RECORD OF DECISION

FORMER FIRE TRAINING AREA

NASA Wallops Flight Facility

Wallops Island, Virginia

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility

DECEMBER 2007

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

μg/L	microgram per liter
AAOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
AS	air sparging
bgs	below ground surface
CDI	chronic daily intake
CERCLA	Comprehensive Environmental, Response, Compensation, and Liability Act
CERCLIS	CERCLA Information System
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
CNS	central nervous system
COC	chemical of concern
COPC	chemical of potential concern
CSM	Conceptual Site Model
DCE	dichloroethene
DEQ	Department of Environmental Quality
EPA	United States Environmental Protection Agency
ERA	ecological risk assessment
ESD	Explanation of Significant Differences
FFTA	Former Fire Training Area
FS	Feasibility Study
GSFC	Goddard Space Flight Center
HEAST	Health Effects Assessment Summary Table
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
LUC	land use control
MCL	Maximum Contaminant Level
MTBE	methyl tert-butyl ether
NASA	National Aeronautics and Space Administration
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	operation and maintenance
ORC	oxygen release compound
ORP	oxidation reduction potential

ACRONYMS AND ABBREVIATIONS (Continued)

PA	Preliminary Assessment
PCB	polychlorinated biphenyl
RAO	remedial action objective
RfC	reference concentration
RfD	reference dose
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SF	slope factor
SI	Site Inspection
SVOC	semivolatile organic compound
TAL	Target Analyte List
TBC	to be considered
TCL	Target Compound List
TOC	total organic carbon
UCL	upper confidence limit
VAC	Virginia Administrative Code
VOC	volatile organic compound
WFF	Wallops Flight Facility

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Former Fire Training Area
NASA Wallops Flight Facility
Wallops Island, Virginia 23337
CERCLIS ID No. VA8800010763

1.2 STATEMENT OF BASIS AND PURPOSE

This decision document presents the Selected Remedy for the Former Fire Training Area (FFTA), or Site, at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Wallops Flight Facility (WFF) in Accomack County, Virginia. The Selected Remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record file for this Site.

NASA and the United States Environmental Protection Agency (EPA) jointly selected the remedy, and the Virginia Department of Environmental Quality (DEQ) concurs with the Selected Remedy.

1.3 ASSESSMENT OF THE SITE

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

1.4 DESCRIPTION OF SELECTED REMEDY

The FFTA is one of the sites currently subject to the EPA/NASA Administrative Agreement on Consent (AAOC) (EPA Docket No. RCRA-03-2004-0201TH). Separate investigations and assessments are being conducted for other sites in accordance with the AAOC and CERCLA. Therefore, this ROD only applies to the FFTA.

The Selected Remedy for the FFTA includes in-situ biological treatment (biostimulation), institutional controls, and monitoring. The Selected Remedy includes the following major components:

- Injecting oxygen-releasing compounds into the groundwater contaminant plume to promote in-situ biological treatment (biostimulation).

- Implementing institutional controls to prevent the development of commercial or residential buildings at the Site and the use of groundwater for drinking purposes until cleanup levels have been met.

- Monitoring groundwater to confirm the effectiveness of treatment and evaluate potential contaminant migration.

1.5 STATUTORY DETERMINATIONS

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

This remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e., reduces toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

This remedy will not result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure. However, the remedy may take more than 5 years to attain remedial action objectives and cleanup levels; therefore, until the remedial action objectives and cleanup levels are attained a review will be conducted within 5 years of construction completion for the Site to ensure that the remedy is, or will be, protective of human health and the environment.

1.6 ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this ROD:

- Chemicals of concern (COCs) and their respective concentrations.

- Baseline risk represented by the COCs.

- Cleanup levels established for COCs and the basis for these levels.

- How source materials constituting principal threats are addressed.

- Current and reasonably anticipated future land use assumptions and current and beneficial uses of groundwater used in the baseline risk assessment and ROD.

- Potential land and groundwater use that will be available at the Site as a result of the Selected Remedy.

- Estimated capital, annual operation and maintenance (O&M), and total present-worth costs, discount rates, and number of years over which the remedy cost estimates are projected.

- Key factor(s) that led to selecting the remedy (i.e., how the Selected Remedy provides the best balances of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision).

Additional information can be found in the Administrative Record file for this Site.

1.7 AUTHORIZING SIGNATURES

Dr. John H. Campbell
Director Wallops Flight Facility

11/1/07
Date

Abraham Ferdas, Director
Waste Chemicals Management Division
U.S. EPA Region 3

12/12/07
Date

James Burke, Director
Hazardous Site Cleanup Division
U.S. EPA Region 3

12/19/07
Date

2.0 DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

WFF is located in Accomack County on the eastern shore of Virginia (Figure 2-1). The facility is comprised of three separate areas: the Main Base, the Mainland, and Wallops Island. The Main Base is the most heavily developed area. The Main Base is bordered to the east by extensive marshland and creeks that drain to the Chincoteague Bay and inlet. Little Mosquito Creek, which eventually flows east into the inlet and the Atlantic Ocean, borders the Main Base to the north and west. State Routes 175 and 798 form the southern and southeastern borders of the facility (Figure 2-2). The Mainland and Wallops Island are located several miles south of and are not contiguous with the Main Base. The EPA identification number for the WFF Main Base is VA8800010763.

NASA is the lead agency for site activities at the WFF. EPA is the lead regulatory agency, and DEQ is the support agency. Funding is provided by NASA.

The FFTA, the Site for which the ROD is being prepared, is located on the north side of the WFF Main Base, adjacent to a former taxiway that is immediately north of and parallel to an active runway (Figure 2-3). The area is currently an open grass field that gently slopes to the north and northeast.

2.2 SITE HISTORY AND ENFORCEMENT ACTIONS

2.2.1 Site History

NASA used the FFTA twice a week for fire fighting training exercises from 1965 until 1987. It was reported that flammable liquids were dispersed onto the ground, into a shallow pit, onto a discarded airplane fuselage, and/or into a tank and ignited for these exercises. There are no records identifying the type of materials used during these training exercises.

2.2.2 Previous Investigations, Removal Actions, and Enforcement Actions

Environmental investigations began at the FFTA in 1986 when the Commonwealth of Virginia conducted an inspection and identified substances thought to be jet fuel and crankcase oil in an unlined pit. The Virginia Department of Waste Management, subsequently renamed Virginia Department of Environmental Quality (DEQ), issued a removal order, to NASA requiring NASA to remove approximately 120 cubic yards of contaminated soil in November 1986.

A Preliminary Assessment (PA) and Site Inspection (SI) were conducted from 1989 through 1990 (Ebasco Services, Inc. 1990). The studies included soil-gas surveys, monitoring well installation, and surface soil and groundwater sampling.

A Remedial Investigation (RI) was conducted from 1993 through 1994 (Metcalf & Eddy, Inc. 1996). Field activities included a soil-gas survey, advancement of soil borings, installation of monitoring wells, and collection of soil and groundwater samples.

A supplemental groundwater investigation was conducted in 2000 (Versar, Inc. 2000). Field activities included sampling and analysis of groundwater.

A supplemental RI field investigation was conducted in 2003 (TtNUS, 2004). Field activities included installation of additional monitoring wells and soil and groundwater sampling.

No other enforcement activities, removal actions, or remediation activities have been initiated at the FFTA.

2.3 COMMUNITY PARTICIPATION

The Supplemental RI Report, Feasibility Study (FS) Report, and Proposed Remedial Action Plan (PRAP) for the FFTA at the NASA WFF were made available to the public. The Supplemental RI Report was made available in July 2004, the FS Report was made available in September 2005, and the PRAP was made available in February 2007. These documents can be found in the Administrative Record file and the Information Repositories maintained at the Eastern Shore Public Library (23610 Front Street, Accomack, Virginia 23301) and Island Library (4077 Main Street, Chincoteague, Virginia 23336). The notice of availability of these documents was placed in the Chincoteague Beacon and Eastern Shore News on February 8 and 14, 2007, respectively. A public comment period on the PRAP was held from February 14, 2007 to March 15, 2007. In addition, a public meeting was held on March 01, 2007 to present the PRAP to a broader community audience than those that had already been involved at the Site. At this meeting, representatives from NASA, EPA, and DEQ were present to answer questions about the Site and the remedial alternatives. No comments were received during the comment period as noted in the Responsiveness Summary section of this ROD.

2.4 SCOPE AND ROLE OF RESPONSE ACTION

The FFTA is one of the sites currently included in the NASA/EPA AAOC. The Selected Remedy is the final remedial action for the FFTA under CERCLA. The function of the remedy is to reduce risks to human health and the environment associated with exposure to groundwater contamination. There were no unacceptable risks to human health or the environment associated with exposure to soil, surface water, or sediment.

The potential exposure to shallow groundwater contamination under a hypothetical future residential exposure scenario constitutes the principal risk to human health. There are no unacceptable risks to ecological receptors (TtNUS, 2004). Although shallow groundwater is contaminated, the contamination is not affecting public drinking water supplies or nearby surface water. The purpose of the remedial action is to prevent future potential exposure to contaminated shallow groundwater.

Separate investigations and assessments are being conducted for the other sites at the WFF in accordance with CERCLA and the AAOC. Therefore, this ROD only applies to the FFTA. Separate RODs or other CERCLA decision documents have been or will be prepared for the other sites subject to the AAOC.

2.5 SITE CHARACTERISTICS

2.5.1 Physical Setting

Site features are shown on Figure 2-3. The FFTA is located on the north side of the Main Base, adjacent to a former taxiway immediately north of Runway 10-28. The area is currently an open grass field that gently slopes to the north and northeast. The surface elevation of the Site ranges from approximately 27 to 32 feet above mean sea level. Areas of higher elevation surround the FFTA. There are no surface water bodies at or near the FFTA. Surface runoff flows to low-lying areas within the Site where it either infiltrates or evaporates.

The FFTA is bordered to the south by an abandoned taxiway. An earthen berm approximately 100 feet long and 4 feet high exists at the edge of the taxiway. The berm is constructed around a discarded airplane fuselage that was used for fire fighting training exercises. The WFF wastewater treatment plant is located west of the FFTA. The former Navy magazine area is located to the north and is separated from the FFTA by an embankment ranging from 3 to 12 feet high. This area is controlled, restricted, and used by NASA as a rocket motor storage and preparation area. The area east of the FFTA is heavily wooded and contains a former disposal and debris pile that was used by the Navy prior to NASA's operations. This area is referred to as the Site 14 Debris Pile and is under investigation by the United States Army Corps of Engineers as part of the federal Formerly Utilized Defense Sites program.

The Columbia Formation lithologic unit underlies the Site and consists predominately of fine- to medium-grained sand with lesser amounts of silt and clay. The Columbia Formation is approximately 50 feet thick beneath the FFTA. A silty clay layer approximately 3 feet thick exists within the Columbia Formation at a depth of approximately 25 feet below ground surface (bgs). This clay lens functions as a leaky aquitard that hydraulically divides the Columbia aquifer into upper and lower units. The lower Columbia unit is underlain by the upper Yorktown aquitard. This aquitard separates the Columbia aquifer from the deeper Yorktown aquifer. A silty clay layer, interpreted to be the upper Yorktown aquitard, was encountered 47 to 52 feet bgs at the Site.

The depth to groundwater is approximately 15 feet bgs. Groundwater in the upper unit of the Columbia aquifer flows to the northeast following regional topography toward the unnamed tributary to Little Mosquito Creek then toward Mosquito Creek. Groundwater in the lower unit generally flows to the north and does not appear to be influenced by the unnamed tributary. There is a downward vertical hydraulic gradient. This indicates that the area is a groundwater recharge area, and the unnamed tributary is not expected to be a significant groundwater discharge point. Little Mosquito Creek and its associated wetlands are expected to be the significant groundwater discharge point for the study area. Groundwater from the Columbia aquifer in the vicinity of the Site is not currently used as a potable water supply. The Town of Chincoteague maintains three water supply wells screened within the Columbia aquifer. These wells are located about 5,000 feet to the east-southeast, upgradient, of the Site and are operated on an as-needed seasonal basis. Drinking water at the WFF is obtained from the Yorktown aquifer. There is no known hydrogeologic connection or communication between the surficial Columbia aquifer and the deeper Yorktown aquifer used for drinking water.

There are no known areas of archeological or historical importance at the FFTA.

2.5.2 <u>Conceptual Site Model</u>

Figure 2-4 is the Conceptual Site Model (CSM) for human receptors and ecological receptors. The CSM graphically integrates information regarding the physical characteristics of the site, exposed populations, sources of contamination, and contaminant mobility (fate and transport) to identify potential exposure routes and receptors evaluated in the risk assessments. A well-defined CSM allows for a better understanding of the risks at a site and aids in the identification of the potential need for remediation.

2.5.3 <u>Sampling Strategy</u>

The release of flammable liquids during fire fighting training exercises is the likely source of contamination.

During the PA/SI in 1989 and 1990, 43 soil-gas samples were collected from an approximately 1-acre study area including the open field north of the berm and suspected location of the training pit (Ebasco Services, Inc., 1990). Soil-gas samples were collected on 100-foot centers and analyzed using a field organic vapor detection instrument. Samples from three monitoring wells were collected and analyzed with the field instrument using the headspace technique. The field data indicated the presence of volatile organic compounds (VOCs) in soil and groundwater. The PA/SI was followed up with an additional sampling program that included collection of four surface soil samples and three groundwater samples. VOCs were not present in surface soil or an upgradient monitoring well, but elevated VOC concentrations were identified in the shallow downgradient monitoring well.

An RI was conducted from 1993 to 1994. The study area included the FFTA and surrounding features, including a reported former drum storage area, wastewater treatment plant sludge pile, and construction debris pile. Soil-gas samples collected throughout the study area were analyzed using a field laboratory equipped with a gas chromatogram for contaminant identification. Eight surface soil samples were collected from around the area that exhibited elevated soil-gas readings. Seventeen subsurface soil samples were collected from six borings advanced in or immediately downgradient of the FFTA. Ten monitoring wells were installed based on the projected groundwater flow direction and suspected source area (fire training pit). The monitoring wells were completed at three depth intervals within the shallow Columbia aquifer. Soil and groundwater samples were analyzed for Target Compound List (TCL) organics and Target Analyte List (TAL) metals. The RI concluded that groundwater contaminated with VOCs was emanating from the former fire training pit area and flowing to the northeast (Metcalf & Eddy, Inc., 1996).

Supplemental groundwater sampling was conducted in 2000 to determine whether site conditions had changed since the RI. The apparent groundwater plume had diminished in the source area and broadened in the downgradient area. It was concluded that past fire fighting training exercises were the source of groundwater contamination identified north of the abandoned taxiway, and the contamination (primarily VOCs) was migrating with the groundwater (Versar, Inc., 2000).

The supplemental RI field investigation conducted in 2003 included installation of seven additional monitoring wells and soil and groundwater sampling. The sampling was conducted to better define the extent of soil and groundwater contamination, groundwater flow direction, and contaminant migration pathways. Eighteen surface and 37 subsurface soil samples were collected from the suspected source area and analyzed for VOCs, semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and TAL metals. Surface soil samples were also analyzed for dioxins, furans, pH, total organic carbon (TOC), and grain size. Groundwater samples were collected from new and existing monitoring wells and analyzed for VOCs plus methyl tert-butyl ether (MTBE), SVOCs, PCBs, TAL total and dissolved metals, and natural attenuation parameters (TtNUS, 2004).

2.5.4 Nature and Extent of Contamination

Contaminants of Concern (COCs) were identified based on the analytical data, risk drivers from the human health and ecological risk assessments (discussed in Section 2.7), and exceedances of regulatory standards and criteria. The concentrations of the groundwater COCs are provided in Table 2-1. The COCs include three VOCs [benzene, cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride], two SVOCs (4-methylphenol and naphthalene), and two metals (arsenic and manganese). Past operations at the FFTA are the likely source of groundwater contamination but the area does not appear to act as a current source of contamination. There are no COCs for soil as all contaminated soil was addressed in 1986 in response to the Virginia Department of Waste Management removal order.

The contaminant plume is primarily defined by the presence of VOCs located downgradient of the former fire training pit area. The plume is essentially confined to the upper flow unit of the Columbia aquifer with the presence of a silty clay lens controlling contaminant migration and groundwater flow. The COC concentrations within the plume have decreased, and the areal extent of the plume appears to be less extensive than it was in 1996. The groundwater contaminant plume covers approximately 1.3 acres. Figure 2-5 shows the COC concentrations detected during the supplemental RI in 2003 and compares them to the preliminary remediation goals identified in the FS Report.

The highest concentrations of benzene are in the area around monitoring well MW-61I. However, the benzene concentrations in samples from that well have decreased from 100 micrograms per liter (µg/L) in 1996 to 31 µg/L in 2000 and to 28 µg/L in 2003. The northern extent of the benzene plume is at MW-57S (3 µg/L in 2003). The south-southwestern extent is at MW-55S (2 µg/L).

The concentrations of cis-1,2-DCE have also decreased over time. Concentrations ranged from 1 to 3,000 µg/L in 1996 and from 1 to 1,700 µg/L in 2000. During the 2003 supplemental RI, cis-1,2-DCE was detected in 10 of 21 samples at concentrations ranging from 1 to 460 µg/L. The highest concentrations extend from MW-61I northeastward to MW-56D (360 µg/L) and MW-57S (110 µg/L). The concentration was 1 µg/L in a sample from MW-105D, which is screened in the deeper portion of the Columbia aquifer near MW-57S.

Vinyl chloride was detected at two locations during the supplemental RI. The concentrations ranged from 2 µg/L at MW-56D to 6 µg/L at MW-61I.

Naphthalene was detected in wells located within and immediately downgradient of the suspected source area at concentrations ranging from 21 µg/L at MW-58S to 66 µg/L at MW-61I. The concentrations of 4-methylphenol ranged from 88 to 300 µg/L at well cluster MW-55S/D.

Arsenic and manganese were detected throughout the VOC and SVOC plumes. The highest concentrations of total arsenic (25.4 µg/L) and total manganese (4,990 µg/L) were from the samples collected from MW-55S and MW-61I, respectively. Filtered samples from these wells also contained the highest concentrations of dissolved arsenic and manganese.

No contamination was detected in a monitoring well (MW-104S) installed at the projected groundwater discharge point near the closest surface water body, Little Mosquito Creek. Similarly, no contamination was detected in upgradient wells including FTA-MW-54S and FTA-MW-101S, FTA-MW-02S & 02D

Additional details on the spatial distribution and concentrations of chemicals detected in all site media and site investigations conducted to date are contained in the Supplemental RI Report (TtNUS, 2004) and the FS Report (TtNUS, 2005).

2.6 CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

The FFTA is currently an open grass field and is no longer used for fire fighting training. The FFTA is not used for any specific purpose, and there are no plans for residential development of the Site. No change in the use of the Site is likely as it is adjacent to an active runway that is an important part of the future facility plan for the installation. Shallow groundwater is not used by NASA for any purpose other than environmental monitoring and restoration and there are no plans for the development of this resource for potable use in the future. However, upgradient and approximately 5,000 feet from the Site the Town of Chincoteague operates 2 shallow Columbia aquifer wells that are used to augment their public water supply, as needed, on a seasonal basis. The Town owns a third well that is in disrepair and is currently not used but is in the vicinity of the 2 operating wells. The shallow Columbia aquifer is not as productive as the deeper, hydraulically unconnected, Yorktown aquifer also present in the area. The Yorktown aquifer is the source of the majority of the Town's and all of NASA's potable water. Nonetheless, the potential use of the groundwater from the Columbia aquifer as a potable water supply represents a potential future use of the resource.

Small unnamed tributaries to Little Mosquito Creek are the only surface water resources near the FFTA. The tributaries lie to the northeast and northwest of the Site and are entirely within the NASA Wallops property boundary. They offer little recreational or commercial use now and are not expected to in the future.

2.7 SUMMARY OF SITE RISKS

2.7.1 Summary of Human Health Risk Assessment

The baseline human health risk assessment estimates the risks that the Site poses if no further action is taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment that was conducted for the Supplemental RI Report. The primary focus of this summary is on those exposure pathways and chemicals found to pose actual or potential risks to human health. The risk assessment in the Supplemental RI Report contains an evaluation of all chemicals of potential concern (COPCs) and exposure pathways, including those that do not pose unacceptable risks to human health. COPCs are those chemicals that are identified as potential threats to human health and are evaluated further in the baseline risk assessment. COCs are a subset of COPCs that are identified in the RI/FS as needing to be addressed by the response action proposed in this ROD.

2.7.1.1 Identification of Chemicals of Concern

Table 2-1 presents the COCs and exposure point concentrations for each of the COCs detected in groundwater based on the risk assessment in the Supplemental RI Report. There are no COCs for soil, surface water, or sediment. COCs either result in an unacceptable risk or exceed a regulatory standard. The exposure point concentration is the concentration that was used to estimate the exposure and risk from each COC. Table 2-1 contains the concentration range of each COC in groundwater, the frequency of detection, the exposure point concentration, and how the exposure point concentration was derived.

Groundwater COCs based on unacceptable risks to human health are cis-1,2-DCE, 4-methyphenol, naphthalene, arsenic, and manganese. Detected concentrations of benzene, cis-1,2-DCE, vinyl chloride, and arsenic are greater than federal Maximum Contaminant Levels (MCLs) for drinking water. Therefore, benzene and vinyl chloride are also COCs for groundwater.

2.7.1.2 Exposure Assessment

This section presents a summary of the exposure assessment detailed in the Supplemental RI Report. The exposure assessment defines and evaluates the type and magnitude of human exposure to the chemicals present at or migrating from a site. The exposure assessment is designed to depict the physical setting of the site, to identify potentially exposed populations, and to estimate chemical intakes under the identified exposure scenarios. Actual or potential exposures are based on the most likely pathways of contaminant release and transport, as well as human activity patterns. A complete exposure pathway has the following three components: a source of chemicals that can be released into the environment, a route of contaminant transport through an environmental medium, and an exposure or contact point for a human receptor.

The compilation of contaminant sources, likely exposure pathways, and receptors at the FFTA is depicted in the CSM (Figure 2-4). Potential receptors include current and future industrial workers, future construction workers, and hypothetical future residents. Examples of activities for the industrial worker include groundskeeping and maintenance, installation and maintenance of airfield equipment, and utility or road work. Construction workers can be involved with any type of excavation activity. Future residential use is not a reasonably anticipated land use but was evaluated to determine whether unrestricted land use could be permitted.

Major assumptions about exposure frequency (days per year), exposure duration (years), and other exposure factors (e.g., body surface area for dermal exposure, ingestion rates) that were included in the exposure assessment can be found in the Supplemental RI Report (TtNUS, 2004).

2.7.1.3 Toxicity Assessment

Table 2-2 provides carcinogenic risk information for COCs in shallow groundwater. Because cis-1,2-DCE, 4-methylphenol, naphthalene, and manganese are not classifiable as human carcinogens, there are no cancer toxicity data available.

Table 2-3 provides noncarcinogenic risk information for COCs in shallow groundwater. All of the COCs have toxicity data indicating their potential for adverse noncarcinogenic effects in humans. At this time inhalation reference concentrations are only available for benzene, vinyl chloride, naphthalene, and manganese.

2.7.1.4 Risk Characterization

For carcinogens, risks are generally expressed as the incremental probability of an individual developing cancer over a lifetime of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$Risk = CDI \times SF$$

Where: Risk = a probability (e.g., 2.0E-05) of an individual developing cancer (unitless)
CDI = chronic daily intake averaged over 70 years (mg/kg-day)
SF = slope factor, expressed as $(mg/kg\text{-}day)^{-1}$

These risks are probabilities that are usually expressed in scientific notation (e.g. 1.0E-06). An excess lifetime cancer risk of 1.0E-06 indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an “excess lifetime cancer risk” because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual developing cancer from all other causes has been estimated to be as high as one in three. The EPA’s generally acceptable risk range for site-related exposure is 1.0E-04 to 1.0E-06, or an excess lifetime cancer risk of 1 in 10,000 to 1 in 1,000,000.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ less than one indicates that a receptor’s dose of a single contaminant is less than the RfD and that toxic noncarcinogenic effects from that chemical are unlikely. The hazard index (HI) is generated by adding the HQs for all COCs that affect the same target organ (e.g., liver). An HI less than one indicates that, based on the sum of all HQs from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI greater than one indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

Where: CDI = chronic daily intake
RfD = reference dose

CDI and RfD are expressed in the same units (e.g., mg/kg-day) and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Carcinogenic Risks

The only unacceptable carcinogenic risks at the Site were for the future child resident and future adult resident as a result to exposure to contaminated groundwater. These are hypothetical exposure scenarios. Carcinogenic effects for all other evaluated receptors were within or less than the EPA acceptable risk range (1.0E-04 to 1.0E-06).

Table 2-4 provides risk estimates for the hypothetical future child resident for exposure to shallow groundwater. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of a child's exposure to shallow groundwater. The risk estimates are based on the toxicity of the COCs (benzene, vinyl chloride, and arsenic). There is no cancer toxicity information available for exposure to cis-1,2-DCE, 4-methylphenol, naphthalene, or manganese. The total risk from direct exposure to shallow groundwater at the FFTA for a future child resident is estimated to be 1.2E-04. The COC contributing most to this risk level is arsenic. This risk level indicates that, if no cleanup action is taken, an individual child resident would have an increased probability of about 1 in 10,000 of developing cancer as a result of site-related exposure to the COCs in shallow groundwater.

Table 2-5 provides risk estimates for the hypothetical future adult resident for exposure to shallow groundwater. These risk estimates are based on a reasonable maximum exposure and were developed by taking into account various conservative assumptions about the frequency and duration of an adult's exposure to shallow groundwater. The risk estimates are based on the toxicity of the COCs (benzene, vinyl chloride, and arsenic). There is no cancer toxicity information available for exposure to cis-1,2-DCE, 4-methylphenol, naphthalene, or manganese. The total risk from direct exposure to shallow groundwater at the FFTA for a future adult resident is estimated to be 1.6E-04. The COC contributing most to this risk level is arsenic. This risk level indicates that, if no cleanup action is taken, an individual adult resident would have an increased probability of about 2 in 10,000 of developing cancer as a result of site-related exposure to the COCs in shallow groundwater.

Noncarcinogenic Risks

The only unacceptable noncarcinogenic risks were for the future child resident and future adult resident. Noncarcinogenic risks for all other evaluated receptors have an HI less than one.

Table 2-6 provides the HQs for the hypothetical future child resident for exposure to shallow groundwater and the HI for all COCs. The estimated HI of 26 indicates the potential for adverse noncarcinogenic health effects from exposure. The COCs contributing most to the groundwater HI are cis-1,2-DCE, 4-methyphenol, arsenic, and manganese. Although each of these COCs affects different target organs, the contributing HQ for each of the COCs is greater than one.

Table 2-7 provides the HQs for the hypothetical future adult resident for exposure to shallow groundwater and the HI for all COCs. The estimated HI of 8.7 indicates the potential for adverse noncarcinogenic health effects from exposure. The COCs contributing most to the groundwater HI are naphthalene and manganese. Although each of these COCs affects different target organs, the contributing HQ for each of the COCs is greater than one.

Uncertainty Analysis

At the FFTA, arsenic is a major contributor to the carcinogenic risks for the groundwater pathway for the hypothetical future resident. Although the accepted basis for evaluating risk associated with exposure to arsenic is to assume it is a carcinogen, there is uncertainty whether carcinogenic effects are the primary health effects expected to be manifested upon exposure to arsenic. There is some scientific information to indicate that humans are capable of metabolizing arsenic to expedite its elimination from the body. On the other hand, arsenic has been associated with a variety of cancers in epidemiological studies. This conflicting information adds to uncertainty regarding carcinogenic risks associated with arsenic exposure.

2.7.2 Summary of Ecological Risk Assessment

The ecological risk assessment (ERA) was performed to characterize potential risks to ecological receptors from site-related contaminants. The primary focus of this summary of the results of the ERA is on exposure pathways and chemicals found to potentially pose threats to ecological receptors. Details may be found in the Supplemental RI Report (TtNUS, 2004). The ERA for the FFTA included the following steps of the eight-step ERA process:

- Step 1 - Preliminary Problem Formulation and Ecological Effects Evaluation
- Step 2 - Preliminary Exposure Assessment and Risk Calculation
- Step 3A - Refinement of COPCs
- Step 8 - Risk Management

The FFTA is a terrestrial habitat and the ERA evaluated the potential impacts from exposure to soil for plants, soil invertebrates, birds, mammals, and reptiles. In addition, the ERA evaluated the potential impacts for contaminant exposure for aquatic receptors from groundwater discharge to surface water. Overall, risks to plants and invertebrates from chemicals detected at the FFTA in surface soil were found to be low to negligible. Similarly, risks to terrestrial wildlife and aquatic receptors were found to be low and similar to background risks.

2.7.3 Risk Assessment Conclusions

The only unacceptable risks to human health are for hypothetical child and adult residents that use shallow groundwater as a source of potable water. There are no unacceptable risks to other human receptors under current land use and reasonably anticipate future land use. The main risk drivers for groundwater are cis-1,2-DCE, 4-methylphenol, naphthalene, arsenic, and manganese. In addition, the detected concentrations of benzene and vinyl chloride are greater than MCLs for drinking water.

There are no unacceptable risks to ecological receptors.

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants into the environment.

2.8 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) provide a general description of what the cleanup will accomplish. These goals typically serve as the design basis for many of the remedial alternatives that are discussed in the Section 2-9. The RAOs provide the basis for evaluating cleanup options for the Site and an understanding of how the risks identified in the previous section will be addressed by the response action.

Based on the recommendations in the Supplemental RI Report, the only medium of concern at the FFTA is shallow groundwater.

The RAOs for remedial action at the FFTA are summarized as follows:

- Prevent the exposure to and use of the FFTA-contaminated groundwater, which presents an unacceptable risk associated with the hypothetical future residential use of shallow groundwater.

- Restore FFTA-impacted groundwater to drinking water standards and attain cleanup levels established in the ROD.

RAOs were not developed for soil, surface water, or sediment. There are no unacceptable risks to human health from exposure to these media under residential land use scenarios, and there are no unacceptable risks to terrestrial or aquatic ecological receptors from exposure to these media.

2.9 DESCRIPTION OF ALTERNATIVES

Remedial alternatives evaluated for the FFTA are presented below. More detailed descriptions of the alternatives can be found in the FS Report (TtNUS, 2005).

2.9.1 Description of Remedy Components

This section provides a list of the major components of each alternative as they occur in the remediation process. This list includes treatment components and the materials they will address, institutional controls operation and maintenance (O&M) activities required to maintain the integrity of the remedy, and monitoring requirements. In addition, the Applicable or Relevant and Appropriate Requirements are listed and summarized in Table 2-12 of this ROD.

2.9.1.1 Alternative 1: No Action

There are no remedy components for the no-action alternative. This alternative is required under CERCLA to establish a basis for comparison with other alternatives. No remedial actions would be implemented, and the shallow groundwater would be available for unrestricted use because no institutional controls would be implemented. Because hazardous substances, pollutants or contaminants would remain at the Site, policy reviews would be conducted every 5 years.

2.9.1.2 Alternative 2: Natural Attenuation, Institutional Controls, and Monitoring

Alternative 2 consists of the following major components: natural attenuation, institutional controls, and monitoring.

Natural Attenuation

Natural attenuation would rely on naturally occurring processes within the Columbia aquifer to reduce the concentrations of benzene, chlorinated solvents, and semi-volatiles. These processes include a combination of breakdown by native microbes, dispersion, dilution, and the binding of contaminants onto the surface of particles in the aquifer. The arsenic and manganese contamination is most likely associated with a low dissolved oxygen, or reducing environment, created by the degradation of contaminants by microorganisms. The extent of arsenic and manganese contamination is not widespread and is found at the wells that exhibit the strongly reducing environment. When the natural attenuation processes to biodegrade the chlorinated solvent and semi-volatile contaminants have been completed, the conditions at the Site will return to an aerobic environment with higher levels of oxygen, that should cause the arsenic and manganese to transform to insoluble oxidized compounds which do not readily dissolve in the groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for drinking purposes until the cleanup goals are met. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan and deed notices, if the property is transferred, to notify subsequent owners that the groundwater is not potable until the cleanup goals are met. Land use control (LUC) plans would be prepared and would prohibit the installation of drinking water wells that would draw water from the Columbia aquifer. Regular site inspections would be performed to verify the implementation of the institutional controls until cleanup goals are met.

Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from within the contaminant plume to assess the performance of natural attenuation processes and downgradient of the leading edge of the contaminant plume to verify that COCs are not migrating. The FS assumed that monitoring would consist of collecting groundwater samples from 20 existing monitoring wells. Samples would be analyzed for VOCs (benzene, cis-1,2-DCE, tetrachloroethene, and vinyl chloride), SVOCs (4-methylphenol, naphthalene, and pentachlorophenol), and total and dissolved arsenic and manganese. It was also assumed that samples would be analyzed for natural attenuation indicator parameters such as oxidation reduction potential (ORP), dissolved oxygen, pH, alkalinity, temperature, conductivity, total organic carbon (TOC), ferrous and total iron, sulfur compounds (sulfates, hydrogen sulfide, and sulfides), orthophosphates, chloride, metabolic gases produced by microbial transformation of contaminants such as methane, ethane, and ethene, and carbon dioxide. A long-term monitoring plan would need to be developed with EPA and DEQ concurrence.

Reviews would be performed every 5 years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary. The need for Five-Year reviews would be terminated after the cleanup goals were attained.

2.9.1.3 Alternative 3: In-Situ Biological Treatment (Biostimulation), Institutional Controls, and Monitoring

Alternative 3 consists of the following major components: in-situ biological treatment (biostimulation), institutional controls, and monitoring.

In-Situ Biological Treatment (Biostimulation)

In-situ biostimulation treatment would consist of using an oxygen release compound (ORC) to encourage the growth of native microorganisms to increase the rate of biodegradation and create favorable conditions to break down the chlorinated solvent and semi-volatile contaminants into nontoxic forms. An ORC is a mixture which contains magnesium peroxide which reacts with the groundwater to produce an insoluble magnesium solid and releases oxygen over the course of several months. For purposes of the FS, it was assumed that the groundwater plume that contains mostly benzene, cis-1,2-DCE, 4-methylphenol, and naphthalene would be treated with ORC. The treatment would consist of two ORC treatment zones. Each treatment zone would consist of 10 ORC injection points with a spacing of 15 feet. The injection points would be 20 feet deep temporary injection wells. The temporary injection wells would be installed across the portion of the Site containing chlorinated solvents and semi-volatile contaminants. The locations would be finalized after the completion of a treatability study. It was assumed that no repeat applications of ORC would be required.

The arsenic and manganese contamination is most likely associated with the reduced environment created by the natural degradation of the organic COCs. The extent of arsenic and manganese contamination is not widespread and is found at the wells that exhibit the highly reducing, low oxygen, environment. In-situ aerobic treatment would change the groundwater into an oxygen-rich environment that should cause the arsenic and manganese to transform from soluble compounds to insoluble oxidized compounds that do not readily mix with groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for drinking purposes until the cleanup goals are met. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan and deed notices, if the property is transferred, to notify subsequent owners that the groundwater is not potable until the cleanup goals are met. LUC plans would be prepared and would prohibit the installation of drinking water wells that would draw water from the Columbia aquifer. Regular site inspections would be performed to verify the implementation of the institutional controls until cleanup goals are met.

2.9.1.3 Alternative 3: In-Situ Biological Treatment (Biostimulation), Institutional Controls, and Monitoring

Alternative 3 consists of the following major components: in-situ biological treatment (biostimulation), institutional controls, and monitoring.

In-Situ Biological Treatment (Biostimulation)

In-situ biostimulation treatment would consist of using an oxygen release compound (ORC) to encourage the growth of native microorganisms to increase the rate of biodegradation and create favorable conditions to break down the chlorinated solvent and semi-volatile contaminants into nontoxic forms. An ORC is a mixture which contains magnesium peroxide which reacts with the groundwater to produce an insoluble magnesium solid and releases oxygen over the course of several months. For purposes of the FS, it was assumed that the groundwater plume that contains mostly benzene, cis-1,2-DCE, 4-methylphenol, and naphthalene would be treated with ORC. The treatment would consist of two ORC treatment zones. Each treatment zone would consist of 10 ORC injection points with a spacing of 15 feet. The injection points would be 20 feet deep temporary injection wells. The temporary injection wells would be installed across the portion of the Site containing chlorinated solvents and semi-volatile contaminants. The locations would be formalized after the completion of a treatability study. It was assumed that no repeat applications of ORC would be required.

The arsenic and manganese contamination is most likely associated with the reduced environment created by the natural degradation of the organic COCs. The extent of arsenic and manganese contamination is not widespread and is found at the wells that exhibit the highly reducing, low oxygen, environment. In-situ aerobic treatment would change the groundwater into an oxygen-rich environment that should cause the arsenic and manganese to transform from soluble compounds to insoluble oxidized compounds that do not readily mix with groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for drinking purposes until the cleanup goals are met. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan and deed notices, if the property is transferred, to notify subsequent owners that the groundwater is not potable until the cleanup goals are met. LUC plans would be prepared and would prohibit the installation of drinking water wells that would draw water from the Columbia aquifer. Regular site inspections would be performed to verify the implementation of the institutional controls until cleanup goals are met.

Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from within the contaminant plume to assess the performance of treatment and downgradient of the leading edge of the contaminant plume to verify that COCs are not migrating. The FS assumed that monitoring would consist of collecting groundwater samples from 20 existing monitoring wells. Samples would be analyzed for VOCs (benzene, cis-1,2-DCE, tetrachloroethene, and vinyl chloride), SVOCs (4-methylphenol, naphthalene, and pentachlorophenol), and total and dissolved arsenic and manganese. It was also assumed that samples would be analyzed for biodegradation indicator parameters such as ORP, dissolved oxygen, pH, alkalinity, temperature, conductivity, TOC, ferrous and total iron, sulfur compounds (sulfates, hydrogen sulfide, and sulfides), orthophosphates, chloride, metabolic gases produced by microbial transformation of contaminants such as methane, ethane, and ethene, and carbon dioxide. A long-term monitoring plan would need to be developed with EPA and DEQ concurrence.

At the end of 5 years, a review would be conducted to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

2.9.1.4 Alternative 4: In-Situ Biological Treatment (Bioaugmentation), Institutional Controls, and Monitoring

Alternative 4 consists of the following major components: in-situ biological treatment (bioaugmentation), institutional controls, and monitoring.

In-Situ Biological Treatment (Bioaugmentation)

In-situ bioaugmentation would consist of injecting a solution of aerobic microbes and food sources to augment natural biodegradation processes to break down the chlorinated solvent and semi-volatile contaminants into nontoxic forms. For purposes of the FS, it was assumed that the groundwater plume that contains mostly benzene, cis-1,2-DCE, 4-methylphenol, and naphthalene would be treated. Treatment would consist of 80 injection points with a spacing of 15 feet. The injection points would be 20 feet deep and would be placed in a grid across the portion of the Site containing the chlorinated solvent and semi-volatile contaminants. The final location and spacing of the injection points would be determined based on the results of a treatability test. It was assumed that no repeat applications would be required.

The arsenic and manganese contamination is most likely associated with the reduced environment created by the natural degradation of the organic COCs. The extent of arsenic and manganese contamination is not widespread and is found at the wells that exhibit the highly reducing, low oxygen, environment. When the in-situ bioaugmentation processes to degrade the VOCs and SVOCs have been completed, conditions at the Site will return to an aerobic environment that should cause the arsenic and manganese to transform from soluble compounds to insoluble oxidized compounds that do not readily mix with groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for drinking purposes until the cleanup goals are met. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan and deed notices, if the property is transferred, to notify subsequent owners that the groundwater is not potable until the cleanup goals are met. LUC plans would be prepared and would prohibit the installation of drinking water wells that would draw water from the Columbia aquifer. Regular site inspections would be performed to verify the implementation of the institutional controls until cleanup goals are met.

Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from within the contaminant plume to assess the performance of treatment and downgradient of the leading edge of the contaminant plume to verify that COCs are not migrating. The FS assumed that monitoring would consist of collecting groundwater samples from 20 existing monitoring wells. Samples would be analyzed for VOCs (benzene, cis-1,2-DCE, tetrachloroethene, and vinyl chloride), SVOCs (4-methylphenol, naphthalene, and pentachlorophenol), and total and dissolved arsenic and manganese. It was also assumed that samples would be analyzed for biodegradation indicator parameters such as ORP, dissolved oxygen, pH, alkalinity, temperature, conductivity, TOC, ferrous and total iron, sulfur compounds (sulfates, hydrogen sulfide, and sulfides), orthophosphates, chloride, metabolic gases produced by microbial transformation of contaminants such as methane, ethane, and ethene, and carbon dioxide. A long-term monitoring plan would need to be developed with EPA and DEQ concurrence.

At the end of 5 years, a review would be conducted to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

2.9.1.5 Alternative 5: In-Situ Air Sparging Treatment, Institutional Controls, and Monitoring

Alternative 5 includes the following major components: in-situ air sparging (AS) treatment, institutional controls, and monitoring.

Air Sparging Treatment

Air sparging (AS) involves pumping air into air injection wells which causes the volatile contaminants to be transformed into vapors which evaporate from the groundwater. The vapors then move through the soil and discharge to the air where they are destroyed through exposure to sunlight or are dispersed. In addition a portion of the contaminants are degraded in the groundwater and soil through the same microbial process discussed under Alternative 2.

This alternative would consist of installing an AS system, which would consist of one or more AS blower systems, each connected to an array of AS wells screened to a specific depth. The following two options were evaluated: Alternative 5A would treat the entire contaminant plume and Alternative 5B would treat only the former source area. For the entire contaminant plume, the FS assumed that the AS system would consist of two blowers, each providing 450 cubic feet per minute (cfm) of air, and 75 wells spaced across the Site approximately 15 feet apart and screened from 15 to 20 feet below the water table (35 to 40 feet bgs). For the former source area, the AS system would consist of one 200 cfm blower and 16 wells installed at the same spacing and screened interval but installed only in the former source area.

The arsenic and manganese contamination is most likely associated with the reduced environment created by the natural degradation of the organic COCs. The extent of the arsenic and manganese contamination is not widespread and is found in the wells that exhibit the highly reducing, low oxygen, environment. AS treatment would change the groundwater to an aerobic environment with higher dissolved oxygen that should cause the arsenic and manganese to transform from soluble compounds to insoluble oxidized compounds that do not readily mix with groundwater.

Institutional Controls

Institutional controls would consist of prohibiting use of groundwater from the Columbia aquifer for drinking purposes until the cleanup goals are met. Use of groundwater would be controlled through restrictions documented in the Facility Master Plan and deed notices, if the property is transferred, to notify subsequent owners that the groundwater is not potable until the cleanup goals are met. LUC plans would be prepared and would prohibit the installation of drinking water wells that would draw water from the Columbia aquifer. Regular site inspections would be performed to verify the implementation of the institutional controls until cleanup goals are met.

Monitoring

Monitoring would consist of regularly collecting and analyzing groundwater samples from within the contaminant plume to assess the performance of treatment and downgradient of the leading edge of the contaminant plume to verify that COCs are not migrating. The FS assumed that monitoring would consist of collecting groundwater samples from 20 existing monitoring wells. Samples would be analyzed for VOCs (benzene, cis-1,2-DCE, tetrachloroethene, and vinyl chloride), SVOCs (4-methylphenol, naphthalene, and pentachlorophenol), and total and dissolved arsenic and manganese. A long-term monitoring plan would need to be developed with EPA and DEQ concurrence.

At the end of 5 years, a review would be conducted to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

2.9.2 Common Elements and Distinguishing Features of Each Alternative

No response actions would be implemented under Alternative 1, the no-action alternative.

Alternative 2 includes natural attenuation to reduce COC concentrations in shallow groundwater. Alternatives 3, 4, and 5 include various forms of in-situ treatment to reduce COC concentrations in shallow groundwater. Alternative 3 includes in-situ biostimulation, and Alternative 4 includes in-situ bioaugmentation. Alternative 5 includes in-situ AS; however, Alternative 5A includes treatment of the entire contaminant plume, and Alternative 5B includes treatment of the contaminant plume only in the former source area.

Institutional controls are a component of Alternatives 2, 3, 4, and 5. Use of groundwater from the Columbia aquifer as a source of drinking water would not be permitted until cleanup goals are met.

Alternatives 2, 3, 4, and 5 include collection of shallow groundwater samples on a regular basis with analysis for VOCs (benzene, cis-1,2DCE, tetrachloroethene, and vinyl chloride) and SVOCs (4-methylphenol, naphthalene, and pentachlorophenol). Alternatives 2, 3, and 4 include analysis for natural attenuation and biodegradation indicator parameters.

Five-year reviews would be required for Alternatives 1, 2, 3, 4, and 5 until cleanup goals are attained. Such reviews are required because these alternatives would result in hazardous substances, pollutants, or contaminants remaining in shallow groundwater above levels that allow for unlimited use and unrestricted exposure.

Alternative 2 includes no time to implement a treatment system and 5 to 10 years to attain all RAOs. Alternatives 3 and 4 would take 2 months to implement and less than 5 years to attain all RAOs. Alternatives 5A and 5B would take 2 and 3 months to implement, respectively, and less than 4 years to attain all RAOs. However, it was assumed that monitoring would be conducted for 10 years for all these alternatives.

The present-worth cost of Alternatives 1, 2, 3, 4, 5A, and 5B is based on 10 years of annual costs and a 3.5 percent annual discount factor. The estimated present-worth costs are as follows:

- Alternative 1: $23,500
- Alternative 2: $591,000
- Alternative 3: $718,000
- Alternative 4: $1,036,000
- Alternative 5A: $1,114,000
- Alternative 5B: $810,000

2.9.3 Expected Outcome of Each Alternative

Under Alternative 1 (no action), no institutional controls would be implemented. This could result in unacceptable risks to human health and the environment from exposure to contaminated groundwater.

Under Alternatives 2, 3, 4, and 5, the use of groundwater from the Columbia aquifer as a source of drinking water would not be permitted until cleanup goals are achieved.

2.10 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The objective of the comparative analysis of alternatives is to evaluate the relative performance of the alternatives with respect to the nine evaluation criteria established in the NCP so that the advantages and disadvantages of each are clearly understood. The first two evaluation criteria, Overall Protection of Human Health and the Environment and Compliance with Applicable or Relevant and Appropriate Requirements (ARARs), are threshold criteria that must be satisfied by a remedial alternative chosen for a site. Table 2-8 contains a summary of the comparative analysis of alternatives.

2.10.1 Overall Protection of Human Health and the Environment

All the alternatives, except the no-action alternative, protect human health and the environment by eliminating, reducing, or controlling risks posed by the Site through removal of contaminants and institutional controls. Therefore, Alternative 1 (no action) will not be considered further in this analysis because it does not satisfy this threshold criterion.

Alternative 2 would be protective of human health and the environment because natural attenuation would reduce COC concentrations to cleanup goals over time. Institutional controls and monitoring would provide immediate protection until the cleanup goals are met by restricting use of groundwater from the Columbia aquifer as a source of drinking water and monitoring potential contaminant migration.

Alternatives 3, 4, and 5 would be more protective than Alternative 2 because, in addition to the same institutional control and monitoring components, these alternatives would also include an active treatment component to remove groundwater COCs. Alternative 5 would be more protective than Alternatives 2, 3, and 4 because it would achieve complete protection in a shorter time.

2.10.2 Compliance with ARARs

As listed and summarized in Table 2-12 of this ROD, Alternatives 2, 3, 4, and 5 have common chemical-specific ARARs associated with cleanup goals for shallow groundwater. These include MCLs for benzene, cis-1,2-DCE, vinyl chloride, and arsenic and site-specific risk-based cleanup goals for 4-methylphenol, naphthalene, and manganese. These alternatives would eventually attain compliance as they attain cleanup goals through natural attenuation (Alternative 2) or active treatment (Alternatives 3, 4, and 5). The first to achieve compliance would be Alternative 5, followed by Alternatives 3 and 4, and followed by Alternative 2.

Alternatives 2, 3, 4, and 5 would also comply with location- and action-specific ARARs.

2.10.3 Long-Term Effectiveness and Permanence

Alternatives 2, 3, 4, and 5 would provide long-term effectiveness and permanence.

Given that source control activities have been implemented, the natural attenuation component of Alternative 2 would effectively and permanently reduce concentrations of groundwater COCs to cleanup goals. The institutional controls component of Alternative 2 would effectively prevent use of the Columbia aquifer as a drinking water source until the cleanup goals have been achieved. The long-term monitoring component of Alternative 2 would provide an effective means of evaluating the progress of remediation and verifying that no migration of COCs is occurring.

Alternatives 3, 4, and 5 would be more effective than Alternative 2 because, in addition to the same institutional controls and monitoring components, these alternatives would also include an active treatment component that would accelerate the removal of COCs. Alternative 5 would be most effective because it would attain the cleanup goals in the least amount of time and would use a well-proven treatment technology. Alternatives 3 and 4 would be slightly less effective than Alternative 5 because the in-situ biological treatment technologies would require treatability testing to confirm long-term effectiveness. Alternatives 3 and 4 would also be slightly less effective than Alternative 5 because they would take somewhat more time to attain the cleanup goals.

Reviews would be conducted at least every 5 years, as required, to evaluate the effectiveness of Alternatives 1, 2, 3, 4, and 5 as long as hazardous substances remain in shallow groundwater at concentrations greater than health based levels that allow for unlimited use and unrestricted exposure.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 and 4 include in-situ biological treatment and Alternative 5 includes in-situ AS treatment to reduce the toxicity of hazardous substances in shallow groundwater. Alternative 2 does not include active treatment to reduce the toxicity, mobility, or volume of hazardous substances in shallow groundwater.

2.10.5 Short-Term Effectiveness

Implementation of Alternatives 2, 3, 4, and 5 would not adversely affect the surrounding community or the environment. There may be minor short-term risks to remediation workers exposed to contaminated groundwater. These risks would be effectively controlled by wearing the appropriate personal protective equipment and compliance with proper site-specific health and safety procedures.

Alternatives 2, 3, 4, and 5 would achieve the first RAO immediately upon implementation of institutional controls. The estimated time to achieve cleanup goals is up to 10 years for Alternative 2, 5 to 10 years for Alternatives 3 and 4, and 4 to 10 years for Alternative 5.

2.10.6 Implementability

Technical implementation of the various components of Alternative 2 would be relatively simple. The resources, equipment, and materials required for the activities associated with these components are readily available.

Technical implementation of Alternatives 3, 4, and 5 would be somewhat more difficult than for Alternative 2 because these three alternatives would require installation and Operations and Maintenance (O&M) of a groundwater treatment system. Of these three alternatives, Alternatives 3 and 4 would be easiest to implement because they would only require installation of small-diameter injection points and feeding of chemicals without installation of permanent equipment. Alternative 5 would be more difficult to implement than Alternatives 3 and 4 because it would require construction of an AS system with numerous sparging wells, interconnecting piping, and one or more blower systems. However, the resources, equipment, and materials necessary to implement these three alternatives are readily available.

Administrative implementation of the institutional controls component of Alternative 2 would be relatively simple because LUCs or a Facility Master Plan, including land and groundwater use restrictions, would be formulated and implemented to prevent the use of groundwater from the shallow Columbia aquifer at the FFTA. Deed notices, if the property is transferred, would be prepared and included in property transfer documents. Administrative implementation of the monitoring component of Alternative 2 would also be relatively simple and would not require permits.

The administrative implementation of Alternatives 3, 4, and 5 would be slightly more difficult than for Alternative 2. In addition to the same requirements as Alternative 2, Alternatives 3 and 4 may require a construction permit for installation of injection points. Alternative 5 may require a construction permit and an erosion and sediment control plan for installation of the AS system. These permits should be relatively easy to obtain.

2.10.7 <u>Cost</u>

The estimated present-worth costs for Alternatives 1, 2, 3, 4, and 5 range from $23,500 for Alternative 1 to $1,114,000 for Alternative 5A (treatment of entire plume). Capital, annual O&M, and present-worth costs are provided in Table 2-8. Present-worth costs are listed below:

- Alternative 1: $23,500
- Alternative 2: $591,000
- Alternative 3: $718,000
- Alternative 4: $1,036,000
- Alternative 5A: $1,114,000 (entire plume)
- Alternative 5B: $810,000 (source area)

2.10.8 <u>State Acceptance</u>

The Commonwealth of Virginia has expressed their support of Alternatives 2, 3, 4, and 5 and agrees with the Selected Remedy.

2.10.9 <u>Community Acceptance</u>

Because no comments were expressed at the public meeting, and no written comments were received during the public comment period, it appears that the community generally agrees with the Selected Remedy. Specific details regarding the public comment period can be found in the Responsiveness Summary section of this ROD.

2.11 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that treatment will be used to address the principal threats posed by a site wherever practicable [40 Code of Federal Regulations (CFR) 300.430(a)(1)(iii)(A)]. Based on the results of the investigations, studies, and sampling conducted, the contaminated groundwater at the FFTA does not constitute a principal threat waste as defined by the NCP. Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. Contaminated groundwater is generally not considered to be a source material.

2.12 SELECTED REMEDY

2.12.1 <u>Summary of Rationale for the Selected Remedy</u>

The Selected Remedy for the FFTA is Alternative 3: In-Situ Biological Treatment (Biostimulation), Institutional Controls, and Monitoring. This alternative meets the RAOs, provides adequate protection of human health and the environment, attains ARARs, and provides the best balance of tradeoffs with respect to the balancing and modifying criteria. Alternative 3 includes active treatment as a principal element and is expected to attain all RAOs in less time than Alternative 2. Although Alternatives 4 and 5 also include treatment, Alternative 3 is equally as effective as these alternatives at a lower cost. Although Alternative 5 would require somewhat less time to attain all RAOs, it would be more difficult to implement and operate than Alternative 3.

2.12.2 <u>Description of Selected Remedy</u>

2.12.2.1 In-Situ Biological Treatment (Biostimulation)

An ORC will be injected into the Columbia aquifer to create an aerobic treatment zone suitable for biodegradation of the organic COCs. The conceptual design in the FS assumed that the ORC will be injected in rows of delivery points to form two treatment zones across the width of the contaminant plume. Each treatment zone will contain 10 injection points with a spacing of 15 feet. The ORC will be injected at a rate of 45 pounds per injection point in the 5- to 20-feet bgs interval (total of 900 pounds). The conceptual design assumed that only one injection event will be needed.

The arsenic and manganese contamination is most likely associated with the reduced environment created by the natural degradation of some of the organic COCs. In-situ biological treatment will change the groundwater to an aerobic environment that is expected to cause the arsenic and manganese to transform from soluble compounds to insoluble oxidized compounds.

2.12.2.2 Institutional Controls

Use of groundwater and commercial or residential development of the Site would be controlled through restrictions documented in the Facility Master Plan and deed notices, if the property is transferred. The institutional controls for the FFTA will meet the following objectives:

- No use of shallow groundwater (Columbia aquifer) as a source of drinking water.

- All other uses of groundwater will require NASA approval. The acceptability of such use will be evaluated based on the chemical concentrations present in the groundwater at the time of such use.

- Prohibit the development of commercial or residential buildings at the Site.

- Maintain the integrity of any current or future remediation and monitoring systems.

The institutional controls will be maintained until the concentrations of hazardous substances in shallow groundwater are reduced to allow for unlimited use and unrestricted exposure.

A LUC Plan will be prepared as the land use component of the Remedial Design. Within 90 days of ROD signature, NASA will be required to prepare and submit to EPA for approval a LUC Plan that shall contain implementation and maintenance actions, including periodic inspections. NASA will implement, maintain, monitor, report on, and enforce the institutional controls in accordance with the LUC Plan. If some or all of the Site property is transferred, NASA will notify the EPA ninety days (90) prior to transfer, or within 7 days of the decision to transfer the property if 90 days notice is not possible. Deed notices notifying subsequent owners that groundwater is not potable and development on the Site is restricted until the cleanup goals are met will be prepared and recorded prior to transfer.

2.12.2.3 Monitoring

Monitoring will involve shallow groundwater sampling as described in Section 2.9.1.3. A monitoring plan will be developed with EPA and DEQ concurrence to detail the frequency, analysis, and locations of the monitoring samples and the exit criteria for cessation of monitoring.

At the end of 5 years, a review will be conducted to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is necessary.

2.12.3 Summary of Estimated Remedy Costs

Cost estimate summaries for the Selected Remedy are provided in Table 2-9 (capital cost), Table 2-10, (annual costs), and Table 2-11 (present-worth analysis). The information in these cost estimate summary tables is based on the best available information regarding the anticipated scope of the remedial alternative. The estimated present-worth cost is $718,000. Changes in the cost elements may occur because of new information or data collected during the engineering design of the remedial alternative. Major changes may be documented in the form of a memorandum in the Administrative Record file, and Explanation of Significant Differences (ESD), or a ROD amendment depending on the scope of the change. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost. These estimates are refined as the remedy is designed and implemented. Even after the remedial action is constructed, the total project cost is still reported as an estimate because of the uncertainty associated with annual O&M expenditures.

2.12.4 Expected Outcomes of the Selected Remedy

After the Selected Remedy has been implemented, the use of shallow groundwater (Columbia aquifer) as a source of drinking water at the FFTA will be prohibited until the cleanup levels are attained. The groundwater can possibly be used for non-drinking purposes depending on contaminant concentrations at the time of the proposed use. The shallow groundwater will be available for unlimited use and unrestricted exposure after the cleanup levels are attained enhancing the value of the FFTA Site should it be developed in the future. The estimated time to achieve the cleanup levels is 5 to 10 years.

2.12.5 Performance Standards

The cleanup levels for the COCs and the basis for each are as follows:

- Benzene - 5 µg/L (MCL)
- cis-1,2-Dichloroethene - 70 µg/L (MCL)
- Vinyl chloride - 2 µg/L (MCL)
- 4-Methylphenol - 27 µg/L (noncancer risk based on target organ HI of 0.5)
- Naphthalene - 16 µg/L (noncancer risk based on target organ HI of 0.5)
- Arsenic - 10 µg/L (MCL)
- Manganese - 124 µg/L (noncancer risk based on target organ HI of 0.5)

NASA will prepare a series of Treatability Testing, Remedial Design, Remedial Action and Remedial Action Monitoring Work Plans and Reports for EPA and DEQ review and EPA approval. These documents will detail the requirements of the remedial action including the specific wells and parameters that will be monitored during the implementation of the Selected Remedy. At a minimum the Remedial Action Monitoring Plan will include the sampling of wells located within and immediately upgradient and downgradient of the contaminant plume. Monitoring wells FTA-MW-54S, FTA-MW-101S, FTA-MW-55S and 55D, FTA-MW-58S, FTA-MW-61I, FTA-MW-102D, FTA-MW-56D, FTA-MW-57S, FTA-MW-105D, FTA-MW-103S, 103I and 103D, and MW-14GW-04 will be included in the monitoring plan unless substitution and/or elimination is approved by EPA. Groundwater samples will be analyzed for the Site COCs benzene, cis-1,2-Dichloroethene, vinyl chloride, 4-methylphenol, naphthalene, arsenic, and manganese. In addition, the monitoring program will include analysis of groundwater samples for pentachlorophenol and tetrachloroethene to confirm that the presence and/or concentrations of these compounds does not significantly contribute to Site risks. Groundwater samples will also be analyzed for indicator compounds necessary to monitor the performance and effectiveness of the remedial action. The monitoring frequency will include, at a minimum, the collection and analysis of quarterly samples for the first year after completion of injection activities, semi-annual samples for the second and third year after completion of injection activities, and annual samples thereafter. Monitoring will continue until 4 consecutive monitoring events confirm that the cleanup goals have been attained in Site monitoring wells included in the Remedial Action Monitoring Plan. The monitoring frequency and program may be modified, with EPA concurrence, after initial sample results reach the cleanup goals or during the remedial action monitoring phase.

2.13 STATUTORY DETERMINATIONS

Under CERCLA Section 121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the toxicity, mobility, or volume of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

2.13.1 Protection of Human Health and the Environment

The Selected Remedy, Alternative 3, will protect human health and the environment using a combination of in-situ biological treatment to reduce COC concentrations in shallow groundwater and institutional controls to prohibit use of contaminated shallow groundwater as a source of drinking water until the cleanup levels have been attained. Exposure levels for each COC will be reduced to attain MCLs or a target organ HI less than 0.5 for each noncarcinogen for which an MCL is not available.

There are no short-term threats associated with the Selected Remedy that cannot be readily controlled. In addition, no cross-media impacts are expected from the Selected Remedy. Monitoring will be conducted to ensure that shallow groundwater contaminants are not migrating off site at unacceptable concentrations.

2.13.2 Compliance with ARARs

The Selected Remedy will meet all identified ARARs and to be considered (TBC) criteria. Federal and state ARARs and TBC criteria for the Selected Remedy are identified and summarized by classification in Tables 2-12, and 2-13.

2.13.3 Cost Effectiveness

In NASA's and EPA's judgment, the Selected Remedy is cost effective. In making this determination, the following definition was used [40 CFR 300.430(f)(1)(ii)(D)]: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and complied with ARARs). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence;

reduction in toxicity, mobility, or volume through treatment; and short-term effectiveness). The overall effectiveness of all the alternatives was considered and then compared to each of their costs.

The estimated present-worth cost of the Selected Remedy (Alternative 3) is $718,000. Although Alternative 2 is approximately $127,000 less expensive, it does not include treatment and is expected to take twice as long to attain the cleanup levels. The present-worth cost of Alternative 5B is approximately 10 percent higher than for Alternative 4; however, Alternative 5B would only treat the source area groundwater while Alternative 4 would treat the entire contaminant plume. The estimated present-worth costs for Alternatives 4 and 5A are approximately 44 and 55 percent higher than for Alternative 3 but are considered equally effective at attaining the cleanup levels. Alternative 5A may take a shorter time to attain the cleanup levels but at a greater cost. The increased cost to achieve cleanup levels more quickly is not justified given the anticipated future use of this Site.

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

NASA and EPA, with DEQ concurrence, have determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the Site. Of those alternatives that are protective of human health and the environment and comply with ARARs, NASA and EPA have determined that the Selected Remedy provides the best balance of trade-offs in terms of the five balancing criteria. NASA and EPA also considered the statutory preference for treatment as a principal element and state and community acceptance.

The Selected Remedy uses in-situ biological treatment to remove organic COCs from the entire contaminant plume. Although biological treatment does not specifically target removal of inorganic COCs (arsenic and manganese), the addition of oxygen is expected to transform these soluble COCs into insoluble oxidized compounds. The Selected Remedy does not present short-term risks different than the other treatment alternatives. There are no special implementability issues that set the Selected Remedy apart from any of the other alternatives evaluated.

2.13.5 Preference for Treatment as a Principal Element

The Selected Remedy includes in-situ biological treatment of the entire contaminant plume where COC concentrations are greater than cleanup levels. By utilizing treatment as a significant portion of the remedy, the statutory preference for remedies that employ treatment as a principal element is satisfied.

2.13.6 <u>Five-Year Review Requirement</u>

While the Selected Remedy will not result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, it may take more than 5 years to attain RAOs and cleanup levels. Therefore, a policy review will be conducted within 5 years of construction completion for the Site to ensure that the remedy is, or will be, protective of human health and the environment.

2.14 DOCUMENTATION OF SIGNIFICANT CHANGES

The PRAP for the FFTA at NASA WFF, Wallops Island, Virginia was released for public comments February 14, 2007. The PRAP identified Alternative 3, In-Situ Biological Treatment (Biostimulation), Institutional Controls, and Monitoring, as the preferred alternative. No written or verbal comments were submitted during the public comment period. It was determined that no significant changes to the remedy, as originally identified in the PRAP, were necessary or appropriate based on public comments.

3.0 RESPONSIVENESS SUMMARY

In accordance with Sections 113 and 117 of CERCLA, NASA provided a public comment period from February 14, 2007 to March 15, 2007 for the proposed remedial action described in the PRAP for the FFTA. Public input is a key element in the decision-making process.

The PRAP is available to the public in the Administrative Record. The Supplemental RI and FS Reports are also available in the Administrative Record. The Information Repositories for the Administrative Record are maintained by the Eastern Shore Public Library (23610 Front Street, Accomack, Virginia 23301) and the Island Library (4077 Main Street, Chincoteague, Virginia 23336). The PRAP was made available on February 14, 2007.

A public meeting to present the PRAP for the FFTA was held at the NASA WFF Visitor Center on March 1, 2007. Public notice of the meeting and availability of documents was placed in the Chincoteague Beacon and Eastern Shore News on February 8 and 14, 2007, respectively.

No comments were received by NASA, EPA, or DEQ during the public comment period. Representatives of NASA, EPA, and DEQ were available at the public meeting to present the PRAP for the FFTA and to answer questions on the proposed remedy.

REFERENCES

Ebasco Services, Inc., 1990. Final Report of Site Investigations. Wallops Flight Facility. Wallops Island, Virginia.

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TtNUS, 2005. Feasibility Study, Former Fire Training Facility, NASA Wallops Flight Facility, Wallops Island, Virginia. Prepared for National Aeronautics and Space Administration Goddard Space Flight Center Wallops Flight Facility, Wallops Island, Virginia under a contract issued by the Engineering Field Activity Northeast of the Naval Facilities Engineering Command. King of Prussia, Pennsylvania.

TABLES

TABLE 2-1

SUMMARY OF CHEMICALS OF CONCERN AND MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATIONS
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Exposure Point	Chemical of Concern	Concentration Detected (µg/L)	Frequency of Detection	Exposure Point Concentration (µg/L)	Statistical Measure
Groundwater – ingestion, dermal contact, inhalation	Benzene	1 – 28	6/21	12.6	97.5% UCL
	cis-1,2-DCE	1 – 460	10/21	321	99% UCL
	Vinyl chloride	2 – 6	2/21	2.03	95% UCL
	4-Methylphenol	88 – 300	2/19	124	97.5% UCL
	Naphthalene	21 – 66	4/20	32.8	97.5% UCL
	Arsenic	5.1 – 25.4	3/20	9.35	95% UCL
	Manganese	9 – 4,990	18/18	4,090	99% UCL

DCE: Dichloroethene.
UCL: Upper confidence limit.

This table presents the chemicals of concern (COCs) and exposure point concentrations (i.e., the concentration that will be used to estimate the exposure and risk) for each of the COCs detected in groundwater.

TABLE 2-2

CANCER TOXICITY DATA SUMMARY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Pathway: Ingestion, Dermal

Chemical of Concern	Oral Cancer Slope Factor	Dermal Cancer Slope Factor	Slope Factor Units	Weight of Evidence	Source	Date
Benzene	5.5E-02	5.5E-02	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03
cis-1,2-DCE	--	--	--	--	--	--
Vinyl chloride	7.2E-01	7.2E-01	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03
4-Methylphenol	--	--	--	--	--	--
Naphthalene	--	--	--	--	--	--
Arsenic	1.5E+00	1.5E+00	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03
Manganese	--	--	--	--	--	--

Pathway: Inhalation

Chemical of Concern	Unit Risk	Units	Inhalation Cancer Slope Factor	Units	Weight of Evidence	Source	Date
Benzene	7.7E-03	$(mg/m^3)^{-1}$	2.7E-02	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03
cis-1,2-DCE	--	--	--	--	--	--	--
Vinyl chloride	4.3E-03	$(mg/m^3)^{-1}$	1.5E-02	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03
4-Methylphenol	--	--	--	--	--	--	--
Naphthalene	--	--	--	--	--	--	--
Arsenic	4.3E+00	$(mg/m^3)^{-1}$	1.51E+01	$(mg/kg/day)^{-1}$	A	IRIS	7/24/03
Manganese	--	--	--	--	--	--	--

--: No information available.
DCE: Dichloroethene.
IRIS: Integrated Risk Information System.

<u>Weight of Evidence</u>
A: Human carcinogen.

TABLE 2-2

CANCER TOXICITY DATA SUMMARY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Cancer slope factors are not available for the dermal route of exposure; the dermal slope factors used in the assessment have been extrapolated from oral values. An adjustment factor is applied and is dependent on how well the chemical is absorbed via the oral route. Adjustments are particularly important for chemicals with less than 50 percent absorption via the ingestion route. However, no adjustments were necessary. Cis-1,2-DCE, 4-methylphenol, naphthalene, and manganese lack sufficient toxicity via the oral route to support the development of specific oral carcinogenic toxicity criteria.

Three of the COCs (benzene, vinyl chloride, and arsenic) are also considered carcinogenic via the inhalation route of exposure. Cis-1,2-DCE, 4-methylphenol, naphthalene, and manganese lack sufficient toxicity via the inhalation route to support the development of specific inhalation carcinogenic toxicity criteria.

TABLE 2-3

NONCANCER TOXICITY DATA SUMMARY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Pathway: Ingestion, Dermal

Chemical of Concern	Chronic/ Subchronic	Oral RfD	Dermal RfD	Units	Target Organ(s)	Uncertainty Factor	Source	Date
Benzene	Chronic	4.0E-03	4.0E-03	mg/kg-day	Blood, Immune	300	IRIS	7/24/03
cis-1,2-DCE	Chronic	1.0E-02	1.0E-02	mg/kg-day	Blood	3,000	HEAST	1997
Vinyl chloride	Chronic	3.0E-03	3.0E-03	mg/kg-day	Liver	30	IRIS	7/24/03
4-Methylphenol	Chronic	5.0E-03	5.0E-03	mg/kg-day	CNS, Respiratory	1,000	HEAST	1997
Naphthalene	Chronic	2.0E-02	2.0E-02	mg/kg-day	Decr. Wt. Gain	3,000	IRIS	7/24/03
Arsenic	Chronic	3.0E-04	3.0E-04	mg/kg-day	Skin, Vascular	3	IRIS	7/24/03
Manganese	Chronic	2.4E-02	9.6E-04	mg/kg-day	CNS	3	IRIS	7/24/03

Pathway: Inhalation

Chemical of Concern	Chronic/ Subchronic	Inhalation RfC	Units	Inhalation RfD	Units	Primary Target Organ	Uncertainty Factor	Source	Date
Benzene	Chronic	3.0E-02	mg/m^3	8.6E-03	mg/kg-day	Blood, Immune	1,000	IRIS	7/24/03
cis-1,2-DCE	--	--	--	--	--	--	--	--	--
Vinyl chloride	Chronic	9.8E-02	mg/m^3	2.8E-02	mg/kg-day	Liver	30	IRIS	7/24/03
4-Methylphenol	--	--	--	--	--	--	--	--	--
Naphthalene	Chronic	3.0E-03	mg/m^3	8.6E-04	mg/kg-day	Respiratory	3,000	IRIS	7/24/03
Arsenic	--	--	--	--	--	--	--	--	--
Manganese	Chronic	5.0E-05	mg/m^3	1.43E-05	mg/kg-day	CNS	1,000	IRIS	7/24/03

--: No information available.
CNS: Central nervous system.
DCE: Dichloroethene.
HEAST: Health Effects Assessment Summary Table.
IRIS: Integrated Risk Information System.
RfC: Reference concentration.
RfD: Reference dose.

TABLE 2-3

NONCANCER TOXICITY DATA SUMMARY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

The chronic toxicity data available for oral exposures have been used to develop oral RfDs. As was the case with carcinogenic data, dermal RfDs can be extrapolated from oral values by applying an adjustment factor as appropriate. However, an adjustment was only necessary for manganese. No adjustment was needed for the other COCs, and the oral values were used as the dermal RfDs for these contaminants. The uncertainty factor is used to account for uncertainty when deriving the RfD from experimental data.

TABLE 2-4

FUTURE CHILD RESIDENT RISK CHARACTERIZATION SUMMARY – CARCINOGENS
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Dermal	Inhalation	Exposure Route Total
Groundwater	Groundwater	Tap Water	Benzene	5.1E-06	6.1E-07	NA	5.7E-06
		Tap Water	Vinyl chloride	1.1E-05	4.6E-07	NA	1.1E-05
		Tap Water	Arsenic	1.0E-04	5.3E-07	NA	1.0E-04
						Groundwater risk total =	**1.2E-04**

NA: Route of exposure is not applicable to this medium.

TABLE 2-5

FUTURE ADULT RESIDENT RISK CHARACTERIZATION SUMMARY – CARCINOGENS
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Dermal	Inhalation	Exposure Route Total
Groundwater	Groundwater	Tap Water	Benzene	6.5E-06	3.3E-07	NA	6.8E-06
		Tap Water	Vinyl chloride	1.4E-05	2.2E-07	NA	1.4E-05
		Tap Water	Arsenic	1.3E-04	3.0E-07	NA	1.3E-04
	Air	Inhalation of Volatiles	Benzene	NA	NA	3.9E-06	3.9E-06
		Inhalation of Volatiles	Vinyl chloride	NA	NA	3.8E-07	3.8E-07
		Inhalation of Volatiles	Arsenic	NA	NA	NT	NT
						Groundwater risk total =	**1.6E-04**

NA: Route of exposure is not applicable to this medium.
NT: Toxicity criteria are not available to quantitatively address this route of exposure.

TABLE 2-6

FUTURE CHILD RISK CHARACTERIZATION SUMMARY – NONCARCINOGENS
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ				
					Ingestion	Dermal	Inhalation	Exposure Route Total
Groundwater	Groundwater	Tap Water	Benzene	Blood, Immune	2.7E-01	3.2E-02	NA	0.3
		Tap Water	cis-1,2-DCE	Blood	2.8E+00	1.9E-02	NA	3.0
		Tap Water	Vinyl chloride	Liver	5.8E-02	2.5E-03	NA	0.06
		Tap Water	4-Methylphenol	CNS, Respiratory	2.1E+00	1.5E-01	NA	2.3
		Tap Water	Naphthalene	Decr. Wt. Gain	1.4E-01	7.0E-02	NA	0.2
		Tap Water	Arsenic	Skin, Vascular	2.7E+00	1.4E-02	NA	2.7
		Tap Water	Manganese	CNS	1.5E+01	1.87E+00	NA	17
							Groundwater Hazard Index Total =	**26**
							Blood Hazard Index =	**3.3**
							CNS Hazard Index =	**19**
							Decreased Weight Gain Hazard Index =	**0.2**
							Immune System Hazard Index =	**0.3**
							Liver Hazard Index =	**0.06**
							Respiratory System Hazard Index =	**2.3**
							Skin Hazard Index =	**2.7**
							Vascular System Hazard Index =	**2.7**

CNS: Central nervous system.
DCE: Dichloroethene.
NA: Route of exposure is not applicable to this medium.

TABLE 2-7

FUTURE ADULT RISK CHARACTERIZATION SUMMARY – NONCARCINOGENS
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Primary Target Organ	Noncarcinogenic Hazard Quotient			
					Ingestion	Dermal	Inhalation	Exposure Route Total
Groundwater	Groundwater	Tap Water	Benzene	Blood, Immune	8.8E-02	4.4E-03	NA	0.09
		Tap Water	cis-1,2-DCE	Blood	8.8E-01	2.8E-02	NA	0.9
		Tap Water	Vinyl chloride	Liver	1.85E-02	3.0E-04	NA	0.02
		Tap Water	4-Methylphenol	CNS, Respiratory	6.8E-01	4.2E-02	NA	0.7
		Tap Water	Naphthalene	Decr. Wt. Gain	4.5E-02	1.2E-02	NA	0.06
		Tap Water	Arsenic	Skin, Vascular	8.5E-01	1.9E-03	NA	0.9
		Tap Water	Manganese	CNS	4.7E+00	2.6E-01	NA	5.0
	Air	Inhalation of Volatiles	Benzene	Blood, Immune	NA	NA	4.9E-02	0.05
		Inhalation of Volatiles	cis-1,2-DCE	Blood	NA	NA	NT	NT
		Inhalation of Volatiles	Vinyl chloride	Liver	NA	NA	2.8E-03	0.003
		Inhalation of Volatiles	4-Methylphenol	CNS, Respiratory	NA	NA	NT	NT
		Inhalation of Volatiles	Naphthalene	Decr. Wt. Gain	NA	NA	1.0E+00	1.0
		Inhalation of Volatiles	Arsenic	Skin, Vascular	NA	NA	NT	NT
		Inhalation of Volatiles	Manganese	CNS	NA	NA	NT	NT
Groundwater Hazard Index Total =								**8.7**
Blood Hazard Index =								**1.0**
CNS Hazard Index =								**5.7**
Decreased Weight Gain Hazard Index =								**1.1**
Immune System Hazard Index =								**0.14**
Liver Hazard Index =								**0.02**
Respiratory System Hazard Index =								**0.7**
Skin Hazard Index =								**0.9**
Vascular System Hazard Index =								**0.9**

TABLE 2-7

FUTURE ADULT RISK CHARACTERIZATION SUMMARY – NONCARCINOGENS
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA
PAGE 2 OF 2

CNS: Central nervous system.
DCE: Dichloroethene.
NA: Route of exposure is not applicable to this medium.
NT: Toxicity criteria are not available to quantitatively address this route of exposure.

TABLE 2-8

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Evaluation Criterion	Alternative 1 – No Action	Alternative 2 –Natural Attenuation, Institutional Controls and Monitoring	Alternative 3 – In-Situ Bioremediation (Biostimulation), Institutional Controls, and Monitoring
Threshold Criteria			
Overall Protection of Human Health and the Environment	No reduction in potential risks.	Groundwater use restrictions and monitoring would reduce risks to human health and the environment.	Groundwater treatment, use restrictions, and monitoring would reduce risks to human health and the environment.
Compliance with ARARs			
Chemical-specific	Would allow ingestion of groundwater exceeding MCLs and risk-based standards.	Groundwater would meet MCLs and risk-based standards in 5 to 10 years.	Groundwater would meet MCLs and risk-based standards in 5 years.
Location-specific	No measures would be taken to prevent the use of private wells at the Site.	Would prevent the use of private wells at the Site.	Would prevent the use of private wells at the Site.
Action-specific	Not applicable.	Not applicable.	Would comply with UIC program drinking water protection standard.
Primary Balancing Criteria			
Long-Term Effectiveness and Permanence	Allows uncontrolled risks to remain.	Natural attenuation would be expected to be effective. Groundwater use restrictions would reduce risks to human health. Monitoring and use restrictions would provide adequate and reliable controls.	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. Monitoring and use restrictions would provide adequate and reliable controls.
Reduction of Toxicity, Mobility, or Volume through Treatment	No treatment.	No treatment.	In-situ biostimulation would reduce toxicity of hazardous substances in groundwater.

TABLE 2-8

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Evaluation Criterion	Alternative 1 – No Action	Alternative 2 –Natural Attenuation, Institutional Controls and Monitoring	Alternative 3 – In-Situ Bioremediation (Biostimulation), Institutional Controls, and Monitoring
Short-Term Effectiveness	Not applicable.	No impacts to community or environment. Potential impacts to workers can be adequately controlled. Five to 10 years to attain clean-up levels.	No impacts to community or environment. Potential impacts to workers can be adequately controlled. One month to construct. Five years to attain clean-up levels.
Primary Balancing Criteria (continued)			
Implementability	Not applicable.	Groundwater use restrictions could be strictly enforced because site is located within a federal facility.	Alternative consists of common remediation practices that are readily available and implementable. Permits may be needed for installation of injection points and chemical injection.
Cost			
Capital	$0	$11,000	$133,000
Annual O&M	$15,000 every 5 years	$168,000 (Year 1), $85,000 (Years 2 and 3), $43,000 (Years 4 to 10) plus $15,000 every 5 years	$173,000 (Year 1), $85,000 (Years 2 and 3), $43,000 (Years 4 to 10) plus $15,000 every 5 years
Present worth	$23,500	$591,000	$718,000
Modifying Criteria			
State Acceptance	Not applicable.	Acceptable.	Acceptable.
Community Acceptance	Not applicable.	Acceptable.	Acceptable.

TABLE 2-8

SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Evaluation Criterion	Alternative 4 – In-Situ Bioremediation (Bioaugmentation), Institutional Controls, and Monitoring	Alternative 5 – In-Situ Air Sparging Treatment, Institutional Controls, and Monitoring
Threshold Criteria		
Overall Protection of Human Health and the Environment	Groundwater treatment, use restrictions, and monitoring would reduce risks to human health and the environment.	Groundwater treatment, use restrictions, and monitoring would reduce risks to human health and the environment.
Compliance with ARARs		
Chemical-specific	Groundwater would meet MCLs and risk-based standards in 5 years.	Groundwater would meet MCLs and risk-based standards in 5 years..
Location-specific	Would prevent the use of private wells at the Site.	Would prevent the use of private wells at the Site.
Action-specific	Would comply with UIC program drinking water protection standard.	Would comply with Federal and state air emission requirements.
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Treatment would be expected to be effective over the long term. Treatability studies needed to confirm effectiveness. Monitoring and use restrictions would provide adequate and reliable controls.	Treatment would be expected to be effective over the long term. Monitoring and use restrictions would provide adequate and reliable controls.
Reduction of Toxicity, Mobility, or Volume through Treatment	In-situ bioaugmentation would reduce toxicity of hazardous substances in groundwater.	In-situ air sparging would reduce toxicity of hazardous substances in groundwater.
Short-Term Effectiveness	No impacts to community or environment. Short-term impacts to workers can be adequately controlled. One month to construct. Five years to attain clean-up levels.	No impacts to community or environment. Short-term impacts workers can be adequately controlled. Two to 3 months to construct. Four years to attain clean-up levels
Implementability	Alternative consists of common remediation practices that are readily available and implementable. Permits may be needed for installation of injection points and chemical injection.	Alternative consists of common remediation practices that are readily available and implementable. Permits may be needed for installation of air sparging system.

TABLE 2-8

**SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA**

Evaluation Criterion	Alternative 4 – In-Situ Bioremediation (Bioaugmentation), Institutional Controls, and Monitoring	Alternative 5 – In-Situ Air Sparging Treatment, Institutional Controls, and Monitoring
Primary Balancing Criteria (continued)		
Cost		
Capital	$457,000	Entire plume: $543,000 Source area only: $327,000
Annual O&M	$168,000 (Year 1), $85,000 (Years 2 and 3), $43,000 (Years 4 to 10) plus $15,000 every 5 years	Entire plume: $208,000 (Year 1), $159,000 (Year 2), $50,000 (Year 3), $26,000 (Years 4 to 10) plus $15,000 every 5 years Source area only: $164,000 (Year 1), $50,000 (Years 2 and 3), $26,000 (Years 4 to 10) plus $15,000 every 5 years
Present worth	$1,036,000	Entire plume: $1,112,000 Source area only: $810,000
Modifying Criteria		
State Acceptance	Acceptable.	Acceptable.
Community Acceptance	Acceptable.	Acceptable.

ARARs Applicable or Relevant and Appropriate Requirements.
COCs Chemicals of concern.
O&M Operation and maintenance.

TABLE 2-9

CAPITAL COST ESTIMATE SUMMARY FOR THE SELECTED REMEDY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

	Item	Quantity	Unit	Unit Cost				Extended Cost				Subtotal
				Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	
1	**PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS**											
1.1	Prepare Documents & Plans including Permits	150	hr			$30.00		$0	$0	$4,500	$0	$4,500
1.2	Prepare Land Use Control (LUC	250	hr			$30.00		$0	$0	$7,500	$0	$7,500
2	**MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT**											
2.1	Office Trailer	1	mo				$286.00	$0	$0	$0	$286	$286
2.2	Office Trailer Mob/Demo	1	ea				$225.00	$0	$0	$0	$225	$225
2.3	Field Office Support	1	mo		$139.00			$0	$139	$0	$0	$139
2.4	Utility Connection/Disconnection (phone/electric	1	ls	$1,500.00				$1,500	$0	$0	$0	$1,500
2.5	Site Utilities (phone & electric)	1	mo		$327.00			$0	$327	$0	$0	$327
2.6	Drill Rig Mobilization/Demobilization	1	ls	$3,000.00				$3,000	$0	$0	$0	$3,000
2.7	Professional Oversight (2p * 5 days/week	3	wk			$1,600.00		$0	$0	$4,800	$0	$4,800
3	**DECONTAMINATION**											
3.1	Decontamination Services	1	mo		$375.00	$1,200.00	$900.00	$0	$375	$1,200	$900	$2,475
3.2	Pressure Washer	1	mo				$1,100.00	$0	$0	$0	$1,100	$1,100
3.3	Equipment Decon Pad	1	ls		$500.00	$450.00	$155.00	$0	$500	$450	$155	$1,105
3.4	Decon Water	1	kgal		$200.00			$0	$200	$0	$0	$200
3.5	Decon Water Storage Tank, 6,000 gallon	1	mo				$635.00	$635	$0	$0	$635	$1,270
3.6	Clean Water Storage Tank, 4,000 gallon	1	mo				$570.00	$570	$0	$0	$570	$1,140
3.7	Disposal of Decon Waste (liquid & solid	1	mo	$900.00				$900	$0	$0	$0	$900
4	**BIOREMEDIATION**											
4.1	Bench-Scale Treatability Study	1	ls	$5,000.00				$5,000	$0	$0	$0	$5,000
4.2	Drill 20 1-inch DPT Points to 25' bgs	500	ft	$28.00				$14,000	$0	$0	$0	$14,000
4.3	ORC Materials	1	ls		$9,500.00			$0	$9,500	$0	$0	$9,500
4.4	Supplier Technical Oversight	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000
5	**SITE RESTORATION**											
5.1	Vegetate Disturbed Areas	1	ls		$300.00	$500.00	$200.00	$0	$300	$500	$200	$1,000
	Subtotal							$27,605	$11,341	$18,950	$4,071	$61,967
	Local Area Adjustments							100.0%	105.3%	85.8%	85.8%	
								$27,605	$11,942	$16,259	$3,493	$59,299
	Overhead on Labor Cost @ 30%									$4,878		$4,878
	G & A on Labor Cost @ 10%									$1,626		$1,626
	G & A on Material Cost @ 10%								$1,194			$1,194
	G & A on Equipment Cost @ 10%										$349	$349
	G & A on Subcontract Cost @ 10%							$2,761				$2,761
	Total Direct Cost							$30,366	$13,136	$22,763	$3,842	$70,107
	Indirects on Total Direct Cost @ 35%											$24,537
	Profit on Total Direct Cost @ 10%											$7,011
	Subtotal											$101,655

TABLE 2-9

CAPITAL COST ESTIMATE SUMMARY FOR THE SELECTED REMEDY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Item	Quantity	Unit	Unit Cost				Extended Cost				Subtotal
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	
Health & Safety Monitoring @ 1%											$1,017
Total Field Cost											$102,671
Contingency on Total Field Costs @ 20%											$20,534
Engineering on Total Field Cost @ 10%											$10,267
TOTAL COST											**$133,473**

TABLE 2-10

ANNUAL COST ESTIMATE SUMMARY FOR THE SELECTED REMEDY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Item	Item Cost Year 1	Item Cost Years 2 and 3	Item Cost Years 4 through 10	Item Cost Every 5 Years	Notes
Annual Inspection and Report	$1,570	$1,570	$1,570		One-day inspection with 2 people.
3-Month Monitoring	$5,090				Monitoring oxygen and carbon dioxide concentrations in the treatment area 3 months after ORC injection
Sampling	$25,680	$12,840	$6,420		Labor and field supplies (local)
Analysis	$50,400	$25,200	$12,600		Analyze 20 water samples for VOCs, SVOCs, and metals. Quarterly - Year 1; semi-annually - Years 2 and 3; annually - Years 4 through 10
Analysis	$70,560	$35,280	$17,640		Analyze 20 water samples for bioremediation indicator parameters. Quarterly - Year 1; semi-annually - Years 2 and 3 annually - Years 4 through 10
Sampling and Analysis Report	$20,000	$10,000	$5,000		Document sampling events and results.
Site Review				$15,000	Perform 5-year review
TOTALS	$173,300	$84,890	$43,230	$15,000	

ORC: Oxygen release compound
SVOCs: Semivolatile organic compounds
VOCs: Volatile organic compounds

TABLE 2-11

PRESENT-WORTH ANALYSIS FOR THE SELECTED REMEDY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

Year	Capital Cost	Annual Cost	Annual Discount Rate at 3.5%	Present Worth
0	$133,473		1.000	$133,473
1		$173,300	0.966	$167,408
2		$84,890	0.934	$79,287
3		$84,890	0.902	$76,571
4		$43,230	0.871	$37,653
5		$58,230	0.842	$49,030
6		$43,230	0.814	$35,189
7		$43,230	0.786	$33,979
8		$43,230	0.759	$32,812
9		$43,230	0.734	$31,731
10		$58,230	0.709	$41,285
			TOTAL PRESENT WORTH	**$718,417**

TABLE 2-12

DESCRIPTION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIRMENTS (ARARs)
FOR THE SELECTED REMEDY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA
PAGE 1 OF 2

ARAR	Citation	Classification	Summary of Requirement	Applicability to Selected Remedy
A. State				
1. Virginia Department of Health Private Well Regulations, 12 VAC 5-630				
a. Well Location	12 VAC 5-630-380	Applicable	Prohibits private wells in locations where a source of contamination could adversely affect the well and preventive, measures are not available to protect the groundwater.	The selected remedy will comply with this regulation by restricting the use of the Columbia aquifer at the Site as a source of drinking water until clean-up levels are attained.
b. Monitoring and Observation Well Construction and Abandonment	12 VAC 5-630-420 and -450	Relevant and Appropriate	Established monitoring well construction requirements if monitoring wells are to remain in place after completion of a groundwater study. Also establishes requirements and procedures for abandoning monitoring wells.	The selected remedy will comply with these regulations by requiring that monitoring wells be abandoned after confirming groundwater has reached clean-up goals.
B. Federal				
1. Safe Drinking Water Act, 42, U.S.C. Section 300f et seq.				
a. Maximum Contaminant Levels	40 C.F.R. Section 141	Relevant and Appropriate	Enforceable standards for public drinking water supply systems. The NCP requires that MCLs shall be attained by remedial actions for groundwater that is a current or potential source of drinking water.	These standards apply to: Benzene, Cis-1-2-Dichloroethene, and Vinyl Chloride. The Selected Remedy will comply with these regulations through in-situ bioremediation.

TABLE 2-12

**DESCRIPTION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIRMENTS (ARARs)
FOR THE SELECTED REMEDY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA**

ARAR	Citation	Classification	Summary of Requirement	Applicability to Selected Remedy
2. Solid Waste Disposal Act Underground Injection Control Program, 40 C.F.R. 144				
a. Underground Injection Control Regulations	40 C.F.R. 144.12	Applicable	Establishes minimum program and performance standards for underground injection programs. Requires protection of underground sources of drinking water.	The Selected Remedy will comply with the substantive requirements of the regulation by assuring that injection of bioremediation chemicals is accomplished in accordance with these standards.

Note: Refer to FS (TtNUS, 2005) for ARARs for other alternatives.

CFR: Code of Federal Regulations.
NCP: National Contingency Plan.
MCLs: Maximum Contaminant Levels.
VAC: Virginia Administrative Code

TABLE 2-13

DESCRIPTION OF TO BE CONSIDERED (TBC) REQUIREMENTS
FOR THE SELECTED REMEDY
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA

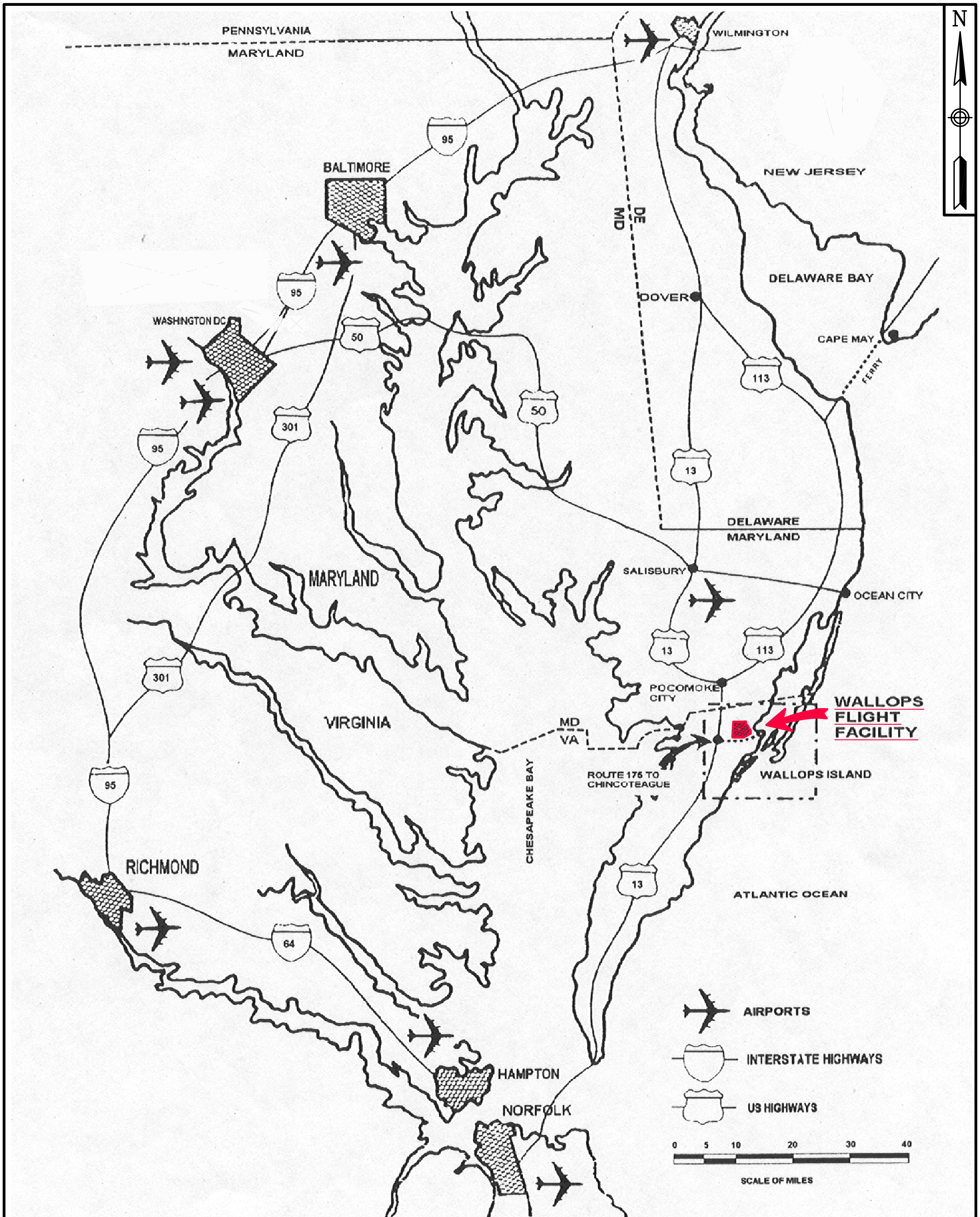
TBC	Citation	Classification	Summary of Requirement	Applicability to Selected Remedy
A. State				
1. State Water Control Board, 9 VAC 25-280 Groundwater Standards; § 62.1-44.15(3a) Code of Virginia				
a. Groundwater Standards	9 VAC 24-280-20 through -50	To Be Considered	Provides general requirements, the anti-degradation policy for groundwater, statewide groundwater standards, and groundwater standards by physiographic province.	The selected remedy will comply with these standards and policies by restoring the groundwater quality to levels that support and protect anticipated uses.
B. Federal				
3. Other				
b. Reference Doses and Cancer Slope Factors		To Be Considered	EPA guidance values that can be used to develop clean-up levels for COCs for which MCLs have not been promulgated.	Clean-up goals based on these values apply to: 4-Methylphenol, and Naphthalene. The Selected Remedy will comply with these clean-up levels through in-situ bioremediation.

Note: Refer to FS (TtNUS, 2005) for ARARs for other alternatives.

COCs: Chemicals of concern.
MCLs: Maximum Contaminant Levels.
VAC: Virginia Administrative Code

FIGURES

112GN1612/1230/1612BM01–1.DWG 10/18/2006 MKB

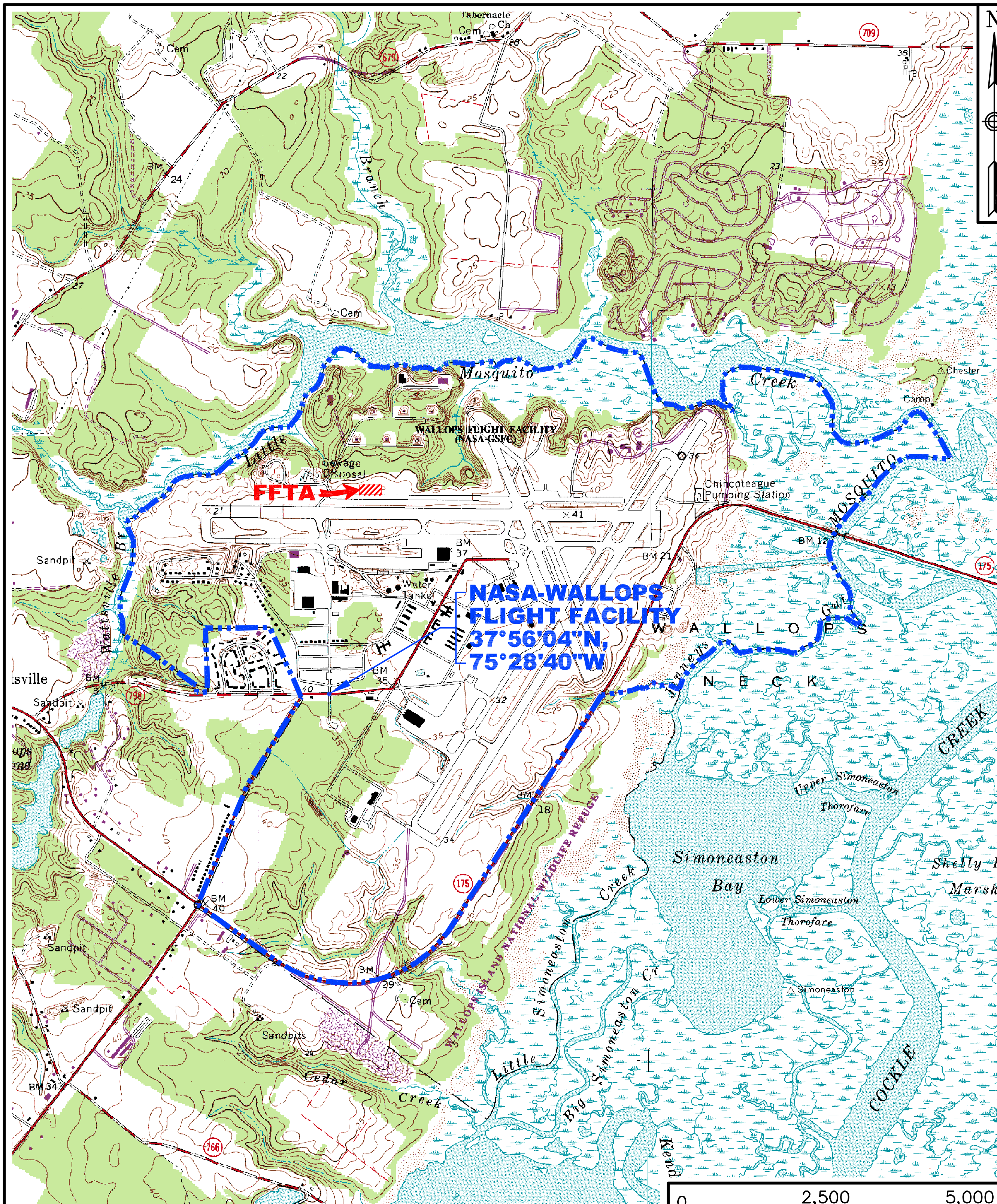


TETRA TECH NUS, INC.

SITE LOCATION MAP OF
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

SCALE	AS NOTED
FILE	1612BM01–1.DWG
REV 0	DATE 10/18/06
FIGURE NUMBER	FIGURE 2–1

112GN1612/1230/1612BM01-2.DWG 10/18/2006 MKB



SOURCE: U.S.G.S. 7.5' QUADRANGLE MAP, CHINCOTEAGUE WEST, VA., (37075-H4-TF-024) PHOTOINSPECTED 1989.

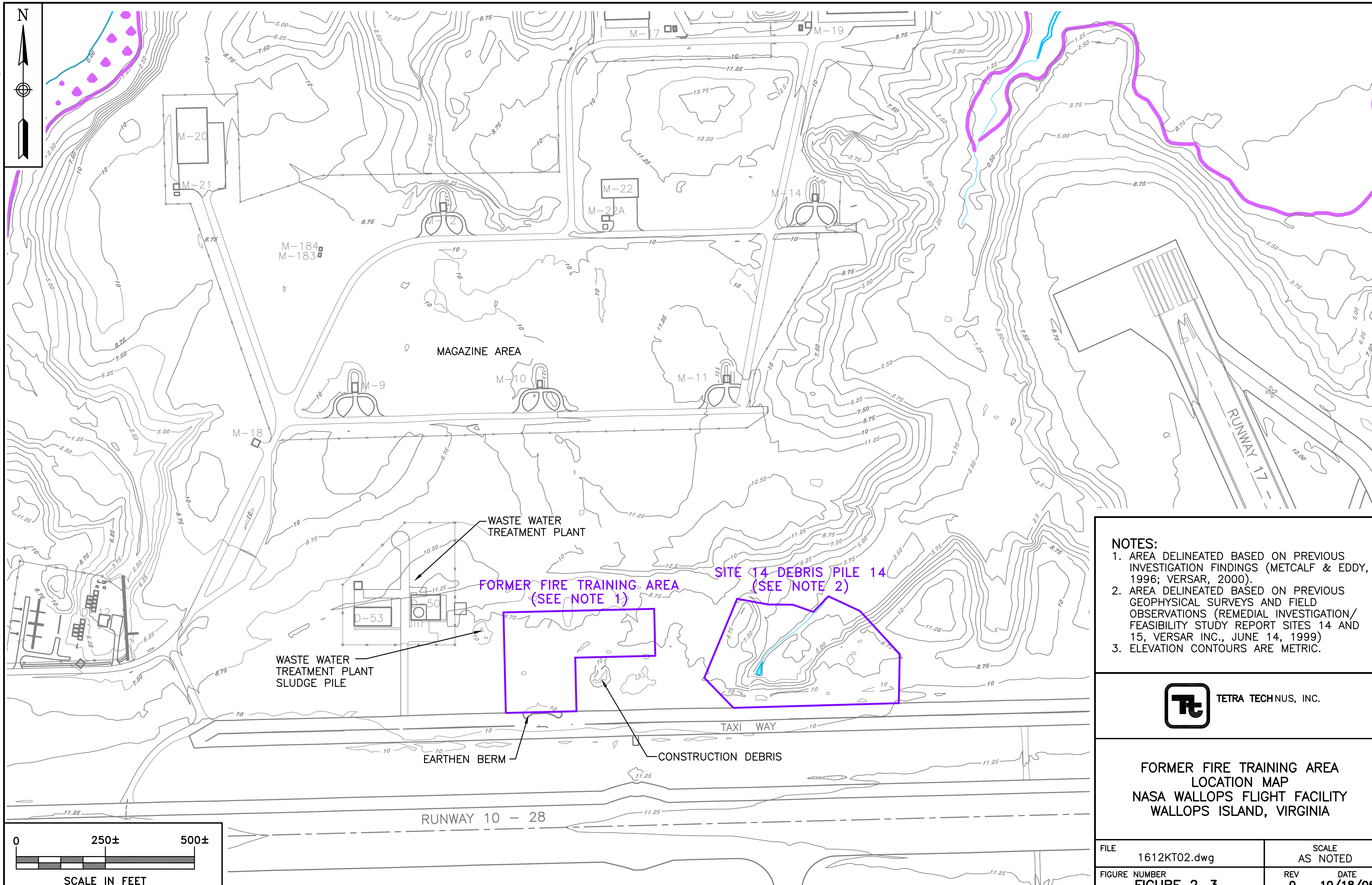
0 2,500 5,000

SCALE IN FEET

TETRA TECH NUS, INC.

STUDY AREA LOCATION MAP OF NASA WALLOPS FLIGHT FACILITY WALLOPS ISLAND, VIRGINIA

SCALE	
AS NOTED	
FILE	
1612BM01-2.DWG	
REV	DATE
0	10/18/06
FIGURE NUMBER	
FIGURE 2-2	



NOTES:

1. AREA DELINEATED BASED ON PREVIOUS INVESTIGATION FINDINGS (METCALF & EDDY, 1996; VERSAR, 2000).
2. AREA DELINEATED BASED ON PREVIOUS GEOPHYSICAL SURVEYS AND FIELD OBSERVATIONS (REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT SITES 14 AND 15, VERSAR INC., JUNE 14, 1999)
3. ELEVATION CONTOURS ARE METRIC.

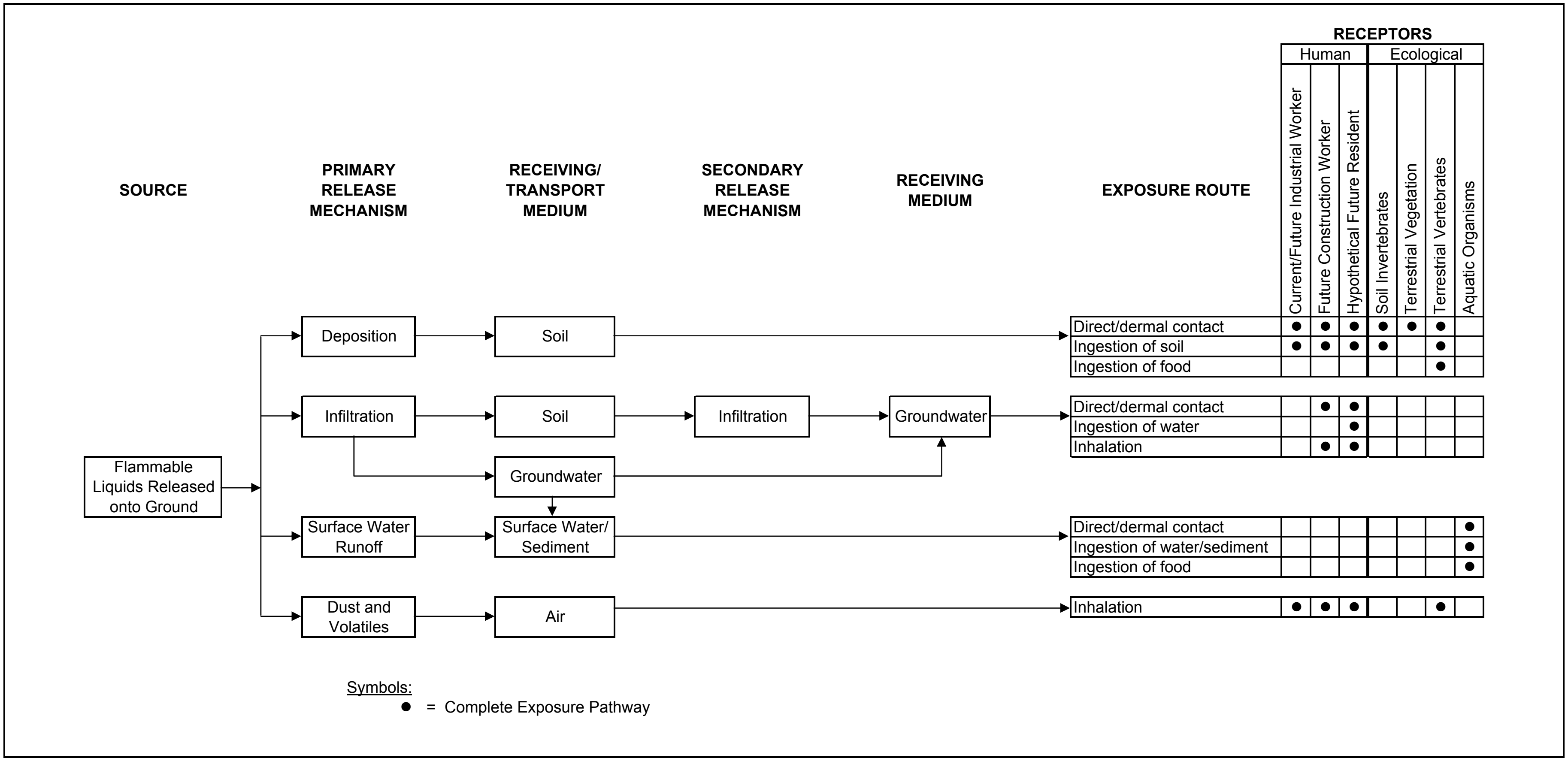
TETRA TECH NUS, INC.

FORMER FIRE TRAINING AREA
LOCATION MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

FILE	SCALE
1612KT02.dwg	AS NOTED

FIGURE NUMBER	REV	DATE
FIGURE 2–3	0	10/18/06

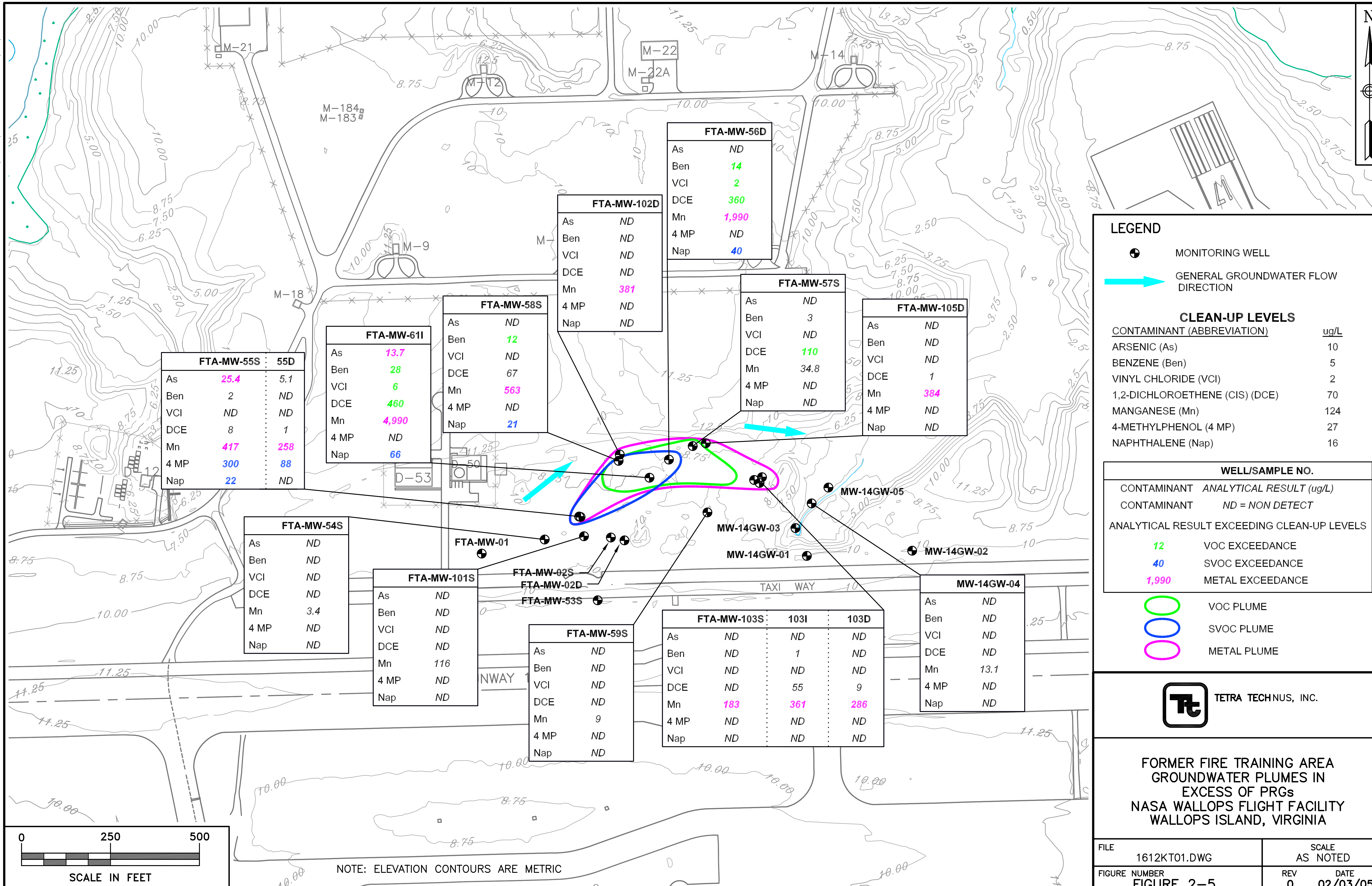
1612\1230\1612KT02.dwg 10/18/06 MKB



Blank space indicates incomplete exposure pathway or relatively insignificant, or not applicable, potential exposure.

FIGURE 2-4

CONCEPTUAL SITE MODEL
FORMER FIRE TRAINING AREA
NASA WFF, WALLOPS ISLAND, VIRGINIA


1612\1230\1612KT01.DWG 10/18/06 MKB
N
FTA-MW-56D
As ND
Ben 14
VCl 2
DCE 360
Mn 1,990
4 MP ND
Nap 40
FTA-MW-102D
As ND
Ben ND
VCl ND
DCE ND
Mn 381
4 MP ND
Nap ND
FTA-MW-57S
As ND
Ben 3
VCl ND
DCE 110
Mn 34.8
4 MP ND
Nap ND
FTA-MW-105D
As ND
Ben ND
VCl ND
DCE 1
Mn 384
4 MP ND
Nap ND
FTA-MW-58S
As ND
Ben 12
VCl ND
DCE 67
Mn 563
4 MP ND
Nap 21
FTA-MW-61I
As 13.7
Ben 28
VCl 6
DCE 460
Mn 4,990
4 MP ND
Nap 66
FTA-MW-55S 55D
As 25.4 5.1
Ben 2 ND
VCl ND ND
DCE 8 1
Mn 417 258
4 MP 300 88
Nap 22 ND
FTA-MW-54S
As ND
Ben ND
VCl ND
DCE ND
Mn 3.4
4 MP ND
Nap ND
FTA-MW-101S
As ND
Ben ND
VCl ND
DCE ND
Mn 116
4 MP ND
Nap ND
FTA-MW-59S
As ND
Ben ND
VCl ND
DCE ND
Mn 9
4 MP ND
Nap ND
FTA-MW-103S 103I 103D
As ND ND ND
Ben ND 1 ND
VCl ND ND ND
DCE ND 55 9
Mn 183 361 286
4 MP ND ND ND
Nap ND ND ND
MW-14GW-04
As ND
Ben ND
VCl ND
DCE ND
Mn 13.1
4 MP ND
Nap ND
FTA-MW-01
FTA-MW-02S
FTA-MW-02D
FTA-MW-53S
MW-14GW-05
MW-14GW-03
MW-14GW-01
MW-14GW-02
M-21
M-22
M-22A
M-14
M-12
M-184
M-183
M-9
M-18
D-53
TAXI WAY
NOTE: ELEVATION CONTOURS ARE METRIC
0 250 500
SCALE IN FEET
LEGEND
MONITORING WELL
GENERAL GROUNDWATER FLOW DIRECTION
CLEAN-UP LEVELS
CONTAMINANT (ABBREVIATION) ug/L
ARSENIC (As) 10
BENZENE (Ben) 5
VINYL CHLORIDE (VCl) 2
1,2-DICHLOROETHENE (CIS) (DCE) 70
MANGANESE (Mn) 124
4-METHYLPHENOL (4 MP) 27
NAPHTHALENE (Nap) 16
WELL/SAMPLE NO.
CONTAMINANT ANALYTICAL RESULT (ug/L)
CONTAMINANT ND = NON DETECT
ANALYTICAL RESULT EXCEEDING CLEAN-UP LEVELS
12 VOC EXCEEDANCE
40 SVOC EXCEEDANCE
1,990 METAL EXCEEDANCE
VOC PLUME
SVOC PLUME
METAL PLUME
TETRA TECH NUS, INC.
FORMER FIRE TRAINING AREA
GROUNDWATER PLUMES IN
EXCESS OF PRGs
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
FILE
1612KT01.DWG
SCALE
AS NOTED
FIGURE NUMBER
FIGURE 2–5
REV
0
DATE
02/03/05