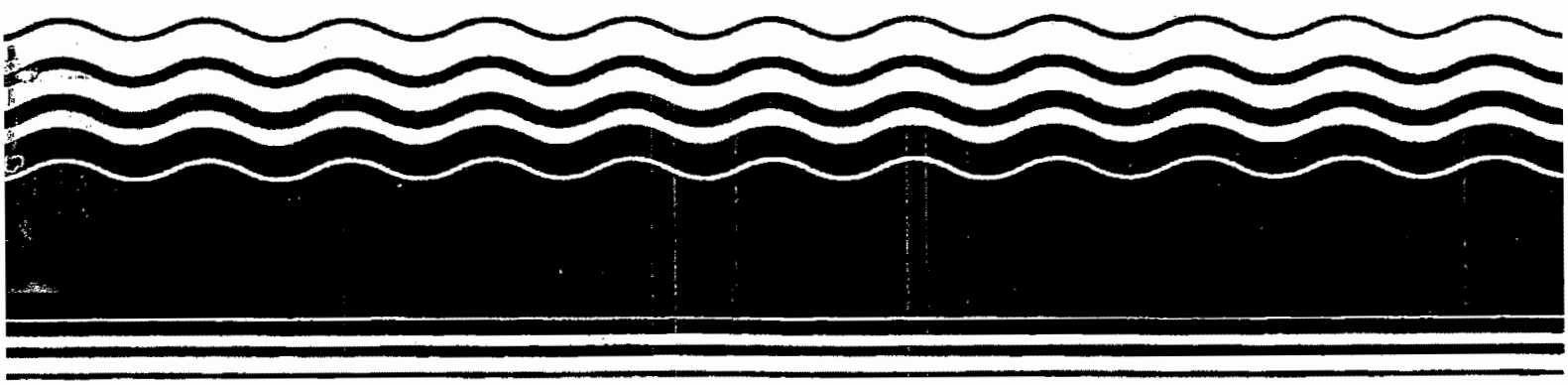
PB99-963907
EPA541-R99-011
1999

EPA Superfund
Record of Decision:

Naval Weapons Station (WPNSTA) OUs 12, 13, 14, & 15
Yorktown, VA
10/13/1998



1.0 DECLARATION OF THE RECORD OF DECISION

1.1 Site Name and Location

Naval Weapons Station (WPNSTA) Yorktown, Yorktown, Virginia
Sites 6 and 7; Operable Units (OUs) XII, XIII, XIV, and XV

1.2 Statement of Basis and Purpose

This Record of Decision (ROD) documents the selected remedial action to reduce the risks posed by contaminated media at Sites 6 and 7 located at WPNSTA Yorktown, Yorktown, Virginia. Sites 6 and 7 have been divided into 4 OUs for remediation:

OU XII - Soil and Sediment at Site 7

- Contaminated soil and sediment from the drainage ditch behind Plant 3. The ditch received outfall from Plant 3 and was contaminated with nitramine/nitroaromatic compounds including: 2,4,6,- trinitrotoluene (TNT), amino-dinitrotoluenes (amino-DNTs), cyclotrimethylenenitramine (RDX) and cyclotetramethylenetetranitramine (HMX). Soil and sediment were removed from the ditch to conduct a full scale pilot study for the bioremediation of explosives contaminated media in 1996.

OU XIII - Site 6 - Flume Area

- Soil and sediment from the Site 6 - Flume Area, which includes historic discharges from Buildings 109 and 110, is contaminated with chlorinated volatile compounds including: 1,1,1-trichloroethane (TCA), trichloroethene (TCE), and tetrachloroethene (PCE); nitramine/nitroaromatic compounds including TNT, amino-DNTs, dinitrotoluenes, HMX, RDX, 1,3,5-trinitrobenzene; and inorganics including nickel and zinc.

- Nitramine/nitroaromatic contaminated explosives residue in Building 109 (RCRA Area of Concern C and Solid Waste Management Unit 179) exists and could be released to the Site 6 - Flume Area if not addressed.

OU XIV - Site 6 - Excavated Area

- Surface soil in the Site 6 - Excavated Area is contaminated with cadmium and zinc.

OU XV - Site 6 - Impoundment Area Surface water and Sediment, Site 7 Surface Water, Site 6 and 7 Groundwater

- The Site 6 - Impoundment Area is located at the terminal end of the Site 6 - Flume Area. Sediment in the Site 6 - Impoundment is contaminated with nitramines/nitroaromatics, chlorinated volatile organics and inorganics. The highest concentrations of these contaminants occur at depth.

- Groundwater beneath Site 6 and 7, which is not currently used as a potable water source, is contaminated with chlorinated volatile organics, nitramines/nitroaromatics, and inorganics. It could also act as a potential source of contamination to Site 6 and Site 7 surface water.

Remedial action was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and, to the extent practicable, with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The information supporting the decisions on the selected remedy is contained in the administrative record. Section 2.2.2 lists major documents contained in the administrative record.

The Commonwealth of Virginia concurs with the selected remedy.

1.3 Assessment of the Sites

Actual or threatened releases of hazardous substances from OUs XIII, XIV, and XV, if not addressed by implementing the remedial action selected in this ROD, may present an imminent and substantial danger to human health and the environment. No further action is proposed for OU XII because risks posed to human health and the environment have been mitigated by a removal action conducted in support of a full-scale Pilot Study for the bioremediation of explosives-contaminated sediment conducted in 1996.

1.4 Description of the Selected Remedy

The remedy for OU XII, OU XIII, OU XIV, and OU XV is part of a comprehensive environmental remediation currently being performed at WPNSTA Yorktown under the Department of Defense (DoD) Installation Restoration (IR) Program.

The removal and treatment of soil/sediment and Building 109 residue at OU XIII, Site 6-Flume Area, and a soil cover at OU XIV, Site 6-Excavated Area, address the principal threat to human health and the environment by eliminating source materials and potential release of these contaminants to the environment. They also mitigate the potential for direct contact with soil at the Site 6-Excavated Area. Long-term monitoring of sediment, surface water, and groundwater at OU XV will: 1) evaluate the efficacy of the removal planned for the Site 6-Flume Area in removing a potential source of continuing contaminant release and 2) provide temporal data about conditions in the Site 6-Impoundment Area and the quality of shallow groundwater which may interconnect with Sites 6 and 7 surface water and sediments. Major components of the selected remedies for OUs XII, XIII, XIV, and XV include:

OU XII - Site 7 - Drainage Area

- No Further Action for OU XII. Approximately 800 cubic yards of nitramine/nitroaromatic and inorganic contaminated soil and sediment were removed as part of a bioremediation pilot study conducted in 1996. Soil and sediment have been cleaned up to levels appropriate for commercial/industrial use, which is the current land use and the most likely future land use for this site. Residual levels of contamination, however, make the site inappropriate for residential uses. Consequently, residential use is prohibited as part of the remedy.

OU XIII - Site 6 - Flume Area

- Excavation of nitramine/nitroaromatic-, chlorinated volatile-, and inorganic-contaminated soil and sediment from the Site 6 - Flume Area.

- Ex situ bioremediation of soil and sediment excavated from the Site 6 - Flume Area. Nitramine/nitroaromatics are readily degraded by the process, but chlorinated volatiles may be recalcitrant to degradation. If volatiles do not degrade during a reasonable cycle of ex situ treatment, a contingency remedy (low temperature thermal desorption) will be employed to remove remaining chlorinated volatiles from the soil.

- Habitat restoration of the Site 6 - Flume Area.

- Pressure washing of the trenches (SWMU 179), and residue removal and pressure washing of the trenches under Building 109 (AOC C).

- Removal of explosives-contaminated residue from SWMU 179 and treatment by burning at the Station's thermal treatment unit.

- This site will be cleaned up to levels appropriate for commercial/industrial use, which is the current land use and the most likely future land use for this site. Residual levels of contamination, however, will make the site inappropriate for residential uses. Consequently, residential use is prohibited as part of the remedy.

OU XIV - Site 6 - Excavated Area

- Grading and placement of backfill as a soil cover (minimum 8 inches) to prevent contact with cadmium and zinc-contaminated surface soil by terrestrial ecological receptors at the Site 6 - Excavated Area. No long-term monitoring will be necessary.

- Activities that interfere with or compromise the integrity of the cover at this site will be prohibited.

OU XV - Site 6 - Impoundment Area Surface Water and Sediment, Surface Water at Site 7, Groundwater at Site 6 and 7

- Long-term monitoring of surface water and sediment will be conducted for nitramines/nitroaromatics and chlorinated volatile organics and inorganics (including nickel and zinc) in the Site 6-Impoundment Area. Long-term monitoring of the groundwater throughout Sites 6 and 7 for nitramines/nitroaromatics, chlorinated volatiles and inorganics will also be conducted, but this is not the final remedy for groundwater. Groundwater at Sites 6 and 7 will be addressed in a separate OU after USEPA Region III completes a watershed study for Felgates Creek scheduled for September, 1998. Long-term monitoring of surface water at Site 7 for similar contaminants.

- Specifics of the long-term monitoring program will be developed by the Navy, the United States Environmental Protection Agency (USEPA) Region III, and Commonwealth of Virginia Department of Environmental Quality (DEQ) and presented in a Long-Term Monitoring Work Plan, a primary document under the WPNSTA Yorktown Federal Facilities Agreement (FFA).

The selected remedy (including the contingency remedy for OU XIII) is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action (ARARs), and is cost-effective. The remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable. The selected remedy meets the statutory preference for treatment at OU XII and OU XIII, but not OU XIV or OU XV, where treatment of contaminants is not practicable. At OU XII, soil and sediment at Site 7, bioremediation was used to treat explosives-contaminated soil as part of a bioremediation pilot study. At OU XIII bioremediation will be used to treat nitramines and nitroaromatics; if chlorinated volatiles do not degrade during a reasonable cycle of bioremediation, a contingency remedy (low temperature thermal desorption) will be employed to remove remaining chlorinated volatiles from the soil.

Because the remedy will result in hazardous substances remaining on-site above conservative health-based levels at all OUs, a review will be conducted within five years after commencement of remedial action to ensure that adequate long-term protection of human health and the environment is maintained.

S.A. Denham — 5 Oct 1998

Captain S.A. Denham, Commanding Officer
Naval Weapons Station Yorktown, Yorktown, Virginia

Date

Abraham Ferdas — 10/13/98

Abraham Ferdas, Acting Division Director
Hazardous Waste Management
United States Environmental Protection Agency, Region III

Date

2.0 DECISION SUMMARY

2.1 Site Name, Location, And Description

WPNSTA Yorktown is a 10,624 acre installation located on the Virginia Peninsula in York and James City Counties and the City of Newport News (Figure 2-1). The Station is bounded on the northwest by the Naval Supply Center Cheatham Annex, the Virginia Emergency Fuel Farm, and the future community development of Whittaker's Mill; on the northeast by the York River and the Colonial National Historic Parkway; on the southwest by Route 143 and Interstate 64; and on the southeast by Route 238 and the community of Lackey. The locations of Sites 6 and 7 are presented in Figure 2-2.

2.1.1 Site 6 - Explosives-Contaminated Wastewater Impoundment

The Site 6 study area covers approximately 94 acres and includes the area surrounding Buildings 109, 110, and 501; the explosives-contaminated wastewater impoundment (a portion of OU XV) with the associated flume (OU XIII); an excavated area (OU XIV); and a tributary to Felgates Creek. The Site 6 study area generally slopes to the west toward the Site 6 - Impoundment Area. The buildings in the study area are surrounded by earthen berms that affect surface water runoff direction. Currently, the Site 6 - Impoundment Area collects only surface runoff from the area between Buildings 109 and 110. A system of trenches and piping originating from Building 109 carried discharge to the Site 6 - Flume Area and the Site 6 - Impoundment Area during operations. Building 109 is no longer in use. Figure 2-3 illustrates the Site 6 - Flume Area.

North of the Site 6 - Impoundment Area, an excavated area has been identified. This area is currently wooded, but concrete rubble and miscellaneous debris are evident in the area. The history of the Site 6 - Excavated Area is not documented. The area may have been a former soil borrow pit, from which soil was obtained to construct the dam for the impoundment.

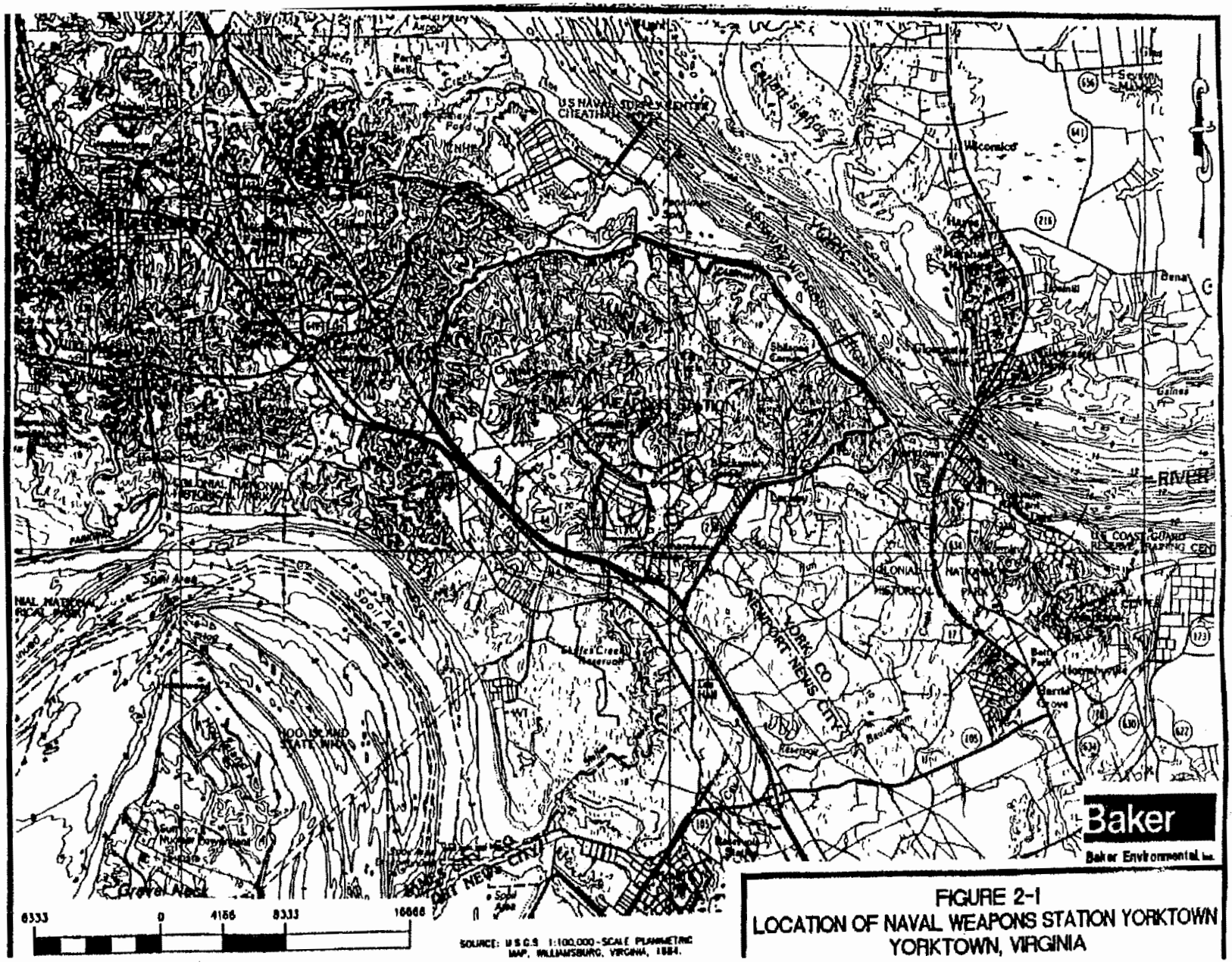


FIGURE 2-1
LOCATION OF NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

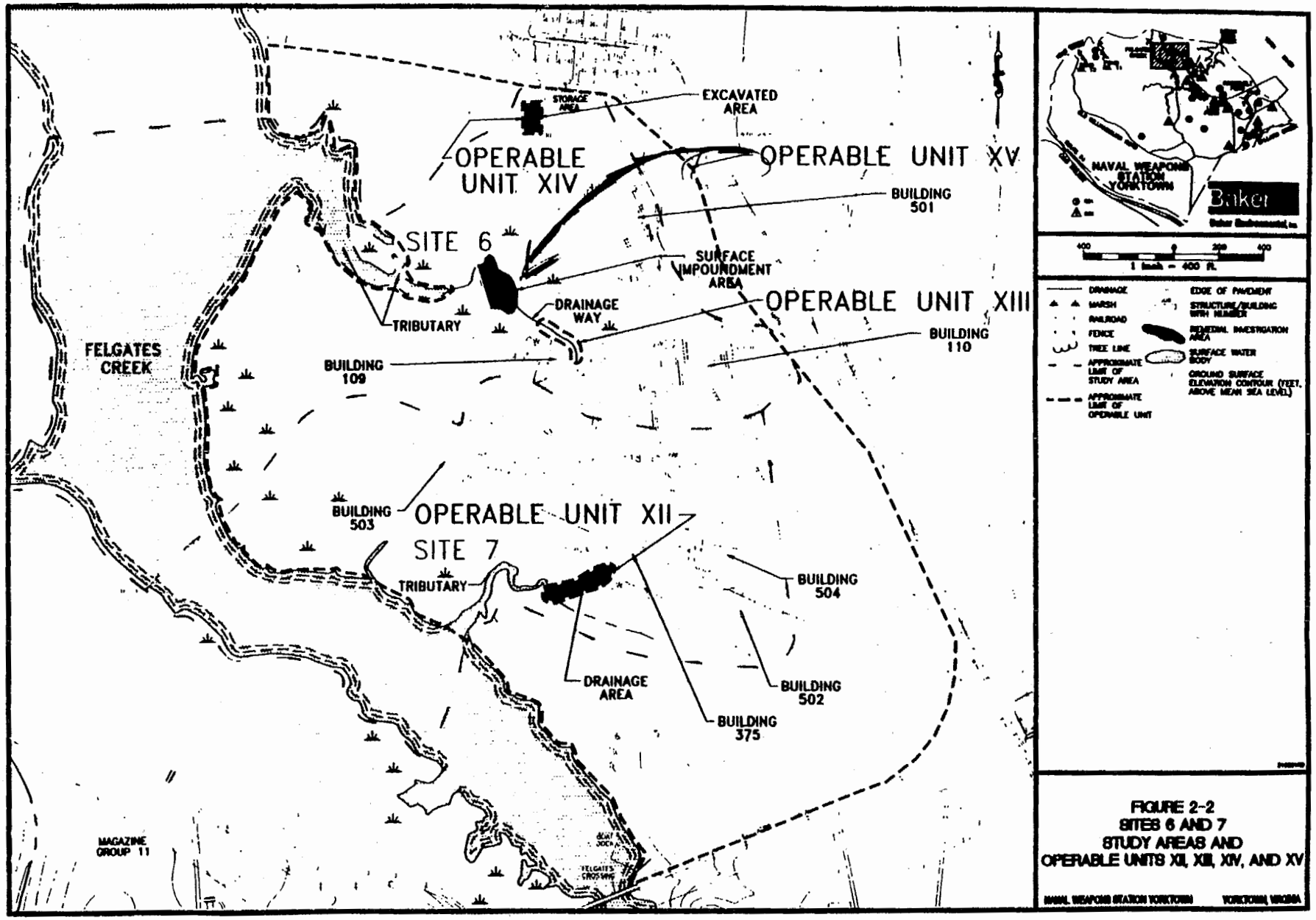


FIGURE 2-2
SITES 6 AND 7
STUDY AREAS AND
OPERABLE UNITS XII, XIII, XIV, AND XV

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

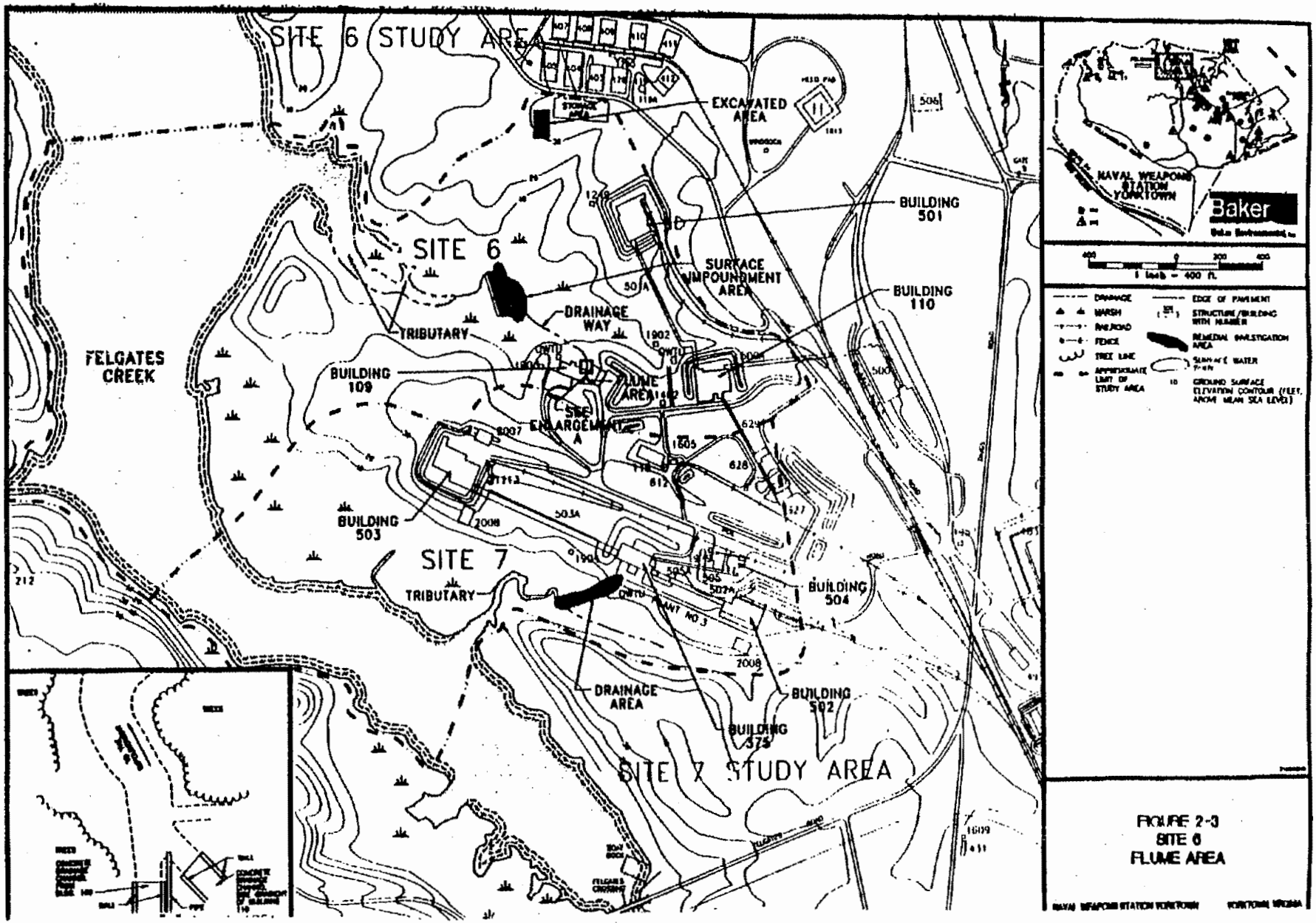


FIGURE 2-3
SITE 6
FLUME AREA

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

2.1.2 Site 7 - Plant 3 Explosives-Contaminated Wastewater Discharge Area

Site 7 is a 300-foot long (approximate length) drainage area located adjacent to wetlands and along a small tributary to Felgates Creek, approximately one mile upstream from the confluence of Felgates Creek and the York River. The buildings in the study area are surrounded by earthen berms that affect surface water runoff direction. The Site 7 study area generally slopes toward a ravine located along the southern portion of the study area. The actual study area for Site 7 covers approximately 62 acres and includes the area surrounding Buildings 375, 502, 503, and 504 (collectively known as Loading Plant 3) as well as a drainage area. Sediment and some soil along the banks of the drainage area (OU XII) were removed for the full-scale Pilot Study for the bioremediation of explosives-contaminated soil conducted in 1996. The removal focused on soil and sediment in the Site 7 - Drainage Area containing concentrations of nitramine/nitroaromatic compounds exceeding human health based remediation levels derived for commercial/industrial property use. The Site 7 - Drainage Area discharges to a small tributary of Felgates Creek.

2.2 Site History and Enforcement Activities

2.2.1 Site History

Originally named the U.S. Mine Depot, WPNSTA Yorktown was established in 1918 to support the laying of mines in the North Sea during World War I. For 20 years after World War I, the depot received, reclaimed, stored, and issued mines, depth charges, and related materials. During World War II, the facility was expanded to include three additional TNT loading plants and new torpedo overhaul facilities. On August 7, 1959, the depot was redesignated the U.S. Naval Weapons Station. Currently, the primary mission of WPNSTA Yorktown is to provide ordnance, technical support, and related services to sustain the war-fighting capability of the armed forces in support of national military strategy.

The Site 6 - Impoundment Area was formerly used during the years of 1942 through 1975 as a settling basin for nitramine-contaminated wash down water. The contaminated wastewater was generated from the explosives reclamation facility at Building 109 and from weapons loading operations at Building 110. This wastewater flowed along concrete flumes in what has been designated as the Site 6 - Flume Area. The explosives reclamation facility released solvents such as TCE and TCA and nitramine/nitroaromatic compounds such as TNT and RDX to the Site 6 - Impoundment Area. The weapons reclamation operations released solvents and nitramine compounds to the Site 6 - Impoundment Area by means of a concrete-lined drainage channel or flume that emanates from Building 109. In 1975, a carbon adsorption tower was installed to treat the contaminated wastewater before it was discharged from Buildings 109 and 110 into the Site 6 - Flume Area. A National Pollutant Discharge Elimination System (NPDES) Permit was granted by the USEPA Region III to allow this discharge. In 1986, the effluent from the tower was diverted to the sanitary sewer and ultimately to the Hampton Roads Sanitation District (HRSD). The Site 6 - Impoundment Area currently collects only surface water runoff from the area between Buildings 109 and 110. Based on a Resource Conservation and Recovery Act (RCRA) Solid Waste Management Unit Investigation at WPNSTA Yorktown, the EPA Office of RCRA programs issued a final report in December 1992 which identified 94 areas at WPNSTA Yorktown that require additional investigation under the RCRA. Two of these areas are AOC C - Building 109 Contaminated Structure and SWMU 179 - Building 109 trenches and piping.

The history of the Site 6 - Excavated Area identified north of the Site 6 - Impoundment Area is not documented. The area may have been a former soil borrow pit, from which soil was obtained to build the dam for the Impoundment Area.

The Site 7 - Drainage Area received nitramine-contaminated wastewater from Loading Plant 3 (Building 375, 502, 503, and 504) between 1945 and 1975. In 1975, a carbon adsorption tower was installed to treat the contaminated wastewater prior to discharge to the Site 7 - Drainage Area. An NPDES Permit was granted by USEPA Region III to allow this discharge. In 1986, the discharge from the tower was diverted to the sanitary sewer and ultimately to the HRSD. The Site 7 - Drainage Area did not receive discharge from Plant 3 after this date. Soil/sediment from the Site 7 - Drainage Area was removed in 1996 as part of the full-scale Pilot Study for bioremediation of explosives contamination and the area restored.

2.2.2 Enforcement Activities

On October 15, 1992, WPNSTA Yorktown was included on the National Priorities List (NPL) because of the facility's proximity to wetlands and the potential impact on the surrounding environment. A FFA between USEPA Region III, the Commonwealth of Virginia, and the Department of the Navy (DoN) was finalized in August of 1994 for WPNSTA Yorktown. The FFA covers the investigation, development, selection, and implementation of response actions, satisfying WPNSTA Yorktown's RCRA corrective action obligations as well as appropriate provisions of CERCLA for all sites, SWMUs, and RCRA AOCs.

In December 1996, a full-scale Pilot Scale study was conducted using Site 7 - Drainage Area soil/sediment to determine if an aqueous-phase, ex-situ biocell could remediate explosives-contaminated soil. Therefore, the source of nitramine/nitroaromatic contamination at Site 7 was removed as part of this study. No other documented enforcement activities have been conducted at either Sites 6 or 7 under the FFA.

The following documents provide details of the site investigations and assessments of cleanup actions for OUs XII, XIII, XIV, and XV.

- C.C. Johnson & Associates, Inc. and CH2M Hill. Initial Assessment Study of Naval Weapons Station, Yorktown. July 1984.
- Dames & Moore. Confirmation Study Step IA (Verification), Round One, Naval Weapons Station, Yorktown, Virginia. June 1986.
- Dames & Moore. Confirmation Study Step IA (Verification) Round Two, Naval Weapons Station, Yorktown, Virginia. June 1988.
- Baker Environmental, Inc. and Roy F. Weston, Inc. Focused Biological Sampling and Preliminary Risk Evaluation Naval Weapons Station, Yorktown, Virginia. July 1993.
- Baker Environmental, Inc. And Roy F. Weston, Inc. Final Round One Remedial Investigation Report for Sites 1-9, 11, 12, 16-19, Naval Weapons Station, Yorktown, Virginia. July 1993.
- Baker Environmental, Inc. Final Habitat Evaluation Report (WPNSTA Sites 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 16, 17, 18, 19, and 21). July 1995.
- Baker Environmental, Inc. Final Pilot Study Report for the Explosives-Contaminated Soil at the Naval Weapons Station Yorktown, Yorktown, Virginia. July 1997.
- Baker Environmental, Inc. Interim Final Remedial Investigation Round Two Report, Naval Weapons Station, Yorktown, Virginia. February 1998.

2.2.3 History of Previous Investigations

The purpose of the Initial Assessment Study (IAS) (C.C. Johnson & Associates, Inc. and CH2M Hill, July 1984) was to identify and assess sites posing a potential threat to human health and/or the environment. A total of 19 potentially contaminated sites were identified based on information from historical records, aerial photographs, field inspections, and personnel interviews. The IAS concluded that 15 of the 19 sites, including Sites 6 and 7, were of sufficient threat to human health or the environment to warrant Confirmation Studies.

A Confirmation Study was then conducted for the 15 sites and two rounds of data were obtained. The first round of data was collected in the winter of 1986. This effort was documented in the "Confirmation Study Step IA (Verification), Round One," (Dames & Moore, June 1986). The second round of sampling was conducted during November-December 1987 and results of the analyses were presented in the "Confirmation Study Step IA (Verification), Round Two," (Dames & Moore, June 1988).

The 15 sites, including Sites 6 and 7, were recommended for further study and were evaluated as part of the Round One Remedial Investigation (RI) (July 1993). Soil, surface water, sediment and groundwater samples were collected and analyzed for Target Compound List (TCL) organics, Target Analyte List (TAL) inorganics, and nitramine/nitroaromatic compounds (explosives). Samples from Sites 6 and 7 indicated the presence of contamination in surface water and sediment. However, the nature and extent of the contamination at Sites 6 and 7 was not completely defined by the results of the Round One RI. Additional sampling was recommended for all media.

The Round Two RI and report for Sites 6 and 7 was completed in February of 1998. Additional soil and sediment data indicated that contamination was present at both sites. These sample data were used as part of the Feasibility Study (FS) Report (March 1998) to determine the extent of soil contamination. FS soil data confirmed that the highest levels of explosives contamination were at the Site 6-Flume Area in sediment.

A Supplemental Investigation to the Round Two RI was conducted in February 1996 at the Site 6-Impoundment Area to collect additional data to delineate the potential extent of contamination within the impoundment. The Supplemental Investigation included the collection of shallow soil samples and sediment samples. Shallow soil samples were collected along the northern and eastern banks of the impoundment and sediment samples were collected throughout the impoundment area. Analytical results indicate that the sediments have been impacted by volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and nitramine compounds, particularly in the vicinity of the former wastewater discharge area of the impoundment.

Following the Supplemental Investigation, USEPA was concerned that there was not enough data on explosives contamination at AOC C and SWMU 179. Although these areas are encompassed by the Site 6 study area, USEPA believed that an insufficient number of samples had been collected in close proximity to evaluate impacts on environmental media. As a result, fourteen additional soil samples were collected in October 1996. The samples were collected at depths ranging from 0 to 4 feet below ground surface (bgs). All of the samples were field tested for TNT and submitted to a laboratory for VOC analysis. The TNT test kit results indicated that all of the soil samples collected had TNT concentrations less than 30 parts per million (ppm), the lower end of the detection limit. Soil samples were not sent to a laboratory for TNT confirmation. Based on the data and information gained from the October 1996 sampling event, no additional RCRA activities were needed at SWMU 179 and AOC C.

A full-scale Pilot Study to treat explosives-contaminated soil/sediment obtained from Site 7 was conducted

between September and December of 1996. The purpose of the study was to determine the technical implementability, effectiveness, and future costs of an anaerobic remediation technology used to treat explosives-contaminated soil. Approximately 770 cubic yards of soil were excavated from the drainage area leading to the tributary at Site 7. Soil with TNT concentrations exceeding 30 ppm was excavated and sent to the newly-constructed biocell at another site at WPNSTA Yorktown. The TNT concentrations in the soil entering the biocell averaged over 1,000 ppm. After treatment, the TNT concentrations ranged from less than 1 ppm to 4 ppm. As a result of this full-scale Pilot Study, the source of contamination has been removed from Site 7.

An ecological toxicity study was conducted on the sediment in the Site 6 - Flume Area at Site 6 in 1997. The purpose of the study was to further define the extent of explosive contamination and to establish toxicity-based site-specific cleanup goals for the explosive contaminants. In August, 1997, Baker collected a series of sediment samples from the Site 6 - Flume Area. The sediment samples were submitted to an off-site analytical laboratory and to an ecological toxicity laboratory for analysis. An acute (10-day) and a chronic (28-day) ecological toxicity study were conducted on the sediments. The tests indicated that TNT concentrations above a range of 68,000 to 118,000 µg/kg may pose risks to benthic macroinvertebrates.

On February 11, 1998, a composite soil sample was collected from the Site 6-Flume Area (near the concrete flumes) by Baker personnel. The soil sample was split with Grace Environmental (a treatability study vendor) for a Soil Optimization Study to determine the ability of Daramend®, a proprietary technology, to remediate volatiles and nitramines/nitroaromatics. Baker submitted the sample to an off-site laboratory for analysis of TCL VOCs, SVOCs, pesticides/polychlorinated biphenyls (PCBs), nitramines, and TAL inorganics.

2.3 Highlights of Community Participation

The Proposed Remedial Action Plan (PRAP) for Sites 6 and 7 was released to the public in May 1998 at the four information repositories listed below:

- York County Public Library
  8500 George Washington Highway
  Yorktown, VA 23692
  (757) 890-3377

- Newport News City Public Library
  Grissom Branch
  366 Deshazor Drive
  Newport News, VA 23608
  (757) 886-7896

- Gloucester Public Library
  P.O. Box 367, Main Street
  Gloucester, VA 23601
  (804) 693-2998

- Naval Weapons Station Yorktown
  Environmental Directorate
  Building 31-B, P.O. Drawer 160
  Yorktown, VA 23691-0160
  (757) 887-4775 (ext. 29) (Contact: Mr. Jeff Harlow)

The notice of availability of this document was published May 10, 1998 in the *Daily Press*. A public comment period was held from May 26, 1998 to July 11, 1998. A fact sheet that summarized the Proposed Plan was distributed to attendees of the Public Meeting held at the York County Recreational Services Meeting Room, 301 Godwin Neck Road, Yorktown, Virginia, on May 26, 1998. This meeting was held to inform interested members of the community about the preferred remedial alternative under consideration. Responses to comments received during the public comment period and a transcript of the Public Meeting are included in the Responsiveness Summary in Section 3.0 of this document.

2.4 Scope and Role of the Remedy

The studies at Sites 6 and 7 are part of comprehensive environmental investigations being conducted under the IR Program at WPNSTA Yorktown. OU XII consists of soil, surface water, and sediment at Site 7. Contaminated sediment was excavated from Site 7 and used in the full-scale Pilot Study for explosives-contaminated soil remediation through bioremediation. No additional action is recommended for OU XII.

OU XIII consists of soil and sediment at Site 6-Flume Area and explosives-contaminated residue under Building 109. The remedial action will consist of removing and treating approximately 20 cubic yards of explosives-contaminated residue and pressure washing AOC C in order to prevent it from being a secondary source of contamination for the Site 6-Flume Area. SWMU 179 will be pressure washed to prevent any future potential releases from the building. Residue will be transported to an on-site burning area for treatment. The Site 6-Flume Area soil/sediment contains concentrations of explosives that pose a potential threat to human health and the environment. The sediment also contains concentrations of volatiles and inorganics that pose a potential ecological risk. The soil/sediment will be excavated until confirmation sampling indicates that all of the contamination has been removed and contaminants remaining in soil are at concentrations equal to, or lower than, risk-based remediation levels (RLs). Contaminated soil/sediment from the Site 6-Flume Area will be treated using an ex situ bioremediation process. A contingency remedy may be necessary to remediate volatile organics to health based goals. If a reasonable cycle (cycle length is weather dependent) of ex situ biological treatment does not reduce volatile organic contamination in soil/sediment to concentrations equal to, or below risk - based treatment goals, low temperature thermal desorption may be employed to reduce chlorinated volatile organic concentrations to health based levels. Successfully treated soil/sediment will be used at the Station as clean fill. The Site 6 - Flume Area will be restored with clean fill and 4 inches of topsoil for revegetation. The Site 6 - Flume Area and contaminant concentrations that exceed risk-based remediation levels (RLs) are shown in Figures 2-4 and 2-5.

OU XV includes groundwater, surface water, and sediment at the Site 6 - Impoundment Area. Although some potential for human health and ecological risk exists at the Site 6 - Impoundment Area, remediation of the site would harm the surrounding ecological receptors by destroying habitat. As such, no active remediation is recommended for the areas contaminated with nitramines/nitroaromatics, chlorinated volatiles, and inorganics. Long-term groundwater, surface water, and sediment monitoring will be conducted to determine if the surface water and groundwater in the Site 6 - Impoundment Area are impacted by the sediment contamination or if contaminant concentrations are increasing or decreasing over time. The Site 6 - Impoundment Area and contaminant concentrations that exceed risk-based remediation levels are shown in Figure 2-4.

Potential for ecological risk exists at OU XIV (Site 6 - Excavated Area). To protect the environment, a soil cover will be placed over the Site 6 - Excavated Area to prevent ecological receptors from coming into contact with the zinc and cadmium-contaminated surface soil. The cover will consist of 8-inches of fill and 4-inches of topsoil for revegetation. The Site 6 - Excavated Area and contaminant concentrations that

exceed risk-based remediation levels are shown in Figure 2-4.

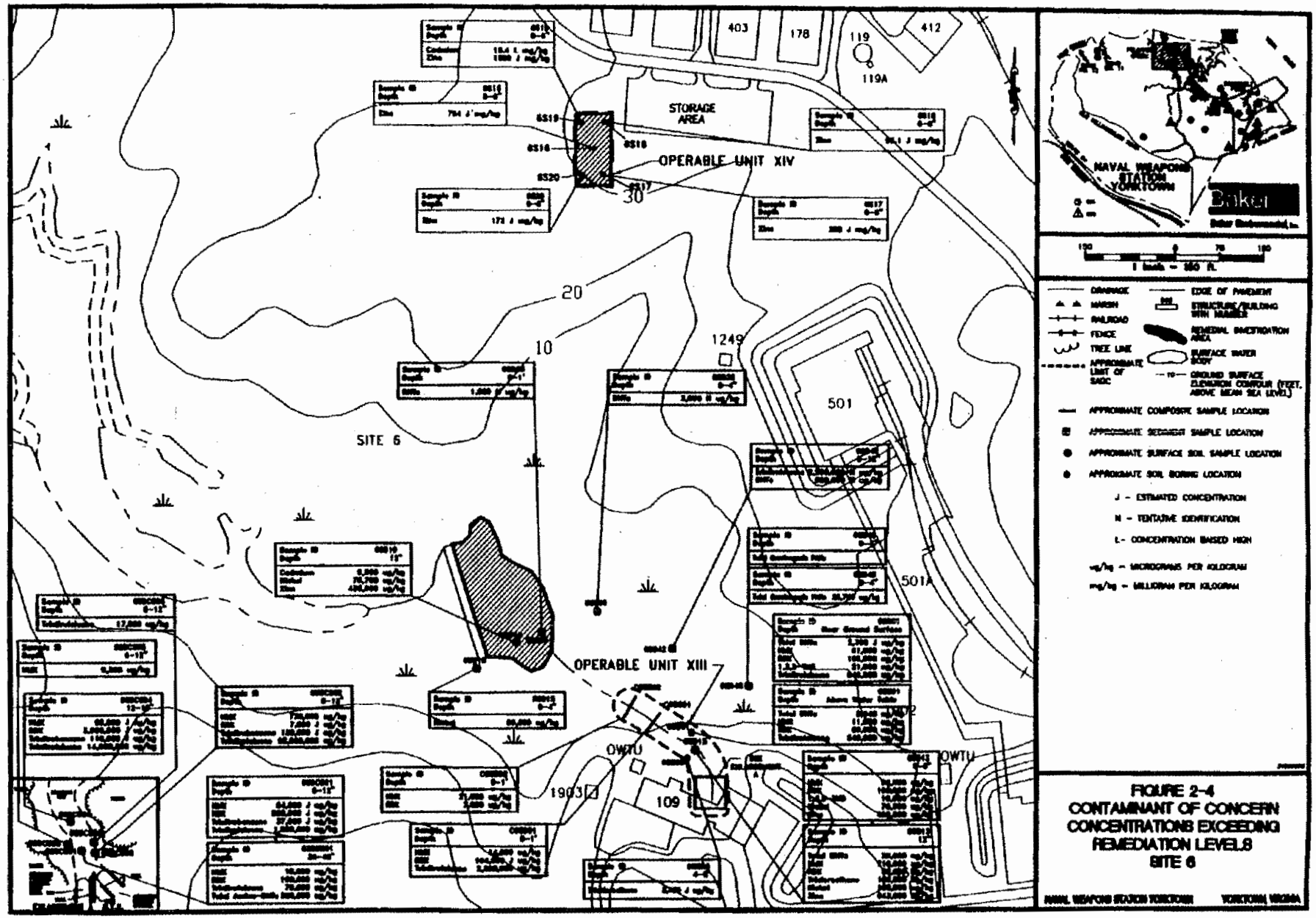


FIGURE 2-4
CONTAMINANT OF CONCERN CONCENTRATIONS EXCEEDING REMEDIATION LEVELS
SITE 6

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

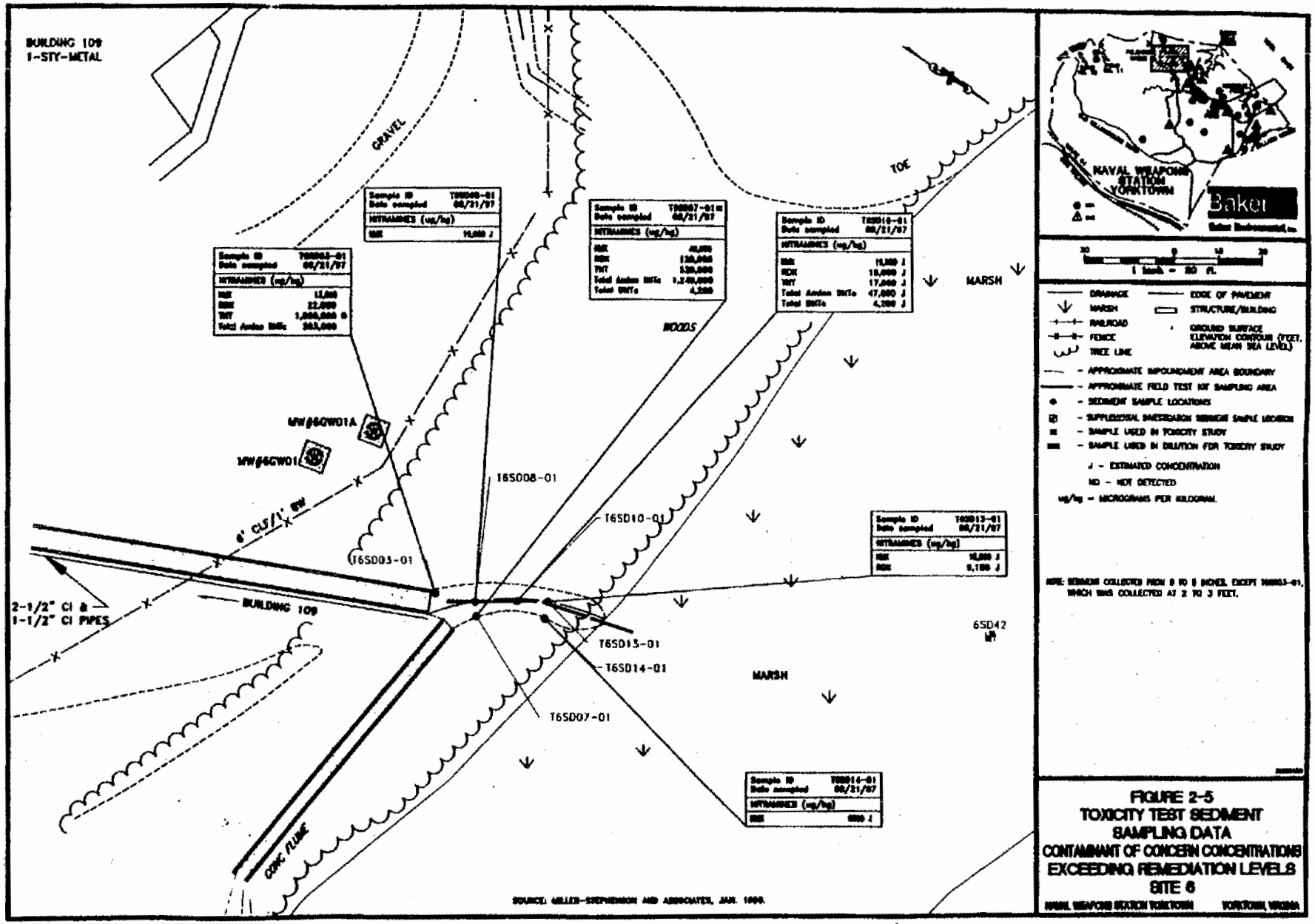


FIGURE 2-5
TOXICITY TEST SEDIMENT SAMPLING DATA
CONTAMINANT OF CONCERN CONCENTRATIONS EXCEEDING REMEDIATION LEVELS
SITE 6
NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

2.5 Summary of Site Characteristics

OU XII - Site 7 - Drainage Area

- Approximately 800 cubic yards of soil and sediment at the Site 7 - Drainage Area was contaminated with nitramines/nitroaromatics including TNT (as high as 40,000 mg/Kg), HMX (as high as 3,200 mg/Kg) and RDX (as high as 14,000 mg/Kg). This soil and sediment was removed during a full-scale Pilot Study for ex-situ bioremediation conducted at the biocell at Site 22 at WPNSTA. The contaminants TNT and RDX could cause both noncarcinogenic and carcinogenic health effects in exposed humans. The most recent toxicity data for HMX indicates that only systemic (noncarcinogenic) health effects could occur in humans subsequent to exposure. TNT, RDX and HMX are only slightly mobile in environmental media, relative to very mobile organic contaminants such as the chlorinated volatile organics.

OU XIII - Site 6 - Flume Area

- Approximately 1,000 cubic yards of soil and sediment in the Site 6 - Flume Area is contaminated with nitramines, nitroaromatics, and VOCs. Contaminants of concern at the Site 6 - Flume Area include TNT (as high as 93,000 mg/Kg), RDX (as high as 3,900 mg/Kg), TCE (as high as 2,600 mg/Kg), nickel (as high as 232J mg/Kg) and zinc (as high as 698 mg/Kg). TCE could cause both systemic health effects as well as carcinogenic health effects in exposed human receptors. Zinc is a systemic toxicant and is not considered to be a known carcinogen. TCE and other chlorinated volatiles are very mobile in environmental media by virtue of their corresponding water solubility and relatively low octanol/water partitioning coefficients. Zinc is relatively immobile in environmental media, as are most inorganic contaminants.

OU XIV - Site 6 - Excavated Area

- Soil from OU XIV may have been excavated to build the dam at the Impoundment Area. Approximately 500 cubic yards of soil in the Site 6 - Excavated Area is contaminated with cadmium (18.4 mg/Kg) and zinc (1,950 mg/Kg). These inorganic constituents pose a potential ecological risk. Cadmium and zinc could cause systemic health effects in potentially exposed human receptors. Both contaminants are considered to be relatively immobile in environmental media.

OU XV - Site 6 - Impoundment Area Surface Water and Sediment, Surface Water at Site 7, Groundwater at Site 6 and 7

- The Site 6 - Impoundment Area is located at the terminal end of the Site 6 - Flume Area. Sediment in the Site 6 - Impoundment is contaminated with nitramines/nitroaromatics, chlorinated volatile organics and inorganics. The highest concentrations of these contaminants occur at depth where TNT was detected at a maximum concentration of 2,500 mg/Kg and 4-amino-2,6-DNT was detected at a maximum of 520 mg/Kg. The contaminant 4-amino-2,6-DNT is a systemic toxicant that is relatively immobile in environmental media.

- Groundwater beneath Site 6 and 7, which is not currently used as a source of potable water, is contaminated with chlorinated volatile organics including TCE which was detected at a maximum concentration of 370 ug/L, nitramines/nitroaromatics including HMX (7.6 ug/L) and RDX (16 ug/L), and inorganics. It could also act as a potential source of contamination to Site 6 surface water where volatile organics such as TCE were detected at concentrations of 15 ug/L during the Round One RI. Nitramines/nitroaromatics were also detected in surface water samples taken from the Site 6 - Impoundment Area.

2.6 Summary of Site Risks

A baseline risk assessment (RA) was conducted as part of the Sites 6 and 7 Round Two Remedial Investigation Report (Baker, 1998). Both human health and ecological RAs were conducted. This section summarizes the results of the baseline RA and those contaminants associated with unacceptable human health risks and potential adverse ecological effects.

Human health risks are described by evaluating noncarcinogenic (systemic) and carcinogenic health effects. Reference dose (RfDs) values have been developed by EPA for indicating the potential for adverse health effects from exposure to contaminants of potential concern (COPCs) exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/Kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. RfDs are derived from human epidemiological data or animal studies to which uncertainty factors have been applied to account for the use of animal data to predict effects on humans. These uncertainty factors help ensure that the RfD's will not underestimate the potential for adverse noncarcinogenic effects to occur.The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g, lifetime) with a reference dose for a similar exposure period. The ratio of exposure to the reference dose is called a hazard quotient (HQ). HQ values are then summed to produce hazard indices (HIs) for each potential receptor and means of exposure (dermal, ingestion, inhalation). If a hazard index is greater than or equal to 1.0, the contaminants included in the hazard index are re-examined to see whether they affect the same target organ (e.g., liver). If they do not, new hazard indices are computed, summing HQ values only for contaminants that affect a single target organ. Contaminants that affect a single target organ and produce a hazard index greater than or equal to 1.0 are considered to be chemicals of concern (COCs) and remedial action is considered to reduce the risk of adverse, noncarcinogenic health effects in the exposed population.

Carcinogenic human health risks are expressed as a probability known as an incremental lifetime cancer risk (ICR). This risk is the incremental probability that an individual will develop cancer in his or her lifetime following exposure to a contaminant. These risks are usually expressed in scientific notation (e.g., 1×10^{-6}). An incremental lifetime cancer risk of 1×10^{-6}, for example, indicates that an individual who receives an estimated reasonable maximum exposure to contaminants at a site has a 1 in 1,000,000 chance of developing cancer as a result. This is referred to as an "incremental lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes (for example, smoking). The ICR values for all potentially carcinogenic COPCs to which a person may be exposed are added together. The total ICR value is compared to EPA's generally acceptable risk range of 1×10^{-4} to 1×10^{-6}. The generally acceptable risk range is the range of cancer risks considered to be acceptable at most sites under most circumstances. For example, the upper end of USEPA's acceptable risk range, 1×10^{-4}, means that one additional cancer case is estimated to occur in an exposed population of 10,000 as a result of exposure to the site. It can also mean that an individual with an ICR value of 1×10^{-4} has an estimated increased probability of 0.01% of contracting cancer following exposure over the course

of a lifetime.

ICR values of 10^{-4} or greater are evaluated to identify those contaminants in environmental media responsible for 95% of the unacceptable risk. These chemicals are considered to be COCs and remedial action is considered to reduce the cancer risk.

Because WPNSTA Yorktown was placed on the National Priority List (NPL) as a result of ecological concerns (proximity to wetlands, etc.) potential ecological receptors are also evaluated at each site. Terrestrial and aquatic receptors are evaluated by: 1) a general comparison to existing toxicity criteria; and 2) conservative contaminant uptake modeling to establish a site specific body burden in an animal or organism and a comparison to published toxicity data for a similar animal or organism. Both phases of the ecological risk assessment culminate with the calculation of ecological HQs. Ecological HQ values greater than or equal to 1.0 indicate the potential for adverse effects on the environment, and chemicals producing these values are considered ecological contaminants of concern. Remediation of these contaminants must be considered carefully, so that the selected remedy does not create more short-term harm to the ecological receptors than is produced by leaving contaminants in place. For example, scientists must decide if more damage will be done by removing sediments and destroying a wetland or by having contaminants remain in the sediment.

2.6.1 Human Health Risk Assessment

Because of the nature of activities conducted at and around Sites 6 and 7, potential current human exposure is limited. Both sites lie within the Explosive Safety Quantity Distance (ESQD) arc (associated with the storage of munitions) and inside the restricted area of the Station. Residential development is not permitted in these areas. Current potential human receptors evaluated in the baseline RA for Sites 6 and 7 include:

- Adolescent (7-15 years old) Trespassers
- Adult Trespassers
- Civilian Adult Workers

The adult and adolescent trespasser scenario is unlikely, but assumes that Station personnel and adolescent family members would trespass onto the site for recreational purposes. The exposure potential was assumed to occur up to 143 days per year for 4 years. This estimate is conservative because current property use restrictions prohibit this type of exposure at Sites 6 and 7.

The civilian adult worker scenario assumes that workers could potentially be exposed to contaminants in surface soil, airborne dust from surface soil, surface water, and sediment during cutting/clearing of tall grasses and trees or other general maintenance activities. This would occur infrequently so the potential exposure was assumed to be 14 days per year, 8 hours per day for 25 years.

Future potential human receptors evaluated in the baseline RA for Sites 6 and 7 include:

- Future On-Site Adult and Young Child (1-6 years old) Residents
- Future Adult and Adolescent (7-15 years old) Recreational Users at Felgates Creek and Tributaries
- Future On-Site Adult Construction Workers
- Future On-Site Adult Commercial Workers

Future residential development is unlikely at Sites 6 and 7 because they fall within the restricted area of the Station. However, the future on-site adult and young child resident scenario was evaluated to address all types of potential exposure and provide a conservative estimate of future human risk. Future adult and young child residents were evaluated for potential exposure to groundwater, surface soil, surface water, and sediment. An exposure frequency for surface soil of 350 days per year with durations of 24 years for adults and 6 years for child residents was used. For groundwater, surface water, and sediment, an exposure frequency of 40 days per year for the same durations as for surface soil was assumed.

Groundwater was also evaluated as part of the future residential scenario. The shallow aquifers (Cornwallis Cave and Upper Yorktown) are not currently used as a source of potable water. Although pump tests were not performed for the Cornwallis Cave or Upper Yorktown-Eastover aquifers in the vicinity of Sites 6 and 7, these aquifers can produce low yields (0 to 10 gallons per minute throughout WPNSTA Yorktown) (Brockman, et al., 1997) and contain naturally-occurring concentrations of inorganics including iron, manganese, and zinc in excess of Secondary Maximum Contaminant Levels (SMCLs). Groundwater was evaluated in the baseline RA for non-potable use, considering a beneficial use scenario such as lawn watering and car washing by future residents. Potential human health risks derived assuming a beneficial use scenario for groundwater fall within the generally acceptable target risk range, but the potential effects on the water quality in the Site 6 - Impoundment Area and the ecology have not been determined.

The following subsections present a summary of the human health risk assessment, unacceptable risks, and the role of the selected remedy in addressing unacceptable risks.

Site 6

Tables 2-1 and 2-2 present COPCs for affected media at Site 6. Tables in Appendix A include concentrations for COPCs at Site 6.

ICR values at Site 6 fall within USEPA's acceptable risk range for all environmental media assuming future residential property use (Table 2-3). Cumulative HI values, the sum of all HQs, exceed 1.0 for future resident children exposed to aluminum, arsenic, antimony, cadmium, iron, and manganese in soil. Individual HQ values calculated specifically for these contaminants do not exceed 1.0. These contaminants do not affect similar target organs; therefore, adverse noncarcinogenic human health risks are not expected to occur following residential exposure to Site 6 soil at any area.

The presence of 4-amino-2,6-DNT; TNT; and iron in the Site 6-Impoundment Area sediment produces cumulative HI values in excess of 1.0 for both exposed children and adults. Individual contaminant HQs do not exceed 1.0, even though TNT and 4-amino-2,6-DNT HQ values are summed because the liver would most likely be the target organ for these contaminants. Under these circumstances, these contaminants do not pose an unacceptable health risk.

Table 2-4 presents ICR and HI values for potential adult and adolescent trespassers. ICR values for all environmental media evaluated at Site 6 fall within USEPA's acceptable risk range of 1×10^{-4} to 1×10^{-6}. HI values are below 1.0 for all media with the exception of the Site 6 - Impoundment Area sediment, where 4-amino-2,6-DNT produces HQ values in excess of 1.0 under reasonable maximum exposure (RME) analysis of both adult (HQ=3.0) and adolescent receptors (HQ=3.8). Cumulative HI values for adults and adolescents exposed to Site 6 - Impoundment Area sediment are 4.4 and 5.7, respectively, indicating the potential for adverse noncarcinogenic health effects to occur subsequent to exposure. Although 4-amino-2,6-DNT produces elevated HQ values, the presence of 4-amino-2,6-DNT at a single location (6SD42), detected at a maximum concentration of 520 mg/Kg is responsible for HQ values in excess of 1.0. No other contaminant detected in the Site 6 - Impoundment Area at any other location produces an HQ value above 1.0.

TABLE 2-1

SITE 6
SUMMARY OF HUMAN HEALTH COPCs FOR SOIL AND SEDIMENT
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Excavated Area Soil	Surface Soil (Round One)	Surface Soil (Round Two)[1]	Subsurface Soil	Flume/ Impoundment Area Sediment[1]	Tributary Sediment
Volatiles:						
1,1-Dichloroethane					X	
1,2-Dichloroethane					X	
1,1-Dichloroethene				X	X	
cis-1,2-Dichloroethene				X		
trans-1,2-Dichloroethene				X		
1,2-Dichloroethene (Total)					X	
1,1,2,2-Tetrachloroethane				X		
Tetrachloroethene				X	X	
1,1,1-Trichloroethane					X	
1,1,2-Trichloroethane				X		
Trichloroethene				X	X	
Vinyl Chloride				X	X	
Semivolatiles:						
Acenaphthene					X	
Anthracene					X	
Benzo(a)anthracene		X			X	
Benzo(a)pyrene		X			X	
Benzo(b)fluoranthene		X			X	
Benzo(k)fluoranthene		X			X	
Benzo(g,h,i)perylene					X	

TABLE 2-1 (continued)

SITE 6
SUMMARY OF HUMAN HEALTH COPCs FOR SOIL AND SEDIMENT
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Excavated Area Soil	Surface Soil (Round One)	Surface Soil (Round Two)[1]	Subsurface Soil	Flume/ Impoundment Area Sediment [1]	Tributary Sediment
Carbazole					X	
Chrysene		X			X	
Dibenzo(a,h) anthracene		X			X	
2,4-Dinitrotoluene					X	
2,6-Dinitrotoluene					X	
Fluoranthene					X	
Fluorene					X	
Indeno(1,2,3-cd) pyrene		X			X	
2-Methylnaphthalene					X	
Naphthalene					X	
Phenanthrene					X	
Pyrene					X	
Nitramines:						
2-Amino-4,6-Dinitrotoluene				X		
4-Amino-2,6-Dinitrotoluene				X	X	
1,3-Dinitrobenzene					X	
HMX					X	
RDX				X	X	
1,3,5-Trinitrobenzene				X	X	
2,4,6-Trinitrotoluene				X	X	

TABLE 2-1 (continued)

SITE 6
SUMMARY OF HUMAN HEALTH COPCs FOR SOIL AND SEDIMENT
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Excavated Area Soil	Surface Soil (Round One)	Surface Soil (Round Two) [1]	Subsurface Soil	Flume/ Impoundment Area Sediment [1]	Tributary Sediment
Inorganics:						
Aluminum	X	X	X		X	X
Antimony	X		X	X	X	
Arsenic	X	X	X	X	X	X
Beryllium	X	X	X	X	X	X
Cadmium	X				X	
Chromium	X			X	X	X
Iron	X	X	X	X	X	X
Manganese			X	X	X	X
Nickel					X	
Vanadium					X	X
Zinc	X				X	

Notes:

[1] Includes COPCs selected from analytical data acquired over the combined Round Two RI and Round Two Supplemental Investigation.

TABLE 2-2

SITE 6
SUMMARY OF HUMAN HEALTH COPCs FOR GROUNDWATER AND SURFACE WATER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Groundwater (Dissolved)	Groundwater (Total)	Impoundment Area Surface Water (Total)	Tributary Area Surface Water (Total)
Volatiles:				
1,1-Dichloroethane	X	X	X	
1,1-Dichloroethene	X	X	X	
cis-1,2-Dichloroethene	X	X		
trans-1,2-Dichloroethene	X	X		
1,2-Dichloroethene (Total)			X	
1,1,2,2-Tetrachloroethane			X	
1,1,1-Trichloroethane	X	X	X	X
Trichloroethene	X	X		
Semivolatiles:				
Benzo(a)anthracene			X	
Benzo(a)pyrene			X	
Benzo(b)fluoranthene			X	
Benzo(k)fluoranthene			X	
Chrysene			X	
Phenanthrene			X	

TABLE 2-2 (continued)

SITE 6
SUMMARY OF HUMAN HEALTH COPCs FOR GROUNDWATER AND SURFACE WATER
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Groundwater (Dissolved)	Groundwater (Total)	Impoundment Area Surface Water (Total)	Tributary Area Surface Water (Total)
Nitramines:				
4-Amino-2,6-Dinitrotoluene	X	X		
HMX			X	
RDX	X	X	X	
2,4,6-Trinitrotoluene			X	
Inorganics:				
Aluminum			X	
Antimony	X			
Arsenic	X	X	X	X
Beryllium			X	
Chromium			X	
Iron		X	X	X
Lead			X	
Manganese	X	X	X	X
Mercury			X	
Nickel			X	
Thallium	X			
Vanadium			X	
Zinc	X			

TABLE 2-3

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
SITE 6
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors[1]			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Surface Soil (Drainage Area-Round One)				
Ingestion	5.7×10^{-06} (6.3×10^{-07})	0.12 (0.03)	1.3×10^{-05} (3.9×10^{-06})	[redacted]
Dermal Contact	1.7×10^{-05} (7.4×10^{-07})	0.29 (0.03)	7.5×10^{-06} (8.0×10^{-07})	0.51 (0.05)
Subtotal	2.3×10^{-05} (1.4×10^{-06})	0.41 (0.06)	2.0×10^{-05} (4.7×10^{-06})	[redacted]
Surface Soil (Drainage Area-Round Two)				
Ingestion	6.3×10^{-06} (5.5×10^{-07})	0.21 (0.05)	1.5×10^{-05} (3.4×10^{-06})	[redacted]
Dermal Contact	1.2×10^{-05} (4.2×10^{-07})	0.61 (0.05)	5.5×10^{-06} (4.5×10^{-07})	[redacted]
Subtotal	1.8×10^{-05} (9.7×10^{-07})	0.82 (0.1)	2.0×10^{-05} (3.8×05^{-06})	[redacted]
Surface Soil (Excavated Area)				
Ingestion	6.6×10^{-06} (6.8×10^{-07})	0.26 (0.07)	1.5×10^{-05} (4.3×10^{-06})	[redacted]
Dermal Contact	1.3×10^{-05} (5.1×10^{-07})	0.66 (0.06)	5.8×10^{-06} (5.6×10^{-07})	[redacted]
Subtotal	2.0×10^{-05} (1.2×10^{-06})	0.92 (0.13)	2.1×10^{-05} (4.9×10^{-06})	[redacted]

TABLE 2-3 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
SITE 6
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors[1]			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Groundwater[2]				
Ingestion	1.4×10^{-06} (2.4×10^{-07})	0.02 0.01	1.6×10^{-06} (7.4×10^{-07})	0.1 (0.05)
Dermal Contact	3.3×10^{-06} (5.2×10^{-07})	0.11 (0.05)	1.5×10^{-06} (5.6×10^{-07})	0.19 (0.07)
Subtotal	4.7×10^{-06} (7.6×10^{-07})	0.13 (0.06)	3.1×10^{-06} (1.3×10^{-06})	0.29 (0.12)
Surface Water[3] (Drainage Area)				
Ingestion	4.2×10^{-07} (1.5×10^{-07})	0.02 (0.02)	4.9×10^{-07} (4.6×10^{-07})	0.1 (0.08)
Dermal Contact	4.4×10^{-07} (1.6×10^{-07})	0.01 (0.01)	2.0×10^{-07} (1.7×10^{-07})	0.02 (0.02)
Subtotal	8.6×10^{-07} (3.1×10^{-07})	0.02 (0.03)	6.9×10^{-07} (6.3×10^{-07})	0.3 (0.1)
Surface Water[3] (Impoundment Area)				
Ingestion	2.4×10^{-06} (5.4×10^{-07})	0.07 (0.03)	2.9×10^{-06} (1.7×10^{-06})	0.32 (0.14)
Dermal Contact	9.5×10^{-05} (3.3×10^{-05})	0.03 (0.01)	4.2×10^{-05} (3.6×10^{-05})	0.06 (0.02)
Subtotal	9.7×10^{-05} (3.4×10^{-05})	0.1 (0.04)	4.5×10^{-05} (3.8×10^{-05})	0.38 (0.16)

TABLE 2-3 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
SITE 6
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors[1]			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Sediment (Drainage Area)				
Ingestion	1.5×10^{-06} (1.9×10^{-07})	0.02 (0.01)	3.5×10^{-06} (1.2×10^{-06})	0.2 (0.07)
Dermal Contact	4.4×10^{-06} (2.2×10^{-07})	0.05 (0.01)	1.9×10^{-05} (2.4×10^{-07})	0.09 (0.01)
Subtotal	5.9×10^{-06} (4.1×10^{-07})	0.07 (0.02)	5.4×10^{-06} (1.4×10^{-06})	0.29 (0.08)
Sediment (Impoundment Area)				
Ingestion	2.0×10^{-06} (2.8×10^{-07})	0.14 (0.04)	4.6×10^{-06} (1.7×10^{-06})	[redacted]
Dermal Contact	1.0×10^{-05} (5.7×10^{-07})	1.1 (0.1)	4.6×10^{-06} (6.2×10^{-07})	[redacted]
Subtotal	1.2×10^{-05} (8.5×10^{-07})	[redacted]	9.2×10^{-06} (2.3×10^{-06})	[redacted]

Notes:

(1) Risk values in parentheses represent central tendency (CT) estimates. Central tendency estimates reflect an average scenario as opposed to a worst-case scenario.
(2) Non-potable use of groundwater evaluated. Risk value derived using organic and dissolved inorganic concentrations.
(3) Risk value derived using organic and total inorganic concentrations.

Shaded areas indicate exceedances of the USEPA's acceptable target risk criteria.

TABLE 2-4

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR CURRENT ADULT AND ADOLESCENT ON-STATION TRESPASSERS
SITE 6
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors[1]			
	Adults		Adolescents (7-15 yrs.)	
	ICR	HI	ICR	HI
Surface Soil (Drainage Area-Round One)				
Ingestion	1.9×10^{-07} (8.5×10^{-08})	0.02 (0.01)	3.7×10^{-07} (1.6×10^{-07})	0.05 (0.02)
Dermal Contact	1.2×10^{-06} (2.0×10^{-07})	0.12 (0.02)	1.4×10^{-06} (2.3×10^{-07})	0.15 (0.02)
Subtotal	1.4×10^{-06} (2.9×10^{-07})	0.14 (0.03)	1.8×10^{-06} (3.9×10^{-06})	0.2 (0.04)
Surface Soil (Drainage Area-Round Two)				
Ingestion	4.3×10^{-07} (1.5×10^{-07})	0.09 (0.03)	2.0×10^{-06} (6.9×15^{-07})	0.4 (0.13)
Dermal Contact	8.4×10^{-07} (1.1×10^{-07})	0.25 (0.03)	1.0×10^{-06} (1.3×10^{-07})	0.31 (0.04)
Subtotal	1.3×10^{-06} (2.6×10^{-07})	0.34 (0.06)	3.0×10^{-06} (8.2×10^{-07})	0.71 (0.17)
Surface Soil (Excavated Area)				
Ingestion	2.2×10^{-07} (9.3×10^{-08})	0.05 (0.02)	4.2×10^{-07} (1.8×10^{-07})	0.1 (0.04)
Dermal Contact	8.9×10^{-07} (1.4×10^{-07})	0.27 (0.04)	1.1×10^{-06} (1.6×10^{-07})	0.34 (0.04)
Subtotal	1.1×10^{-06} (2.3×10^{-07})	0.32 (0.06)	1.5×10^{-06} (3.4×10^{-06})	0.44 (0.08)

TABLE 2-4 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR CURRENT ADULT AND ADOLESCENT ON-STATION TRESPASSERS
SITE 6
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors[1]			
	Adults		Adolescents (7-15 yrs.)	
	ICR	HI	ICR	HI
Surface Water[2] (Drainage Area)				
Ingestion	2.5×10^{-07} (2.4×10^{-07})	0.08 (0.06)	4.7×10^{-07} (4.5×10^{-07})	0.03 (0.03)
Dermal Contact	2.6×10^{-07} (2.5×10^{-07})	0.05 (0.03)	3.3×10^{-07} (2.8×10^{-07})	0.06 (0.04)
Subtotal	5.1×10^{-07} (4.9×10^{-07})	0.13 (0.09)	8.0×10^{-07} (7.3×10^{-07})	0.09 (0.07)
Surface Water[2] (Impoundment Area)				
Ingestion	1.5×10^{-06} (8.6×10^{-07})	0.25 (0.1)	2.8×10^{-06} (1.6×10^{-06})	0.46 (0.2)
Dermal Contact	5.6×10^{-05} (5.3×10^{-05})	0.12 (0.05)	7.0×10^{-05} (7.0×10^{-05})	0.14 (0.07)
Subtotal	5.8×10^{-05} (5.4×10^{-05})	0.37 (0.15)	7.3×10^{-05} (7.2×10^{-05})	0.6 (0.27)
Sediment (Drainage Area)				
Ingestion	9.0×10^{-07} (2.9×10^{-07})	0.08 (0.03)	1.7×10^{-06} (5.6×10^{-07})	0.15 (0.05)
Dermal Contact	2.6×10^{-06} (3.5×10^{-07})	0.18 (0.02)	3.2×10^{-06} (4.0×10^{-07})	0.22 (0.03)
Subtotal	3.5×10^{-06} (6.4×10^{-07})	0.26 (0.05)	4.9×10^{-06} (9.6×10^{-07})	0.37 (0.08)

TABLE 2-4 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR CURRENT ADULT AND ADOLESCENT ON-STATION TRESPASSERS
SITE 6
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors[1]			
	Adults		Adolescents (7-15 yrs.)	
	ICR	HI	ICR	HI
Sediment (Impoundment Area)				
Ingestion	1.2×10^{-06} (4.5×10^{-07})	0.49 (0.14)	2.2×10^{-06} (8.4×10^{-07})	0.93 (0.26)
Dermal Contact	6.2×10^{-06} (1.4×10^{-06})	[redacted]	7.7×10^{-06} (1.6×10^{-06})	[redacted]
Subtotal	7.4×10^{-06} (1.9×10^{-06})	[redacted]	9.9×10^{-06} (1.0×10^{-06})	[redacted]

Notes:

(1) Risk values in parentheses represent central tendency (CT) estimates. Central tendency estimates reflect an average scenario as opposed to a worst-case scenario.
(2) Risk value derived using organic and total inorganic concentrations.

Shaded areas indicate exceedances of the USEPA's acceptable target risk criteria.

TNT in subsurface soil produces an HQ value of 3.2 for future construction workers who may dig throughout the Site 6 study area. The total HI for future construction workers exposed to subsurface soil is 4.4 (Table 2-5). Subsurface soil samples obtained in the vicinity of the Site 6 - Impoundment Area are responsible for the elevated concentrations of TNT. The ICR value for future construction workers falls within USEPA's acceptable risk range.

Site 7

Table 2-6 presents human health COPCs evaluated for Site 7. Data presented in this section were collected prior to the removal action conducted in 1996, but do not include qualitative data for nitramines/nitroaromatics collected in the Site 7 - Drainage Area as part of the removal action and full scale Pilot Study. Detailed COPC summaries are presented in Appendix A along with a comparison to appropriate Station-wide background concentrations.

Analyses of risks to future adult and child residents exposed to Site 7 soil produce HI values of 1.2 and 4.4, respectively (Table 2-7). These elevated HI values are caused by inorganics including iron, antimony, manganese and arsenic. Of these COPCs only iron produced HQ values greater than or equal to 1.0. Iron was detected at a single soil sampling location in excess of Station-wide background and this detection is responsible for the majority of the elevated HI values for both children and adults. This soil location was situated within the Site 7 - Drainage Area and was removed in 1996. Iron does not exceed the maximum Station-wide anthropogenic background surface soil concentration (46,400 mg/kg) at any other sampling location. Arsenic, antimony, and manganese account for the remainder of the elevated HI values but do not produce HQs in excess of 1.0 individually and do not affect the same target organ. Therefore, unacceptable noncarcinogenic health effects are not expected subsequent to surface soil exposure at Site 7. ICR values for all media evaluated at Site 7 fall within or below USEPA's acceptable risk range of 10^{-4} to 10^{-6}.

Potential current adult and adolescent trespassers exposed to environmental media at Site 7 exhibit HI values below 1.0, indicating that adverse noncarcinogenic health effects are not expected to occur. ICR values for all media fall below or within USEPA's acceptable risk range (Table 2-8). However, qualitative data from the Site 7 Drainage Area indicate the presence of TNT, RDX and amino-DNTs at concentrations that would produce both carcinogenic and noncarcinogenic human health risks subsequent to exposure.

2.6.2 Ecological Risk Assessment

The ecological risk assessment evaluates Sites 6 and 7 considering potential exposure of terrestrial and aquatic receptors to contaminants at the sites. Table 2-9 presents the ecological contaminants of concern (ECOCs) for both Sites 6 and 7. Appendix B presents detailed ECOC tables for both sites by medium and a comparison to appropriate Station-wide background concentrations in similar media.

TABLE 2-5

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE CONSTRUCTION WORKERS
SITES 6 AND 7
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Site 6[1]	
	Construction Workers	
	ICR	HI
Subsurface Soil		
Accidental Ingestion	1.5×10^{-06} (8.7×10^{-07})	[redacted]
Dermal Contact	8.1×10^{-07} (6.7×10^{-08})	[redacted]
Inhalation[2]	3.6×10^{-10} (2.5×10^{-10})	<0.01 (<0.01)
TOTAL	2.3×10^{-06} (9.4×10^{-07})	[redacted]

Notes:

(1) Risk values in parentheses represent central tendency (CT) estimates. Central tendency estimates reflect an average scenario as opposed to a worst-case scenario.

(2) Fugitive dusts.

Shaded areas indicate exceedances of the USEPA's acceptable target risk criteria.

TABLE 2-6

SITE 7 AND FELGATES CREEK
SUMMARY OF HUMAN HEALTH COPCs
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Site 7 Shallow Soils	Site 7 Subsurface Soil	Site 7 Groundwater (Dissolved	Site 7 Groundwater (Total)	Site 7 Drainage Area Surface Water (Total)	Felgates Creek Surface Water (Total)	Site 7 Drainage Area Sediment	Felgates Creek Sediment
Volatiles:								
1,1-Dichloroethane			X	X				
1,1-Dichloroethene			X	X				
1,1,1-Trichloroethane			X	X				
Nitramines:								
4-Amino-2,6-DNT			X	X				
RDX			X	X				
Inorganics:								
Aluminum	X	X		X			X	X
Antimony	X	X	X	X				
Arsenic	X	X		X	X	X	X	X
Beryllium	X	X					X	X
Cadmium	X							
Chromium	X	X		X			X	X
Iron	X	X		X	X	X	X	X
Manganese	X	X		X	X	X	X	X
Vanadium				X			X	X

TABLE 2-7

**INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
SITE 7
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Pathway	Receptors[1]			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Surface Soil (Study Area)				
Ingestion	9.7×10^{-06} (8.1×10^{-07})	0.3 (0.07)	2.3×10^{-05} (5.1×10^{-06})	[redacted]
Dermal Contact	1.9×10^{-05} (6.1×10^{-07})	0.93 (0.08)	8.4×10^{-06} (6.6×10^{-07})	[redacted]
Subtotal	2.9×10^{-05} (1.4×10^{-06})	[redacted]	3.1×10^{-05} (5.8×10^{-06})	[redacted]
Groundwater[2]				
Ingestion	6.0×10^{-07} (9.4×10^{-08})	0.06 (0.02)	7.0×10^{-07} (2.9×10^{-07})	0.26 (0.1)
Dermal Contact	1.3×10^{-07} (1.9×10^{-08})	0.03 (0.01)	5.7×10^{-08} (2.1×10^{-08})	0.05 (0.02)
Subtotal	7.3×10^{-07} (1.1×10^{-07})	0.09 (0.03)	7.6×10^{-07} (3.1×10^{-07})	0.31 (0.12)
Surface Water[3] (Study Area)				
Ingestion	2.4×10^{-07} (7.1×10^{-08})	<0.01 (<0.01)	2.8×10^{-07} (2.2×10^{-07})	0.02 (0.01)
Dermal Contact	2.7×10^{-08} (7.4×10^{-09})	<0.01 (<0.01)	1.2×10^{-08} (8.1×10^{-09})	<0.01 (<0.01)
Subtotal	2.7×10^{-07} (7.8×10^{-08})	<0.01 (<0.01)	2.9×10^{-07} (2.3×10^{-07})	0.02 (0.01)

TABLE 2-7 (Continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
SITE 7
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors[1]			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
Sediment (Study Area)				
Ingestion	1.3×10^{-06} (2.3×10^{-07})	0.04 (0.02)	3.1×10^{-06} (1.4×10^{-06})	0.38 (0.18)
Dermal Contact	2.7×10^{-06} (1.8×10^{-07})	0.12 (0.02)	1.2×10^{-06} (1.9×10^{-07})	0.2 (0.03)
Subtotal	4.0×10^{-06} (4.1×10^{-07})	0.16 (0.04)	4.3×10^{-06} (1.6×10^{-06})	0.58 (0.21)

Notes:

(1) Risk values in parentheses represent central tendency (CT) estimates. Central tendency estimates reflect an average scenario as opposed to a worst-case scenario.
(2) Non-potable use of groundwater evaluated. Risk value derived using organic and dissolved inorganic concentrations.
(3) Risk value derived using organic and total inorganic concentrations.

Shaded areas indicate exceedances of the USEPA's acceptable target risk criteria.

TABLE 2-8

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR CURRENT ADULT AND ADOLESCENT ON-STATION TRESPASSERS
SITE 7
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Pathway	Receptors[1]			
	Adults		Adolescents (7-15 yrs.)	
	ICR	HI	ICR	HI
Surface Soil (Study Area)				
Ingestion	3.3×10^{-07} (1.1×10^{-07})	0.06 (0.02)	6.2×10^{-07} (2.1×10^{-07})	0.12 (0.04)
Dermal Contact	1.3×10^{-06} (1.7×10^{-07})	0.45 (0.05)	1.6×10^{-06} (1.9×10^{-07})	0.55 (0.05)
Subtotal	1.6×10^{-06} (2.8×10^{-07})	0.51 (0.07)	2.2×10^{-06} (4.0×10^{-07})	0.67 (0.1)
Surface Water[2] (Study Area)				
Ingestion	1.4×10^{-07} (1.1×10^{-07})	0.01 (0.01)	2.7×10^{-07} (2.1×10^{-07})	0.02 (0.02)
Dermal Contact	1.6×10^{-08} (1.2×10^{-08})	0.01 (<0.01)	2.0×10^{-08} (1.3×10^{-08})	0.01 (<0.01)
Subtotal	1.6×10^{-07} (7.8×10^{-08})	0.02 (0.01)	2.9×10^{-07} (2.3×10^{-07})	0.03 (<0.01)
Sediment (Study Area)				
Ingestion	4.0×10^{-07} (1.8×10^{-07})	0.07 (0.03)	7.6×10^{-07} (3.5×10^{-07})	0.14 (0.06)
Dermal Contact	1.6×10^{-06} (2.8×10^{-07})	0.42 (0.07)	2.0×10^{-06} (3.1×10^{-07})	0.52 (0.08)
Subtotal	2.0×10^{-06} (4.6×10^{-07})	0.49 (0.1)	2.8×10^{-06} (6.6×10^{-07})	0.66 (0.14)

Notes:

(1) Risk values in parentheses represent central tendency (CT) estimates. Central tendency estimates reflect an average scenario as opposed to a worst-case scenario.

(2) Risk value derived using organic and total inorganic concentrations.

Shaded areas indicate exceedances of the USEPA's acceptable target risk criteria.

TABLE 2-9

ECOLOGICAL CONTAMINANTS OF CONCERN PER MEDIA
SITES 6 AND 7
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Site 6								Site 7				Felgates Creek	
	Impoundment Area			Flume Area	Excavated Area	Tributary		Ground-Water	Surface Soil	Surface Water	Sediment	Ground-Water	Surface Water	Sediment
	Surface Soil	Surface Water	Sediment	Sediment	Surface Soil	Surface Water	Sediment							
Volatiles														
Acetone			X	X			X				X			X
Carbon Disulfide			X				X	X			X			
Chloroethane			X											
Chloromethane			X											
1,1-Dichloroethane			X	X										
1,2-Dichloroethane			X											
1,2-Dichloroethene (total)				X										
Tetrachloroethene			X	X										
1,1,1-Trichloroethane			X	X										
Trichloroethene				X										
Vinyl Chloride			X	X										
Semivolatiles														
Acenaphthene			X	X										
Anthracene			X	X										
Benzo(a)anthracene	X		X	X										
Benzo(a)pyrene	X		X	X										
Benzo(b)fluoranthene	X													
Benzo(k)fluoranthene	X													
Benzo(g,h,i)perylene	X		X	X										
Bis(2-ethylhexyl)phthalate			X	X										
Carbazole			X	X										
Chrysene	X		X	X										
Di-n-butylphthalate											X			X

TABLE 2-9 (continued)

ECOLOGICAL CONTAMINANTS OF CONCERN PER MEDIA
SITES 6 AND 7
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Site 6								Site 7				Felgates Creek	
	Impoundment Area			Flume Area	Excavated Area	Tributary								
	Surface Soil	Surface Water	Sediment	Sediment	Surface Soil	Surface Water	Sediment	Ground-Water	Surface Soil	Surface Water	Sediment	Ground-Water	Surface Water	Sediment
Semivolatiles (continued)														
Dibenzo(a,h)anthracene			X	X										
Fluoranthene	X		X	X										
Fluorene			X	X										
Indeno(1,2,3-cd)pyrene	X		X											
2-Methylnaphthalene			X	X										
4-Methylphenol			X	X										
Naphthalene				X										
n-Nitrosodiphelamine				X										
Pentachlorophenol			X											
Phenanthrene	X		X	X										
Phenol							X							
Pyrene	X		X	X										
Pesticides														
4,4'-DDD				X										
4,4'-DDE				X										
4,4'-DDT				X										
Nitramines														
4-amino-2,6-Dinitrotoluene			X	X				X				X		
2-amino-4,5-Dinitrotoluene				X										
2,4-Dinitrotoluene			X	X										
2,6-Dinitrotoluene			X	X										
HMX	X	X	X	X				X				X		
RDX	X	X	X	X				X				X		
1,3,5-Trinitrobenzene			X	X										

TABLE 2-9 (continued)

ECOLOGICAL CONTAMINANTS OF CONCERN PER MEDIA
SITES 6 AND 7
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Ecological Contaminant of Concern	Site 6								Site 7				Felgates Creek	
	Impoundment Area			Flume Area	Excavated Area	Tributary		Ground-Water						
	Surface Soil	Surface Water	Sediment	Sediment	Surface Soil	Surface Water	Sediment		Surface Soil	Surface Water	Sediment	Ground-Water	Surface Water	Sediment
Nitramines (continued)														
2,4,6-Trinitrotoluene		X	X	X										
Inorganics														
Aluminum	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Antimony	X				X				X					
Arsenic			X	X			X	X			X	X		X
Beryllium	X		X	X	X		X		X		X			X
Cadmium			X	X	X		X		X					
Chromium	X	X	X		X				X					
Cobalt		X	X	X			X	X			X	X	X	X
Copper		X	X	X				X	X			X		
Cyanide				X					X					
Iron	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lead	X	X	X	X	X				X					
Manganese		X	X			X	X	X	X	X	X	X	X	X
Mercury	X	X	X	X					X					X
Nickel	X	X	X	X	X	X	X		X	X	X	X	X	X
Selenium			X	X										X
Silver											X			
Vanadium	X		X	X	X		X		X		X			X
Zinc	X	X	X	X	X		X		X		X	X		X

Site 6

Potential ecological risks were evaluated for both the terrestrial and aquatic environment within the Site 6 study area.

Soil samples were collected throughout the Site 6 study area. Concentrations of several soil-borne contaminants were greater than conservative flora/fauna toxicity benchmark values or were identified by computer models, known as terrestrial contaminant uptake models, as posing risks to animals and plants, including: RDX, aluminum, antimony, chromium, copper, iron, lead, mercury, vanadium, and zinc. Soil concentrations of aluminum, antimony, chromium, copper, iron, lead, mercury, vanadium, and zinc are similar to Station-wide background surface soil concentrations. Antimony, aluminum, mercury, and zinc exceeded background levels sporadically throughout the Site 6 - Impoundment; while zinc was detected in 12 out of 12 samples, only samples from two locations (6S06 and 6S15) exceeded background levels. It is not practical to remediate soil so as to reduce contaminant concentrations below background concentrations. Soil concentrations of RDX (detected in only one soil sample near the Site 6 - Flume Area) exceed soil flora and fauna values, but do not produce unacceptable risks in the terrestrial models. No action is, therefore, warranted for soil because of the presence of RDX from an ecological standpoint.

Surface water collected during the Round One RI from the Site 6 - Impoundment Area demonstrated potential risk to aquatic receptors from concentrations of TCA, HMX, RDX, TNT, aluminum, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, and zinc. This surface water was collected in 1991 and surface water was not present in the Site 6 - Impoundment Area during the Round Two RI. Surface water may be influenced by groundwater which has been affected by past activities at Site 6. Remediation of surface water as a medium is not possible because of the intermittent nature of its occurrence in the Site 6 - Impoundment Area. As such, long-term monitoring of surface water in the Site 6-Impoundment Area has been specified as the remedial action.

Sediment collected from the Site 6 - Impoundment Area demonstrated risk to benthic macroinvertebrates/aquatic receptors from concentrations of TCA, several polynuclear aromatic hydrocarbons (PAHs), beryllium, cadmium, chromium, iron, manganese, and nickel. Nitramine/nitroaromatic compounds (4-amino-DNT, 2,4-DNT, 2,6-DNT, HMX, RDX, 1,3,5-trinitrobenzene , and TNT) were detected in the sediment but were not initially evaluated because of a lack of comparison toxicity values. Site specific toxicity data were subsequently developed from the performance of both acute and chronic toxicity tests to provide an indication of the potential ecological effects associated with the presence of these contaminants in sediment. Sediment concentrations of beryllium, chromium, iron, manganese, and nickel were detected sporadically throughout the Impoundment at concentrations exceeding background levels. Of the contaminants detected at levels higher than background: fifty-four out of fifty-five samples showed concentrations of TCA that posed no risk to animals or plants; only one of fifty-five samples contained a concentration of TCA that might pose a potential risk to ecological receptors, because the concentration was greater than a risk-based screening concentration. Computer models, known as aquatic receptor contaminant uptake models, indicated that PAHs in sediment posed no unacceptable risks to aquatic plants or animals, however, one sediment sample contained cadmium at a concentration greater than the Effects Range-Medium value, which indicates that this particular sample was above the medium range of the ecological toxicity test value for cadmium. Based on risks presented in the contaminant uptake models, site-specific toxicity data and comparisons of sediment contaminant concentrations and background concentration levels, nitramine/nitroaromatic compounds appear to be the primary ECOCs in the sediment collected from the Impoundment Area. Because the removal of sediments with contaminants exceeding screening levels or background would result in the destruction of wetland habitat, Site 6 - Impoundment Area sediment will be part of the long-term monitoring effort.

The Site 6 - Impoundment Area is downstream from the Site 6 - Flume Area, which received discharge from Building 109. Sediment collected in the Site 6 - Flume Area was assessed by comparing contaminant levels to sediment benchmark screening levels. In addition, chronic benthic toxicity tests were conducted to determine potential effects. Nitramine/nitroaromatic compounds (4-amino-DNT; 2-amino-4,6-DNT; 2,4-DNT; 2,6-DNT; HMX; RDX; 1,3,5-TNB; and TNT) detected in the sediment were identified as posing potential risks to the benthic macroinvertebrate community, based on the results of the site-specific toxicity study. In addition to the nitramine compounds, the benthic community within the Site 6 - Flume Area may also be impacted by concentrations of PCE, TCA, TCE, PAHs, beryllium, cadmium, iron, lead, mercury; nickel, selenium and zinc.

Based on the results of previously mentioned site specific toxicity studies and the exceedence of sediment toxicity values, chlorinated volatile organics, PAHs; nitramines/nitroaromatics, nickel and zinc are the primary sediment ECOCs in the Site 6 - Flume Area. Sediment in the Site 6 - Flume Area is an ecological medium of concern and will be removed and treated ex situ using a bioremediation technology. The Site 6 - Flume Area will be back-filled and revegetated to protect ecological receptors and future human receptors as well.

Surface water contaminants in the Tributary to Felgates Creek identified as potential risks to the aquatic environment include: aluminum, iron, manganese, and nickel. However, site concentrations of these inorganic ECOCs were detected below tidal freshwater background concentrations. Therefore, surface water is not an ecological medium of concern in the tributary at Site 6 and remediating environmental media to concentrations below background is not practical.

Sediment concentrations of phenol, beryllium, iron, and manganese pose potential risks to benthic receptors within the Tributary at Site 6. In addition, sediment concentrations of aluminum and iron demonstrated potential risks in the aquatic receptor models. With the exception of phenol, site sediment

concentrations were also within the range of background. One detection of phenol exceeded toxicity benchmark values, but when this detection was used in conservative uptake models, it did not result in risks to aquatic receptors. As such, no action is necessary to protect aquatic receptors.

Site 6 - Excavated Area soil ECOCs exceeding flora/fauna toxicity benchmark values or demonstrating risks in the terrestrial models include: aluminum, antimony, cadmium, chromium, iron, lead, vanadium, and zinc. Aluminum, antimony, chromium, iron, lead, and vanadium in soil were detected sporadically at concentrations above maximum Station-wide background values. Based on risks presented in the terrestrial models and exceedences of background concentrations, aluminum, antimony, and chromium do not produce significant ecological risks. Cadmium and zinc do produce unacceptable risks in terrestrial models and appear to be the primary ECOCs in the soil at the Site 6 - Excavated Area. Therefore, the soil in the Site 6 - Excavated Area will be covered to prevent contact by terrestrial ecological receptors to affected soil.

Site 7

Potential ecological risks were evaluated in the terrestrial and aquatic environment within the Site 7 study area and the Tributary to Felgates Creek.

The following Site 7 Soil ECOCs exceeded flora/fauna toxicity benchmark values or demonstrated risks in the terrestrial models: aluminum, antimony, cadmium, chromium, copper, iron, lead, manganese, mercury, vanadium, and zinc. Aluminum, antimony, chromium, iron, manganese, and vanadium were detected sporadically at concentrations exceeding the maximum Station-wide background level for surface soil. The contaminants generating potential ecological risk in modeling and exceeding background concentrations include: cadmium, copper, lead, mercury, and zinc. The maximum detections of these five inorganics were found in one soil sample collected from sample location 7S09. The soil at this sample location was excavated and removed from the Site 7 - Drainage Area along with sediment in the drainage ditch during the full-scale Pilot Study. These inorganics are no longer potential ECOCs for Site 7. No additional action beyond the removal action for the purposes of the full-scale Pilot Study, which has already been conducted, is necessary to protect ecological receptors at Site 7.

Surface water ECOCs identified in the tributary at Site 7 include aluminum, iron, manganese, and nickel. Concentrations of these inorganic surface water ECOCs were detected within tidal freshwater background ranges. Remediation of environmental media to concentrations below Station background is not practical and no action is warranted.

Sediment collected from the Site 7 tributary poses potential risks to benthic macroinvertebrates or aquatic receptors because of detected concentrations of di-n-butylphthalate, aluminum, beryllium, iron, and manganese. Sediment concentrations of aluminum, beryllium, iron, and manganese were detected within the range of background sediment concentrations. Only one of six detections of di-n-butylphthalate exceeded a published toxicity benchmark value; however, this concentration did not produce unacceptable HQ values in conservative uptake modeling. Therefore, no action is necessary to protect aquatic ecological receptors.

2.6.3 Summary of Risk Assessment Results

Table 2-10 presents remediation levels (RLs) for contaminants detected in Site 6 soil and sediment. These contaminants are those chemicals responsible for unacceptable human health risks or ecological effects described previously. These RLs were derived by selecting the lowest and most protective of two possible

RLs, one for human health and one for the ecological receptors. The following paragraphs present a summary of findings of the baseline RA.

TABLE 2-10

SUMMARY OF REMEDIATION LEVEL (RL) VALUES FOR SITE 6 SEDIMENT AND SOIL WPNSTA YORKTOWN, YORKTOWN, VIRGINIA

Medium/Chemical of Concern	RL Value (mg/kg)	RL Value Source	Treatment[6] Goals (mg/kg)
SEDIMENT			
Trichloroethene	1.6	Ecological[1]	32
1,2-Dichloroethene(total)	3.5	Ecological[1]	700
Tetrachloroethene	31	Human[2]	7
1,1-Dichloroethane	200,000	Human[2]	6,500
1,1,1-Trichloroethane	70,500	Human[2]	2,700
Carcinogenic Polycyclic Aromatic Hydrocarbons (PAHs)	10	Human[2]	10
total PAHs	44	Ecological[1]	44
amino-DNTs	10	Human[2]	10
2,4-dinitrotoluene	60	Human[2]	60
2,6-dinitrotoluene	29	Human[2]	29
HMX	5.7	Ecological[3]	5.7
RDX	5.0	Human[2]	5.0
1,3,5-TNB	1.6	Ecological[3]	1.6
2,4,6-TNT	14.0	Human[2]	14.0
Cadmium	9.6	Ecological[1]	9.6
Nickel	52	Ecological[1]	52
Zinc	410	Ecological[1]	410
SOIL			
Cadmium	4.0	Ecological[4]	4.0
Zinc	48.4	Background [5]	48.4

Notes:

[1] Effects Range Median (ER-M) value.
[2] Based on future commercial property use scenario.
[3] Derived from site specific toxicity testing.
[4] Will and Suter value for flora toxicity.
[5] Maximum detected Station-wide surface soil background value.
[6] Treatment Goals differ for F002 listed waste constituents.
* Considers a scenario for all carcinogenic polycyclic aromatic hydrocarbons as benzo(a)pyrene where risk of concern increases by one cancer case in 100,000.

Site 6 - Flume Area

The presence of nitramines/nitroaromatics and chlorinated volatile compounds in Site 6 - Flume Area sediment produced unacceptable risks to human health and aquatic ecological receptors. Elevated concentrations of contaminants were detected in samples obtained from the Site 6 - Flume Area during acute and chronic toxicity testing to develop site-specific toxicity values. Concentrations encountered in Site 6 - Flume Area sediments exceeded human health-based RL values and caused increased mortality in benthic organisms tested during the chronic toxicity testing. To protect both human health and the environment, Site 6 - Flume Area sediment contaminated with nitramines/nitroaromatics (amino-DNTs, 2,4/2,6-DNT, TNT, HMX, RDX, and 1,3,5-TNB), PAHs, chlorinated volatiles, and inorganics will be excavated and treated ex situ using a bioremediation technology. Residual contamination will remain at the site after excavation and treatment, however, that will make the site inappropriate for residential uses. Consequently, residential use will be prohibited as part of the remedy.

Site 6 - Impoundment Area

Surface water and sediment of the Site 6 - Impoundment Area have also been affected by past activities at Site 6, posing potential adverse affects on aquatic ecological receptors. The compound 4-amino-2,6-DNT detected at the 12-inch depth interval in one sample could pose unacceptable systemic human health risks to exposed trespassing adolescents and adults. Nitramines, chlorinated volatiles and inorganics including nickel and zinc detected throughout the Site 6 - Impoundment may be responsible for unacceptable ecological risks, including exceedences of flora/fauna toxicity values and ecological HQ values exceeding 1.0. Unlike the Site 6 - Flume Area, contaminants occur sporadically throughout the impoundment and at depth. Remediation of the area could cause greater harm to ecological receptors than no action, and additional data are necessary to determine the potential ecological impacts associated with these contaminants. Therefore the selected remedy will include long-term monitoring of Site 6 - Impoundment Area surface water, sediment, and groundwater to determine if more aggressive remediation is necessary to protect the environment.

Site 6 - Excavated Area

Surface soil in the Site 6-Excavated Area is contaminated with inorganics including cadmium and zinc that pose unacceptable risks to terrestrial ecological receptors. This area is relatively small. Regrading the area, adding soil cover, and revegetating the area will protect terrestrial ecological receptors from exposure to soil contaminants.

Site 7 - Drainage Area

Environmental media investigated at the Site 7 - Drainage Area posed no unacceptable human health or ecological risks under any land use scenario. However, qualitative data for TNT, RDX and amino-DNTs generated as part of the full-scale Pilot Study indicate that carcinogenic and noncarcinogenic human health risks would occur in this area subsequent to exposure. Excavation of contaminated soil and sediment for the full-scale Pilot Study in 1996 removed contaminants that posed potential risks to both human health and the environment and no additional action at this site is necessary. However, a landuse restriction will be implemented to prohibit future residential use of the area because soil and sediment were removed to protect individuals exposed under commercial/industrial land use scenarios and not residential property use.

2.7 Description of Remedial Alternatives for Site 6

The DoN considered a range of potential remedial action alternatives (RAAs) for the remediation of contaminated soil and sediment at Site 6. Each of the action alternatives (Alternatives 2 through 6) requires that the residue be removed from the trenches under Building 109 and pressure washed. Each of the "treatment" alternatives (Alternatives 3 through 6) requires that the sediment in the Site 6 - Flume Area be treated in situ or ex situ. The following alternatives were evaluated:

- Alternative 1 - No Action
- Alternative 2 - Monitoring and Residue Removal from Building 109
- Alternative 3 - In Situ Biological Treatment, Soil Cover, and Residue Removal from Building 109
- Alternative 4 - Ex Situ Biological Treatment, Limited Excavation and Off-Site Disposal, and Residue Removal from Building 109
- Alternative 5 - Excavation with Off-Site Incineration and Residue Removal from Building 109
- Alternative 6 - Ex Situ Biological Treatment, Soil Cover, Limited Excavation, and Residue Removal from Building 109

2.7.1 Alternative 1: No Action

This alternative involves no remedial action to contain, remove, or treat contaminants in Site 6 soil/sediment. It is not protective of human health or the environment. There are no Applicable or Relevant and Appropriate Requirements of federal or state law (ARARs) for this alternative. It was, however, evaluated to provide a baseline for comparison to other remedial alternatives.

- Estimated Capital Cost: **$0**
- Estimated Operation and Maintenance (O&M) Costs: **$0**
- Estimated Present Worth Cost: **$0**
- Estimated Time to Implement: Immediate

2.7.2 Alternative 2: Monitoring and Residue Removal

This alternative does not involve actions to contain, remove, or treat Site 6 soil/sediment contaminants, but does provide for long term monitoring of Impoundment Area sediment which would provide data to be used to assess the potential impact to human health and the environment. Long-term monitoring would also indicate if contaminant concentrations in sediment are decreasing. Numerous studies have shown that indigenous microbes can metabolize TNT. TNT in surficial water or soil can also be broken down by strong sunlight (ultraviolet radiation). Finally, plants have been shown to decrease concentrations of explosives in soil and groundwater through several processes including: enhanced biodegradation, phyto-extraction (phyto-accumulation), phyto-degradation, and phyto-stabilization. These processes either remove, transfer, stabilize, or destroy the contaminants. Wetland plants, such as cattails, canary grass, milfoil, and parrotfeather are being studied because they contain an enzyme called nitroreductase which, with other plant enzymes, can degrade TNT, RDX, and HMX. Chlorinated volatile compounds can be degraded in the soil zone where plant roots grow.

This alternative provides some protection of human health and the environment through the removal of residue from the trenches of Building 109 (considered a potential secondary source of contamination). The residue will be removed and the trenches pressure washed. The residue will be transported to an on-site, permitted burning area for proper disposal. Wastewater from the pressure washing will be collected and safely disposed.

Since contaminated soil/sediment would remain on site under RAA 2 and will continue to be a source of contamination, annual sediment monitoring will be conducted to assess the potential, ongoing impact to human health and the environment. Two sediment samples will be collected annually at the Site 6 - Flume Area and will be analyzed for VOCs and explosives. No fewer than six sediment samples will be collected annually at the Site 6 - Impoundment Area and analyzed for VOCs, SVOCs, explosives, and inorganics. The details of the monitoring program will be addressed in the LTM Work Plan.

Implementation of this alternative would require compliance with location- and action-specific ARARs because wetlands and possibly archeological resources are present at the site. No chemical-specific ARARs have been established for the soil/sediment contaminants of concern (COCs).

- Estimated Capital Cost: $57,700
- Estimated O&M Costs: $11,800
- Estimated Present Worth Cost: $239,000
- Estimate to Implement:

  This alternative can be implemented in a period of weeks, assuming remedial action work plans and long-term monitoring plans are completed. No design is necessary for this alternative. Sediment sampling can begin immediately after the approval of the LTM Work Plan and the pressure washing of Building 109 trenches can be completed in several weeks. A LUCIP will be submitted within 180 days following residue removal and disposal.

2.7.3 Alternative 3: In Situ Biological Treatment, Soil Cover, and Residue Removal

In situ biological treatment would be used to treat approximately 1,000 cubic yards of contaminated soil and sediment from the Site 6-Flume Area. The affected area will be tilled every two weeks to mix in the additives and control the soil conditions to alternate between aerobic and anaerobic conditions. Indigenous microbe growth will be enhanced. The additives will bulk the soil and sediment by approximately 10 percent. No active remediation will occur at the Site 6-Impoundment Area to prevent extensive disturbance to the marshy area. Long-term monitoring, as described under RAA 2, will be conducted to assess the potential ongoing impact to human health and the environment. At the Site 6-Excavated Area, the cadmium- and zinc-contaminated soil will remain in place and a soil cover will be installed. The soil cover will consist of a minimum of 8 inches of soilfill to prevent erosion. Residue will be removed from the trenches under Building 109, as described under RAA 2. Operation and maintenance (O&M) will entail maintenance of the Site 6 - Excavated Area soil cover. Long-term monitoring of surface water, sediment, and groundwater will be implemented as part of this remedy. Details of long-term monitoring will be developed in consultation with USEPA Region III and VDEQ personnel.

The remedy for the Site 6 - Flume Area and the 1996 removal action at Site 7 are designed to reduce contamination to levels that will be safe for people engaged in typical commercial or industrial activities. Land use controls will be established to prevent residential exposure to the contaminants remaining at Site 7 and the Site 6 - Flume Area. Land use controls will also be established to prohibit activities that interfere with or compromise the integrity of the cover at the Site 6 - Excavated Area.

Some earth moving activities are involved with this alternative. Implementation will require compliance with location-specific ARARs because wetlands, and possibly archeological resources, are present at the site. Action-specific ARARs associated with the identification, regulation, production, and disposal of solid wastes will apply. No chemical-specific ARARs have been established for the soil/sediment COCs.

- Estimated Capital Cost: $393,000
- Estimated O&M Costs: $11,000
- Estimated Present Worth Cost: $566,700
- Estimated Time to Implement:

  Assuming that all work plans and long-term monitoring plans are completed, this alternative can be implemented within approximately 6 to 9 months. The installation of the soil cover should be completed within six months. Treatment of the soil/sediment may be completed within three to nine months. Sediment monitoring can begin immediately.

2.7.4 Alternative 4: Ex Situ Biological Treatment, Limited Excavation and Off-Site Disposal, and Residue Removal

Alternative 4 involves removing approximately 1,000 cubic yards of contaminated soil and sediment from the Site 6 - Flume Area and transporting it to the existing aqueous phase biocell at Site 22 for ex situ biological treatment. Treated soil/sediment will be used as backfill at the Station. No active remediation will be done at the Site 6 - Impoundment Area in order to prevent disturbance to the marshy area and destruction of existing habitat. Approximately 500 cubic yards of cadmium and zinc contaminated surface soil at the Site 6 - Excavated Area will be excavated and loaded onto trucks for off-site disposal. Confirmatory sampling will be conducted to ensure that the inorganic COCs are removed from the site. The Site 6 - Excavated Area will then be backfilled and covered with topsoil for revegetation. Residue will be removed from the trenches under Building 109 as described under RAA 2.

Because earth moving activities are involved for this alternative, location-specific ARARs apply because wetland, and possibly archeological resources, are present at the site. Action-specific ARARs associated with the identification, regulation, production, and disposal of solid wastes and hazardous wastes will apply. No chemical-specific ARARs have been established for the soil/sediment COCs.

Long-term monitoring of surface water, sediment and groundwater will be implemented as part of this remedy. Details of long-term monitoring will be developed in consultation with USEPA Region III and VDEQ personnel.

The remedy for the Site 6 - Flume Area, and the 1996 removal action at Site 7, is designed to reduce contamination to levels that will be safe for people engaged in typical commercial or industrial activities. Land use controls will be established to prevent residential exposure to the contaminants remaining at Site 7 and the Site 6 - Flume Area.

- Estimated Capital Cost: $426,000
- Estimated O&M Costs: $10,800
- Estimated Present Worth Cost: $592,000
- Estimated Time to Implement:

Assuming that all work plans and long-term monitoring plans are completed, this alternative can be implemented within approximately nine months. The organic-contaminated soil can be excavated and placed in the biocell within approximately three months. Treatment of the soil may be completed within three to nine months.

2.7.5 Alternative 5: Excavation with Off-Site Thermal Treatment and Residue Removal

This alternative involves excavation of approximately 1,500 cubic yards of contaminated soil and sediment from the Site 6-Flume Area and the Site 6 - Excavated Area. The organic-contaminated soil/sediment excavated from the Site 6 - Flume Area will be transported off-site for incineration. The inorganic-contaminated surface soil excavated from the Site 6 - Excavated Area will be transported off-site for disposal. Confirmation sampling will be conducted to verify that soil and sediment with COC concentrations exceeding the final RLs have been removed. Both of the disturbed areas will be backfilled with clean fill and topsoil for revegetation. No active remediation will be done at the Site 6 - Impoundment Area to prevent extensive disturbance of the marshy area and destruction of existing habitat. However, long-term sediment monitoring, as described under previous RAAs, will be conducted to assess the Site 6-Impoundment Area. Residue will be removed from the trenches under Building 109 as described under RAA 2.

Because earth moving activities are involved with this alternative, location-specific ARARs apply because wetlands, and possibly archeological resources, are present at the site. Action-specific ARARs associated with the identification, regulation, production, and disposal of solid wastes and hazardous wastes will apply.

Long-term monitoring of surface water, sediment, and groundwater will be implemented as part of this remedy. Details of long-term monitoring will be developed in consultation with USEPA Region III and VDEQ personnel.

The remedy for the Site 6 - Flume Area, and the 1996 removal action at Site 7, are designed to reduce contamination to levels that will be safe for people engaged in typical commercial or industrial activities. Land use controls will be established to prevent residential exposure to the contaminants remaining at Site 7 and the Site 6 - Flume Area.

In the proposed plan, Remedial Alternative 5 included described two different treatment technologies: off-site incineration of contaminated soil and sediment (Alternative 5a) and on-site low temperature thermal desorption (LTTD) (Alternative 5b). After the proposed plan was issued, it was determined that the LTTD could not be used to treat the levels of nitramine/nitroaromatic contamination at Site 6. Consequently, in this ROD, Alternative 5 does not include a description of LTTD.

- Estimated Capital Cost: $791,000
- Estimated O&M Costs: $10,800
- Estimated Present Worth Cost: $957,000
- Estimated Time to Implement:

This alternative can be implemented within approximately three to six months assuming that an off-site incineration facility and off-site landfill facility are available, and all work plans are completed. Sediment monitoring can begin immediately assuming all monitoring plans are completed.

2.7.6 Alternative 6: Limited Excavation, Ex Situ Biological Treatment, Soil Cover, Residue Removal

Alternative 6 consists of excavating approximately 1,000 cubic yards of contaminated soil and sediment at the Site 6-Flume Area and treating it on-site with an ex situ bioremediation process. The same process as described for Alternative 3 will be used for this treatment with the exception that the soil and sediment will be excavated, placed, and treated at a staging area instead of being treated in place. If the bioremediation process is not able to reduce concentrations of chlorinated volatile organics in the soil to remediation levels specified in table 2-10, low temperature thermal treatment will be employed to reduce chlorinated volatile organic concentrations to remediation levels specified in Table 2-10. To prevent extensive disturbance to the marshy area at the Site 6-Impoundment Area, no active remediation will be performed. However, long-term sediment, surface water, and groundwater monitoring will be conducted to assess conditions in the Impoundment Area. The monitoring program would be similar to that described under RAA 2, except that area groundwater and Impoundment Area surface water would also be monitored. A soil cover will be installed at the Site 6-Excavated Area as described in Alternative 3. Residue will be removed from the trenches under Building 109 as described under RAA 2.

Location-specific ARARs apply because wetlands, and possibly archeological resources, are present at the site. Action-specific ARARs associated with the identification, regulation, production, and disposal of solid wastes and hazardous wastes will apply. No chemical-specific ARARs have been established for the sediment/soil COCs.

Long-term monitoring of surface water, sediment, and groundwater will be implemented as part of this remedy. Details of long-term monitoring will be developed in consultation with USEPA Region III and VDEQ personnel.

The remedy for the Site 6 - Flume Area, and the 1996 removal action at Site 7, are designed to reduce contamination to levels that will be safe for people engaged in typical commercial or industrial activities. Land use controls will be established to prevent residential exposure to the contaminants remaining at Site 7 and the Site 6 - Flume Area. Land use controls will also be established to prohibit activities that interfere with or compromise the integrity of the cover at the Site 6 - Excavated Area.

- Estimated Capital Cost: $461,000
- Estimated O&M Costs: $20,200
- Estimated Present Worth Cost: $771,500
- Estimated Time to Implement:

This alternative can be completed within approximately six months to a year. The installation of the soil cover should be completed within six months. The sediment, groundwater, and surface water monitoring can begin immediately. Excavation of organic-contaminated soil/sediment can be completed within approximately three months. Treatment of the soil/sediment may be completed within three to nine months.

2.8 Evaluation of Alternatives

As required by CERCLA, the six remedial alternatives were evaluated using the nine criteria specified by USEPA (Table 2-11). This section and Table 2-12 summarize the detailed analysis of each alternative.

As part of the FS process, each of the RAAs was assessed against nine evaluation criteria which fall into three categories: threshold criteria, primary balancing criteria, and modifying criteria. The threshold criteria must be met for an alternative to be eligible for selection. The primary balancing criteria are used to weigh major trade-offs among alternatives. Generally, the modifying criteria are taken into account after public comment is received on the PRAP. The nine evaluation criteria include:

Threshold Criteria

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

Primary Balancing Criteria

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Cost

Modifying Criteria

- State Acceptance
- Community Acceptance

TABLE 2-11

USEPA EVALUATION CRITERIA FOR REMEDIAL ALTERNATIVES
SITE 6
WPNSTA YORKTOWN, YORKTOWN, VIRGINIA

1.	**Overall protection of human health and the environment**
	Addresses whether a cleanup method adequately protects human health and the environment and describes how risks presented by each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.
2.	**Compliance with ARARs**
	Addresses whether a cleanup method meets all ARARs (federal and state environmental requirements) and provides grounds for invoking a waiver.
3.	**Long-term effectiveness and permanence**
	Refers to the ability of the cleanup method to reliably protect human health and the environment over time, after the action is completed.
4.	**Reduction of toxicity, mobility, or volume through treatment**
	Addresses the effectiveness of a cleanup method in reducing the toxicity, mobility, or volume of hazardous substances through treatment.
5.	**Short-term effectiveness**
	Addresses the period of time needed to complete the cleanup, and any adverse impacts on human health and the environment that may occur during construction and operation.
6.	**Implementability**
	Refers to the technical and administrative feasibility of a cleanup method, including the availability of required materials and services.
7.	**Cost**
	Includes the estimated capital and O&M costs of each cleanup method.
8.	**State acceptance**
	Indicates whether the Commonwealth of Virginia agrees with the preferred cleanup method.
9.	**Community acceptance**
	Indicates whether public concerns are addressed by the cleanup method and whether the community has a preference. (Public comment is an important part of the final decision.)

TABLE 2-12

SUMMARY OF DETAILED ANALYSIS
SITE 6
WPNSTA YORKTOWN, YORKTOWN, VIRGINIA

Evaluation	RAA 1: No Action	RAA 2: No Action with Monitoring and Sludge Removal	RAA 3: In Situ Biological Treatment, Soil Cover, and Sludge Removal	RAA 4: Ex Situ Biological Treatment, Limited Excavation and Off-Site Disposal	RAA 5: Excavation with Off-Site Incineration and Sludge Disposal	RAA 6: Ex Situ Biological Treatment, Soil Cover, Limited Excavation, and Sludge Removal
Overall Protectiveness	• No reduction in risk to human health or the environment. • Existing conditions could allow migration of contaminants off-site.	• Removes potential source of contamination to other environmental media (sewer sludge). • Direct exposure to contaminated soils and sediments is not reduced. • Monitors quality of sediment.	• Significant reduction in risk by treatment of sediments, capping of soils, removal of sludge. • Capping prevents erosion and percolation reducing migration of contaminants. • Monitors quality of sediment.	• Significant reduction in risk by treatment and removal of sediments, soils, and sludge. • Monitors quality of sediment.	• Significant reduction in risk by treatment and removal of sediments, soils, and sludge. • Monitors quality of sediment.	• Significant reduction in risk by treatment and removal of sediments, soils, and sludge. • Capping prevents erosion and percolation reducing migration of contaminants. • Monitors quality of sediment, surface water, and groundwater.
Compliance with ARARs	No ARARs.	Will meet ARARs.	Will meet ARARs.	Will meet ARARs.	Will meet ARARs.	Will meet ARARs.
Long-Term Effectiveness and Performance	• Unknown	• Removal of sludge will permanently reduce risk. • Sediment monitoring will indicate if remedial action is required in the Impoundment Area.	• Soil/sediment treatment and sludge removal will permanently reduce risk. • If cap is maintained, will be effective. • Sediment monitoring will indicate if remedial action is required in the Impoundment Area.	• Soil/sediment treatment and sludge removal will permanently reduce risk. • Sediment monitoring will indicate if remedial action is required in the Impoundment Area.	• Soil/sediment removal will be an effective and permanent option. • Sediment monitoring will indicate if remedial action is required in the Impoundment Area.	• Soil/sediment removal will be an effective and permanent option. • If cap is maintained, will be effective and permanent at reducing exposure. • Sediment monitoring will indicate if remedial action is required in the Impoundment Area.
Reduction of Toxicity, Mobility, or Volume Through Treatment	• Will not treat contaminants.	• Will not treat contaminants.	• Soil/sediment COCs will be treated by biological methods to reduce toxicity.	• Soil/sediment COCs will be treated by biological methods to reduce toxicity.	• Soil/sediment COCs will be treated by thermal methods to reduce toxicity and volume.	• Soil/sediment COCs will be treated by biological methods to reduce toxicity. A contingent technology such as low temperature thermal desorption may be employed to reduce volatile to health based levels.
Short-Term Effectiveness	• Risk to community not increased. • No significant risk to workers.	• Risk to community not increased. • Increased risk to workers during sludge removal.	• Risk to community may increase due to fugitive dust from earth moving activities. • Increased risk to workers during soil treatment activities and cap installation.	• Risk to community may increase due to fugitive dust from earth moving activities. • Increased risk to workers during soil treatment and removal activities.	• Risk to community may increase due to fugitive dust from earth moving activities. • Increased risk to workers during soil removal activities.	• Risk to community may increase due to fugitive dust from earth moving activities. • Increased risk to workers during soil removal, treatment activities and cap installation.
Implementability	• No construction operation activities planned. • No monitoring proposed.	• Monitoring and sludge removal activities easily implemented. • Equipment and materials readily available.	• Monitoring, sludge removal, capping and treatment activities easily implemented. • Equipment and materials readily available.	• Monitoring, sludge removal and treatment activities easily implemented. • Equipment, materials and biocell readily available. • Permitting required for soil disposal.	• Monitoring, sludge removal and excavation activities easily implemented. • Equipment and materials readily available. • Permitting required for soil disposal and off-site incineration facilities.	• Monitoring, sludge removal, capping and treatment activities easily implemented. • Equipment and materials readily available. • Permitting possibly required for sediment disposal.
Costs (NPW)	$0.00	$250,000	$539,000	$620,000	$1,058.000	$652,000

2.8.1 Threshold Criteria

Overall Protection of Human Health and the Environment:

Evaluation of the overall protectiveness of alternatives focused on whether a specific alternative would achieve adequate protection of human health and the environment and how risks posed by each pathway would be eliminated, reduced, or controlled through treatment, engineering, or institutional land use controls. The overall assessment of the level of protection included the evaluations conducted under other criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Alternative 6 provides the greatest extent of protection to human health and the environment since it provides source control by removing and treating the primary source of contamination at Site 6 - Flume Area and removes a potential secondary source of contamination (the sludge within Building 109 trenches). The No Action Alternative (Alternative 1) does not reduce potential risks to human health or the environment (except through natural attenuation). Because the no action alternative does not meet threshhold criterion of protecting human health and the environment, it will not be analyzed further. Alternative 2 will provide some overall protection with the removal of the potential secondary source of contamination (residue under Building 109), but will not comply with soil and sediment RLs at the Site 6 - Flume Area and Site 6-Excavated Area. Alternatives 3 and 4 provide slightly less protection to human health and the environment than Alternative 6. Alternative 3 employs in situ biological treatment and may not adequately reduce contaminants to any appreciable extent with depth. Alternative 4 would consider the use of the existing biocell at Site 22 to remediate nitramines/nitroaromatics in soil and sediment. Treatment at the biocell may not reduce concentrations of chlorinated volatile organics. Alternative 5 would be as protective as Alternative 6. None of the alternatives will meet the sediment RLs established for organics at the Site 6 - Impoundment Area except possibly by natural attenuation processes. Sediment will not be removed or treated in order to protect existing habitat.

Compliance with ARARs:

This evaluation involved determining whether each alternative would meet all of the pertinent Federal and state ARARs (as identified in Section 2.11.2 of this report).

Each alternative was evaluated for compliance with applicable or relevant and appropriate Federal and state requirements. The evaluation summarized which requirements are applicable or relevant and appropriate to each alternative. The following items were considered for each alternative:

- Compliance with chemical-specific ARARs (e.g., ambient water quality criteria). This factor addresses whether the ARARs can be met, and, if not, whether a waiver may be appropriate.

- Compliance with location-specific ARARs (e.g., preservation of historic sites, regulations relative to activities near wetlands or floodplains, etc.). As with other ARAR-related factors, these involve consideration of whether the ARARs can be met or whether a waiver is appropriate.

- Compliance with action-specific ARARs (e.g., RCRA minimum technology standards). It must be determined whether ARARs can be met or must be waived.

No chemical specific ARARs apply to the remediation of Site 6. Alternatives 2, 3, 4, 5, and 6 will comply with all location-specific and action-specific ARARs.

2.8.2 Primary Balancing Criteria

Long-term Effectiveness and Permanence:

This criterion evaluated alternatives with respect to their long-term effectiveness and the degree of permanence. The primary focus of this evaluation was the residual risk that will remain at the sites and the effectiveness of the controls that will be applied to manage residual risks. The assessment of long-term effectiveness was made considering the following four factors:

- The magnitude of the residual risk to human and environmental receptors remaining from untreated waste or treatment residues at the completion of remedial activities.

- An assessment of the type, degree, and adequacy of long-term management (including engineering controls, institutional controls, monitoring, and operation and maintenance) required for untreated waste or treatment residues remaining at the site.

- An assessment of the long-term reliability of engineering and/or institutional controls to provide continued protection from untreated waste or treatment residues.

- The potential need for replacement of the remedy and the continuing need for repairs to maintain the performance of the remedy.

Alternative 2 does not include removal of soil or sediment but does include removal of the Building 109 residue. It is not effective in reducing risk to ecological receptors. Alternative 3 is permanent, but its long-term effectiveness is dependent on the ability to degrade contaminants in situ at the Site 6 - Flume Area and future cover maintenance at the Site 6 - Excavated Area. Alternative 4 would likely not be effective because treatment at the Site 22 biocell would not reduce concentrations of volatile organics.

Alternative 5 is permanent because the contaminated soil and sediment from the Site 6 - Flume Area and soil from the Site 6 - Excavated Area will be removed and treated using a permitted off-site incineration facility. Alternative 6 is also permanent because the contaminated soil and sediment in the Site 6 - Flume Area will be removed and biologically treated. However, long-term effectiveness for the Site 6 - Excavated Area is a function of ongoing soil cover maintenance by Station personnel. None of the alternatives are permanent with regard to the organic contamination in the Site 6 - Impoundment Area because the sediment will not be removed to protect existing habitat. Long-term monitoring at the Site 6 - Impoundment Area will assess area groundwater and Impoundment Area surfacewater/sediment quality for all of the alternatives except for Alternative 1 (No Action). If degradation of groundwater, surface water, and sediment quality is observed, remedial action at the Site 6 - Impoundment Area may be evaluated. Natural attenuation may occur at the Site 6 - Impoundment Area because the contaminants are organic. This occurrence will be detected through the long-term monitoring program.

Reduction of Toxicity, Mobility, or Volume Through Treatment:

This evaluation criterion addressed the degree to which the alternatives employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. Alternatives that do not employ treatment technologies do not reduce toxicity, mobility, or volume of COCs. The evaluation considered the following specific factors:

- The treatment processes, the remedies that will be employed, and the materials that will be treated.
- The amount or volume of hazardous materials that will be destroyed or treated.
- The degree of expected reduction in toxicity, mobility, or volume, including how the principal threat is addressed through treatment.
- The degree to which the treatment will be irreversible.
- The type and quantity of treatment residuals that will remain following treatment.

Alternative 2 does not employ treatment technologies which reduce toxicity, mobility, or volume. Alternative 3 may reduce the toxicity of the organic-contaminated soil in the Site 6-Flume Area through biological treatment depending on the efficacy of the in situ treatment process with respect to contamination at depth. The process is irreversible and will reduce contaminant concentrations below the established RLs. Alternative 4 utilizes in situ biological treatment to destroy explosives and other organic contaminants and produces relatively non-toxic intermediates. It may not, however, reduce toxicity, mobility or volume of volatile organics in contaminated soil and sediment. Alternatives 5 and 6 do reduce toxicity, mobility, and volume of waste at the site. Alternatives 5 and 6 are also irreversible and will reduce contaminant concentrations to below the established RLs. There will be residual contamination associated with Alternative 5 (residual ash) that will be disposed of by the vendor responsible for off-site treatment by incineration. There will be no residual waste associated with Alternative 6 (other than investigation derived waste [IDW]).

Short-Term Effectiveness:

The short-term effectiveness of each alternative was evaluated for its effect on human health and the environment during implementation of the remedial action. Potential threats to human health and the environment associated with handling, treatment, or transportation of hazardous substances were considered. The short-term effectiveness assessment was based on four key factors:

- Short-term risks that might be posed to the community during implementation of an alternative.
- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures.
- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.
- Time until remedial response objectives are achieved.

Although excavation and sludge removal activities could potentially expose workers to contamination during implementation of Alternatives 3, 4, 5, and 6, these alternatives are protective of human health and the environment in the short-term and could be completed within one year after implementation. Alternative 2 is less protective of human health and the environment in the short term compared to the other alternatives because the contaminated soil and sediment will remain in place. Of these alternatives, Alternative 2 could be implemented most quickly (several weeks). Excavation activities for Alternatives 3, 4, 5, and 6 could be implemented in approximately three months. However, for Alternative 3 and 6 involve earth moving activities for the soil cover placement could take six months to implement.

Implementability:

Implementability considerations included the technical and administrative feasibility of each alternative and the availability of various materials and services required for its implementation. The following factors were considered during the implementability analysis:

- *Technical Feasibility*: The relative ease of implementing or completing an action based on site-specific constraints, including the use of established technologies, such as:
  - Ability to construct the alternative as a whole (constructability).
  - Operational reliability or the ability of a technology to meet specified process efficiencies or performance goals.
  - Ability to undertake future remedial actions that may be required.
  - Ability to monitor the effectiveness of the remedy.
- *Administrative Feasibility*: The ability and time required to obtain any necessary approvals and permits from regulatory agencies

- *Availability of Services and Materials*: The availability of the technologies, materials, or services required to implement an alternative, including:

  - Available capacity and location of needed treatment, storage, and disposal services.
  - Availability of necessary equipment, specialists, and provisions for necessary additional resources.
  - Timing of the availability of prospective technologies under consideration.
  - Availability of services and materials, plus the potential for obtaining bids that are competitive (this may be particularly important for innovative technologies).

All of the alternatives are technically feasible. Conventional equipment and construction practices are required for implementation, operation, and monitoring under each alternative.

Alternatives 2 is readily implementable as it does not require permits for any off-site facilities. Alternatives 3 and 4 can be implemented only if a permitted off-site disposal facility is available for soil and sediment. From an administrative viewpoint, Alternative 5 can be implemented only if permitted off-site incineration and disposal facilities are available. Alternative 6 is readily implementable and does not require any special administrative considerations to proceed.

Services and materials required for each alternative are readily available. As mentioned before, permits will be required for any off-site disposal Disposal facilities should be available. A vendor is be available for service for biological treatment process described in Alternatives 3 and 6. The biocell at Site 22 is available and operating for Alternative 4.

Cost:

For each remedial alternative, a detailed cost analysis was developed based on conceptual engineering and analyses. Unit prices were based on published construction cost data, quotes from vendors and contractors, and/or engineering judgment. Costs are expressed in terms of 1998 dollars. In order to allow the costs of remedial alternatives to be compared on the basis of a single figure, the net present worth (NPW) value of all capital and annual costs was determined for each alternative. The USEPA CERCLA RI/FS Guidance Document recommends that a 5 percent discount rate be used in present worth analyses. Of the treatment alternatives, Alternative 3 has the lowest NPW at $566,700. Alternative 4 is the next lowest at $592,000. Alternative 5 has the highest NPW at $1,011,000. Alternative 6 has a NPW at $771,500, but one-third of these costs (approximately $257,000) will be absorbed by the bioremediation technology vendor, making Alternative 6 the most cost effective alternative.

2.8.3 Modifying Criteria

State Acceptance:

The Commonwealth of Virginia was involved in the selection of the remedy for Sites 6 and 7. Information regarding remedy selection was conveyed through Restoration Advisory Board (RAB) meetings, the FS Report and at the public meeting. No state comments were received disputing the final remedy. The Commonwealth is satisfied that the appropriate process was followed in evaluating remedial action alternatives for Sites 6 and 7 and concurs with the selected remedy.

Community Acceptance:

WPNSTA Yorktown solicited input from the public on the development of alternatives and on the alternatives identified in the Proposed Plan. A public meeting on the Proposed Plan was held on May 26, 1998. Community members of the Restoration Advisory Board (RAB) in attendance during the public meeting agreed with the selection of Alternative 6 as the preferred alternative. No additional information on the Proposed Plan has been requested and the 45 day public comment period closed on July 11, 1998, with no additional comments being received on the selection of a remedy.

2.9 Selected Remedy

The Selected Remedy for the cleanup of explosives-contaminated soil at Site 6 is Alternative 6. This alternative is protective of human health and the environment; complies with all ARARs; has a high degree of short-term and long-term effectiveness and permanence; and reduces the toxicity, mobility, and volume of wastes to be disposed of through removal and treatment. The Selected Remedy is more protective of human health and the environment than Alternatives 3 and 4 because the treatment method in Alternative 6 is more likely to be effective than the treatment methods in the other alternatives. The Selected Remedy will not produce residual ash, a drawback to Alternative 5 which utilizes incineration technology. Alternative 6 may require the use of a commonly applied contingent technology such as low temperature thermal desorption to reduce volatile contaminants to health based levels. The Selected Remedy is the third least costly treatment alternative evaluated during the remedial process, if one does not consider that one-third of these costs (approximately $257,000) will be absorbed by the bioremediation technology vendor. If one does take the vendor's contribution into account, Alternative 6 is the least costly remedy. Table 2-13 presents the detailed costs for the Selected Remedy.

2.10 Description of Selected Remedy and Performance Standards

The Selected Remedy requires the physical removal of residue in the trenches under Building 109. The residue shall be transported to an on-site, permitted burning area for proper disposal. The trenches shall be pressure washed after residue removal, and the waste water resulting from the steam cleaning shall be collected and properly disposed. The remedy shall reduce contaminants to remediation levels presented in Table 2-10. If a reasonable cycle of bioremediation is not able to reduce concentrations of chlorinated VOCs in the soil to the remediation levels specified in Table 2-10, then low temperature thermal desorption will be used to treat the soil and reduce concentrations of chlorinated VOCs to the remediation levels in Table 2-10.

The Selected Remedy also requires the excavation of the Site 6-Flume Area soil/sediment contaminated with nitramines/nitroaromatics, chlorinated volatiles, and inorganics to a depth of approximately 4 feet bgs. Of the COCs identified for Site 6, the following RLs shall be used to identify soil and sediment to be excavated:

- TCE 16 mg/Kg
- Total cPAHs 10 mg/Kg
- Total Amino-DNTs 10 mg/Kg
- HMX 5.7 mg/Kg
- RDX 5.0 mg/Kg
- 1,3,5-TNB 1.6 mg/Kg
- 2,4,6-TNT 14 mg/Kg
- Nickel 52 mg/Kg
- Zinc 410 mg/Kg

Any soil or sediment in the Flume Area containing concentrations of these chemicals greater than the RLs shown in the bullets above shall be excavated. The excavated soil and sediment shall be transported to a staging and treatment area where it shall be treated by ex situ biological treatment.

TABLE 2-13

SITE 6 COST ESTIMATE: RAA 6 - EX SITU BIOLOGICAL TREATMENT, SOIL COVER, LIMITED EXCAVATION, AND SLUDGE REMOVAL NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Cost Component	Unit	Quantity	Unit Cost	Subtotal Cost	Total Cost	Source	Basis/Comments
DIRECT CAPITAL COSTS							
General							
Pre-construction Submittals	LS	1	$20,000	$20,000		Engr. Est.	Work, E&S, H&S, & QC Plans; Permits; Shop Drawings
Treatability Study	LS	1	$26,670	$26,670		Engr. Est.; vendor quote	In situ biological treatment bench-scale study
Mobilization/Demobilization	LS	1	$110,000	$110,000		Engr. Est.	Includes mobe/demobe for all subconctractors
Decontamination Pad	LS	1	$10,000	$10,000		Engr. Est.	Includes decon/laydown area
Stockpile Area	LS	1	$10,000	$10,000		Engr. Est.	Stockpile area for treated soil
Contract Administration	LS	1	$40,000	$40,000		Engr. Est.	Invoicing, project management, field supervision, H&S, etc.
Post-Construction Submittals	LS	1	$10,000	$10,000		Engr. Est.	Record drawings, etc.
General - Subtotal					$226,670		
Site Work							
Clearing and Grubbing	Acre	0.3	$1,300	$390		Engr. Est.; Means Site Work, 1998, 021-104-0150	For wooded areas at SAOC #3
Temporary Safety Fencing	LF	1,100	$3.32	$3,652		Engr. Est.; Means Site Work, 1998, 028-320-5000	Assumes safety fencing around SAOCs #1 and #3
Temporary Silt Fencing	LF	700	$0.82	$574		Engr. Est.; Means Site Work, 1998, 022-704-1000	Assumes silt fencing at SAOCs #1 and #3
Site Restoration:							
Backfill	CY	370.00	$5.60	$2,072		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assume 5 feet of backfill from on-site borrow pit (no material costs) at SAOC #1
Topsoil	CY	25	$17.04	$426		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 4" of top soil at SAOC #1; cost includes mat'l, hauling from stockpile & compacting
Fine Grading/Seeding (Revegetation)	SY	220	$2.19	$482		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over SAOC#1
Site Work - Subtotal					$7,596		
Sludge Removal							
Excavation From Building 109	CY	18	$73.50	$1,323		Engr. Est.; Means Site Work, 1998, 022-250-0220	Assumes sludge residue is excavated by hand; assumes 1/2 inch of sludge under entire area of Building 109.
Steam Clean Building 109	LS	1	$400	$400		Engr. Est.; Means Site Work, 1998, 016-420-6310	Assumes crew and equip. rental cost/per day = $40.45/day; 200 gal/hr unit; 10 days
Grout Culverts Leading to Concrete Flume	CF	5.5	$5.50	$30		Engr. Est.;Means Site Work, 1998, 041-024-2600	Includes material and labor.
Waste Water Collection and Disposal	LS	1	$5,000	$5,000		Engr. Est.	
Hauling Sludge to Treatment Area	CY	18	$6.55	$118		Engr. Est.; Means Site Work, 1998, 022-266-0100	Assumes 2 mile round trip haul to on-site permitted burning area.
Sludge Removal - Subtotal					$6,871		

TABLE 2-13 (continued)

SITE 6 COST ESTIMATE: RAA 6 - EX SITU BIOLOGICAL TREATMENT, SOIL COVER, LIMITED EXCAVATION, AND SLUDGE REMOVAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Off-Site Disposal for SAOC #2							
Confirmatory Sampling - Labor	HR	40	$40	$1,600		Engr. Est.	1 person for 1 week
Sampling - Travel/Per Diem	LS	1	$1,500	$1,500		Engr. Est.	Airfare, per diem, hotel, rental car for 5 days for 1 person
Confirmation Sediment Sampling - Analysis							
Inorganics	Sample	22	$145	$3,190		Baker Average BOAs	Assumes 20 samples for delineation and 2 samples for confirmation during excavation (assuming sediment will be excavated).
Miscellaneous Expenses	Event	1	$200	$200		Engr. Est.	Includes Hau rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Excavation	CY	4	$1.68	$7		Engr. Est.; Means Site Work, 1998, 022-238-0260	Assumes 1 foot deep excavation in a 100 sqare foot area.
Off Site Disposal	Ton	5	$180	$900		Engr. Est.	Includes transportation, disposal costs; assumes 1 to 1 conversion factor for cy to ton; assumes 1.2 bulking factor of in place cubic yards
Site Restoration							
Backfill	CY	2.5	$5.60	$14		Engr. Est.; Means Site Work, 1998, A12.1-724-1400	Assumes 8" of backfill from on-site borrow pit (no material costs) at SAOC#3; accounts for 1.2 shrinkage factor when placed
Topsoil	CY	1.5	$17.04	$26		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 4" of top soil; cost includes mat'l, hauling from stockpile & compacting at nickel contaminated area at SAOC #2
Fine Grading/Seeding (Revegetation)	SY	15	$2.19	$33		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over all excavation areas at nickel contaminated area at SAOC #2
Off-Site Disposal for SAOC #2 - Subtotal							
Soil Cover at SAOC #3							
Backfill	CY	180	$7.20	$1,296		Engr. Est.; Means Site Work, 1998, 022-216-4000	Includes borrow, loading and spreading
Topsoil	CY	90	$17.04	$1,534		Engr. Est.; Means Site Work, 1998, 022-216-7000	Assumes 4" of top soil at SAOC #3; cost includes mat'l, hauling from stockpile & compacting
Fine Grading/Seeding (Revegetation)	SY	800	$2.19	$1,752		Engr. Est.; Means Site Work, 1998, 022-286-1000	Revegetation over SAOC #3
Soil Cover at SAOC #3 - Subtotal					$4,582		

TABLE 2-13 (continued)

SITE 6 COST ESTIMATE: RAA 6 - EX SITU BIOLOGICAL TREATMENT, SOIL COVER, LIMITED EXCAVATION, AND SLUDGE REMOVAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

Ex Situ Biological Treatment							
Excavation	CY	370	$1.68	$622		Engr. Est.; Means Site Work, 1998, 022-238-0260	SAOC #1 (370 cy in place)
Sampling - Labor	Hrs.	20	$40.00	$800		Engr. Est.	SAOC #1; 1 day/event; 2 geo./eng. samplers @ $40/hr ea.; 10 hrs/day
Confirmation Sediment Sampling - Analysis							
VOCs	Sample	40	$126	$5,040		Baker Average BOAs	Assumes 40 samples during treatment.
Nitramines	Sample	40	$150	$6,000		Baker Average BOAs	Assumes 40 samples during treatment.
Miscellaneous Expenses	Event	1	$200	$200		Engineering Estimate	Includes Haul rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Transport to Staging and Treatment Area	CY	600	$2.58	$1,548		Engr. Est.; Means Site Work, 1998, 022-266-0310	Assumes 12 CY dump trailer, 1/4 mile round trip to existing biocell; assumes 1.2 bulking factor of 370 cy in place sediment
Biological Treatment	Ton	600	$150	$90,000		Vendor Quote	factor during excavation; includes additives (1.2 factor increase in volume), soil mixing equipment operation, labor
Ex Situ Biological Treatment - Subtotal					$108,588		
Off-Site Disposal at SAOC #1							
Disposal of Listed Waste	TON	50	$536.00	$26,800		Vendor Quote	Includes hauling, disposal fees and taxes; assumes 1 to 1 conversion factor from cubic yards to tons, and 1.2 bulking factor.
Off-Site Disposal at SAOC #1 - Subtotal					$26,800		
DIRECT CAPITAL COSTS - TOTAL					$381,107		
INDIRECT CAPITAL COSTS							
Engineering and Design	LS	1	$22,866	$22,866		Engr. Est.	Assume 6% of Total Direct Capital Costs
Contingency Allowance	LS	1	$57,166	$57,166		Engr. Est.	Assume 15% of Total Direct Capital Costs
INDIRECT CAPITAL COSTS - TOTAL					$80,032		
CAPITAL COSTS (DIRECT AND INDIRECT)					$461,139		

TABLE 2-13 (continued)

SITE 6 COST ESTIMATE: RAA 6 - EX SITU BIOLOGICAL TREATMENT, SOIL COVER, LIMITED EXCAVATION, AND SLUDGE REMOVAL
NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

ANNUAL OPERATION AND MAINTENANCE COSTS							
Monitoring							
Sampling - Labor	Hrs.	120	$40.00	$4,800		Engr. Est.	Annual sampling at SAOC #2; 2 days/event; 2 geo./eng. samplers @ $40/hr ea.; 1 event/yr, 10 hrs/day
Sampling - Travel/Per Diem	Event	1	$2,100	$2,100		Engr. Est.	Airfare, per diem, hotel, rental car for 3 days for 2 people
Sediment Sampling - Analysis							
VOCs	Sample	6	$126	$756		Baker Average BOAs	6 samples at SSAOC#2; 1 event/yr
SVOCs	Sample	6	$225	$1,350		Baker Average BOAs	6 samples at SSAOC#2; 1 event/yr
Nitramines	Sample	6	$150	$900		Baker Average BOAs	6 samples at SSAOC#2; 1 event/yr
Groundwater and Surface Water Sampling - Analysis							
VOCs	Sample	10	$110	$1,100		Baker Average BOAs	10 groundwater samples/event; 10 surface water samples/event; 1 event/yr
SVOCs	Sample	10	$200	$2,000		Baker Average BOAs	10 groundwater samples/event; 10 surface water samples/event; 1 event/yr
Nitramines	Sample	10	$150	$1,500		Baker Average BOAs	3 groundwater samples/event; 3 surface water samples/event; 1 event/yr
Miscellaneous Expenses	Event	1	$200	$200		Engineering Estimate	Includes Hau rental, H&S equipment, sampling & decon expendables, ice & DI water
Reporting	LS	1	$5,000	$5,000		Engr. Est.	Letter report
Monitoring - Subtotal					$19,706		
SAOC #3 Maintenance							
Cap Repair	SF	720	$0.70	$504		Engr. Est.; Means Site Work, 1998, 029-316-1200	Assumes 10% of soil cover area will require maintenance every year.
SAOC #3 Maintenance - Subtotal					$504		
ANNUAL O&M COSTS - 30 years of maintenance					$20,210		
TOTAL NET PRESENT WORTH: RAA 6					$771,500	By: ELB Chk: CMC	Date Completed: April 9, 1998

Habitat at the Site 6 - Flume area shall be restored.

A soil cover (minimum 8 inches) shall be placed over the cadmium and zinc contaminated surface soil at the Site 6 - Excavated Area. The soil cover shall require long-term maintenance.

Long-term sediment, surface water, and groundwater monitoring shall be conducted at the Site 6 - Impoundment Area, (OU XV) in accordance with a long term monitoring plan which shall be approved by the USEPA, the VDEQ and the Navy. If area groundwater quality or Site 6 - Impoundment Area surface water and sediment quality degrades, posing a risk to human health and the environment, further remedial action may have to be evaluated.

WPNSTA Yorktown shall prohibit (i) residential use of the area surrounding the Site 6 - Flume Area, (ii) residential use of the area surrounding the Site 7 - Drainage Area and (iii) activities that interfere with or compromise the integrity of the soil cover at the Site 6 - Excavated Area. These are the "land use control objectives" for Sites 6 and 7. The precise boundaries of the areas in which residential use is prohibited shall be fixed during the development of the Land Use Control Implementation Plan described in the next paragraph.

Within 90 days of the execution of this ROD, WPNSTA Yorktown shall develop a Land Use Control Implementation Plan (LUCIP) with the concurrence of EPA Region III and in consultation with the Commonwealth of Virginia. The LUCIP shall include:

(1) a description and the location of Sites 6 and 7, including a map, a description of their approximate size and a description of the COCs;

(2) the land use control objectives (LUCs) selected above;

(3) the particular controls and mechanisms to achieve these goals;

(4) a reference to this ROD; and

(5) any other pertinent information.

Within 180 days following the execution of this ROD, the Navy, with the concurrence of EPA Region III and in consultation with the Commonwealth of Virginia, shall develop a Land Use Control Assurance Plan (LUCAP) for WPNSTA Yorktown. The LUCAP shall contain Station-wide periodic inspection, condition certification and agency notification procedures designed to ensure the maintenance by Station personnel of any site specific LUCs deemed necessary for future protection of human health and the environment, including LUCs selected in this ROD. A fundamental premise underlying execution of the LUCAP is that through the Navy's substantial good-faith compliance with procedures called for therein, reasonable assurances will be provided to USEPA and the Commonwealth of Virginia as to the permanency of those remedies which include the use of specific LUCs.

Although the terms and conditions of the LUCAP will not be specifically incorporated or made enforceable as to this or any other ROD, it is understood and agreed by the Navy, USEPA and the Commonwealth of Virginia that the contemplated permanence of the remedy reflected herein shall be dependent upon the Station's good-faith compliance with specific LUC maintenance commitments reflected herein. Should such compliance not occur or should the LUCAP be terminated it is understood that the protectiveness of the remedy concurred in may be reconsidered and that additional measures may need to be taken to adequately ensure necessary future protection of human health and the environment.

2.11 Statutory Determination

The Selected Remedy for Site 6 satisfies the requirements under Section 121 of CERCLA to:

- Protect human health and the environment.
- Comply with ARARs.
- Use permanent solutions and treatment technologies/resource recovery technologies to the maximum extent practicable.
- Satisfy the preference for treatment as a principal element.

2.11.1 Overall Protection of Human Health and the Environment

The Selected Remedy will provide a significant reduction in risks to human health and the environment through removal and biological treatment of soil/sediment in the Flume Area; a cover at the Site 6-Excavated Area; monitoring of groundwater, surface water, and sediment in the Site 6-Impoundment Area; and the removal and disposal of residue from AOC C and SWMU 179 (Building 109). As such, this alternative will protect human health and the environment. The potential source of contamination to other environmental media will be removed or covered.

2.11.2 Compliance with ARARs

The selected remedy for Site 6 complies with all Federal and state location and action specific ARARs as outlined below. Chemical specific ARARs or to-be-considered criterion (TBCs) are not available for soil or sediment; therefore, risk-based RLs were developed that are protective of both human health and the environment

Location-Specific ARARs

- **Migratory Bird Treaty Act**
  (16 U.S.C. 703-712)
  Action to prohibit any disturbance to nesting sites of listed migratory birds will be implemented. The remedial action will be planned such that the osprey nesting sites near Site 6 will not be disturbed.

- **National Historic Preservation Act**
  (32 CFR Parts 229 and 229.4; 43 CFR Part 171; and 36 CFR Part 800)
  Archeological resources encountered during excavation must be reviewed by Federal and Commonwealth archeologists. The Act also applies to potentially historic buildings. Building 109 is a World War II era building. The WPNSTA Yorktown Environmental Directorate and Draft Historic Preservation Plan for WPNSTA Yorktown will be contacted and reviewed prior to development of the Remedial Action Work Plan.

- **Executive Order 11990 Protection of Wetlands**
  (40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302)
  Action to minimize the destruction, loss, or degradation of wetlands that could be impacted by a remedial action. Monitoring of the Site 6-Impoundment Area is preferred over active remediation to maintain existing wetlands habitat. Erosion from excavation activities could affect the Site 6-Impoundment Area. An erosion control plan will be established as part of the Remedial Action Work Plan.

- **Clean Water Act, Section 404, 33 U.S.C. 1344**
  (40 CFR 230.10; 40 CFR 231 (231.1, 231.2, 231.7, 231.8))
  Action to prohibit discharge of dredged or fill material into a wetland without a permit if the discharge of dredge or fill is planned as part of the remedial alternative. No material taken from either Site 6 or removed from the bioremediation staging and treatment area after treatment will be discharged or placed into wetlands.

- **Virginia Wetlands Regulation**
  (VR 450-01-0051/4 VAC 20-390-10 to -50)
  Regulates activities that impact wetlands. The remedial action will be undertaken in such a way as to limit potential impacts on wetlands via erosion from Site 6 during excavation and reuse of treated soil/sediment.

Action-Specific ARARs

- **Resource Conservation and Recovery Act (RCRA)**
  Subtitle C, 42 U.S.C. 6921-6939e
  Applicable to any action at WPNSTA Yorktown involving treatment, storage, or disposal of hazardous waste.

  - Identification and Listing of Hazardous Waste
    (40 CFR Part 261)
    Any wastes hazardous by characteristic must be identified as part of the remedial action. Soil/sediment at the Site 6-Flume Area is contaminated by chlorinated volatiles, considered a hazardous waste by listing (RCRA F002)

- Releases from Solid Waste Management Units
(40 CFR Part 264, Subpart F)
All units on-site will comply with substantive requirements concerning potential releases. This ARAR applies to the biological treatment area and Building 109.

- Use and Management of Containers
(40 CFR Part 264, Subpart I)
Regulates the use and management of containers being stored at all hazardous waste facilities. Remediation may generate containerized waste, such as IDW. The Selected Remedy reduces the use of containers because a portion of the Site 6 soil/sediment will be treated at the staging and treatment area near Site 6. Also, the surface soil at the Site 6-Excavated Area will not be excavated or moved.

- Land Treatment
(40 CFR Part 264, Subpart M)
Regulates design, treatment demonstration, operating equipment, monitoring, closure and post-closure care of the treatment cell and treatment area. The selected remedy shall meet these requirements.

- **Virginia Hazardous Waste Management Regulations**
(VR 672-10-1/9 VAC 20-60-10 et seq.)
Regulates the treatment, storage, and disposal of hazardous waste.

  - Identification and Listing of Hazardous Waste
(VR 672-10-1, Part III; 9 VAC 20-60 Part III)
Applies to determining waste types by characteristic. Soil and sediment at the Site 6-Flume Area is contaminated by waste that is hazardous by listing (RCRA F002).

  - Releases from Solid Waste Management Units
(VR 672-10-1, Part X, Section 10.5; VAC 20-60-790)
Applies to owners/operators of facilities that treat hazardous waste. Regulates potential releases from all onsite solid waste management units. This ARAR applies to the biological treatment area and to Building 109.

  - Land Treatment
(VR 672-10-1, Part X, Section 10.12; 9 VAC 20-60-860)
Regulates design, treatment demonstration, operating requirements, monitoring, and closure and post-closure care of the treatment cell and treatment area.

  - Use and Management of Containers
(VR 672 -10-1, Part X, Section 10.8; 9 VAC 60-20-820)
Applies to Site 6 where the IDW associated with confirmation sampling may be containerized before off-site disposal.

- **Virginia Erosion and Sediment Control Regulations**
(VR 625-02-00; 4 VAC 50-30-10 to -110)
Applicable for remedial actions involving land disturbing activities. Activities including the excavation at Site 6 will have an erosion control plan submitted to Atlantic Division, Naval Facilities Engineering Command (LANTDIV) for approval.

2.11.3 Cost Effectiveness

Of the four "treatment" alternatives, the Selected Remedy (Alternative 6) is the most cost effective. It provides maximum long-term protection of human health and the environment and short-term protection of human health and the environment. It is the least costly of the treatment alternatives (considering that a portion of the cost of treatment will be shared by the treatment technology vendor) and will addresses all contaminant types.

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

The selected remedy is a permanent solution and uses treatment technologies to the maximum extent practicable. Contaminated Site 6 - Flume Area soil and sediment will be treated at the staging and treatment area using biological treatment to destroy nitramines/nitroaromatics and chlorinated volatiles. A contingent technology such as low temperature thermal desorption may be employed to address chlorinated volatiles. The clean soil will then be taken from the staging and treatment area and used as fill at the Station. The soil cover at the Site 6 - Excavated Area is not a treatment technology but will reduce mobility of the inorganic contaminants by preventing contact with runoff and infiltration. Permanence of the soil cover will depend on long-term maintenance.

2.12 Documentation of Significant Changes

The Proposed Plan presents the selected remedy as the preferred alternative. No significant changes to the remedy have been made.

3.0 RESPONSIVENESS SUMMARY

The final component of this Record of Decision is the Responsiveness Summary. The purpose of this section is to provide a summary of the public's comments, concerns, and questions about Sites 6 and 7.

During the public comment period, written comments, concerns and questions were solicited. An announcement of the public comment period and the public meeting was published in the *Daily Press* on May 24, 1998. A public meeting was held on May 26, 1998 at the York County Recreational Services Building to formally present the Proposed Plan and to answer questions and receive comments. The transcript of this meeting is presented in Appendix C of this Record of Decision. All comments and concerns concerning the remedy have been considered by the DoN and USEPA in the selection of the remedial alternatives for Sites 6 and 7.

The responsiveness summary is divided into the following sections:

- Overview
- Background on community involvement
- Summary of comments received during the public comment period

3.1 Overview

At the time of the public meeting, the DoN had endorsed No Further Action to protect human health and the environment at Site 7, WPNSTA, Yorktown.

In addition, the DoN endorsed a preferred alternative for Site 6, WPNSTA, Yorktown, for the cleanup of explosives-contaminated soil/sediment at the Site 6 - Flume Area, explosives and volatile contaminated soil/sediment at the Site 6 - Impoundment Area and inorganic contaminated soil at the Site 6 - Excavated Area. The alternative required removal and disposal of residue from the trenches under Building 109 and excavation and ex situ biological treatment of contaminated sediment and soil from the Site 6 - Flume Area. Site 6 - Flume Area soil and sediment would be treated using a nutrient source to enhance indigenous microbe growth to biologically degrade the contaminants. A soil cover would be installed over and around the cadmium- and zinc-contaminated soil at the Site 6 - Excavated Area. This would prevent the soils with cadmium and zinc concentrations above the RLs of 4.0 mg/kg and 48.4 mg/kg, respectively, from coming into contact with the ecological receptors. Long-term sediment, surface water, and groundwater monitoring would be conducted at the Site 6-Impoundment Area and surrounding area to assess the potential impact to human health and the environment and to preserve wetland habitat. USEPA Region III and the Commonwealth of Virginia concurred with the preferred alternative.

There were no comments received from the community during the public comment period in opposition to the proposed remedy. Community members of the Restoration Advisory Board (RAB) in attendance during the public meeting agreed with the selection of Alternative 6 as the preferred alternative.

3.2 Background on Community Involvement

Nearby communities have a good working relationship with WPNSTA Yorktown because the Station maintains a good neighbor policy through the Public Affairs Office. WPNSTA Yorktown participates in community events and celebrations to foster close ties with the community. As part of the ongoing Community Relations Program (CRP), community interviews were conducted in 1991 to inform the community of the IR Program and solicit feedback on the listing of WPNSTA Yorktown as an NPL site. The community expressed concern about three issues: water resources, cleanup funding, and information availability/validity. This public openness has been maintained by the Public Affairs Office and the Environmental Directorate at WPNSTA Yorktown through the CRP and resulted in the formation of the RAB. The WPNSTA RAB is comprised of agency representatives, technical and business people, and members of the community at large. The RAB meets regularly and progress at sites such as Sites 6 and 7 is discussed from the work plan stage to selection of the remedial alternative (if necessary). Preliminary Site 6 and 7 results were discussed at several past and at the most recent RAB meetings. No significant comments were received for either site at these meetings.

3.3 Summary of Comments Received During the Public Comment Period

The Public Comment Period closed on July 11, 1998. A copy of the revised final PRAP is presented in Appendix D.

APPENDIX A
HUMAN HEALTH COPC SUMMARIES

TABLE A-1

SURFACE SOIL STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SURFACE SOIL SAMPLE ANALYSIS SITE 6 - IMPOUNDMENT AREA (ROUND ONE) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg
Semivolatiles:				
Benzo(a)anthracene	2/7	0.036J-0.15J	0.17	
Benzo(a)pyrene	2/7	0.026J-0.12J	0.17	
Benzo(b)fluoranthene	2/7	0.085J-0.12J	0.18	
Benzo(k)fluoranthene	2/7	0.1J-0.11J	0.18	
Chrysene	2/7	0.13J-0.15J	0.19	
Dibenzo(a,h)anthracene	1/7	0.029J	0.18	
Indeno (1,2,3-cd) pyrene	2/7	0.033J-0.16J	0.17	
Inorganics:				
Aluminum	7/7	3,770-10,400	5,790.00	1,960 - 24,100
Arsenic	7/7	3.4J-6.4J	4.76	0.466 - 63.9
Beryllium	7/7	0.31-0.76	0.49	0.23J - 0.93J
Iron	7/7	11,800-23,000	14,914.29	1,440 - 46,400

mean is higher than max detected value
This implies that ½ of detection lim - is > max detected concentration.
That seems strange to me — but is it correct?

Notes:

J = Analyte was positively identified, value is estimated.
K = Analyte was positively identified, value is biased high.
L = Analyte was positively identified, value is biased low.
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-2

SURFACE SOIL STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SURFACE SOIL SAMPLE ANALYSIS SITE 6 (DRAINAGE AREA (ROUND TWO AND SUPPLEMENTAL INVESTIGATION) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Inorganics:				
Aluminum	5/5	6,230-11,200	8,338.00	1,960 - 24,100
Antimony	1/2	13.8L	8.93	9.2L - 11L
Arsenic	5/5	1.6L-7.6L	4.50	0.46L - 63.9
Beryllium	5/5	0.48-0.68	0.59	0.23J - 0.93J
Iron	5/5	5,570-23,900	15,330.00	1,440 - 46,400
Manganese	5/5	48.1-206	121.30	7.6L - 491

Notes:

J = Analyte was positively identified, value is estimated.

L = Analyte was positively identified, value is biased low.

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-3

SURFACE SOIL STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SURFACE SOIL SAMPLE ANALYSIS
SITE 6 - EXCAVATED AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Inorganics:				
Aluminum	6/6	13,100J-27,000J	19,550.00	1.960 - 24,100
Antimony	1/6	11.9L	6.49	9.2L - 11L
Arsenic	6/6	4.1-8	5.92	0.46L - 63.9
Beryllium	6/6	0.47-0.82	0.64	0.23J - 0.93J
Cadmium	2/6	3.4L-18.4L	4.09	1.2J - 1.5
Chromium	6/6	20.1-52.2	36.77	2.6 - 33.5
Iron	6/6	14,400J-35,300J	24,433.33	1,440 - 46,400
Zinc	6/6	93.1J-2,340J	934.18	3.2KJ - 48.4

Notes:

J = Analyte was positively identified, value is estimated.
K = Analyte was positively identified, value is biased high.
L = Analyte was positively identified, value is biased low.

ND = Not Detected

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-4

SUBSURFACE SOIL STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCI
FROM SUBSURFACE SOIL SAMPLE ANALYSIS
SITE 6 AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Volatiles:				
1,1-Dichloroethene	1/20	0.12	0.01	--
cis-1,2-Dichloroethene	3/17	0.041J-3.1J	0.25	--
trans-1,2-Dichloroethene	2/20	0.01J-0.26	0.02	--
Tetrachloroethene	1/20	0.016J	0.01	--
1,1,2,2-Tetrachloroethane	1/20	0.003J	0.01	--
1,1,2-Trichloroethane	1/20	0.008J	0.01	--
Trichloroethene	4/20	0.012-3.4J	0.21	--
Vinyl Chloride	1/20	4.7J	0.24	--
Nitramines:				
2-Amino-4,6-Dinitrotoluene	1/17	2.5	0.62	--
4-Amino-2,6-Dinitrotoluene	1/17	2.5	0.62	--
RDX	3/20	46-160	13.85	--
1,3,5-Trinitrobenzene	1/20	21	1.42	--
2,4,6-Trinitrotoluene	3/20	410-640	79.70	--
Inorganics:				
Antimony	6/13	8.4J-13.1L	7.11	8.5L - 31.3L
Arsenic	20/20	0.82-15.8	5.37	0.23J - 43.7
Beryllium	20/20	0.31-0.9	0.53	0.3J - 9.8

TABLE A-4 (Continued)

SUBSURFACE SOIL STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
FROM SUBSURFACE SOIL SAMPLE ANALYSIS
SITE 6 AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Chromium	19/20	6-46.6	20.8	5.2L - 33.5
Iron	20/20	3,270-35,200	14,618.50	3,810 - 51,100
Manganese	20/20	21.2-314	117.59	3.5J - 2,840

Notes:

L = Estimated value, biased low
J = Analyte was positively identified, value is estimated.
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-5

STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
FROM GROUNDWATER SAMPLE ANALYSIS
SITE 6 AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (µg/L)	ARITHMETIC* MEAN (µg/L)	RANGE OF STATION BACKGROUND (µg/L)
Volatiles				
1,1-Dichloroethane	2/5	14-14	5.90	--
1,1-Dichloroethene	2/5	36-45	16.50	--
cis-1,2-Dichloroethene	2/5	98-110	41.90	--
trans-1,2-Dichloroethene	1/5	1	3.00	--
1,1,1-Trichloroethane	2/5	13-14J	5.70	--
Trichloroethene	2/5	320-350	134.30	--
Nitramines				
4-Amino-2,6-Dinitrotoluene	2/5	1.2-1.4	0.82	--
RDX	2/5	63-80	28.78	--
Inorganics (Dissolved)				
Antimony	2/5	17.1-20.6	11.20	18.5J
Arsenic	3/5	3-12.6	5.94	ND
Manganese	5/5	23-233	131.38	1.1J - 12.2J
Thallium	1/5	6.3K	3.03	ND
Zinc	1/5	1,740J	352.18	2.9J - 5.9J

Notes:
J = Analyte was positively identified, value is estimated
K = Value estimated; biased high
ND = Not Detected
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-6

SURFACE WATER STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SURFACE WATER SAMPLE ANALYSIS
SITE 6 - IMPOUNDMENT AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (µg/L)	ARITHMETIC* MEAN (µg/L)	RANGE OF STATION BACKGROUND (µg/L)
Volatiles:				
1,2-Dichloroethene	1/4	4J	4.75	
1,1,2,2-Tetrachloroethane	1/4	1J	4.00	
Semivolatiles:				
Benzo(a)anthracene	1/4	0.9J	4.10	--
Benzo(a)pyrene	1/4	0.6J	4.03	--
Benzo(b)fluoranthene	1/4	0.6J	4.03	--
Benzo(k)fluoranthene	1/4	0.6J	4.03	--
Chrysene	1/4	0.9J	4.10	--
Phenanthrene	1/4	0.8J	4.08	--
Nitramines:				
HMX	3/4	2.8-12	4.68	--
RDX	3/4	5.8-33	13.03	--
2,4,6-Trinitrotoluene	1/4	36	9.49	--
Inorganics:				
Aluminum	4/4	178J-17,900J	6,624.50	171J - 5,600
Arsenic	3/3	3.2-10.4	5.73	1.2L - 3.5L
Beryllium	2/4	1.3-2.1	1.10	ND
Chromium	3/4	17.3-61.2	25.73	ND
Iron	4/4	838J-45,000J	19,359.50	289J - 6,650

TABLE A-6 (Continued)

SURFACE WATER STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
FROM SURFACE WATER SAMPLE ANALYSIS
SITE 6 - IMPOUNDMENT AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (µg/L)	ARITHMETIC* MEAN (µg/L)	RANGE OF STATION BACKGROUND (µg/L)
Lead	4/4	3.8-78.8J	42.60	1.2L - 5.4L
Manganese	4/4	51.4J-450J	223.10	33.1 - 379
Mercury	1/4	0.21	0.09	ND
Vanadium	4/4	74.8-125	97.53	5J - 14.4J

Notes:

J = Analyte was positively identified, value is estimated
K = Value is estimated; biased high.
L = Value is estimated; biased low

ND = Not Detected

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-7

SURFACE WATER STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SURFACE WATER SAMPLE ANALYSIS
SITE 6 - TRIBUTARY
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (µg/L)	ARITHMETIC* MEAN (µg/L)	RANGE OF STATION BACKGROUND (µg/L)
Volatiles:				
1,1,1-Trichloroethane	1/4	6J	5.25	--
Inorganics:				
Arsenic (carc)	1/4	1.8J	1.05	1.2L - 3.5L
Iron	4/4	1,200-1,530	1,402.50	289J - 1,150
Manganese	4/4	53.2-86.1	72.80	33.1 - 379
Inorganics (Dissolved):				
Arsenic (carc)	1/4	1.5J	0.91	1.2J - 13L
Manganese	4/4	18.6-44.4	29.38	2J - 290

Notes:

J = Analyte was positively identified, value is estimated
L = Value is estimated; biased low
*The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-8

STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
FROM SEDIMENT SAMPLE ANALYSIS
SITE 6 - IMPOUNDMENT
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Semivolatiles:				
Benzo(a)anthracene	2/8	0.21J-0.45J	0.3	--
Benzo(b)fluoranthene	2/8	0.29J-0.63	0.33	--
Benzo(k)fluoranthene	2/8	0.083J-0.21J	0.25	--
Benzo(a)pyrene	2/8	0.18J-0.4J	0.29	--
Chrysene	2/8	0.22J-0.5	0.31	--
Indeno(1,2,3-cd)pyrene	1/8	0.17J	0.27	--
Inorganics:				
Aluminum	8/8	2,560-16,000	NC	482K - 17,700J
Arsenic (carc)	8/8	1.5-23.8	NC	0.276 - 5.4L
Beryllium	5/9	0.33-0.86	NC	0.28J - 0.99J
Iron	8/8	8,130-27,000	NC	329 - 27,700J
Vanadium	9/8	9.2-81.6	NC	1.9J - 38.9

Notes:

FIX

L = Estimated value, biased low
K = Estimated value, biased high
J = Analyte was positively identified, value is estimated.

NC = Not Calculated

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-9

SEDIMENT STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSIS
SITE 6 - IMPOUNDMENT AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Volatiles:				
1,1-Dichloroethane	2/55	0.052-4.5J	0.1	--
1,2-Dichloroethane	3/55	0.008J-88	1.62	--
1,1-Dichloroethene	1/55	0.44	0.17	--
1,2-Dichloroethene (Total)	3/53	0.009J-0.05	0.17	--
Tetrachloroethene	2/55	0.091-180	3.29	--
1,1,1-Trichloroethane	2/55	0.031J-190	3.48	--
Trichloroethene	1/55	0.005J	0.17	--
Vinyl Chloride	2/55	0.063-014	0.17	
Semivolatiles:				
Acenaphthene	6/55	0.068J-2.6J	0.6	
Anthracene	7/55	0.069J-6.8J	0.64	--
Benzo(a)anthracene	21/55	0.094J-9.1J	0.68	--
Benzo(b)fluoranthene	21/55	0.079J-2.4	0.72	--
Benzo(k)fluoranthene	16/55	0.088J-0.96J	0.6	--
Benzo(g,h,i)perylene	16/55	0.086J-2.3J	0.55	--
Benzo(a)pyrene	26/55	0.094J-9.6J	0.69	--
Carbazole	3/55	0.058J-3.1J	0.63	--
Chrysene	21/55	0.12J-11	0.77	--
Dibenzo(a,h)anthracene	6/55	0.062J-0.33J	0.61	--
2,4-Dinitrotoluene	2/55	1.9-28J	1.13	--

TABLE A-9 (Continued)

SEDIMENT STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
FROM SEDIMENT SAMPLE ANALYSIS
SITE 6 - IMPOUNDMENT AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
2,6-Dinitrotoluene	1/55	0.55J	0.6	--
Fluoranthene	26/55	0.067J-3.9	0.74	--
Fluorene	4/55	0.065J-5J	0.62	--
Indeno(1,2,3-cd)pyrene	13/55	0.097J-1.8	0.63	--
2-Methylnaphthalene	4/55	0.17J-0.45J	0.63	--
Naphthalene	1/55	0.067J	0.65	--
Phenanthrene	18/55	0.084J-15	0.8	--
Pyrene	30/55	0.063J-22	1.07	--
Nitramines:				
4-Amino-2,6-Dinitrotoluene	8/46	0.098N-520N	11.52	--
1,3-Dinitrobenzene	1/55	0.210N	0.11	--
HMX	2/55	96-710	15.19	--
RDX	2/55	63-160	4.36	--
1,3,5-Trinitrobenzene	3/55	0.45N-19	0.67	--
2,4,6-Trinitrotoluene	10/55	0.13N-2,500N	45.86	--
Inorganics:				
Aluminum	11/11	2,150J-38,900	9,500.91	1,510 - 40,500
Antimony	1/11	48.2	18.19	18.9L
Arsenic (carc)	11/11	4-22.1	8.03	1.4J - 13.1
Beryllium	7/11	0.73-1.7	1.00	0.55J - 1.6J
Cadmium	5/11	2.5-9.8	3.74	ND

TABLE A-9 (Continued)

SEDIMENT STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSIS SITE 6 - IMPOUNDMENT AREA NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Chromium	11/11	9.8-94.8	34.40	3.8 - 66.1
Iron	11/11	9,120J-61,600	23,220.00	3,060 - 46,000
Manganese	11/11	60.9J-245	135.20	7.4 - 1,980
Nickel	9/11	12.5-100	40.60	9.3K - 55.2
Vanadium	11/11	39.6-382	145.96	4.8J - 67.6
Zinc	11/11	45.8-643	277.16	4J - 202J

Notes:

J = Analyte was positively identified, value is estimated.
K = Estimated value; biased high.

ND = Not Detected

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-10

SEDIMENT STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSIS
SITE 6 - TRIBUTARY
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Inorganics:				
Aluminum	8/8	9,430-33,300	24,528.75	1,510 - 40,500
Arsenic (carc)	8/8	4.5-11.2	8.74	1.4J - 13.1
Beryllium	7/8	1.1-1.5	1.13	0.55J - 1.6J
Chromium	8/8	20.2-58.8	45.81	3.8 - 66.1
Iron	8/8	19,000-39,900	34,000.00	3,060 - 46,000
Manganese	8/8	67.1-286	213.01	7.4 - 1,980
Vanadium	8/8	37.2-81.9	59.96	4.8J - 67.6

Notes:

J = Analyte was positively identified, value is estimated.

ND = Not Detected

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-11

SURFACE SOIL STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SURFACE SOIL SAMPLE ANALYSIS SITE 7 - STUDY AREA NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Inorganics:				
Aluminum	4/4	6,010-19,100	13,552.50	1,960 - 24,100
Antimony	1/4	18.6L	8.09	9.2L - 11L
Arsenic	4/4	4.5-11	7.15	0.46L - 63.9
Beryllium	4/4	0.48-0.95	0.72	0.23J - 0.93J
Cadmium	1/4	6	1.96	1.2J - 1.5
Chromium	4/4	13.7-40.2	29.88	2.6 - 18.3
Iron	4/4	14,300-28,200	21,800.00	1,440 - 46,400
Manganese	4/4	155-382	240.50	7.6L - 491

Notes:

J = Analyte was positively identified, value is estimated.
L = Analyte was positively identified, value is biased low.

ND = Not Detected

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-12

SUBSURFACE SOIL STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SUBSURFACE SOIL SAMPLE ANALYSIS
SITE 7
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Inorganics:				
Aluminum	13/13	2,920-14,000	6,697.69	2,710 - 28,200
Antimony	2/13	10.5L-16.5L	5.53	8.5L - 31.3L
Arsenic	13/13	0.96K-14.5	3.71	0.23J - 42.7
Beryllium	11/13	0.27-1.7	0.64	0.3J - 9.8
Chromium	13/13	4.8-63.4	17.7	5.2L - 33.5
Iron	13/13	4,110-46,100	14,155.38	3,810 - 51,100
Manganese	13/13	41.1-429	163.87	3.5J - 2,940

Notes:

J = Analyte was positively identified, value is estimated.
K = Estimated value, biased high
L = Estimated value, biased low
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-13

STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM GROUNDWATER SAMPLE ANALYSIS SITE 7 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (μg/L)	ARITHMETIC* MEAN (μg/L)	RANGE OF STATION BACKGROUND (μg/L
Volatiles				
1,1-Dichloroethane	1/3	16	NC	--
1,1-Dichloroethene	1/3	4	NC	--
1,1,1-Trichloroethane	2/3	2-40	NC	--
Nitramines				
4-Amino-2,6-Dinitrotoluene	3/3	2.5-37	NC	--
RDX	3/3	13-180	NC	--
Inorganics (Dissolved)				
Antimony	1/3	13.7	NC	18.5J

Notes:

J = Analyte was positively identified, value is estimated
NC = Not Calculated
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-14

SURFACE WATER STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SURFACE WATER SAMPLE ANALYSIS SITE 7 - STUDY (TRIBUTARY) AREA NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (μg/L)	ARITHMETIC* MEAN (μg/L)	RANGE OF STATION BACKGROUND (μg/L)
Inorganics (Dissolved):				
Arsenic (carc)	2/3	1.3-1.8	NC	1.2J - 13L

Notes:

J = Analyte was positively identified, value is estimated
L = Value is estimated; biased low

NC = Not Calculated

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-15

SURFACE WATER STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SURFACE WATER SAMPLE ANALYSIS
FELGATES CREEK
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (μg/L)	ARITHMETIC* MEAN (μg/L)	RANGE OF STATION BACKGROUND (μg/L)
Inorganics (Dissolved):				
Manganese	9/9	36.7J-99.7J	69.79	2J - 290

Notes:

J = Analyte was positively identified, value is estimated
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-16

SEDIMENT STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN
FROM SEDIMENT SAMPLE ANALYSIS
SITE 7 - STUDY (TRIBUTARY) AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Inorganics:				
Aluminum	6/6	19,300-34,100	27,850.00	1,510 - 40,500
Arsenic	6/6	9.7-13.3	11.38	1.4J - 13.1
Beryllium	6/6	1.1-1.6	1.38	0.55J - 1.6J
Chromium	6/6	42.5-61.5	53.07	3.8 - 66.1
Iron	6/6	39,100-45,500	42,316.67	3,060 - 46,000
Manganese	6/6	252-385	312	7.4 - 1,980
Vanadium	6/6	52.1-69.2	62.48	4.8J - 67.0

Notes:

J = Analyte was positively identified, value is estimated.
L = Estimated value, biased low.
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE A-17

SEDIMENT STATISTICAL SUMMARY OF HUMAN HEALTH CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSIS FELGATES CREEK NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

CHEMICAL	FREQUENCY OF DETECTION	RANGE OF DETECTED CONCENTRATIONS (mg/kg)	ARITHMETIC* MEAN (mg/kg)	RANGE OF STATION BACKGROUND (mg/kg)
Inorganics:				
Aluminum	12/12	13,700-38,500	24,441.67	1,510 - 40,500
Arsenic	12/12	6.7-14.9	10.11	1.4J - 13.1
Beryllium	12/12	0.88-1.6	1.19	0.55J - 1.6J
Chromium	12/12	29.4-59.8	45.88	3.8 - 66.1
Iron	12/12	25,100-43,800	35,091.67	3,060 - 46,000
Manganese	12/12	202-327	254.08	7.4 - 1,980
Vanadium	12/12	36.2-71.2	56.25	4.8J - 67.6

Notes:

J = Analyte was positively identified, value is estimated.

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

APPENDIX B
ECOLOGICAL ECOC SUMMARIES

TABLE B-1

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SURFACE SOIL SAMPLE ANALYSES SITE 6 - IMPOUNDMENT AREA (ROUND ONE, ROUND TWO, AND SUPPLEMENTAL INVESTIGATION) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detected Detections (µg/kg)	Arithmetic* Mean (µg/kg)	Range of Station Background (µg/kg)
Semivolatiles				
Benzo(a)anthracene	2/17	36J - 150J	188.59	--
Benzo(a)pyrene	2/17	26J - 120J	186.24	--
Benzo(b)fluoranthene	2/17	85J - 120J	189.71	--
Benzo(g,h,i)perylene	2/17	35J - 150J	188.53	--
Benzo(k)fluoranthene	2/17	100J - 110J	190	--
Chrysene	2/17	130J - 150J	194.12	--
Fluoranthene	3/17	30J - 420	203.82	--
Indeno(1,2,3-cd)pyrene	2/17	33J - 160J	189	--
Phenanthrene	2/12	27J - 320J	195.17	--
Pyrene	3/17	27J - 240J	188.35	--
Nitramines				--
HMX	1/17	5,600	788.24	--
RDX	1/17	2,900	560.29	--

TABLE B-1 (continued)

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
FROM SURFACE SOIL SAMPLE ANALYSES
SITE 6 - IMPOUNDMENT AREA (ROUND ONE, ROUND TWO, AND SUPPLEMENTAL INVESTIGATION)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detected Detections (mg/kg)	Arithmetic* Mean (mg/kg)	Range of Station Background (mg/kg)
Inorganics				
Aluminum	12/12	3,770 - 11,200	6,851.67	1,960-24,100
Antimony	1/9	13.8L	6.08	2L-11L
Beryllium	12/12	0.31 - 0.76	0.53	0.23J-0.93J
Chromium	12/12	8.8 - 32.6	17.56	2.6-33.5
Iron	12/12	5,570 - 23,900	15,087.5	1,440-46,400
Lead	12/12	6.7 - 22.1J	11.75	2.1-43.1
Mercury	1/12	0.09	0.03	0.05J
Nickel	10/12	3.8 - 15.9	7.12	3.8J-12.5
Vanadium	11/12	8.7 - 25.8	15.86	5.2J-64.7
Zinc	12/12	21.5 - 63.3	37.56	3.2KJ-48.4

Notes:

NC Not Calculated
ND Not Detected
J Estimated value
K Estimated value, biased high
L Estimated value, biased low
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-2

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SURFACE WATER SAMPLE ANALYSES SITE 6 - IMPOUNDMENT AREA (ROUND ONE AND ROUND TWO) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/L)	Arithmetic* Mean (µg/L)	Range of Station Background (µg/L)
Nitramines				
HMX	3/6	2.8 - 12	3.22	--
RDX	3/6	5.8 - 33	8.78	--
2,4,6-Trinitrotoluene	1/6	36	9.49	--
Inorganics				
Aluminum	6/6	36.3 - 17,900J	4,433.5	171J - 5,600
Chromium	3/6	17.3 - 61.2	17.65	ND
Cobalt	2/6	6.9 - 11	4.65	5.3J - 8.5J
Copper	4/6	6.1 - 50.3	24.03	5.6J - 6.7J
Iron	6/6	514 - 45,000J	13,086.83	289J - 6,650
Lead	4/6	3.8 - 78.8J	28.57	1.2L - 5.4L
Manganese	6/6	15.8 - 450J	154.00	33.1 - 379
Mercury	1/6	0.21	0.09	ND
Nickel	3/6	23.2J - 34.3J	18.47	19.8K - 55.5K
Zinc	6/6	83.6 - 554	190.72	7.9J - 80.2

Notes:

J Estimated value
K Estimated value, biased high
L Estimated value, biased low
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-3

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSES SITE 6 - IMPOUNDMENT AREA (ROUND ONE, ROUND TWO, AND SUPPLEMENTAL INVESTIGATION) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
Volatiles				
Acetone	28/46	24J - 760J	318.59	--
Carbon Disulfide	3/45	12J - 47J	196.77	--
Chloroethane	2/46	15J - 24J	196.96	--
Chloromethane	1/46	16J	196.67	--
1,1-Dichloroethane	1/46	4,500J	121.36	--
1,2-Dichloroethane	3/46	8J - 88,000	1,935.66	--
Tetrachloroethene	2/46	91 - 180,000	3,939	--
1,1,1-Trichloroethane	2/46	31J - 190,000	4,152.91	--
Vinyl Chloride	1/46	140	198.76	--
Semivolatiles				
Acenaphthene	2/46	240J - 440J	589.02	--
Anthracene	3/46	120J - 520J	560.54	--
Benzo(a)anthracene	17/46	94J - 2,100	550.85	--
Benzo(a)pyrene	15/46	150J - 2,000	570.00	--
Benzo(g,h,i)perylene	11/46	130J - 1,600J	548.48	--
Bis(2-ethylhexyl)phthalate	22/46	150J - 36,000	2,421.63	--

TABLE B-3 (continued)

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
FROM SEDIMENT SAMPLE ANALYSES
SITE 6 - IMPOUNDMENT AREA (ROUND ONE, ROUND TWO, AND SUPPLEMENTAL INVESTIGATION)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
Carbazole	1/46	340J	574.02	--
Chrysene	17/46	120J - 2,400	601.63	--
Dibenzo(a,h)anthracene	5/46	62J - 330J	539.5	--
Fluoranthene	18/46	79J - 3,900	666.57	--
Fluorene	1/46	220J	570.41	--
Indeno(1,2,3-cd)pyrene	10/46	170J - 1,800	566.74	--
2-Methylnaphthalene	3/46	210J - 450	557.17	--
4-Methylphenol	1/46	1,500J	599.24	--
Pentachlorophenol	1/46	230J	1,413.59	--
Phenanthrene	15/46	110J - 2,400	573.26	--
Pyrene	24/46	63J - 4,000	679.85	--
Nitramines				
4-amino-Dinitrotoluene	6/37	98N - 3,000N	429.03	--
2,4-Dinitrotoluene	1/46	28,000J	1,125.11	--
2,6-Dinitrotoluene	1/46	550J	528.37	--
HMX	2/46	96,000 - 710,000	18,040.23	--
RDX	2/46	63,000 - 160,000	5,218.06	--

TABLE B-3 (continued)

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
FROM SEDIMENT SAMPLE ANALYSES
SITE 6 - IMPOUNDMENT AREA (ROUND ONE, ROUND TWO, AND SUPPLEMENTAL INVESTIGATION)
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
1,3,5-Trinitrobenzene	2/46	5,400 - 19,000	861.97	--
2,4,6-Trinitrotoluene	8/19	130N - 6,200	535.44	--
Inorganics		(mg/kg)	(mg/kg)	(mg/kg)
Aluminum	19/19	2,150J - 38,900	9,004.21	1,510-40,500
Arsenic	19/19	1.5 - 23.8	8.53	1.4J-13.1
Beryllium	12/19	0.33 - 1.7	0.76	0.55J-1.6J
Cadmium	5/19	2.5 - 9.8	2.57	ND
Chromium	19/19	9.8 - 94.8	30.63	3.8-66.1
Cobalt	12/19	1.6 - 12.4	4.67	3.8J-15J
Copper	19/19	2.3 - 130	29.62	3.7J-43.1
Iron	19/19	8,130 - 61,600	20,137.37	3,060-46,000
Lead	14/19	3.6J - 68.1J	25.84	3.4-51.6
Manganese	19/19	10.7 - 245	90.68	292J-9,720K
Mercury	2/19	0.12 - 0.22K	0.13	0.18L-0.29L
Nickel	16/19	4.9K - 100	28.32	9.3K-55.2
Selenium	4/19	0.36L - 1.2L	0.59	0.46L-1.5L
Vanadium	19/19	9.2 - 382	96.78	4.8J-67.6

TABLE B-3 (continued)

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSES SITE 6 - IMPOUNDMENT AREA (ROUND ONE, ROUND TWO, AND SUPPLEMENTAL INVESTIGATION) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
Zinc	19/19	22.6 - 643	197.42	4J-202J

Notes:

NC Not Calculated
J Estimated Value
K Estimated value, biased high
L Estimated value, biased low
N Tentatively Identified Compound
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-4

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSES SITE 6 - FLUME AREA NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
Volatiles				
Acetone	2/7	64B - 170	NC	--
1,1-Dichloroethane	7/7	12J - 980	NC	--
1,2-Dichloroethene (total)	7/7	42J - 110,000DJ	NC	--
Tetrachloroethene	3/7	9J - 100J	NC	--
1,1,1-Trichloroethane	4/7	90 - 270	NC	--
Trichloroethene	7/7	21J - 2,600,000DJ	NC	--
Vinyl Chloride	6/7	29 - 4,000D	NC	--
Semivolatiles				
Acenaphthene	4/7	80J - 230J	NC	--
Anthracene	5/7	84J - 410J	NC	--
Benzo(a)anthracene	6/7	99J - 1,200J	NC	--
Benzo(a)pyrene	2/7	490J - 1,000J	NC	--
Benzo(g,h,i)perylene	4/7	160J - 850J	NC	--
Bis(2-ethylhexyl)phthalate	7/7	400J - 5,500J	NC	--
Carbazole	3/7	110J - 230J	NC	--
Chrysene	6/7	120J - 1,500J	NC	--

TABLE B-4 (continued)

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSES SITE 6 - FLUME AREA NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
Dibenzo(a,h)anthracene	1/7	140J	NC	--
Fluoranthene	6/7	200J - 2,000J	NC	--
Fluorene	5/7	87J - 260J	NC	--
2-Methylnaphthalene	6/7	1,100J - 3,300J	NC	--
4-Methylphenol	6/7	93J - 530J	NC	--
Naphthalene	6/7	510J - 1,000J	NC	--
n-Nitrosodiphelamine	3/7	80J - 210J	NC	--
Phenanthrene	6/7	270J - 2,000J	NC	--
Pyrene	6/7	310J - 2,900J	NC	--
Pesticides				
4,4'-DDD	2/7	16J - 31J	NC	--
4,4'-DDE	3/7	26J - 49J	NC	--
4,4'-DDT	1/7	16J	NC	--
Nitramine/Nitroaromatic Compounds				
2-amino-4,5-Dinitrotoluene	5/7	7,400J - 600,000	NC	--
4-amino-Dinitrotoluene	5/7	4,800J - 640,000	NC	--

TABLE B-4 (continued)

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN
FROM SEDIMENT SAMPLE ANALYSES
SITE 6 - FLUME AREA
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
2,4-Dinitrotoluene	4/7	580J - 3,700J	NC	--
2,6-Dinitrotoluene	2/7	320J - 590J	NC	--
HMX	7/7	3,300J - 45,000	NC	--
RDX	6/7	2,100J - 120,000	NC	--
1,3,5-Trinitrobenzene	2/7	610J - 6,800	NC	--
2,4,6-Trinitrotoluene	6/7	870J - 1,000,000D	NC	--

Chemical	Frequency of Detection	Range of Detection Concentrations (mg/kg)	Arithmetic Mean* (mg/kg)	Range of Station Background (mg/kg)
Inorganics				
Aluminum	7/7	2,680 - 10,500	NC	482K - 17,700J
Arsenic	7/7	6.7J - 27.4J	NC	0.27L - 5.4L
Beryllium	7/7	0.16 - 1.2	NC	0.28J - 0.99J
Cadmium	7/7	3.6 K - 15.8K	NC	ND
Cobalt	7/7	1.3 - 9.4J	NC	1.1J - 7.9J
Copper	7/7	53.1J - 227J	NC	1J - 6.3J
Cyanide	4/7	0.75 - 1.3	NC	ND

TABLE B-4 (continued)

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSES SITE 6 - FLUME AREA NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
Iron	7/7	11,700J -31,300J	NC	329 - 27,700J
Lead	7/7	68.8 - 220	NC	1.8L - 381L
Mercury	6/7	0.1 - 0.96	NC	0.06L - 0.09L
Nickel	7/7	6J - 232J	NC	4.6K - 17.5K
Selenium	3/7	1.3 - 1.9	NC	0.86L
Vanadium	7/7	20.9J - 1,250J	NC	1.9J - 38.9
Zinc	7/7	185K - 1,000K	NC	3.2J - 143

Notes:

NC Not Calculated
ND Not Detected
D Sample required dilution
J Analyte was positively identified, value is estimated
K Estimated value, biased high
L Estimated value, biased low
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-5

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SURFACE WATER SAMPLE ANALYSES SITE 6 - TRIBUTARY(ROUND TWO) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/L)	Arithmetic Mean* (µg/L)	Range of Station Background (µg/L)
Inorganics				
Aluminum	4/4	491 - 1,130	851	171J - 5,600
Iron	4/4	1,200 - 1,530	1,402.5	289J - 6,650
Manganese	4/4	53.2 - 86.1	72.8	33.1 - 379
Nickel	2/4	19.8 - 49.6	21.35	19.8K - 55.5K

Notes:

J Estimated value
K Estimated value, biased high
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-6

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSES SITE 6 - TRIBUTARY(ROUND TWO) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic* Mean (µg/kg)	Range of Station Background (µg/kg)
Volatiles				
Acetone	6/8	27J - 220J	94.56	--
Carbon Disulfide	2/8	12J - 110J	26.69	--
Semivolatiles				
Phenol	1/8	890J	534.38	--
Inorganics				
Aluminum	8/8	9,430 - 33,300	24,528.75	1,510 - 40,500
Arsenic	8/8	4.5 - 11.2	8.74	1.4J - 13.1
Beryllium	7/8	1.1 - 1.5	1.13	0.55J - 1.6J
Cadmium	1/8	2.4	1.66	ND
Cobalt	8/8	2.6 - 12.5	8.46	3.8J - 15J
Iron	8/8	19,000 - 39,900	34,000	3,060 - 46,000
Manganese	8/8	67.1 - 286	213.01	7.4 - 1,980
Nickel	8/8	13.4 - 36.1	27.01	9.3K - 55.2
Vanadium	8/8	37.2 - 81.9	59.96	4.8J - 67.6
Zinc	8/8	79.6 - 153	131.45	4J - 202J

Notes:

ND Not Detected
J Estimated Value
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-7

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SURFACE SOIL SAMPLE ANALYSES SITE 6 - EXCAVATED AREA (ROUND TWO) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (mg/kg)	Arithmetic* Mean (mg/kg)	Range of Station Background (mg/kg)
Inorganics				
Aluminum	6/6	13,100J - 27,000J	19,550.00	1,960 - 24,100
Antimony	1/6	11.9L	6.49	9.2L - 11L
Beryllium	6/6	0.47 - 0.82	0.64	0.23J - 0.93J
Cadmium	2/6	3.4L - 18.4L	4.09	1.2J - 1.5
Chromium	6/6	20.1 - 52.2	36.77	2.6 - 33.5
Iron	6/6	14,400J - 35,300J	24,433.33	1,440 - 46,400
Lead	6/6	9.6K - 43.1K	25.55	2.1 - 43.1
Nickel	5/6	4.6L - 9.2L	6.36	3.8J - 12.5
Vanadium	6/6	25 - 53.6	40.22	5.2J - 64.7
Zinc	6/6	93.1J - 2,340J	934.18	3.2KJ - 48.4

Notes:

J Estimated value
K Estimated value, biased high
L Estimated value, biased low
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-8

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SURFACE SOIL SAMPLE ANALYSES SITE 7 - STUDY AREA (ROUND TWO) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	~~Range of Detected Detections~~ Concentrations (mg/kg)	Arithmetic* Mean (mg/kg)	Range of Station Background (mg/kg)
Inorganics				
Aluminum	4/4	6,010 - 19,100	13,552.5	1,960 - 24,100
Antimony	1/4	18.6L	8.09	9.2L - 11L
Beryllium	4/4	0.48 - 0.95	0.72	0.23J - 0.93J
Cadmium	1/4	6	1.96	1.2J - 1.5
Chromium	4/4	13.7 - 40.2	29.88	2.6 - 33.5
Copper	4/4	4.4 - 145	41.73	1.2J - 24.4
Cyanide	1/4	1.2	0.57	ND
Iron	4/4	14,300 - 28,200	21,800.00	1,440 - 46,400
Lead	4/4	8.9K - 148	49.00	2.1 - 43.1
Manganese	4/4	155 - 382	240.50	7.6L - 491
Mercury	3/4	0.08 - 0.53	0.18	0.05J
Nickel	4/4	11.5 - 27.2	17.65	3.8J - 12.5
Vanadium	4/4	20.6 - 43.8	35.95	5.2J - 64.7
Zinc	4/4	25.3 - 928	270.80	3.2KJ - 48.4

Notes:

ND Not Detected
J Estimated value
K Estimated value, biased high
L Estimated value, biased low

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-9

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SURFACE WATER SAMPLE ANALYSES SITE 7 - TRIBUTARY (ROUND TWO) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detected ~~Detections~~ (µg/L)	Arithmetic Mean* (µg/L)	Range of Station Background (µg/L)
Inorganics				
Aluminum	3/3	841 - 1,460	1,088.67	171J - 5,600
Iron	3/3	1,090 - 1,870	1,403.33	289J - 6,650
Manganese	3/3	79.7 - 87.5	83.6	33.1 - 379

Notes:

J Estimated value

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-10

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSES SITE 7 - TRIBUTARY (ROUND TWO) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection (µg/kg)	Range of Detected Detections (µg/kg)	Arithmetic Mean* (µg/kg)	Range of Station Background (µg/kg)
Volatiles				
Acetone	6/6	25J - 300J	143.33	--
Carbon Disulfide	1/6	66J	25.50	--
Semivolatiles				
Di-n-Butylphthalate	1/6	2,700	879.17	--

Chemical	Frequency of Detection (mg/kg)	Range of Detected Detections (mg/kg)	Arithmetic Mean (mg/kg)	Range of Station Background (mg/kg)
Inorganics				
Aluminum	6/6	19,300 - 34,100	27,850.00	1,510 - 40,500
Arsenic	6/6	9.7 - 13.3	11.38	64J - 13.1
Beryllium	6/6	1.1 - 1.6	1.38	0.55J - 1.6J
Cobalt	6/6	7.9 - 11.5	10.12	38J - 15J
Iron	6/6	39,100 - 45,500	42,316.67	3,060 - 46,000
Manganese	6/6	252 - 385	312.00	7.4 - 1.980
Nickel	6/6	28.5 - 40.9	32.65	9.3K - 55.2
Silver	2/6	2.4 - 3.1	1.84	2.2J
Vanadium	6/6	52.1 - 69.2	62.48	4.8J - 67.6
Zinc	6/6	131 - 154	146.00	4J - 202J

Notes:

ND Not Detected
J Estimated value
K Estimated value - biased high
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-11

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SURFACE WATER SAMPLE ANALYSES FELGATES CREEK (ROUND TWO) NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detected Detections (µg/L)	Arithmetic Mean* (µg/L)	Range of Station Background (µg/L)
Inorganics				
Aluminum	9/9	433J - 1,360J	854.89	171J - 5,600
Cobalt	1/9	4.6	2.29	5.3J - 8.5J
Iron	9/9	810J - 1,980J	1,319.79	289J - 6,650
Manganese	9/9	98.4J - 168J	137.71	33.1 - 379
Nickel	3/9	21.2K - 27.8K	13.18	19.8K - 55.5K

Notes:

J Estimated value
K Estimated value, biased high
* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

TABLE B-12

STATISTICAL SUMMARY OF ECOLOGICAL CHEMICALS OF POTENTIAL CONCERN FROM SEDIMENT SAMPLE ANALYSES FELGATES CREEK NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

Chemical	Frequency of Detection	Range of Detection Concentrations (µg/kg)	Arithmetic* Mean (µg/kg)	Range of Station Background (µg/kg)
Volatiles				
Acetone	3/12	26J - 160J	34.08	--
Semivolatiles				
Di-n-Butylphthalate	7/12	3,500 - 16,000	3,748.33	--

Chemical	Frequency of Detection	Range of Detection Concentrations (mg/kg)	Arithmetic Mean (mg/kg)	Range of Station Background (mg/kg)
Inorganics				
Aluminum	12/12	13,700 - 38,500	24,441.67	1,510-40,500
Arsenic	12/12	6.7 - 14.9	10.11	1.4J-13.1
Beryllium	12/12	0.88 - 1.6	1.19	0.55J-1.6J
Cobalt	12/12	7.7 - 12.2	9.83	3.8-66.1
Iron	12/12	25,100 - 43,800	35,091.67	3,060-46,000
Manganese	12/12	202 - 327	254.08	7.4-1,980
Mercury	1/12	0.31K	0.13	0.18L-0.29L
Nickel	12/12	13 - 37.9	23.53	9.3K-55.2
Selenium	7/12	0.63L - 2.5K	1.05	0.46L-1.5L
Vanadium	12/12	36.2 - 71.2	56.25	4.8J-67.6
Zinc	12/12	99.7J - 172J	131.23	4J-202J

Notes:

J Estimated value
K Estimated value, biased high
L Estimated value, biased low

* The arithmetic mean is calculated using positive detections and one half of the detection limit for non-detections.

APPENDIX C
PUBLIC MEETING TRANSCRIPT

CERTIFIED ORIGINAL

NAVAL WEAPONS STATION

YORKTOWN

PROPOSED REMEDIAL ACTION PLANS FOR

SITES 1 & 3 and SITES 6 & 7

TRANSCRIPT OF PROCEEDINGS

Yorktown, Virginia

March 26, 1998

Appearances:

Jeff Harlow, Weapons Station Yorktown

Rich Hoff, Baker Environmental, Inc.

Scott Park, LANT Division

Bob Stroud, U.S. EPA, Region 3

TAYLOE ASSOCIATES, INC.

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PROCEEDINGS

KAYE PHILLIPS: I'm Kaye Phillips, public affairs officer. I replaced Tom Black just about a year ago, and so it's nice seeing all of you here tonight. And captain -- I almost goofed there. Captain Denham is here with us. He's our commanding officer for the station. And Jay Dewing is our chairman for us -- cochairman.

Captain, did you have anything you wanted to say?

CAPTAIN DENHAM: No, I don't have anything. Go ahead.

KAYE PHILLIPS: Jay?

JAY DEWING: Not until later.

KAYE PHILLIPS: Okay. If any of you noticed in Sunday's paper, we had the ad that's running that's required for 45 days regarding this proposed remediation plan that's coming up for Sites 1 and 3 and 6 and 7. It started on the 26th of May. And the period will run from 10 July and any -- that' open for public comments. And all comments would be sent to my office, and then I turn it over to Jeff an these gentlemen that are working on this program.

Tonight, Jeff, along with -- we have Bob Stroud, who is new. I think it is his first official

meeting.

BOB STROUD: Second.

KAYE PHILLIPS: Okay. But Bob was still here the last time, right?

BOB STROUD: No, he wasn't here.

KAYE PHILLIPS: But Bob replaced Rob and he's here with us from EPA. And Scott Park and Rich will be working with Jeff in making his presentation tonight.

If any of you know anyone in the community that has any comments or anything to make regarding these, my phone number is 887-4939. That's in the ad that's in the paper. And, please, feel free to call me, and we'll get the information for you that's desired.

So without anything further, I'm going to turn it over to Jeff. And I will mention that I think there's been some question about budget that wasn't on your agenda, but that will be covered before the close of the program this evening.

JEFF HARLOW: I guess first thing is we tried to incorporate this public meeting type scenario in with the RAB meeting. I'm interested in comments if you'd like to do this or we can take the technical stuff. I kind of thought this might be a quick way to

get up to speed to what's going on here in the next year or so at the station.

But, again, if we don't like this, we can change the format to just have a separate public meeting, just trying to save a little money and work it in. The trade-off of that is, is that, you know, we're sacrificing some of our RAB time for it. And then the other thing is we get in a pinch that we've scheduled so far ahead that when we announced the meeting, we were kind of set to do it; whereas in the past, we probably allowed for a couple of weeks for the announcement to hit the paper and then actually had the public presentation.

And I guess with that, what I'm going to do is we're going to do this as a joint effort like Kaye was saying. I'm going to let Bob pick up. He is new to the sites, but he's getting on board real quick and has been a big asset, as far as I'm concerned, and he's got the first four slides here for us to get us started, and then I'm going go into the site descriptions and then Scott and Rich will follow it u on the back end.

BOB STROUD: Good evening. I guess you-all know, my name is Bob Stroud. I'm the new EPA project manager for Yorktown. I've been involved wit

the sites for about six months or so. My first meeting was in December of '97. What we want to try and do tonight is present to you the proposed remedial action plans for four different sites at Yorktown, Sites 1 and 3 and Sites 6 and 7. Actually, I'm probably going to be repeating what Jeff and Kaye just said.

Okay. This presentation to this meeting is to just let all concerned citizens know that Yorktown is going to be evaluating the four sites that I've mentioned, Sites 1 and 3 and 6 and 7. And as Kaye had mentioned to you, the public comment period begins today, May 26, and continues for 45 days, through July 10th, 1998. So if anyone has any comments, suggestions, or concerns, they can contact Kaye, I guess, by letter or phone or what have you.

This slide here just represents a couple -- actually, this is the entire facility. This map here represents the entire facility, with this being Felgates Creek in this area and this being Indian Field Creek. Sites 1 and 3 and 6 and 7 are in these two areas right here. I think the next slide shows it.

Here we are with Felgates, as I said, and Indian Field Creek here, Sites 6 and 7 and Sites 1 and

3. The reason that we're doing them together like this is because of their location. Since they are located so close to each either, it just makes sense in saving money and that sort of thing, to do these sites together.

With that, I'll turn it over to Jeff Harlow.

JEFF HARLOW: Okay. I get to do site description since I'm the resident expert, I guess. We'll do Site 1 first. Ultimately it was a landfill at the station from 1965 through just beyond 1979. It operated under a conditional use permit. And a little note here for lens grinding dust, we have had a lieutenant command on our site, generally they make all the lenses -- or all the glassware for all the military. I think the Army closed their facilities down, and it's a pretty big business there.

But at one time they were dumping their lens grinding dust in our landfill, pretty much an inert plastic material.

This is Site 1 specifically, the entrance point down here in the bottom of the slide. Generally, all the debris is in this area here on the right-hand side of this access road that you see here. It's kind of a typical scenario, I guess, for

landfills in the past. This was once a borrow area for sand and fill. They had a hole. What do you do with a hole? You fill it back in, and it became a landfill.

You see a small ponded area here. Word on it was it was an excavated area that just never got filled. It dries up in the summertime. And you see a green patch. It's kind of a little wildlife management area. It's beyond the boundaries of the landfill itself. Indian Field you're seeing here in the background right here.

Site 3 is a two-acre dump area, same thing. This one is even older than Dudley Road Landfill. It's been real difficult to even get -- except this document only speculates that it was used in the early 1900s as a fill area for us developing our industrial area. A lot of cuts, you know, steep walls and stuff where it just looks like they're in there mining out the fill for using somewhere else.

Ultimately the same thing came down, you had a hole in the ground and what to do with it but try to fill it back in.

This is Site 3 looking at the main roads here. Putting some perspective, Dudley Road Landfill would be down here at the bottom. You can't see the

pointer very good down here. And the beginning of Indian Field Creek, or at least one of the branches, would kind of run between the two sites. And ultimately Indian Field would run down here at my feet or whatever. You're seeing some of our magazines here in the background.

Here's a perspective of the two sites together. Here you're seeing Dudley Road Landfill. And back in here you can kind of see some reduced growth. That's the landfill here. And then ultimately Felgates Creek coming out this way.

Site 6 -- and what we're doing -- I'm just going to back up here. We're actually incorporating both of these perhaps together in one presentation. So 1 and 3 is the first one. We're doing those two sites together as one unit. And ultimately you'll see a rod for those two sites.

And now for Sites 6 and 7, there will be a separate rod for that, and I just wanted to break that out so we can work it all in one presentation.

Site 6 is a washout facility, basically there since 1942-43. It's always been a reclaim facility for TNT. We did install a carbon absorption tower in 1975 which theoretically should have alleviated the waste that we would have been putting

in the creeks.

And then ultimately we hooked up HRSD, and we've been knocking this around. I have to do a little more research, but I thought it was the early '80s. We're saying '86. That's the best we have as of right now.

There's also -- along with some of the cooperative efforts with EPA, they had some considerable concerns with the actual building itself being contaminated, potentially the contaminants migrating out into the facility. And so we're also looking at some of the trenches and stuff inside the building. It won't be a perfect clean closure of a building, but at least we'll negate any potential for the building itself contaminating out in the environment.

We then in the future have schedules to do building demolition under the MIL COM program where it should appropriately be done.

This is building 109. You see here in the shadows a little bit, you see the trench here that went out into, what we call now, the impoundment area. There's a dam or what -- the impoundment here that you see. And you don't see it on here, but it's along this general area. And all of that wastewater

went out from this ditch into this marshy area.

There's another thing with this site off to the side here, there's an annex that had a vapor phase degreaser in there and some TCU problems here on the site along with some explosives. This was a second phase. I guess this building generally went through two improvements, I guess, or modifications. And this equipment went in the early '40s and then it went through an upgrade.

At one time there was a tank inside this building that actually they did TCE liquid solution and degreasing or actually tar removal of the lining material inside the bomb casings. And what I understood what they do is when it got dirty, you'd open up the valve and out in the creek it would go.

This is looking back towards Building 109, and you can now see the impoundment itself here. It was also -- just to put a time line, it was built at the same time the building was built, in 1942.

As far as the whole area here -- and I guess Rich will get more into it, but the impoundment itself is not really showing any large amounts of explosive contamination. We're seeing it right at th edge of the trench, right at the end of it.

And, of course, in the proposal we're

going to look at just doing long-term monitoring to see where it's at instead of destroying the wetlands to see what might be out there.

Here you're seeing a view from the building and the trench here going out into the marsh. That concludes 6. And I'll go into 7.

Now, 7 was our actual explosive loading plant three. You had a loading facility. You load weapons or casings of bombs, and whatever you had at the end of the day, you'd have washdown procedures, whether it be the kettle or just the building itself. Before 1975, that wastewater went right directly into the creek.

After 1975 it, at least, went through carbon tower, and then ultimately we went to HRSD. All of these -- and just to reiterate, all of these buildings for both 6 and 7 are since closed. 109 has been closed since the mid '80s. And plant two, I guess, closed about three years ago or two and a half years. And so that's where we're at on that.

This would be a view of plant three here. Just a quick overview, you had the prep building where your empty casings would come in. This was the actual loading facility here. You did remote loading. During the actual loading process, you'd be

in the bunkers and actually be loading remotely. And that discharge water came out the building right here. And you see like a -- here it's hard to see; we'll get to a few slides down in the bottom of this presentation, but there's a run of rip rap here.

We did a removal action a couple of years ago, and that's the biocell or bioslurry job that we did. And I don't want to steal Rich's thunder here, but essentially we succeeded in doing a good treatability study so we don't have to go back out here and clean this thing up.

And with that -- who is it, Scott or Rich?

RICH HOFF: What we're going to do tonight is a much more linear presentation of the remedial action plan for these sites because of the number of sites we have. In the past we have come in here and we've discussed in detail the analytical data, the risk assessments, and the evaluation of all of the proposed remedial actions.

We thought in order to keep it a little shorter and open it up for questions, that we would run through this information in a little more streamline manner. That was based on comments we received from EPA Region 3. We've given these

presentations to their hierarchy. And one of their recommendations was to streamline the process and get more information out to you-all quicker.

I'm going to start with Sites 1 and 3. Scott will take 6 and 7.

As a recap, remedial investigations were performed at both Sites 1 and 3. That included both Round 1 RI and a Round 2 remedial investigation. Data that was collected during these investigations were compiled into a focused feasibility study.

We did a focused feasibility study rather than a full-blown feasibility study because the areas of contamination in both sites were rather small. In fact, the first time we did a proposed plan, we were suggesting no action at both sites.

But because of the partnering process that we're involved in, we've been able to sit down with the regulators and really dissect the information. And there were some concerns that came out of it, the least of which is not the state's concern about Site 1 and the fact that it was a former solid waste limited landfill.

There were some findings that there were low-lying areas that needed to be filled in. And so when we went through the process, we wanted to focus

on those technologies that would supplement the reestablishment of the cupboard.

I also wanted to mention that EPA Region 3 is going to be doing a comprehensive surface water investigation at Indian Field Creek and Pelgates Creek in the next few months. And because of the interconnectedness between groundwater and surface water in Indian Field Creek, we didn't want to evaluate any remedial alternatives at this time for those media. So this focused feasibility study really concentrated on the soils in both Site 1 and Site 3.

This is one of our worst figures. I apologize for the quality of it. But this is Site 1 and here's Site 3. You saw through the pictures that there was a ravine or a ditch that sort of bisected the two, and then you enter one of the branches, one of the two branches of Indian Field Creek on either side of Site 3.

To evaluate the human health and ecological risks, when we conducted the risk assessment, there were really no unacceptable risks. Current receptors, again no unacceptable risks. Because of the frequency of exposure, it's rather limited.

Future receptors. The concentrations

when averaged over a large area really didn't give us much of an average or an upper 95th percent that we would have to worry about. But there were some hot spots.

The terrestrial and aquatic receptors under the ecological risks is one of the few sites where we had no really significant ecological concerns.

When we were doing the focused FS, there were one or two locations around Site 1. In fact, they were well-boring locations that had high arsenic concentrations. And by "high," I mean they were above station-wide backdrops, which is about 63 parts per million.

And we did some additional system sampling to figure out what the extent of this was, and we also tried to get to the bottom of why there might be this increased arsenic concentration. But we never really figured out the latter, but we did take additional samples, quite a number of them, to define the hot spot. And we used 63 parts per million and above as a way of incorporating the hot spot and evaluating the extent of potential contamination.

And, again, the solid waste landfill cover will be reestablished as part of the remedy.

It's not really a risk-driven action, but, again, it's out there and we wanted to address it as part of the remedy.

At Site 3, again with current receptors, there were no unacceptable health risks. Future receptors, there were some unacceptable risks for adult and children. And this was based on another hot spot. And at Site 3 we had PAHs. And if you remember the site description for Site 3, you saw a lot of oils, greases, sludges, and solvents that went in there. And this is, in fact, what we're turning up; those PAHs are usually a constituent of those types of waste materials.

True to form, the terrestrial demonstrated a slight risk again to the PAHs. And the aquatic, with the limited data that we had on Indian Field Creek, there was no significant risk present. Again, I want to state that EPA is going to be collecting additional data, and that's one of the reasons we don't want to make any comments on the aquatic, Indian Field Creek, and the groundwater at this time.

This is, again, kind of difficult to see, but if you take a look at Site 1, we have an area of debris that we're going to pick up. This is the

extent of the arsenic hot spot. It's very small. And what's interesting is it's really off of the main body of what was considered to be the solid waste landfill. So to my knowledge, we really have no idea as to why that arsenic exists there. But sure enough when we take those samples, that area is well in excess of all the other areas at Site 1.

Site 3, again the same situation, where there are a number of debris piles that we have identified. This is what we consider the extent of Site 3 proper. And the small red area in the center is the area of soil that we're concerned about. This was identified and delineated using PAH test kits down to a depth of four feet, and we have a very good handle on the extent of contamination.

To wrap it up, we're proposing remedial action three, and there are a number of remedial actions proposed for each site, and I would encourage you-all to take a look at the total remedial action plan for the details associated with each one of the RAAs and the associated costs.

We're proposing at this point in time to reestablish the soil cupboard at Site 1, to do the debris removal, and to do the soil excavation and off-site disposal in the area of the arsenic hot

spot. One of the reasons this was a focused FS is that with such a small volume, it really doesn't make sense to develop techniques such as in situ vitrification or any of the in situ technology that might be out there. It really wouldn't be cost effective.

Site 3 we selected RAA-4, and it's very similar. We're going to remove the debris that exists in the area and we're going to excavate the PAH hot spot. And, again, because of the limited size, we're going to off-site disposal. And this will be disposed of as nonhazardous. We have to do TCLP to confirm that. But, again, you're talking about such a small area that it really doesn't make sense to look at any land finding or compost technologies. And the present work for this remedial action, the alternative is 155,000.

With that, I'd like to turn to Scott and he'll tell you a little bit about 6 and 7.

SCOTT PARK: Okay. Moving over to Sites 6 and 7. Again, like Sites 1 and 3, we conducted remedial investigations and post RI investigations at each of those sites. And then a feasibility study report evaluated the data collected from those investigations and also took a look at our remedial

action alternatives.

Again, we screened many and broke it down to about six or seven, and I'll present to you which one we came up with as our selection and that we're proposing, again in the proposed remedial action plan that you can review.

Sites 6 and 7, the -- let's see. Operable Unit 14 is the whole area that bounds -- runs along Felgates Creek. Site 6 is generally in this area. That's the building Jeff showed you. Here's the drainage way from that building and the large impoundment that he showed to you. Site 7 is down here. And you'll get some site pictures of those.

Site 7 is Operable Unit 12. And Operable Unit 13 is the flume area or drainage way leading from Building 109 out towards the surface impoundment. And then Operable Unit 15 is an excavated area. I'll talk about that a little bit more and why it's there, what we're doing with it.

Based on risk assessment summaries, conclusions from Site 6 first were unacceptable risks to human health from future residential exposure to the soil and sediment in the impoundment area. Highly unlikely that it will be developed for future residential, but the possibility, I guess, does exist

and there are some risks to doing that.

Unacceptable ecological risks to receptors in the impoundment area, the flume area, and the excavation areas, those are called areas of concern. But actually the flume area is AOC, or Area of Concern 1, the impoundment area is Area of Concern 2, and the excavation area is Area of Concern 3. You'll see a picture of all of those.

Site 7 conclusions were there were no unacceptable risks to human receptors under any land-use scenario, no unacceptable ecological risks, and all the risks were mitigated by the removal action conducted for the full-scale pilot study. Jeff talked about that.

Soil was removed and was taken to our biotreatment cell where it was put into a slurry using the simplex saber technology, and that's been cleaned up. And we're also using that cell right now to clean up Site 19 which is another site we have evaluated and moved to Rodham (phonetic).

This is a picture of Site 7. I'll cover that first since it was basically taken care of already. This is the area of concern that was cleaned up. This is a little before my time. These guys can help me out. I believe this material here is gravel

that was placed down after the excavation took place just to show a level where we had excavated to if it ever came back later and somebody had to go back down, they would know the area that had been taken care of.

This is just a grading of that area and regrading it, and it wasn't revegetated, but it is starting to vegetate itself, I believe. It's a low spot down by Site 7.

Areas of Concern 1 and 2. First, again the building is down in this area and there's the drainage way coming out of the building that leads out towards the impoundment. There's a concrete channel -- a system of channels underneath the building and then a channel that leads wastewater out into the flume area, as we call it, and then further along into Area of Concern 2, which is right here. That's the impoundment area.

As Jeff mentioned, most of the contamination that was found that had risks associated with it was right in this area, Area of Concern 1. And that's the area that we're focusing our actual cleanup, if you will, as I'll tell you about in our remedial action alternatives.

This is AOC-3. It's an excavated area, very uniform and rectangular as you can see. We're

not really sure where that came from. We don't know if it's a basement for a house or a building or a borrow area. I don't think it's a house, but it looks more like something like a borrow area or something somebody was getting ready to construct and they never did. And it's just an area that's there, and actually we're just going to fill that in and cover it. And we haven't found any risks associated with that.

The selected remedial alternative for Sites 6 and 7. Site 6, again, many were considered. We're proposing in situ biological treatment using a different biological treatment than the Simplot process.

In our last meeting we discussed a joint venture we're working on with W.R. Grace and the Canadian government, and we're looking for split funding from both of those two entities, and the Navy; the three of us are going to share-cost that. We're in the treatability study phase right now, and it's going well. If we have full proof that the technology works, that's what we're proposing to use. It will be a land farming treatment on the station and it will be in a greenhouse type of structure.

And we'll clean up about a thousand cubic yards of material, is what we're expecting right now.

That's from our Area of Concern 1. There will be a soil cover area in Area of Concern 3 which was excavated, that we're not quite sure where that hole came from.

Also as part of the project, we're going to do sludge removal from the channel system underneath the building and the channel running out to Area of Concern 1. And that will remove all the contaminants and residual contaminants from operations in that building so we can then block off the channel from the building out to our site. And that way in the future if any water were to get in the building or anything came out from those channels, it would be clean because we had already taken care of it; we wouldn't recontaminate our site.

Then we'll do long-term monitoring of surface water and groundwater in the entire area. And, again, Jeff had said the Area of Concern 1 was our primary area of contamination, and it didn't seem it was getting into the surface impoundment. And we're going to do long-term monitoring of the surface water and groundwater to make sure that there's nothing going on. The net present worth is about $673,000.

And then Site 7, there's no action

alternative because the site has actually been cleaned up under a pilot study. And that present worth is obviously zero.

Just to move along to the public participation. Our public comment period began today in the newspaper in The Daily Press. Kaye talked about that. And the purpose is to encourage you and other members of the public to participate in that process and the selection of the proposed alternatives for all four of these sites.

The comment period will close on July 10th of 1998. It's a 45-day comment period. We look forward to hearing your comments today and by mail or by phone call if you should choose to do that.

And on that, we'll go to comments, questions, concerns, open the floor up to anything anybody would like to talk about on these sites.

CINDY BARBRAU: Cindy Barbrau, York County Business. You said that Site 7 was done under a pilot study. Do you have anything about approximately how much that --

SCOTT PARK: The cost of it?

CINDY BARBRAU: Yeah.

JEFF HARLOW: It was a large-scale pilot study.

RICH HOFF: It was about a million dollars.

SCOTT PARK: Did that include the construction of the cell?

RICH HOFF: Yeah. That included the construction of the biocell area, the excavation of the area which expanded in scope once we started into the digging, which, I think, a lot of these areas will probably grow past the data that we now have. The nice thing about that is that although we did spend a million dollars in the up-front, we are starting to see some returns from the presence of the biocell, and it's greatly cheapened the remedial action for Site 19.

SCOTT PARK: The capital cost will be recouped every time we use that cell, so it will be recovered.

JEFF HARLOW: I guess the fortunate thing or the unfortunate thing, however you look at it, Grace came into play in the middle of all of this and now we're looking at another alternative, innovative technology, to treat contaminated soils, along with TCE.

The original plans of the cell was to, you know, not only clean up Site 7 and 19, but we also

COURT REPORTER'S CERTIFICATE

I, SCOTT D. GREGG, RPR, and Notary Public, certify that I recorded verbatim by Stenotype the proceedings in the captioned cause before a public hearing, Proposed Remedial Action Plans for Sites 1 & 3 and Sites 6 & 7, Yorktown, Virginia, on May 26, 1998.

I further certify that to the best of my knowledge and belief, the foregoing transcript constitutes a true and correct transcript of the said proceedings.

Given under my hand this 10th day of June, 1998, at Norfolk, Virginia.

Scott D. Gregg