the corresponding D-flagged compound result in the dilution.

A summary of qualifications required is provided on the following page. Please do not hesitate to contact DataQual ES with any questions regarding this validation report.

Sincerely,

Jacqueline Cleveland
Vice-President

Summary of Data Qualifications

LC-VOA

Sample ID	Compound	Results	Q Flag	Q code
LW03-TB020708, LW03-MW05-13-08A, LW03-MW05-07-08A	vinyl chloride bromomethane trichlorofluoromethane	+/-	J/UJ	CCH
LW03-TB020808, LW03-MW06-13-08A, LW03-MW06-07-08A, LW03-MW02-13-08A, LW03-MW02-10-08A	chloroethane trichlorofluoromethane freon-113 methyl acetate	+/-	J/UJ	CCH
all samples	"B" flagged TICs	+	B	BL
LW03-MW05-07-08A	trans-1,3-dichloropropane-d4	+	J/UJ	SSL
LW03-MW06-13-08A	1,2-dichloropropane-d6	+	J/UJ	SSL
LW03-MW06-07-08A	1,2-dichloropropane-d6 trans-1,3-dichloropropane-d4	+	J/UJ	SSL
LW03-MW02-10-08A	1,1-dichloroethene-d2	+	J/UJ	SSL

VOA

Sample ID	Compound	Results	Q Flag	Qual code
LW03-MW07-13-08A	acetone	+/-	J/UJ	CCH
LW03-MW12-15-08A, LW03-MW12-09-08A	all E-flagged compounds	+	R	DL
LW03-MW12-15-08ADL, LW03-MW12-09-08ADL	all resulted except D-flagged compounds	+/-	R	DL

SVOA

Sample ID	Compound	Results	Q Flag	Qual code
No qualifications required.				

ICP-MS Total & Dissolved Metals

Sample ID	Analyte	Results	Q Flag	Q code
LW03-MW07-13-08A total	thallium	+ up to action limit	B	BL

Glossary of Qualification Flags and Abbreviations

Qualification Flags (Q-Flags)

U	not detected above the reported sample quantitation limit
J	estimated value
UJ	reported quantitation limit is qualified as estimated
R	result is rejected; the presence or absence of the analyte cannot be verified
D	result value is based on dilution analysis result
NJ	analyte has been tentatively identified, estimated value
L	analyte present, biased low
UL	not detected, quantitation limit is probably higher
K	analyte present, biased high
Q	estimated dioxin/furan concentration
I	interferences present which may cause the results to be biased high

Method Blank Qualification Flags (Q-Flags)

NA — The sample result for the blank contaminant is greater than the sample RL and is greater than 5X the blank value. The sample result for the blank contaminant is not qualified with any blank qualifiers.

B — The sample result for the blank contaminant is less than or greater than the sample RL and is less than 5X the blank value. The sample result for the blank contaminant is qualified as B at the compound value reported.

General Abbreviations

IDL	Instrument Detection Limit
MDL	Method Detection Limit
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
Q Code	Qualifier Code
Q Flag	Qualifier Flag
+	positive result
-	non-detect result

QUALIFIER CODE REFERENCE

Qualifier	Description
TN	Tune
BSL	Blank Spike/LCS - Low Recovery
BSH	Blank Spike/LCS - High Recovery
BD	Blank Spike/Blank Spike Duplicate (LCS/LCSD) Precision
BRL	Below Reporting Limit
EMPC	Estimated Possible Maximum Concentration
ISL	Internal Standard - Low Recovery
ISH	Internal Standard - High Recovery
MSL	Matrix Spike and/or Matrix Spike Duplicate - Low Recovery
MSH	Matrix Spike and/or Matrix Spike Duplicate - High Recovery
MI	Matrix interference obscuring the raw data
MDP	Matrix Spike/Matrix Spike Duplicate Precision
2S	Second Source - Bad reproducibility between tandem detectors
SSL	Spiked Surrogate - Low Recovery
SSH	Spiked Surrogate - High Recovery
SD	Serial Dilution Reproducibility
ICL	Initial Calibration - Low Relative Response Factors (RRF)
ICH	Initial Calibration - High Relative Response Factors (RRF)
ICB	Initial Calibration - Bad Linearity or Curve Function
CCL	Continuing Calibration - Low Recovery or %Difference
CCH	Continuing Calibration - High Recovery or %Difference
LD	Lab Duplicate Reproducibility
HT	Holding Time
PD	Pesticide Degradation
2C	Second Column - Poor Dual Column Reproducibility
LR	Concentration Exceeds Linear Range
BL	Blank Contamination- MBL, EBL, FBL, TBL
RE	Redundant Result - due to Re-analysis or Re-extraction
DL	Redundant Result - due to Dilution
FD	Field Duplicate
OT	Other - explained in data validation report
%Sol	High percent moisture

CH2M HILL
15010 Conference Center Dr. Suite 200
Chantilly, VA 20151

November 3, 2008

SDG# CTO48-4, Katahdin Analytical Services
NAB Little Creek

Dear Ms. Brower,

The following Data Validation report is provided as requested for the parameters noted in the table below for SDG # CTO48-4. The data validation was performed in accordance with the CLP statements of work OLC03.2 for low concentration volatiles, OLM04.3 for volatiles and semivolatiles and ILM05.3 for thallium, total and dissolved. Also used in the validation of these samples were the Region III Modifications to the National Functional Guidelines for Organic Data Review, 9/94, and to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Data Review, 4/93, (as referred by the Region III document Innovative Approaches to Data Validation, 6/95, for Level M3/IM-2 review), as applicable, as well as the National Functional Guidelines for Low Concentration Organic Data Review (June 2001).

Sample ID	Lab ID	Matrix	LCV	VOA	SV	Total Tl	Dissolved Tl
LW03-MW03-07-08C	SB5182-1/2	water	X		X	X	X
LW03-TB091508	SB5182-3	water	X				
LW03-FB091508	SB5182-4/5	water	X		X	X	X
LW03-MW03-13-08C	SB5182-6/7	water	X		X	X	X
LW03-MW08-0708C	SB5182-8/9	water		X	X	X	X
LW03-EB091508	SB5182-10/11	water	X		X	X	X
LW03-MW08-13-08C	SB5182-12/13	water		X	X	X	X
LW03-MW08P-07-08C	SB5182-14/15	water		X	X	X	X
LW03-MW04-07-08C	SB5216-1/2	water	X		X	X	X
LW03-MW04P-07-08C	SB5216-3/4	water	X		X	X	X
LW03-TB091608	SB51216-5	water	X				
LW03-MW04-13-08C	SB5216-6/7	water	X		X	X	X
LW03-MW05-07-08C	SB5216-8/9	water	X		X	X	X
LW03-MW05-13-08C	SB5216-10/11	water	X		X	X	X
LW03-MW10-13-08C	SB5216-12/13	water	X		X	X	X
LW03-MW10-18-08C	SB5216-14/15	water	X		X	X	X
LW03-TB091708	SB5242-1	water	X				
LW03-MW12-15-08C	SB5242-2/3	water		X	X	X	X
LW03-MW12-09-08C	SB5242-4/5	water		X	X	X	X
LW03-MW07-07-08C	SB5242-6/7	water		X	X	X	X
LW03-MW07-13-08C	SB5242-8/9	water		X	X	X	X
LW03-MW11-08-08C	SB5242-10/11	water	X		X	X	X
LW03-MW11-15-08C	SB5242-12/13	water	X		X	X	X
LW03-MW03-07-08C MS	SB5182-1/2MS	water	X		X	X	X
LW03-MW03-07-08C MSD	SB5182-1/2MSD	water	X		X	X	X
LW03-MW12-15-08C MS	SB5242-2/3MS	water		X	X	X	X
LW03-MW12-15-08C MSD	SB5242-2/3MSD	water		X	X	X	X

The following quality control samples were provided with this SDG: sample LW03-MW04P-07-08C-field duplicate of sample LW03-MW04P-07-08C; sample LW03-MW08P-07-08C-field duplicate of sample LW03-MW08P-07-08C; samples LW03-TB091508, LW03-TB091608 and LW03-TB091708-trip blanks; sample LW03-EB091508-equipment blank; and sample LW03-FB091508-field blank.

All areas of concern are discussed in the body of the report and a summary of data qualification is provided. The samples were evaluated based on the following criteria:

- Data Completeness *
- Technical Holding Times *
- Initial/Continuing Calibrations
- CRI Standards *
- Interference Check Sample *
- Blanks
- Internal Standards *
- Surrogates/DMCs
- Laboratory Control Samples *
- Matrix Spike Recoveries *
- Matrix Duplicate RPDs *
- Post Digestion Spike Recoveries *
- Serial Dilutions *
- Field Duplicates *
- Identification/Quantitation
- Reporting Limits *
- Tentatively Identified Compounds *

*- indicates that no qualifications were required based on this criteria

Overall Evaluation of Data/Potential Usability Issues

Specific details regarding qualification of the data are addressed in the Specific Evaluation section of this narrative. If an issue is not addressed there were no actions required based on unmet quality criteria. When more than one qualifier is associated with a compound/analyte the validator has chosen the qualifier that best indicates possible bias in the results and flagged the data accordingly. However, information regarding all quality control issues is provided in the body of the report and on the qualification summary page.

Major Problems

No issues requiring rejection of the data were found in this SDG.

Minor Problems

Issues requiring qualification of the analytical data were found in the validation of this SDG. A summary of these issues for each fraction is presented in the following paragraphs. All results qualified as estimated J/UJ or biased high, K or biased low, L/UL, should be considered usable but estimated.

LC-VOA

The continuing calibrations exhibited high %Ds and low RRF result that required qualifications to be added to the data.

Blank contamination was noted in QC blanks associated with samples in this batch. Qualifications were added to the data.

One sample exhibited low recoveries for three DMC compounds that resulted in qualifying all results as biased low.

One sample required a dilution to obtain results within the calibration range.

VOA

The continuing calibrations exhibited low RRF result that required qualifications to be added to the data.

Blank contamination was noted in QC blanks associated with samples in this batch. Qualifications were added to the data.

Two samples required a dilution to obtain results within the calibration range.

SVOA

No qualifications were required to be added to the data.

ICP MS Total & Dissolved Metals

No qualifications to the data were required. Please note that some samples were diluted due to the interference of sodium with internal standard recoveries. The reporting limits were adjusted accordingly.

Specific Evaluation of Data

Data Completeness

The SDG was received complete and intact. Resubmissions were not required.

Technical Holding Times

According to chain of custody records, sampling was performed on 09/15-17/08 and samples were received at the laboratory 09/16-18/08. All sample preparation and analysis was performed within Region III and/or method holding time requirements.

Initial/Continuing Calibration

LC-VOA

Calibration standards exhibited %Ds and RRFs that were non-compliant. A summary of these non-compliances and affected samples are noted in the following table. Sample results are qualified as indicated.

Standard ID	Compound(s)	RRF, %RSD, %D	Samples	Q Flag	Q Code
CC 09/23/08	dichlorodifluoromethane trichlorofluoromethane	73.7% 57.2%	LW03-TB091608, LW03-TB091508, LW03-FB091508, LW03-EB091508, LW03-MW03-07-08C, LW03-MW03-13-08C, LW03-MW04-07-08C, LW03-MW04P-07-08C, LW03-MW04-13-08C, LW03-MW05-07-08C, LW03-MW05-13-08C, LW03-MW10-13-08C, LW03-MW10-18-08C	J/UJ	CCH
CC 09/24/08	dichlorodifluoromethane trichlorofluoromethane	87.3% 74.7%	LW03-TB091708, LW03-MW11-08-08C, LW03-MW11-15-08C	J/UJ	CCH
	methyl acetate	0.044		L/R	CCL

VOA

Calibration standards exhibited RRFs that were non-compliant. A summary of these non-compliances and affected samples are noted in the following table. Sample results are qualified as indicated.

Standard ID	Compound(s)	RRF, %RSD, %D	Samples	Q Flag	Q Code
CC 09/25/08 CC 09/29/08	1,2-dibromo-3-chloropropane	0.036 0.025	all samples	L/R	CCL

Blanks

LC-VOA

The associated field QC blanks exhibited contamination as noted in the following table. Compounds for which there was no action required, are not included in the following table.

Blank ID	Compound	Concentration (ug/L)	Reporting Limit (ug/L)
LW03-TB091508	chloromethane	0.4J	0.5
LW03-TB091608	chloromethane	0.5	0.5
LW03-TB091708	chloromethane	0.6	0.5
LW03-FB091508	chloromethane	0.2J	0.5

Associated samples and required qualifications are noted in the following table.

Sample ID	Compound	Q Flag	Q Code
LW03-MW03-07-08C, LW03-MW04-07-08C, LW03-MW04P-07-08C, LW03-MW04-13-08C, LW03-MW05-13-08C, LW03-MW10-13-08C, LW03-MW10-18-08C, LW03-MW11-15-08C	chloromethane	B	BL

VOA

The associated field QC blanks exhibited contamination as noted in the following table. Compounds for which there was no action required, are not included in the following table.

Blank ID	Compound	Concentration (ug/L)	Reporting Limit (ug/L)
LW03-EB091508	acetone	9	5

Associated samples and required qualifications are noted in the following table.

Sample ID	Compound	Q Flag	Q Code
LW03-MW08-13-08C	acetone	B	BL

Deuterated Monitoring Compounds

LC-VOA

Sample LW03-MW05-07-08C exhibited low DMC recovery for 1,1-dichloroethene-d2 at 58% (QC limit 65-130%), 1,2-dichloropropane-d6 at 81% (QC limit 84-123%) and trans-1,3-dichloropropene-d4 at 79% (QC limit 80-128%); therefore all results were qualified as biased low (L/UL, Qualifier Code SSL)

Identification/Quantitation

LC-VOA

A dilution was required for sample LW03-MW05-07-08C to obtain results within the calibration range; therefore, the E-flagged results in the initial analyses were rejected in favor of the corresponding D-flagged results in the dilution analysis (qualifier code: DL).

VOA

A dilution was required for samples LW03-MW12-15-08C and LW03-MW12-09-08C to obtain results within the calibration range; therefore, the E-flagged results in the initial analyses were rejected in favor of the corresponding D-flagged results in the dilution analysis (qualifier code: DL).

A summary of qualifications required is provided on the following page. Please do not hesitate to contact DataQual ES with any questions regarding this validation report.

Sincerely,

Laura Maschhoff
President

Jacqueline Cleveland
Vice-President

Summary of Data Qualifications

LC-VOA

Sample ID	Compound	Results	Q Flag	Q code
LW03-TB091608, LW03-TB091508, LW03-FB091508, LW03-EB091508, LW03-MW03-07-08C, LW03-MW03-13-08C, LW03-MW04-07-08C, LW03-MW04P-07-08C, LW03-MW04-13-08C, LW03-MW05-07-08C, LW03-MW05-13-08C, LW03-MW10-13-08C, LW03-MW10-18-08C	dichlorodifluoromethane trichlorofluoromethane	+/-	J/UJ	CCH
LW03-TB091708, LW03-MW11-08-08C, LW03-MW11-15-08C	dichlorodifluoromethane trichlorofluoromethane	+/-	J/UJ	CCH
LW03-TB091708, LW03-MW11-08-08C, LW03-MW11-15-08C	methyl acetate	+/-	L/R	CCL
LW03-MW03-07-08C, LW03-MW04-07-08C, LW03-MW04P-07-08C, LW03-MW04-13-08C, LW03-MW05-13-08C, LW03-MW10-13-08C, LW03-MW10-18-08C, LW03-MW11-15-08C	chloromethane	+	B	BL
LW03-MW05-07-08C	all results	+/-	L/UL	SSL
LW03-MW05-07-08C	all E-flagged results	+	R	DL
LW03-MW05-07-08CDL	all results except D-flagged compounds	+/-	R	DL

VOA

Sample ID	Compound	Results	Q Flag	Qual code
all samples	1,2-dibromo-3-chloropropane	+/-	L/R	CCL
LW03-MW08-13-08C	acetone	+	B	BL
LW03-MW12-15-08C, LW03-MW12-09-08C	all E-flagged results	+	R	DL
LW03-MW12-15-08CDL, LW03-MW12-09-08CDL	all results except D-flagged compounds	+/-	R	DL

SVOA

Sample ID	Compound	Results	Q Flag	Qual code
No qualifications.				

ICP-MS Total & Dissolved Metals

Sample ID	Analyte	Results	Q Flag	Q code
No qualifications were required				

Glossary of Qualification Flags and Abbreviations

Qualification Flags (Q-Flags)

U	not detected above the reported sample quantitation limit
J	estimated value
UJ	reported quantitation limit is qualified as estimated
R	result is rejected; the presence or absence of the analyte cannot be verified
D	result value is based on dilution analysis result
NJ	analyte has been tentatively identified, estimated value
L	analyte present, biased low
UL	not detected, quantitation limit is probably higher
K	analyte present, biased high
Q	estimated dioxin/furan concentration
I	interferences present which may cause the results to be biased high

Method Blank Qualification Flags (Q-Flags)

NA — The sample result for the blank contaminant is greater than the sample RL and is greater than 5X the blank value. The sample result for the blank contaminant is not qualified with any blank qualifiers.

B — The sample result for the blank contaminant is less than or greater than the sample RL and is less than 5X the blank value. The sample result for the blank contaminant is qualified as B at the compound value reported.

General Abbreviations

IDL	Instrument Detection Limit
MDL	Method Detection Limit
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
Q Code	Qualifier Code
Q Flag	Qualifier Flag
+	positive result
-	non-detect result

QUALIFIER CODE REFERENCE

Qualifier	Description
TN	Tune
BSL	Blank Spike/LCS - Low Recovery
BSH	Blank Spike/LCS - High Recovery
BD	Blank Spike/Blank Spike Duplicate (LCS/LCSD) Precision
BRL	Below Reporting Limit
EMPC	Estimated Possible Maximum Concentration
ISL	Internal Standard - Low Recovery
ISH	Internal Standard - High Recovery
MSL	Matrix Spike and/or Matrix Spike Duplicate - Low Recovery
MSH	Matrix Spike and/or Matrix Spike Duplicate - High Recovery
MI	Matrix interference obscuring the raw data
MDP	Matrix Spike/Matrix Spike Duplicate Precision
2S	Second Source - Bad reproducibility between tandem detectors
SSL	Spiked Surrogate - Low Recovery
SSH	Spiked Surrogate - High Recovery
SD	Serial Dilution Reproducibility
ICL	Initial Calibration - Low Relative Response Factors (RRF)
ICH	Initial Calibration - High Relative Response Factors (RRF)
ICB	Initial Calibration - Bad Linearity or Curve Function
CCL	Continuing Calibration - Low Recovery or %Difference
CCH	Continuing Calibration - High Recovery or %Difference
LD	Lab Duplicate Reproducibility
HT	Holding Time
PD	Pesticide Degradation
2C	Second Column - Poor Dual Column Reproducibility
LR	Concentration Exceeds Linear Range
BL	Blank Contamination- MBL, EBL, FBL, TBL
RE	Redundant Result - due to Re-analysis or Re-extraction
DL	Redundant Result - due to Dilution
FD	Field Duplicate
OT	Other - explained in data validation report
%Sol	High percent moisture

CH2M HILL
15010 Conference Center Dr. Suite 200
Chantilly, VA 20151

November 3, 2008
SDG# CTO48-5, Katahdin Analytical Services
NAB Little Creek

Dear Ms. Brower,

The following Data Validation report is provided as requested for the parameters noted in the table below for SDG # CTO48-5. The data validation was performed in accordance with the CLP statements of work OLC03.2 for low concentration volatiles, OLM04.3 for volatiles and semivolatiles and ILM05.3 for thallium, total and dissolved. Also used in the validation of these samples were the Region III Modifications to the National Functional Guidelines for Organic Data Review, 9/94, and to the Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Data Review, 4/93, (as referred by the Region III document Innovative Approaches to Data Validation, 6/95, for Level M3/IM-2 review), as applicable, as well as the National Functional Guidelines for Low Concentration Organic Data Review (June 2001).

Sample ID	Lab ID	Matrix	LCV	VOA	SV	Total Tl	Dissolved Tl
LW03-MW02-07-08C	SB5299-1/2	water	X		X	X	X
LW03-MW02-13-08C	SB5299-3/4	water	X		X	X	X
LW03-MW09-10-08C	SB5299-5/6	water	X		X	X	X
LW03-MW09-18-08C	SB5299-7/8	water	X		X	X	X
LW03-MW09P-18-08C	SB5299-9/10	water	X		X	X	X
LW03-MW01-07-08C	SB5299-11/12	water	X		X	X	X
LW03-MW01-13-08C	SB5299-13/14	water	X		X	X	X
LW03-TB091808	SB5299-15	water	X				
LW03-EB091908	SB5329-1/2	water	X		X	X	X
LW03-TB091908	SB5329-3	water	X				
LW03-MW14-09-08C	SB5329-4/5	water	X		X	X	X
LW03-MW14-16-08C	SB5329-6/7	water	X		X	X	X
LW03-MW15-10-08C	SB5329-8/9	water	X		X	X	X
LW03-MW15-18-08C	SB5329-10/11	water	X		X	X	X
LW03-MW13-07-08C	SB5329-12/13	water	X		X	X	X
LW03-MW06-07-08C	SB5357-1/2	water		X	X	X	X
LW03-MW06-10-08C	SB5357-3/4	water		X	X	X	X
LW03-TB092208	SB5357-5	water	X				
LW03-MW06-16-08C	SB5357-6/7	water		X	X	X	X
LW03-MW06P-16-08C	SB5357-8/9	water		X	X	X	X
LW03-MW13-14-08C	SB5357-10/11	water	X		X	X	X
LW03-FB092208	SB5357-12/13	water	X		X	X	X
LW03-MW14-16-08C MS	SB5329-6/7MS	water	X			X	X
LW03-MW14-16-08C MSD	SB5329-6/7MSD	water	X			X	X

The following quality control samples were provided with this SDG: sample LW03-MW09P-18-08C-field duplicate of sample LW03-MW09-18-08C; sample LW03-MW06-16P-08C-field duplicate of sample LW03-MW06-16-08C; samples LW03-TB091808, LW03-TB091908 and LW03-TB092208-trip blanks; sample LW03-EB091908-equipment blank; and sample LW03-FB092208-field blank. All areas of concern are discussed in the body of the report and a summary of data qualification is provided. The samples were evaluated based on the following criteria:

- Data Completeness *
- Technical Holding Times *
- Initial/Continuing Calibrations
- CRI Standards *
- Interference Check Sample *
- Blanks
- Internal Standards *
- Surrogates/DMCs *
- Laboratory Control Samples *
- Matrix Spike Recoveries *
- Matrix Duplicate RPDs *
- Post Digestion Spike Recoveries *
- Serial Dilutions *
- Field Duplicates *
- Identification/Quantitation *
- Reporting Limits *
- Tentatively Identified Compounds

*- indicates that no qualifications were required based on this criteria

<u>Overall Evaluation of Data/Potential Usability Issues</u>

Specific details regarding qualification of the data are addressed in the Specific Evaluation section of this narrative. If an issue is not addressed there were no actions required based on unmet quality criteria. When more than one qualifier is associated with a compound/analyte the validator has chosen the qualifier that best indicates possible bias in the results and flagged the data accordingly. However, information regarding all quality control issues is provided in the body of the report and on the qualification summary page.

Major Problems

No issues requiring rejection of the data were found in this SDG.

Minor Problems

Issues requiring qualification of the analytical data were found in the validation of this SDG. A summary of these issues for each fraction is presented in the following paragraphs. All results qualified as estimated J/UJ or biased high, K or biased low, L/UL, should be considered usable but estimated. When more than one qualifier is associated with a compound/analyte the validator has chosen the qualifier that best indicates possible bias in the results and flagged the data accordingly. However, information regarding all quality control issues is provided in the body of the report and on the qualification summary page.

LC-VOA

The continuing calibrations exhibited high %Ds and low RRF result that required qualifications to be added to the data.

Blank contamination was noted in QC blanks associated with samples in this batch. Qualifications were added to the data.

VOA

The continuing calibrations exhibited low RRF result that required qualifications to be added to the data.

SVOA

Blank contamination was noted in method and QC blanks associated with samples in this batch. Qualifications were added to the data.

ICP MS Total & Dissolved Metals

No qualifications to the data were required. Please note that some samples were diluted due to the interference of sodium with internal standard recoveries. The reporting limits were adjusted accordingly.

Specific Evaluation of Data

Data Completeness

The SDG was received complete and intact. Resubmissions were not required.

Technical Holding Times

According to chain of custody records, sampling was performed on 09/18-22/08 and samples were received at the laboratory 09/19-23/08. All sample preparation and analysis was performed within Region III and/or method holding time requirements.

Initial/Continuing Calibration

LC-VOA

Calibration standards exhibited %Ds and RRFs that were non-compliant. A summary of these non-compliances and affected samples are noted in the following table. Sample results are qualified as indicated.

Standard ID	**Compound(s)**	**RRF, %RSD, %D**	**Samples**	**Q Flag**	**Q Code**
CC 09/24/08	dichlorodifluoromethane trichlorofluoromethane	87.3% 74.7%	LW03-TB091808, LW03-EB091908, LW03-TB091908, LW03-MW02-07-08C, LW03-MW02-13-08C, LW03-MW09-10-08C, LW03-MW09-18-08C, LW03-MW09P-18-08C, LW03-MW01-07-08C, LW03-MW01-13-08C, LW03-MW14-09-08C	J/UJ	CCH
	methyl acetate	0.044		L/R	CCL
CC 09/25/08	dichlorodifluoromethane trichlorofluoromethane	93.4% 73.8%	LW03-TB092208, LW03-FB092208, LW03-MW14-16-08C, LW03-MW15-10-08C, LW03-MW15-18-08C, LW03-MW13-07-08C, LW03-MW13-14-08C	J/UJ	CCH

VOA

Calibration standards exhibited RRFs that were non-compliant. A summary of these non-compliances and affected samples are noted in the following table. Sample results are qualified as indicated.

Standard ID	**Compound(s)**	**RRF, %RSD, %D**	**Samples**	**Q flag**	**Q Code**
CC 09/25/08 CC 09/29/08	1,2-dibromo-3-chloropropane	0.036 0.025	all samples	L/R	CCL

Blanks

LC-VOA

The associated field QC blanks exhibited contamination as noted in the following table. Compounds for which there was no action required, are not included in the following table.

Blank ID	**Compound**	**Concentration (ug/L)**	**Reporting Limit (ug/L)**
LW03-TB091808	chloromethane	0.3J	0.5
	methylene chloride	0.45J	0.5
	chloroform	0.8	0.5

Blank ID	Compound	Concentration (ug/L)	Reporting Limit (ug/L)
LW03-TB091908	chloroform	0.7	0.5
	chloromethane	0.5J	0.5
	methylene chloride	0.4J	0.5
LW03-TB092208	chloromethane	0.5	0.5
	methylene chloride	0.5J	0.5
	chloroform	0.7	0.5
LW03-FB092208	acetone	11	5.0
	methylene chloride	2	0.5
LW03-EB091908	acetone	12	0.5
	methylene chloride	2	0.5

Associated samples and required qualifications are noted in the following table.

Sample ID	Compound	Q Flag	Q Code
LW03-MW02-07-08C, LW03-MW02-13-08C, LW03-MW09-10-08C, LW03-MW09-18-08C, LW03-MW09P-18-08C, LW03-MW01-11-08C, LW03-MW13-14-08C	chloromethane	B	BL
LW03-MW13-14-08C	acetone	B	BL

SVOA

The associated method and QC blanks exhibited contamination for TICs. All B flagged TICs in the field samples are flagged B and crossed out in accordance with the Region III modifications to the National Functional Guidelines.

A summary of qualifications required is provided on the following page. Please do not hesitate to contact DataQual ES with any questions regarding this validation report.

Sincerely,

Laura Maschhoff
President

Jacqueline Cleveland
Vice-President

Summary of Data Qualifications

LC-VOA

Sample ID	Compound	Results	Q Flag	Q code
LW03-TB091808, LW03-EB091908, LW03-TB091908, LW03-MW02-07-08C, LW03-MW02-13-08C, LW03-MW09-10-08C, LW03-MW09-18-08C, LW03-MW09P-18-08C, LW03-MW01-07-08C, LW03-MW01-13-08C, LW03-MW14-09-08C	dichlorodifluoromethane trichlorofluoromethane	+/-	J/UJ	CCH
LW03-TB091808, LW03-EB091908, LW03-TB091908, LW03-MW02-07-08C, LW03-MW02-13-08C, LW03-MW09-10-08C, LW03-MW09-18-08C, LW03-MW09P-18-08C, LW03-MW01-07-08C, LW03-MW01-13-08C, LW03-MW14-09-08C	methyl acetate	+/-	L/R	CCL
LW03-TB092208, LW03-FB092208, LW03-MW14-16-08C, LW03-MW15-10-08C, LW03-MW15-18-08C, LW03-MW13-07-08C, LW03-MW13-14-08C	dichlorodifluoromethane trichlorofluoromethane	+/-	J/UJ	CCH
LW03-MW02-07-08C, LW03-MW02-13-08C, LW03-MW09-10-08C, LW03-MW09-18-08C, LW03-MW09P-18-08C, LW03-MW01-11-08C, LW03-MW13-14-08C	chloromethane	+	B	BL
LW03-MW13-14-08C	acetone	+	B	BL

VOA

Sample ID	Compound	Results	Q Flag	Qual code
all samples	1,2-dibromo-3-chloropropane	+/-	L/R	CCL

SVOA

Sample ID	Compound	Results	Q Flag	Qual code
all samples	"B" flagged TICs	+	B	BL

ICP-MS Total & Dissolved Metals

Sample ID	Analyte	Results	Q Flag	Q code
No qualifications were required				

Glossary of Qualification Flags and Abbreviations

Qualification Flags (Q-Flags)

U	not detected above the reported sample quantitation limit
J	estimated value
UJ	reported quantitation limit is qualified as estimated
R	result is rejected; the presence or absence of the analyte cannot be verified
D	result value is based on dilution analysis result
NJ	analyte has been tentatively identified, estimated value
L	analyte present, biased low
UL	not detected, quantitation limit is probably higher
K	analyte present, biased high
Q	estimated dioxin/furan concentration
I	interferences present which may cause the results to be biased high

Method Blank Qualification Flags (Q-Flags)

NA — The sample result for the blank contaminant is greater than the sample RL and is greater than 5X the blank value. The sample result for the blank contaminant is not qualified with any blank qualifiers.

B — The sample result for the blank contaminant is less than or greater than the sample RL and is less than 5X the blank value. The sample result for the blank contaminant is qualified as B at the compound value reported.

General Abbreviations

IDL	Instrument Detection Limit
MDL	Method Detection Limit
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
Q Code	Qualifier Code
Q Flag	Qualifier Flag
+	positive result
-	non-detect result

QUALIFIER CODE REFERENCE

Qualifier	Description
TN	Tune
BSL	Blank Spike/LCS - Low Recovery
BSH	Blank Spike/LCS - High Recovery
BD	Blank Spike/Blank Spike Duplicate (LCS/LCSD) Precision
BRL	Below Reporting Limit
EMPC	Estimated Possible Maximum Concentration
ISL	Internal Standard - Low Recovery
ISH	Internal Standard - High Recovery
MSL	Matrix Spike and/or Matrix Spike Duplicate - Low Recovery
MSH	Matrix Spike and/or Matrix Spike Duplicate - High Recovery
MI	Matrix interference obscuring the raw data
MDP	Matrix Spike/Matrix Spike Duplicate Precision
2S	Second Source - Bad reproducibility between tandem detectors
SSL	Spiked Surrogate - Low Recovery
SSH	Spiked Surrogate - High Recovery
SD	Serial Dilution Reproducibility
ICL	Initial Calibration - Low Relative Response Factors (RRF)
ICH	Initial Calibration - High Relative Response Factors (RRF)
ICB	Initial Calibration - Bad Linearity or Curve Function
CCL	Continuing Calibration - Low Recovery or %Difference
CCH	Continuing Calibration - High Recovery or %Difference
LD	Lab Duplicate Reproducibility
HT	Holding Time
PD	Pesticide Degradation
2C	Second Column - Poor Dual Column Reproducibility
LR	Concentration Exceeds Linear Range
BL	Blank Contamination- MBL, EBL, FBL, TBL
RE	Redundant Result - due to Re-analysis or Re-extraction
DL	Redundant Result - due to Dilution
FD	Field Duplicate
OT	Other - explained in data validation report
%Sol	High percent moisture

MEMORANDUM CH2MHILL

Data Validation Summary

Little Creek, CTO-WE61, SWMU 3

TO: Megan Morrison/SAN

Anita Dodson/VBO

FROM: Tiffany McGlynn/GNV

CC: Herb Kelly/GNV

DATE: September 9, 2014

Introduction

The following data validation report discusses the data validation process and findings for Empirical Laboratories, for SDG 1408083.

Samples were analyzed using the following analytical methods:

- SW8260B Volatiles

The samples included in this SDG are listed in the table below.

Sample Name	Matrix
LW03-MW03-14C	Water
LW03-MW04-14C	Water
LW03-MW07-14C	Water
LW03-MW07P-14C	Water
LW03-TB-081214	Water

Data Evaluation

Data was evaluated in accordance with the analytical methods and with the criteria found in the following guidance documents: Sampling and Analysis Plan for Pre-Feasibility Study Groundwater Sampling at Solid Waste Management Unit (SWMU) 3 Joint Expeditionary Base (JEB) Little Creek-Fort Story JEB Little Creek Virginia Beach, Virginia Contract Task Order WE61 (August 2014) and Region III Modifications for Organic Data Review (EPA 1994), as applicable. The samples were evaluated based on the following criteria:

- Data Completeness
- Technical Holding Times
- Instrument Tuning
- Initial/Continuing Calibrations
- Blanks
- Internal Standards
- Laboratory Control Sample
- Matrix Spike Recoveries
- Surrogates
- Field Duplicate
- Identification/Quantitation
- Reporting Limits

Overall Evaluation of Data/Potential Usability Issues

Specific details regarding qualification of the data are addressed in the sections below. If an issue is not addressed there were no actions required based on unmet quality criteria. When more than one qualifier is associated with a compound/analyte, the validator has chosen the qualifier that best indicates possible bias in the results and qualified these data accordingly.

Data Completeness

The SDG was received complete and intact.

Technical Holding Times

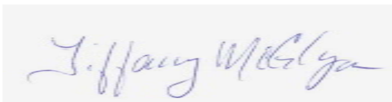
According to the chain of custody records, sampling was performed on 8/12/14. Samples were received at the laboratory on 8/13/14. All sample preparation and analyses were performed within holding time requirements.

Conclusion

These data can be used in the project decision-making process as qualified by the data quality evaluation process.

Please do not hesitate to contact us about this validation report.

Sincerely,



Tiffany McGlynn

Qualification Flags

Exclude	More appropriate data exist for this analyte.
R	Data were rejected for use.
UL	Analyte not detected, quantitation limit is potentially biased low.
UJ	Analyte not detected, estimated quantitation limit.
U	Analyte not detected.
B	Not detected substantially above the level reported in laboratory or field blanks.
L	Analyte present, estimated value potentially biased low.
K	Analyte present, estimated value potentially biased high.
N	Analyte identification presumptive; no second column analysis performed or GC/MS tentative identification.
J	Analyte present, estimated value.
NJ	Analysis indicates the presence of an analyte that was "tentatively identified" and the associated value represents its approximate concentration.
None	Placeholder for calculating quality control issues that do not require flagging.
=	Analyte was detected at a concentration greater than the quantitation limit.

Qualifier Code Reference

Value	Description
%SOL	High Moisture content
2C	Second Column – Poor Dual Column Reproducibility
2S	Second Source – Bad reproducibility between tandem detectors
BD	Blank Spike/Blank Spike Duplicate(LCS/LCSD) Precision
BRL	Below Reporting Limit
BSH	Blank Spike/LCS – High Recovery
BSL	Blank Spike/LCS – Low Recovery
CC	Continuing Calibration
CCBL	Continuing Calibration Blank Contamination
CCH	Continuing Calibration Verification – High Recovery
CCL	Continuing Calibration Verification – Low Recovery
DL	Redundant Result – due to Dilution
EBL	Equipment Blank Contamination
EMPC	Estimated Possible Maximum Concentration
ESH	Extraction Standard - High Recovery
ESL	Extraction Standard - Low Recovery
FBL	Field Blank Contamination
FD	Field Duplicate
HT	Holding Time
ICB	Initial Calibration – Bad Linearity or Curve Function
ICH	Initial Calibration – High Relative Response Factors
ICL	Initial Calibration – Low Relative Response Factors
IR15	Ion ratio exceeds +/- 15% difference
ISH	Internal Standard – High Recovery
ISL	Internal Standard – Low Recovery
LD	Lab Duplicate Reproducibility
LR	Concentration Exceeds Linear Range
MBL	Method Blank Contamination
MDP	Matrix Spike/Matrix Spike Duplicate Precision
MI	Matrix interference obscuring the raw data

Value	Description
MSH	Matrix Spike and/or Matrix Spike Duplicate – High Recovery
MSL	Matrix Spike and/or Matrix Spike Duplicate – Low Recovery
OT	Other
PD	Pesticide Degradation
RE	Redundant Result - due to Reanalysis or Re-extraction
SD	Serial Dilution Reproducibility
SSH	Spiked Surrogate – High Recovery
SSL	Spiked Surrogate – Low Recovery
TBL	Trip Blank Contamination
TN	Tune

Data Validation Summary

Little Creek, CTO-WE61, SWMU 3

TO: Megan Morrison/SAN

Anita Dodson/VBO

FROM: Tiffany McGlynn/GNV

CC: Herb Kelly/GNV

DATE: September 9, 2014

Introduction

The following data validation report discusses the data validation process and findings for Empirical Laboratories, for SDG 1408095.

Samples were analyzed using the following analytical methods:

- SW8260B Volatiles

The samples included in this SDG are listed in the table below.

Sample Name	Matrix
LW03-MW02-14C	Water
LW03-MW02P-14C	Water
LW03-MW08-14C	Water
LW03-MW09-14C	Water
LW03-MW10-14C	Water
LW03-MW13-14C	Water
LW03-TB01-081314	Water

Data Evaluation

Data was evaluated in accordance with the analytical methods and with the criteria found in the following guidance documents: Sampling and Analysis Plan for Pre-Feasibility Study Groundwater Sampling at Solid Waste Management Unit (SWMU) 3 Joint Expeditionary Base (JEB) Little Creek-Fort Story JEB Little Creek Virginia Beach, Virginia Contract Task Order

WE61 (August 2014) and Region III Modifications for Organic Data Review (EPA 1994), as applicable. The samples were evaluated based on the following criteria:

- Data Completeness
- Technical Holding Times
- Instrument Tuning
- Initial/Continuing Calibrations
- Blanks
- Internal Standards
- Laboratory Control Sample
- Matrix Spike Recoveries
- Surrogates
- Field Duplicate
- Identification/Quantitation
- Reporting Limits

Overall Evaluation of Data/Potential Usability Issues

Specific details regarding qualification of the data are addressed in the sections below. If an issue is not addressed there were no actions required based on unmet quality criteria. When more than one qualifier is associated with a compound/analyte, the validator has chosen the qualifier that best indicates possible bias in the results and qualified these data accordingly.

Data Completeness

The SDG was received complete and intact.

Technical Holding Times

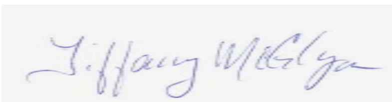
According to the chain of custody records, sampling was performed on 8/13/14. Samples were received at the laboratory on 8/14/14. All sample preparation and analyses were performed within holding time requirements.

Conclusion

These data can be used in the project decision-making process as qualified by the data quality evaluation process.

Please do not hesitate to contact us about this validation report.

Sincerely,



Tiffany McGlynn

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None	Placeholder for calculating quality control issues that do not require flagging.
=	Analyte was detected at a concentration greater than the quantitation limit.

Qualifier Code Reference

Value	Description
%SOL	High Moisture content
2C	Second Column – Poor Dual Column Reproducibility
2S	Second Source – Bad reproducibility between tandem detectors
BD	Blank Spike/Blank Spike Duplicate(LCS/LCSD) Precision
BRL	Below Reporting Limit
BSH	Blank Spike/LCS – High Recovery
BSL	Blank Spike/LCS – Low Recovery
CC	Continuing Calibration
CCBL	Continuing Calibration Blank Contamination
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HT	Holding Time
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ICH	Initial Calibration – High Relative Response Factors
ICL	Initial Calibration – Low Relative Response Factors
IR15	Ion ratio exceeds +/- 15% difference
ISH	Internal Standard – High Recovery
ISL	Internal Standard – Low Recovery
LD	Lab Duplicate Reproducibility
LR	Concentration Exceeds Linear Range
MBL	Method Blank Contamination
MDP	Matrix Spike/Matrix Spike Duplicate Precision
MI	Matrix interference obscuring the raw data

Value	Description
MSH	Matrix Spike and/or Matrix Spike Duplicate – High Recovery
MSL	Matrix Spike and/or Matrix Spike Duplicate – Low Recovery
OT	Other
PD	Pesticide Degradation
RE	Redundant Result - due to Reanalysis or Re-extraction
SD	Serial Dilution Reproducibility
SSH	Spiked Surrogate – High Recovery
SSL	Spiked Surrogate – Low Recovery
TBL	Trip Blank Contamination
TN	Tune

MEMORANDUM CH2MHILL

Data Validation Summary

Little Creek, CTO-WE61, SWMU 3

TO: Megan Morrison/SAN

Anita Dodson/VBO

FROM: Tiffany McGlynn/GNV

CC: Herb Kelly/GNV

DATE: September 9, 2014

Introduction

The following data validation report discusses the data validation process and findings for Empirical Laboratories, for SDG 1408104.

Samples were analyzed using the following analytical methods:

- SW8260B Volatiles

The samples included in this SDG are listed in the table below.

Sample Name	Matrix
LW03-MW01-14C	Water
LW03-MW06-14C	Water
LW03-MW11-14C	Water
LW03-MW15-14C	Water
LW03-TB01-081414	Water

Data Evaluation

Data was evaluated in accordance with the analytical methods and with the criteria found in the following guidance documents: Sampling and Analysis Plan for Pre-Feasibility Study Groundwater Sampling at Solid Waste Management Unit (SWMU) 3 Joint Expeditionary Base (JEB) Little Creek-Fort Story JEB Little Creek Virginia Beach, Virginia Contract Task Order WE61 (August 2014) and Region III Modifications for Organic Data Review (EPA 1994), as applicable. The samples were evaluated based on the following criteria:

- Data Completeness
- Technical Holding Times
- Instrument Tuning
- Initial/Continuing Calibrations
- Blanks
- Internal Standards
- Laboratory Control Sample
- Matrix Spike Recoveries
- Surrogates
- Field Duplicate
- Identification/Quantitation
- Reporting Limits

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Specific details regarding qualification of the data are addressed in the sections below. If an issue is not addressed there were no actions required based on unmet quality criteria. When more than one qualifier is associated with a compound/analyte, the validator has chosen the qualifier that best indicates possible bias in the results and qualified these data accordingly.

Data Completeness

The SDG was received complete and intact.

Technical Holding Times

According to the chain of custody records, sampling was performed on 8/14/14. Samples were received at the laboratory on 8/15/14. All sample preparation and analyses were performed within holding time requirements.

Conclusion

These data can be used in the project decision-making process as qualified by the data quality evaluation process.

Please do not hesitate to contact us about this validation report.

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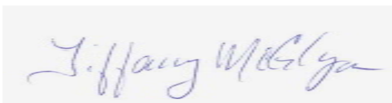

Tiffany McGlynn

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Qualifier Code Reference

Value	Description
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2S	Second Source – Bad reproducibility between tandem detectors
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ISL	Internal Standard – Low Recovery
LD	Lab Duplicate Reproducibility
LR	Concentration Exceeds Linear Range
MBL	Method Blank Contamination
MDP	Matrix Spike/Matrix Spike Duplicate Precision
MI	Matrix interference obscuring the raw data

Value	Description
MSH	Matrix Spike and/or Matrix Spike Duplicate – High Recovery
MSL	Matrix Spike and/or Matrix Spike Duplicate – Low Recovery
OT	Other
PD	Pesticide Degradation
RE	Redundant Result - due to Reanalysis or Re-extraction
SD	Serial Dilution Reproducibility
SSH	Spiked Surrogate – High Recovery
SSL	Spiked Surrogate – Low Recovery
TBL	Trip Blank Contamination
TN	Tune

MEMORANDUM CH2MHILL

Data Validation Summary

Little Creek, CTO-WE61, SWMU 3

TO: Megan Morrison/SAN

Anita Dodson/VBO

FROM: Tiffany McGlynn/GNV

CC: Herb Kelly/GNV

DATE: September 9, 2014

Introduction

The following data validation report discusses the data validation process and findings for Empirical Laboratories, for SDG 1408123.

Samples were analyzed using the following analytical methods:

- SW8260B Volatiles

The samples included in this SDG are listed in the table below.

Sample Name	Matrix
LW03-EB01-081514	Water
LW03-MW12-14C	Water
LW03-MW14-14C	Water
LW03-TB01-081514	Water

Data Evaluation

Data was evaluated in accordance with the analytical methods and with the criteria found in the following guidance documents: Sampling and Analysis Plan for Pre-Feasibility Study Groundwater Sampling at Solid Waste Management Unit (SWMU) 3 Joint Expeditionary Base (JEB) Little Creek-Fort Story JEB Little Creek Virginia Beach, Virginia Contract Task Order WE61 (August 2014) and Region III Modifications for Organic Data Review (EPA 1994), as applicable. The samples were evaluated based on the following criteria:

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- Instrument Tuning
- Initial/Continuing Calibrations
- Blanks
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Data Completeness

The SDG was received complete and intact.

Technical Holding Times

According to the chain of custody records, sampling was performed on 8/15/14. Samples were received at the laboratory on 8/16/14. All sample preparation and analyses were performed within holding time requirements.

Conclusion

These data can be used in the project decision-making process as qualified by the data quality evaluation process.

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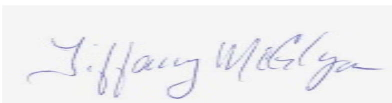

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CCBL	Continuing Calibration Blank Contamination
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ICL	Initial Calibration – Low Relative Response Factors
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ISH	Internal Standard – High Recovery
ISL	Internal Standard – Low Recovery
LD	Lab Duplicate Reproducibility
LR	Concentration Exceeds Linear Range
MBL	Method Blank Contamination
MDP	Matrix Spike/Matrix Spike Duplicate Precision
MI	Matrix interference obscuring the raw data

Value	Description
MSH	Matrix Spike and/or Matrix Spike Duplicate – High Recovery
MSL	Matrix Spike and/or Matrix Spike Duplicate – Low Recovery
OT	Other
PD	Pesticide Degradation
RE	Redundant Result - due to Reanalysis or Re-extraction
SD	Serial Dilution Reproducibility
SSH	Spiked Surrogate – High Recovery
SSL	Spiked Surrogate – Low Recovery
TBL	Trip Blank Contamination
TN	Tune

Appendix C
August 2014
Human Health Risk Assessment Tables

Table 2.1

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Groundwater - Tap Water and Water in Excavation Trench	**75-34-3**	**1,1-Dichloroethane**	**1.1E+00 DJ**	**3.0E+00 D**	**UG/L**	**LW03-MW07P-14C**	**3/14**	**0.25 - 0.5**	**3.0E+00**	**N/A**	**2.7E+00 C**	**N/A**		**YES**	**ASL**
	156-59-2	**cis-1,2-Dichloroethene**	**2.5E+00 D**	**2.8E+01 D**	**UG/L**	**LW03-MW12-14C**	**3/14**	**0.25 - 0.5**	**2.8E+01**	**N/A**	**3.6E+00 N**	**7.0E+01**	**MCL**	**YES**	**ASL**
	156-60-5	trans-1,2-Dichloroethene	2.7E+00 D	1.2E+01 D	UG/L	LW03-MW12-14C	2/14	0.25 - 0.5	1.2E+01	N/A	3.6E+01 N	1.0E+02	MCL	NO	BSL
	79-01-6	**Trichloroethene**	**2.0E+00 DJ**	**6.0E+00 D**	**UG/L**	**LW03-MW07P-14C**	**2/14**	**0.25 - 0.5**	**6.0E+00**	**N/A**	**2.8E-01 N**	**5.0E+00**	**MCL**	**YES**	**ASL**
	75-01-4	**Vinyl chloride**	**2.9E+00 D**	**1.6E+01 D**	**UG/L**	**LW03-MW12-14C**	**2/14**	**0.25 - 0.5**	**1.6E+01**	**N/A**	**1.9E-02 C**	**2.0E+00**	**MCL**	**YES**	**ASL**

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values not available.

[4] Oak Ridge National Laboratory (ORNL). May, 2014. Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites.
Tap water RSLs. RSLs based on noncancer based on hazard quotient of 0.1, RSLs based on cancer based on cancer risk of 10^{-6}.

[5] Rationale Codes

Selection Reason: Above Screening Levels (ASL)

Deletion Reason: Below Screening Level (BSL)

COPC = Chemical of Potential Concern

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered

J = Estimated Value

D = Sample Diluted

C = Carcinogenic

N = Noncarcinogenic

MCL = Maximum Contaminant Level

N/A = not available/not applicable

Table 2.2

OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Point	CAS Number	Chemical	Minimum [1] Concentration Qualifier	Maximum [1] Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration [2] Used for Screening	Background [3] Value	Screening [4] Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for [5] Contaminant Deletion or Selection
Groundwater - Water Vapors at Showerhead and Excavation Trench	**75-34-3**	**1,1-Dichloroethane**	**1.1E+00 DJ**	**3.0E+00 D**	**UG/L**	**LW03-MW07P-14C**	**3/14**	**0.25 - 0.5**	**3.0E+00**	**N/A**	**2.7E+00 C**	**N/A**		**YES**	**ASL**
	156-59-2	**cis-1,2-Dichloroethene**	**2.5E+00 D**	**2.8E+01 D**	**UG/L**	**LW03-MW12-14C**	**3/14**	**0.25 - 0.5**	**2.8E+01**	**N/A**	**3.6E+00 N**	**7.0E+01**	**MCL**	**YES**	**ASL**
	156-60-5	trans-1,2-Dichloroethene	2.7E+00 D	1.2E+01 D	UG/L	LW03-MW12-14C	2/14	0.25 - 0.5	1.2E+01	N/A	3.6E+01 N	1.0E+02	MCL	NO	BSL
	79-01-6	**Trichloroethene**	**2.0E+00 DJ**	**6.0E+00 D**	**UG/L**	**LW03-MW07P-14C**	**2/14**	**0.25 - 0.5**	**6.0E+00**	**N/A**	**2.8E-01 N**	**5.0E+00**	**MCL**	**YES**	**ASL**
	75-01-4	**Vinyl chloride**	**2.9E+00 D**	**1.6E+01 D**	**UG/L**	**LW03-MW12-14C**	**2/14**	**0.25 - 0.5**	**1.6E+01**	**N/A**	**1.9E-02 C**	**2.0E+00**	**MCL**	**YES**	**ASL**

[1] Minimum/Maximum detected concentrations.

[2] Maximum concentration is used for screening.

[3] Background values not available.

[4] Oak Ridge National Laboratory (ORNL). May, 2014. Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites.
Tap water RSLs. RSLs based on noncancer based on hazard quotient of 0.1, RSLs based on cancer based on cancer risk of 10^{-6}.
RSL value for n-hexane used as surrogate for methylcyclohexane.

[5] Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
J = Estimated Value
D = Sample Diluted
C = Carcinogenic
N = Noncarcinogenic
MCL = Maximum Contaminant Level
N/A = not available/not applicable

TABLE 4.1.RME
VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Industrial Worker	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				IR-W	Ingestion Rate of Water	1.25	liters/day	EPA, 2014 (1)	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	250	days/year	EPA, 2014	
				ED	Exposure Duration	25	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9,125	days	EPA, 1989	
	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-W	Ingestion Rate of Water	2.5	liters/day	EPA, 2014	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 2014	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				IR-W	Ingestion Rate of Water	0.78	liters/day	EPA, 2014	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				IR-W-A	Ingestion Rate of Water, Adult	2.5	liters/day	EPA, 2014	CW x IR-W-Adj x EF x CF1 x 1/AT
				IR-W-C	Ingestion Rate of Water, Child	0.78	liters/day	EPA, 2014	
				IR-W-Adj	Ingestion Rate of Water, Age-adjusted	0.94	liter-year/kg-day	calculated	IR-W-Adj (liter-year/kg-day) =
				EF	Exposure Frequency	350	days/year	EPA, 2014	(ED-C x IR-W-C / BW-C) +
				ED-A	Exposure Duration, Adult	20	years	EPA, 2014	(ED-A x IR-W-A / BW-A)
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW-A	Body Weight , Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	0.71	hr/event	EPA, 2014	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	20,900	cm^2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	80	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	0.54	hr/event	EPA, 2014	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	6,378	cm^2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	6	years	EPA, 2014	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	15	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	

TABLE 4.1.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal (cont'd)	Resident	Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) = DA-Adj x EF x 1/AT
				DAevent-A	Dermally Absorbed Dose per Event, Adult	Calculated	mg/cm^2-event	calculated	
				DAevent-C	Dermally Absorbed Dose per Event, Child	Calculated	mg/cm^2-event	calculated	DA-Adj = (DAevent-A x SA-A x ED-A x 1/BW-A)
				DA-Adj	Dermally Absorbed Dose, Age-adjusted	Calculated	mg-year/event-kg	calculated	+ (DAevent-C x SA-C x ED-C x 1/BW-C)
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}-A	Event Time, Adult	0.71	hr/event	EPA, 2014	t_{event}<t*: DAevent (mg/cm^2-event) =
				t_{event}-C	Event Time, Child	0.54	hr/event	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 xτ x t_{event})/π))
				SA-A	Skin Surface Area, Adult	20,900	cm^2	EPA, 2014	x CF1 x CF2
				SA-C	Skin Surface Area, Child	6,378	cm^2	EPA, 2014	
				EV	Event Frequency	1	events/day	EPA, 2004	t_{event}>t*: DAevent (mg/cm^2-event) =
				EF	Exposure Frequency	350	days/year	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				ED-A	Exposure Duration, Adult	20	years	EPA, 2014	$((1 + 3B + 3B^2)/(1+B)^2)$) x CF1 x CF2
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				BW-A	Body Weight, Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	
	Construction Worker	Adult	Water in Excavation Trench	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	chemical specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	chemical specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	chemical specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF2 x CF3
				t*	Time to Reach Steady-state	chemical specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	chemical specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	8	hr/day	(2)	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	3,515	cm^2	EPA, 2011 (3)	2 x FA x Kp x CW x (sqrt((6 xτ x t_{event})/π))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF2 x CF3
				EF	Exposure Frequency	125	days/year	(4)	
				ED	Exposure Duration	1	years	EPA, 1991	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	80	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	$((1 + 3B + 3B^2)/(1+B)^2)$) x CF2 x CF3
				AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989	
				CF2	Conversion Factor 2	0.001	mg/µg	- -	
				CF3	Conversion Factor 3	0.001	l/cm^3	- -	

(1) Based on EPA 1991 use of 1/2 of the residential water ingestion rate.

(2) Professional Judgment based on construction activities that would result in contact with groundwater would occur 8 hrs per day for the RME.

(3) SA is weighted average of mean values for feet, hands, and forearms (male and female, 21+years).

(4) Assumes contact with groundwater during construction could occur 125 days per year.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2011. Exposure Factors Handbook: 2011 Edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F. Available from the National Technical Information Service, Springfield, VA, and online at http://www.epa.gov/ncea/efh.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.2.RME

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Adult	Shallow Aquifer - Water Vapors at Showerhead	CW	Chemical Concentration in Water	See Table 3.2	µg/l	See Table 3.2	Chronic Daily Intake (CDI) (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3 (non-carcinogenic)	Calculated	CA x ED x EF x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2014	
				ED	Exposure Duration	20	years	EPA, 2014	Use Foster & Chrostowski Shower model to
				ET	Exposure Time	0.71	hr/day	EPA, 2014	calculate CA
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	7,300	days	EPA, 2014	
	Construction Worker	Adult	Shallow Aquifer - Water Vapors in Excavation Trench	CW	Chemical Concentration in Water	See Table 3.2	µg/l	See Table 3.2	Chronic Daily Intake (CDI) (mg/m^3) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3 (non-carcinogenic); $\mu g/m^3$ (carcinogenic)	Calculated	CA x ET x EF x ED x CF x 1/AT
				ET	Exposure Time	8	hr/day	(1)	
				EF	Exposure Frequency	125	days/year	(2)	CA calculated using two-film volatilization model
				ED	Exposure Duration	1	years	EPA, 1991	
				CF	Conversion Factor	1/24	day/hour	- -	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	EPA, 1989	

Notes:

(1) Professional Judgment based on construction activities that would result in contact with groundwater would occur 8 hrs per day for the RME.

(2) Assumes contact with groundwater during construction could occur 125 days per year.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	Chronic Daily Intake (CDI) (mg/kg-day) =
				IR-W	Ingestion Rate of Water	0.99	liters/day	EPA, 2011 (2)	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	9	years	EPA, 2011 (3)	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	80	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 2014	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				IR-W	Ingestion Rate of Water	0.31	liters/day	EPA, 2011 (4)	CW x IR-W x EF x ED x CF1 x 1/BW x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW	Body Weight	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
		Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				IR-W-A	Ingestion Rate of Water, Adult	0.99	liters/day	EPA, 2011 (2)	CW x IR-W-Adj x EF x CF1 x 1/AT
				IR-W-C	Ingestion Rate of Water, Child	0.31	liters/day	EPA, 2011 (4)	
				IR-W-Adj	Ingestion Rate of Water, Age-adjusted	0.24	liter-year/kg-day	calculated	IR-W-Adj (liter-year/kd-day) =
				EF	Exposure Frequency	350	days/year	EPA, 2004	(ED-C x IR-W-C / BW-C) +
				ED-A	Exposure Duration, Adult	9	years	EPA, 2011 (3)	(ED-A x IR-W-A / BW-A)
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				BW-A	Body Weight , Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	0.28	hr/event	EPA, 2011 (5)	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	20,900	cm^2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	9	years	EPA, 2011 (3)	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	80	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 2014	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	
		Child	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) =
				DAevent	Dermally Absorbed Dose per Event	Calculated	mg/cm^2-event	calculated	DAevent x SA x EV x EF x ED x 1/BW x 1/AT
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}	Event Time	0.37	hr/event	EPA, 2011 (6)	t_{event}<t*: DAevent (mg/cm^2-event) =
				SA	Skin Surface Area Available for Contact	6,378	cm^2	EPA, 2014	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				EV	Event Frequency	1	events/day	EPA, 2004	x CF1 x CF2
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	6	years	EPA, 2014	t_{event}>t*: DAevent (mg/cm^2-event) =
				BW	Body Weight	15	kg	EPA, 2014	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	((1 + 3B + $3B^2$)/$(1+B)^2$)) x CF1 x CF2
				AT-N	Averaging Time (Non-Cancer)	2,190	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	

TABLE 4.1.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Dermal	Resident	Child/Adult	Tap Water	CW	Chemical Concentration in Water	See Table 3.1	µg/l	See Table 3.1	CDI (mg/kg-day) = DA-Adj x EF x 1/AT
(cont'd)				DAevent-A	Dermally Absorbed Dose per Event, Adult	Calculated	mg/cm^2-event	calculated	
				DAevent-C	Dermally Absorbed Dose per Event, Child	Calculated	mg/cm^2-event	calculated	DA-Adj = (DAevent-A x SA-A x ED-A x 1/BW-A)
				DA-Adj	Dermally Absorbed Dose, Age-adjusted	Calculated	mg-year/event-kg	calculated	+ (DAevent-C x SA-C x ED-C x 1/BW-C)
				FA	Fraction absorbed water	Chemical-specific	dimensionless	EPA, 2004	
				K_p	Permeability Coefficient	Chemical-specific	cm/hr	EPA, 2004	Inorganics: DAevent (mg/cm^2-event) =
				τ	Lag Time	Chemical-specific	hr/event	EPA, 2004	Kp x CW x t_{event} x CF1 x CF2
				t*	Time to Reach Steady-state	Chemical-specific	hours	EPA, 2004	
				B	Ratio of Permeability of Stratum Corneum to Epidermis	Chemical-specific	dimensionless	EPA, 2004	Organics :
				t_{event}-A	Event Time, Adult	0.28	hr/event	EPA, 2011 (5)	t_{event}<t*: DAevent (mg/cm^2-event) =
				t_{event}-C	Event Time, Child	0.37	hr/event	EPA, 2011 (6)	2 x FA x Kp x CW x (sqrt((6 x τ x t_{event})/π))
				SA-A	Skin Surface Area, Adult	20,900	cm^2	EPA, 2014	x CF1 x CF2
				SA-C	Skin Surface Area, Child	6,378	cm^2	EPA, 2014	
				EV	Event Frequency	1	events/day	EPA, 2004	t_{event}>t*: DAevent (mg/cm^2-event) =
				EF	Exposure Frequency	350	days/year	EPA, 2004	FA x Kp x CW x (t_{event}/(1+B) + 2 x τ x
				ED-A	Exposure Duration, Adult	9	years	EPA, 2011 (3)	$((1 + 3B + 3B^2)/(1+B)^2)$) x CF1 x CF2
				ED-C	Exposure Duration, Child	6	years	EPA, 2014	
				BW-A	Body Weight, Adult	80	kg	EPA, 2014	
				BW-C	Body Weight, Child	15	kg	EPA, 2014	
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				CF1	Conversion Factor 1	0.001	mg/µg	- -	
				CF2	Conversion Factor 2	0.001	l/cm^3	- -	

(1) Assumes half ingestion rate of resident adult.

(2) 50th percentile consumer only ingestion value of drinking water from Table 3-33 (> 21 years).

(3) Table 16-108, 50th percentile value for both sexes.

(4) Weighted average of 50th percentile consumer only ingestion values from Table 3-15 and 3-33 (birth to < 6 years).

(5) Table 16-1, mean value for time spent bathing/showering (ages 18 years and older). 17 minutes/day divided by 60 minutes/hour.

(6) Table 16-1, mean value for time spent bathing (birth to <6 years). 22 minutes/day divided by 60 minutes/hour.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2011. Exposure Factors Handbook: 2011 Edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F. Available from the National Technical Information Service, Springfield, VA, and online at http://www.epa.gov/ncea/efh.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 4.2.CTE

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Adult	Shallow Aquifer - Water Vapors at Showerhead	CW	Chemical Concentration in Water	See Table 3.2	µg/l	See Table 3.2	Chronic Daily Intake (CDI) (mg/kg-day) =
				CA	Chemical Concentration in Air	Calculated	mg/m^3 (non-carcinogenic)	Calculated	CA x ED x EF x 1/AT
				EF	Exposure Frequency	350	days/year	EPA, 2004	
				ED	Exposure Duration	9	years	EPA, 2004	Use Foster & Chrostowski Shower model to
				ET	Exposure Time	0.28	hr/day	EPA, 2011 (1)	calculate CA
				AT-C	Averaging Time (Cancer)	25,550	days	EPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3,285	days	EPA, 2014	

Notes:

(1) Table 16-1, mean value for time spent bathing/showering (ages 18 years and older). 17 minutes/day divided by 60 minutes/hour.

Sources:

EPA, 1989: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1991: Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual - Supplemental Guidance, Standard Default Exposure Factors. Interim Final. OSWER Directive 9285.6-03.

EPA, 2004 . Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment (Final). EPA/540/R/99/005. July 2004.

EPA, 2011. Exposure Factors Handbook: 2011 Edition. National Center for Environmental Assessment, Washington, DC; EPA/600/R-09/052F. Available from the National Technical Information Service, Springfield, VA, and online at http://www.epa.gov/ncea/efh.

EPA, 2014: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, OSWER Directive 9200.1-120, February 6, 2014.

TABLE 5.1
NON-CANCER TOXICITY DATA -- ORAL/DERMAL
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD		Oral Absorption Efficiency for Dermal (1)	Absorbed RfD for Dermal (2)		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfD:Target Organ(s)	
		Value	Units		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
1,1-Dichloroethane	Chronic	2.0E-01	mg/kg-day	>50%	2.0E-01	mg/kg-day	Kidney	3,000	PPRTV	9/27/2006
1,1-Dichloroethane	Subchronic	2.0E+00	mg/kg-day	>50%	2.0E+00	mg/kg-day	Kidney	300	PPRTV	9/27/2006
cis-1,2-Dichloroethene	Chronic	2.0E-03	mg/kg-day	>50%	2.0E-03	mg/kg-day	Kidney	3000	IRIS	7/22/2014
cis-1,2-Dichloroethene	Subchronic	2.0E-02	mg/kg-day	>50%	2.0E-02	mg/kg-day	Kidney	300	PPRTV	2/11/2011
Trichloroethene	Chronic	5.0E-04	mg/kg-day	> 50%	5.0E-04	mg/kg-day	Immune System, Developmental, Heart	10 - 1000	IRIS	7/22/2014
Trichloroethene	Subchronic	N/A			N/A					
Vinyl Chloride	Chronic	3.0E-03	mg/kg-day	> 50%	3.0E-03	mg/kg-day	Liver	30 / 1	IRIS	7/22/2014
Vinyl Chloride	Subchronic	N/A			N/A					

Notes:

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Section 4.2 and Exhibit 4-1. EPA recommends that the oral RfD should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%. Constituents that do not have oral absorption efficiencies reported on this table were assumed to have an oral absorption efficiency of 100%.

(2) Adjusted based on RAGS Part E. (Dermal RfD = Oral RFD x Oral Absorption Efficiency)

Definitions:
IRIS = Integrated Risk Information System
N/A = Not Available
PPRTV = Provisional Peer Reviewed Toxicity Value
RfD = Reference Dose

TABLE 5.2
NON-CANCER TOXICITY DATA -- INHALATION
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC		Primary Target Organ(s)	Combined Uncertainty/Modifying Factors	RfC : Target Organ(s)	
		Value	Units			Source(s)	Date(s) (MM/DD/YYYY)
1,1-Dichloroethane	Chronic	5.0E-01	mg/m^3	Kidney	1000	HEAST	7/1997
1,1-Dichloroethane	Subchronic	5.0E+00	mg/m^3	Kidney	100	HEAST	7/1997
cis-1,2-Dichloroethene	Chronic/Subchronic	N/A					
Trichloroethene	Chronic	2.0E-03	mg/m^3	Immune System, Developmental, Heart	10 - 100	IRIS	7/22/2014
Trichloroethene	Subchronic	N/A					
Vinyl Chloride	Chronic	1.0E-01	mg/m^3	Liver	30 / 1	IRIS	7/22/2014
Vinyl Chloride	Subchronic	7.7E-02	mg/m^3	Liver	30 / 1	ATSDR	7/2006

Definitions:
ATSDR = Agency for Toxic Substances & Disease Registry Minimal Risk Levels
HEAST = Health Effects Assessment Summary Tables
IRIS = Integrated Risk Information System
N/A = Not Available
RfC = Reference Concentration

TABLE 6.1
CANCER TOXICITY DATA -- ORAL/DERMAL
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Oral Cancer Slope Factor		Oral Absorption Efficiency for Dermal (1)	Absorbed Cancer Slope Factor for Dermal (2)		Weight of Evidence/ Cancer Guideline Description	Oral CSF	
	Value	Units		Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
1,1-Dichloroethane	5.7E-03	$(mg/kg\text{-}day)^{-1}$	> 50%	5.7E-03	$(mg/kg\text{-}day)^{-1}$	C	Cal/EPA	8/20/2014
cis-1,2-Dichloroethene	N/A			N/A				
Trichloroethene	4.6E-02	$(mg/kg\text{-}day)^{-1}$	> 50%	4.6E-02	$(mg/kg\text{-}day)^{-1}$	Carcinogenic to humans	IRIS	7/22/2014
Trichloroethene (Kidney) (3)	9.3E-03	$(mg/kg\text{-}day)^{-1}$	> 50%	9.3E-03	$(mg/kg\text{-}day)^{-1}$	Carcinogenic to humans	IRIS	7/22/2014
Trichloroethene (NHL + Liver)	3.7E-02	$(mg/kg\text{-}day)^{-1}$	> 50%	3.7E-02	$(mg/kg\text{-}day)^{-1}$	Carcinogenic to humans	IRIS	7/22/2014
Vinyl Chloride (Adulthood) (3)	7.2E-01	$(mg/kg\text{-}day)^{-1}$	> 50%	7.2E-01	$(mg/kg\text{-}day)^{-1}$	A	IRIS	7/22/2014
Vinyl Chloride (From Birth) (3)	1.5E+00	$(mg/kg\text{-}day)^{-1}$	> 50%	1.5E+00	$(mg/kg\text{-}day)^{-1}$	A	IRIS	7/22/2014

Notes:

(1) Source: Risk Assessment Guidance for Superfund. Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. Section 4.2 and Exhibit 4-1. EPA recommends that the oral slope factor should not be adjusted to estimate the absorbed dose for compounds when the absorption efficiency is greater than 50%. Constituents that do not have oral absorption efficiencies reported on this table were assumed to have an oral absorption efficiency of 100%.

Definitions:
Cal/EPA = California Environmental Protection Agency
CSF = Cancer Slope Factor
IRIS = Integrated Risk Information System
N/A = Not Available
NHL = Non-Hodgkin Lymphoma

(2) Adjusted based on RAGS Part E. Dermal CSF = Oral CSF / Oral Absorption Efficiency

(3) This chemical operates with a mutagenic mode of action (EPA 2005) and would exhibit a greater effect in early-life versus later-life exposure.
With the exception of vinyl chloride, chemical-specific toxicity data are not available for childhood and early-life exposures; thus, EPA (2005) default age-dependant adjustment factors (ADAF) will be applied to the oral slope factor as follows:

AGE	AGE ADAF	Exposure Duration
0-<2	10	2 years
2-<6	3	4 years
6-<16	3	10 years
16-<26	1	10 years

Weight of Evidence definitions:
Group A chemicals (known human carcinogens) are agents for which there is sufficient evidence to support the causal association between exposure to the agents in humans and cancer.
Group B1 chemicals (probable human carcinogens) are agents for which there is limited evidence of possible carcinogenicity in humans.
Group B2 chemicals (probable human carcinogens) are agents for which there is sufficient evidence of carcinogenicity in animals but inadequate or a lack of evidence in humans.
Group C chemicals (possible human carcinogens) are agents for which there is limited evidence of carcinogenicity in animals and inadequate or a lack of human data.
Group D chemicals (not classifiable as to human carcinogenicity) are agents with inadequate human and animal evidence of carcinogenicity or for which no data are available.

TABLE 6.2
CANCER TOXICITY DATA -- INHALATION
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Unit Risk		Weight of Evidence/ Cancer Guideline Description	Unit Risk	
	Value	Units		Source(s)	Date(s) (MM/DD/YYYY)
1,1-Dichloroethane	1.6E-06	$(ug/m^3)^{-1}$	C	Cal/EPA	8/20/2014
cis-1,2-Dichloroethene	N/A				
Trichloroethene	4.1E-06	$(ug/m^3)^{-1}$	Carcinogenic to humans	IRIS	7/22/2014
Trichloroethene (kidney) (1)	1.0E-06	$(ug/m^3)^{-1}$	Carcinogenic to humans	IRIS	7/22/2014
Trichloroethene (NHL + Liver)	3.1E-06	$(ug/m^3)^{-1}$	Carcinogenic to humans	IRIS	7/22/2014
Vinyl Chloride (Adulthood) (1)	4.4E-06	$(ug/m^3)^{-1}$	A	IRIS	7/22/2014
Vinyl Chloride (From Birth) (1)	8.8E-06	$(ug/m^3)^{-1}$	A	IRIS	7/22/2014

Definitions: Cal/EPA = California Environmental Protection Agency
IRIS = Integrated Risk Information System
N/A = Not Available
NHL = Non-Hodgkin Lymphoma

(1) This chemical operates with a mutagenic mode of action (EPA 2005) and would exhibit a greater effect in early-life versus later-life exposure. With the exception of vinyl chloride, chemical-specific toxicity data are not available for childhood and early-life exposures; thus, EPA (2005) default age-dependant adjustment factors (ADAF) will be applied to the inhalation unit risk as follows:

AGE	AGE ADAF	Exposure Duration
0-<2	10	2 years
2-<6	3	4 years
2-<16	3	10 years
16-<26	1	10 years

Weight of Evidence definitions:
Group A chemicals (known human carcinogens) are agents for which there is sufficient evidence to support the causal association between exposure to the agents in humans and cancer.
Group B1 chemicals (probable human carcinogens) are agents for which there is limited evidence of possible carcinogenicity in humans.
Group B2 chemicals (probable human carcinogens) are agents for which there is sufficient evidence of carcinogenicity in animals but inadequate or a lack of evidence in humans.
Group C chemicals (possible human carcinogens) are agents for which there is limited evidence of carcinogenicity in animals and inadequate or a lack of human data.
Group D chemicals (not classifiable as to human carcinogenicity) are agents with inadequate human and animal evidence of carcinogenicity or for which no data are available.

EPA. 2005. Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum. EPA/630/P-03/001F. March.

TABLE 7.1.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Tap Water	Ingestion	1,1-Dichloroethane	3.0E+00	ug/L	N/A		N/A		N/A	9.0E-05	mg/kg/day	2.0E-01	mg/kg/day	4.5E-04
				cis-1,2-Dichloroethene	2.8E+01	ug/L	N/A		N/A		N/A	8.4E-04	mg/kg/day	2.0E-03	mg/kg/day	4.2E-01
				Trichloroethene	6.0E+00	ug/L	N/A		N/A		N/A	1.8E-04	mg/kg/day	5.0E-04	mg/kg/day	3.6E-01
				Vinyl chloride	1.6E+01	ug/L	N/A		N/A		N/A	4.8E-04	mg/kg/day	3.0E-03	mg/kg/day	1.6E-01
			Exp. Route Total								N/A					9.4E-01
			Dermal[1]	1,1-Dichloroethane	3.0E+00	ug/L	N/A		N/A		N/A	7.3E-06	mg/kg/day	2.0E-01	mg/kg/day	3.6E-05
				cis-1,2-Dichloroethene	2.8E+01	ug/L	N/A		N/A		N/A	7.6E-05	mg/kg/day	2.0E-03	mg/kg/day	3.8E-02
				Trichloroethene	6.0E+00	ug/L	N/A		N/A		N/A	3.1E-05	mg/kg/day	5.0E-04	mg/kg/day	6.2E-02
				Vinyl chloride	1.6E+01	ug/L	N/A		N/A		N/A	2.6E-05	mg/kg/day	3.0E-03	mg/kg/day	8.8E-03
			Exp. Route Total								N/A					1.1E-01
		Exposure Point Total									N/A					1.0E+00
	Exposure Medium Total										N/A					1.0E+00
	Air	Water Vapors at Showerhead	Inhalation[2]	1,1-Dichloroethane	3.2E-04	mg/m^3	N/A		N/A		N/A	3.1E-04	mg/m^3	5.0E-01	mg/m^3	6.2E-04
				cis-1,2-Dichloroethene	3.0E-03	mg/m^3	N/A		N/A		N/A	2.9E-03	mg/m^3	N/A	mg/m^3	N/A
				Trichloroethene	5.8E-04	mg/m^3	N/A		N/A		N/A	5.5E-04	mg/m^3	2.0E-03	mg/m^3	2.8E-01
				Vinyl chloride	2.2E-03	mg/m^3	N/A		N/A		N/A	2.1E-03	mg/m^3	1.0E-01	mg/m^3	2.1E-02
			Exp. Route Total								N/A					3.0E-01
		Exposure Point Total									N/A					3.0E-01
	Exposure Medium Total										N/A					3.0E-01
Groundwater Total											N/A					1.3E+00
										Total of Receptor Risk	N/A				Total of Receptor Hazard	1.3E+00

Notes-
N/A = Not applicable.
[1] DAevent for exposure to groundwater calculated on Table 7.1.RME Supplement A.
[2] Air concentration of chemical of potential concern volatilizing from groundwater while showering calculated on Table 7.1.RME Supplement C.

Table 7.1.RME Supplement A
Calculation of DAevent for Groundwater
Adult Resident
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
1,1-Dichloroethane	3.0E+00	6.7E-03	2.6E-02	3.8E-01	9.2E-01	1.0E+00	0.71	2.9E-08	2
cis-1,2-Dichloroethene	2.8E+01	7.7E-03	2.9E-02	3.7E-01	8.8E-01	1.0E+00	0.71	3.0E-07	2
Trichloroethene	6.0E+00	1.2E-02	5.1E-02	5.8E-01	1.4E+00	1.0E+00	0.71	1.2E-07	2
Vinyl chloride	1.6E+01	5.6E-03	1.7E-02	2.4E-01	5.7E-01	1.0E+00	0.71	1.1E-07	3

Table 7.1.RME Supplement A
Calculation of DAevent for Groundwater
Adult Resident
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Water Concentration (CW) (µg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq

Notes:
NA - Not applicable
All parameter values except water concentrations and duration of event from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005.
For contituents not listed in RAGS Part E, parameters are calculated in Table 7.1.RME Supplement B.
B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis.
t* - Time to reach steady-state

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm2-event) =
If tevent<t*, then DAevent =
2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =
FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + $3xB^2$)/$(1+B)^2$) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

Table 7.1.RME Supplement B

CALCULATION OF DA_{EVENT} CHEMICAL PARAMETERS

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Chemical	MW	log K_{ow}	K_{ow}	log K_p[1]	K_p (cm/hr)	B[1]	log D_{sc}/l_{sc}[1]	D_{sc}/l_{sc}[1]	l_{sc} (cm)	D_{sc} (cm^2/hr)	τ_{event}[1] (hr)	c[1]	b[1]	t*[1] (hr)
cis-1,2-Dichloroethene	9.69E+01	1.86E+00	7.24E+01	-2.12E+00	7.67E-03	2.91E-02	-3.34E+00	4.54E-04	1.00E-03	4.54E-07	3.67E-01	3.53E-01	3.21E-01	8.80E-01

1. Equations from *Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final)* , EPA/540/R/99/005. July 2004.

MW and log K_{ow} from Risk Assessment Information System (http://rais.ornl.gov/cgi-bin/tools/TOX_search).

Parameter	Definition
MW	Molecular weight (g/mole)
K_{ow}	Octanol/water partition coefficient (dimensionless)
K_p	Dermal permeability coefficient of compound in water (cm/hr)
B[1]	Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis (dimensionless).
l_{sc}	Apparent thickness of stratum corneum (cm) (default value = 0.001)
D_{sc}	Effective diffusion coefficient for chemical transfer through the stratum corneum (cm^2/hr)
τ_{event}[1]	Lag time per event (hr/event)
c[1]	Correlation coefficient which has been fitted to the Flynn's data to give Equation 3.8 of RAGS E (Empirical Predictive Correlation for Permeability Coefficient of Organics)
b[1]	Correlation coefficient which has been fitted to the Flynn's data to give Equation 3.8 of RAGS E (Empirical Predictive Correlation for Permeability Coefficient of Organics)
t*[1]	Time to ready steady-state (hr)

K_p (Equation 3.8)

$$K_p = 10^{-2.80 + 0.66 \log K_{ow} - 0.0056 MW}$$

B (Equation A.1)

$$B = K_p \sqrt{\frac{MW}{2.6}}$$

D_{sc}/l_{sc} (Equation A.3)

$$\frac{D_{sc}}{l_{sc}} = 10^{-2.80 - 0.0056\, MW}$$

D_{sc}

$$D_{sc} = \left(\frac{D_{sc}}{l_{sc}}\right) \times l_{sc}$$

τ_{event} (Equation A.4)

$$\tau event = \frac{l^2{}_{sc}}{6D_{sc}}$$

b (Equation A.7)

$$b = \frac{2 \times (1 + B)^2}{\pi} - c$$

c (Equation A.8)

$$c = \frac{1 + 3B + 3B^2}{3 \times (1 + B)}$$

t* (Equation A.5 and A.6)

If B ≤ 0.6, then $t^* = 2.4\tau_{event}$

If B>0.6, then $t^* = 6\tau_{event}\left(b - \sqrt{b^2 - c^2}\right)$

TABLE 7.1.RME Supplement C
Inhalation Exposure Concentrations from Foster and Chrostowski Shower Model - Groundwater Air, Adult Resident
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Exposure Point Concentration Cwo (µg/L)	Molecular weight (MW) (g/mole)	Henry's Law Constant (H) (atm-m^3/mole)	Kg (VOC) (cm/hr)	Kl (VOC) (cm/hr)	KL (cm/hr)	Kal (cm/hr)	Cwd (µg/L)	S (µg/m^3 -min)	Ca (mg/m^3)
1,1-Dichloroethane	3.0E+00	9.9E+01	5.6E-03	1.3E+03	1.3E+01	1.3E+01	1.7E+01	4.0E-01	3.4E-01	3.2E-04
cis-1,2-Dichloroethene	2.8E+01	9.7E+01	4.8E-03	1.3E+03	1.3E+01	1.3E+01	1.7E+01	3.8E+00	3.1E+00	3.0E-03
Trichloroethene	6.0E+00	1.3E+02	9.9E-03	1.1E+03	1.2E+01	1.1E+01	1.5E+01	7.2E-01	6.0E-01	5.8E-04
Vinyl chloride	1.6E+01	6.3E+01	2.8E-02	1.6E+03	1.7E+01	1.7E+01	2.2E+01	2.7E+00	2.3E+00	2.2E-03

Variables	Units	Exposure Assumptions
Kg(VOC) = gas-film mass transfer coefficient	cm/hr	Solved by Eq 1
Kl(VOC) = liquid-film mass transfer coefficient	cm/hr	Solved by Eq 2
KL = overall mass transfer coefficient	cm/hr	Solved by Eq 3
Kal = adjusted overall mass transfer coeff.	cm/hr	Solved by Eq 4
Tl = Calibration temp. of water	K (20C +273)	293
Ts = Shower water temperature	k (45C)	318
Us = water viscosity at Ts	centipoise	0.596
Ul = water viscosity at Tl	cp	1.002
Cwd = conc. leaving droplets after time sdt	µg/l	Solved by Eq 5
sdt = shower droplet drop time	sec	0.5
d = shower droplet diameter	mm	1
FR = shower water flow rate	l/min	10
SV = shower room air volume	m^3	12
S = indoor VOC generation rate	µg/m^3-min	Solved by Eq 6
VR = ventilation rate	l/min	13.8
Ds = duration of shower	min	42.6
Dt = total duration in shower room	min	60
R = air exchange rate	min^{-1}	0.0083
Ca = indoor air concentration of VOCs	µg/m^3	Solved by Eq 7

Equation 1:	Kg(VOC) =	$3000 * (18 / MW)^{0.5}$
Equation 2:	Kl(VOC) =	$20 * (44 / MW)^{0.5}$
Equation 3:	KL =	$((1 / Kl(VOC)) + (0.024 / (Kg (VOC) * H)))^{-1}$
Equation 4:	Kal =	$(KL * (((Tl * Us) / (Ts * Ul))^{-0.5}))$
Equation 5:	Cwd =	(Cwo * (1-EXP((-1 * Kal * sdt)/(60 * d))))
Equation 6:	S =	(Cwd * FR / SV)
Equation 7:	Ca =	If t>Ds [(S / R) * (Ds + (EXP(-R * Dt) / R)-(EXP(R *(Ds - Dt)) / R)] * 1/1440 min/day * 1/1000 ug/mg

Notes:

MW and Henry's Law Constant from Oak Ridge National Laboratory (ORNL). May 2014. [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml

TABLE 7.2.RME
CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Tap Water	Ingestion	1,1-Dichloroethane	3.0E+00	ug/L	N/A		N/A		N/A	1.5E-04	mg/kg/day	2.0E-01	mg/kg/day	7.5E-04
				cis-1,2-Dichloroethene	2.8E+01	ug/L	N/A		N/A		N/A	1.4E-03	mg/kg/day	2.0E-03	mg/kg/day	7.0E-01
				Trichloroethene	6.0E+00	ug/L	N/A		N/A		N/A	3.0E-04	mg/kg/day	5.0E-04	mg/kg/day	6.0E-01
				Vinyl chloride	1.6E+01	ug/L	N/A		N/A		N/A	7.9E-04	mg/kg/day	3.0E-03	mg/kg/day	2.6E-01
			Exp. Route Total								N/A					1.6E+00
			Dermal[1]	1,1-Dichloroethane	3.0E+00	ug/L	N/A		N/A		N/A	1.0E-05	mg/kg/day	2.0E-01	mg/kg/day	5.1E-05
				cis-1,2-Dichloroethene	2.8E+01	ug/L	N/A		N/A		N/A	1.1E-04	mg/kg/day	2.0E-03	mg/kg/day	5.4E-02
				Trichloroethene	6.0E+00	ug/L	N/A		N/A		N/A	4.4E-05	mg/kg/day	5.0E-04	mg/kg/day	8.8E-02
				Vinyl chloride	1.6E+01	ug/L	N/A		N/A		N/A	3.6E-05	mg/kg/day	3.0E-03	mg/kg/day	1.2E-02
			Exp. Route Total								N/A					1.5E-01
		Exposure Point Total									N/A					1.7E+00
	Exposure Medium Total										N/A					1.7E+00
Groundwater Total											N/A					1.7E+00
										Total of Receptor Risk	N/A				Total of Receptor Hazard	1.7E+00

Notes-
N/A = Not applicable.
[1] DAevent for exposure to groundwater calculated on Table 7.2.RME Supplement A.

Table 7.2.RME Supplement A
Calculation of DAevent for Groundwater
Child Resident
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Water Concentration (CW) (μg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq
1,1-Dichloroethane	3.0E+00	6.7E-03	2.6E-02	3.8E-01	9.2E-01	1.0E+00	0.54	2.5E-08	2
cis-1,2-Dichloroethene	2.8E+01	7.7E-03	2.9E-02	3.7E-01	8.8E-01	1.0E+00	0.54	2.6E-07	2
Trichloroethene	6.0E+00	1.2E-02	5.1E-02	5.8E-01	1.4E+00	1.0E+00	0.54	1.1E-07	2
Vinyl chloride	1.6E+01	5.6E-03	1.7E-02	2.4E-01	5.7E-01	1.0E+00	0.54	8.8E-08	2

Notes:
NA - Not applicable
All parameter values except water concentrations and duration of event from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005.
For contituents not listed in RAGS Part E, parameters are calculated in Table 7.1.RME Supplement B.
B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis.
t* - Time to reach steady-state

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm2-event) =
If tevent<t*, then DAevent =
2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =
FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + $3xB^2$)/$(1+B)^2$) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

TABLE 7.3.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Tap Water	Ingestion	1,1-Dichloroethane	3.0E+00	ug/L	3.9E-05	mg/kg/day	5.7E-03	1/mg/kg-day	2.2E-07	N/A		N/A		N/A
				cis-1,2-Dichloroethene	2.8E+01	ug/L	3.6E-04	mg/kg/day	N/A	1/mg/kg-day	N/A	N/A		N/A		N/A
				Trichloroethene (Kidney)[1,2]	6.0E+00	ug/L			9.3E-03	1/mg/kg-day	2.2E-06	N/A		N/A		N/A
				Trichloroethene (NHL + Liver)	6.0E+00	ug/L	7.7E-05	mg/kg/day	3.7E-02	1/mg/kg-day	2.8E-06	N/A		N/A		N/A
				Vinyl chloride[2]	1.6E+01	ug/L			1.5E+00	1/mg/kg-day	2.0E-04	N/A		N/A		N/A
			Exp. Route Total								2.1E-04					N/A
			Dermal[3]	1,1-Dichloroethane	3.0E+00	ug/L	3.0E-06	mg/kg/day	5.7E-03	1/mg/kg-day	1.7E-08	N/A		N/A		N/A
				cis-1,2-Dichloroethene	2.8E+01	ug/L	3.1E-05	mg/kg/day	N/A	1/mg/kg-day	N/A	N/A		N/A		N/A
				Trichloroethene (Kidney)[1,2]	6.0E+00	ug/L			9.3E-03	1/mg/kg-day	3.5E-07	N/A		N/A		N/A
				Trichloroethene (NHL + Liver)	6.0E+00	ug/L	1.3E-05	mg/kg/day	3.7E-02	1/mg/kg-day	4.7E-07	N/A		N/A		N/A
				Vinyl chloride[2]	1.6E+01	ug/L			1.5E+00	1/mg/kg-day	1.0E-05	N/A		N/A		N/A
			Exp. Route Total								1.1E-05					N/A
		Exposure Point Total									2.2E-04					N/A
	Exposure Medium Total										2.2E-04					N/A
	Air	Water Vapors at Showerhead	Inhalation[4]	1,1-Dichloroethane	3.2E-04	mg/m^3	8.9E-02	ug/m^3	1.6E-06	$(\mu g/m^3)^{-1}$	1.4E-07	N/A		N/A		N/A
				cis-1,2-Dichloroethene	3.0E-03	mg/m^3	8.3E-01	ug/m^3	N/A	$(\mu g/m^3)^{-1}$	N/A	N/A		N/A		N/A
				Trichloroethene	5.8E-04	mg/m^3	1.6E-01	ug/m^3	4.1E-06	$(\mu g/m^3)^{-1}$	6.5E-07	N/A		N/A		N/A
				Vinyl chloride	2.2E-03	mg/m^3	6.0E-01	ug/m^3	4.4E-06	$(\mu g/m^3)^{-1}$	2.6E-06	N/A		N/A		N/A
			Exp. Route Total								3.4E-06					N/A
		Exposure Point Total									3.4E-06					N/A
	Exposure Medium Total										3.4E-06					N/A
Groundwater Total											2.2E-04					N/A
										Total of Receptor Risk	2.2E-04				Total of Receptor Hazard	N/A

Notes-

N/A = Not applicable.

[1] Risk estimates for Trichloroethene take into account the mutagenic mode of action on the kidney and are added to the risk estimates for liver and non-Hodgkin's Lymphoma.

[2] Mutagenic Mode of Action (MMOA): Cancer risk is calculated using age dependent adjustment factors (see Table 7.3.RME Supplement A).

[3] DAevent for exposure to groundwater calculated on Tables 7.1.RME Supplement A and Table 7.2.RME Supplement A.

[4] Air concentration of chemical of potential concern volatilizing from groundwater while showering calculated on Table 7.1.RME Supplement B.

TABLE 7.3.RME Supplement A

CALCULATION OF CHEMICAL CANCER RISKS FOR COPC WITH MUTAGENIC MODE OF ACTION

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations														
							Intake							CSF/Unit Risk							Cancer Risk
					Value	Units	Value						Units	Value						Units	
							0-2 yrs	2-6 yrs	6-16 years	16-26 yrs	0-6 yrs	6-26 yrs		0-2 yrs (ADAF=10)	2-6 yrs (ADAF=3)	6-16 yrs (ADAF=3)	16-26 yrs (ADAF=1)	0-6 yrs	6-26 yrs		
Groundwater	Groundwater	Tap Water	Ingestion	Trichloroethene (1)	6.0E+00	ug/L	8.6E-06	1.7E-05	2.6E-05	2.6E-05	--	--	mg/kg/day	9.3E-02	2.8E-02	2.8E-02	9.3E-03	--	--	1/(mg/kg-day)	2.2E-06
				Vinyl chloride (2)	1.6E+01	ug/L	--	--	--	--	6.8E-05	1.4E-04	mg/kg/day	--	--	--	--	1.5E+00	7.2E-01	1/(mg/kg-day)	2.0E-04
			Dermal	Trichloroethene (1)	6.0E+00	ug/L	1.3E-06	2.5E-06	4.4E-06	4.4E-06	--	--	mg/kg/day	9.3E-02	2.8E-02	2.8E-02	9.3E-03	--	--	1/(mg/kg-day)	3.5E-07
				Vinyl chloride (2)	1.6E+01	ug/L	--	--	--	--	3.1E-06	7.5E-06	mg/kg/day	--	--	--	--	1.5E+00	7.2E-01	1/(mg/kg-day)	1.0E-05

Cancer risk = $(Intake_{0-2} \times CSF_{0-2}) + (Intake_{2-6} \times CSF_{2-6}) + (Intake_{6-16} \times CSF_{6-16}) + (Intake_{16-26} \times CSF_{16-26})$

(1) Risk estimates for trichloroethene take into account the mutagenic mode of action on the kidney and are added to the risk estimates for liver and non-Hodgkin's Lymphoma (see Table 7.3.RME).

(2) Risk estimates for vinyl chloride were calculated using "continuous lifetime exposure during adulthood" and "continuous lifetime exposure from birth" slope factors and inhalation unit risks.

TABLE 7.4.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC Value	EPC Units	Cancer Risk Calculations: Intake/Exposure Concentration Value	Intake/Exposure Concentration Units	CSF/Unit Risk Value	CSF/Unit Risk Units	Cancer Risk	Non-Cancer Hazard Calculations: Intake/Exposure Concentration Value	Intake/Exposure Concentration Units	RfD/RfC Value	RfD/RfC Units	Hazard Quotient
Groundwater	Groundwater	Tap Water	Ingestion	1,1-Dichloroethane	3.0E+00	ug/L	1.2E-05	mg/kg/day	5.7E-03	1/mg/kg-day	6.6E-08	3.2E-05	mg/kg/day	2.0E-01	mg/kg/day	1.6E-04
				cis-1,2-Dichloroethene	2.8E+01	ug/L	1.1E-04	mg/kg/day	N/A	1/mg/kg-day	N/A	3.0E-04	mg/kg/day	2.0E-03	mg/kg/day	1.5E-01
				Trichloroethene	6.0E+00	ug/L	2.3E-05	mg/kg/day	4.6E-02	1/mg/kg-day	1.1E-06	6.4E-05	mg/kg/day	5.0E-04	mg/kg/day	1.3E-01
				Vinyl chloride	1.6E+01	ug/L	6.1E-05	mg/kg/day	7.2E-01	1/mg/kg-day	4.4E-05	1.7E-04	mg/kg/day	3.0E-03	mg/kg/day	5.7E-02
			Exp. Route Total								4.5E-05					3.4E-01
	Exposure Medium Total										4.5E-05					3.4E-01
Groundwater Total											4.5E-05					3.4E-01
										Total of Receptor Risk	4.5E-05				Total of Receptor Hazard	3.4E-01

Notes-
N/A = Not applicable.

TABLE 7.5.RME

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Water in Excavation	Dermal[1]	1,1-Dichloroethane	3.0E+00	ug/L	3.7E-08	mg/kg/day	5.7E-03	1/mg/kg-day	2.1E-10	2.6E-06	mg/kg/day	2.0E+00	mg/kg/day	1.3E-06
				cis-1,2-Dichloroethene	2.8E+01	ug/L	3.9E-07	mg/kg/day	N/A	1/mg/kg-day	N/A	2.8E-05	mg/kg/day	2.0E-02	mg/kg/day	1.4E-03
				Trichloroethene	6.0E+00	ug/L	1.3E-07	mg/kg/day	4.6E-02	1/mg/kg-day	6.1E-09	9.3E-06	mg/kg/day	5.0E-04	mg/kg/day	1.9E-02
				Vinyl chloride	1.6E+01	ug/L	1.6E-07	mg/kg/day	7.2E-01	1/mg/kg-day	1.2E-07	1.1E-05	mg/kg/day	3.0E-03	mg/kg/day	3.7E-03
			Exp. Route Total								1.2E-07					2.4E-02
		Exposure Point Total									1.2E-07					2.4E-02
	Exposure Medium Total										1.2E-07					2.4E-02
	Air	Water Vapors in Excavation	Inhalation[2]	1,1-Dichloroethane	1.1E-05	mg/m^3	1.8E-05	ug/m^3	1.6E-06	$(\mu g/m^3)^{-1}$	3.0E-11	1.3E-06	mg/m^3	5.0E+00	mg/m^3	2.6E-07
				cis-1,2-Dichloroethene	1.1E-04	mg/m^3	1.7E-04	ug/m^3	N/A	$(\mu g/m^3)^{-1}$	N/A	1.2E-05	mg/m^3	N/A	mg/m^3	N/A
				Trichloroethene	2.1E-05	mg/m^3	3.4E-05	ug/m^3	4.1E-06	$(\mu g/m^3)^{-1}$	1.4E-10	2.4E-06	mg/m^3	2.0E-03	mg/m^3	1.2E-03
				Vinyl chloride	6.7E-05	mg/m^3	1.1E-04	ug/m^3	4.4E-06	$(\mu g/m^3)^{-1}$	4.8E-10	7.7E-06	mg/m^3	7.7E-02	mg/m^3	1.0E-04
			Exp. Route Total								6.5E-10					1.3E-03
		Exposure Point Total									6.5E-10					1.3E-03
	Exposure Medium Total										6.5E-10					1.3E-03
Groundwater Total											1.2E-07					2.5E-02
										Total of Receptor Risk	1.2E-07				Total of Receptor Hazard	2.5E-02

Notes-
N/A = Not applicable.
[1] DAevent for exposure to groundwater calculated on Table 7.5.RME Supplement A.
[2] Air concentration of chemical of potential concern volatilizing from excavation calculated on Table 7.5.RME Supplement B.

Table 7.5.RME Supplement A
Calculation of DAevent for Groundwater
Adult Construction Worker
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Water Concentration (CW) (μg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm²-event)	Eq
1,1-Dichloroethane	3.0E+00	6.7E-03	2.6E-02	3.8E-01	9.2E-01	1.0E+00	8	1.7E-07	3
cis-1,2-Dichloroethene	2.8E+01	7.7E-03	2.9E-02	3.7E-01	8.8E-01	1.0E+00	8	1.8E-06	3
Trichloroethene	6.0E+00	1.2E-02	5.1E-02	5.8E-01	1.4E+00	1.0E+00	8	6.2E-07	3
Vinyl chloride	1.6E+01	5.6E-03	1.7E-02	2.4E-01	5.7E-01	1.0E+00	8	7.4E-07	3

Notes:
NA - Not applicable
All parameter values except water concentrations and duration of event from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005. The default permeability coefficient value of 0.001 was assigned to inorganics not listed in this document.
For contituents not listed in RAGS Part E, parameters are calculated in Table 7.1.RME Supplement B.
B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis.
t* - Time to reach steady-state

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm2-event) =
If tevent<t*, then DAevent =
2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =
FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + 3xB^2)/(1+B)^2) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

TABLE 7.5.RME SUPPLEMENT B

Inhalation of Volatiles from Groundwater During Construction

Inhalation Exposure Concentrations Calculated Using a Two-Film Volatilization Model

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Chemical	Cw (µg/L)	MW (gram/mol)	KH (unitless)	Kl (cm/hr)	Kg (cm/hr)	Kv (cm/hr)	ER (mg/hr-cm²)	ERa (g/sec-m²)	Ca (µg/m³)	Ca (mg/m³)
1,1-Dichloroethane	3.0E+00	9.9E+01	2.3E-01	4.8E-02	2.0E+03	4.8E-02	1.4E-07	4.0E-10	1.1E-02	1.1E-05
cis-1,2-Dichloroethene	2.8E+01	9.7E+01	1.7E-01	4.8E-02	2.0E+03	4.8E-02	1.3E-06	3.7E-09	1.1E-01	1.1E-04
Trichloroethene	6.0E+00	1.3E+02	4.0E-01	4.4E-02	1.9E+03	4.4E-02	2.7E-07	7.4E-10	2.1E-02	2.1E-05
Vinyl chloride	1.6E+01	6.3E+01	1.1E+00	5.4E-02	2.3E+03	5.4E-02	8.5E-07	2.4E-09	6.7E-02	6.7E-05

Equations

Equation 1 $Kv = 1/(1/K_l + 1/K_H*K_g)$

Equation 2 $K_g = 700(18/MW)^{1/4}V$

Equation 3 $K_l = (32/MW)^{1/4}Ka'$

Equation 4 $ER = Kv * Cw * L/1000\ cm^3 * mg/1000\ \mu g$

Equation 5 $ERa = ER * g/1000\ mg * hr/60\ min * min/60\ sec * 10000\ cm^2/m^2$

Variables	Units	Exposure Assumptions
Cw = groundwater concentration	(µg/L)	chem-specific
MW = molecular weight	(mol/gram)	chem-specific
K_H - Henry's Law Constant	(unitless)	chem-specific
Kv = volatilization rate	(cm/hr)	Solved by Eq 1
K_g = gas phase transfer coefficient	(cm/hr)	Solved by Eq 2
K_l = liquid phase transfer coefficient	(cm/hr)	Solved by Eq 3
V = wind speed	(m/s)	4.4
Ka' = aeration rate	(cm/hr)	0.0633
ER = emission rate	(mg/hr-cm²)	Solved by Eq 4
A = area of excavation (based on utility ditch)	(m²)	2,700
ERa = area emission rate	(g/sec-m²)	Solved by Eq 5
Ca = air concentration	(mg/m³)	Solved using SCREEN3 model

Note: aeration rate based on aeration rate for small surface water body (0.1/day) multiplied by depth of water in excavation (1/2 ft)

MW and Henry's Law Constant from Oak Ridge National Laboratory (ORNL). May 2014. [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml

TABLE 7.1.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Tap Water	Ingestion	1,1-Dichloroethane	3.0E+00	ug/L	N/A		N/A		N/A	3.6E-05	mg/kg/day	2.0E-01	mg/kg/day	1.8E-04
				cis-1,2-Dichloroethene	2.8E+01	ug/L	N/A		N/A		N/A	3.3E-04	mg/kg/day	2.0E-03	mg/kg/day	1.7E-01
				Trichloroethene	6.0E+00	ug/L	N/A		N/A		N/A	7.1E-05	mg/kg/day	5.0E-04	mg/kg/day	1.4E-01
				Vinyl chloride	1.6E+01	ug/L	N/A		N/A		N/A	1.9E-04	mg/kg/day	3.0E-03	mg/kg/day	6.3E-02
			Exp. Route Total								N/A					3.7E-01
			Dermal[1]	1,1-Dichloroethane	3.0E+00	ug/L	N/A		N/A		N/A	4.6E-06	mg/kg/day	2.0E-01	mg/kg/day	2.3E-05
				cis-1,2-Dichloroethene	2.8E+01	ug/L	N/A		N/A		N/A	4.8E-05	mg/kg/day	2.0E-03	mg/kg/day	2.4E-02
				Trichloroethene	6.0E+00	ug/L	N/A		N/A		N/A	2.0E-05	mg/kg/day	5.0E-04	mg/kg/day	3.9E-02
				Vinyl chloride	1.6E+01	ug/L	N/A		N/A		N/A	1.6E-05	mg/kg/day	3.0E-03	mg/kg/day	5.3E-03
			Exp. Route Total								N/A					6.8E-02
		Exposure Point Total									N/A					4.4E-01
	Exposure Medium Total										N/A					4.4E-01
	Air	Water Vapors at Showerhead	Inhalation[2]	1,1-Dichloroethane	7.7E-05	mg/m^3	N/A		N/A		N/A	7.4E-05	mg/m^3	5.0E-01	mg/m^3	1.5E-04
				cis-1,2-Dichloroethene	7.2E-04	mg/m^3	N/A		N/A		N/A	6.9E-04	mg/m^3	N/A	mg/m^3	N/A
				Trichloroethene	1.4E-04	mg/m^3	N/A		N/A		N/A	1.3E-04	mg/m^3	2.0E-03	mg/m^3	6.6E-02
				Vinyl chloride	5.2E-04	mg/m^3	N/A		N/A		N/A	5.0E-04	mg/m^3	1.0E-01	mg/m^3	5.0E-03
			Exp. Route Total								N/A					7.1E-02
		Exposure Point Total									N/A					7.1E-02
	Exposure Medium Total										N/A					7.1E-02
Groundwater Total											N/A					5.1E-01
										Total of Receptor Risk	N/A				Total of Receptor Hazard	5.1E-01

Notes-
N/A = Not applicable.
[1] DAevent for exposure to groundwater calculated on Table 7.1.CTE Supplement A.
[2] Air concentration of chemical of potential concern volatilizing from groundwater while showering calculated on Table 7.1.CTE Supplement B.

Table 7.1.CTE Supplement A
Calculation of DAevent for Groundwater
Adult Resident
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Water Concentration (CW) (μg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm²-event)	Eq
1,1-Dichloroethane	3.0E+00	6.7E-03	2.6E-02	3.8E-01	9.2E-01	1.0E+00	0.28	1.8E-08	2
cis-1,2-Dichloroethene	2.8E+01	7.7E-03	2.9E-02	3.7E-01	8.8E-01	1.0E+00	0.28	1.9E-07	2
Trichloroethene	6.0E+00	1.2E-02	5.1E-02	5.8E-01	1.4E+00	1.0E+00	0.28	7.8E-08	2
Vinyl chloride	1.6E+01	5.6E-03	1.7E-02	2.4E-01	5.7E-01	1.0E+00	0.28	6.4E-08	2

Table 7.1.CTE Supplement A
Calculation of DAevent for Groundwater
Adult Resident
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Water Concentration (CW) (μg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm^2-event)	Eq

Notes:
NA - Not applicable
All parameter values except water concentrations and duration of event from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005.
For contituents not listed in RAGS Part E, parameters are calculated in Table 7.1.RME Supplement B.
B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis.
t* - Time to reach steady-state

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm2-event) =
If tevent<t*, then DAevent =
2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =
FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + $3xB^2$)/$(1+B)^2$) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

TABLE 7.1.CTE Supplement B
Inhalation Exposure Concentrations from Foster and Chrostowski Shower Model - Groundwater Air, Adult Resident
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Exposure Point Concentration Cwo (µg/L)	Molecular weight (MW) (g/mole)	Henry's Law Constant (H) (atm-m^3/mole)	Kg (VOC) (cm/hr)	Kl (VOC) (cm/hr)	KL (cm/hr)	Kal (cm/hr)	Cwd (µg/L)	S (µg/m^3 -min)	Ca (mg/m^3)
1,1-Dichloroethane	3.0E+00	9.9E+01	5.6E-03	1.3E+03	1.3E+01	1.3E+01	1.7E+01	4.0E-01	3.4E-01	7.7E-05
cis-1,2-Dichloroethene	2.8E+01	9.7E+01	4.8E-03	1.3E+03	1.3E+01	1.3E+01	1.7E+01	3.8E+00	3.1E+00	7.2E-04
Trichloroethene	6.0E+00	1.3E+02	9.9E-03	1.1E+03	1.2E+01	1.1E+01	1.5E+01	7.2E-01	6.0E-01	1.4E-04
Vinyl chloride	1.6E+01	6.3E+01	2.8E-02	1.6E+03	1.7E+01	1.7E+01	2.2E+01	2.7E+00	2.3E+00	5.2E-04

Variables	Units	Exposure Assumptions
Kg(VOC) = gas-film mass transfer coefficient	cm/hr	Solved by Eq 1
Kl(VOC) = liquid-film mass transfer coefficient	cm/hr	Solved by Eq 2
KL = overall mass transfer coefficient	cm/hr	Solved by Eq 3
Kal = adjusted overall mass transfer coeff.	cm/hr	Solved by Eq 4
Tl = Calibration temp. of water	K (20C +273)	293
Ts = Shower water temperature	k (45C)	318
Us = water viscosity at Ts	centipoise	0.596
Ul = water viscosity at Tl	cp	1.002
Cwd = conc. leaving droplets after time sdt	µg/l	Solved by Eq 5
sdt = shower droplet drop time	sec	0.5
d = shower droplet diameter	mm	1
FR = shower water flow rate	l/min	10
SV = shower room air volume	m^3	12
S = indoor VOC generation rate	µg/m^3-min	Solved by Eq 6
VR = ventilation rate	l/min	17
Ds = duration of shower	min	16.8
Dt = total duration in shower room	min	30
R = air exchange rate	min^{-1}	0.0083
Ca = indoor air concentration of VOCs	µg/m^3	Solved by Eq 7

Equation 1:	Kg(VOC) =	$3000 * (18 / MW)^{0.5}$
Equation 2:	Kl(VOC) =	$20 * (44 / MW)^{0.5}$
Equation 3:	KL =	$((1 / Kl(VOC)) + (0.024 / (Kg (VOC) * H)))^{-1}$
Equation 4:	Kal =	$(KL * (((Tl * Us) / (Ts * Ul))^{-0.5}))$
Equation 5:	Cwd =	(Cwo * (1-EXP((-1 * Kal * sdt)/(60 * d))))
Equation 6:	S =	(Cwd * FR / SV)
Equation 7:	Ca =	If t>Ds [(S / R) * (Ds + (EXP(-R * Dt) / R)-(EXP(R *(Ds - Dt)) / R)] * 1/1440 min/day * 1/1000 ug/mg

Notes:

MW and Henry's Law Constant from Oak Ridge National Laboratory (ORNL). May 2014. [Online]. Available: http://epa-prgs.ornl.gov/chemicals/index.shtml

TABLE 7.2.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Tap Water	Ingestion	1,1-Dichloroethane	3.0E+00	ug/L	N/A		N/A		N/A	6.0E-05	mg/kg/day	2.0E-01	mg/kg/day	3.0E-04
				cis-1,2-Dichloroethene	2.8E+01	ug/L	N/A		N/A		N/A	5.5E-04	mg/kg/day	2.0E-03	mg/kg/day	2.8E-01
				Trichloroethene	6.0E+00	ug/L	N/A		N/A		N/A	1.2E-04	mg/kg/day	5.0E-04	mg/kg/day	2.4E-01
				Vinyl chloride	1.6E+01	ug/L	N/A		N/A		N/A	3.2E-04	mg/kg/day	3.0E-03	mg/kg/day	1.1E-01
			Exp. Route Total								N/A					6.2E-01
			Dermal[1]	1,1-Dichloroethane	3.0E+00	ug/L	N/A		N/A		N/A	8.5E-06	mg/kg/day	2.0E-01	mg/kg/day	4.3E-05
				cis-1,2-Dichloroethene	2.8E+01	ug/L	N/A		N/A		N/A	8.9E-05	mg/kg/day	2.0E-03	mg/kg/day	4.5E-02
				Trichloroethene	6.0E+00	ug/L	N/A		N/A		N/A	3.7E-05	mg/kg/day	5.0E-04	mg/kg/day	7.3E-02
				Vinyl chloride	1.6E+01	ug/L	N/A		N/A		N/A	3.0E-05	mg/kg/day	3.0E-03	mg/kg/day	9.9E-03
			Exp. Route Total								N/A					1.3E-01
		Exposure Point Total									N/A					7.5E-01
	Exposure Medium Total										N/A					7.5E-01
Groundwater Total											N/A					7.5E-01
										Total of Receptor Risk	N/A				Total of Receptor Hazard	7.5E-01

Notes-
N/A = Not applicable.
[1] DAevent for exposure to groundwater calculated on Table 7.2.CTE Supplement A.

Table 7.2.CTE Supplement A
Calculation of DAevent for Groundwater
Child Resident
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Chemical of Potential Concern	Water Concentration (CW) (μg/L)	Permeability Coefficient (Kp) (cm/hr)	B (dimensionless)	Lag Time (τ_{event}) (hr)	t* (hr)	Fraction Absorbed Water (FA) (dimensionless)	Duration of Event (tevent) (hr)	DAevent (mg/cm²-event)	Eq
1,1-Dichloroethane	3.0E+00	6.7E-03	2.6E-02	3.8E-01	9.2E-01	1.0E+00	0.37	2.1E-08	2
cis-1,2-Dichloroethene	2.8E+01	7.7E-03	2.9E-02	3.7E-01	8.8E-01	1.0E+00	0.37	2.2E-07	2
Trichloroethene	6.0E+00	1.2E-02	5.1E-02	5.8E-01	1.4E+00	1.0E+00	0.37	9.0E-08	2
Vinyl chloride	1.6E+01	5.6E-03	1.7E-02	2.4E-01	5.7E-01	1.0E+00	0.37	7.3E-08	2

Notes:
NA - Not applicable
All parameter values except water concentrations and duration of event from EPA 2004, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment - Final).* EPA/540/R/99/005.
For contituents not listed in RAGS Part E, parameters are calculated in Table 7.1.RME Supplement B.
B - Dimensionless ratio of the permeability coefficient of a compound through the stratum corneum relative to its permeability coefficient across the viable epidermis.
t* - Time to reach steady-state

Inorganics: DAevent (mg/cm2-event) =
Kp x CW x tevent x 0.001 mg/ug x 0.001 l/cm^3 (eq 1)

Organics: DAevent (mg/cm2-event) =
If tevent<t*, then DAevent =
2 x FA x Kp x CW x (sqrt((6 x τ_{event} x t_{event})/π)) x 0.001 mg/ug x 0.001 l/cm^3 (eq 2)

If tevent>t*, then DAevent =
FA x Kp x CW x (t_{event}/(1+B) + 2 x τ_{event} x ((1 + 3xB + 3xB^2)/(1+B)^2) x 0.001 mg/ug x 0.001 l/cm^3 (eq 3)

TABLE 7.3.CTE

CALCULATION OF CHEMICAL CANCER RISKS AND NON-CANCER HAZARDS

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		Cancer Risk Calculations					Non-Cancer Hazard Calculations				
					Value	Units	Intake/Exposure Concentration		CSF/Unit Risk		Cancer Risk	Intake/Exposure Concentration		RfD/RfC		Hazard Quotient
							Value	Units	Value	Units		Value	Units	Value	Units	
Groundwater	Groundwater	Tap Water	Ingestion	1,1-Dichloroethane	3.0E+00	ug/L	9.9E-06	mg/kg/day	5.7E-03	1/mg/kg-day	5.6E-08	N/A		N/A		N/A
				cis-1,2-Dichloroethene	2.8E+01	ug/L	9.2E-05	mg/kg/day	N/A	1/mg/kg-day	N/A	N/A		N/A		N/A
				Trichloroethene (Kidney)[1,2]	6.0E+00	ug/L			9.3E-03	1/mg/kg-day	5.9E-07	N/A		N/A		N/A
				Trichloroethene (NHL + Liver)	6.0E+00	ug/L	2.0E-05	mg/kg/day	3.7E-02	1/mg/kg-day	7.3E-07	N/A		N/A		N/A
				Vinyl chloride[2]	1.6E+01	ug/L			1.5E+00	1/mg/kg-day	5.8E-05	N/A		N/A		N/A
			Exp. Route Total								5.9E-05					N/A
			Dermal[3]	1,1-Dichloroethane	3.0E+00	ug/L	1.3E-06	mg/kg/day	5.7E-03	1/mg/kg-day	7.5E-09	N/A		N/A		N/A
				cis-1,2-Dichloroethene	2.8E+01	ug/L	1.4E-05	mg/kg/day	N/A	1/mg/kg-day	N/A	N/A		N/A		N/A
				Trichloroethene (Kidney)[1,2]	6.0E+00	ug/L			9.3E-03	1/mg/kg-day	1.8E-07	N/A		N/A		N/A
				Trichloroethene (NHL + Liver)	6.0E+00	ug/L	4.6E-06	mg/kg/day	3.7E-02	1/mg/kg-day	1.7E-07	N/A		N/A		N/A
				Vinyl chloride[2]	1.6E+01	ug/L			1.5E+00	1/mg/kg-day	5.3E-06	N/A		N/A		N/A
			Exp. Route Total								5.7E-06					N/A
		Exposure Point Total									6.5E-05					N/A
	Exposure Medium Total										6.5E-05					N/A
	Air	Water Vapors at Showerhead	Inhalation[4]	1,1-Dichloroethane	7.7E-05	mg/m^3	9.5E-03	ug/m^3	1.6E-06	$(\mu g/m^3)^{-1}$	1.5E-08	N/A		N/A		N/A
				cis-1,2-Dichloroethene	7.2E-04	mg/m^3	8.9E-02	ug/m^3	N/A	$(\mu g/m^3)^{-1}$	N/A	N/A		N/A		N/A
				Trichloroethene	1.4E-04	mg/m^3	1.7E-02	ug/m^3	4.1E-06	$(\mu g/m^3)^{-1}$	6.9E-08	N/A		N/A		N/A
				Vinyl chloride	5.2E-04	mg/m^3	6.4E-02	ug/m^3	4.4E-06	$(\mu g/m^3)^{-1}$	2.8E-07	N/A		N/A		N/A
			Exp. Route Total								3.7E-07					N/A
		Exposure Point Total									3.7E-07					N/A
	Exposure Medium Total										3.7E-07					N/A
Groundwater Total											6.5E-05					N/A
										Total of Receptor Risk	6.5E-05				Total of Receptor Hazard	N/A

Notes-

N/A = Not applicable.

[1] Risk estimates for Trichloroethene take into account the mutagenic mode of action on the kidney and are added to the risk estimates for liver and non-Hodgkin's Lymphoma.

[2] Mutagenic Mode of Action (MMOA): Cancer risk is calculated using age dependent adjustment factors (see Table 7.3.RME Supplement A).

[3] DAevent for exposure to groundwater calculated on Tables 7.1.RME Supplement A and Table 7.2.RME Supplement A.

[4] Air concentration of chemical of potential concern volatilizing from groundwater while showering calculated on Table 7.1.RME Supplement B.

TABLE 7.3.CTE Supplement A

CALCULATION OF CHEMICAL CANCER RISKS FOR COPC WITH MUTAGENIC MODE OF ACTION

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Exposure Route	Chemical of Potential Concern		EPC		Cancer Risk Calculations												
								Intake						CSF/Unit Risk						Cancer Risk
						Value	Units	Value					Units	Value					Units	
								0-2 yrs	2-6 yrs	16-25 yrs	0-6 yrs	16-25 yrs		0-2 yrs (ADAF=10)	2-6 yrs (ADAF=3)	16-25 yrs (ADAF=1)	0-6 yrs	16-25 yrs		
Groundwater	Groundwater	Tap Water	Ingestion	Trichloroethene	(1)	6.0E+00	ug/L	3.4E-06	6.8E-06	9.2E-06	--	--	mg/kg/day	9.3E-02	2.8E-02	9.3E-03	--	--	1/(mg/kg-day)	5.9E-07
				Vinyl chloride	(2)	1.6E+01	ug/L	--	--	--	2.7E-05	2.4E-05	mg/kg/day	--	--	--	1.5E+00	7.2E-01	1/(mg/kg-day)	5.8E-05
			Dermal	Trichloroethene	(1)	6.0E+00	ug/L	1.0E-06	2.1E-06	2.5E-06	--	--	mg/kg/day	9.3E-02	2.8E-02	9.3E-03	--	--	1/(mg/kg-day)	1.8E-07
				Vinyl chloride	(2)	1.6E+01	ug/L	--	--	--	2.6E-06	2.0E-06	mg/kg/day	--	--	--	1.5E+00	7.2E-01	1/(mg/kg-day)	5.3E-06

Cancer risk = $(Intake_{0\text{-}2} \times CSF_{0\text{-}2}) + (Intake_{2\text{-}6} \times CSF_{2\text{-}6}) + (Intake_{16\text{-}25} \times CSF_{16\text{-}25})$

(1) Risk estimates for trichloroethene take into account the mutagenic mode of action on the kidney and are added to the risk estimates for liver and non-Hodgkin's Lymphoma (see Table 7.4.CTE).

(2) Risk estimates for vinyl chloride were calculated using "continuous lifetime exposure during adulthood" and "continuous lifetime exposure from birth" slope factors and inhalation unit risks.

TABLE 9.1.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	1,1-Dichloroethane	N/A	N/A	N/A	N/A	Kidney	5E-04	N/A	4E-05	5E-04
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	Kidney	4E-01	N/A	4E-02	5E-01
			Trichloroethene	N/A	N/A	N/A	N/A	Immune System, Developmental, Heart	4E-01	N/A	6E-02	4E-01
			Vinyl chloride	N/A	N/A	N/A	N/A	Liver	2E-01	N/A	9E-03	2E-01
			Chemical Total	N/A	N/A	N/A	N/A		9E-01	N/A	1E-01	1E+00
		Exposure Point Total					N/A					1E+00
	Exposure Medium Total						N/A					1E+00
	Air	Water Vapors at Showerhead	1,1-Dichloroethane	N/A	N/A	N/A	N/A	Kidney	N/A	6E-04	N/A	6E-04
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Trichloroethene	N/A	N/A	N/A	N/A	Immune System, Developmental, Heart	N/A	3E-01	N/A	3E-01
			Vinyl chloride	N/A	N/A	N/A	N/A	Liver	N/A	2E-02	N/A	2E-02
			Chemical Total	N/A	N/A	N/A	N/A		N/A	3E-01	N/A	3E-01
		Exposure Point Total					N/A					3E-01
	Exposure Medium Total						N/A					3E-01
Groundwater Total							N/A					1E+00
Receptor Total							N/A				Receptor HI Total	1E+00

Notes:
N/A = Not applicable
HI = Hazard Index

Total Kidney HI =	5E-01
Total Liver HI =	2E-01
Total Immune System HI =	7E-01
Total Developmental HI =	7E-01
Total Heart HI =	7E-01

TABLE 9.2.RME
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
REASONABLE MAXIMUM EXPOSURE
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	1,1-Dichloroethane	N/A	N/A	N/A	N/A	Kidney	8E-04	N/A	5E-05	8E-04
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	Kidney	7E-01	N/A	5E-02	8E-01
			Trichloroethene	N/A	N/A	N/A	N/A	Immune System, Developmental, Heart	6E-01	N/A	9E-02	7E-01
			Vinyl chloride	N/A	N/A	N/A	N/A	Liver	3E-01	N/A	1E-02	3E-01
			Chemical Total	N/A	N/A	N/A	N/A		2E+00	N/A	2E-01	2E+00
		Exposure Point Total					N/A					2E+00
	Exposure Medium Total						N/A					2E+00
Groundwater Total							N/A					2E+00
Receptor Total							N/A				Receptor HI Total	2E+00

Notes:
N/A = Not applicable
HI = Hazard Index

Total Kidney HI =	8E-01
Total Liver HI =	3E-01
Total Immune System HI =	7E-01
Total Developmental HI =	7E-01
Total Heart HI =	7E-01

TABLE 9.3.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	1,1-Dichloroethane	2E-07	N/A	2E-08	2E-07	Kidney	N/A	N/A	N/A	N/A
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	Kidney	N/A	N/A	N/A	N/A
			Trichloroethene (Kidney)	2E-06	N/A	4E-07	3E-06	Immune System, Developmental, Heart	N/A	N/A	N/A	N/A
			Trichloroethene (NHL + Liver)	3E-06	N/A	5E-07	3E-06	Immune System, Developmental, Heart	N/A	N/A	N/A	N/A
			Vinyl chloride	2E-04	N/A	1E-05	2E-04	Liver	N/A	N/A	N/A	N/A
			Chemical Total	2E-04	N/A	1E-05	2E-04		N/A	N/A	N/A	N/A
		Exposure Point Total					2E-04					N/A
	Exposure Medium Total						2E-04					N/A
	Air	Water Vapors at Showerhead	1,1-Dichloroethane	N/A	1E-07	N/A	1E-07	Kidney	N/A	N/A	N/A	N/A
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Trichloroethene	N/A	6E-07	N/A	6E-07	Immune System, Developmental, Heart	N/A	N/A	N/A	N/A
			Vinyl chloride	N/A	3E-06	N/A	3E-06	Liver	N/A	N/A	N/A	N/A
			Chemical Total	N/A	3E-06	N/A	3E-06		N/A	N/A	N/A	N/A
		Exposure Point Total					3E-06					N/A
	Exposure Medium Total						3E-06					N/A
Groundwater Total							2E-04					N/A
Receptor Total							2E-04	Receptor HI Total				N/A

Notes:

N/A = Not applicable

TABLE 9.4.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	1,1-Dichloroethane	7E-08	N/A	N/A	7E-08	Kidney	2E-04	N/A	N/A	2E-04
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	Kidney	1E-01	N/A	N/A	1E-01
			Trichloroethene	1E-06	N/A	N/A	1E-06	Immune System, Developmental, Heart	1E-01	N/A	N/A	1E-01
			Vinyl chloride	4E-05	N/A	N/A	4E-05	Liver	6E-02	N/A	N/A	6E-02
			Chemical Total	4E-05	N/A	N/A	4E-05		3E-01	N/A	N/A	3E-01
		Exposure Point Total					4E-05					3E-01
	Exposure Medium Total						4E-05					3E-01
Groundwater Total							4E-05					3E-01
Receptor Total							4E-05				Receptor HI Total	3E-01

Notes:
N/A = Not applicable
HI = Hazard Index

Total Kidney HI =	1E-01
Total Liver HI =	6E-02
Total Immune System HI =	1E-01
Total Developmental HI =	1E-01
Total Heart HI =	1E-01

TABLE 9.5.RME

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

REASONABLE MAXIMUM EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Water in Excavation	1,1-Dichloroethane	N/A	N/A	2E-10	2E-10	Kidney	N/A	N/A	1E-06	1E-06
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	Kidney	N/A	N/A	1E-03	1E-03
			Trichloroethene	N/A	N/A	6E-09	6E-09	Immune System, Developmental, Heart	N/A	N/A	2E-02	2E-02
			Vinyl chloride	N/A	N/A	1E-07	1E-07	Liver	N/A	N/A	4E-03	4E-03
			Chemical Total	N/A	N/A	1E-07	1E-07		N/A	N/A	2E-02	2E-02
		Exposure Point Total					1E-07					2E-02
	Exposure Medium Total						1E-07					2E-02
	Air	Water Vapors in Excavation	1,1-Dichloroethane	N/A	3E-11	N/A	3E-11	Kidney	N/A	3E-07	N/A	3E-07
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Trichloroethene	N/A	1E-10	N/A	1E-10	Immune System, Developmental, Heart	N/A	1E-03	N/A	1E-03
			Vinyl chloride	N/A	5E-10	N/A	5E-10	Liver	N/A	1E-04	N/A	1E-04
			Chemical Total	N/A	7E-10	N/A	7E-10		N/A	1E-03	N/A	1E-03
		Exposure Point Total					7E-10					1E-03
	Exposure Medium Total						7E-10					1E-03
Groundwater Total							1E-07					2E-02
Receptor Total							1E-07	Receptor HI Total				2E-02

Notes:
N/A = Not applicable
HI = Hazard Index

Total Kidney HI =	1E-03
Total Liver HI =	4E-03
Total Immune System HI =	2E-02
Total Developmental HI =	2E-02
Total Heart HI =	2E-02

TABLE 9.1.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	1,1-Dichloroethane	N/A	N/A	N/A	N/A	Kidney	2E-04	N/A	2E-05	2E-04
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	Kidney	2E-01	N/A	2E-02	2E-01
			Trichloroethene	N/A	N/A	N/A	N/A	Immune System, Developmental, Heart	1E-01	N/A	4E-02	2E-01
			Vinyl chloride	N/A	N/A	N/A	N/A	Liver	6E-02	N/A	5E-03	7E-02
			Chemical Total	N/A	N/A	N/A	N/A		4E-01	N/A	7E-02	4E-01
		Exposure Point Total					N/A					4E-01
	Exposure Medium Total						N/A					4E-01
	Air	Water Vapors at Showerhead	1,1-Dichloroethane	N/A	N/A	N/A	N/A	Kidney	N/A	1E-04	N/A	1E-04
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Trichloroethene	N/A	N/A	N/A	N/A	Immune System, Developmental, Heart	N/A	7E-02	N/A	7E-02
			Vinyl chloride	N/A	N/A	N/A	N/A	Liver	N/A	5E-03	N/A	5E-03
			Chemical Total	N/A	N/A	N/A	N/A		N/A	7E-02	N/A	7E-02
		Exposure Point Total					N/A					7E-02
	Exposure Medium Total						N/A					7E-02
Groundwater Total							N/A					5E-01
Receptor Total							N/A				Receptor HI Total	5E-01

Notes:
N/A = Not applicable
HI = Hazard Index

Total Kidney HI =	2E-01
Total Liver HI =	7E-02
Total Immune System HI =	2E-01
Total Developmental HI =	2E-01
Total Heart HI =	2E-01

TABLE 9.2.CTE
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs
CENTRAL TENDENCY EXPOSURE
SWMU 3
NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	1,1-Dichloroethane	N/A	N/A	N/A	N/A	Kidney	3E-04	N/A	4E-05	3E-04
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	Kidney	3E-01	N/A	4E-02	3E-01
			Trichloroethene	N/A	N/A	N/A	N/A	Immune System, Developmental, Heart	2E-01	N/A	7E-02	3E-01
			Vinyl chloride	N/A	N/A	N/A	N/A	Liver	1E-01	N/A	1E-02	1E-01
			Chemical Total	N/A	N/A	N/A	N/A		6E-01	N/A	1E-01	7E-01
		Exposure Point Total					N/A					7E-01
	Exposure Medium Total						N/A					7E-01
Groundwater Total							N/A					7E-01
Receptor Total							N/A				Receptor HI Total	7E-01

Notes:
N/A = Not applicable
HI = Hazard Index

Total Kidney HI =	3E-01
Total Liver HI =	1E-01
Total Immune System HI =	3E-01
Total Developmental HI =	3E-01
Total Heart HI =	3E-01

TABLE 9.3.CTE

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs

CENTRAL TENDENCY EXPOSURE

SWMU 3

NAB Little Creek, Virginia Beach, Virginia

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical of Potential Concern	Carcinogenic Risk				Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total	Primary Target Organ(s)	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water	1,1-Dichloroethane	6E-08	N/A	8E-09	6E-08	Kidney	N/A	N/A	N/A	N/A
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	Kidney	N/A	N/A	N/A	N/A
			Trichloroethene (Kidney)	6E-07	N/A	2E-07	8E-07	Immune System, Developmental, Heart	N/A	N/A	N/A	N/A
			Trichloroethene (NHL + Liver)	7E-07	N/A	2E-07	9E-07	Immune System, Developmental, Heart	N/A	N/A	N/A	N/A
			Vinyl chloride	6E-05	N/A	5E-06	6E-05	Liver	N/A	N/A	N/A	N/A
			Chemical Total	6E-05	N/A	6E-06	7E-05		N/A	N/A	N/A	N/A
		Exposure Point Total					7E-05					N/A
	Exposure Medium Total						7E-05					N/A
	Air	Water Vapors at Showerhead	1,1-Dichloroethane	N/A	2E-08	N/A	2E-08	Kidney	N/A	N/A	N/A	N/A
			cis-1,2-Dichloroethene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
			Trichloroethene	N/A	7E-08	N/A	7E-08	Immune System, Developmental, Heart	N/A	N/A	N/A	N/A
			Vinyl chloride	N/A	3E-07	N/A	3E-07	Liver	N/A	N/A	N/A	N/A
			Chemical Total	N/A	4E-07	N/A	4E-07		N/A	N/A	N/A	N/A
		Exposure Point Total					4E-07					N/A
	Exposure Medium Total						4E-07					N/A
Groundwater Total							7E-05					N/A
Receptor Total							7E-05				Receptor HI Total	N/A

Notes:

N/A = Not applicable

Appendix D
Trend Analysis

Table D-1
Mann Kendall Trend Evaluation
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Constituent	Location	Number of Detects	Number of Results	Percent Detects	Calculated S Statistic	Calculated Probability	Decision
cis-1,2-Dichloroethene	LW03-MW05	3	5	60	3	0.325	No Significant Change
cis-1,2-Dichloroethene	LW03-MW06	2	6	33	-5	0.184	No Significant Change
cis-1,2-Dichloroethene	LW03-MW07	6	6	100	-5	0.226	No Significant Change
cis-1,2-Dichloroethene	LW03-MW12	5	5	100	-2	0.403	No Significant Change
Tetrachloroethene	LW03-MW05	1	5	20	4	0.242	No Significant Change
Tetrachloroethene	LW03-MW06	2	6	33	-5	0.184	No Significant Change
Tetrachloroethene	LW03-MW07	1	6	17	-5	0.121	No Significant Change
Tetrachloroethene	LW03-MW12	0	5	0	-	-	All Non-Detects
trans-1,2-Dichloroethene	LW03-MW05	2	5	40	1	0.500	No Significant Change
trans-1,2-Dichloroethene	LW03-MW06	1	6	17	-5	0.121	No Significant Change
trans-1,2-Dichloroethene	LW03-MW07	6	6	100	-3	0.354	No Significant Change
trans-1,2-Dichloroethene	LW03-MW12	5	5	100	0	0.592	No Significant Change
Trichloroethene	LW03-MW05	1	5	20	4	0.242	No Significant Change
Trichloroethene	LW03-MW06	2	6	33	-5	0.184	No Significant Change
Trichloroethene	LW03-MW07	2	6	33	1	0.500	No Significant Change
Trichloroethene	LW03-MW12	5	5	100	0	0.592	No Significant Change
Vinyl chloride	LW03-MW05	3	5	60	3	0.325	No Significant Change
Vinyl chloride	LW03-MW06	2	6	17	-5	0.121	No Significant Change
Vinyl chloride	LW03-MW07	6	6	100	1	0.500	No Significant Change
Vinyl chloride	LW03-MW12	5	5	100	-2	0.403	No Significant Change

Table D-2
Data Used for Statistical Evaluation
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	**MCL-Groundwater**	LW03-MW05									
Sample ID		LW03-MW05-98C	LW03-MW05-05-02C	LW03-MW05-15-02C	LW03-MW05-07A	LW03-MW05-07-07C	LW03-MW05-13-07C	LW03-MW05-07-08A	LW03-MW05-13-08A	LW03-MW05-07-08C	LW03-MW05-13-08C
Sample Date		09/18/98	08/31/02	08/31/02	02/13/07	09/19/07	09/19/07	02/07/08	02/07/08	09/16/08	09/16/08
Chemical Name											
Volatile Organic Compounds (UG/L)											
Tetrachloroethene	5	1 U	0.5 U	0.5 U	10 U	10 UJ	10 UJ	0.5 U	0.5 U	0.5 UL	0.5 U
Trichloroethene	5	**5**	0.5 B	0.5 U	10 U	10 UJ	10 UJ	0.5 U	0.5 U	**2 L**	**0.8**
cis-1,2-Dichloroethene	70	**23**	**5**	**0.21 J**	10 U	10 UJ	10 UJ	**1**	**0.4 J**	**27**	**11**
trans-1,2-Dichloroethene	100	**3**	**0.18 J**	0.5 U	10 U	10 UJ	10 UJ	0.5 U	0.5 U	**9 L**	**4**
Vinyl chloride	2	**5**	**2.7**	**0.14 J**	10 U	10 UJ	10 UJ	**0.6 J**	0.5 UJ	**10 L**	**4**

Notes:
Shading indicates exceedance of MCL-Groundwater criteria
Bold indicates detections
* - Duplicate sample collected. Most conservative value reported.
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccurate
UL - Analyte not detected, quantitation limit is probably higher
UG/L - Micrograms per liter

Table D-2
Data Used for Statistical Evaluation
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

Station ID	MCL-Groundwater	LW03-MW06											
Sample ID		LW03-MW06-08-02C	LW03-MW06-18-02C*	LW03-MW06-07A*	LW03-MW06-07-07C	LW03-MW06-10-07C	LW03-MW06-16-07C	LW03-MW06-07-08A	LW03-MW06-13-08A	LW03-MW06-10-08C	LW03-MW06-16-08C*	LW03-MW06-07-08C	LW03-MW06-14C
Sample Date		08/31/02	08/31/02	02/15/07	09/21/07	09/21/07	09/21/07	02/08/08	02/08/08	09/22/08	09/22/08	09/22/09	08/14/14
Chemical Name													
Volatile Organic Compounds (UG/L)													
Tetrachloroethene	5	**190**	**210**	10 U	10 U	10 UJ	10 U	0.5 U	**0.3 J**	10 U	10 U	10 U	0.5 U
Trichloroethene	5	**170**	**180**	10 U	10 U	10 UJ	10 U	**0.6**	**0.9**	10 U	10 U	10 U	0.5 U
cis-1,2-Dichloroethene	70	**42**	**47**	10 U	10 U	10 UJ	10 U	**0.2 J**	**0.3 J**	10 U	10 U	10 U	0.5 U
trans-1,2-Dichloroethene	100	**12**	**14**	10 U	10 U	10 UJ	10 U	0.5 U	0.5 U	10 U	10 U	10 U	0.5 U
Vinyl chloride	2	**21**	**21**	10 U	10 U	10 UJ	10 U	0.5 U	0.5 U	10 U	10 U	10 U	0.5 U

Notes:
Shading indicates exceedance of MCL-Groundwater criteria
Bold indicates detections
* - Duplicate sample collected. Most conservative value reported.
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccurate
UL - Analyte not detected, quantitation limit is probably higher
UG/L - Micrograms per liter

Table D-2
Data Used for Statistical Evaluation
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

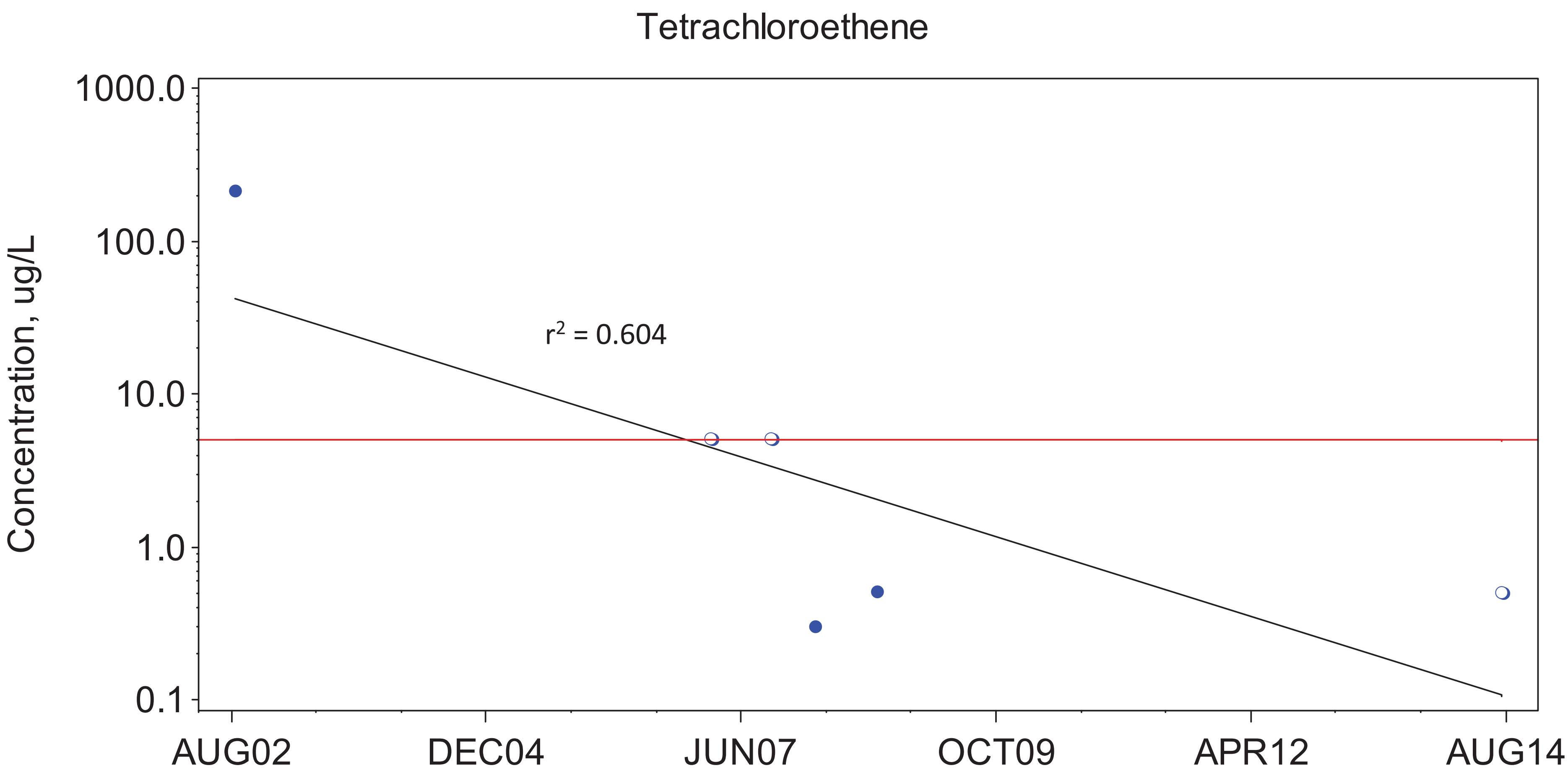
Station ID	MCL-Groundwater	LW03-MW07									
Sample ID		LW03-MW07-05-02C	LW03-MW07-15-02C	LW03-MW07-07A	LW03-MW07-07-07C	LW03-MW07-12-07C*	LW03-MW07-07-08A*	LW03-MW07-13-08A	LW03-MW07-07-08C	LW03-MW07-13-08C	LW03-MW07-14C*
Sample Date		08/30/02	08/30/02	02/14/07	09/18/07	09/18/07	02/07/08	02/07/08	09/17/08	09/17/08	08/12/14
Chemical Name											
Volatile Organic Compounds (UG/L)											
Tetrachloroethene	5	**0.18 J**	0.5 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 U
Trichloroethene	5	**3.4**	2 B	10 U	10 U	10 U	10 U	10 U	10 U	10 U	**6.01**
cis-1,2-Dichloroethene	70	**52**	**48**	**21**	**23**	**19**	**24**	**18**	**30**	**27**	**12.9**
trans-1,2-Dichloroethene	100	**10**	**9.2**	**5 J**	**8.5 J**	**7.6 J**	**7 J**	**6 J**	**11**	**10 J**	**2.69**
Vinyl chloride	2	0.5 U	**14**	**10**	**12**	**9.6 J**	**10 J**	**8 J**	**16**	**14**	**2.86**

Notes:
Shading indicates exceedance of MCL-Groundwater criteria
Bold indicates detections
* - Duplicate sample collected. Most conservative value reported.
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccurate
UL - Analyte not detected, quantitation limit is probably higher
UG/L - Micrograms per liter

Table D-2
Data Used for Statistical Evaluation
SWMU 3 Focused Feasibility Study
JEB Little Creek
Virginia Beach, Virginia

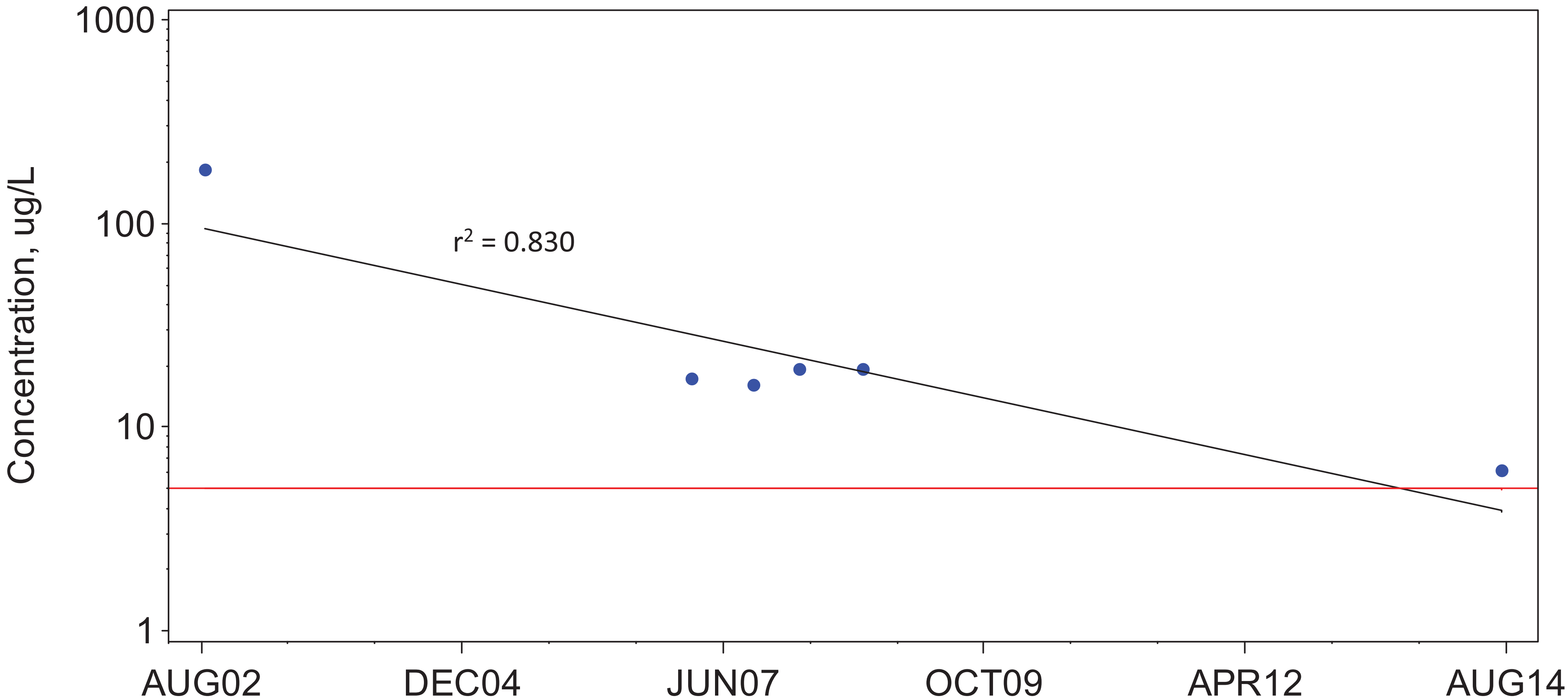
Station ID	**MCL-Groundwater**	LW03-MW12							
Sample ID		LW03-MW12-07A*	LW03-MW12-09-07C	LW03-MW12-15-07C	LW03-MW12-09-08A	LW03-MW12-15-08A	LW03-MW12-09-08C	LW03-MW12-15-08C	LW03-MW12-14C
Sample Date		02/13/07	09/19/07	09/19/07	02/07/08	02/07/08	09/17/08	09/17/08	08/15/14
Chemical Name									
Volatile Organic Compounds (UG/L)									
Tetrachloroethene	5	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 U
Trichloroethene	5	**17**	**16**	**13**	**19**	**18**	**19**	**19**	**2 J**
cis-1,2-Dichloroethene	70	**260**	**140**	**110**	**190**	**210**	**310**	**280**	**28**
trans-1,2-Dichloroethene	100	**79**	**64**	**44**	**83**	**79**	**130**	**120**	**12.2**
Vinyl chloride	2	**56 J**	**35**	**33**	**54**	**55**	**85**	**84**	**15.9**

Notes:
Shading indicates exceedance of MCL-Groundwater criteria
Bold indicates detections
* - Duplicate sample collected. Most conservative value reported.
B - Analyte not detected above the level reported in blanks
J - Analyte present, value may or may not be accurate or precise
U - The material was analyzed for, but not detected
UJ - Analyte not detected, quantitation limit may be inaccurate
UL - Analyte not detected, quantitation limit is probably higher
UG/L - Micrograms per liter

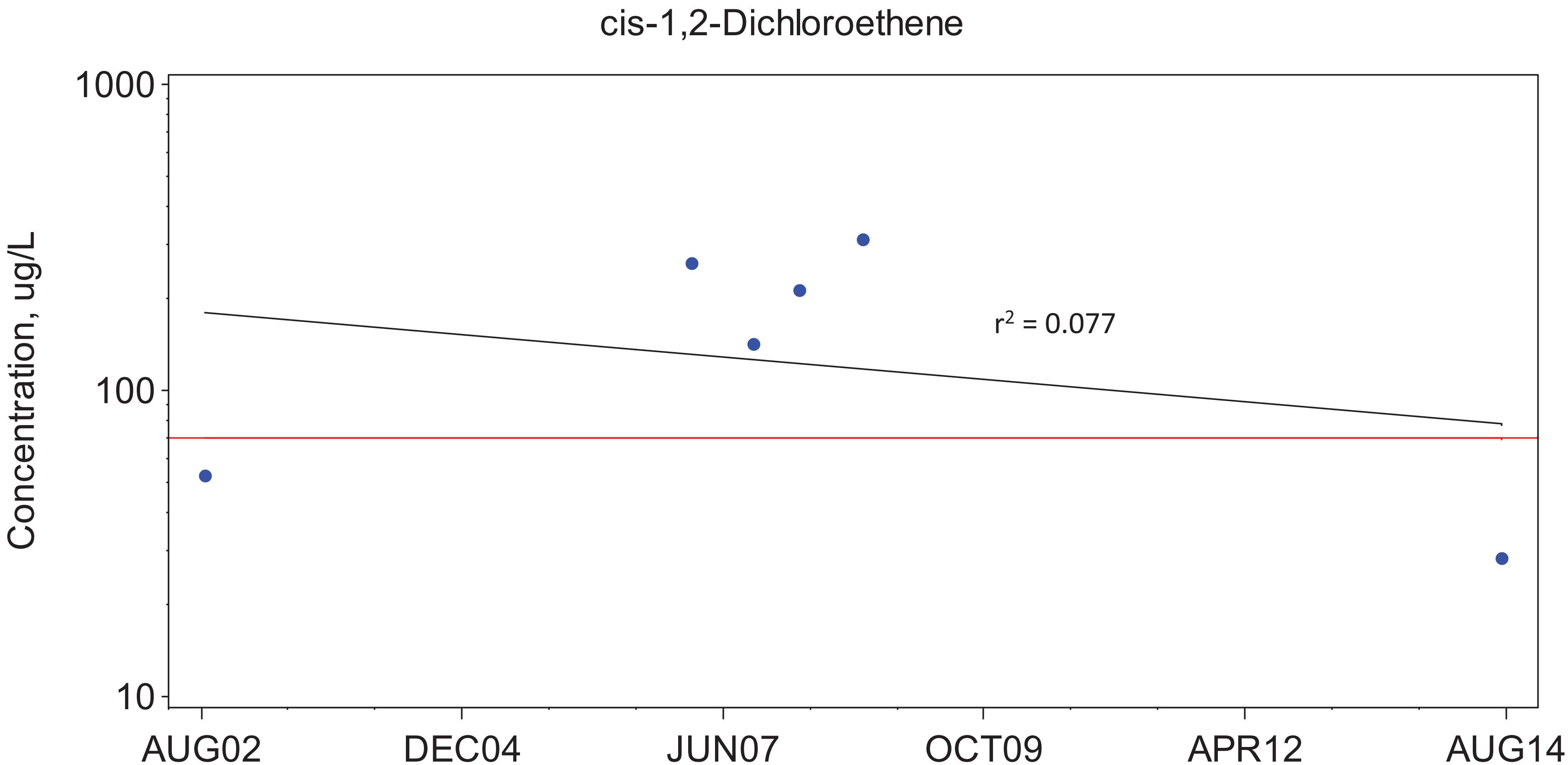


Blue Open Symbols Represent Non-Detect Proxies (1/2 Limit of Detection); Green Closed Symbols Represent Detects
Red Horizontal Line at MCL;

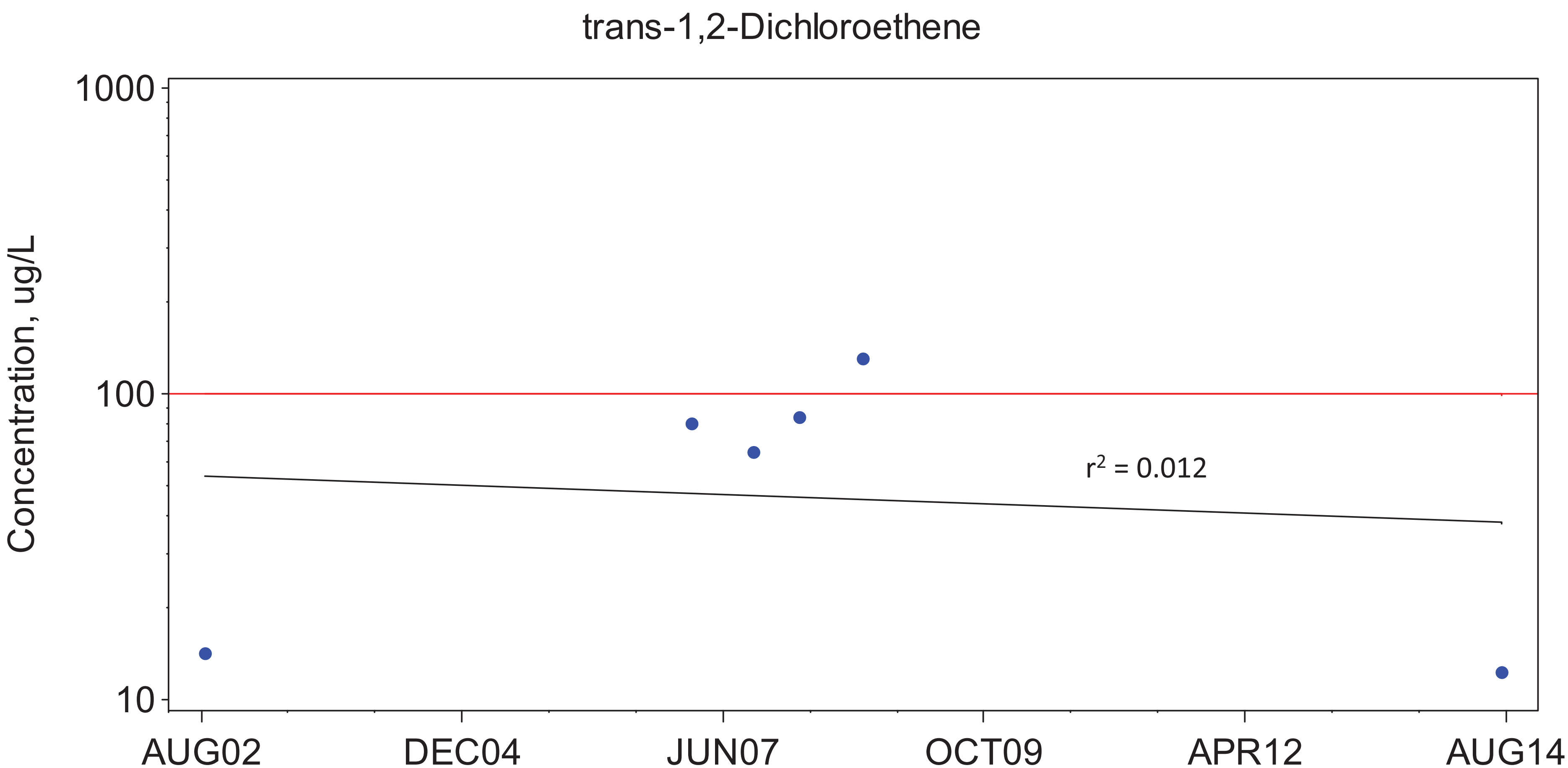
Trichloroethene



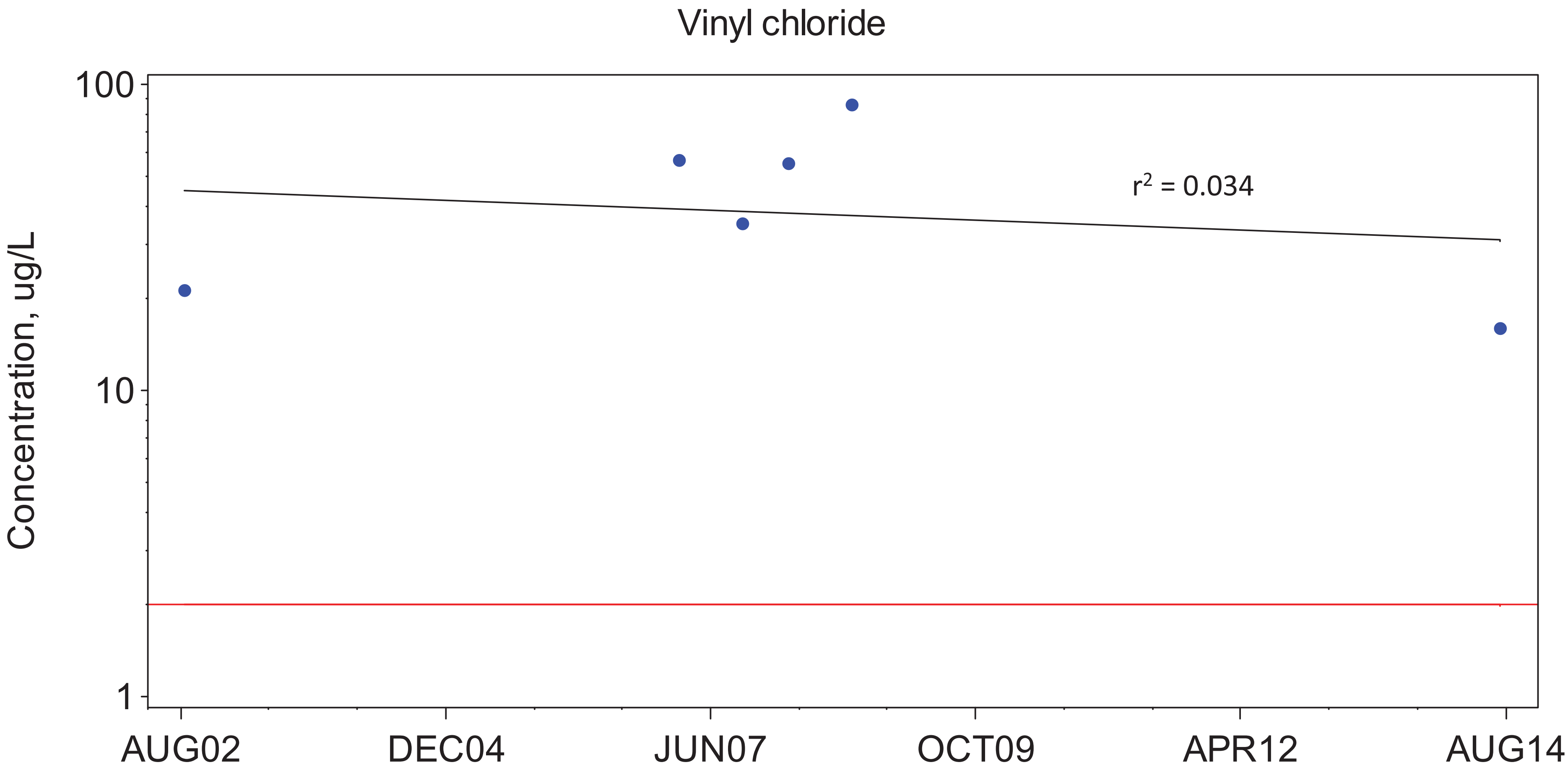
Blue Open Symbols Represent Non-Detect Proxies (1/2 Limit of Detection); Green Closed Symbols Represent Detects
Red Horizontal Line at MCL;



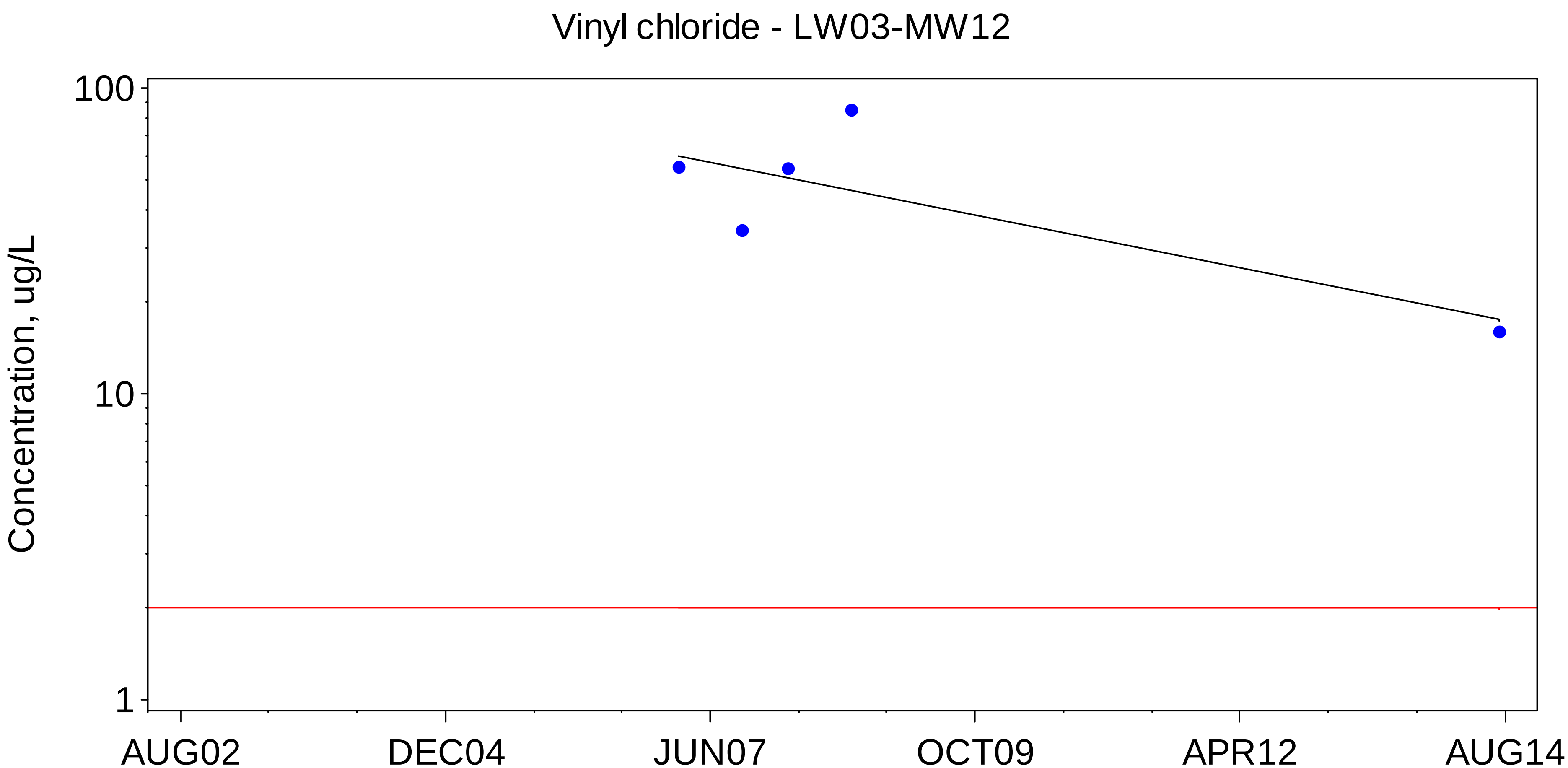
Blue Open Symbols Represent Non-Detect Proxies (1/2 Limit of Detection); Green Closed Symbols Represent Detects
Red Horizontal Line at MCL;



Blue Open Symbols Represent Non-Detect Proxies (1/2 Limit of Detection); Green Closed Symbols Represent Detects
Red Horizontal Line at MCL;



Blue Open Symbols Represent Non-Detect Proxies (1/2 Limit of Detection); Green Closed Symbols Represent Detects
Red Horizontal Line at MCL;



Blue Open Symbols Represent Non-Detect Proxies (1/2 Limit of Detection); Green Closed Symbols Represent Detects
Red Horizontal Line at MCL;

Parameter	MCL	Units	Slope	Intercept	exp (Intercept)	Best Estimate of Date Goal Reached
Vinyl chloride	2	ug/L	0.164	4.10	66.17	10/28/2027

Appendix E
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 E-1

Federal Chemical-Specific ARARs

SWMU 3 Focused Feasibility Study

Joint Expeditionary Base Little Creek

Virginia Beach, Virgnia

Media	Requirement	Prerequisite	Citation	Alternative	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(1), (5), and (9)	2	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 E-2

Virginia Chemical-Specific ARARs

SWMU 3 Focused Feasibility Study

Joint Expeditionary Base Little Creek

Virginia Beach, Virgnia

Media	Requirement	Prerequisite	Citation	Alternative	ARAR/TBC Determination	Comment

No Virginia Chemical-Specific ARARs apply.

TABLE E-3

Federal Location-Specific ARARs

SWMU 3 Focused Feasibility Study

Joint Expeditionary Base Little Creek

Virginia Beach, Virgnia

Location	Requirement	Prerequisite	Citation	Alternative	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	2	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(a), (b); .36(a)	2	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. Activites performed on-site and in compliance with CERCLA are not subject to adminsitrative review; however, the substantive requirements of making a consistency determination will be met.

TABLE E-4

Virginia Location-Specific ARARs

SWMU 3 Focused Feasibility Study

Joint Expeditionary Base Little Creek

Virginia Beach, Virgnia

Location	Requirement	Prerequisite	Citation	Alternative	ARAR/TBC Determination	Comment

No Virginia Location-Specific ARARs apply.

TABLE E-5

Federal Action-Specific ARARs

SWMU 3 Focused Feasibility Study

Joint Expeditionary Base Little Creek

Virginia Beach, Virgnia

Action	Requirement	Prerequisite	Citation	Alternative	ARAR/TBC Determination	Comment

No Federal Action-Specific ARARs apply.

TABLE E-6

Virginia Action-Specific ARARs

SWMU 3 Focused Feasibility Study

Joint Expeditionary Base Little Creek

Virginia Beach, Virgnia

Action	Requirement	Prerequisite	Citation	Alternative	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)	2	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	2	Applicable	It is possible that hazardous waste will be generated and staged onsite in containers for less than 90 days
Monitoring Well Construction and Maintenace						
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)	2	Applicable	Monitoring wells will be installed and abandoned in accordance with the Virginia regulations.

Appendix F
Cost Estimate

TABLE F-1

Engineer's Cost Estimate for Alternative 2: MNA and LUCs

SWMU 3 Focused Feasibility Study

JEB Little Creek

Virginia Beach, Virginia

Description: Alternative 2 consists of MNA and LUCs. Initial remedy implementation will include a site survey and filing a survey plat with the City of Virginia Beach; and development of a groundwater monitoring plan. LUCs, via the survey plat, will be utlized to restrict site access and use. Annual site inspections will be conducted to ensure that there are no violations of the LUCs. The degradation of site-realted COCs through natural processes will be monitored via periodic groundwater sampling at an assumed frequency of one sampling event every 5 years.

Site: SWMU 3 - Pier 10 Sandblast Yard, JEB Little Creek
Location: Virginia Beach, VA
Date: 9/24/2014

CAPITAL COSTS

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Groundwater Monitoring	Groundwater Monitoring Sampling and Analysis Plan	1	Lump Sum	$30,000	$30,000	Assumes that the groundwater monitoring sampling and analysis plan will be utilized throughout the life of the remedy.
Site Survey						
	Field Surveying, Data Evaluation, and Reporting	1	Lump Sum	$2,500.00	$2,500	Engineer's Estimate
Deed Restriction						
	Deed Restriction Filing Fees	1	Lump Sum	$500.00	$500	Engineer's Estimate
	Deed Restriction Filing Labor hours	50	Hour	$110.00	$5,500	Engineer's Estimate
	SUBTOTAL				**$38,500**	
	Project Management	10%	of	$38,500	$3,850	Engineer's Estimate
	SUBTOTAL				**$42,350**	
	Contingency	15%	of	$42,350	$6,352.50	Engineer's Estimate
	TOTAL CAPITAL COST				**$48,800**	

OPERATIONS AND MAINTENANCE COST

	DESCRIPTION	QTY	UNIT	COST	TOTAL	NOTES
Annual Groundwater Monitoring						
	Fieldwork (2 person crew)	40	Hour	$65	$2,600	Assume 7 monitoring wells, 3 QA/QC samples, and 2 10-hour days per event.
	Equipment and Consumables	1	Lump Sum	$1,200	$1,200	Includes mobilization/demobilization
	Analytical Data Laboratory Analysis and Data Validation	10	Per Sample	$410	$4,100	2014 Navy CLEAN BOA Rates. Laboratory analysis includes select VOCs (TCE and vinyl chloride) and geochemistry parameters (alkalinity, chloride, dissolved manganese, methane, ethane, ethene, nitrate, sulfate, sulfide, TOC, TDS, and volatile fatty acids [VFA]). See note below for list of field water quality parameters.
	Data Analysis and Reporting	1	Lump Sum	$12,000	$12,000	Engineer's Estimate
	SUBTOTAL				**$19,900**	
	Project Management	10%	of	$19,900	$1,990.00	Engineer's Estimate
	SUBTOTAL				**$21,890**	
Inspections						
	Annual Inspections	1	Each	$1,500	$1,500	Engineer's Estimate
	SUBTOTAL				**$1,500**	
	Contingency	15%	of	$23,390	$3,509	Engineer's Estimate
	TOTAL ANNUAL O&M COST				**$26,900**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 3.0%

End Year	COST TYPE	TOTAL COST	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$48,800	$48,800	1.000	$48,800
1	ANNUAL COST - O&M	$26,900	$26,900	0.971	$26,117
2	ANNUAL COST - O&M	$26,900	$26,900	0.943	$25,356
3	ANNUAL COST - O&M	$26,900	$26,900	0.915	$24,617
4	ANNUAL COST - O&M	$26,900	$26,900	0.888	$23,900
5	ANNUAL COST - O&M	$26,900	$26,900	0.863	$23,204
6	ANNUAL COST - O&M	$26,900	$26,900	0.837	$22,528
7	ANNUAL COST - O&M	$26,900	$26,900	0.813	$21,872
8	ANNUAL COST - O&M	$26,900	$26,900	0.789	$21,235
9	ANNUAL COST - O&M	$26,900	$26,900	0.766	$20,617
10	ANNUAL COST - O&M	$26,900	$26,900	0.744	$20,016
11	ANNUAL COST - O&M	$26,900	$26,900	0.722	$19,433
12	ANNUAL COST - O&M	$26,900	$26,900	0.701	$18,867
13	ANNUAL COST - O&M	$26,900	$26,900	0.681	$18,318
14	ANNUAL COST - O&M	$26,900	$26,900	0.661	$17,784
15	ANNUAL COST - O&M	$26,900	$26,900	0.642	$17,266
		TOTAL PRESENT VALUE OF ALTERNATIVE			**$370,000**
				+50%	**$555,000**
				-30%	**$259,000**

References and Source Notes

- Base costs used are 2014 dollars.
- Pricing for surveying and deed restriction based on recent similar projects including the JEBLC Sites 11a and 13 Survey Plats.
- USEPA, 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasiblity Study* , EPA 540-R-00-002 OSWER 9355.0-75. July

Assumptions and Exclusions

1. Unit prices for field surveying include mobilization/demobilization and all supplies, equipment, and materials required to complete the work

2. Groundwater monitoring will be conducted annually

3. The enclosed Engineer's Estimate is only an estimate of possible construction costs for budgeting purposes. This estimate is limited to the conditions existing at its issuance and is not a guarantee of actual price or cost. 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 etc may affect the accuracy of this estimate. CH2M Hill is not responsible for any variance from this estimate or actual prices and conditions obtained. This is an order-of-magnitude cost estimate that is expected to be within +50 to -30 percent of the anticipated costs in the Focused FS.