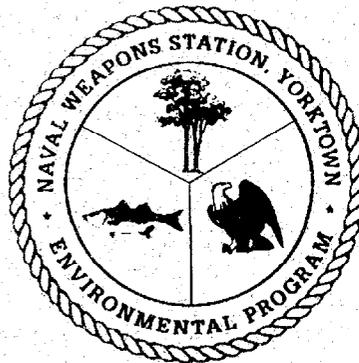


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Final
Round Two
Remedial Investigation Report
Sites 9 and 19
Naval Weapons Station Yorktown
Yorktown, Virginia
Text and Figures



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TABLE OF CONTENTS

	<u>Page</u>
LIST OF ACRONYMS AND ABBREVIATIONS	xi
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION	1-1
1.1 Site 9 and 19 Description and History	1-2
1.1.1 Site 9 - Plant 1 Explosives-Contaminated Wastewater Discharge Area	1-3
1.1.2 Site 19 - Conveyor Belt Soil at Building 10	1-3
1.2 Previous Investigations	1-4
1.2.1 Initial Assessment Study	1-4
1.2.2 Confirmation Study and RI Interim Report	1-5
1.2.3 Focused Biological Sampling and Preliminary Risk Evaluation Report	1-5
1.2.4 Round One Remedial Investigation	1-5
1.2.5 Habitat Evaluation Results	1-12
1.3 References	1-14
2.0 STUDY AREA INVESTIGATION	2-1
2.1 Introduction	2-1
2.2 Round Two Field Sampling Program	2-1
2.2.1 Soil Investigation	2-2
2.2.2 Groundwater Investigation	2-5
2.2.3 Surface Water, Sediment, and Biota Investigation	2-10
2.3 Quality Assurance/Quality Control Sampling Procedures	2-13
2.4 Decontamination Procedures	2-15
2.5 Investigation Derived Waste Management	2-15
2.6 References	2-16
3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA	3-1
3.1 General Physiography	3-1
3.2 Geology	3-2
3.2.1 Regional Geology	3-2
3.2.2 Sites 9 and 19 Geology	3-2
3.3 Hydrogeology	3-4
3.3.1 WPNSTA Yorktown	3-4
3.3.2 Site Hydrogeology	3-5
3.4 Land Use and Demography	3-7
3.5 References	3-7
4.0 NATURE AND EXTENT OF CONTAMINATION	4-1
4.1 Potential Non-Site-Related Analytical Results	4-1
4.1.1 Sampling/Laboratory Contaminants	4-2
4.1.2 Naturally Occurring Inorganic Elements	4-4

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
4.2	Round Two RI Analytical Results 4-4
4.2.1	Site 9 Analytical Results 4-5
4.2.2	Site 19 Investigation 4-10
4.3	Extent of Contamination 4-13
4.3.1	Site 9 4-13
4.3.2	Site 19 4-16
4.4	References 4-17
5.0	CONTAMINANT FATE AND TRANSPORT 5-1
5.1	Chemical and Physical Properties 5-1
5.2	Contaminant Transport Pathways 5-5
5.2.1	Off-Site Atmospheric Deposition of Windblown Dust 5-6
5.2.2	Surface Soil Runoff 5-7
5.2.3	Sediment Migration 5-7
5.2.4	Leaching of Sediment Contaminants to Surface Water 5-8
5.2.5	Migration of Contaminants in Surface Water 5-8
5.2.6	Leaching of Soil Contaminants to Groundwater 5-9
5.2.7	Migration of Groundwater Contaminants Offsite 5-10
5.3	Fate and Transport Summary 5-12
5.3.1	Volatile Organic Compounds 5-12
5.3.2	Semivolatile Organic Compounds 5-13
5.3.3	Nitramine Compounds 5-13
5.3.4	Inorganics 5-14
5.4	References 5-15
6.0	HUMAN HEALTH RISK ASSESSMENT 6-1
6.1	Overview 6-1
6.2	Identification of Chemicals of Potential Concern 6-2
6.2.1	COPC Selection Criteria 6-3
6.2.2	Re-inclusion of Chemicals as COPCs 6-6
6.2.3	Selection of COPCs 6-8
6.2.4	Summary of COPCs 6-19
6.3	Exposure Assessment 6-19
6.3.1	Potential Human Receptors 6-21
6.3.2	Conceptual Site Model 6-24
6.3.3	Quantification of Exposure 6-24
6.3.4	Exposure Factors Used To Derive Chronic Daily Intakes 6-28
6.4	Toxicity Assessment 6-33
6.4.1	Reference Doses 6-34
6.4.2	Carcinogenic Slope Factors 6-34
6.4.3	Dermal Absorption Efficiency 6-35

TABLE OF CONTENTS
(Continued)

		<u>Page</u>
6.5	Risk Characterization	6-36
	6.5.1 Carcinogenic Compounds	6-36
	6.5.2 Noncarcinogenic Compounds	6-37
6.5.3	Potential Human Health Effects	6-38
6.6	Sources of Uncertainty	6-44
	6.6.1 Sampling and Analysis	6-44
	6.6.2 Selection of COPCs	6-45
	6.6.3 Exposure Assessment	6-46
	6.6.4 Toxicological Assessment	6-47
	6.6.5 Toxicity Criteria for Evaluating the Dinitrotoluenes	6-49
	6.6.6 Risk Characterization	6-50
6.7	Summary of Risk Assessment Results	6-50
	6.7.1 Current Potential Receptors	6-51
	6.7.2 Future Potential Receptors	6-51
6.8	References	6-54
7.0	ECOLOGICAL RISK ASSESSMENT	7-1
7.1	Problem Formulation	7-2
	7.1.1 Round One Remedial Investigation	7-3
	7.1.2 Round Two Remedial Investigation	7-3
	7.1.3 Ecological Endpoints	7-4
	7.1.4 Criteria for Selecting Ecological Contaminants of Concern	7-6
	7.1.5 Selection of Ecological Contaminants of Concern	7-9
7.2	Ecological Receptor Characterization	7-10
	7.2.1 Site 9	7-11
	7.2.2 Site 19	7-11
7.3	Exposure Pathways	7-12
	7.3.1 Surface Soil Exposure Pathway	7-12
	7.3.2 Groundwater Exposure Pathway	7-13
	7.3.3 Surface Water/Sediment Exposure Pathway	7-13
	7.3.4 Air Exposure Pathway	7-14
7.4	Exposure Assessment	7-14
7.5	Ecological Effects Characterization	7-16
	7.5.1 Surface Soil	7-17
	7.5.2 Surface Water	7-20
	7.5.3 Sediment	7-21
	7.5.4 Biota Quality	7-21
7.6	Risk Characterization	7-23
	7.6.1 Surface Soil	7-23
	7.6.2 Surface Water	7-25
	7.6.3 Sediment	7-26

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
7.6.4 Threatened and/or Endangered Species	7-27
7.6.5 Wetlands	7-27
7.6.6 Other Sensitive Environments	7-27
7.7 Risk Assessment	7-27
7.7.1 Aquatic Assessment Endpoint	7-28
7.7.2 Terrestrial Assessment Endpoint	7-30
7.8 Uncertainty	7-32
7.8.1 Sampling Method	7-32
7.8.2 Benthic Macroinvertebrate Interpretation	7-32
7.8.34 Screening Levels	7-33
7.8.5 Assessment of Nitramines in the Environment	7-35
7.8.56 Terrestrial Models	7-35
7.9 Interpretation	7-36
7.9.1 Site 9	7-36
7.9.2 Site 19	7-38
7.10 References	7-38
8.0 SUMMARY AND CONCLUSIONS	8-1
8.1 Summary	8-1
8.1.1 Site 9	8-1
8.1.2 Site 19	8-3
8.2 Conclusions	8-4
8.2.1 Site 9	8-4
8.2.2 Site 19	8-6

APPENDICES

A	Round One Analytical Data
B	Results of Immediate Removal at Site 9
C	Well Construction Records
D	Well Development Forms
E	Slug Test Data and Gradient Calculations
F	Field Data Forms
G	Chain of Custody Forms
H	Round Two Sampling Summary
I	Round Two Laboratory Results
J	Round Two QA/QC Results and Data Validation Summaries
K	Data Summary Tables for Human Health Risk Assessment
L	Risk Calculations
M	Risk Summary Tables
N	Ecological Risk Assessment Supplemental Information
O	Fish and Benthic Macroinvertebrate Data
P	Terrestrial Support Data

LIST OF TABLES

- ES-1 Total Site Lifetime Incremental Cancer Risk (ICR) and Hazard Index (HI) Values for Current Potential Human Receptors
- ES-2 Total Site Lifetime Incremental Cancer Risk (ICR) and Hazard Index (HI) Values for Future Potential Human Receptors
- ES-3 Quotient Index Ratios - Terrestrial Intake Model Site 9
- ES-4 Quotient Index Ratios - Terrestrial Intake Model Site 19

- 1-1 Metals Concentrations for Groundwater Samples Round One Remedial Investigation - Site 9
- 1-2 Metals Concentrations for Surface Water Samples Round One Remedial Investigation - Site 9

- 2-1 RI/FS Objectives - Sites 9 and 19
- 2-2 Summary of the Round Two RI Surface Soil Sampling Program - Sites 9 and 19
- 2-3 Summary of the Round Two RI Subsurface Soil Sampling Program - Sites 9 and 19
- 2-4 Summary of Well Construction Details Sites 9 and 19
- 2-5 Summary of HydroPunch™/Temporary and Permanent Monitoring Well Groundwater Sampling Program - Sites 9 and 19
- 2-6 Summary of Water Level Measurements - Sites 9 and 19
- 2-7 Summary of the Round Two RI Surface Water Sampling Program - Sites 9 and 19
- 2-8 Summary of the Round Two RI Sediment Sampling Program - Sites 9 and 19
- 2-9 Summary of the Field QA/QC Sampling Program for the Soil Investigation - Sites 9 and 19
- 2-10 Summary of the Field QA/QC Sampling Program for the Groundwater Investigation - Sites 9 and 19
- 2-11 Summary of the Field QA/QC Sampling Program for the Surface Water Investigations - Sites 9 and 19
- 2-12 Summary of the Field QA/QC Sampling Program for the Sediment Investigations - Sites 9 and 19
- 2-13 Summary of the Field QA/QC Sampling Program for All Media Investigations - Sites 9 and 19

- 3-1 Summary of Hydraulic Conductivities in Selected Monitoring Wells - Sites 9 and 19

- 4-1 Data Qualifier Definitions and Notes - Sites 9 and 19
- 4-2 Station-Wide and Site-Specific Background Inorganic Concentrations Detected in Surface and Subsurface Soils - Sites 9 and 19
- 4-3 Surface Soil - Positive Detection Summary Inorganics - Site 9
- 4-4 Surface Soil - Positive Detection Summary Organic Compounds - Site 9
- 4-5 Shallow Subsurface Soil - Positive Detection Summary Inorganics - Site 9
- 4-6 Shallow Subsurface Soil - Positive Detection Summary Organic Compounds - Site 9
- 4-7 Deep Subsurface Soil - Positive Detection Summary Inorganics - Site 9
- 4-8 Deep Subsurface Soil - Positive Detection Summary Organic Compounds - Site 9
- 4-9 Shallow Groundwater - Positive Detection Summary Total Inorganics - Site 9
- 4-10 Shallow Groundwater - Positive Detection Summary Dissolved Inorganics - Site 9
- 4-11 Shallow Groundwater - Positive Detection Summary Organic Compounds - Site 9
- 4-12 Deep Groundwater - Positive Detection summary Total Inorganics - Site 9
- 4-13 Deep Groundwater - Positive Detection Summary Dissolved Inorganics - Site 9
- 4-14 Deep Groundwater - Positive Detection Summary Organic Compounds - Site 9

LIST OF TABLES (Continued)

- 4-15 Sediment - Positive Detection Summary Inorganics - Site 9
- 4-16 Sediment - Positive Detection Summary Organic Compounds - Site 9
- 4-17 Surface Water - Positive Detection Summary Total Inorganics - Site 9
- 4-18 Surface Water - Positive Detection Summary Dissolved Inorganics - Site 9
- 4-19 Surface Water - Positive Detection Summary Organic Compounds - Site 9
- 4-20 Surface Soil - Positive Detection Summary Inorganics - Site 19
- 4-21 Surface Soil - Positive Detection Summary Organic Compounds - Site 19
- 4-22 Shallow Subsurface Soil - Positive Detection Summary Inorganics - Site 19
- 4-23 Shallow Subsurface Soil - Positive Detection Summary Organic Compounds - Site 19
- 4-24 Deep Subsurface Soil - Positive Detection Summary Inorganics - Site 19
- 4-25 Deep Subsurface Soil - Positive Detection Summary Organic Compounds - Site 19
- 4-26 Shallow Groundwater - Positive Detection Summary Total Inorganics - Site 19
- 4-27 Shallow Groundwater - Positive Detection Summary Dissolved Inorganics - Site 19
- 4-28 Shallow Groundwater - Positive Detection Summary Organic Compounds - Site 19
- 4-29 Deep Groundwater - Positive Detection Summary Total Inorganics - Site 19
- 4-30 Deep Groundwater - Positive Detection Summary Dissolved Inorganics - Site 19
- 4-31 Deep Groundwater - Positive Detection Summary Organic Compounds - Site 19

- 5-1 Organic Physical and Chemical Properties - Sites 9 and 19
- 5-2 Relative Mobilities of Inorganics as a Function of Environmental Conditions (Eh, pH) - Sites 9 and 19

- 6-1 Summary of Organic Blank Contaminant Results - Sites 9 and 19
- 6-2 Surface Soils Data and COPC Selection Summary - Site 9
- 6-3 Surface Soils Data and COPC Selection Summary - Site 19
- 6-4 Shallow Subsurface Soil Data and COPC Selection Summary - Site 9
- 6-5 Shallow Subsurface Soil Data and COPC Selection Summary - Site 19
- 6-6A Shallow Groundwater Data and COPC Selection Summary - Site 9
- 6-6B Deep Groundwater Data and COPC Selection Summary - Site 9
- 6-7A Shallow Groundwater Data and COPC Selection Summary - Site 19
- 6-7B Deep Groundwater Data and COPC Selection Summary - Site 19
- 6-8 Surface Water Data and COPC Selection Summary - Site 9
- 6-9 Sediment Data and COPC Selection Summary - Site 9
- 6-10 Summary of COPCs - Site 9
- 6-11 Summary of COPCs - Site 19
- 6-12 Exposure Input Parameters for Current Adult Civilian Worker at Site 9
- 6-13 Exposure Input Parameters for Current Commercial Adult On-Site Workers at Site 19
- 6-14 Reasonable Maximum (RME) and Central Tendency (CT) Exposure Input Parameters for Future Resident Children and Adults - Sites 9 and 19
- 6-15 Exposure Input Parameters for Future Construction Workers at Sites 9 and 19
- 6-16 Human Health Risk Assessment Toxicity Factors - Sites 9 and 19
- 6-17 Total Site Lifetime Incremental Cancer Risk (ICR) and Hazard Index (HI) Values for Current Potential Human Receptors - Sites 9 and 19
- 6-18 Total Site Lifetime Incremental Cancer Risk (ICR) and Hazard Index (HI) Values for Future Potential Human Receptors - Sites 9 and 19
- 6-19 Incremental Lifetime Cancer Risk (ICR) and Hazard Index (HI) for Future Adult and Child On-Site Residents RME and Central Tendency Values Using Shallow Groundwater - Site 9

LIST OF TABLES (Continued)

- 6-20 Incremental Lifetime Cancer Risk (ICR) and Hazard Index (HI) for Future Adult and Child On-Site Residents RME and Central Tendency Values Using Deep Groundwater - Site 9
- 6-21 Incremental Lifetime Cancer Risk (ICR) and Hazard Index (HI) for Future Adult and Child On-Site Residents RME and Central Tendency Values - Site 19
- 6-22 Summary of Uncertainties in the Results of the Human Health Risk Assessment - Sites 9 and 19

- 7-1 Ecological Contaminants of Concern Per Media Per Site
- 7-2 Frequency and Range of Detection Compared to Surface Soil Screening Levels - Site 9
- 7-3 Frequency and Range of Detection Compared to Surface Water Screening Levels - Site 9
- 7-4 Frequency and Range of Detection Compared to Sediment Screening Levels - Site 9
- 7-5 Frequency and Range of Detection Compared to Surface Soil Screening Levels - Site 19
- 7-6 Sampling Station Characteristics
- 7-7 Benthic Macroinvertebrate Species
- 7-8 Contaminant Detections Compared to Surface Soil Flora and Fauna Toxicity Values - Site 9
- 7-9 Contaminant Detections Compared to Surface Soil Flora and Fauna Toxicity Values - Site 19
- 7-10 Toxicity Reference Values
- 7-11 Terrestrial Total Daily Intake Model Exposure Parameters
- 7-12 Sediment Grainsize Analysis
- 7-13 Summary Statistics of Benthic Macroinvertebrate Species
- 7-14 Results of the Jaccard Coefficient and the Sorenson Index for Community Similarity Between Stations and Background Freshwater Stations
- 7-15 Quotient Index Ratios -Terrestrial Intake Model -Site 9
- 7-16 Quotient Index Ratios -Terrestrial Intake Model -Site 19
- 7-17 Surface Water Quotient Index Per Station
- 7-18 Surface Water Quotient Index Per Ecological Contaminant of Concern
- 7-19 Sediment Quotient Index Per Station
- 7-20 Sediment Quotient Index Per Ecological Contaminant of Concern

LIST OF FIGURES

- 1-1 Location of Naval Weapons Station Yorktown - 311200RI
- 1-2 Locations of Areas of Investigations (Sites and SSAs)
- 1-3 Aerial Photograph of Sites 9 and 19
- 1-4 Aerial Photographs of Sites 9 and 19
- 1-5 Surface Soil Samples from Lee Pond Sites 9 and 19
- 1-6 Groundwater Samples from Lee Pond Sites 9 and 19
- 1-7 Surface Water Samples from Lee Pond Sites 9 and 19
- 1-8 Sediment Samples from Lee Pond Sites 9 and 19
- 1-9 Preliminary Soil Characterization Results, Site 9 - Plant 1 Explosives Contaminated Wastewater Discharge Area
- 1-10 Preliminary Soil Characterization Results, Site 19 - Conveyor Belt Soils at Building 10
- 1-11 Biohabitat Map Sites 9 and 19

- 2-1 Surface Soil Sampling Locations Sites 9 and 19
- 2-2 Sampling Locations, Groundwater and Subsurface Soil Sites 9 and 19
- 2-3 Typical Shallow Groundwater Monitoring Well Construction Diagram - Above Grade Surface Completion
- 2-4 Typical Deep Groundwater Monitoring Well Construction Diagram - Above Grade Surface Completion
- 2-5 Sampling Locations, Surface Water, Sediment, and Biota Sites 9 and 19

- 3-1 Hydrogeologic Units in York County
- 3-2 Generalized Geologic Cross-Section
- 3-3 Cross-Section Location Map Sites 9 and 19
- 3-4 Hydrogeologic Cross-Section A-A' Sites 9 and 19
- 3-5 Hydrogeologic Cross-Section B-B' Sites 9 and 19
- 3-6 Groundwater Contour Map, Cornwallis Cave Aquifer Sites 9 and 19
- 3-7 Groundwater Contour Map, Yorktown-Eastover Aquifer Sites 9 and 19

- 4-1 Round Two RI Positive Detections of Select Inorganic Analytes in Surface Soil Sites 9 and 19
- 4-2 Round Two RI Positive Detections of Select Organic Analytes in Surface Soil Sites 9 and 19
- 4-3 Round Two RI Positive Detections of Select Inorganic Analytes in Subsurface Soil Sites 9
- 4-4 Round Two RI Positive Detections of Select Organic Analytes in Subsurface Soil Sites 9 and 19
- 4-5 Positive Detections of Select Inorganic Analytes in Groundwater Sites 9 and 19
- 4-6 Positive Detections of Select Organic Analytes in Groundwater Sites 9 and 19
- 4-7 Positive Detections of Select Inorganic Analytes in Surface Water Sites 9 and 19
- 4-8 Positive Detections of Select Organic Analytes in Surface Water Sites 9 and 19
- 4-9 Positive Detections of Select Inorganic Analytes in Sediment Sites 9 and 19
- 4-10 Positive Detections of Select Organic Analytes in Sediment Sites 9 and 19

- 6-1 Conceptual Site Model For Site 9 Naval Weapons Station Yorktown
- 6-2 Conceptual Site Model For Site 19 Naval Weapons Station Yorktown

LIST OF FIGURES (Continued)

- 7-1 Potential Exposure Pathways and Ecological Receptors
- 7-2 Round Two RI Select Benthic Macroinvertebrate Statistics, Site 9

- 8-1 Positive Detections of Select Organic Analytes in Surface Soil Site 9
- 8-2 Positive Detections of Select Organic Analytes in Subsurface Soil Site 9
- 8-3 Positive Detections of Select Organic Analytes in Surface Soil Site 19
- 8-4 Positive Detections of Select Organic Analytes in Subsurface Soil Site 19

EXECUTIVE SUMMARY

This report presents the results of the Round Two Remedial Investigation (RI) completed for Sites 9 (Plant 1 Explosives-Contaminated Wastewater Discharge Area) and 19 (Conveyor Belt Soil at Building 10) at the U.S. Naval Weapons Station Yorktown (WPNSTA Yorktown), Yorktown, Virginia. This RI Report has been prepared by Baker Environmental, Inc. (Baker) under the Department of the Navy's (DoN's) Comprehensive Long-Term Environmental Action Navy (CLEAN) contract administered by the Naval Facilities Engineering Command, Atlantic Division (LANTDIV).

The objectives of this RI are: (1) to develop an RI Report based on the evaluation of the Round One and Two RI effort conducted at Sites 9 and 19; (2) to assess the nature and extent of contamination at each site and/or to identify data gaps preventing an adequate understanding of site conditions; and (3) to assess potential human health and ecological risks associated with any contamination at Sites 9 or 19.

1.1.1 Site 9 - Plant 1 Explosives-Contaminated Wastewater Discharge Area

This section provides a description of Site 9, the Plant 1 Explosives-Contaminated Wastewater Discharge Area, as well as the site history.

Site 9 is a discharge area that had been used as a drainage way for Plant 1 (Building 10) nitramine/nitroaromatic (explosive)-contaminated wastewater and possibly for organic solvents. The drainage ditch runs east to west, away from Building 10, crossing Bollman Road through a culvert, and ultimately emptying into Lee Pond. The drainage area was reportedly used from the late 1930s to 1975. In 1975, a carbon adsorption tower was installed to treat the contaminated wastewater prior to discharge to the drainage way. A National Pollutant Discharge Elimination System (NPDES) permit was granted by USEPA Region III to allow this discharge. In 1986, the discharge from the treatment tower was diverted to the sanitary sewer and ultimately to the Hampton Roads Sanitation District (HRSB). In 1994, a removal action was conducted to address contaminated soils and sediments at the lower end of the drainage way before it crosses Bollman Road. Contaminated soils were excavated, clean fill was added, and the area was revegetated.

Site 9 is topographically downgradient from Site 19, Conveyor Belt Soil at Building 10. Based on estimated discharges of 100 parts per million (ppm) of trinitrotoluene (TNT) and RDX and 30 ppm of HMX at 5 gallons per minute (gpm) for 2 hours per workday for 40 years, an estimated 5,200 pounds of TNT and RDX and 1,600 pounds of HMX may have been discharged to the site (C.C. Johnson & Associates, Inc. and CH₂M Hill, 1984). Solvents such as trichloroethene (TCE) may have been discharged from Plant 1 with the explosives contaminated wastewater. Contaminants from Plant 1 may have migrated via surface water into Lee Pond or across the upper soil via overland flow in the area of the depression near Building 10. Lee Pond drains into the eastern branch of Felgates Creek, which in turn flows northward to the York River, approximately 1.5 miles from Site 9. The location of Site 9 is presented on Figure 1-5.

1.1.2 Site 19 - Conveyor Belt Soil at Building 10

This section provides description of Site 19, the Conveyor Belt Soil at Building 10, as well as the site history.

The conveyor belt at Site 19 (between Buildings 10 and 98) carried TNT powder packaged in containers across a depression into the loading building. The conveyor belt is completely enclosed with corrugated metal, but holes are visible along the floors and walls. Fine particles of explosives-related compounds may have been released to the soil in the vicinity of the conveyor belt during explosives loading operations. The conveyor and walls/floors were sprayed with water to control dust; this rinse water may have dripped onto the ground surface below.

TNT-contaminated soil has been reported in the vicinity of the conveyor belt. Soil beneath the belt was removed in 1973-1974, but later tests indicated the presence of RDX and TNT. The location of Site 19 is presented on Figure 1-5.

Previous Investigations

Previous investigation reports completed through the IRP include:

- The Initial Assessment Study (IAS, July 1984)
- Two Confirmation Study Reports (June 1986 and June 1988)

- RI Interim Report (July 1991)
- Focused Biological Sampling and Preliminary Risk Evaluation Report (July 1993)
- Round One RI Report (July 1993)
- Soil Removal Action Report (1995)
- Soil Characterization Study (1995)
- Habitat Evaluation Report (July 1995).

NATURE AND EXTENT OF CONTAMINATION

Site 9 - Nature and Extent of Contamination

Surface Soil

Following evaluation of data collected during the Round One RI, SVOCs, (primarily PAHs) and nitramines were identified as soil contaminants across Site 9. Some of the highest detections of nitramines were at sampling points located at the lower end of the drainage way from Building 10 to Lee Pond. Based upon these analytical results, soils, sediments, and debris from this area were subsequently removed.

Although contaminants were detected during the Round One RI, it was not clear whether PAHs and nitramines were wide spread across the site or confined to specific locations. Data collected during the Round Two RI clarified this issue.

PAH contamination in soils appears to be concentrated in the drainage way from Building 10 to Lee Pond. Benzo (a) pyrene was detected in six locations from the northwestern corner of Building 10 to the bottom of the drainage way at levels ranging from 94J to 1,200 µg/Kg. Additional PAHs were detected at levels ranging from 130J to 2,200 µg/Kg.

Nitramine compounds were not detected in the soil samples collected at Site 9 during the Round Two RI. Nitramine contamination was probably addressed during the removal action. Round Two RI results are consistent with the results of the soil sampling conducted in support of the treatability study for explosives-contaminated soils.

Overland transport of contaminated soils by runoff flowing toward Lee Pond is likely. However, the extent of this migration and its results cannot be evaluated, since investigation of Lee Pond was not included in this study.

Subsurface Soil

Results of the subsurface soil investigation at Site 9 supported the premise that the drainage way is the main area of contamination. PAHs were detected at four locations within the drainage way; again benzo (a) pyrene was detected at each location at levels ranging from 160J to 1,700 µg/Kg. The highest levels of PAHs were again detected at location 9HA06-01 near the end of the drainage way. A single nitramine detection, 33,000 µg/Kg of 2,4,6-TNT, was also noted at this location. No organic compounds were detected in any of the soil borings advanced prior to well installation.

Transport of subsurface soil is unlikely unless surface soils are removed. However, contaminants in the subsurface soils may leach to groundwater.

During the Round One RI three HydroPunches™ were installed at Site 9 to evaluate groundwater contamination. VOCs and PAHs were not detected in the groundwater. However, nitramine compounds were detected at two of the three sampling locations. The highest levels of nitramine contamination were noted at location 9HP03.

During the Round Two RI monitoring wells were installed at Site 9 including a shallow and a deep well at locations 9GW02 and 9GW02A near the Round One location 9HP03. Results of the Round Two RI supported those from Round One; VOCs and PAHs were not detected in the groundwater. However, nitramines were again detected, primarily in the wells at 9GW02 and 9GW02A. In the shallow well 2,4,6-TNT was detected at 830µg/L and amino-DNTs were detected at 4400µg/L. Very low levels (0.79µg/L) of 1,3,5 TNB were detected in the corresponding deep wells.

Shallow groundwater at Site 9 appears to be moving toward Lee Pond. However, since investigation of Lee Pond was not included as part of the investigation of Site 9 extent of potential migration of contaminants to the pond cannot be evaluated at this time.

Surface Water

During the Round One RI, VOCs and nitramines were detected in three samples collected in the drainage way at Site 9. Surface water samples collected during the Round Two RI were somewhat consistent with the Round One results; while VOCs and SVOCs were not detected in the surface water, nitramine compounds were detected. Five different nitramines were detected at levels ranging from 0.44NJ to 480 µg/L and were found in all three samples of surface water collected. Again, surface water results support the premise that the drainage way is the main area of contamination at Site 9.

Surface water from the drainage way migrated directly to Lee Pond. However, the extent of potential contamination within Lee Pond was outside the focus of this investigation.

Sediment

Seven sediment samples were collected at Site 9 during the Round One RI. While PAHs were detected in the sediments, no nitramine compounds were identified. Results of the Round Two RI confirmed these findings and again supported the contention that contamination is most prevalent in the drainage way. Benzo(a)pyrene was found at each sampling location at levels ranging from 180J to 2,100 µg/Kg. Four additional PAHs were detected at levels ranging from 91J to 2,600 µg/Kg.

Sediments in the drainage way are directly transported to Lee Pond by surface water, particularly during storms or long periods of precipitation when the drainage way directs runoff from Site 9 to Lee Pond. The extent of potential contamination of sediments in Lee Pond was not addressed since it was outside the scope of this investigation.

This section describes the extent to which contamination has migrated at Site 19 and the potential for future migration of contaminants.

Site 19 - Conveyor Belt Soil at Building 10

Surface Soil

During the Round One RI, PAHs and nitramines were detected in soils adjacent to and beneath the conveyor at Site 19. Results of the Round Two RI confirmed that the conveyor belt is the prime area of contamination in soil at Site 19. Amino-DNTs were detected in four soil samples collected from the northwest side of the conveyor at levels ranging from 1,000J to 2,100 µg/Kg. A single PAH, benzo (a) pyrene was detected in two locations at the rail end of the conveyor at 95J and 140J µg/Kg respectively.

Overland transport of contaminated soil from Site 19 is possible; however, detections of contaminants in soils across the site do not confirm this.

Subsurface Soil

During the Round Two RI subsurface soil samples were collected at both hand auger locations and in the borings advanced prior to well installation. No VOCs or SVOCs were detected in any of the hand auger samples; no organic compounds were detected in the soil borings at significant levels. Amino-DNTs were detected at two locations at 1,200 and 8,200 µg/Kg. These two detections correspond to detections in the surface soil.

During the Round One RI three monitoring wells were installed and a single round of sampling was conducted. Two nitramines were identified in well 19GW03 at relatively low levels (1.3J and 5.1 µg/Kg. During the Round Two RI the existing wells were samples and additional wells were installed. Samples collected and analyzed verified that nitramines were present at the upper and lower ends of the conveyor and between Site 19 and Site 9. Detections of nitramines diminished closer to Site 9.

Groundwater

During the Round One RI three monitoring wells were installed and a single round of sampling was conducted. Two nitramines were identified in well 19GW03 at relatively low levels (1.3J and

5.1 µg/Kg. During the Round Two RI the existing wells were sampled and additional wells were installed. Samples collected and analyzed verified that nitramines were present at the upper and lower ends of the conveyor and between Site 19 and Site 9. Detections of nitramines diminished closer to Site 9.

BASELINE HUMAN HEALTH RISK ASSESSMENT

A baseline human health risk assessment was conducted to evaluate potential risks to human health from contaminants at the site. Potential current receptors to COPCs detected in environmental media at Sites 9 and 19 include:

- Current civilian adult workers (Site 9)
- Current on-site commercial adult workers (Site 19)

The total ICR values presented in Table ES-1 for the civilian adult workers at Site 19 and on-site commercial adult workers at Site 9, fall within the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} . The target risk range represents the range of potential risks that USEPA generally believes to be acceptable. HI values also presented in Table ES-1 for current potential human receptors fall below 1.0, indicating that noncarcinogenic adverse human health risks will probably not occur subsequent to exposure.

Property use at Sites 9 and 19 will remain the same in the foreseeable future. Future residential development of Sites 9 and 19 is highly unlikely given its location within an area encumbered by the ESQD arc, which prohibits its development as Station housing. However for the sake of conservatism, future residential development and associated potential risks were evaluated. The potential human receptors evaluated for Sites 9 and 19 under the future scenarios were:

- Future residents (adult and child combined)
- Future adult construction workers

Table ES-2 presents the summary of the total ICR and HI values for the future receptors. A discussion of the results for each of these scenarios is presented below.

Future Residents

For the future residents (adult and child) it was assumed that exposure to COPCs in surface soil and groundwater could occur at Sites 9 and 19, while exposure to surface water and sediment could occur at Site 9. Future development of groundwater for potable purposes is unlikely even in the event of future residential development because of the availability of municipal water; however, potential potable exposure to COPCs in shallow and deep groundwater was evaluated for the sake of conservatism. Table ES-2 presents the total ICR and HI values for the future potential residential development of Sites 9 and 19. The total ICR and HI values for future residents are the sum of the resident adult and resident child HI and ICR values, respectively.

Site 9

The ICR value for the future residents (the sum total for children and adults) exceeded the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} when using both the RME- and CT-case exposure scenarios. This was due primarily to contaminants detected in shallow groundwater; the presence of dissolved arsenic and 2,4,6-TNT accounted for the exceedence of the target risk range.

The HI value derived using both the CT- and RME-case scenarios for future residents was greater than 1.0, suggesting that noncarcinogenic adverse health effects may occur subsequent to exposure. The amino-DNTs, 2,4,6-TNT, and dissolved arsenic in the shallow groundwater were the main contributors to the total HI value (using organic and dissolved inorganic results). Furthermore, the presence of arsenic in the surface soil; amino-DNTs, 2,4,6-TNT, and dissolved arsenic in the shallow groundwater; 1,3,5-TNB and dissolved arsenic in the deep groundwater; and the amino-DNTs and 2,4,6-TNT in the surface water also contributed to the exceedance of the total HI value when using the RME-case scenario. Comparisons of maximum detected site concentrations to Station background value, and site-specific background values where applicable, yielded the following results:

- The maximum concentration of arsenic (23.3 mg/Kg) in the surface soils at Site 9 was less than the maximum Station (63.9 mg/Kg) background value but greater than the maximum site-specific (0.97 mg/Kg) background value.

- The amino-DNTs and 2,4,6-TNT were not detected in the Station background groundwater wells for the Cornwallis Cave Aquifer; however, the maximum dissolved arsenic concentration (25.9 µg/L) was below the maximum Station background concentration (36.4 µg/L), as reported for the Cornwallis Cave Aquifer.
- 1,3,5-TNB was not detected in the Station background deep groundwater well for the Yorktown Eastover Aquifer; however, the maximum detected dissolved arsenic concentration in the Yorktown Eastover Aquifer (5.5L µg/L) was greater than the maximum detected concentration (1.8 µg/L) for the deep groundwater at Site 9.
- Amino-DNTs and 2,4,6-TNT were detected in the Site 9 surface water samples; however, the nitramines were not detected in the Station background surface water samples, as reported for freshwater streams.

Site 19

For the future residents (the sum total for children and adults), the total RME- and CT-case ICR values, as well as the total ICR value derived using groundwater from shallow monitoring well 19GW05, were within the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} . The target risk range represents the range of potential risks that the USEPA generally believes to be acceptable. However, the total RME- and CT-case HI values, in addition to the total HI value derived for groundwater in shallow monitoring well 19GW05, were greater than 1.0. An HI value greater than 1.0 suggests that noncarcinogenic adverse health effects may occur subsequent to exposure. The amino-DNTs, 2,4,6-TNT, and 1,3,5-TNB in the shallow groundwater were the main contributors to the total HI value (using organic and dissolved inorganic results). Furthermore, the presence of aluminum and arsenic in the surface soil also contributed to the exceedance of the total RME-case HI value. Comparisons of the maximum detected site concentrations to the maximum detected Station and site-specific background values, where applicable, yielded the following results:

- The maximum detected concentration of aluminum (90,600 mg/Kg) in the surface soils at Site 19 was greater than the maximum Station (19,200 mg/Kg) and site-specific (8,380 mg/Kg) background values. However, the maximum detected concentration of arsenic (14 mg/Kg) in the surface soils at Site 19 was less than the

maximum detected Station (63.9 mg/Kg) background value, but greater than the site-specific (2.1 mg/Kg) background value.

- The amino-DNTs, 2,4,6-TNT, and 1,3,5-TNB which were detected in the shallow groundwater at Site 19, were not detected in the Station background wells, as reported for the Cornwallis Cave Aquifer.

Future Adult Construction Worker

Future potential adult construction workers could be exposed to COPCs in shallow subsurface soil during future building/excavation activities at Sites 9 and 19. The total ICR value derived for the future adult construction worker was within the USEPA's target risk range; therefore, carcinogenic health effects would not be expected to occur. The HI value did not exceed unity; therefore, noncarcinogenic health effects are also not expected to occur subsequent to exposure. Table ES-2 presents the total ICR and HI values for the future adult construction worker.

ECOLOGICAL RISK ASSESSMENT

An ecological risk assessment was conducted to evaluate risks to ecological receptors from contaminants at the site. The conclusions of the ecological RA are discussed below with respect to both Sites 9 and 19.

Site 9

Both an aquatic and a terrestrial endpoint were addressed at Site 9. The following sections provides an overview of any potential risk to the ecological environment identified at Site 9 during this assessment. Risks to the aquatic environment at Site 9 are demonstrated by the cumulative QI ratios calculated for both surface water and sediment greater than one. In addition, risks to the terrestrial environment are demonstrated by exceedances of soil toxicity values and risk exhibited in terrestrial TDI models.

Aquatic Ecosystem

Surface water concentrations of heptachlor epoxide; amino-DNTs; 2,4,6-trinitrobenzene; cyanide; iron; and manganese may potentially adversely impact the aquatic environment in the drainage way at Site 9. Note, that the highest concentrations of heptachlor epoxide, nitramines, and cyanide were detected at Station 9SW08.

Cumulative QI ratios were calculated for the surface water at 3.02 for acute and 54.81 for chronic. However, the heptachlor epoxide detected in one surface water sample is most likely the result of base-wide pesticide control and not a site-related contaminant. Amino DNTs were detected in every surface water sample collected at the site. These nitramines are breakdown products of site-related 2,4,6-trinitrotoluene.

In addition, the benthic community in the drainage way may be adversely impacted by the contaminants detected in the sediment. The sediment contained elevated levels of PAHs; amino-DNTs; 2,4-dinitrotoluene; 2,4,6-trinitrotoluene; arsenic; and iron. The highest concentrations of SVOCs and inorganics were detected at Station 9SD08 and the highest concentrations of nitramines were detected in the deep sediment sample collected from Station 9SD09.

The risk to the aquatic community posed by the sediment is demonstrated by high cumulative QI values (78.04 for the ER-L and 16.51 for the ER-M). The concentrations detected in the sediment may be site-related contaminants. PAH concentrations in surface soil have been detected above soil screening levels in the vicinity of Site 9 and surface water concentrations also have exceeded surface water screening levels. The PAH exceedances of surface soil and surface water screening levels indicates that surface runoff may be contributing to the PAH concentrations detected in the sediment. It is noted that the nitramines detected in the sediment during this investigation (Round Two) have not been detected in any previous investigations in the drainage way, indicating that the surface water concentrations of nitramines are beginning to influence the quality of the sediment.

Terrestrial Ecosystem

Based on the data collected during the Round Two investigation and TDI modeling, there appears to be a potential risk to terrestrial receptors at Site 9 (see Table ES-3). Soil flora and fauna toxicity values were exceeded for PAHs, copper, lead, vanadium, and zinc, which may potentially adversely impact terrestrial flora and fauna.

Risks to the terrestrial receptors are driven by heptachlor epoxide; 2,4,6-trinitrotoluene, and vanadium. It is noted that the heptachlor epoxide was detected in one surface water sample and drives the risk in one model (raccoon). Because heptachlor epoxide is not a site-related contaminant, the removal of this concentrations removes the risk to the raccoon. In addition, vanadium drives risk to the background rabbit. Therefore, concentrations of 2,4,6-trinitrotoluene are most likely the site-related contaminants contributing to terrestrial risk at Site 9.

In conclusion, site-related contaminants of PAHs, nitramines, and inorganics are impacting the terrestrial environment at Site 9.

Site 19

Only the terrestrial ecosystem was assessed at Site 19. Overall, risk to the terrestrial environment is demonstrated by exceedances of soil toxicity values and risks demonstrated in the terrestrial TDI models. Concentrations of phenanthrene, aluminum, copper, iron, lead, and zinc exceeded surface soil toxicity values.

Terrestrial models demonstrated risks driven by aluminum, iron, and zinc (see Table ES-4). These inorganics driving the terrestrial model risk also exceed surface soil toxicity values. Aluminum poses only a moderate risk to terrestrial ecological receptors including the raccoon and rabbit.

SUMMARY AND CONCLUSIONS

This section presents an itemized summary of the results of the Round Two RI for Sites 9 and 19. The summary is focused on the nature and extent of contamination at the sites in addition to the

results of the baseline human health and ecological RAs. The significant findings of this investigation are presented in the following paragraphs. Following the summary are conclusions based on the results of the Round One and Round Two RIs and data obtained as part of the confirmation sampling conducted for the soil treatability study underway at WES. Limited conclusions have been made regarding Lee Pond; the scope for this investigation focused on source areas first. Investigations of Lee Pond will be undertaken at a later date.

Site 9 Summary

- PAHs and nitramines were detected in surface soil samples obtained near the drainage way that leads from Building 10 to Lee Pond. The highest levels of PAHs and nitramines were present at sample location 9HA06 at the bottom of the drainage way just above the area where debris and soil were removed in 1994. No VOCs were detected in surface soils at Site 9.
- PAHs were also detected in subsurface soil near the drainage way. Again, the highest levels were detected at location 9HA06. The nitramine compound 2,4,6-TNT was also detected at this particular location (33,000 µg/Kg) and in other subsurface soil samples obtained near the Site 9 drainage way.
- PAHs were also detected in shallow and deep sediment samples obtained from the drainage way. These COPCs were present at concentrations similar to those detected in Site 9 surface soils.
- Nitramines were detected in the three surface water samples collected from the drainage way at Site 9. Five different nitramine compounds were detected at levels ranging from 0.44NJ (1,3,5-TNB) to 480 µg/L (2,4,6-TNT).
- During the Round Two RI, nitramines were detected in groundwater at location 9GW02 and 9GW02A. Compounds detected included 2,4,6-TNT (830 µg/L) and amino-DNTs (4,400 µg/L) in the shallow well and 1,3,5-TNB (0.79 µg/L) in the deep well.

- The total ICR values for the civilian adult workers at Site 9 fall within the target risk range the USEPA generally believes to be acceptable. HI values fall below 1.0, indicating that noncarcinogenic adverse human health risks will probably not occur.
- For the sake of conservatism, future residential development of Site 9 property and associated potential risks were evaluated. The ICR for the future residents (the sum total for children and adults) exceeded the USEPA's target risk range when using both the RME and central tendency (CT) exposure scenarios. This was primarily due to contaminants detected in shallow groundwater, particularly at shallow well location 9GW02.
- The HI value derived using both the CT and RME for potential future residents at Site 9 was greater than 1.0, suggesting that noncarcinogenic adverse health effects may occur. Again, contamination in shallow groundwater detected at location 9GW02, was primarily responsible for the elevated HI value.
- Surface water concentrations of heptachlor epoxide; amino-DNTs; 2,6-DNT; HMX; 1,3,5-TNB; 2,4,6-TNB; cyanide; iron; and manganese have the potential to adversely impact the aquatic environment in the drainage way at Site 9. In addition, the benthic community in the drainage way may be adversely impacted by contaminants detected in the sediment. Sediment contaminants included PAHs; amino-DNTs; 2,4-DNT; 2,4,6-TNT; arsenic; cadmium; and iron. However, results of the aquatic survey at Site 9 are inconclusive because the drainage way is an intermittent stream. Apparent effects may reflect the natural stream conditions rather than site contaminants.
- Based on the data collected during the Round Two RI and the Terrestrial Daily Intake (TDI) modeling, there appears to be a potential risk to terrestrial receptors at Site 9. This risk is driven by the presence of PAHs, nitramines, and inorganics in surface soil samples.

Site 19 Summary

- The PAH benzo (a) pyrene and amino-DNTs were identified in surface soil samples collected at Site 19. Surface soil contamination was concentrated at the rail end of the conveyor and along the northwest side of the conveyor. Detections of aluminum above Station-wide background appear to correlate with the nitramine/nitroaromatic constituent detections in Site 19 surface soils.
- Amino-DNTs were detected in two subsurface soil locations at Site 19, both of which corresponded with surface soil detections of nitramines.
- Relatively low concentrations of nitramine compounds were detected in groundwater at the upper and lower ends of the conveyor and between the conveyor and Lee Pond. The highest concentrations were detected at location 19GW05 where amino DNTs were detected at 130 µg/L.
- The total ICR values for the on-site commercial adult workers fall within the target risk range the USEPA generally believes to be acceptable. HI values fall below 1.0, indicating that non-carcinogenic adverse human health risks will probably not occur.
- For the future residents, the total RME- and CT-derived ICR values were within USEPA's target risk range. The total RME- and CT-derived HI values were greater than 1.0 because of COPCs detected in samples obtained from well 19GW05. This suggests that noncarcinogenic adverse health effects may occur.
- The total ICR value derived for the future adult construction worker was within USEPA's generally acceptable target risk range. The HI value did not exceed unity; therefore, noncarcinogenic health effects are not expected to occur subsequent to exposure.

- Only the terrestrial ecosystem was addressed at Site 19. Overall, potential risk to the terrestrial environment is suggested by exceedences of soil toxicity values and results of the terrestrial uptake models.

Site 9 Conclusions

- At Site 9 contamination is confined to the drainage way from Building 10 to Lee Pond, based upon findings of the Round One and Round Two RIs and, to a lesser extent, the confirmation sampling for the treatability study (see Figure 8-1). Contaminants of concern include PAHs and nitramines found primarily in the soils. During the Round One RI, PAHs were detected at five out of six surface soil sampling locations at levels ranging from 19J $\mu\text{g}/\text{Kg}$ to 1,100 $\mu\text{g}/\text{Kg}$. Nitramines detected included 2,4,6-TNT; 2,4-DNT; and 1,3,5-TNB at levels ranging from 2,900 $\mu\text{g}/\text{Kg}$ to 2,100,000 $\mu\text{g}/\text{Kg}$.

During the Round Two RI, PAHs were detected in five surface soil sampling locations, all within the drainage way at levels ranging from 94J to 2,200 $\mu\text{g}/\text{Kg}$. The compound 2,4,6-TNT was detected in four of the five samples from locations within the drainage way at levels ranging from 210 to 540 $\mu\text{g}/\text{Kg}$.

The findings of the soil characterization study support this conclusion. During this study, composite samples were collected and analyzed for explosives. The nitramines, 2,4,6-TNT and amino-DNTs, were detected at relatively low levels ranging from 109 to 547 $\mu\text{g}/\text{Kg}$.

No discrete subsurface soil samples were collected during the Round One RI or the treatability study soil characterization. However, subsurface soil samples collected during the Round Two also show PAH and nitramine contamination (see Figure 8-2). PAHs were detected at levels ranging from 91J to 2,500 $\mu\text{g}/\text{Kg}$ in five samples of subsurface soil. Nitramines were detected in five samples; compounds included 2,4,6-TNT and amino-DNTs and were detected at levels ranging from 70J to 42,000NJ $\mu\text{g}/\text{Kg}$.

- Nitramines were also present in the surface water in the drainage way at Site 9. During the Round One RI, five nitramine compounds (HMX; RDX; 1,3,5-TNB; 2,4-DNT; 2,4,6-TNT) were detected at three locations in the drainage way at levels ranging from .29J to 370 µg/L. During the Round Two RI, nitramines were detected in all three surface water samples collected within the drainage way at levels ranging from .44 NJ to 480 µg/L. Surface water is probably not a primary source of contamination, but serves as a secondary source reflecting contamination by site soils. Because aquatic criteria are not available, it is difficult to quantify the effects of this surface water contamination.
- PAHs present in the sediments are probably site-related. PAH compounds were used during the loading process; in addition disposal of railroad ties in the drainage way may have contributed to PAH contamination. (These railroad ties have been removed.)
- Nitramines are present in the shallow groundwater at Site 9. This groundwater contamination could potentially be a result of past nitramine releases associated with loading operations in Building 10. Past practices may also explain the presence of nitramine contamination of surface and subsurface soils. Contamination of the shallow groundwater is driving the human health risk at Site 9.
- Ecological receptors at Site 9 could potentially be affected by PAHs, nitramines, and inorganics in the surface soils. Nitramines in the surface water may affect the aquatic environment; effects cannot be assessed because adequate criteria are not available. In addition, the drainage way is an intermittent stream. Apparent effects may actually reflect natural stream conditions.
- Because none of the site media could be excluded based on the results of the human health and/or ecological risk assessments, contamination in all media will be initially addressed in the Feasibility Study. Specifically, the FS at Site 9 will focus on PAH and nitramine contamination in soils and sediment and nitramine contamination in surface water and groundwater.

Site 19 Conclusions

- Nitramines in the surface soils at Site 19 are the primary concern (see Figure 8-3). Nitramines are generally concentrated along the conveyor between the rail line and Building 10. During the Round One RI nitramines were detected in two locations. Four different compounds (1,3,5-TNB; 2,4,6-TNT; 2,4-DNT; and 2,6-DNT) were detected at levels ranging from 770J to 120,000 µg/Kg. Sampling locations for the Round Two RI were selected to provide additional information regarding nitramine contamination along the conveyor. Data from Round Two indicated that nitramines (2,4,6-TNT; amino-DNTs) were found at five sampling locations at levels ranging from 130 to 2,100 µg/Kg. Soils collected during the characterization for the treatability study may provide the data most representative of site conditions. For this study, samples were collected across grids and composited. Three compounds (2,4,6-TNT; HMX; amino-DNTs) were detected at levels ranging from 135 to 863,000 µg/Kg in 13 samples.

No discrete subsurface samples were collected at Site 19 during either the Round One RI or the characterization for the treatability study. However, subsurface soils were collected during the Round Two RI. Nitramines were detected in the subsurface soil at four locations. Two compounds were identified (2,4,6-TNT, amino-DNTs) at levels ranging from 1,000NJ to 8,200 µg/Kg.

- Nitramines may have migrated to the shallow groundwater from overlying soils. Nitramines were detected in one of the three samples obtained from monitoring wells installed at Site 19 during the Round One RI. The compounds 1,3,5-TNB and 2,4,6-TNT were detected at 1.3J µg/L and 5.1 µg/L respectively. During the Round Two RI, the existing wells were resampled and four new wells were installed. Nitramines were again detected in groundwater samples; samples from four wells exhibited nitramine compounds (RDX; amino-DNTs; 1,3,5-TNB; 2,4,6-TNT) at levels ranging from 0.77 to 130 µg/L. Nitramine contamination in the shallow groundwater is responsible for driving the future potential risk to residential receptors at Site 19.

- PAHs, nitramines, and inorganics may be affecting terrestrial ecological receptors at Site 19. Aquatic receptors are not present at the site.
- Because none of the site media could be excluded based on the results of the human health and/or ecological risk assessments, contamination in all media will be initially addressed in the Feasibility Study. Specifically, the FS at Site 19 will focus on nitramine contamination in soil and groundwater.

TABLE ES-1

**TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND
HAZARD INDEX (HI) VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Receptors	Site 9		Site 19	
	Total ICR	Total HI	Total ICR	Total HI
Adult Civilian Worker ⁽¹⁾	8.5 x 10 ⁻⁰⁶	0.09	--	--
Adult On-Site Commercial Worker ⁽²⁾	--	--	1.7 x 10 ⁻⁰⁵	0.26

Notes: ⁽¹⁾ Current adult civilian workers could potentially be exposed to COPCs by accidental ingestion and dermal contact of surface soils, surface water, and sediments as well as inhalation of fugitive dusts in surface soils.

⁽²⁾ Current on-site adult commercial workers could be potentially exposed to COPCs by accidental ingestion, dermal contact, and inhalation of fugitive dusts in surface soils.

TABLE ES-2

**TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND
HAZARD INDEX (HI) VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Future Receptors	Site 9		Site 19	
	Total ICR	Total HI	Total ICR	Total HI
On-Site Residents ⁽¹⁾⁽²⁾ (RME and CT Values using shallow groundwater)	$1.2 \times 10^{-03(3)}$ (2.3×10^{-04})	227 ⁽³⁾ (52)	$6.7 \times 10^{-05(3)}$ (9.3×10^{-06})	5 ⁽³⁾ (3.3)
On-Site Residents ⁽¹⁾⁽²⁾ (RME and CT Values using deep groundwater)	$2.2 \times 10^{-04(4)}$ (3.3×10^{-05})	6 ⁽⁴⁾ (2.2)	NA	NA
Construction Workers ⁽⁵⁾	4.4×10^{-06}	0.81	2.1×10^{-06}	0.42

- Notes:
- (1) Residents could potentially be exposed to COPCs by dermal contact and accidental ingestion of surface soils and groundwater at Sites 9 and 19, and surface water and sediments at Site 9.
 - (2) Total HI and ICR values for residents are the sum total of the resident adult and resident child HI and ICR values, respectively.
 - (3) ICR and HI values are elevated because of the presence of 2,4,6-TNT (Sites 9 and 19), dissolved arsenic (Site 9), 1,3,5-TNB (Site 19), and amino-DNTs (Sites 9 and 19) in the shallow groundwater; aluminum and arsenic in the Site 19 surface soil; arsenic in the Site 9 surface soil; and the amino-DNTs and 2,4,6-TNT in the Site 9 surface water.
 - (4) ICR and HI values are elevated because of the presence of 1,3,5-TNB in the deep groundwater at Site 9; arsenic in the Site 9 surface soil; and the amino-DNTs and 2,4,6-TNT in the Site 9 surface water.
 - (5) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of shallow subsurface soils, as well as the inhalation of fugitive dusts during excavation activities.

TABLE ES-3

QUOTIENT INDEX RATIOS - TERRESTRIAL INTAKE MODEL
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

	Raccoon ⁽¹⁾	White-tailed Deer	Red Fox ⁽²⁾	Bobwhite Quail	Eastern Cottontail Rabbit ⁽³⁾
Total	2.31×10^{-02}	2.80×10^{-01}	5.59×10^{-00}	6.91×10^{-01}	5.17×10^{-00}

Notes:

- (1) Risk is driven by heptachlor epoxide detected in the surface water and surface soil.
- (2) Risk is driven by 2,4,6-Trinitrotoluene detected in the surface water and surface soil.
- (3) Risk is driven by 2,4,6-Trinitrotoluene and vanadium detected in the surface water and surface soil.

TABLE ES-4

QUOTIENT INDEX RATIOS - TERRESTRIAL INTAKE MODEL
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

	Raccoon ⁽¹⁾	White-tailed Deer	Red Fox	Bobwhite Quail	Eastern Cottontail Rabbit ⁽²⁾
Total	1.88×10^{-01}	2.14×10^{-01}	1.44×10^{-01}	6.55×10^{-00}	1.20×10^{-01}

Notes:

- (1) Risk is driven by aluminum detected in the surface soil.
- (2) Risk is driven by aluminum, iron, and zinc detected in the surface soil.

1.0 INTRODUCTION

This report presents the results of the Round Two Remedial Investigation (RI) completed for Sites 9 (Plant 1 Explosives-Contaminated Wastewater Discharge Area) and 19 (Conveyor Belt Soil at Building 10) at the U.S. Naval Weapons Station Yorktown (WPNSTA Yorktown), Yorktown, Virginia (Figure 1-1). This RI Report has been prepared by Baker Environmental, Inc. (Baker) under the Department of the Navy's (DoN's) Comprehensive Long-Term Environmental Action Navy (CLEAN) contract administered by the Naval Facilities Engineering Command, Atlantic Division (LANTDIV).

The development of this RI was based on LANTDIV's Scope of Work dated June 6, 1995 for Contract Task Order (CTO) 0334. This RI Report has been prepared in accordance with the WPNSTA Yorktown Federal Facility Agreement (FFA), the Yorktown Master Work Plans (Baker, 1994a), and applicable Federal, Commonwealth, and local regulations. Details of the Round Two RI Scope of Work at Sites 9 and 19 are contained in the Site-Specific Work Plan for Sites 9 and 19 (Baker, 1995a). In addition, the United States Environmental Protection Agency's (USEPA's) document, Guidance for Conducting Remedial Investigations and Feasibility Studies Under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (USEPA, 1988) has been used as guidance for preparing this report. The RI Report has been prepared using available information from the previous investigations, such as the Round One RI effort (Baker/Weston, 1993a) and from data collected during the Round Two RI, which was conducted during September and October 1995.

The objectives of this RI are: (1) to conduct a Round Two remedial investigation based on the results of the Round One RI and composite soil sampling conducted for the explosives-contaminated soil treatability study currently being conducted by the Army Corps of Engineers Waterways Experimental Station (WES); (2) to assess the nature and extent of contamination at each site and/or to address data gaps observed after the Round One RI preventing an adequate understanding of site conditions; and (3) to assess potential human health and ecological risks associated with any contamination at Sites 9 or 19 and identify any potential remaining data gaps.

This document is organized into seven additional sections. Section 2.0 describes the field activities conducted during the Round Two RI at Sites 9 and 19. This section describes the purpose of the

study of individual media, sampling procedures, and sampling locations for all media. Figures are included to show sampling locations. This section also discusses quality control (QC) conducted during the sampling and the management of the investigation derived waste (IDW).

Section 3.0 presents the physical features of Sites 9 and 19. This section discusses the physical geography, meteorology, surface water hydrology, geology, soil, hydrogeology, and land use and demography.

Section 4.0 presents the nature and extent of contamination found at Sites 9 and 19. This section presents the results of the field sampling activities conducted as part of this RI. The results are presented by media: surface and subsurface soil, groundwater, surface water, sediment, and biota. This section also discusses the potential sources of contaminants detected during the sampling activities.

Section 5.0 characterizes the fate and transport of the contaminants found at Sites 9 and 19. This characterization includes: potential routes of contaminant migration, contaminant persistence, and contaminant migration.

Sections 6.0 and 7.0 contain the baseline risk assessments (RAs) conducted for the sites. The baseline human health RA (Section 6.0) contains a human health evaluation and an environmental evaluation. An ecological RA is included in Section 7.0.

A summary and conclusions are presented in Section 8.0. This section summarizes the nature and extent of contamination, contaminant fate and transport, and potential human health and ecological impacts associated with the site.

1.1 Site 9 and 19 Description and History

Fifteen sites requiring RI/Feasibility Study (FS) activities are identified in the Fiscal Year 1995-1996 Site Management Plan (SMP) for WPNSTA Yorktown (Baker, 1995b). The location of these sites, including Sites 9 and 19 within WPNSTA Yorktown, is presented on Figure 1-2. Figure 1-3 is an aerial photograph of Sites 9 and 19 taken on April 4, 1993. Figure 1-4 presents additional aerial photographs that provide a closer view of the sites.

1.1.1 Site 9 - Plant 1 Explosives-Contaminated Wastewater Discharge Area

This section provides a description of Site 9, the Plant 1 Explosives-Contaminated Wastewater Discharge Area, as well as the site history.

Site 9 is a discharge area that had been used as a drainage way for Plant 1 (Building 10) nitramine/nitroaromatic (explosive)-contaminated wastewater and possibly for organic solvents. The drainage ditch runs east to west, away from Building 10, crossing Bollman Road through a culvert and ultimately emptying into Lee Pond. The drainage area was reportedly used from the late 1930s to 1975. In 1975, a carbon adsorption tower was installed to treat the contaminated wastewater prior to discharge to the drainage way. A National Pollutant Discharge Elimination System (NPDES) permit was granted by USEPA Region III to allow this discharge. In 1986, the discharge from the treatment tower was diverted to the sanitary sewer and ultimately to the Hampton Roads Sanitation District (HRSD). In 1994, a removal action was conducted to address contaminated soils and sediments at the lower end of the drainage way before it crosses Bollman Road. Contaminated soils were excavated, clean fill was added, and the area was revegetated.

Site 9 is topographically downgradient from Site 19, Conveyor Belt Soil at Building 10. Based on estimated discharges of 100 parts per million (ppm) of trinitrotoluene (TNT) and RDX and 30 ppm of HMX at 5 gallons per minute (gpm) for 2 hours per workday for 40 years, an estimated 5,200 pounds of TNT and RDX and 1,600 pounds of HMX may have been discharged to the site (C.C. Johnson & Associates, Inc. and CH₂M Hill, 1984). Solvents such as trichloroethene (TCE) may have been discharged from Plant 1 with the explosives-contaminated wastewater. Contaminants from Plant 1 may have migrated via surface water into Lee Pond or across the upper soil via overland flow in the area of the depression near Building 10. Lee Pond drains into the eastern branch of Felgates Creek, which in turn flows northward to the York River, approximately 1.5 miles from Site 9. The location of Site 9 is presented on Figure 1-5.

1.1.2 Site 19 - Conveyor Belt Soil at Building 10

This section provides description of Site 19, the Conveyor Belt Soil at Building 10, as well as the site history.

The conveyor belt at Site 19 (between Buildings 10 and 98) carried TNT powder packaged in containers across a depression into the loading building. The conveyor belt is completely enclosed with corrugated metal, but holes are visible along the floors and walls. Fine particles of explosives-related compounds may have been released to the soil in the vicinity of the conveyor belt during explosives loading operations. The conveyor and walls/floors were sprayed with water to control dust; this rinse water may have dripped onto the ground surface below.

TNT-contaminated soil has been reported in the vicinity of the conveyor belt. Soil beneath the belt was removed in 1973-1974, but later tests indicated the presence of RDX and TNT. The location of Site 19 is presented on Figure 1-5.

1.2 Previous Investigations

Previous investigation reports completed through the IRP include: the Initial Assessment Study (IAS, July 1984), two Confirmation Study Reports (June 1986 and June 1988), an RI Interim Report (July 1991), a Focused Biological Sampling and Preliminary Risk Evaluation Report (July 1993), a Round One RI Report (July 1993), and a Habitat Evaluation Report (July 1995). These reports have been generated in conjunction with the continuing development of the Department of Defense (DoD) IRP. Summaries of previous investigations are provided in the following sections.

1.2.1 Initial Assessment Study

The IAS for WPNSTA Yorktown (C.C. Johnson & Associates, Inc. and CH2M Hill, July 1984) was conducted in 1984 to identify and assess sites posing a potential threat to human health and/or the environment because of contamination from past operations. A total of 19 potentially contaminated sites were identified at the Station based on information from historical records, aerial photographs, field inspections, and personnel interviews. Each site was evaluated for the type of contamination, migration pathways, and pollutant receptors. The IAS concluded that 15 of the 19 sites, including Sites 9 and 19, were of sufficient threat to human health or the environment to warrant Confirmation Studies.

1.2.2 Confirmation Study and RI Interim Report

Two rounds of data were obtained during the Confirmation Study. This effort was documented in the "Confirmation Study Step IA (Verification), Round One" (Dames & Moore, June 1986). The results of the analyses and comparisons with appropriate regulatory standards were presented in the Confirmation Study Step IA (Verification), Round Two" (Dames & Moore, June 1988). The results of these field efforts were combined and summarized in the Draft RI Interim Report (Dames & Moore, February 1989). This report was subsequently revised by Versar in 1991 to incorporate comments from the Technical Review Committee (TRC); this report is referred to as the RI Interim Report. The RI Interim Report recommended that further RI activities be completed at 14 of the 15 sites for which data were available, including Site 9 and Site 19.

1.2.3 Focused Biological Sampling and Preliminary Risk Evaluation Report

The Focused Biological Sampling and Preliminary Risk Evaluation Report (Baker/Weston, July 1993b) summarized the results of a limited biological tissue, surface water, and sediment sampling effort conducted in October 1992. The primary objective of the sampling program was to evaluate the potential human health risk associated with consumption of fish and shellfish taken from select waters within WPNSTA Yorktown.

1.2.4 Round One Remedial Investigation

The results of the Round One RI (Baker/Weston, 1993a) indicated that further investigation was needed at all of the sites to better define the nature and extent of contamination associated with each site. A summary of the results of the Round One RI for Sites 9 and 19 is presented below. These data indicate that surface soil, subsurface soil, groundwater, surface water, and sediment have been potentially impacted by past site activities. The Round One analytical data and frequency of detection tables for these data are presented in Appendix A.

1.2.4.1 Site 9 Round One RI Investigation

Analytical results collected during the Round One RI for Site 9 are summarized below.

Surface Soil Sampling Results

Soil samples were collected at Site 9 and analyzed for the full suite of Contract Laboratory Program (CLP) parameters. Soil was collected from the 0- to 2- foot below ground surface (bgs) interval. Results of the sample analyses are presented on Figure 1-5 and summarized in the following section. Six surface soil samples collected from Site 9 for the Round One RI indicate that polynuclear aromatic hydrocarbons (PAHs) were detected across the site. The highest PAH concentrations were detected in the sample collected from location 9S16, ranging from 39J micrograms per kilogram ($\mu\text{g}/\text{Kg}$) fluorene to 1,100 $\mu\text{g}/\text{Kg}$ fluoranthene. The "J" qualifier indicates that the reported sample concentration value has been estimated. No volatile organic compounds (VOCs) were detected in any of the surface soil samples. The explosive analyses showed the presence of 2,4,6-TNT in four of the soil samples (9S15, 9S16, 9S17, and 9S19) at levels above the criteria ranging from 2,900 $\mu\text{g}/\text{Kg}$ to 2,100,000 $\mu\text{g}/\text{Kg}$. Explosive compounds 2,4-dinitrotoluene (2,4-DNT) and 1,3,5-trinitrobenzene (1,3,5-TNB) also were detected in the sample collected from location 9S19, at concentrations below the criteria of 3,200 and 3,000 $\mu\text{g}/\text{Kg}$, respectively. Inorganic concentrations and pH levels were within the ranges found in the background surface soil samples.

One soil sample was collected from the soil boring advanced at the location of HydroPunch™ 9HP03 and analyzed for VOCs because odors observed in the field indicated the possible presence of volatile compounds. Ethylbenzene, at an estimated concentration of 8J $\mu\text{g}/\text{Kg}$, was the only VOC detected. This compound was not detected in the groundwater sample collected from the same location.

Subsurface Soil Sampling Results

Subsurface soil samples were not collected at Site 9 during the Round One RI.

Groundwater Sampling Results

Three groundwater samples collected from Site 9, (See Figure 1-6) using a HydroPunch™ sampler, showed no detectable concentrations of VOCs. The only semi-volatile organic compound (SVOC) detected in the groundwater samples was 1J $\mu\text{g}/\text{L}$ diethylphthalate from sample location 9HP01. No explosives were detected in this sample. Explosives were detected in the other two groundwater

samples. Sample 9HP03 contained 0.89 µg/L of 2,4-DNT and 2,300 µg/L of 2,4,6-TNT. Sample 9HP02 was found to contain 6.3 µg/L of 1,3,5-TNB, 2.2 µg/L of 2,4,6-TNT, and 12J µg/L of 2,4-DNT.

Inorganic analysis results from the groundwater samples collected from Site 9 are summarized below and are presented in Table 1-1. Dissolved inorganic concentrations were below Federal and Commonwealth standards and criteria with the exception of zinc, which was detected at 16.90 µg/L in dissolved groundwater sample 9HP03-001.

Surface Water Sampling Results

A total of seven surface water and sediment samples were collected at Site 9 during the Round One RI (See Figures 1-7 and 1-8). The surface water sample collected from station 9SW06 showed the presence of 6J micrograms per liter (µg/L) of 1,1 dichloroethane and 18 µg/L of 1,1,1-trichloroethane (1,1,1-TCA); 1,1,1-TCA also was detected in surface water sample 9SW01 (1J µg/L). Trace amounts (<20 µg/L) of acetone were detected in surface water samples 9SW04, 9SW05, and 9SW07. Explosives were detected in all surface water samples collected at Site 9 except for 9SW02 and 9SW03, which were obtained at points furthest away from the suspected source. Samples 9SW01 and 9SW06 showed the highest levels of explosives contamination along with the widest range of contaminants. 2,4,6-TNT was present in high concentrations (190 to 370 µg/L) in samples 9SW01, 9SW04, and 9SW06, located along the main drainage channel.

The inorganic analysis results for the surface water samples at Site 9 are presented on Table 1-2. Most inorganic concentrations were below Virginia Water Quality Standards (VWQS) and Clean Water Act (CWA) freshwater chronic criteria. Exceptions to this observation include total lead (9SW02-001 [19.8 µg/L]), which exceeded both the CWA freshwater chronic level of 3.2 µg/L; the total zinc concentration, which exceeded both the CWA and VWQS criteria; and total copper, which exceeded the Freshwater Chronic Criterion in sample 9SW06-007. The dissolved inorganic sample did not contain detectable concentrations of lead or zinc concentrations above the criteria.

Sediment Sampling Results

The sediment samples collected in association with Site 9 showed the presence of several SVOCs; previous results showed similar concentrations. Sediment samples collected from locations 9SD01 and 9SD04 contained concentrations of SVOCs that exceeded the National Oceanic and Atmospheric Administration (NOAA) effects range-low (ER-L) criteria and the Apparent Effects Threshold (AET). Sediment samples from stations 9SD05 and 9SD06 contained levels of SVOCs above the NOAA effects range-median (ER-M) and AET concentrations. Acetone and 2-butanone were the only VOCs detected in any of the sediment samples (samples 9SD07-001 and 9SD07-002); however, these compounds are common laboratory contaminants and are not considered to be site related. No explosives were detected in any of the sediment samples collected from Site 9, consistent with previous investigation results. Inorganic concentrations were generally similar to those found in the background sediment samples. Arsenic, lead, mercury, copper, and zinc were detected in at least one sediment sample collected from Site 9 at concentrations above the NOAA ER-L criteria.

1.2.4.2 Site 19 Round One RI Investigation

Analytical results from the Round One RI for Site 19 are summarized below.

Surface Soil Sampling Results

Six surface soil samples were collected during the Round One RI at Site 19 (See Figure 1-5). Acetone (a common laboratory contaminant) and toluene the only VOCs detected in the surface soil samples. PAHs were detected in the surface soil samples, with the highest concentrations (24 to 480 $\mu\text{g}/\text{Kg}$) and the largest number of analytes present in sample 19S19, the sample collected from beneath the conveyor belt connecting Buildings 10 and 528. Explosives were also detected in sample 19S17, which was collected from a drainage swale along the road west of Site 19, and in sample 19S20, which was collected midway between the two conveyor belts in this area. Soil samples collected from beneath and adjacent to the conveyor belt did not contain any explosive compounds. Inorganic concentrations in the surface soil were generally close to Round One RI surface soil levels in the site control samples, with occasional variations.

The explosives analysis of the surface soil collected from beneath the conveyor belt showed lower concentrations than in investigations conducted before the Round One RI. The partial removal of the soil around the conveyor belt during the 1970s could account for this difference.

Subsurface Soil Sampling Results

Six soil samples were collected from the soil borings advanced prior to installation of the groundwater monitoring wells at Site 19. Analysis of these samples indicated the following:

- No VOCs or SVOCs were detected in the shallow sample from soil boring 19SB01, the boring advanced prior to installation of monitoring well 19GW01. The deep sample, collected from just above the water table, contained 61J µg/Kg of di-n-butylphthalate. This compound was not detected in the duplicate sample.
- Results of soil sample 19SB02-001, collected from 0- to 2- ft bgs, showed 2J µg/Kg of toluene, 57J µg/Kg of di-n-butylphthalate, and 210J µg/Kg of bis(2-ethylhexyl)phthalate. The deep soil sample from soil boring 19SB02 showed 45J µg/Kg of di-n-butylphthalate and 2,120J µg/Kg of bis(2-ethylhexyl)phthalate.
- Several SVOCs were detected in the shallow soil sample collected from soil boring 19SB03 including fluoranthene (74J µg/Kg), pyrene (95J µg/Kg), benzo(b)fluoranthene (140J µg/Kg), benzo(k)fluoranthene (130J µg/Kg), benzo(a)pyrene (86J µg/Kg), and indeno(1,2,3-cd)pyrene (74J µg/Kg). The only SVOC detected in the deep soil sample was phenol (280J µg/Kg). No VOCs were detected.
- The only soil boring sample containing explosives was the deep soil sample from soil boring 19SB03, which contained 8,200 µg/Kg of 2,4,6-TNT (below criteria). All inorganic concentrations in the soil boring samples were within background soil boring concentration ranges.

Groundwater Sampling Results

Three groundwater samples were collected from the monitoring wells at Site 19 (See Figure 1-6). No VOCs, SVOCs, nitrates, or explosives were detected in groundwater samples 19GW01 and 19GW02. Explosives were the only compounds detected in sample 19GW03 (1.3J µg/L 1,3,5-TNB and 5.1 µg/L 2,4,6-TNT).

The total and dissolved inorganic analyses performed on the groundwater samples did not indicate the presence of any inorganics above criteria (see Table 1-1). The concentrations of magnesium, calcium, and manganese were above background in the total and dissolved inorganic samples collected from 19GW03. Groundwater samples collected from the other two monitoring wells showed inorganic concentrations similar to background.

Site 19 appears to have been impacted by explosives contamination, as evidenced by the presence of these compounds in the soil and groundwater. Sediment does not appear to have been affected by previous site operations. SVOCs are present but appear to be widespread in this area and are not necessarily site related.

Surface Water Sampling Results

There was no surface water present at Site 19 during the Round One RI.

Sediment Sampling Results

Two sediment samples were collected from a concrete drainage way located along the west side of Building 10. No VOCs or explosives were detected in these samples. Several SVOCs were detected in both samples at concentrations that exceeded the NOAA sediment screening criteria. All of the constituents detected in sample 19SD01-001 exceeded the ER-M and AET concentrations. The concentrations of inorganics detected in the sediment samples at Site 19 were comparable to those found in background sediment samples. The zinc concentration in sample 19SD01-001 was slightly higher than the NOAA ER-L concentration.

1.2.4.3 Immediate Removal Action

A soil removal action was conducted at Site 9 in September 1994 (IT, 1995) to address contamination at the lower end of the drainage way in the vicinity of Round One RI sampling locations 9S19 and 9S18. Six confirmatory samples were collected and analyzed for VOCs, SVOCs, polychlorinated biphenyls (PCBs), nitramine compounds, and pesticides. Based upon available data, SVOCs were detected in soil. One VOC, TCE, was detected in one soil sample at a concentration of 2 µg/Kg. Results of this removal action are included in Appendix B.

1.2.4.4 Confirmation Sampling for Treatability Study

A Soil Characterization Study (Baker, 1995e) was conducted to support a treatability study for explosives-contaminated soil and included Sites 6, 7, 9, and 19. Representative, composite soil samples were collected and analyzed for nitramine compounds. The soil was collected from 0- to 12-inches below ground surface (bgs).

A total of ten soil samples, excluding QC samples, were collected at Site 9 (see Figure 1-9). The composite soil samples were obtained from areas on both sides of the drainage area and were taken from just east of Bollman Road, following the drainage path, to just east of the removal area. Soil also was taken from the drainage way running northwest of this removal area.

Explosives were detected in six of the soil samples. 2,4,6-TNT was detected in six samples while amino-DNTs were detected in four samples. The concentration levels of these explosives were relatively low; therefore, this site was not included in the treatability study.

As part of the Soil Characterization Study, a total of 32 composite soil samples were collected and analyzed for nitramine compounds at Site 19 (see Figure 1-10). Samples were collected from both sides of the conveyor belt along its length and along the railroad tracks adjacent to the conveyor belt. A total of 19 of the samples were non-detections, while 2,4,6-TNT was detected in 12 samples at concentrations ranging from 136 µg/Kg to 863,000 µg/Kg. Based on the results, the next phase of this characterization study involved collecting 70 percent of the study samples in two areas within Site 19.

1.2.5 Habitat Evaluation Results

1.2.5.1 Site 9

Three different habitats are present in the vicinity of Site 9 (see Figure 1-11). The area around the buildings and along the fence line is open. Deciduous upland forest is present on the higher ground, although upland species are mixed with lowland species in the ecotones around the edges of the forested areas. Deciduous lowland forest is present along the drainageway itself. No endangered species were noted at Site 9.

Few species were noted in the open areas. Grasses are dominant in these areas and are kept closely mowed within the fence and roughly mowed outside the fence. The mowed areas extend directly up to the forested areas without a shrub transition zone.

Upland forest is present on the higher ground. Beech (Fagus grandifolia) and white oak (Quercus alba) are dominant in some areas of the forest. Other species are interspersed among stands of beech and oak, particularly along the edges of the forest in the ecotone or transition zone. No species is dominant in the understory, which included five woody species. The forest floor in the upland area is sparsely covered in many locations, but the plants that are present are typical of a deciduous forest with acidic soil. Lowland and wetland species replace upland forest species along the actual drainage way. However, upland species are also present where the drainage way is narrow. A number of wetland forbs are present along the drainage way, particularly where it flows into Lee Pond. Birds, mammals, and amphibians were observed at Site 9. Birds did not appear to be common, perhaps because overgrown fields and shrubby ecotones are not present and the wooded areas are relatively small.

A small drainage way is present at Site 9 from the corner of Building 10 to Lee Pond. This drainage way functions as an intermittent stream and can support small fish and other aquatic organisms depending upon the water level. The area at the Lee Pond end of the drainage way supports wetland vegetation. However, this area has been affected by the immediate removal activities.

1.2.5.2 Site 19

Three habitat types are present at Site 19: open areas around the buildings and the conveyor, a deciduous upland knoll, and an ecotone along the fence around the buildings and the power line. These habitats are presented on Figure 1-11. No endangered species were noted at Site 19.

The open area is dominated by grass, which is kept closely mowed. This mowed grass extends up to the forested knoll and to the fence line. The only wildlife observed in this open area was a woodchuck (Marmota monax), which was living in a burrow excavated in the bare soil directly beneath the conveyor.

The upland knoll is dominated by deciduous trees, although no single specie is dominant. Several of the beech trees in the interior of the forest were larger than the other trees and their branches spread to the ground, which indicates that they were probably growing in the open in the past. The interior of the forest is consistent with an upland beech forest, while the edges resemble a mixed forest. The understory of the forest is also well-mixed. Vines are also present in the upland forest, particularly along the edges where the forest abuts the mowed field. The forest floor of the knoll is sparsely vegetated, and the species that are present are those of the upland forest.

Upland forest is also present around Site 19, particularly on the other side of an ecotone along the boundary fence around the building complex. This ecotone appears to have been created when the area along the fence was cleared. The species present in this area are influenced somewhat by the upland forest. Saplings and seedlings of sweetgum (Liquidambar styraciflua) and tulip poplar (Liriodendron tulipifera) are dominant in some portions of the ecotone and appear to have seeded from trees in the adjacent forest. Forbs are growing among the saplings and shrubs in the ecotone. No specie of forbs is dominant, however.

Limited avifauna was observed at Site 19 during the habitat evaluation, which seemed unusual given the types of habitat present. Birds may have been scarce because many migratory and summer residents had already left the area. Food, particularly beech nuts and acorns, was very plentiful in the upland forest knoll and there were signs of wild turkey (Meleagris gallopavo) feeding in the area.

In addition to the woodchuck observed living under the conveyor belt, two other mammals were noted at Site 19. These included raccoons (Procyon lotor) and squirrels (Sciurus sp.). No reptiles or amphibians were observed at Site 19.

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SECTION 1.0 TABLES

TABLE I-1

METALS CONCENTRATIONS ($\mu\text{g/L}$) FOR GROUNDWATER SAMPLES
 ROUND ONE REMEDIAL INVESTIGATION
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

SITE ID	Federal MCL	Federal SMCL	VGS	9HP01-001	9HP02-001	9HP03-001	19GW01-001
Aluminum		200		85,300 J (c)	62,800 J (c)	31,100 J (c)	181.9 U (c)
Aluminum (dissolved)				35.00 UJ	35.00 UJ	35.00 UJ	89.90 UJ
Antimony	6			44.00 R	44.00 R	44.00 R	44.00 U
Antimony (dissolved)				44.00 R	44.00 R	44.00 R	44.00 U
Arsenic	50		50	2.00 R	2.60 J	6.90 J	2.00 U
Arsenic (dissolved)				2.00 R	2.00 R	23.20 J	2.00 U
Barium	2,000		1,000	2,070 (d)	1,010 J (a)	728 J *	59.10
Barium (dissolved)				22.90	39.60 J	515 J *	63.20
Beryllium	4			25.30 (b)	10.40 J (b)	5.10 J (b)	1.00 U
Beryllium (dissolved)				1.00 U	1.10 J	1.10 J	1.00 U
Cadmium	5		0.04	4.00 U	4.00 U	1.580 (d)	4.00 UJ
Cadmium (dissolved)				4.00 U	4.00 U	4.00 U	4.00 UJ
Calcium				125,000	2,030,000 J *	85,300 J	118,000
Calcium (dissolved)				41,500	126,000 J	83,700 J	130,000
Chromium	100		50	205 J (d)	299 J (d)	32.40 J	8.00 U
Chromium (dissolved)				8.00 UJ	8.00 UJ	8.00 U	8.00 U
Cobalt				339 *	147 J *	34.30 J *	6.00 U
Cobalt (dissolved)				6.00 U	6.00 UJ	11.60 J	6.00 U
Copper	1,300**	1,000	1000	26.00 *	56.30 J *	16.00 J	5.00 UJ
Copper (dissolved)				5.00 U	5.00 UJ	5.00 UJ	5.00 UJ
Iron		300	300	256,000 J (e)	251,000 J (e)	107,000 J (e)	2,090 J (e)
Iron (dissolved)				23.30 UJ	19.00 U	12,300 J (e)	792 J (e)
Lead	15**		50	39.20 J (b)	119 (d)	248 (d)	2.00 U
Lead (dissolved)				2.00 UJ	2.00 UJ	20.00 UJ	2.00 U
Magnesium				12,400 *	23,500 J *	27,500 J *	1,910 J
Magnesium (dissolved)				2,100	3,360 J	26,500 J *	2,120 J
Manganese		50	50	9.530 (e)	3,390 J (e)	1,070 J (e)	30.20
Manganese (dissolved)				21.90	587 J (e)	251 J (e)	23.90
Mercury	2		0.05	1.24 (a)	1.82 J (a)	0.10 UJ	0.10 U
Mercury (dissolved)				0.10 U	0.10 UJ	0.10 UJ	0.10 U
Nickel	100			118 (b)	154 J (b)	38.00 J	18.00 U
Nickel (dissolved)				18.00 U	18.00 UJ	18.00 UJ	18.00 U
Potassium				8,420 *	11,600 *	27,200 *	970 U
Potassium (dissolved)				970 U	1,400	26,900 *	970 U
Selenium	50		10	2.00 R	20.00 R	2.00 R	2.00 UJ
Selenium (dissolved)				2.00 R	2.00 R	2.00 R	2.00 UJ
Silver		100		20.90	13.60	9.40	6.00 UJ
Silver (dissolved)				6.00 U	6.00 U	6.00 U	6.00 UJ
Sodium			100,000	5,540 J	28,600 J *	22,900 J *	5,270
Sodium (dissolved)				5,110 J	12,200 J *	23,800 J *	6,010
Thallium	2			2.00 UJ	2.00 UJ	2.00 UJ	2.00 U
Thallium (dissolved)				2.00 UJ	2.00 UJ	2.00 UJ	2.00 U
Vanadium				203 J *	363 J *	40.60 J *	6.00 U
Vanadium (dissolved)				9.10 U	13.90 UJ	6.00 UJ	6.00 U
Zinc		5,000	50	347 J (a)	498 J (a)	3,940 J (a)	16.50
Zinc (dissolved)				12.20 J	6.10 J	77.4 J (a)	6.00 U
Nitrates	10,000		5,000	NA	NA	NA	100 U

TABLE I-1 (Continued)

METALS CONCENTRATIONS (µg/L) FOR GROUNDWATER SAMPLES
 ROUND ONE REMEDIAL INVESTIGATION
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

SITE ID	Federal	Federal	VGS	19GW02-001	19GW03-001
ANALYTE	MCL	SMCL			
Aluminum		200		2,590 J (c)	4,510 J (c)
Aluminum (dissolved)				76.80 UJ	35.00 UJ
Antimony	6			44.00 U	44.00 U
Antimony (dissolved)				44.00 U	44.00 U
Arsenic	50		50	2.00 U	8.60
Arsenic (dissolved)				2.00 U	2.00 U
Barium	2,000		1,000	95.30	64.40
Barium (dissolved)				86.20 *	52.70
Beryllium	4			1.00 U	1.00 U
Beryllium (dissolved)				1.00 U	1.00 U
Cadmium	5		0.04	4.50 J (a)	4.00 UJ
Cadmium (dissolved)				4.00 UJ	4.00 UJ
Calcium				157,000	175,000
Calcium (dissolved)				148,000	185,000
Chromium	100		50	11.70	14.00
Chromium (dissolved)				8.00 U	8.00 U
Cobalt				6.00 U	6.00 U
Cobalt (dissolved)				6.00 U	6.00 U
Copper	1,300**	1,000	1000	5.00 UJ	5.00 UJ
Copper (dissolved)				8.10 U	5.00 UJ
Iron		300	300	6,150 J (c)	15,300 J (c)
Iron (dissolved)				19.00 U	19.00 U
Lead	15**		50	5.00	6.70
Lead (dissolved)				2.00 U	2.00 U
Magnesium				2,940 J	5,900 J *
Magnesium (dissolved)				2,730 J	5,710 J *
Manganese		50	50	79.00 (e)	3,480 (e)
Manganese (dissolved)				26.20	40.0 (e)
Mercury	2		0.05	0.10 U	0.10 U
Mercury (dissolved)				0.10 U	0.10 U
Nickel	100			18.00 U	18.00 U
Nickel (dissolved)				18.00 U	18.00 U
Potassium				2,640 U	2,250 U
Potassium (dissolved)				970 U	970 U
Selenium	50		10	2.00 UJ	2.00 UJ
Selenium (dissolved)				2.00 UJ	2.00 UJ
Silver		100		6.00 UJ	6.00 U
Silver (dissolved)				6.00 UJ	6.00 UJ
Sodium			100,000	6,120	9,480
Sodium (dissolved)				5,500	8,650
Thallium	2			2.00 U	2.00 U
Thallium (dissolved)				2.00 U	2.00 U
Vanadium				7.50	19.10
Vanadium (dissolved)				6.00 U	6.00 U
Zinc		5,000	50	35.80	31.50
Zinc (dissolved)				13.90	7.60
Nitrates	10,000		5,000	100 U	100 U

TABLE 1-2

METALS CONCENTRATIONS (µg/L) FOR SURFACE WATER SAMPLES
 ROUND ONE REMEDIAL INVESTIGATION
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

SITE ID	VWQS	CWA	9SW01-001	9SW02-001	9SW03-001
ANALYTE	Criteria	Criteria			
Aluminum			116	1,820	35.00 U
Aluminum (dissolved)			35.00 U	35.00 U	35.00 U
Antimony			44.00 U	44.00 U	44.00 U
Antimony (dissolved)			44.00 U	44.00 U	44.00 U
Arsenic		190/36	3.00	16.10	2.60
Arsenic (dissolved)			2.00	2.10	2.30
Barium			35.70	84.70	13.00
Barium (dissolved)			43.70	50.90	26.80
Beryllium			1.00 U	1.00 U	1.00 U
Beryllium (dissolved)			1.00 U	1.00 U	1.00 U
Cadmium	-/9.3	1.1/-	4.00 U	4.00 U	4.00 U
Cadmium (dissolved)			4.00 U	4.00 U	4.00 U
Calcium			86,600 J	54,900 J	33,400 J
Calcium (dissolved)			90,400 J	44,900 J	35,200 J
Chromium	11/50		8.00 U	8.00 U	8.00 U
Chromium (dissolved)			8.00 U	8.00 U	8.00 U
Cobalt			6.00 U	6.00 U	6.00 U
Cobalt (dissolved)			6.00 U	6.00 U	6.00 U
Copper	-/2.9	12/2.9	5.00 U	5.00 U	5.00 U
Copper (dissolved)			5.00 U	5.00 U	5.00 U
Iron			812 J	25,500 J	789 J
Iron (dissolved)			19.00 UJ	94.50 UJ	197 J
Lead		3.2/8.5	2.00 UJ	19.30 UJ	2.00 UJ
Lead (dissolved)			2.00 UJ	2.00 UJ	2.00 UJ
Magnesium			1,930	1,650	1,010
Magnesium (dissolved)			1,890	1,210	1,040
Manganese			51.00	645	36.40
Manganese (dissolved)			37.80	131	19.60
Mercury	.012/.025	.012/.025	0.10 U	0.10 U	0.10 U
Mercury (dissolved)			0.10 U	0.10 U	0.10 U
Nickel	-/8.3	160/8.3	18.00 U	18.00 U	18.00 U
Nickel (dissolved)			18.00 U	18.00 U	18.00 U
Potassium			1,450	1,710	970 U
Potassium (dissolved)			970 UJ	970 UJ	970 UJ
Selenium	5/71	5/71	2.00 R	2.00 R	2.00 R
Selenium (dissolved)			2.00 R	2.00 R	2.00 R
Silver			6.00 U	6.00 U	6.00 U
Silver (dissolved)			6.00 U	6.00 U	6.00 U
Sodium			7,160 J	4,140 J	3,900 J
Sodium (dissolved)			7,250 J	4,240 J	3,780 J
Thallium			2.00 UJ	2.00 U	2.00 U
Thallium (dissolved)			2.00 UJ	2.00 U	2.00 UJ
Vanadium			6.00 U	40.00	6.00 U
Vanadium (dissolved)			6.00 U	6.00 U	6.00 U
Zinc	-/86	110/86	45.20 U	92.80	20.10
Zinc (dissolved)			14.50	15.20	16.90

METALS CONCENTRATIONS (µg/L) FOR SURFACE WATER SAMPLES
 ROUND ONE REMEDIAL INVESTIGATION
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA

SITE ID	VWQS	CWA	9SW03-101	9SW04-001	9SW05-001	9SW06-001	9SW07-001
ANALYTE	Criteria	Criteria					
Aluminum			76.10	106	66.30	613	159
Aluminum (dissolved)			35.00 U	35.00 U	35.00 U	35.00 U	35.00 U
Antimony			44.00 U	44.00 UJ	44.00 UJ	44.00 UJ	44.00 U
Antimony (dissolved)			44.00 U	44.00 UJ	44.00 UJ	44.00 UJ	44.00 U
Arsenic		190/36	2.70	2.40 J	2.70 J	46.10 J	4.10
Arsenic (dissolved)			2.00	2.00 R	2.00R	3.40 J	2.20
Barium			15.90	35.70	42.70	63.50	44.30
Barium (dissolved)			26.80	34.50	37.30	39.50	53.20
Beryllium			1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Beryllium (dissolved)			1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cadmium	--/9.3	1.1/--	4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
Cadmium (dissolved)			4.00 U	4.00 U	4.00 U	4.00 U	4.00 U
Calcium			33,800 J	84,500	88,100	68,200	55,500 J
Calcium (dissolved)			35,100 J	82,500	81,900	64,800	55,200 J
Chromium	11/50		8.00 U	8.00 U	8.00 U	8.00 U	8.00 U
Chromium (dissolved)			8.00 U	8.00 U	8.00 U	8.00 U	8.00 U
Cobalt			6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Cobalt (dissolved)			6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Copper	--/2.9	12/2.9	5.00 U	7.70 J	5.00 U	15.40 J (d)	5.00 U
Copper (dissolved)			5.00 U	7.70 J	7.70 J	5.00 U	5.00 U
Iron			926 J	944	1,350	21,300	3,780 J
Iron (dissolved)			296 J	61.80	54.00	98.90	361 J
Lead		3.2/8.5	2.00 UJ	2.00 U	2.00 U	2.90 J	2.00 UJ
Lead (dissolved)			2.00 UJ	2.00 U	2.00 U	2.00 U	2.00 UJ
Magnesium			1,010	1,950	2,060	2,800	1,600
Magnesium (dissolved)			1,210	1,960	1,860	2,640	1,430
Manganese			40.70	40.50	81.00	145	207
Manganese (dissolved)			22.40	33.30	49.60	87.40	158
Mercury	.012/.025	.012/.025	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Mercury (dissolved)			0.10 U	0.10 U	0.10 U	0.10 U	0.10 U
Nickel	--/8.3	160/8.3	18.00 U	18.00 U	18.00 U	18.00 U	18.00 U
Nickel (dissolved)			18.00 U	18.00 U	18.00 U	18.00 U	18.00 U
Potassium			1,530	970 U	970 U	1,220	3,790
Potassium (dissolved)			970 U	976	1,470	970 U	1,100 J
Selenium	5/71	5/71	0.00 R	2.00 UJ	2.00 UJ	2.00 UJ	2.00 R
Selenium (dissolved)			2.00 R	2.00 UJ	2.00 UJ	2.00 UJ	2.00 R
Silver			6.00 U	6.00 U	7.90	6.00 U	6.00 U
Silver (dissolved)			6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Sodium			3,560 J	8,510 J	8,700 J	7,230 J	4,590 J
Sodium (dissolved)			3,790 J	8,280 J	8,440 J	6,780 J	4,930 J
Thallium			2.00 U	2.00 UJ	2.00 UJ	2.60 J	2.00 U
Thallium (dissolved)			2.00 U	2.00 UJ	2.00 UJ	2.00 UJ	2.00 UJ
Vanadium			6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Vanadium (dissolved)			6.00 U	6.00 U	6.00 U	6.00 U	6.00 U
Zinc	--/86	110/86	24.00 U	30.00 J	27.00 J	43.80 J	29.90 U
Zinc (dissolved)			15.10	16.50 J	15.60 J	19.90 J	17.10

SECTION 1.0 FIGURES

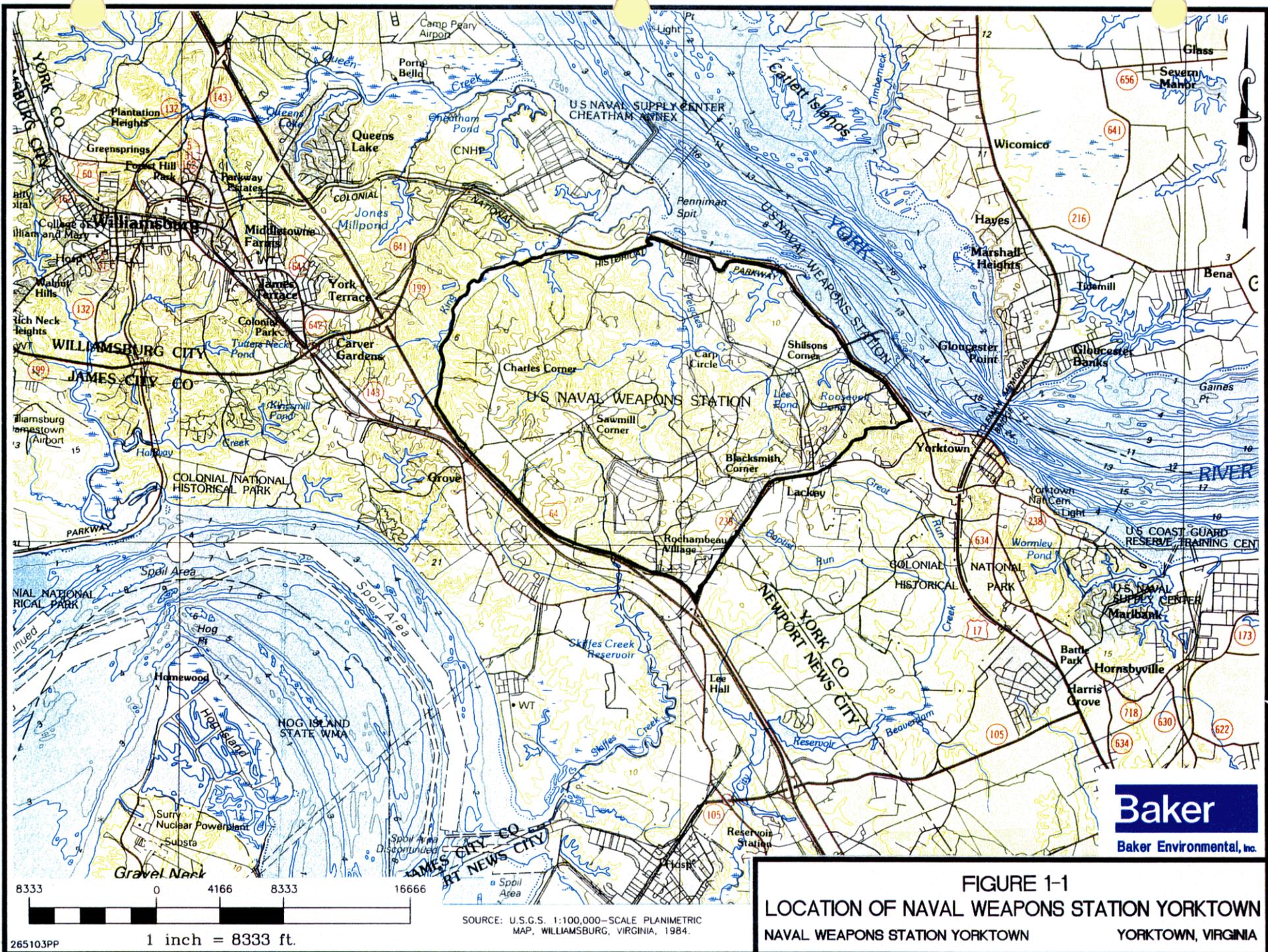
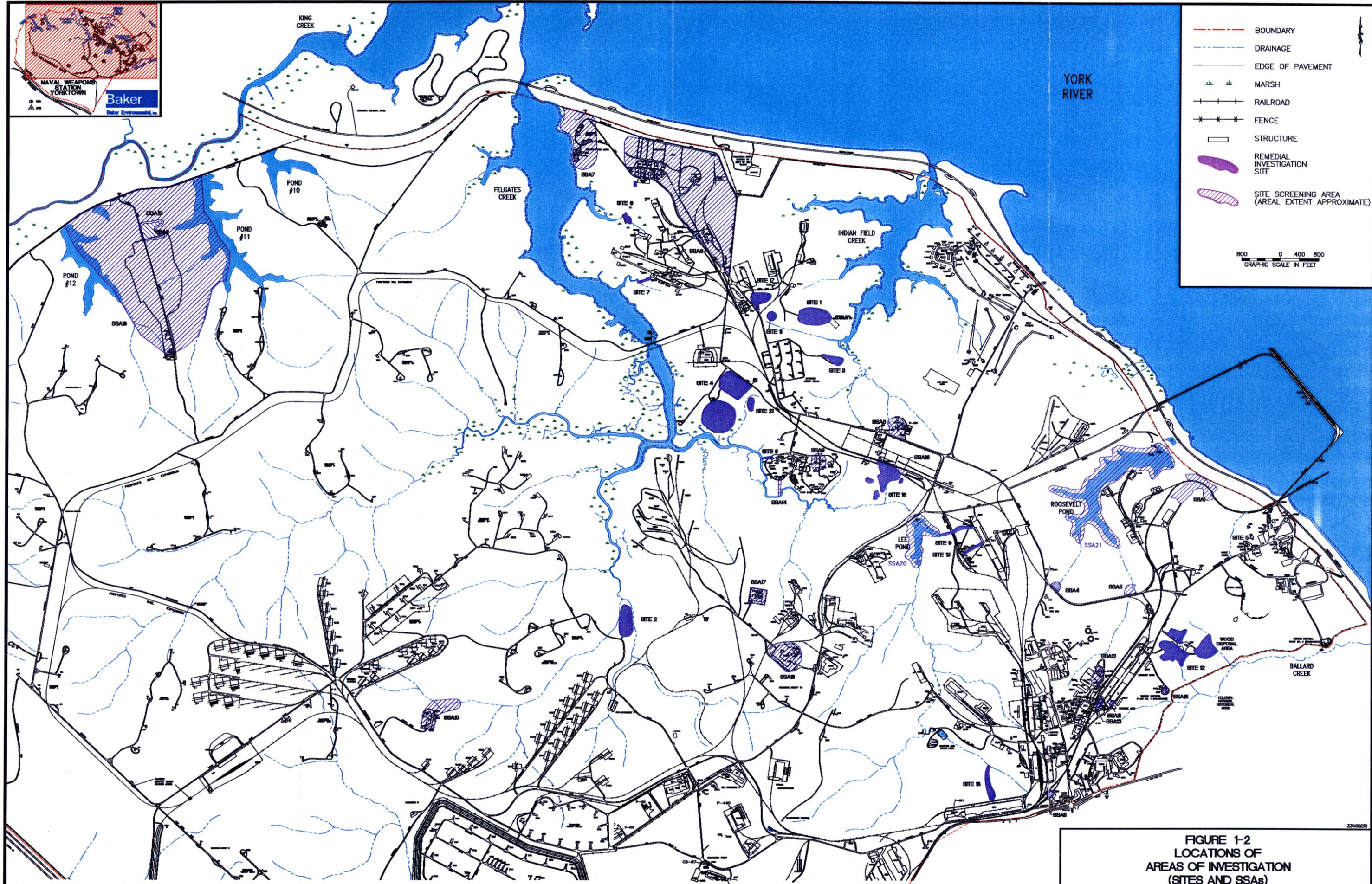


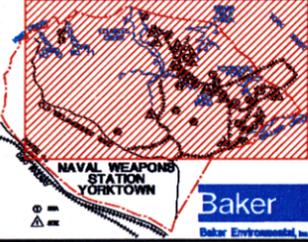
FIGURE 1-1
 LOCATION OF NAVAL WEAPONS STATION YORKTOWN
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

00889BB1V



--- BOUNDARY
 - - - DRAINAGE
 ——— EDGE OF PAVEMENT
 ■■■ MARSH
 + + + RAILROAD
 * * * FENCE
 □ STRUCTURE
 ■■■ REMEDIAL INVESTIGATION SITE
 ■■■ SITE SCREENING AREA (AREAL EXTENT APPROXIMATE)

800 0 400 800
 GRAPHIC SCALE IN FEET



33400228
FIGURE 1-2
LOCATIONS OF
AREAS OF INVESTIGATION
(SITES AND SSAs)
 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

SOURCE: NAVAL WEAPONS STATION YORKTOWN, YORKTOWN, VIRGINIA.



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FIGURE 1-3
AERIAL PHOTOGRAPH
SITES 9 AND 19

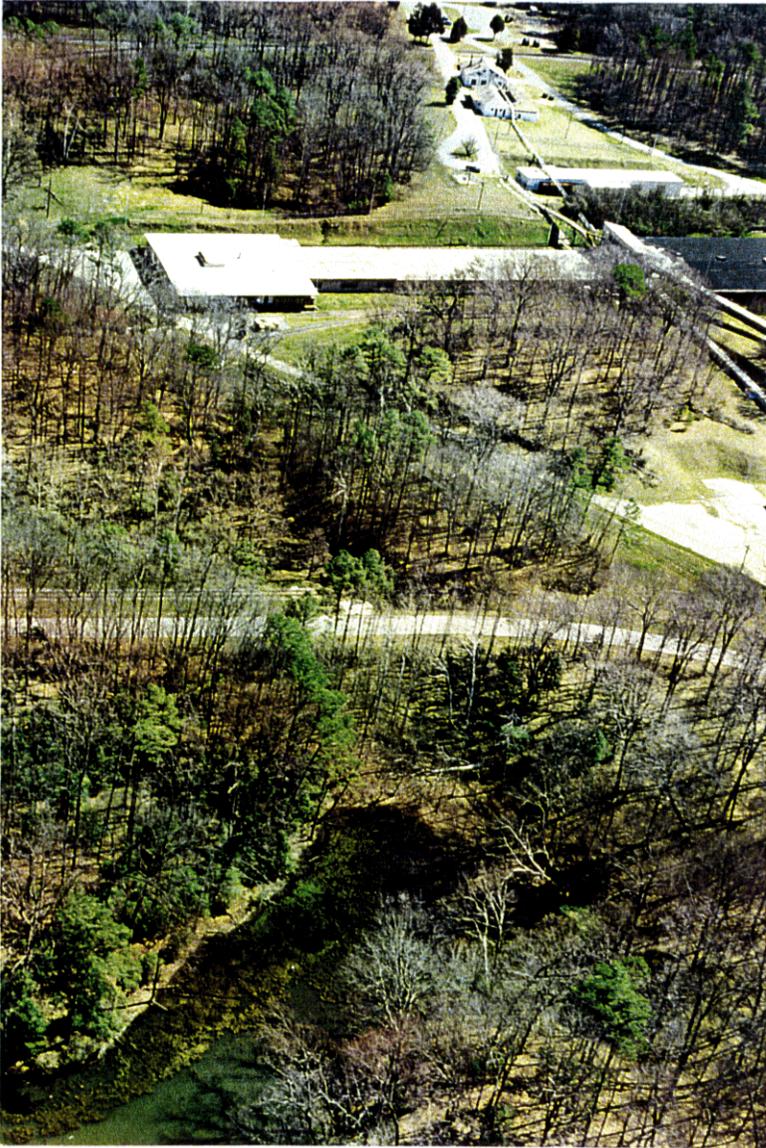
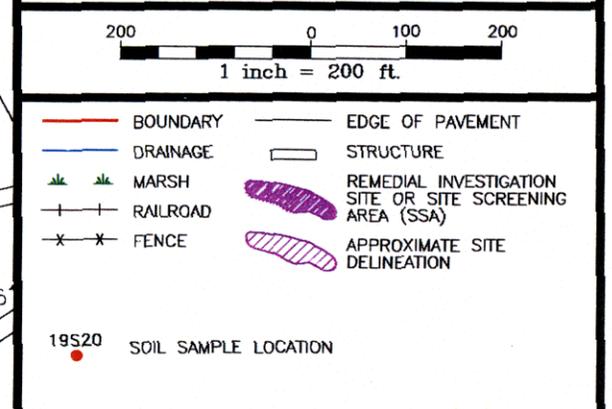
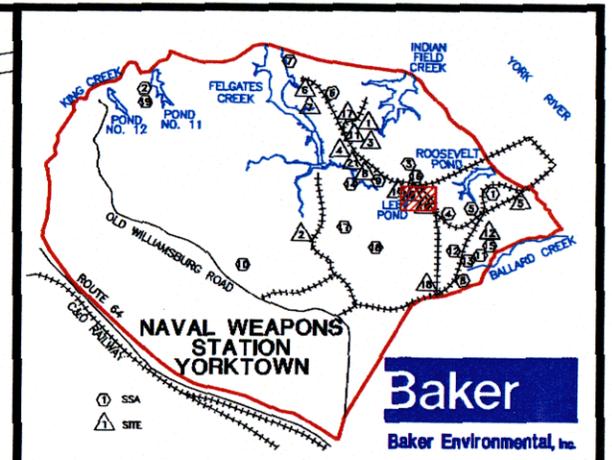
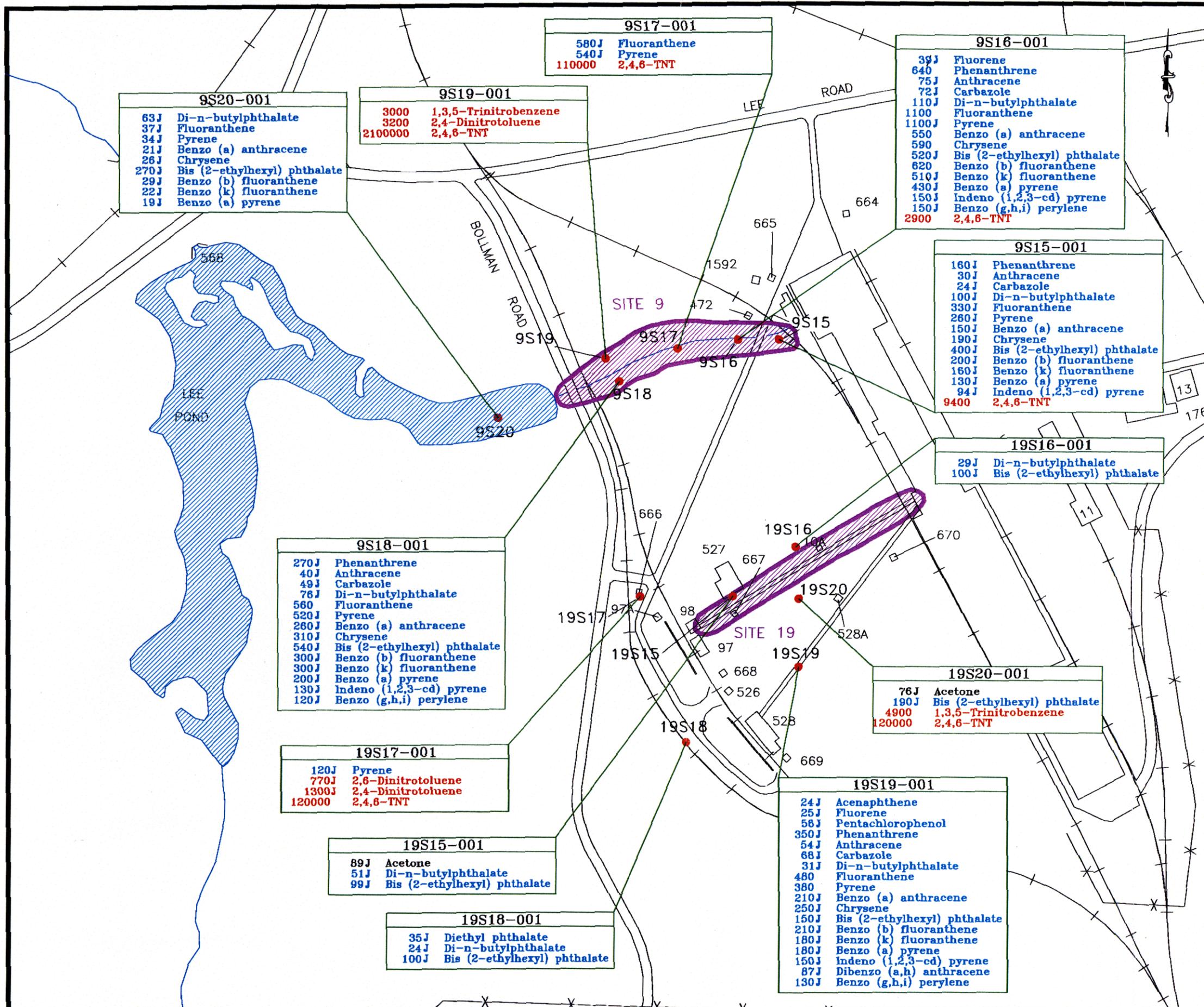


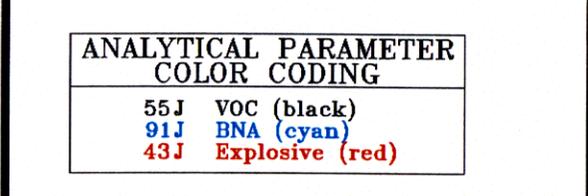
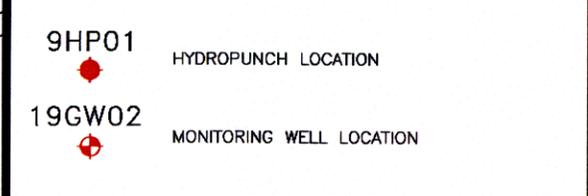
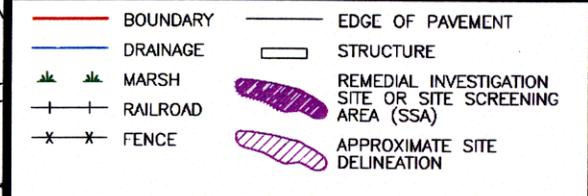
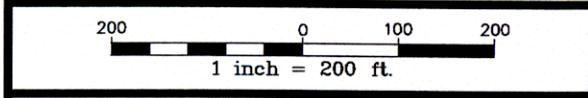
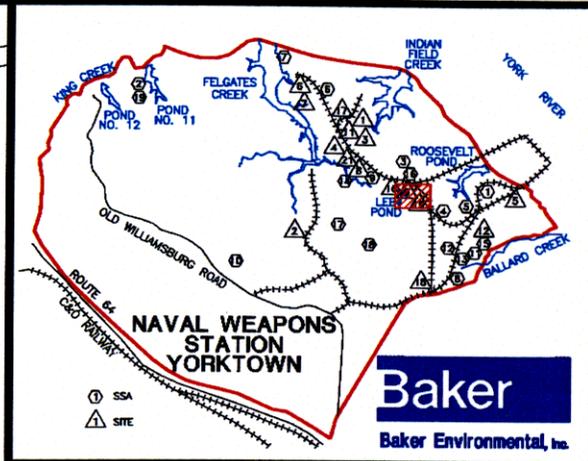
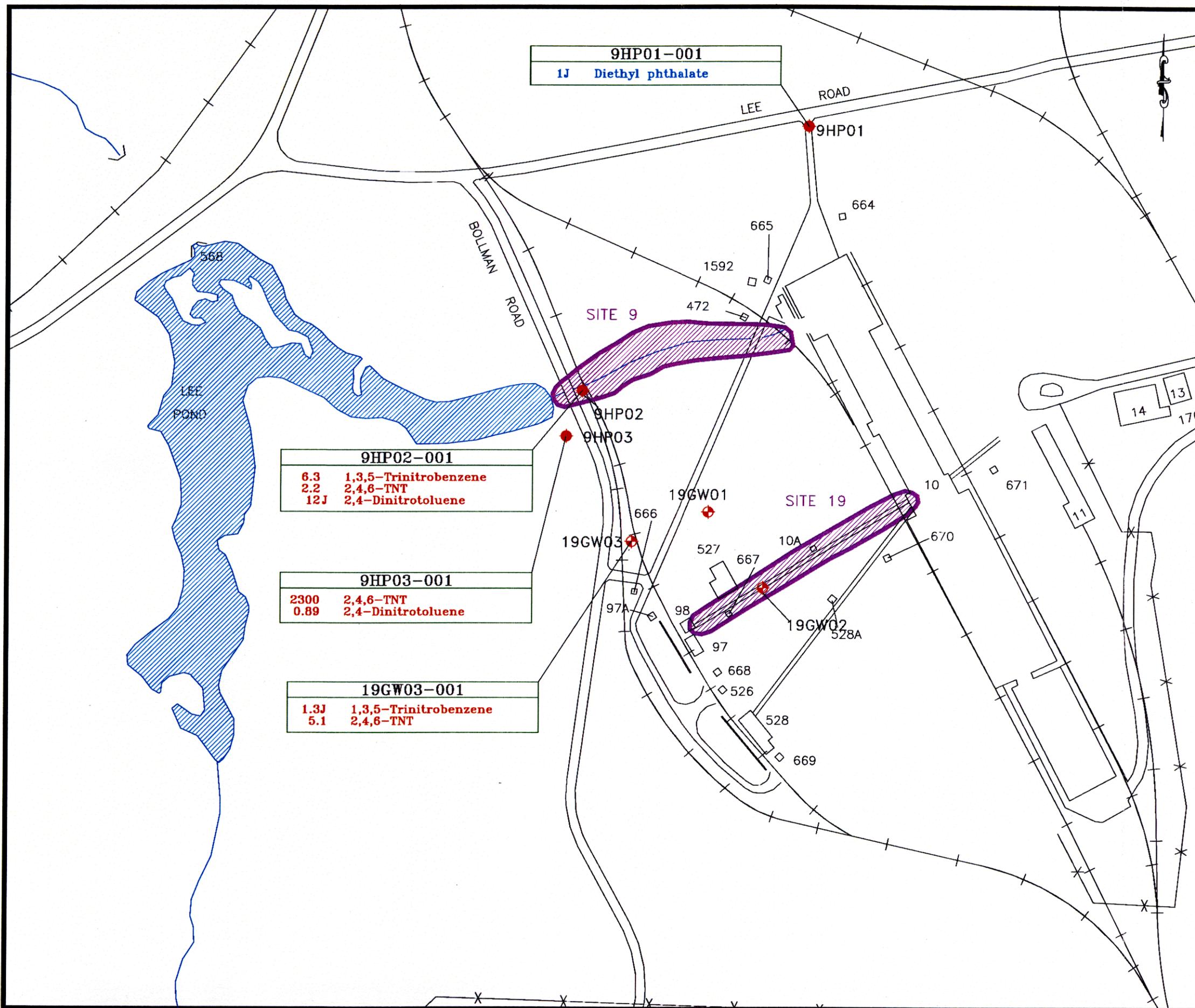
FIGURE 1-4
AERIAL PHOTOGRAPH
SITES 9 AND 19



ANALYTICAL PARAMETER COLOR CODING	
55J	VOC (black)
91J	BNA (cyan)
43J	Explosive (red)
61J	Pesticide (green)
43J	PCB (orange)

NOTE: ALL CONCENTRATIONS ARE IN ug/kg.

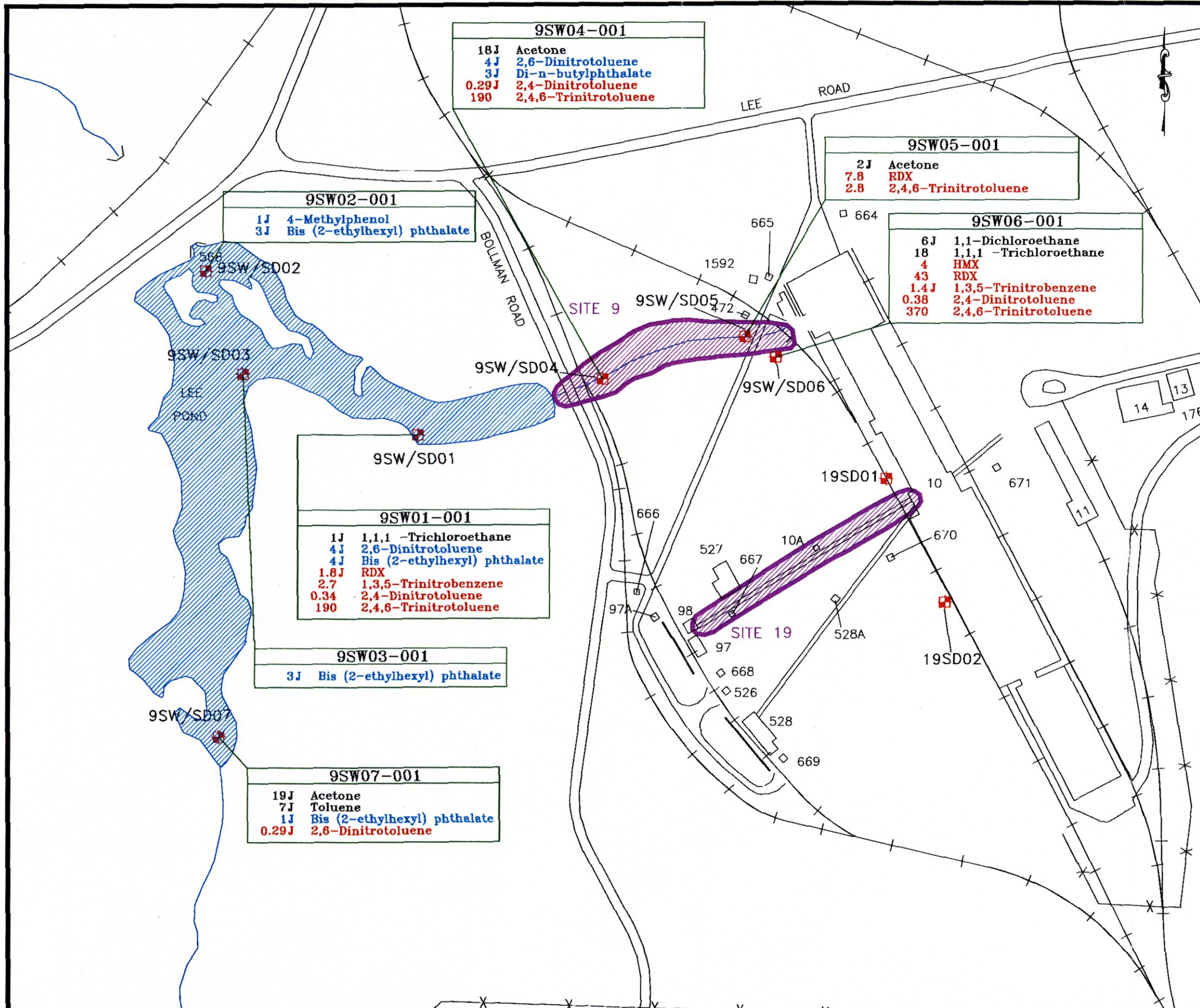
FIGURE 1-5
SURFACE SOIL SAMPLES
SITES 9 AND 19



NOTE: ALL CONCENTRATIONS ARE IN ug/L

FIGURE 1-6
GROUNDWATER SAMPLES
SITES 9 AND 19

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



9SW04-001	
18J	Acetone
4J	2,6-Dinitrotoluene
3J	Di-n-butylphthalate
0.29J	2,4-Dinitrotoluene
190	2,4,6-Trinitrotoluene

9SW05-001	
2J	Acetone
7.8	RDx
2.8	2,4,6-Trinitrotoluene

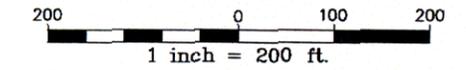
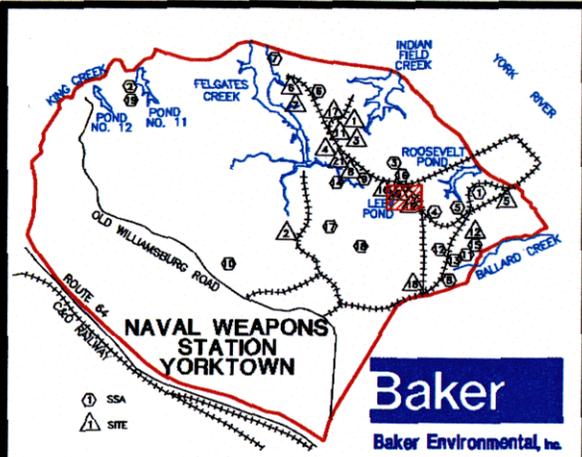
9SW06-001	
6J	1,1-Dichloroethane
18	1,1,1-Trichloroethane
4	HMX
43	RDx
1.4J	1,3,5-Trinitrobenzene
0.38	2,4-Dinitrotoluene
370	2,4,6-Trinitrotoluene

9SW02-001	
1J	4-Methylphenol
3J	Bis (2-ethylhexyl) phthalate

9SW01-001	
1J	1,1,1-Trichloroethane
4J	2,6-Dinitrotoluene
4J	Bis (2-ethylhexyl) phthalate
1.8J	RDx
2.7	1,3,5-Trinitrobenzene
0.34	2,4-Dinitrotoluene
190	2,4,6-Trinitrotoluene

9SW03-001	
3J	Bis (2-ethylhexyl) phthalate

9SW07-001	
19J	Acetone
7J	Toluene
1J	Bis (2-ethylhexyl) phthalate
0.29J	2,6-Dinitrotoluene



- BOUNDARY
- DRAINAGE
- MARSH
- RAILROAD
- FENCE
- EDGE OF PAVEMENT
- STRUCTURE
- REMEDIAL INVESTIGATION SITE OR SITE SCREENING AREA (SSA)
- APPROXIMATE SITE DELINEATION

9SW/SD06 SURFACE WATER/SEDIMENT/BIOTA SAMPLE LOCATION

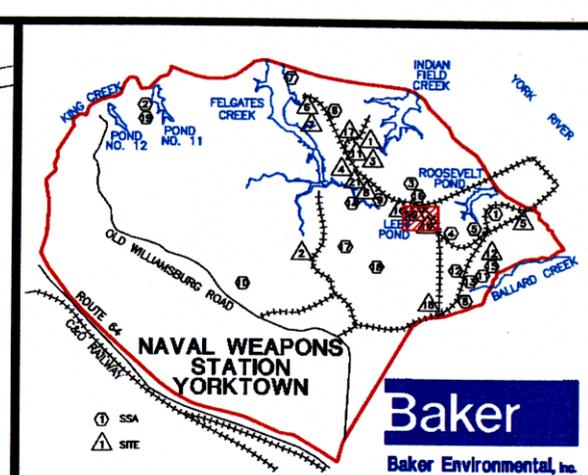
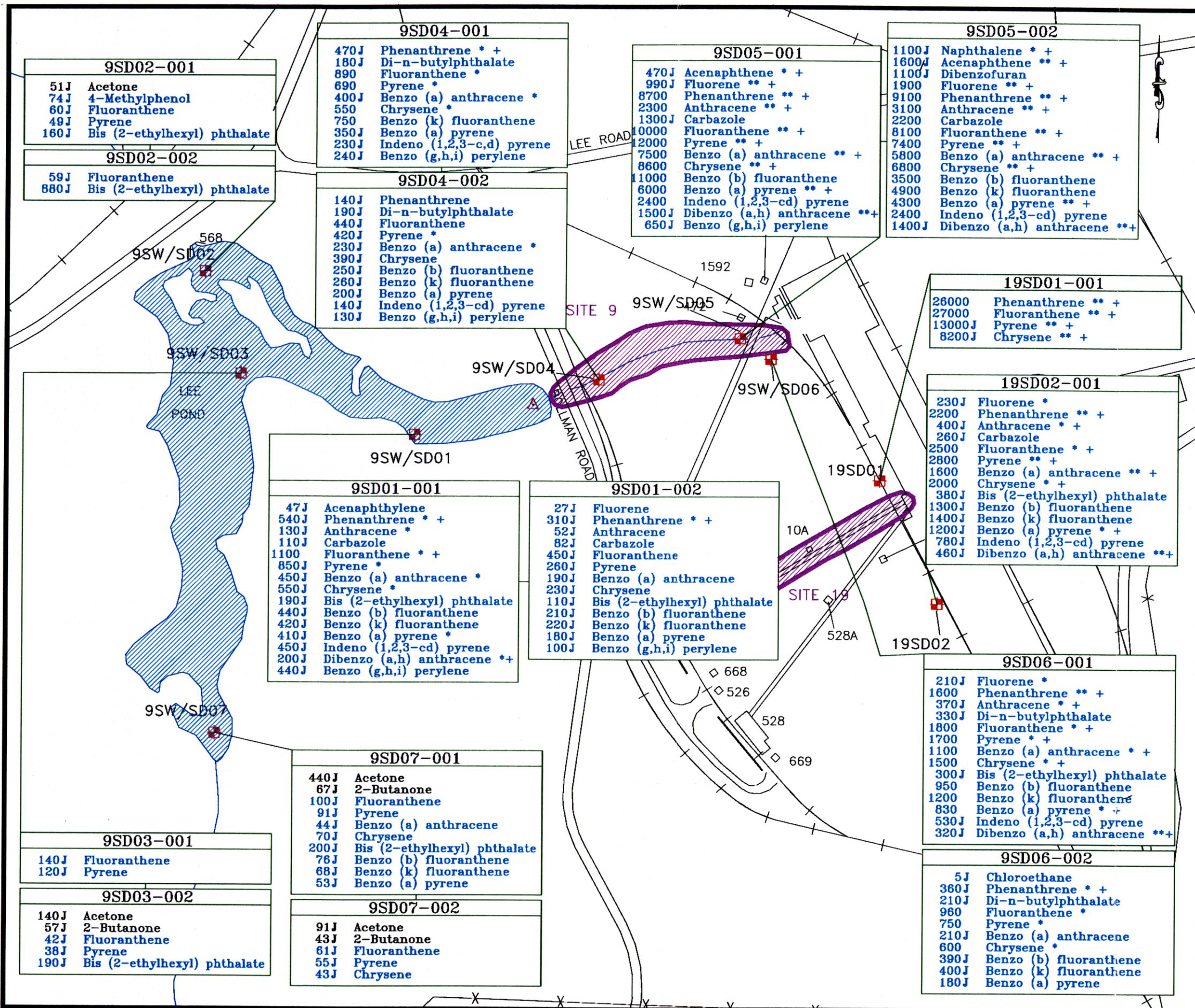
ANALYTICAL PARAMETER COLOR CODING	
55J	VOC (black)
91J	BNA (cyan)
43J	Explosive (red)

NOTE: ALL CONCENTRATIONS ARE IN ug/L

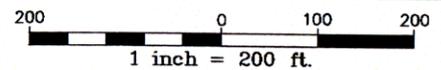
292519WP

FIGURE 1-7
SURFACE WATER SAMPLES
SITES 9 AND 19

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



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- BOUNDARY
- DRAINAGE
- MARSH
- RAILROAD
- FENCE
- EDGE OF PAVEMENT
- STRUCTURE
- REMEDIAL INVESTIGATION SITE OR SITE SCREENING AREA (SSA)
- APPROXIMATE SITE DELINEATION

19SD01 SURFACE WATER/SEDIMENT/BIOTA SAMPLE LOCATION

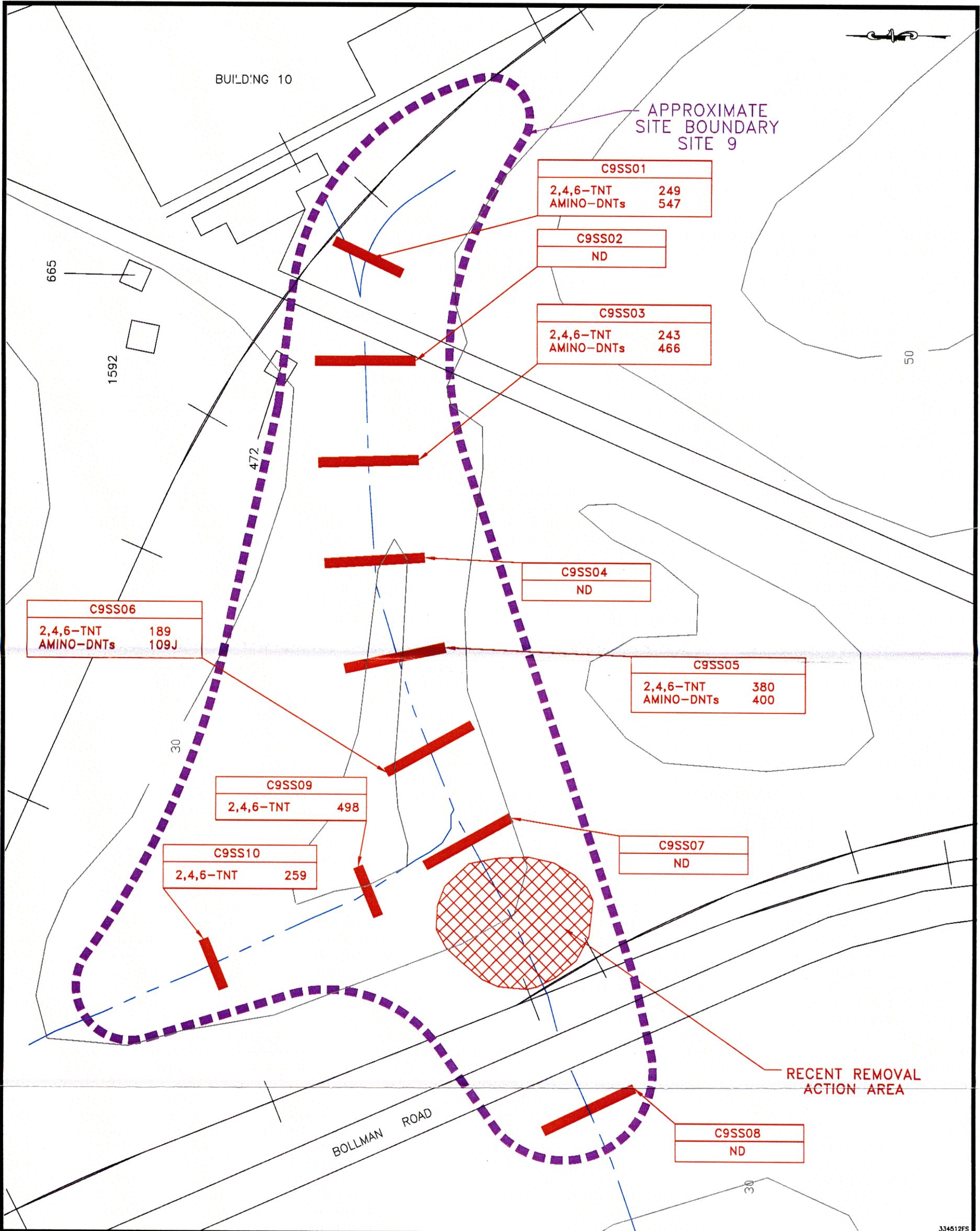
ANALYTICAL PARAMETER COLOR CODING

- 55J VOC (black)
- 91J BNA (cyan)
- 43J PCB (orange)

- + - Exceeds NOAA apparent effects threshold
- * - Meets or exceeds NOAA low effects range criteria
- ** - Meets or exceeds NOAA median effects range criteria

NOTE: ALL CONCENTRATIONS ARE IN ug/kg.

**FIGURE 1-8
SEDIMENT SAMPLES
SITES 9 AND 19**



C9SS06	
2,4,6-TNT	189
AMINO-DNTs	109J

C9SS01	
2,4,6-TNT	249
AMINO-DNTs	547

C9SS02	
ND	

C9SS03	
2,4,6-TNT	243
AMINO-DNTs	466

C9SS04	
ND	

C9SS05	
2,4,6-TNT	380
AMINO-DNTs	400

C9SS09	
2,4,6-TNT	498

C9SS10	
2,4,6-TNT	259

C9SS07	
ND	

C9SS08	
ND	

LEGEND

- BOUNDARY
- DRAINAGE
- MARSH
- RAILROAD
- FENCE
- CONTOUR LINE
- EDGE OF PAVEMENT
- STRUCTURE
- APPROXIMATE SITE DELINEATION
- APPROXIMATE SAMPLE LOCATION (COMPOSITE) DEPTH 0-12 INCHES

NOTES:

- ALL CONCENTRATIONS ARE IN ug/kg UNITS.
- ND = NOT DETECTED.



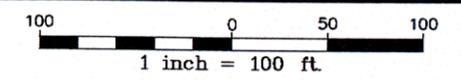
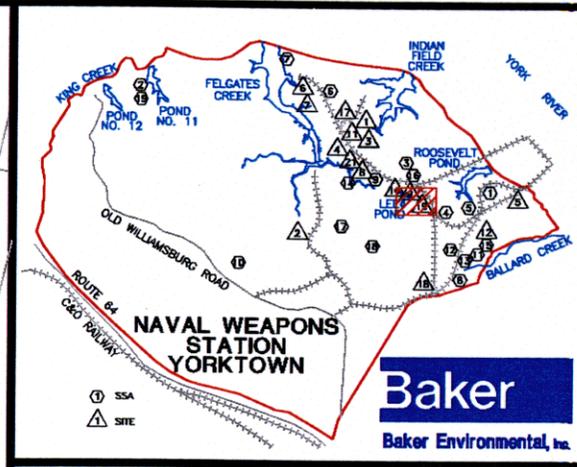
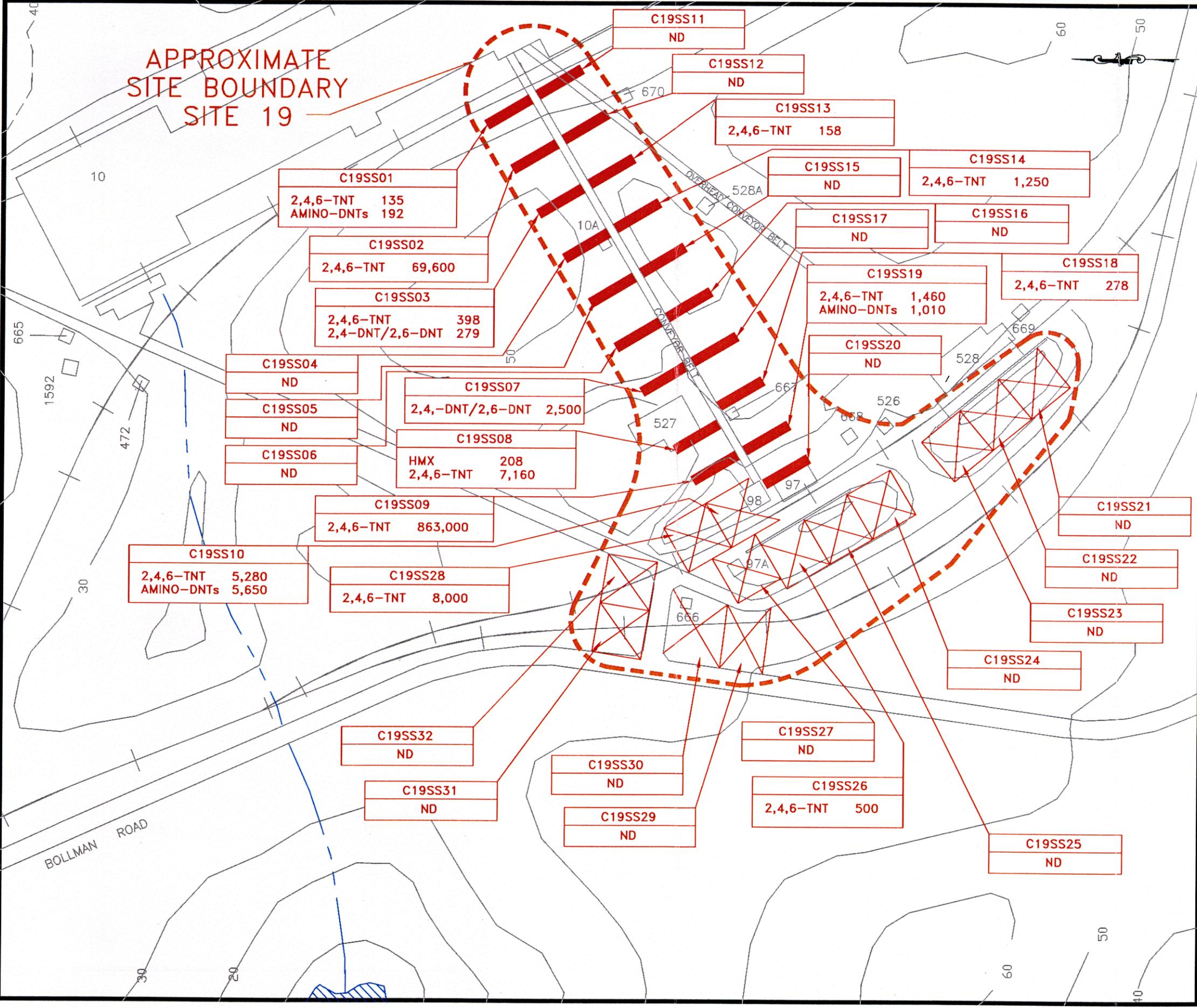
**FIGURE 1-9
SOIL CHARACTERIZATION RESULTS
SITE 9
PLANT 1 EXPLOSIVES
CONTAMINATED WASTEWATER
DISCHARGE AREA**

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

50 0 25 50
1 inch = 50 ft.

334512FS

APPROXIMATE
SITE BOUNDARY
SITE 19



LEGEND

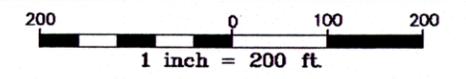
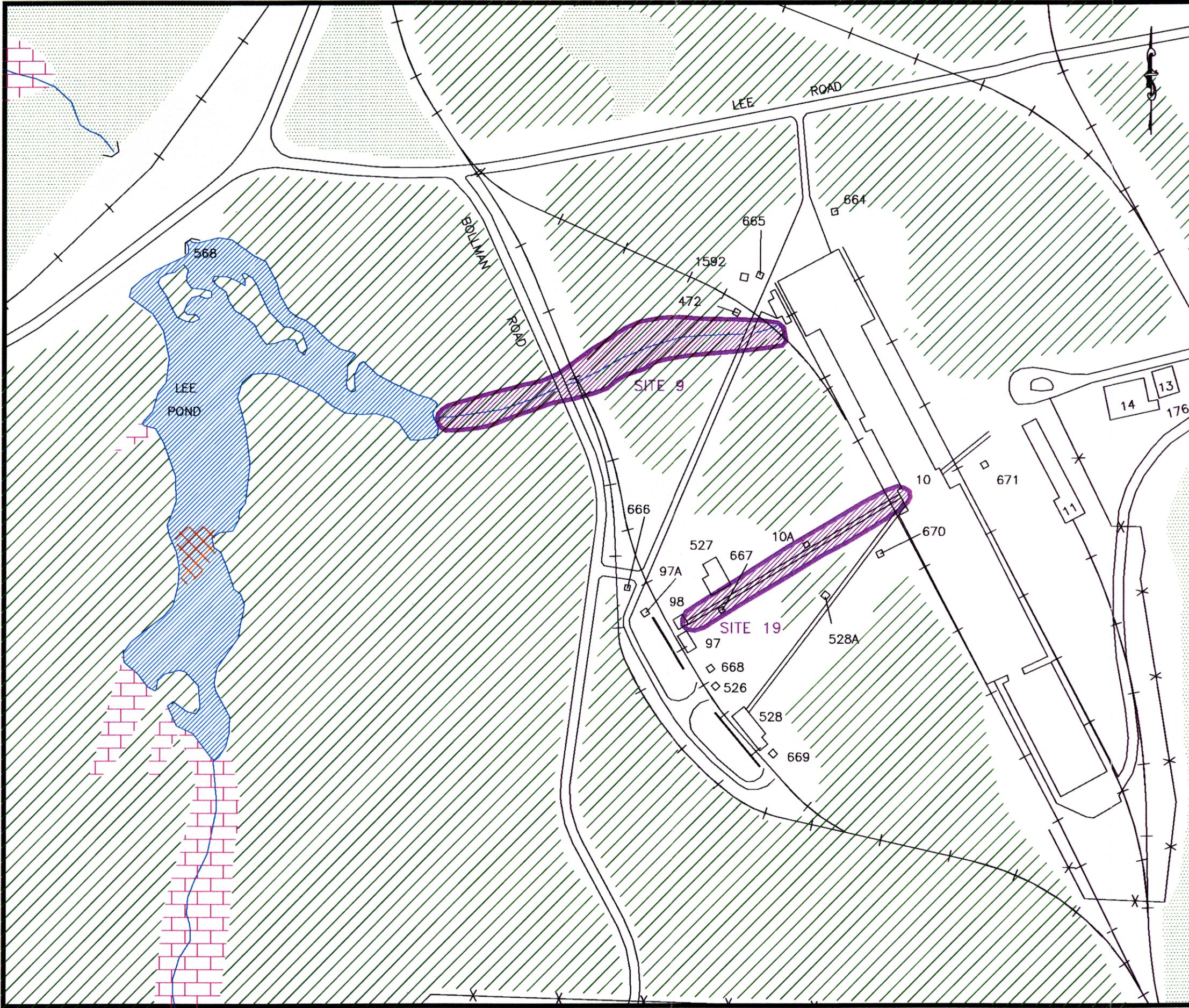
- BOUNDARY
- DRAINAGE
- MARSH
- RAILROAD
- FENCE
- 60 — CONTOUR LINE
- EDGE OF PAVEMENT
- STRUCTURE
- APPROXIMATE SITE DELINEATION
- ⊗ APPROXIMATE SAMPLE LOCATION (COMPOSITE) DEPTH 0-12 INCHES

NOTES:

- ALL CONCENTRATIONS ARE IN ug/kg UNITS.
- ND = NOT DETECTED.

FIGURE 1-10
SOIL CHARACTERIZATION RESULTS
SITE 19
CONVEYOR BELT SOILS
AT BUILDING 10

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



- | | | | |
|---|----------|---|--|
| — | BOUNDARY | — | EDGE OF PAVEMENT |
| — | DRAINAGE | □ | STRUCTURE |
| — | MARSH | ■ | REMEDIAL INVESTIGATION SITE OR SITE SCREENING AREA (SSA) |
| — | RAILROAD | ▨ | APPROXIMATE SITE DELINEATION |
| — | FENCE | | |
-
- | | |
|---|--|
| ▨ | DECIDUOUS FOREST |
| □ | OPEN/INDUSTRIAL AREA |
| ▨ | PALUSTRINE FORESTED, DECIDUOUS WETLAND |
| ▨ | PALUSTRINE, EMERGENT PERSISTANT EMERGENT WETLAND |
| ▨ | MIXED FOREST |
| ▨ | PALUSTRINE, UNCONSOLIDATED BOTTOM, PERMANENTLY FLOODED WETLAND |

208504HB

**FIGURE 1-11
BIOHABITAT MAP
SITES 9 AND 19**

2.0 STUDY AREA INVESTIGATION

This section describes the Round Two field sampling activities conducted during the RI at Sites 9 and 19. The objectives of the study, individual media investigated, sampling procedures, and sampling locations are discussed. This section also discusses Quality Control (QC) procedures conducted during the sampling as well as management of the Investigation Derived Waste (IDW).

2.1 Introduction

The Round Two field program at Sites 9 and 19 was designed to provide information necessary to characterize potential human health effects and ecological impacts resulting from previous site activities. The following subsections present the sites and RI/FS objectives that will be used in the human health and ecological Risk Assessments (RAs) for each site.

Data gathered during the Round One RI indicated potential contamination in all media sampled at Site 9 and in soil and groundwater at Site 19. However, the extent of potential contamination could not be defined. In addition, soil samples were collected from the 0- to 2-foot interval, which is no longer consistent with 0- to 6-inch soil samples used in human health risk assessments. Therefore, the field program conducted at Sites 9 and 19 was designed to further evaluate the extent of contamination in surface soil, subsurface soil and groundwater and additionally at Site 9, surface water, sediment, and biota to provide data for human health and ecological risk assessments. Objectives of the RI/FS conducted for Sites 9 and 19 are summarized in Table 2-1.

2.2 Round Two Field Sampling Program

The field investigation at Sites 9 and 19 commenced in September 1995 and continued until the beginning of October 1995. Groundwater monitoring wells were installed at Sites 9 and 19 and surface soil, subsurface soil, and groundwater samples were collected. Surface water, sediment, and biota samples were also collected at Site 9. These activities are outlined in the following subsections.

2.2.1 Soil Investigation

The soil investigation for Sites 9 and 19 included the collection of both surface and subsurface soil samples in accordance with the Final Work Plan for Sites 9 and 19 (Baker, 1995). Surface soil samples were collected with stainless-steel spoons and subsurface soil samples were collected with either a hand auger or with a drill rig during the installation of monitoring wells. A summary of the surface soil sampling program at Sites 9 and 19, including sampling locations, the sampling date, and analytical parameters is provided in Table 2-2. Table 2-3 provides similar information for subsurface soils. Surface soil sampling locations are presented in Figure 2-1.

2.2.1.1 Surface Soil Sampling

Surface (0- to 6-inch bgs) soil samples at Site 9 were collected near locations sampled during the Round One RI and in the drainage way immediately downstream of the concrete culvert running parallel to Building 10. Samples were collected in September 1995 from seven soil sampling stations (9HA01, 9HA02, 9HA03, 9HA04, 9HA05, 9HA06, and 9HA07) and from two background stations (9HA08 and 9HA09).

Surface soil samples were collected along the Site 19 conveyor belt area. Six samples were collected from the conveyor belt area (19HA01, 19HA02, 19HA03, 19HA04, 19HA05, and 19HA06); one from Buildings 98 and 527 area (19HA07); and one from the outer area surrounding the conveyor belt (19HA08). The samples were collected in September 1995.

The surface soil samples were collected using stainless-steel sampling spoons; aluminum pie pans were used to composite the soil in each individual sample. Any leaves and matted roots were removed prior to sample collection. The samples were placed in the appropriate containers and submitted for laboratory analysis. The samples were prepared according to USEPA Region III SOPs, Section 3.8 of the Final Master FSP (Baker, 1994a), and Sections 4.1.1.1, 4.1.1.2, 4.2.1.1., and 4.2.1.2 of the Final Work Plan for Sites 9 and 19 (Baker, 1995).

The analytical program for surface soil investigation is summarized in Table 2-2.

2.2.1.2 Subsurface Soil Sampling

Subsurface (deeper than 6-inches bgs) soil samples were collected to evaluate the horizontal and vertical extent of potentially impacted soil and for the RA evaluation purposes. Figure 2-2 presents subsurface soil sampling locations for Sites 9 and 19.

Subsurface soils were collected at Site 9 via hand augering at seven sampling stations (9HA01, 9HA02, 9HA03, 9HA04, 9HA05, 9HA06, and 9HA07) and from two background stations (9HA08 and 9HA09). The samples were collected at the 2- to 4-foot interval for the site-specific background stations. The other seven subsurface soil samples were collected from the 6- to 12-inch interval because groundwater was encountered at around two feet bgs in the area.

Subsurface soils at Site 19 were collected via hand augering at eight sampling stations (19HA01, 19HA02, 19HA03, 19HA04, 19HA05, 19HA06, 19HA07, and 19HA08). The samples were collected at the 2- to 4-foot interval.

Subsurface soil borings were drilled at Sites 9 and 19 to collect subsurface soil samples and install monitoring wells for groundwater sampling as presented on Figure 2-2. All soil borings, whether or not they were sampled for chemical analysis, were advanced using a split-spoon sampler and hollow-stem augers. Standard operating procedures (SOPs) for soil boring advancement and subsurface soil sampling are presented in the Final Master FSP (Baker, 1994a).

Five boreholes, shown in Figure 2-2, were advanced at Site 9. Three of the soil borings (9SB/GW01, 9SB/GW02, and 9SB/GW03) were advanced around the site to further characterize the shallow subsurface soil. Soil boring 9SB/GW01 was advanced to characterize the upgradient conditions of the shallow subsurface soil. Two soil borings (9SB/GW02A and 9SB/GW04A) were advanced to facilitate deeper monitoring well (Type III) installation and to characterize the deeper subsurface soil. Soil boring 9SB/GW04A was advanced to characterize the upgradient conditions of the deeper subsurface soil. During advancement of soil boring 9SB/GW04A, thin-walled open (shelby) tube sample was collected in the low hydraulic conductivity zone (Yorktown confining unit) where the surface casing was set. The shelby tube sample was collected according to American Society for Testing and Materials (ASTM) Method D1587- 83(04.08) (ASTM, 1983) and analyzed for vertical hydraulic conductivity and grain size (sieve and hydrometer).

Six boreholes, shown in Figure 2-2, were advanced at Site 19. Three of the soil borings (19SB/GW04, 19SB/GW05, and 19SB/GW06) were advanced around the site to further characterize the shallow subsurface soil. 19SB/GW03A was advanced to facilitate deeper monitoring well (Type III) installation and to characterize the deeper subsurface soil. 19SB01 was advanced to characterize the upgradient subsurface conditions and to determine the site lithology for Sites 9 and 19. 19SB/HP07 was advanced to complete two HydroPunches™ within the surficial unconfined aquifer and the deeper confined aquifer.

From each of these borings, three subsurface soil samples were collected; one sample from the upper one to two feet, one from just about the top of the water table, and one from the midpoint between these two locations. The sampling protocols are described in Section 3.9 of the Final Master FSP (Baker, 1994a) and Sections 4.1.1.3 and 4.2.1.3 of the Final Work Plan for Sites 9 and 19 (Baker, 1995).

Samples collected during advancement of Type II monitoring wells were collected at continuous 2-foot intervals until a confining unit was encountered. Type III monitoring wells were advanced using a combination of hollow-stem auger and rotary drilling techniques (when applicable). The rotary drilling was only utilized to install the surface casing, and not to install the monitoring well or to drill the soil boring. Samples collected in the zone of the surface casing were obtained in the same manner as the Type II monitoring well installation. Samples collected during the installation of the monitoring well after the surface casing was installed were collected (via hollow stem augers and split-spoon sampling) from the bottom of the surface casing at continuous 2-foot intervals 15-feet into the saturated soil for the underlying aquifer. Soil cuttings and drilling water generated during the drilling program (i.e., IDW) were containerized and handled according to the procedures outlined in Section 2.8.

Each split-spoon was classified visually by the on-site geologist. Lithological descriptions of site soil are provided on the Test Boring Records and Well Construction Records in Appendix C. Specific sampling and soil classification procedures are outlined in Sections 4.1.1 and 4.2.1 of the Final Work Plan for Sites 9 and 19 (Baker, 1995) and Section 3.9 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.1.3 Field Screening and Air Monitoring

Several air monitoring and field screening procedures were implemented during drilling and sampling activities for health and safety and initial contaminant monitoring. Data obtained in the field were recorded in a field logbook and PID measurements are provided on the Test Boring Records and Well Construction Records in Appendix C. Specific screening and monitoring requirements are outlined in the Final Work Plan for Sites 9 and 19, Health and Safety Plan Addendum (Baker, 1995) and the Final Master HASP (Baker, 1994b) for WPNSTA Yorktown.

2.2.2 **Groundwater Investigation**

The Round Two RI groundwater sampling program developed for Sites 9 and 19 was designed to determine if former site activities adversely impacted the quality of groundwater. Moreover, the program was developed to consider potential human health and ecological risks associated with the Contaminants of Potential Concern (COPCs).

In general, the field procedures and sampling methods employed for the groundwater investigation were implemented in accordance with USEPA Region III SOPs. These procedures also included sample handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in Sections 4.1.2.3 and 4.2.2.4 of the Final Work Plan for Sites 9 and 19 (Baker, 1995) and Sections 3.14 and 3.15 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.2.1 Monitoring Well Installation

As mentioned in Section 2.2.1.2, two types of monitoring wells were installed during this field program, Type II (shallow, no surface casing) and Type III (deep, surface casing) monitoring wells. Each type is briefly described in the following subsections; additional detail is located in Section 4.1.2. of the Final Work Plan for Sites 9 and 19 (Baker, 1995). Refer to Section 3.3 for a discussion of aquifers.

2.2.2.1.1 Shallow Wells

Three shallow Type II monitoring wells (9SB/GW01, 9SB/GW02, and 9SB/GW03) were installed at Site 9, and three shallow monitoring wells (19GW04, 19GW05, and 19GW06) were installed at Site 19, at the locations shown on Figure 2-2. A perched groundwater unit was not encountered when installing these wells; therefore, surface casing was not required. The monitoring well depths at Site 9 ranged from 17- to 25-feet bgs, while at Site 19 depths ranged from 20- to 30-feet bgs.

Well construction details for the existing and newly installed shallow wells are summarized in Table 2-4 and are shown on the Well Construction Records provided in Appendix C. Typical shallow monitoring well construction details are shown on Figure 2-3 for above ground completion. Specific monitoring well installation procedures are outlined in Sections 4.1.2 and 4.2.2 of the Final Work Plan for Sites 9 and 19 (Baker, 1995) and Sections 3.10 and 3.11 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.2.1.2 Deep Wells

Type III (i.e., outer casing installed) deep monitoring wells were installed where a significant volume of perched groundwater was encountered or where significant volumes of perched groundwater might accumulate. These wells were installed using a combination of hollow stem auger and rotary drilling techniques (when required). The rotary drilling techniques only were used for reaming to install the stainless steel surface casing and were not used to install the monitoring well or to drill the soil boring.

Two deep monitoring wells (9GW02A and 9GW04A) were installed at Site 9, and well depths ranged from 60- to 70-feet bgs. One deep monitoring well (19GW03A) was installed at Site 19 at 60-feet bgs. Well construction details for the newly installed deep wells are summarized on Table 2-4 and are shown on the Well Construction Records provided in Appendix C. The steel surface casing was installed a minimum of two feet into the Yorktown confining unit to insure a proper seal between strata. This seal will mitigate the potential downward migration of perched groundwater along the borehole/well interface. The surface casing was grouted in place and allowed to set overnight. The borehole was then advanced through the 10-inch casing and the well was completed in the underlying Yorktown-Eastover aquifer. Subsequent monitoring well installation

and construction procedures were the same as those employed for the shallow monitoring wells except that a bentonite slurry was placed above the sand pack in place of the bentonite pellets. The top of the sand pack remained at least two feet below the bottom of the confining unit. Typical Type III monitoring well construction details are shown on Figure 2-4 for above ground completion.

2.2.2.2 Well Development

Following well construction and curing of the bentonite and grout seals (i.e., 48 hours or more), each newly installed well was developed to remove fine-grained sediment from the screen and to establish interconnection between the well and the formation. The monitoring wells were developed by a combination of surging and bailing (with disposable polyethylene bailers) or pumping (Waterra or centrifugal pumps). All equipment (i.e., bailers and polyethylene tubing) inserted down the monitoring wells was dedicated to that specific monitoring well and discarded following use. Specific well development procedures are outlined in Section 3.12 of the Final Master FSP (Baker, 1994a) and in Section 4.1.2.2 of the Final Work Plan for Sites 9 and 19 (Baker, 1995).

Measurements of pH, specific conductance, temperature, and turbidity were recorded to assist in determining well stabilization. Well Development Forms summarizing this information are provided in Appendix D.

2.2.2.3 Groundwater Sampling

The following subsections describe the groundwater sampling procedures, including the HydroPunch™ sampling, and the analytical requirements for the groundwater samples collected. Groundwater sampling took place a minimum of seven days after the completion of well development. The samples were collected to confirm the presence or absence of contaminants and evaluate overall groundwater chemistry. Groundwater samples were collected from the five newly installed monitoring wells at Site 9, and the four newly installed and three existing monitoring wells at Site 19, between September 6 and October 5, 1995. Figure 2-2 shows the well locations. Groundwater sampling procedures, discussed below, were performed in accordance with USEPA Region III SOPs.

2.2.2.3.1 Procedures

Prior to groundwater purging, water levels from each well were measured and the borehole volumes were calculated according to section 4.1.2.2 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown. Following well volume calculations, a minimum of three to five well volumes were purged from each well prior to sampling. Water was purged from each well using either a disposable polyethylene bailer or a low flow pump. Purge water was containerized and handled as described in Section 2.5 of this report. Section 4.2.2.4 of the Final Work Plan for Sites 9 and 19 (Baker, 1995) outlines the protocol for purging wells.

Groundwater samples were collected using either disposable polyethylene bailers dedicated to each monitoring well or a low flow pump with dedicated tubing. The samples were introduced into laboratory-prepared and certified, preserved sample containers and stored on ice. Sample bottles for the VOC analysis were filled first, followed by SVOCs, nitramine compounds, TAL inorganics (total and dissolved), cyanide, nitrate/nitrite, total dissolved solids (TDS), and total suspended solids (TSS). Samples analyzed for dissolved inorganics were collected in laboratory-prepared and certified bottles and filtered prior to placement in preserved bottles for shipment to the laboratory. The samples were filtered in the field through a disposable 0.45 micron membrane. A peristaltic pump was used for the filtering procedure.

Preparation of groundwater samples incorporated procedures similar to those described for the other samples. Sample collection information, including well number, sample identification number, time, date, samplers, and analytical parameters, was recorded in the field logbook and on the sample labels. Chain-of-custody documentation accompanied the samples to the laboratory. Specific sampling procedures are outlined in Section 4.1.2.3 for Site 9 in the Final Work Plan for Sites 9 and 19 (Baker, 1995) and Section 3.15 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown. The analytical program for the groundwater investigation is summarized in Table 2-5.

2.2.2.3.2 Temporary Monitoring Well/HydroPunch™ Installation and Sampling

Groundwater sampling activities via temporary monitoring well/HydroPunch™ at Site 19 occurred in September 1995. One temporary monitoring well and HydroPunch™ was installed to collect

groundwater samples at one location without the installation, development, and materials cost of a monitoring well. The HydroPunch™ location is shown on Figure 2-2.

The soil borings were advanced with a hollow-stem auger as described in Section 2.2.1 to at least five feet below the top of the water table and the drill rods were removed. The temporary monitoring well was utilized to speed sample collection within the surficial aquifer (water table). This method involved installing a 2-inch outside diameter (OD), polyvinyl chloride (PVC), five-foot screen and a riser into the boring from a point at least five feet below the top of the water table to above the ground surface. A dedicated bailer was used to collect the groundwater sample. A minimum of two liters of sample volume was collected.

The HydroPunch™ technique used at Site 19 involved hydraulically pushing the HydroPunch™ sampler to the zone of interest (approximately four feet into the confined Yorktown-Eastover Aquifer). The cover of the HydroPunch™ was then retracted, allowing water to flow into the device. A "mini" bailer was used to retrieve the volume required for analysis. Specific sampling procedures are outlined in Section 4.2.2 for Site 19 Final Work Plan for Sites 9 and 19 (Baker, 1995) and Section 3.14 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

The analytical program for the HydroPunch™/temporary monitoring well groundwater investigation is summarized in Table 2-5.

2.2.2.4 Water Level Measurements and Surveying

Static water level measurements were collected twice during the field investigation from top-of-casing (TOC) reference points at each newly installed well, once they were developed, and existing wells. Water level data was used to evaluate groundwater flow patterns (i.e., horizontal hydraulic gradient) at the site. Measurements were recorded using an electric measuring tape to the nearest 0.01-foot. The water level measurements were collected on September 14, 1995 and October 6, 1995 and are presented in Table 2-6.

After drilling was completed, all on-site monitoring wells were surveyed to establish vertical elevation in relation to mean sea level (msl) and horizontal control. Vertical accuracy of each well (established to TOC at each well) was measured to 0.01 feet and horizontal accuracy to within

0.01 foot. Control was established by using horizontal and vertical control points near the site that are tied into the Virginia State Plan Coordinate System. A registered surveyor in Virginia (Patton, Harris, Rust, and Associates, P.E.) was retained to perform the survey. Specific procedures are outlined in Section 4.3.1 of the Final Work Plan for Sites 9 and 19 (Baker, 1995) and Sections 3.17 and 3.21 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.2.5 In situ Hydraulic Conductivity Testing Procedures

In situ hydraulic conductivity tests ("slug tests") were performed in three monitoring wells at Site 9 after the groundwater sampling was completed to determine aquifer hydraulic conductivity in the vicinity of the well. The tests were performed using solid PVC slugs and clean bailer rope. A pressure transducer attached to an electronic recording device (Hermit™ data logger) was used to record the test data. Two Type II monitoring wells (9GW02 and 9GW03), reflecting unconfined conditions, and one Type III monitoring well (9GW02A), reflecting confined conditions, were chosen for in situ hydraulic conductivity testing at Site 9. The selected wells varied lithologically within the screened section. The slug test data are presented in Appendix E, and are discussed in Section 3.3.2, Site Hydrogeology. Specific testing procedures are outlined in Section 3.16 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

2.2.3 Surface Water, Sediment, and Biota Investigation

Surface water and sediment samples were collected from September 6 through September 7, 1995. A summary of the Site 9 surface water sampling program describing the sample designations, collection dates, and analytical parameters is provided in Table 2-7. A summary of the Site 9 sediment sampling program is provided in Table 2-8. Surface water and sediment locations are presented on Figure 2-5. The locations were chosen to coincide with the aquatic ecological sampling stations. Surface water and sediment field data forms are provided in Appendix F.

2.2.3.1 Surface Water

Surface water investigations were conducted at Site 9 in the drainage ditch located to the east of Lee Pond from September 6 through September 7, 1995. Data from these studies will be used to assess

potential impacts to the environment from Site 9 and used in conjunction with the biota data in the ecological RA.

Four surface water and sediment sampling stations were identified to characterize the drainage way to Lee Pond (Figure 2-5). These sample locations were chosen to coincide with the aquatic ecological sampling described in Section 2.2.3.2. Sample locations 9SW/SD08, 9SW/SD09, 9SW/SD10, and 9SW/SD11 were selected to address the conditions of the drainage way from Site 9. Location 9SW/SD11 also coincided with Round One RI location 9SW01 where additional sampling was recommended. Surface water was not present at 9SW/SD10 and, therefore, could not be collected.

One surface water sample was collected from midstream at each sampling location. The samples were collected as described in Section 3.7.1 of the Master FSP and Section 4.1.3 of the Final Work Plan for Sites 9 and 19 (Baker 1995), and USEPA Region III SOPs.

Surface water samples were filtered in the field through a disposable 0.45 micron membrane. A peristaltic pump was used for the filtering procedure. Sample preparation also included documentation of sample number, location, date, and time in a field logbook and on the sample labels. Chain-of-custody documentation accompanied the samples to the laboratory. Specific sampling procedures are outlined in Section 4.1.3 of the Final Work Plan for Sites 9 and 19 (Baker, 1995) and Section 3.7.1 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

Table 2-7 summarizes the environmental samples collected and analytical parameters for the surface water samples. In addition, analyses for temperature, dissolved oxygen, salinity, specific conductivity, and turbidity (by Secchi disk) were performed on surface water samples in the field. The procedures for performing these measurements can be found in the Master FSP, Section 3.29 (Baker, 1994a).

2.2.3.2 Sediment

Sediment sampling was conducted from September 6, through September 7, 1995 at the four surface water/sediment sampling stations. A summary of the sediment sampling program, outlining the

sample identification, collection date, sample interval, and analytical methods is provided in Table 2-8.

Surface (0- to 4-inches) and subsurface (4- to 8-inches) sediment samples were collected for chemical analysis at all four sediment sampling locations. The sediment samples were collected with a sediment sleeve. The coring sleeve was pushed into the sediment to a depth of 12 inches or until refusal. The sediment samples were extruded with a decontaminated extruder into a laboratory-supplied and certified sampling bottle.

Sediment samples were prepared according to USEPA Region III SOPs. Following sample collection, each sample was stored on ice in a cooler. Sample preparation also included documentation of sample number, location, date, and time in a field logbook and on the sample labels. COC documentation accompanied the samples to the laboratory. Specific sampling procedures are outlined in Section 4.5.3 of the Final Work Plan (Baker, 1994) and in Section 3.7 of the Final Master FSP (Baker 1994a) for WPNSTA Yorktown.

Table 2-8 summarizes the environmental samples collected and analytical parameters for these samples. The procedures for performing these measurements can be found in the Master FSP, Section 3.29 (Baker, 1994a).

2.2.3.3 Biota Investigation

Aquatic ecological investigations were conducted at the four surface water/sediment locations as shown in Figure 2-5. In general, the field procedures and sampling methods employed for the biota investigation were implemented in accordance with USEPA Region III SOPs. These procedures also included sample handling and preservation and documentation procedures. Specific sampling procedures are outlined in Section 4.1.4 for Site 9 of the Final Work Plan for Sites 9 and 19 (Baker, 1995) and Section 3.18 of the Final Master FSP (Baker, 1994a) for WPNSTA Yorktown.

The following subsections pertain to the fish population sampling and benthic macroinvertebrate sampling procedures.

2.2.3.3.1 Fish

A fish survey was attempted at Site 9 using hoop nets. No species were collected; however, mosquito fish were observed.

2.2.3.3.2 Benthics

The benthic macroinvertebrate samples were collected by using a petite Ponar bottom grab sampler. As recommended in the Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (USEPA, 1990), three replicate grab samples were collected at three of the four sampling stations (9SW15D08, 9SW15009, 9SW15011). No water was present at station 9SW15D10 and a sample was not collected. Specific sampling procedures are outlined in Section 4.1.3 of the Final Work Plan for Sites 9 and 19 (Baker 1995) and Section 3.18 of the Final Master FSP (Baker 1994a) for WPNSTA Yorktown.

2.3 Quality Assurance/Quality Control Sampling Procedures

Field QA/QC samples were collected during the sampling program. These samples were obtained to: (1) ensure that decontamination procedures were properly implemented (i.e., equipment rinsate blanks); (2) evaluate field methodology (i.e., duplicate samples); (3) establish field background conditions (i.e., field blanks); and (4) evaluate whether cross-contamination occurred during sampling and/or shipping (i.e., trip blanks).

Several types of field QA/QC samples were collected and analyzed. These QA/QC samples are defined below.

- Duplicate Sample (D): Two samples collected simultaneously into separate containers from the same source under identical conditions. One duplicate sample was collected for every 10 environmental samples (10 percent) collected for each media type.
- Equipment Rinsate Blank (RB): Sample obtained by running laboratory grade deionized water over/through sample collection equipment after the piece of

equipment was decontaminated. These samples are used to determine if decontamination procedures are adequate. One sample was collected per day per different type of sampling equipment.

- **Field Blank (FB)**: Sample obtained from each water source utilized during the field program. The water sources used during the field program included: laboratory grade deionized water utilized to collect rinsate blanks; store-bought distilled water utilized for decontamination; and potable water from each drill rig collected from the discharge point before the water would be used within the well installation process. One sample from each source was collected each month.
- **Trip Blank (TB)**: Trip blanks are prepared at the laboratory, shipped with the sample containers, and kept with the investigative samples throughout the sampling event. The trip blanks are then packaged for shipment with the other VOC samples and sent for analysis. At no time after their preparation were the trip blank sample containers opened before they reached the laboratory. At least one trip blank per shipping cooler containing VOC samples was sent to the laboratory for VOC analysis.

In addition to samples collected to monitor field quality control, samples are used to monitor quality within the laboratory. These include the following:

- **Matrix Spike**: Aliquot of a matrix, either soil or water, that is spiked with known quantities of specific compounds and subjected to the entire analytical procedure. By measuring recovery, the appropriateness of the method for the matrix can be determined.
- **Matrix Spike Duplicate**: A second aliquot of the same matrix as the matrix spike to determine the precision of the method.

A complete discussion of the QA/QC procedures can be found in Section 8.0 of the Master Quality Assurance Project Plan (QAPP) (Baker, 1994c). The QA/QC Sampling Program for soil is outlined

in Table 2-9; for groundwater in Table 2-10; for surface water on Table 2-11; for sediment in Table 2-12; and for all media in Table 2-13.

2.4 Decontamination Procedures

Decontamination procedures for heavy equipment (i.e., drilling augers), personnel, and sampling equipment were followed as per Section 3.25 of the Final FSP (Baker 1994a) for WPNSTA Yorktown. For sampling equipment, the decontamination procedures included a soap and water wash with liquinox; rinse with deionized water; rinse with nitric acid; rinse with deionized water; and a final rinse with methanol before air drying. Heavy equipment decontamination included steam cleaning on a decontamination pad. Decontamination fluids were handled as outlined in Section 2.5 of this report.

2.5 Investigation Derived Waste Management

Solid (approximately 8 cubic yards) and liquid (approximately 800 gallons) IDW was generated during the field program. Solids included soil cuttings and excess split-spoon samples; liquids included well development and purge water and decontamination fluids (i.e., water, liquinox soap solution, methanol, and 5 percent nitric acid solution).

Containerization and handling of solids were performed in two phases. At the completion of drilling, soil was temporarily placed into a backhoe bucket, then transported and emptied into the roll-off box for final containerization. Composite samples were collected from the roll-off box for full TCLP and Resource Conservation and Recovery Act (RCRA) hazardous waste characteristic analysis.

Liquids generated during the field program also were containerized and handled in two phases. Initially, development and purge water from each well and the heavy equipment decontamination water were placed in 55-gallon steel drums, then pumped into a tanker for final containerization. Decontamination water containing acids and solvents used for cleaning small sampling equipment was also pumped into the tanker for final containerization.

Items of personal protective equipment (PPE), such as disposable gloves, Tyvek, and disposable bailers were decontaminated, if appropriate, and double bagged in plastic bags and placed in the trash dumpster at Baker's Field Trailer. Specific procedures for decontamination are outlined in Section 4.6.2 of the Final Work Plan for Sites 6, 7, 12, 16 SSA 16, and Background (Baker, 1994) and Section 3.26 of the Final Master FSP (Baker, 1994) for WPNSTA Yorktown.

2.6 References

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SECTION 2.0 TABLES

TABLE 2-1

**RI/FS OBJECTIVES
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Site and Medium of Concern	RI/FS Objective	Criteria for Meeting Objective	Investigation/Study
Sites 9 and 19 Soil	Assess potential impacts to soil from past operations.	Determine contaminant levels in surface and subsurface soil.	Soil investigation
	Assess human health and ecological risks associated with exposure to surface soil.	Determine contaminant levels in surface and subsurface soil.	Soil investigation Risk assessment
	Assess areas of surface soil contamination resulting from site run-off.	Determine contaminant levels in surface soil at downgradient drainage areas.	Soil investigation
Sites 9 and 19 Groundwater	Assess health risks posed by future usage of the shallow groundwater near Sites 9 and 19.	Evaluate groundwater quality and compare to regulatory criteria and health based action levels.	Groundwater investigation Risk assessment
	Define vertical and horizontal extent of groundwater contamination.	Characterize on-site groundwater quality in shallow and deeper portions of the aquifer.	Groundwater investigation
	Assess potential impact to groundwater from contaminated soil.	Characterize on-site groundwater quality.	Soil investigation Groundwater investigation
	Define hydrogeologic characteristics for fate and transport evaluations and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, permeability).	Groundwater investigation
Sites 9 and 19 Surface Water	Assess the presence or absence of surface water contamination in drainage ditches.	Determine surface water quality along drainage ditches.	Surface water investigation

TABLE 2-1 (Continued)

RI/FS OBJECTIVES
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site and Medium of Concern	RI/FS Objective	Criteria for Meeting Objective	Investigation/Study
Sites 9 and 19 Sediment	Assess human health and ecological risks associated with exposure to contaminated sediment.	Characterize nature and extent of sediment contamination in drainage ditches.	Sediment investigation Risk assessment Biota Investigation
	Determine the extent of sediment contamination for purposes of identifying areas of remediation.	Identify extent of sediment contamination where levels exceed health based action levels.	Sediment investigation

TABLE 2-2

SUMMARY OF THE ROUND TWO RI SURFACE SOIL SAMPLING PROGRAM
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Site	Sample Identification	Sampe Interval (bgs)	Collection Date	Analytical Parameters
Site 9	9HA01-00	0-6"	9/10/95	TCL Volatile Organics, TCL Semivolatile Organics, Nitramine Compounds, TAL Inorganics, Pesticides/PCBs, pH
	9HA01-00D*	0-6"	9/10/95	
	9HA01-01	6-12"	9/10/95	
	9HA02-00	0-6"	9/10/95	
	9HA02-01	6-12"	9/10/95	
	9HA03-00	0-6"	9/10/95	
	9HA03-01	6-12"	9/10/95	
	9HA04-00	0-6"	9/10/95	
	9H04-01	6-12"	9/10/95	
	9HA05-00	0-6"	9/10/95	
	9HA05-01	6-12"	9/10/95	
	9HA05-01D*	6-12"	9/10/95	
	9HA06-00	0-6"	9/10/95	
	9HA06-01	6-12"	9/10/95	
	9HA07-00	0-6"	9/10/95	
	9HA07-01	6-12"	9/10/95	
	9HA08-00	0-6"	9/7/95	
	9HA08-00D*	0-6"	9/7/95	
	9HA08-02	2-4'	9/7/95	
	9HA09-00	0-6"	9/8/95	
9HA09-02	2-4'	9/8/95		

TABLE 2-2 (Continued)

SUMMARY OF THE ROUND TWO RI SURFACE SOIL SAMPLING PROGRAM
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Site	Sample Identification	Sampe Interval (bgs)	Collection Date	Analytical Parameters
Site 19	19HA01-00	0-6"	9/8/95	TCL Volatile Organics, TCL Semivolatile Organics, Nitramine Compounds, TAL Inorganics, Pesticides/PCBs, pH
	19HA01-00D*	0-6"	9/8/95	
	19HA01-02	2-4'	9/8/95	
	19HA-02-00	0-6"	9/8/95	
	19HA-02-02	2-4'	9/8/95	
	19HA03-00	0-6"	9/9/95	
	19HA03-02	2-4'	9/9/95	
	19HA04-00	0-6"	9/9/95	
	19HA04-02	2-4'	9/9/95	
	19HA05-00	0-6"	9/9/95	
	19HA05-02	2-4'	9/9/95	
	19HA05-02D*	2-4'	9/9/95	
	19HA06-00	0-6"	9/9/95	
	19HA06-02	2-4'	9/9/95	
	19HA07-00	0-6"	9/9/95	
	19HA07-02	2-4'	9/9/95	
	19HA08-00	0-6"	9/9/95	
	19HA08-02	2-4'	9/9/95	
19HA09-00	0-6"	9/8/95		
19HA09-00D*	0-6"	9/8/95		
19HA09-02	2-4'	9/8/95		

Notes:

- bgs - Below ground surface
- * - Indicates duplicate sample
- TAL - Target Analyte List
- TCL - Target Compound List
- ▨ - Indicates background sample

TABLE 2-3

SUMMARY OF THE ROUND TWO RI SUBSURFACE SOIL SAMPLING PROGRAM
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Sample Interval (feet, bgs)	Analytical Parameters
Site 9	9SB01-01	9/10/95	1-3	TCL Volatile Organics, TCL Semivolatile Organics, Nitramine Compounds, TAL Inorganics, Pesticides/PCBs, pH
	9SB01-01D*	9/10/95	1-3	
	9SB01-05	9/10/95	9-11	
	9SB01-07	9/10/95	13-15	
	9SB02-01	9/11/95	1-3	Grain size, bulk density, TOC
	9SB02-02	9/11/95	3-5	
	9SB02-03	9/11/95	5-7	Grain size, bulk density, TOC
	9SB02-05	9/11/95	9-11	Grain size, bulk density
	9SB02-11	9/11/95	21-23	
	9SB02A-16	9/11/95	31-33	Grain size, bulk density
	9SB02A-27	9/11/95	53-55	Grain size, bulk density
	9SB02B-06	9/11/95	11-13	
	9SB03-01	9/12/95	1-3	
	9SB03-04	9/12/95	7-9	
	9SB03-04D*	9/12/95	7-9	
	9SB03-06	9/12/95	11-13	
	9SB04A-01	9/10/95	1-3	Grain size, bulk density, pH
	9SB04A-03	9/10/95	5-7	
	9SB04A-05	9/10/95	9-11	
	9SB04A-09	9/10/95	17-19	
9SB04A-32	9/13/95	63-65	Grain size, bulk density	

TABLE 2-3 (Continued)

SUMMARY OF THE ROUND TWO RI SUBSURFACE SOIL SAMPLING PROGRAM
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Sample Interval (feet, bgs)	Analytical Parameters
Site 19	19SB01-01	9/8/95	1-3	Grain size, bulk density, TOC
	19SB01-01D	9/8/95	1-3	
	19SB01-07	9/8/95	13-15	
	19SB01-10	9/8/95	19-21	
	19SB01-16	9/8/95	31-33	
	19SB03A-01	9/8/95	1-3	Grain size, bulk density
	19SB03A-05	9/8/95	9-11	
	19SB03A-09	9/9/95	17-19	
	19GW03A-21	9/10/95	41-43	
	19SB04-01	9/9/95	1-3	Grain size, bulk density, pH
	19SB04-05	9/9/95	9-11	
	19SB04-07	9/9/95	13-15	
	19SB04-12	9/9/95	23-25	
	19SB05-01	9/8/95	1-3	Grain size, bulk density, pH
	19SB05-05	9/8/95	9-11	
	19SB05-05D*	9/8/95	9-11	
	19SB05-07	9/8/95	13-15	
	19SB05-08	9/8/95	15-17	
	19SB06-01	9/9/95	1-3	
	19SB06-07	9/9/95	13-15	
19SB06-10	9/9/95	19-21		
19SB07-01	9/7/95	1-3		
19SB07-08	9/6/95	15-17		
19SB07-13	9/6/95	25-27		

Notes:

- bgs - Below ground surface
- TCL - Target Compound List
- TAL - Target Analyte List
- TOC - Total Organic Carbon
- * - Indicates duplicate sample

TABLE 2-4

SUMMARY OF WELL CONSTRUCTION DETAILS
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Site	Well No.	Date Installed	Top of PVC Casing Elevation (feet, above msl)	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, bgs)	Well Depth (inches)	Screen Interval Depth (feet, bgs)	Sand Pack Interval Depth (feet, bgs)	Bentonite Interval Depth (feet, bgs)	Stick-up (feet, bgs)
Site 9	9GW01	9/10/95	37.53	35.40	17.0	17.0	6.5-16.5	4-17	2-4	2.5
	9GW02	9/11/95	33.66	31.15	23.5	23.0	11-23	11-23.5	8.5-11	2.5
	9GW02A	9/12/95	33.05	30.99	60.5	60.0	45-60	42-60.5	29-42	2.5
	9GW03	9/12/95	33.22	30.68	27.0	24.6	14-24	12-24.8	9-12	2.5
	9GW04A	9/12/95	45.19	42.84	70.0	69.5	54-69	51-70	15-51	2.5
Site 19	19GW01	6/17/92	34.46	31.70	24.0	23.5	7.5-22.5	5.50-23	3.5-5.5	2.37
	19GW02	6/18/92	46.63	44.30	26.0	25.5	10.5-25.5	8-26	6-8	1.89
	19GW03	6/17/92	35.14	32.18	29.0	20.0	5-20	4-20	2-4	3.00
	19GW03A	9/10/95	34.38	32.26	60.5	60.0	45-60	42-60	25.5-42	2.5
	19GW04	9/9/95	43.36	40.09	31.0	30.0	20-30	18-30	14-18	2.5
	19GW05	9/8/95	33.09	30.96	21.0	20.0	9.5-19.5	7.5-20	5.5-7.5	2.5
	19GW06	9/9/95	47.06	44.93	27.0	25.0	14.5-24.5	12-25	8-12	2.5

Notes:

bgs = Below ground surface

msl = Mean sea level

Horizontal positions are referenced to Virginia State Plan Coordinate System.

TABLE 2-5

SUMMARY OF HYDROPUNCH/TEMPORARY AND PERMANENT MONITORING WELL
GROUNDWATER SAMPLING PROGRAM
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Analytical Parameters
Site 9	9GW01-01	10/2-10/4/95	TCL Volatile Organics, TCL Semivolatile Organics, Nitramine Compounds, TAL Inorganics (total and dissolved), Pesticides/PCBs, Nitrate/Nitrite, TDS/TSS, pH
	9GW02A-01	10/3/95	
	9GW02-01	10/3/95	
	9GW02-01D*	10/3/95	
	9GW03-01	10/4/95	
9GW04A-01	10/5/95		
Site 19	19GW01-02	9/6/95	
	19GW01-02D*	9/6/95	
	19GW02-02	9/7/95	
	19GW03-02	9/6/95	
	19GW03A-01	10/5/95	
	19GW04-01	10/4/95	
	19GW04-01D*	10/4/95	
	19GW05-01	10/4/95	
	19GW06-01	10/4-10/5/95	
19HP07-01	9/7/95		
19HP07-02	9/7/95		

Notes:

- * - Indicates duplicate sample
- TAL - Target Analyte List
- TCL - Target Compound List
- TDS - Total dissolved solids
- TSS - Total suspended solids

TABLE 2-6

SUMMARY OF WATER LEVEL MEASUREMENTS
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Monitoring Well	Date	Static Water Level (feet below top of PVC)	Water Level Elevation (feet above msl)	Date	Static Water Level (feet below top of PVC)	Water Level Elevation (feet above msl)
9GW01	9/14/95	17.71	19.82	10/6/95	15.05	22.48
9GW02	9/14/95	16.27	17.39	10/6/95	18.52	15.14
9GW02A	9/14/95	18.46	14.59	10/6/95	15.87	17.18
9GW03	9/14/95	17.42	15.80	10/6/95	16.45	16.77
9GW04A	9/14/95	25.09	20.10	10/6/95	24.65	20.54
19GW01	9/14/95	19.31	15.15	10/6/95	18.78	15.68
19GW02	9/14/95	24.11	22.52	10/6/95	24.05	22.58
19GW03	9/14/95	20.12	15.02	10/6/95	17.69	17.45
19GW03A	9/14/95	17.07	17.31	10/6/95	16.63	17.75
19GW04	9/14/95	29.31	14.05	10/6/95	29.09	14.27
19GW05	9/14/95	17.26	15.83	10/6/95	16.80	16.29
19GW06	9/14/95	25.06	22.60	10/6/95	24.68	22.38

msl = Mean sea level

PVC = Polyvinyl Chloride (pipe)

TABLE 2-7

SUMMARY OF THE ROUND TWO RI SURFACE WATER SAMPLING PROGRAM
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Site	Sample Identification	Collection Date	Analytical Parameters
Site 9	9SW08	9/6/95	TCL Volatile Organics, TCL Semivolatile Organics, Nitramine Compounds, TAL Inorganics (total and dissolved), Pesticides/PCBs, Nitrate/Nitrite, hardness, TOC
	9SW09	9/7/95	
	9SW11	9/6/95	
	9SW11D*	9/6/95	

Notes:

- * - Indicates duplicate sample
- TAL - Target Analyte List
- TCL - Target Compound List
- TOC - Total Organic Carbon

TABLE 2-8

**SUMMARY OF THE ROUND TWO RI SEDIMENT SAMPLING PROGRAM
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Site	Sample Identification	Collection Date	Sample Interval (feet, bgs)	Analytical Parameters
Site 9	9SD08-01	9/7/95	0-4	TCL Volatile Organics, TCL Semivolatile Organics, Nitramine Compounds, TAL Inorganics, Pesticides/PCBs, pH, TOC
	9SD08-02	9/7/95	4-8	
	9SD09-01	9/7/95	0-4	Grain size, bulk density
	9SD09-02	9/7/95	4-8	Grain size, bulk density
	9SD10-01	9/7/95	0-4	Grain size, bulk density
	9SD10-02	9/7/95	4-8	Grain size, bulk density
	9SD11-01	9/6/95	0-4	Grain size, bulk density
	9SD11-01D*	9/6/95	0-4	
	9SD11-02	9/6/95	4-8	Grain size, bulk density

Notes:

- bgs - Below ground surface
- TCL - Target Compound List
- TAL - Target Analyte List
- TOC - Total Organic Carbon
- * - Indicates duplicate sample

TABLE 2-9

SUMMARY OF FIELD QA/QC SAMPLING PROGRAM
 FOR THE SOIL INVESTIGATION
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

QA/QC Samples ⁽¹⁾	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks ⁽²⁾	One per Cooler	6	TCL Volatiles
Field Blanks	One per Month ⁽³⁾	3	TCL Organics, TAL Inorganics, N/N
Equipment Rinsates	One per Day	6	TCL Organics, TAL Inorganics, N/N
Field Duplicates	10% of Sample Frequency	8	TCL Organics, TAL Inorganics, N/N, pH

Notes:

N/N - Nitramine compounds

TAL - Target Analyte List

TCL - Target Compound List

⁽¹⁾ QA/QC sample types defined in text.

⁽²⁾ Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.

⁽³⁾ Field blank collected for laboratory supplied deionized water (1), store bought distilled water (1), and truck-mounted rig (1).

TABLE 2-10

SUMMARY OF FIELD QA/QC SAMPLING PROGRAM
FOR THE GROUNDWATER INVESTIGATION
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

QA/QC Samples ⁽¹⁾	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks ⁽²⁾	One per Cooler	5	TCL Volatiles
Field Blanks	One per Month ⁽³⁾	4	TCL Organics, TAL Inorganics, (T&D), N/N, NO ₂ /NO ₃ , TDS/TSS
Equipment Rinsates	One per Day	6	TCL Organics, TAL Inorganics, (T&D), N/N, NO ₂ /NO ₃ , TDS/TSS
Field Duplicates	10% of Sample Frequency	3	TCL Organics, TAL Inorganics, (T&D), N/N, NO ₂ /NO ₃ , TDS/TSS

Notes:

- TAL - Target Analyte List
- TCL - Target Compound List
- T&D - Total and dissolved inorganics
- N/N - Nitramine compounds
- NO₂/NO₃ - Nitrate/nitrite
- TDS - Total dissolved solids
- TSS - Total suspended solids

⁽¹⁾ QA/QC sample types defined in text.

⁽²⁾ Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.

⁽³⁾ Field blank collected for laboratory supplied deionized water (2), store bought distilled water (2).

TABLE 2-11

SUMMARY OF FIELD QA/QC SAMPLING PROGRAM
FOR THE SURFACE WATER INVESTIGATIONS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

QA/QC Samples ⁽¹⁾	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks ⁽²⁾	One per Cooler	2	TCL Volatiles
Field Blanks	One per Month ⁽³⁾	2	TCL Organics, TAL Inorganics (T&D) N/N, NO ₂ /NO ₃ , Hardness, TOC ⁽⁴⁾
Equipment Rinsates	One per Day	2	TCL Organics, TAL Inorganics (T&D) N/N, NO ₂ /NO ₃ , Hardness, TOC ⁽⁴⁾
Field Duplicates	10% of Sample Frequency	1	TCL Organics, TAL Inorganics (T&D) N/N, NO ₂ /NO ₃ , Hardness, TOC ⁽⁴⁾

Notes:

- TOC - Total Organic Carbon
- TAL - Target Analyte List
- TCL - Target Compound List
- T&D - Total and dissolved inorganics
- N/N - Nitramine compounds
- NO₂/NO₃ - Nitrate/nitrite

⁽¹⁾ QA/QC sample types defined in text.

⁽²⁾ Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.

⁽³⁾ Field blank collected for laboratory supplied deionized water (1), store bought distilled water (1).

⁽⁴⁾ Hardness for surface water QA/QC only.

TABLE 2-12

**SUMMARY OF FIELD QA/QC SAMPLING PROGRAM
FOR THE SEDIMENT INVESTIGATIONS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

QA/QC Samples ⁽¹⁾	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks ⁽²⁾	One per Cooler	2	TCL Volatiles
Field Blanks	One per Month ⁽³⁾	2	TCL Organics, TAL Inorganics, Niramine Compounds, TOC
Equipment Rinsates	One per Day	2	TCL Organics, TAL Inorganics, Niramine Compounds, TOC
Field Duplicates	10% of Sample Frequency	1	TCL Organics, TAL Inorganics, Niramine Compounds, TOC

Notes:

TOC - Total Organic Carbon
 TAL - Target Analyte List
 TCL - Target Compound List

⁽¹⁾ QA/QC sample types defined in text.

⁽²⁾ Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.

⁽³⁾ Field blank collected for laboratory supplied deionized water (1), store bought distilled water (1).

⁽⁴⁾ Hardness for surface water QA/QC only.

TABLE 2-13

SUMMARY OF FIELD QA/QC SAMPLING PROGRAM
FOR ALL MEDIA
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

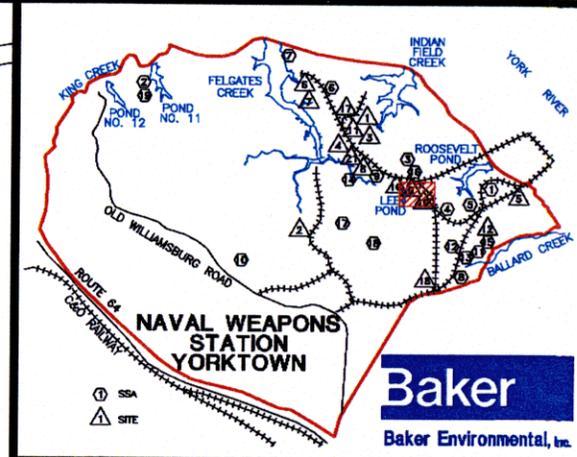
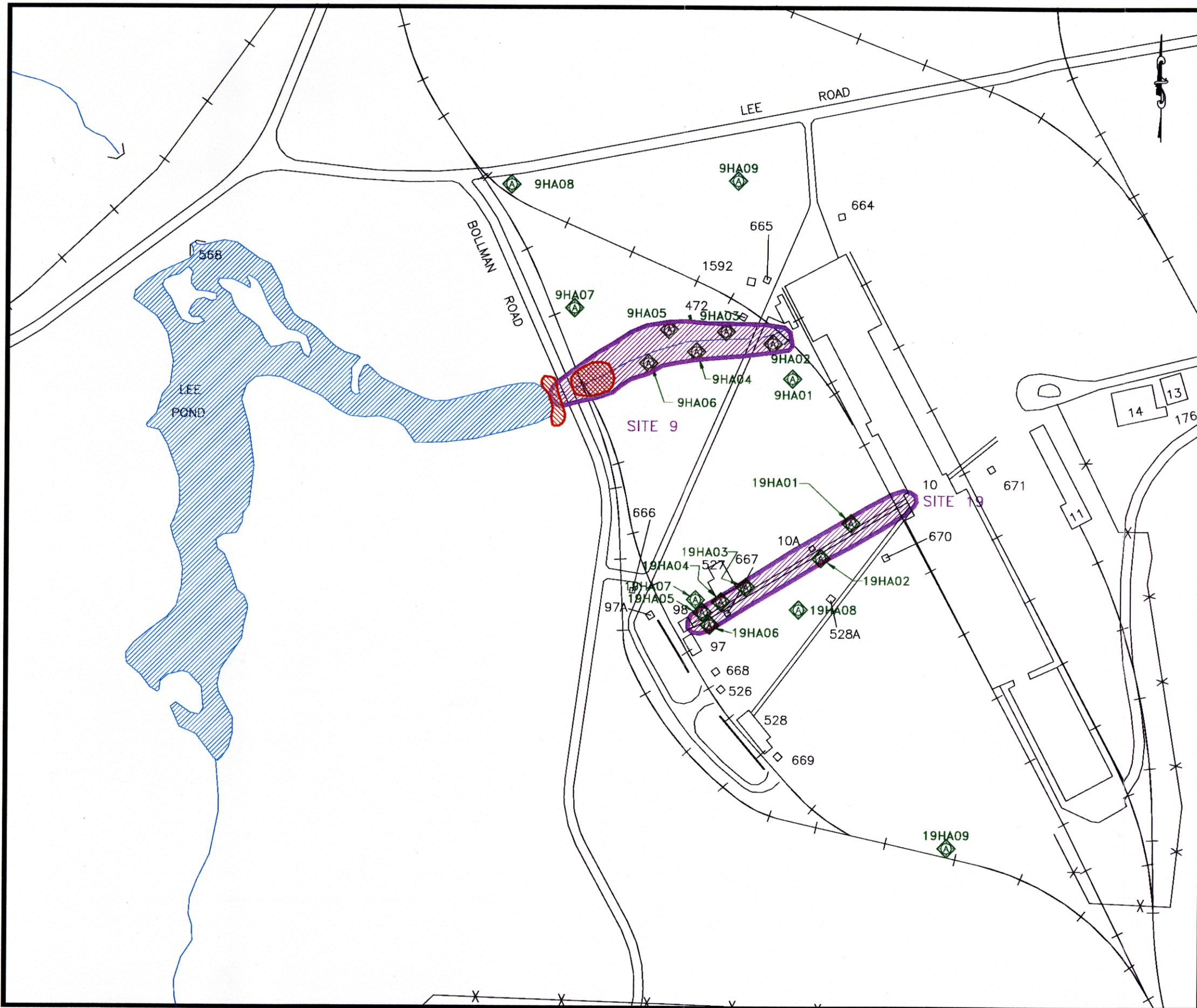
QA/QC Samples ⁽¹⁾	Frequency of Collection	Number of Samples	Analytical Parameters
Trip Blanks ⁽²⁾	One per Cooler	13	TCL Volatiles
Field Blanks	One per Month ⁽³⁾	5	TCL Organics, TAL Inorganics, (T&D) ⁽⁴⁾ N/N, NO ₂ /NO ₃ , TDS/TSS ⁽⁴⁾ , TOC
Equipment Rinsates	One per Day	15	TCL Organics, TAL Inorganics, (T&D) ⁽⁴⁾ N/N, NO ₂ /NO ₃ , TDS/TSS ⁽⁴⁾ , TOC
Field Duplicates	10% of Sample Frequency	15	TCL Organics, TAL Inorganics, (T&D) ⁽⁴⁾ N/N, NO ₂ /NO ₃ , TDS/TSS ⁽⁴⁾ , TOC

Notes:

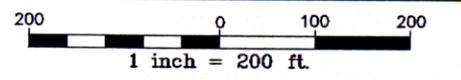
TAL - Target Analyte List
TCL - Target Compound List
TOC - Total Organic Compound
T&D - Total and dissolved inorganics
N/N - Nitramine compounds
NO₂/NO₃ - Nitrate/nitrite
TDS/TSS - Total dissolved solids/Total suspended solids

- ⁽¹⁾ QA/QC sample types defined in text.
⁽²⁾ Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL Volatiles only.
⁽³⁾ Field blank collected for laboratory supplied deionized water (2), store bought distilled water (2), and truck-mounted rig water (1).
⁽⁴⁾ Dissolved metals for water sample QA/QC only.
NO₂/NO₃ and TDS/TSS for groundwater sample QA/QC only.
Hardness for surface water sample QA/QC only.

SECTION 2.0 FIGURES



Baker
Baker Environmental, Inc.

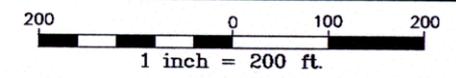
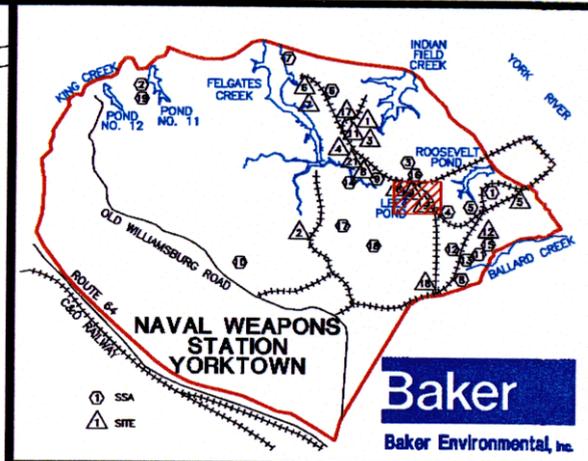
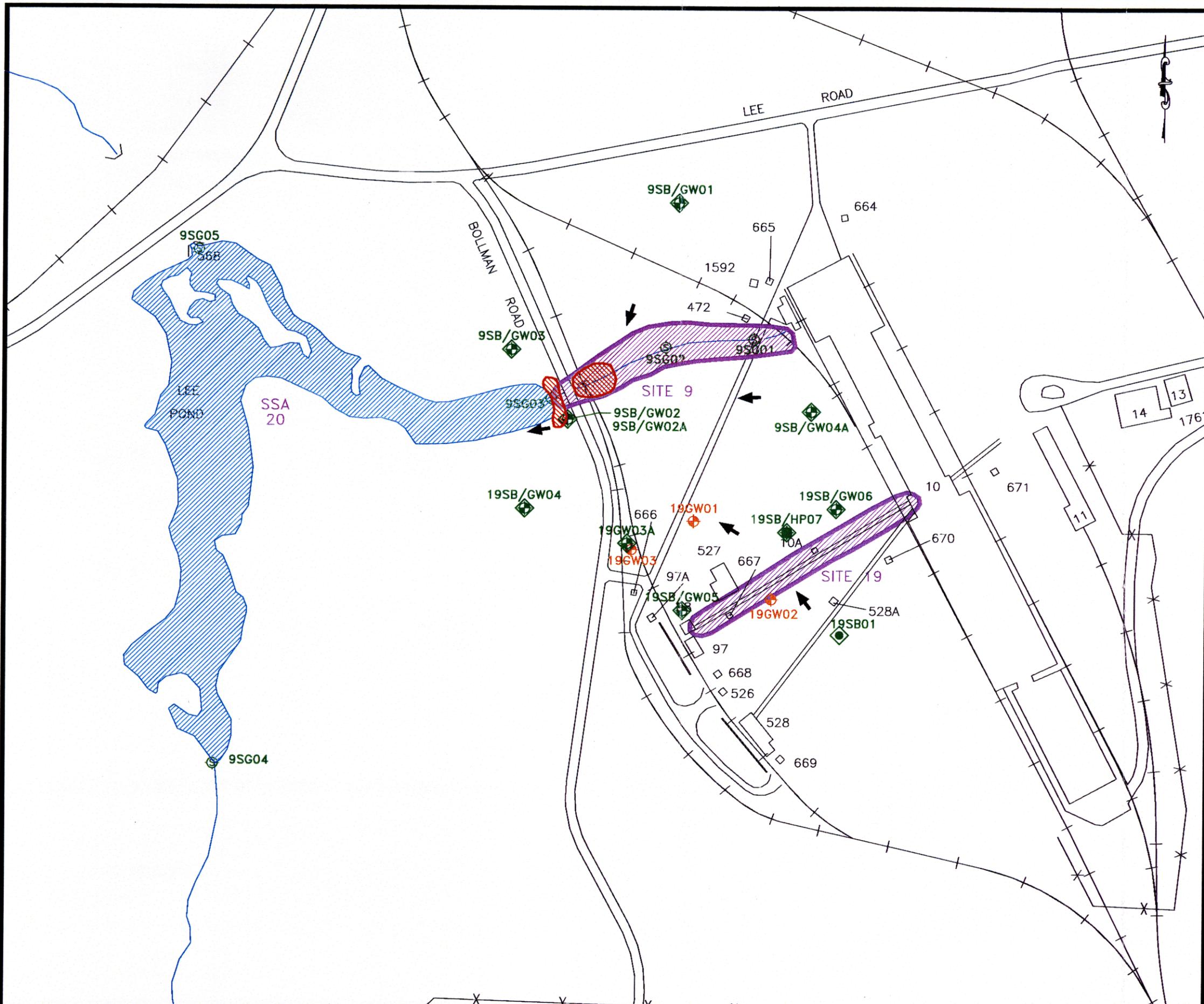


- | | | | |
|---|----------|---|--|
| — | BOUNDARY | — | EDGE OF PAVEMENT |
| — | DRAINAGE | — | STRUCTURE |
| — | MARSH | — | REMEDIAL INVESTIGATION SITE OR SITE SCREENING AREA (SSA) |
| — | RAILROAD | — | APPROXIMATE SITE DELINEATION |
| — | FENCE | — | APPROXIMATE AREA OF REMOVAL ACTION |
- 19HA09 SURFACE/SUBSURFACE SAMPLING LOCATIONS (HAND-AUGERED SAMPLES)

334003R1

FIGURE 2-1
SURFACE SOIL SAMPLING
LOCATIONS
SITES 9 AND 19

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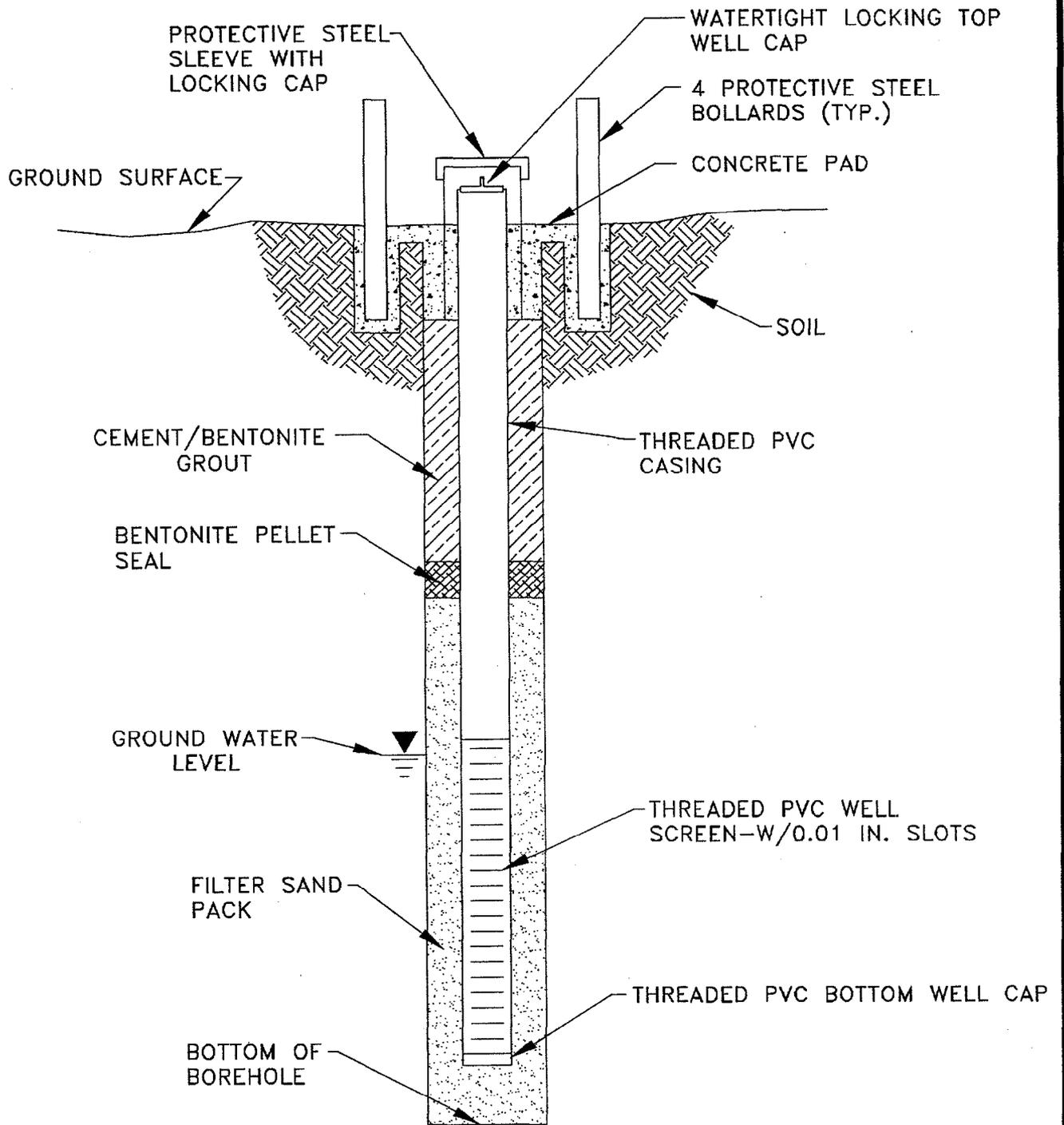


- BOUNDARY
- DRAINAGE
- MARSH
- RAILROAD
- x-x- FENCE
- EDGE OF PAVEMENT
- STRUCTURE
- REMEDIAL INVESTIGATION SITE OR SITE SCREENING AREA (SSA)
- APPROXIMATE SITE DELINEATION
- APPROXIMATE AREA OF REMOVAL ACTION

- 19GW03 EXISTING MONITORING WELL
- 19GW03A DEEP MONITORING WELL LOCATION
- 9SB/GW02 SOIL BORING/SHALLOW MONITORING WELL LOCATION
- 9SB/GW02A SOIL BORING/DEEP MONITORING WELL LOCATION
- 9SG01 STAFF GAUGE LOCATION
- 19SB01 SOIL BORING LOCATION
- 19SB/HP07 HYDROPUNCH/SOIL BORING LOCATION
- ← ESTIMATED GROUNDWATER FLOW DIRECTION

334004R1

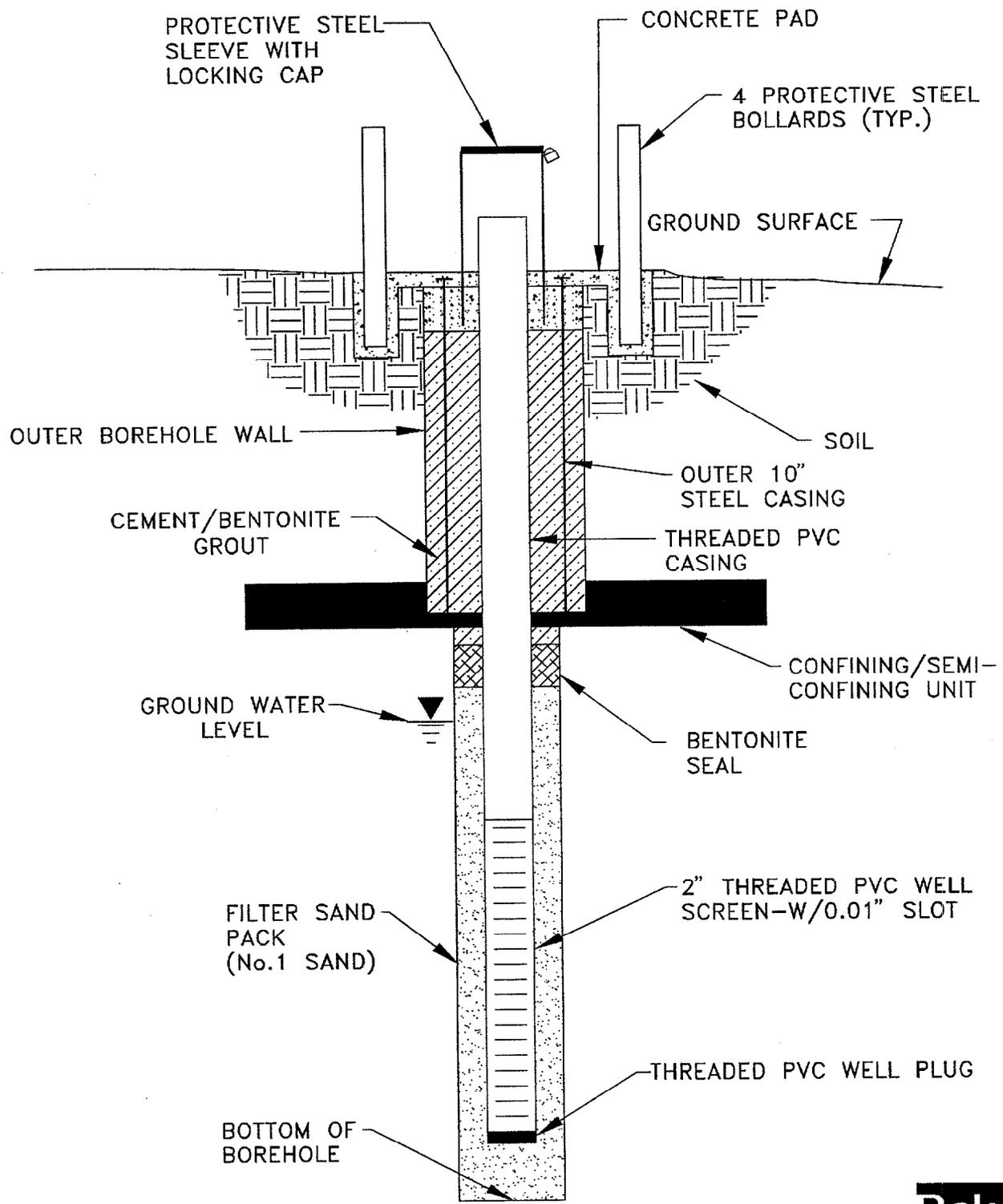
FIGURE 2-2
SAMPLING LOCATIONS
GROUNDWATER AND SUBSURFACE SOIL
SITES 9 AND 19



N.T.S.



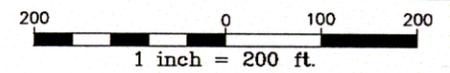
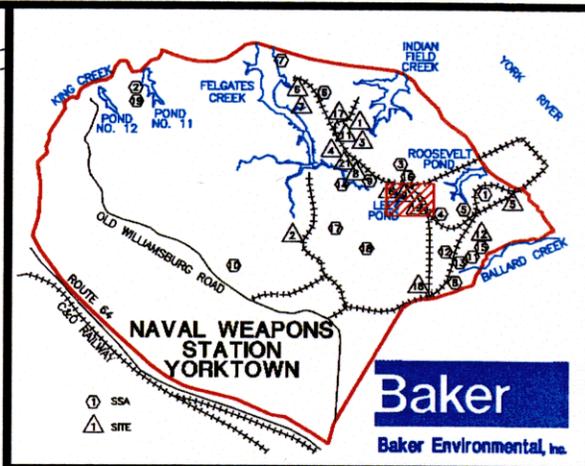
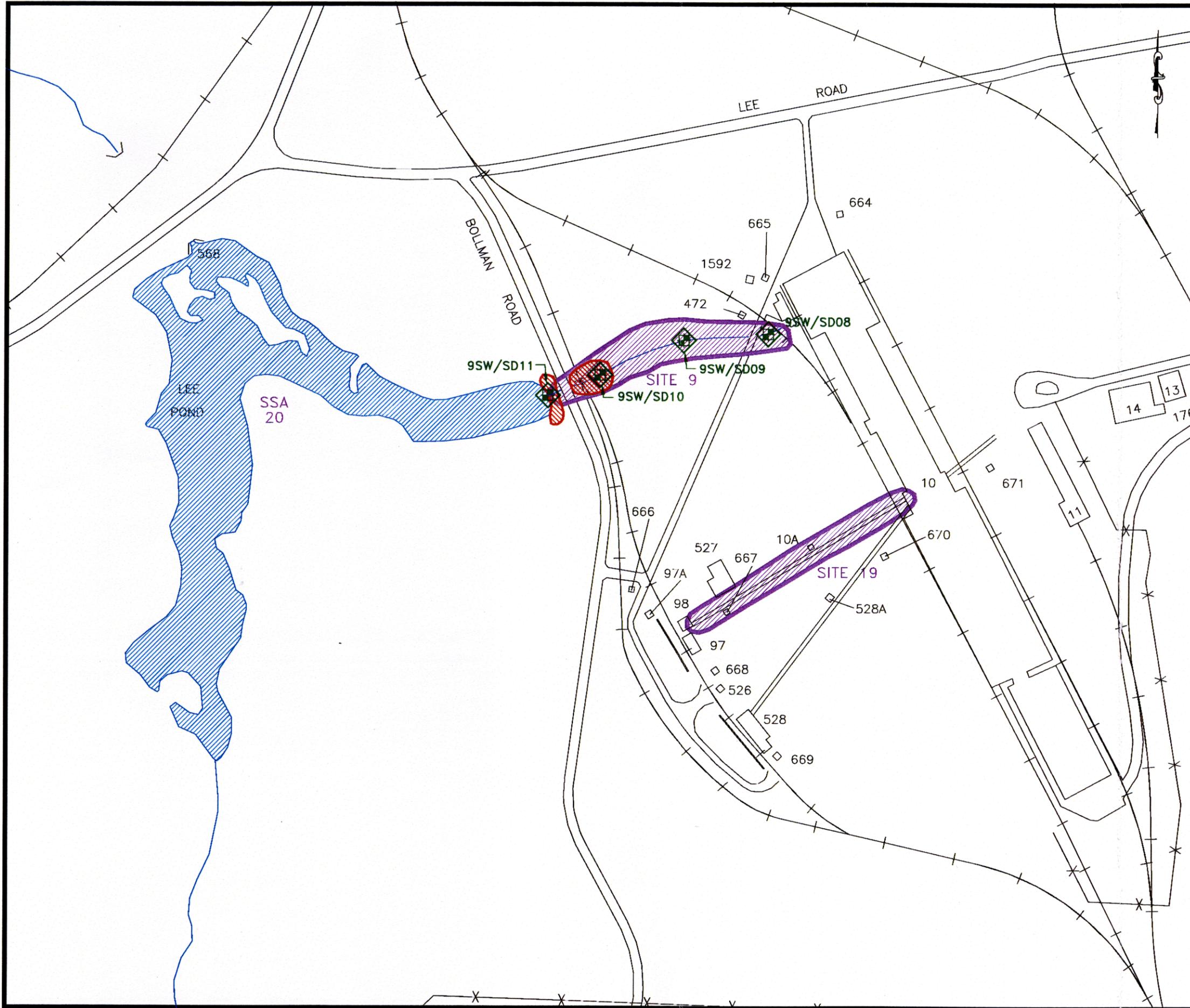
FIGURE 2-3
TYPICAL SHALLOW GROUNDWATER MONITORING WELL
CONSTRUCTION DIAGRAM - ABOVE GRADE SURFACE COMPLETION
SITES 9 AND 19



N.T.S.



FIGURE 2-4
TYPICAL DEEP GROUNDWATER MONITORING WELL
CONSTRUCTION DIAGRAM - ABOVE GRADE SURFACE COMPLETION
SITES 9 AND 19



- BOUNDARY
- DRAINAGE
- MARSH
- RAILROAD
- x-x- FENCE
- EDGE OF PAVEMENT
- STRUCTURE
- REMEDIAL INVESTIGATION SITE OR SITE SCREENING AREA (SSA)
- APPROXIMATE SITE DELINEATION
- APPROXIMATE AREA OF REMOVAL ACTION

9SW/SD08
 PROPOSED SURFACE WATER, SEDIMENT, BENTHIC SAMPLING LOCATION

334007RI

FIGURE 2-5
SAMPLING LOCATIONS SURFACE WATER, SEDIMENT AND BIOTA
SITES 9 AND 19

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

00889B03Y

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section presents a summary of information regarding the environmental setting of the Station including geography, meteorology, surface water hydrology, soil, geology, hydrogeology, land use, and demography. Additional information on the environmental setting is found in the Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin (Baker, 1995).

3.1 General Physiography

WPNSTA Yorktown is located in the southeast portion of Virginia on the York-James Peninsula. The local terrain is gently rolling and the land is dissected by ravines and stream valleys.

The climate of WPNSTA is maritime with mild winters and long, warm, humid summers. Prevailing winds are usually from the south-southwest. The average precipitation during the investigation at Sites 9 and 19 (September to mid-October) was 17.5 inches.

WPNSTA is situated within two major drainage basins of the York and the James Rivers. Sites 9 and 19 are located within the York River Basin. Within the York River Basin, four tributaries (King Creek, Felgates Creek, Indian Field Creek, and Ballard Creek) drain the northern and eastern portions of the Station.

The major portion of surface water from Site 9 flows toward a small intermittent creek (wastewater drainage way) at the central portion of the site that empties into Lee Pond. This drainage encompasses the eastern, southern, and western portions of the site. The northern portion of the site is segregated by an abandoned railroad bed, and the surface water flows to the northwest and infiltrates into the subsurface. The surface water from Site 19 may be transported off site in three ways. First, surface water flows to the north where it is intercepted by a concrete drainage culvert and transported to the intermittent creek at Site 9. Secondly, surface water flows to the entrenched conveyor belt where it infiltrates to the subsurface. Finally, the surface water flows southwest along an access road toward the rear facility gate (Site 19) where it is captured by manmade drainage features and transported along Bollman Road, then discharged to Lee Pond.

3.2 Geology

The following sections contain a summary of the regional geology of WPNSTA Yorktown and the site-specific geology of Sites 9, and 19. Additional details on the regional geology are found in the Background Report (Baker, 1995).

3.2.1 Regional Geology

The Atlantic Coastal Plain physiographic province is underlain by unconsolidated sediments of Quaternary, Tertiary, and Cretaceous ages (see Figures 3-1 and 3-2) that dip gently to the southeast and have a combined thickness of approximately 1,900 feet in the vicinity of WPNSTA Yorktown (Teifke, 1973).

Most of the surficial unconsolidated sediments at WPNSTA Yorktown have been mapped as the Windsor Formation of the Pleistocene series (Johnson, 1972; Mixon et al., 1989a). This formation is composed of a series of sand and silt deposited in marine and estuarine environments. Its thickness is estimated to vary from 0- to 40-feet at WPNSTA Yorktown. The Bacons Castle Formation of Pliocene age underlies the Windsor Formation and is described as a clayey silt and silty fine-grained sand. The unit rests unconformably on the weathered top of the Upper Yorktown Formation, also of Pliocene age. The presence of calcite-cemented shells and shell fragments is characteristic of the upper portion of the Yorktown Formation. This type of lithology was encountered during the Station Background Investigation (Baker, 1995) and during this investigation.

3.2.2 Sites 9 and 19 Geology

Nine soil borings were advanced within the vicinity of Sites 9 and 19 to characterize the subsurface soil conditions, to collect soil samples for laboratory analysis, to collect groundwater samples via temporary piezometer and HydroPunch™ sampler, and for monitoring well installation. In general, the site is underlain by unconsolidated deposits of coarse to fine-grained sand, silt, clay, and marine shells. These findings were consistent with subsurface soil data from five existing soil borings for monitoring wells completed by Dames & Moore during Round One of the Confirmation Study at

WPNSTA Yorktown (Dames & Moore, 1986) and by Roy F. Weston for the Round One RI (Baker, 1992).

The surficial strata at Sites 9 and 19 are generally characterized by medium to fine grained sands with varying amounts of silt and trace amounts of clay and gravel. Underlying these deposits, a stratum containing marine shell fragments with sand, silt, and clay (Cornwallis Cave Aquifer) was encountered. This stratum, where groundwater was encountered, ranged in thickness from 5 to 10 feet. A moist to damp, greenish-gray, silty clay and/or clayey silt (Yorktown Confining unit) was described below this water-bearing stratum. This cohesive unit ranged in thickness from 15 feet at the northern portion of the site to 25 feet at the southern portion of the site (cross section traverse A to A') adjacent to Lee Pond. Underlying this interval, deposits became coarser grained and were described on the boring logs as fine grained sand with varying amounts of silt, clay, and marine shell fragments (Yorktown-Eastover Aquifer). This depositional trend of the subsurface soil was generally observed in the other soil borings throughout Sites 9 and 19. These units were consistent with descriptions of the Cornwallis Cave Aquifer, Yorktown Confining Unit, and the Yorktown-Eastover Aquifer as defined by Brockman and Richardson (1992). The Test Boring Records are provided in Appendix C.

Cross-sections depicting the subsurface geologic conditions underlying the site were developed based on information obtained during the drilling program. As shown on Figure 3-3, two cross sections at the site were traversed. In general, cross-section A to A' (Figure 3-4) traverses northeast to southwest, while cross-section B to B' (Figure 3-5) traverses southwest to northeast.

During the field investigation, one thin-walled (Shelby) tube sample was collected from 9GW04A within the Yorktown Confining Unit at a depth of 29- to 31-feet bgs. Grain size and hydraulic conductivity analyses were performed on the samples. The test results classified (via the Unified Soil Classification System) the soil as CH, fine grained, sandy silty clay of high plasticity. The hydraulic conductivity of the sample was determined to be 1.3×10^{-7} centimeters per second (cm/sec) which is within the range of hydraulic conductivity for marine clay (Fetter, 1988). Test results of the samples are presented at the end of Appendix I.

3.3 Hydrogeology

The following section summarizes the hydrogeology of the Station and of the sites investigated. Additional hydrogeological details are found in the Background Report (Baker, 1995).

3.3.1 WPNSTA Yorktown

The Atlantic Coastal Plain sediments are the most important source of potable water in the region. Recharge to the groundwater system is derived from precipitation. Approximately 50 percent of the precipitation is lost to evapotranspiration. The remaining 50 percent either results in surface runoff or infiltrates and is introduced into the groundwater regime. Recharge of aquifers may occur at the surface near outcrop zones or from downward migration from overlying strata (Baker, 1994).

The shallow aquifer system in York County is comprised of the following seven units: (1) the undivided York County shallow aquifer system, (2) the Columbia aquifer, (3) the Cornwallis Cave confining unit, (4) the Cornwallis Cave aquifer, (5) the Yorktown confining unit, (6) the Yorktown-Eastover aquifer, and (7) the Eastover-Calvert confining unit (Brockman and Richardson, 1992). These hydrogeologic units and their relation to the geologic units are listed in Figure 3-1.

The undivided York County shallow aquifer system exists where one or more of the confining units commonly present in other areas of the county is absent (typically adjacent to the York River) and two or more aquifers form one hydraulic unit. The Columbia aquifer consists of sandy deposits which exist under confined (water table) conditions. Clayey or silty sediments typically comprise the Cornwallis Cave confining unit which underlie the Columbia aquifer. Most of the county is underlain by this aquifer and confining unit, but the units are missing in areas of western and west-central York county and in a narrow band along the York River. The Cornwallis Cave aquifer consists of sandy and shelly sediments and is defined by the water table (where unconfined). This unit is usually distinguished by the shelly deposits of the Yorktown Formation. The Yorktown confining unit which underlies the Cornwallis Cave aquifer is comprised of clays and silts and is usually distinguishable by its dark greenish gray color. The Yorktown-Eastover aquifer underlies the Yorktown confining unit, which is comprised of sandy and shelly sediments which is typically confined, but locally may be unconfined (e.g., adjacent to the York River, provides the source of

water for some of the domestic supply wells in the county. The basal unit within the York County shallow aquifer system is the Eastover-Calvert confining unit, which consists of silt and clay.

3.3.2 Site Hydrogeology

As described in Section 3.2, the shallow subsurface portion of the site is characterized by unconsolidated deposits of silt with marine shell fragments and clay, clayey silt, and fine-grained sand, which is consistent with the shallow hydrogeological framework described by Brockman and Richardson (1992). Collectively, these units form the shallow aquifer system at Sites 9 and 19 and correspond to the Cornwallis Cave aquifer, the Yorktown Confining Unit, and the Yorktown-Eastover aquifer. The Columbia aquifer and Cornwallis Cave confining unit are absent at this location.

Six monitoring wells (9GW01 through 9GW04 and 19GW04 through 19GW06) were installed at the site within the shallow (Cornwallis Cave) aquifer, which consisted of sand, silts, clays, and marine shell fragments. These wells ranged in depth from 17-foot bgs (9GW01) to 30-foot bgs (19GW04). Three monitoring wells (9GW02A, 9GW04A, and 19GW03A) were installed at the site within the deeper confined (Yorktown-Eastover) aquifer, which consisted of sand, silt, and marine shell fragments. These monitoring wells ranged in depth from 60-foot bgs (9GW02A) to 69-foot bgs (9GW04A). A summary of well construction details is presented on Table 2-4. During the drilling program, groundwater was encountered at approximately 10- to 29-foot bgs for the shallow monitoring wells and 39- to 51-foot bgs for the deep monitoring wells. Groundwater level measurements were obtained from the existing and newly installed monitoring wells throughout the investigation. These data are presented on Table 2-6.

Potentiometric surface (contour) maps depicting the groundwater flow patterns within the shallow aquifer at Sites 9 and 19 on October 6, 1995 are presented as Figure 3-6. As shown on these figures, groundwater flow on-site is generally southwest towards Lee Pond. A potentiometric surface map also was generated for the deeper confined aquifer and shown on Figure 3-7. The groundwater flow on-site is generally west/southwest southeast.

In-situ hydraulic conductivity ("slug") tests were performed on October 4, 1994 through October 6, 1995 in monitoring wells 19GW03, 9GW02, and 9GW02A. The static water levels for monitoring

wells 19GW03 and 9GW02 were below the top of the screen. Therefore, during falling head slug tests, this condition created an artificially high rate of fall in the water table because induced head change recharged the unsaturated zone and sand pack surrounding the well screen. This phenomenon tended to overestimate the hydraulic conductivity (Bouwer, 1989). Therefore, only rising head test data were used to estimate the specific hydraulic conductivities for this shallow (Type II) monitoring well. Falling and rising head tests were conducted in one deep (Type III) monitoring well where the static water level encompassed the entire screen section. Specific testing procedures are outlined in Section 4.4.9 of the Master FSP for Naval Weapons Station Yorktown (Baker, 1994).

The field data were evaluated using the Geraghty and Miller aquifer test solver (AQTESOLV) program. The shallow (Type II) monitoring well data were evaluated using the Bouwer and Rice (1976) method for unconfined aquifers. The hydraulic conductivities obtained during the Round Two field activities had a wide range of values (3.0×10^{-3} ft/day to 7.6 ft/day); therefore, the previous data were used to determine the average hydraulic conductivity for the shallow water-bearing zone. The average hydraulic conductivity for the Cornwallis Cave Aquifer at the site is 3.4 feet per day (ft/day) or 1.27×10^{-3} cm/sec. The results of the hydraulic conductivity tests are summarized on Table 3-1. These values are within the range of hydraulic conductivities for silty sand and sandy clay deposits (Fetter, 1988).

The deep (Type III) monitoring well data were evaluated using the Bouwer and Rice (1976) methods for a confined aquifer. The average hydraulic conductivity for the Yorktown-Eastover Aquifer at the site is 3.3 ft/day or 1.2×10^{-3} cm/sec. The results of the hydraulic conductivity tests are summarized on Table 3-1. These values are within the range of hydraulic conductivities for silty sand and sandy silt deposits (Fetter, 1988). A copy of the field data and AQTESOLV results are provided in Appendix E.

The groundwater gradients for both the Cornwallis Cave (shallow) Aquifer and the Yorktown-Eastover (deeper) Aquifer were calculated from the October 6, 1995 groundwater level data. The average groundwater gradient for the Cornwallis Cave Aquifer was calculated at 1.6×10^{-2} feet/foot. The groundwater gradient for the Yorktown-Eastover Aquifer is not as steep at 7.0×10^{-3} feet/foot.

Using the average groundwater gradient and average hydraulic conductivity determined for each water-bearing zone (Cornwallis Cave and Yorktown-Eastover Aquifers), the average groundwater flow velocity can be estimated using a variation of Darcy's equation:

$$V = Ki/N_e$$

where: V = estimated groundwater flow velocity

K = hydraulic conductivity

i = hydraulic gradient

N_e = average effective porosity, as a decimal fraction

The hydraulic conductivity of the Cornwallis Cave Aquifer was determined using an average K of 3.4 ft/day calculated from the hydraulic conductivity tests, a groundwater gradient of 1.6×10^{-2} feet/feet, and an estimated effective porosity for silty sand of 0.35 (Fetter, 1988). The average groundwater flow velocity is 1.55×10^{-1} ft/day.

The average groundwater flow velocity of the Yorktown-Eastover Aquifer is 7.7×10^{-2} ft/day. This was determined using an average K of 3.3 ft/day, a groundwater gradient of 7.0×10^{-3} feet/feet, and an estimated effective porosity for silty sand of 0.30 (Fetter, 1988).

3.4 Land Use and Demography

WPNSTA personnel employed at Building 10 at Sites 9 and 19 continue to load explosives on a limited basis. The buildings appear to be occupied on a daily basis. The area is partially wooded, with the remaining area being covered with grass and asphalt. The facility is scheduled to be decommissioned in the fiscal year 1997.

3.5 References

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SECTION 3.0 TABLES

TABLE 3-1

**SUMMARY OF HYDRAULIC CONDUCTIVITIES IN SELECTED MONITORING WELLS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Monitoring Well	Hydraulic Conductivity (ft/day)	Lithology of Screened Interval
19GW01 ⁽¹⁾	1.5	Silty clay with shell fragments
19GW02 ⁽¹⁾	2.7	
19GW03 ⁽¹⁾	6.4	Silty clay with shell fragments
9GW02 ⁽¹⁾	3.0x10 ⁻³	Silty clay with fine sand
9GW03 ⁽¹⁾	6.6	Silty sand to silty clay with shell fragments
9GW02A ⁽²⁾	3.3	Fine-grained sand, trace silt with shell fragments

Notes:

Hydraulic conductivity average for the Cornwallis Cave aquifer at the site:

3.4 ft/day or 2.3x10⁻³ ft/min

Hydraulic conductivity average for the Yorktown-Eastover aquifer at the site:

3.3 ft/day or 2.3x10⁻³ ft/min

⁽¹⁾ Type II monitoring wells screened within the Cornwallis Cave aquifer

⁽²⁾ Type III monitoring wells screened within the Yorktown-Eastover aquifer

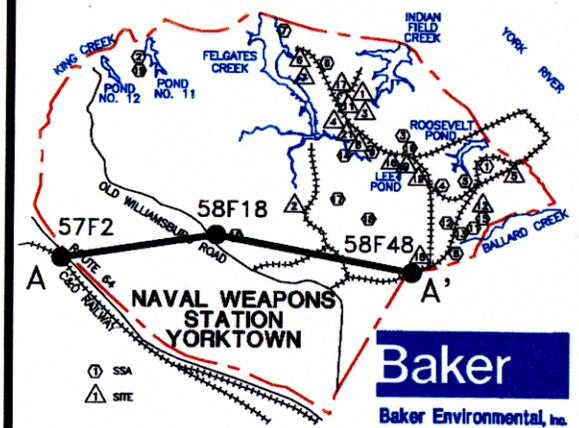
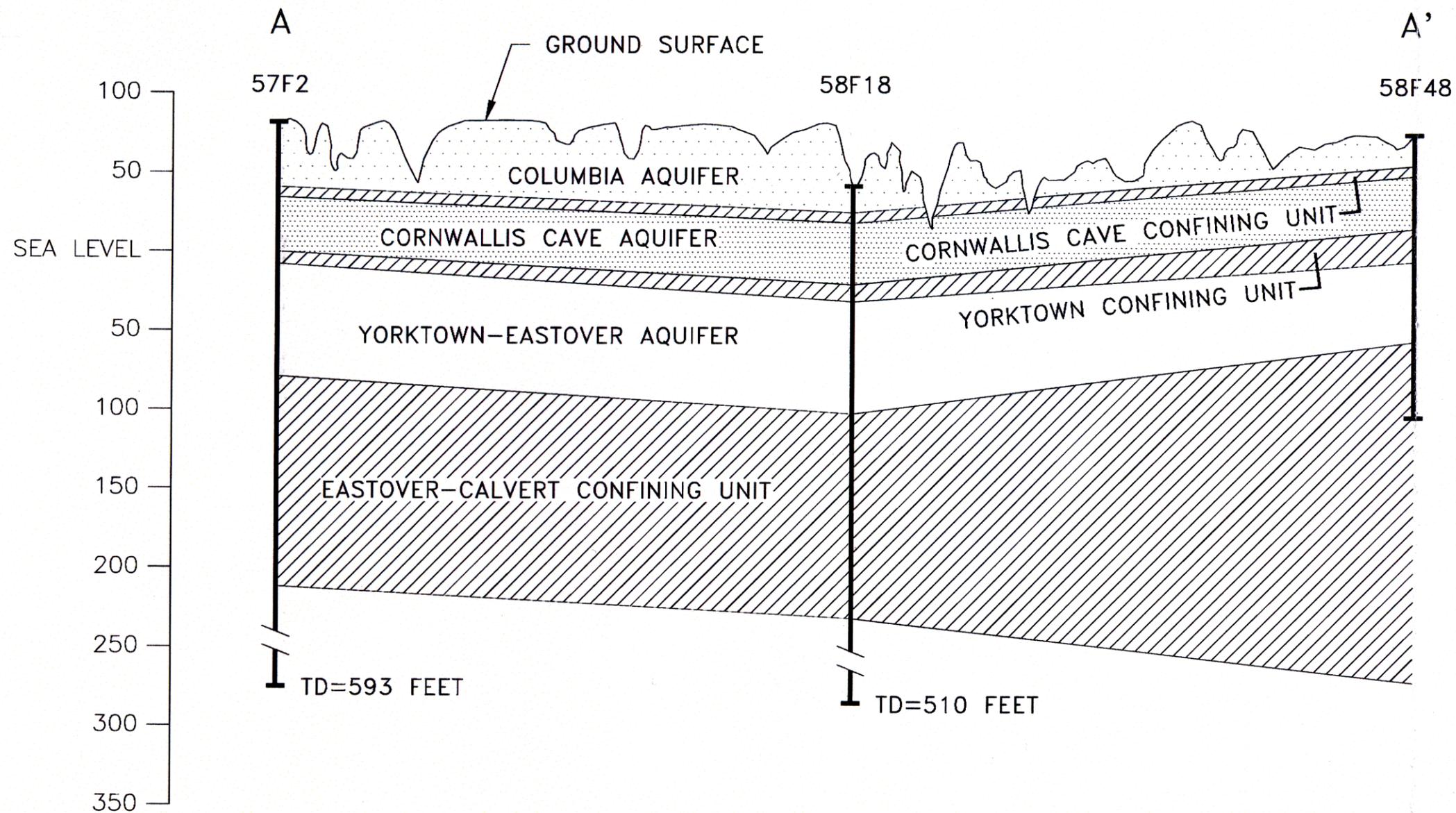
SECTION 3.0 FIGURES

SYSTEM	SERIES	GEOLOGIC UNIT	HYDROGEOLOGIC UNIT IN THIS REPORT	HYDROGEOLOGIC UNITS OF MENG AND HARSH (1988)		
QUATERNARY	HOLOCENE	ALLUVIAL AND MARSH DEPOSITS	YORK COUNTY SHALLOW AQUIFER SYSTEM	COLUMBIA AQUIFER (WHERE UNCONFINED)		
	PLEISTOCENE	TABB FORMATION			CORNWALLIS CAVE CONFINING UNIT	
		SHIRLEY FORMATION				
		CHUCKATUCK FORMATION				
		WINDSOR FORMATION				
TERTIARY	PLIOCENE	BACONS CASTLE FORMATION	YORKTOWN CONFINING UNIT	CORNWALLIS CAVE AQUIFER (WHERE CONFINED)		
		CHESAPEAKE GROUP			YORKTOWN FORMATION	MOORE HOUSE MEMBER
						MORGARTS BEACH MEMBER
						RUSHMERE MEMBER
						SUNKEN MEADOW MEMBER
						YORKTOWN-EASTOVER AQUIFER
	MIOCENE	EASTOVER FORMATION	COBHAM BAY MEMBER	EASTOVER-CALVERT CONFINING UNIT		
			CLAREMONT MANOR MEMBER			
		ST. MARYS FORMATION	CALVERT FORMATION		CALVERT CONFINING UNIT	

SOURCE: BROCKMAN, A.R. AND RICHARDSON, D.L. 1992
 HYDROGEOLOGIC FRAMEWORK OF THE SHALLOW AQUIFER SYSTEM OF YORK COUNTY, VIRGINIA:
 U.S. GEOLOGICAL SURVEY WATER-RESOURCES INVESTIGATIONS REPORT 92-4111.



FIGURE 3-1
 HYDROGEOLOGIC UNITS
 IN YORK COUNTY



LEGEND

DESCRIPTION OF CROSS SECTION UNITS

COASTAL PLAIN DEPOSITS

-  COLUMBIA AQUIFER - UNCONFINED AQUIFER OF SANDY SEDIMENTS OF THE UPPER PLEISTOCENE BACONS CASTLE FORMATION AND PLEISTOCENE SEDIMENTS OF THE WINDSOR, CHUCKATUCK, SHIRLEY, AND TABB FORMATIONS.
-  CORNWALLIS CAVE AQUIFER - CONFINED AND UNCONFINED AQUIFER OF SANDY AND SHELLY SEDIMENTS OF THE UPPER PLEISTOCENE YORKTOWN FORMATION AND BACONS CASTLE FORMATION AND PLEISTOCENE SEDIMENTS OF THE WINDSOR, CHUCKATUCK, SHIRLEY, AND TABB FORMATIONS.
-  YORKTOWN-EASTOVER AQUIFER - CONFINED AQUIFER IN SANDY AND SHELLY SEDIMENTS OF THE UPPER MIOCENE EASTOVER FORMATION AND THE LOWER PLEISTOCENE SEDIMENTS OF THE YORKTOWN FORMATION.
-  SEMI CONFINING UNITS COMPRISED OF SILTS AND CLAYS CORRESPONDING TO THE CORNWALLIS CAVE, YORKTOWN AND EASTOVER-CALVERT CONFINING UNITS.

57F2 BORING OR WELL LOCATION.

REFERENCES CITED:

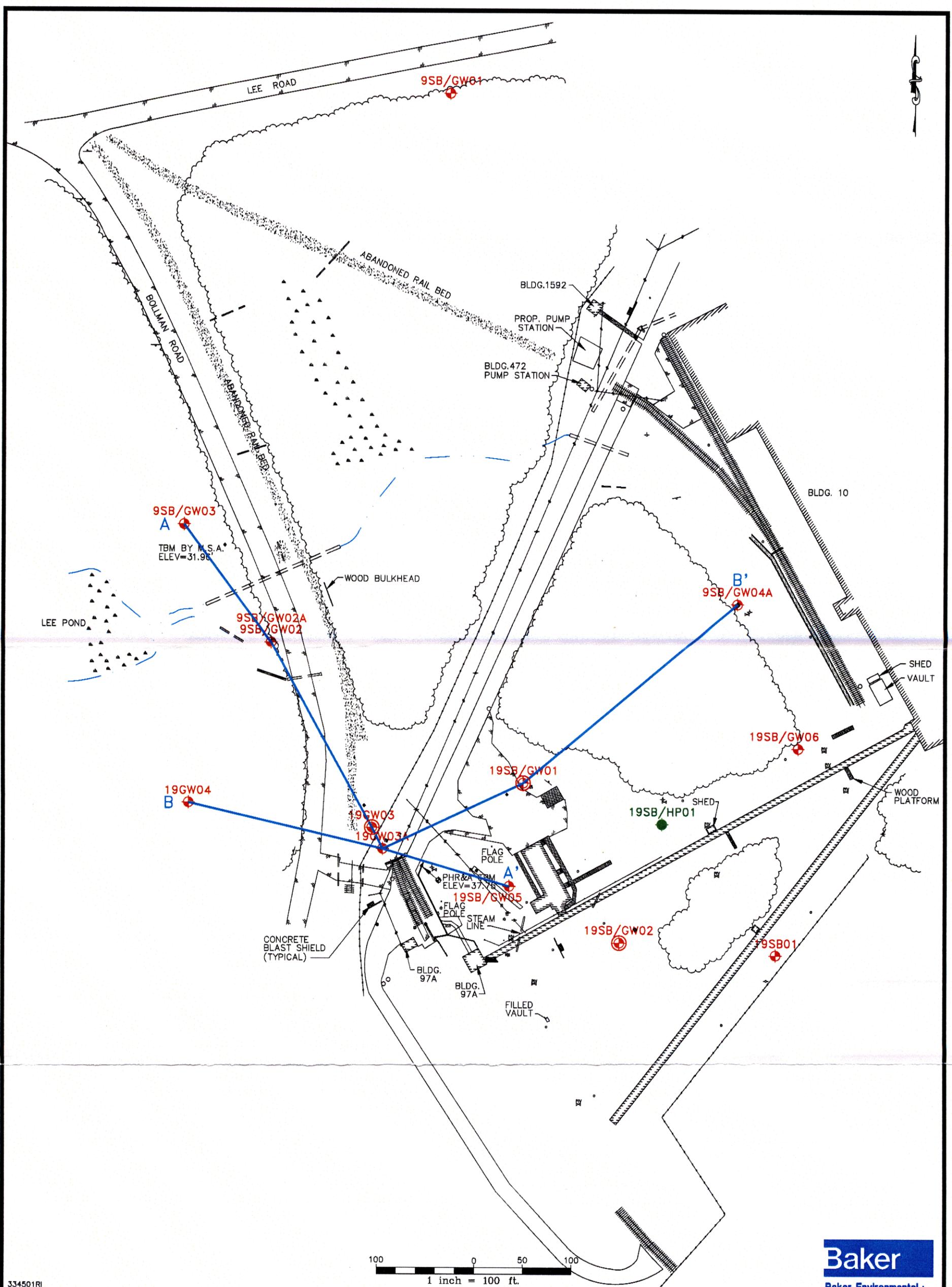
BROCKMAN, A.R. AND D.L. RICHARDSON, 1992. "HYDROGEOLOGIC FRAMEWORK OF THE SHALLOW AQUIFER SYSTEM OF YORK COUNTY, VIRGINIA".

320528WP

**FIGURE 3-2
GENERALIZED HYDROGEOLOGIC
CROSS SECTION
WPNSTA YORKTOWN, VIRGINIA**

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

00889BB4Y



334501RI

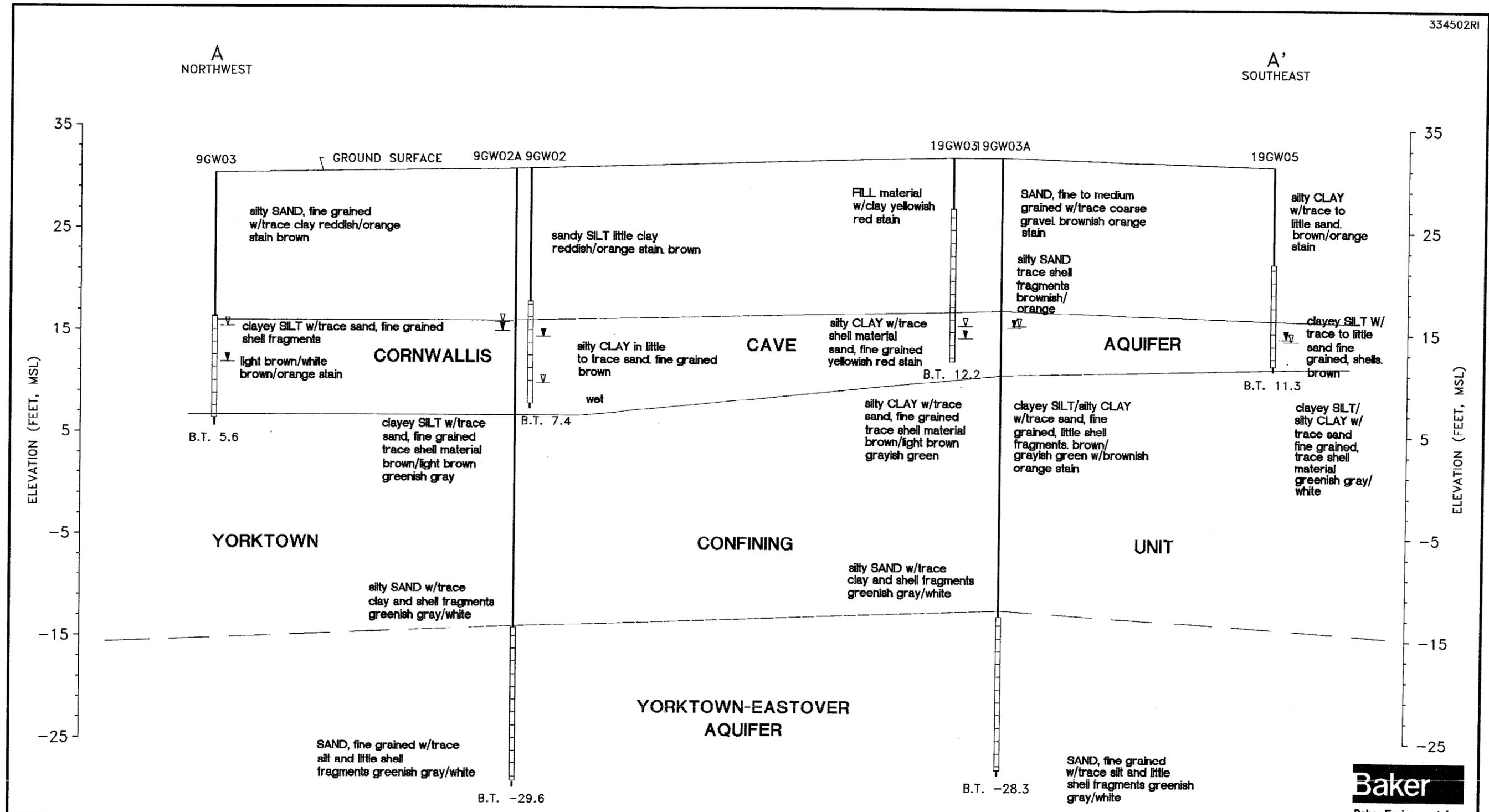
LEGEND

	- CROSS-SECTION LOCATION
	- EXISTING MONITORING WELL INSTALLED BY WESTON, 1991
	- MONITORING WELL INSTALLED BY BAKER, 1995
	- INTERMITTANT CREEK

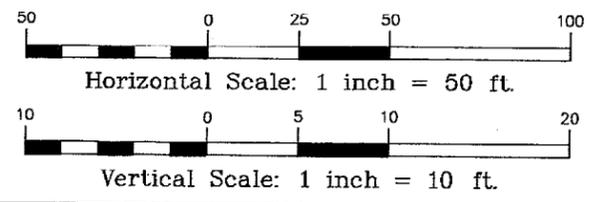
SOURCE: PATTON, HARRIS, RUST & ASSOCIATES, 1995.

**FIGURE 3-3
CROSS-SECTION LOCATION MAP
SITES 9 AND 19**

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



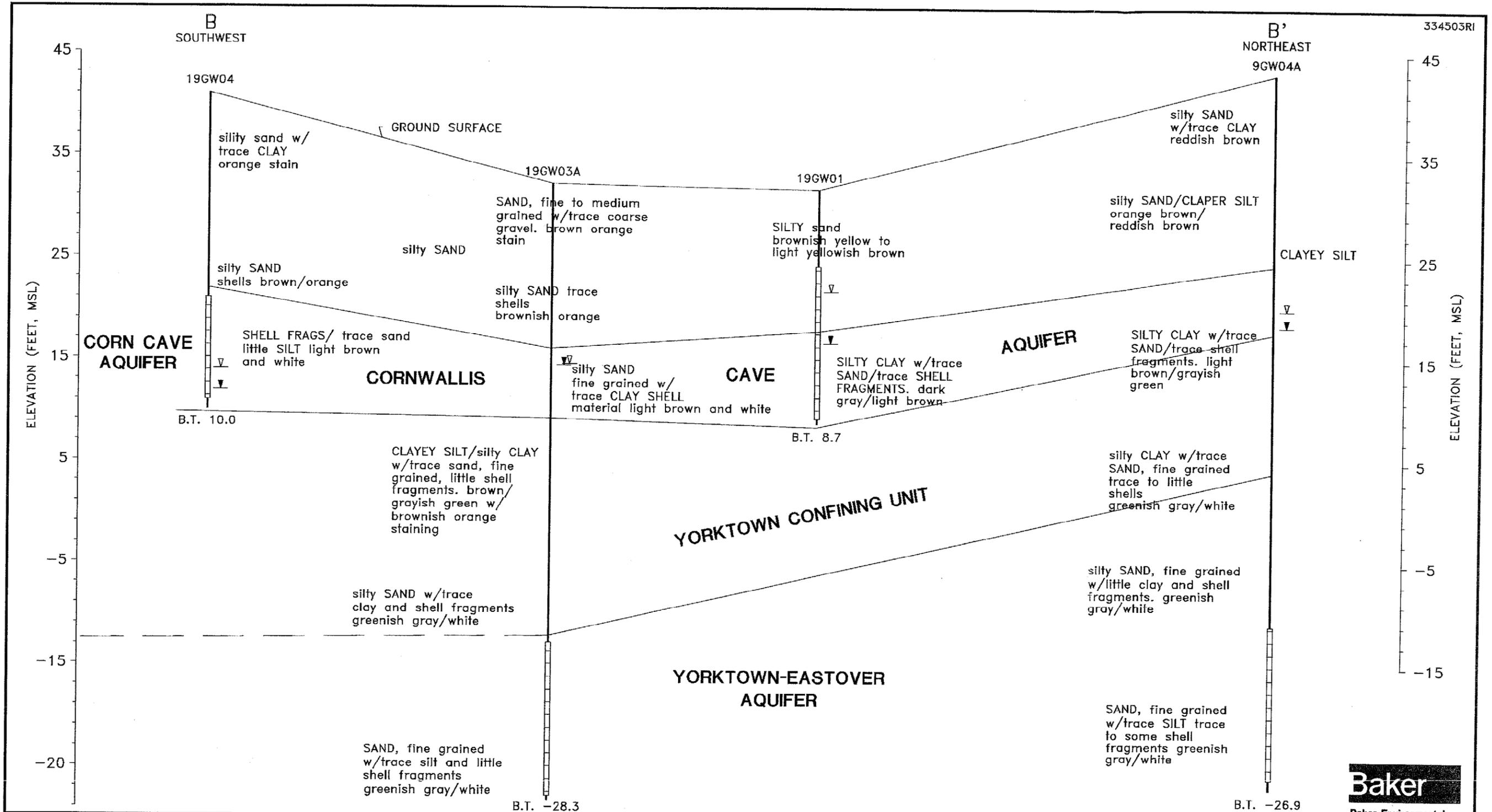
- LEGEND**
- ▽ GROUNDWATER ELEVATION (13.1)
 - ▽ GROUNDWATER ENCOUNTERED DURING DRILLING
 - B.T. -29.5' BORING TERMINATED, ELEVATION MSL
 - WELL SCREEN INTERVAL
 - ESTIMATED
 - - - PROJECTED



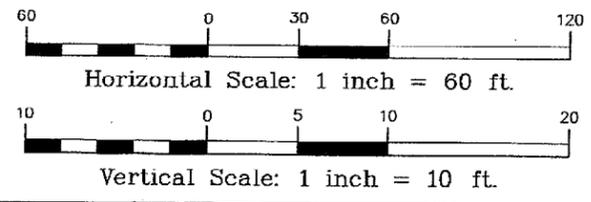
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-4
HYDROGEOLOGIC CROSS-SECTION A-A'
SITE 9 AND 19





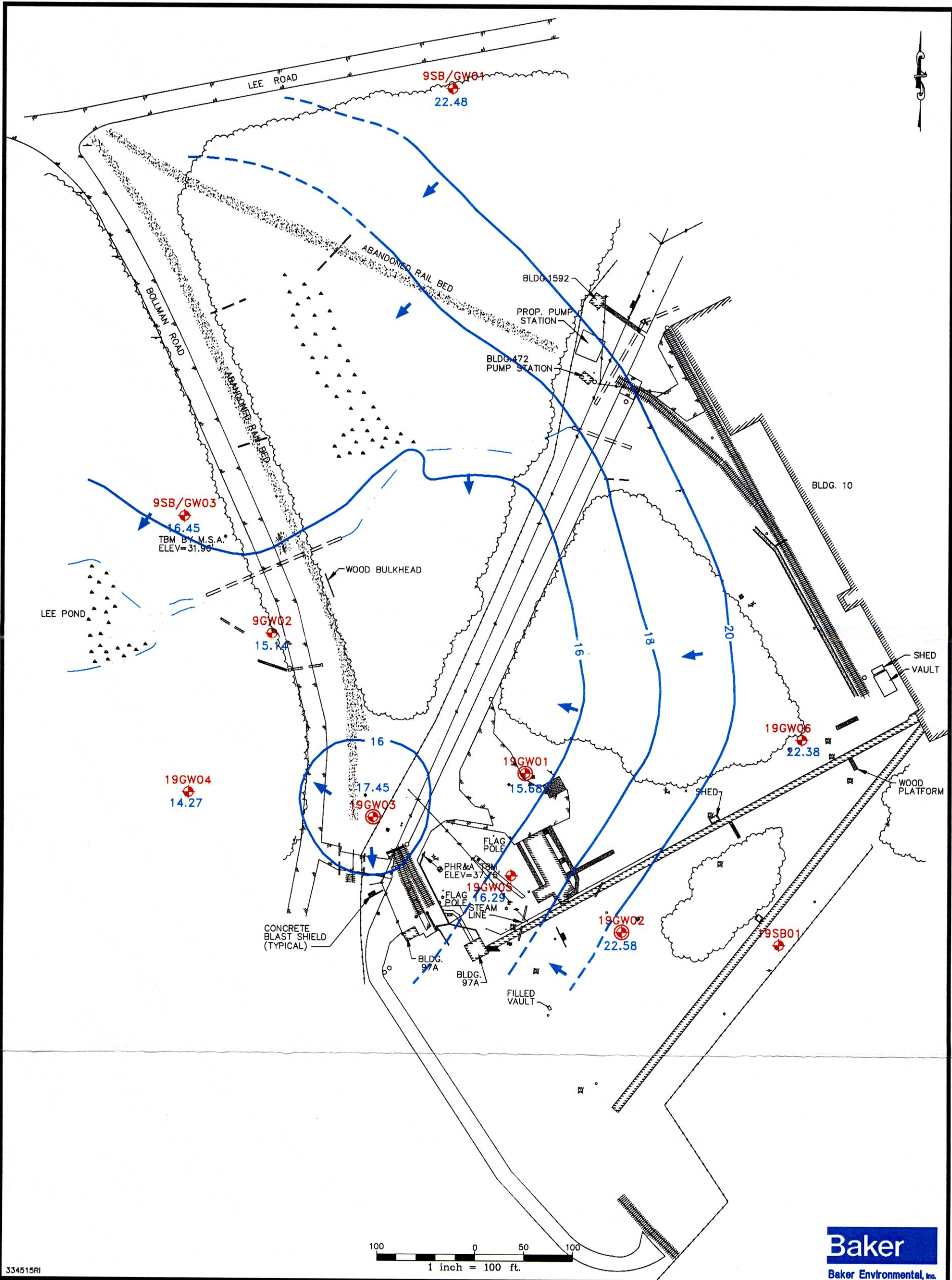
- LEGEND**
- GROUNDWATER ELEVATION (13.1)
 - GROUNDWATER ENCOUNTERED DURING DRILLING
 - B.T. -28.3' BORING TERMINATED, ELEVATION MSL
 - WELL SCREEN INTERVAL
 - ESTIMATED
 - - - PROJECTED



THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-5
HYDROGEOLOGIC CROSS-SECTION B-B'
SITES 9 AND 19





334515RI

LEGEND	
22.58	- GROUNDWATER ELEVATION (MSL)
—	- PROJECTED GROUNDWATER CONTOUR LINE
- - -	- ESTIMATED GROUNDWATER CONTOUR LINE
→	- GROUNDWATER FLOW DIRECTION
⊕	- EXISTING MONITORING WELL INSTALLED BY WESTON, 1991
⊕	- MONITORING WELL INSTALLED BY BAKER, 1995
- - -	- INTERMITTANT CREEK

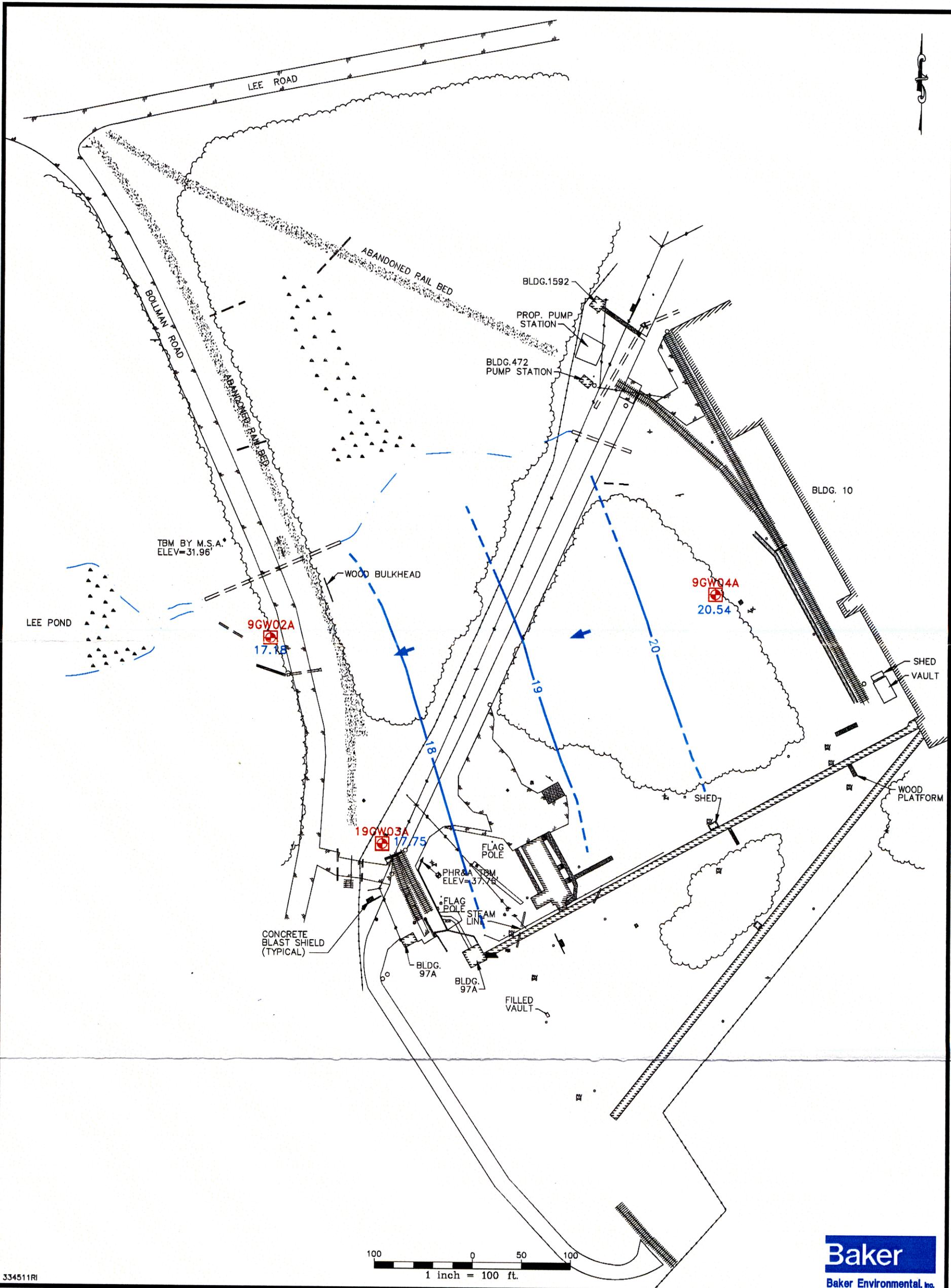
SOURCE: PATTON, HARRIS, RUST & ASSOCIATES, 1995.

**FIGURE 3-6
GROUNDWATER CONTOUR MAP
CORNWALLIS CAVE AQUIFER
SITES 9 AND 19**

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



00889BB6Y



334511R1

Baker
Baker Environmental, Inc.

LEGEND

- 20.54 - GROUNDWATER ELEVATION (MSL)
- PROJECTED GROUNDWATER CONTOUR LINE
- - - ESTIMATED GROUNDWATER CONTOUR LINE
- ➔ GROUNDWATER FLOW DIRECTION
- 9GW02A - MONITORING WELL INSTALLED BY BAKER, 1995

FIGURE 3-7
GROUNDWATER CONTOUR MAP
YORKTOWN-EASTOVER AQUIFER
SITES 9 AND 19

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents chemical analytical results obtained as part of the Round Two RI performed at Sites 9 and 19 and discusses both Round One and Round Two sampling results. The objectives of this section are to characterize the nature and delineate the extent of possible site contamination. The characterization of Sites 9 and 19 is based upon collection and analysis of samples of the following environmental media: surface and subsurface soil, groundwater, surface water, sediment, and biota.

The analytical results are presented in two groups. Non-site related analytical results, presented in Section 4.1, include laboratory contaminants, essential nutrients, and other naturally occurring inorganic elements. Analytical results from the environmental investigation, presented in Section 4.2, include results of the soil, groundwater, surface water, and sediment investigations (Section 7.0 presents the results of the biota sampling). Section 4.2 includes the environmental sample results (i.e., soil samples collected from within the study area) and related background sample results (i.e., site-specific background soil samples) to evaluate whether or not the detected constituents (particularly the inorganics) are site-related. Section 4.3 describes the extent to which contaminants have migrated from probable source areas and the potential for future migration using the Round One and Round Two sampling results. A summary of the nature and extent of contamination is provided in Section 4.4.

Appendices G through J present the Round Two chain-of-custody forms, Round Two sampling summary, Round Two analytical laboratory results, and Round Two QA/QC results with data validation summaries, respectively. Figures 4-1 through 4-10 provide a graphical depiction of organic and inorganic contaminants as they occur throughout the site. Positive detections of organic compounds and inorganic analytes according to media are presented in summary tables included at the end of this section (Tables 4-3 through 4-31).

4.1 Potential Non-Site-Related Analytical Results

Many of the organic compounds and inorganic constituents detected during investigations of the various environmental media could potentially be attributed to non-site-related conditions. Two

potential sources of this include sampling/laboratory (blank) contaminants and the presence of naturally occurring constituents (background).

4.1.1 Sampling/Laboratory Contaminants

Blank samples provide a measure of contamination that has been introduced into a sample set during its collection, transportation, preparation, and/or analysis. The concentrations of chemicals detected in blanks were compared with concentrations of the same chemicals detected in environmental samples.

Common laboratory contaminants (i.e., acetone, 2-butanone, methylene chloride, and phthalate esters) are considered by USEPA as positive results only when concentrations in the environmental sample exceed ten times the concentration detected in any blank. If the concentration of a common laboratory contaminant in an environmental sample was less than ten times the associated blank concentration, then it was concluded that the chemical was not detected in that particular sample (USEPA, 1989). Because of the complexity of associating laboratory or sampling induced contamination with concentrations detected in environmental samples, maximum detected concentrations of laboratory or sampling induced contaminants detected in blanks were used in the nature and extent of contamination evaluation to focus on the most pertinent chemicals detected in environmental media at sites 9 and 19. The maximum concentrations of common laboratory contaminants detected in blanks during the investigation at Sites 9 and 19 are as follows:

- Acetone 100J µg/L
- Toluene 14J µg/L
- bis(2-Ethylhexyl)phthalate 280J µg/L
- Di-n-butylphthalate 25J µg/L

The “J” qualifier indicates that the reported sample concentration value has been estimated. A “B” qualifier indicates that the reported concentration is itself qualified as blank contamination because of an association with another type of blank (for example, a trip blank qualified because of contamination in a laboratory blank). A list of the qualifiers and their definitions is presented in Table 4-1.

Organic contaminants detected in laboratory blanks but not considered to be common laboratory contaminants also were evaluated. In general, all organic compounds at less than five times the maximum level of contamination noted in any blank may not be attributed specifically to the site conditions. The maximum concentrations of all other detected blank contaminants (organics) are as follows:

●	Chloroform	81 µg/L
●	1,1-Dichloroethene	3J µg/L
●	1,2-Dichloroethene	7J µg/L
●	2-Butanone	76 µg/L
●	Ethylbenzene	2J µg/L
●	Bromodichloromethane	7J µg/L
●	Xylenes (total)	14J µg/L
●	Phenol	9J µg/L
●	Diethylphthalate	12 µg/L
●	Napthalene	4J µg/L
●	RDX	25J µg/L
●	2,6-Dinitrotoluene	3J µg/L
●	2,4,6-Trinitrotoluene	.14NJ µg/L
●	Amino-Dinitrotoluenes	.28 µg/L
●	Tetryl	4NJ µg/L

Possible laboratory contaminants for each site are presented/discussed in Section 6.0 and listed in Table 6-1. The above-listed compounds are presented in the positive detection summary tables in this section; however, the majority of them are not included in the figures (Figures 4-1 through 4-10). The compounds 1,3-dinitrobenzene, 2,4-dinitrotoluene, HMX, RDX, and 1,3,5-trinitrobenzene will, however, be discussed in the following sections and are included on the figures because they were detected in previous investigations and are likely attributable to past activities at both Sites 9 and 19.

4.1.2 Naturally Occurring Inorganic Elements

In order to differentiate between inorganic contamination from site operations and naturally-occurring inorganic elements, the results of the sample analyses (concentrations) were compared to information regarding background conditions at WPNSTA Yorktown. This information was collected during a Station-wide investigation in 1994 and presented in the Draft Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin (Baker, 1995). A summary of these data is provided in Table 4-2.

In addition to comparisons with Station-wide background data, inorganic analyses of surface soil samples were compared to site-specific background samples. Site specific background results will also be presented in Table 4-2.

4.2 Round Two RI Analytical Results

The following subsections present analytical results for the environmental samples collected during the Round Two RI at Sites 9 and 19. Analytical results are presented for the :

- Surface and subsurface soil investigation
- Groundwater investigation
- Surface water investigation
- Sediment investigation

Laboratory contaminants and naturally occurring constituents detected in the various samples are not evaluated in this section. Inorganic constituents considered to be essential human nutrients will not be addressed in this section. Essential nutrients typically include calcium, iron, magnesium, potassium, and sodium (USEPA, 1989). Results of the biota investigation are presented in Section 7.0 (Ecological Risk Assessment).

4.2.1 Site 9 Analytical Results

The following sections present analytical results for the environmental samples collected during the Round Two RI at Site 9 by media.

4.2.1.1 Analytical Results

The analytical results from the surface and subsurface soil investigation at Site 9 are discussed below.

Surface Soil Investigation Results

The results of the Round One RI were used to select sampling locations for the Round Two RI. In general, the results of the Round Two surface soil investigation at Site 9 were consistent with the Round One results. VOCs were not detected in surface soils at Site 9.

SVOC compounds (primarily PAHs) were detected at Site 9 and were concentrated in the drainage way from the northwestern corner of Building 10 to Lee Pond. At the top of the drainage way, benzo (a) pyrene was detected at locations 9HA01 and 9HA02 at levels of 94J and 120J $\mu\text{g}/\text{Kg}$ respectively. Benzo (a) pyrene was also detected at four locations within the drainage way. At location 9HA03 benzo(a)pyrene was detected at 830 $\mu\text{g}/\text{Kg}$. At this location two additional SVOCs were also identified, benzo (b) fluoranthene at 1,100 $\mu\text{g}/\text{Kg}$ and dibenzo (a,h) anthracene at 130J $\mu\text{g}/\text{Kg}$. At locations 9HA04 and 9HA05 benzo (a) pyrene was the only SVOC detected and was found at levels of 500 and 270J $\mu\text{g}/\text{Kg}$ respectively.

The highest levels of SVOCs were detected at 9HA06 at the bottom of the drainage way just above the area where debris was removed in fall of 1994. Benzo (a) pyrene was found at this location at 1200 $\mu\text{g}/\text{Kg}$, benzo (a) anthracene at 1100 $\mu\text{g}/\text{Kg}$, benzo (b) fluoranthene at 2200 $\mu\text{g}/\text{Kg}$, and dibenzo (a,h) anthracene at 160J $\mu\text{g}/\text{Kg}$.

Nitramine compounds were not detected in surface soil samples collected at Site 9 during the Round Two RI. (This is generally consistent with the results of the confirmation sampling collection for the treatability study.) Two inorganic constituents were detected at levels above Station-wide

background levels. Vanadium was detected in the sample from location 9HA06 at a level of 68.6J mg/Kg and cadmium was detected in samples 9HA03 and 9HA04 at 1.8K mg/Kg. Other inorganic constituents including arsenic, chromium, and lead were detected in Site 9 surface soil samples. Although arsenic falls within Station-wide background concentrations, it was detected at higher concentrations in surface soil samples obtained using hand augers (9HA01 through 9HA07). These samples were obtained from the banks of the drainage ditch at Site 9 where arsenic concentrations ranged from 15.5K mg/Kg (9HA01-00) to 23.3 mg/Kg (9HA04-00). Soils obtained using hand augers in the drainage ditch were comprised of silts and sands, little clay, and traces of root/plant material. These samples were also damp.

Positive detections of inorganic and organic analytes are presented, by sampling location, on Figures 4-1 and 4-2. Tables 4-3 and 4-4 summarize analytical results for surface soils at Site 9.

Subsurface Soil Investigation Results

Subsurface soil samples were not collected as part of the Round One RI; therefore, subsurface samples were collected at both surface soil locations (at a deeper sampling interval) and soil boring locations during the Round Two RI. Most hand auger samples were obtained from shallow subsurface soils (no deeper than 1 foot) because groundwater was encountered at greater depths. These locations and the inorganic and organic analytes detected at each location are presented in Figures 4-3 and 4-4. Tables 4-5 to 4-8 summarize results for subsurface soils at Site 9.

VOCs were not detected in the subsurface soil. PAHs were detected at four locations within the drainage way from Building 10 to Lee Pond. Benzo (a) pyrene and dibenzo (a,h) anthracene were detected at location 9HA03-01 at levels of 580 and 110J respectively and at location 9HA04-01 at levels of 460 and 91J respectively. At location 9HA05-01 benzo (a) pyrene was the only SVOC identified at 160J µg/Kg.

The highest levels of PAHs were detected at location 9HA06-01 near the end of the drainage way. At this location five compounds were identified: benzo (a) pyrene (1,700 µg/Kg), benzo (a) anthracene (1,700 µg/Kg), benzo (b) fluoranthene (2,500 µg/Kg), indeno (1,2,3-cd) pyrene (1,000 µg/Kg), and dibenzo (a,h) anthracene (270J). Benzo (a) pyrene was also found at location 9HA07-01 (6- to 12-inch interval) at 210J µg/Kg.

Nitramines were identified in the subsurface soil at a single location at Site 9. The compound 2,4,6 TNT was detected at 33,000 µg/Kg at 9HA06-01 in a sample obtained in the 6- to 12-inch interval of the soil horizon. Nitramines were not detected in other subsurface soil samples obtained at Site 9.

Organic compounds were not detected in any of the soil samples from the borings advanced for installation of groundwater monitoring wells.

Inorganic compounds above Station-wide background levels were identified at four locations. Beryllium was the most prevalent inorganic found at three of the four locations; additional inorganics included cadmium, chromium, and vanadium. At location 9HA06-01 cadmium (4.5 mg/Kg), chromium (44 mg/Kg), and vanadium (219 mg/Kg) were detected. Beryllium was detected at 9SB01-05 and 9SB03-04 at 1 and 1.2L mg/Kg respectively. Beryllium was also detected at location 9SB04A-05 at 4.1 mg/Kg; chromium and vanadium were also detected at this location as well at 46.5 and 66.7 mg/Kg respectively.

Arsenic was detected in subsurface soil samples obtained from the banks of the drainage way at relatively higher concentrations than other subsurface soils. A maximum detected arsenic concentration of 54.7K mg/Kg was obtained from soil sample 9HA04-01. No other arsenic concentrations exceeded Station-wide background subsurface soil values. In addition to soil arsenic results obtained from 9HA04-01, concentrations of arsenic in other shallow subsurface soil samples obtained using hand augers ranged from 13.8 mg/Kg (9HA01-01) to 37.8 mg/Kg (9HA07-01). Arsenic concentrations in deeper subsurface soils ranged from 3.6 mg/Kg (9SB01-05) to 29.5 mg/Kg (9SB03-04). Arsenic concentrations in subsurface soil samples obtained from directly above groundwater fall within Station-wide background values.

4.2.1.2 Groundwater Investigation Results

During the Round Two RI nitramines and inorganics were detected in groundwater samples collected at Site 9 (see Figures 4-5 and 4-6 and Tables 4-9 to 4-14). Most of the contaminants detected were found at location 9GW02 and 9GW02A, a monitoring well which was installed near locations 9HP02 and 9HP03 sampled during the Round One RI.

In the shallow well 9GW02 2,4,6 TNT was detected at 830 µg/L and amino DNTs were detected at 4,400 µg/L. The compound 1,3,5 TNB was detected in the corresponding deep well 9GW02A at 0.79 µg/L.

Inorganics were detected in unfiltered groundwater samples from three of the four wells at Site 9 at levels above Station-wide background levels. At well 9GW02 arsenic (27.6 µg/L), barium (408 µg/L), and cyanide (246 µ/L) were detected. At well 9GW03 aluminum (11,800J µg/L), arsenic (3.1L µg/L), chromium (43.3J µg/L), and vanadium (41.2 µg/L) were identified. Arsenic was the only inorganic compound detected at well 9GW04A at 2.2 µg/L.

Arsenic was detected in a filtered sample (and duplicate) obtained from shallow well 96W02 and the deeper well 96W02A. Dissolved arsenic concentrations were 25.6 µg/l and 1.8 µg/l respectively. Only groundwater obtained from the shallow well (96W02) exceeded Station-wide dissolved arsenic concentrations. Aluminum was detected in only one shallow dissolved groundwater sample (96W01) and one deep dissolved groundwater sample at concentrations of 21.4 µg/L and 140 µg/L respectively. Aluminum concentrations detected in Site 9 groundwater do not exceed Station-wide background concentrations.

4.2.1.3 Surface Water, Sediment, and Biota Investigation

Surface Water Investigation Results

During the Round Two RI three surface water samples were collected from four sampling locations (See Figures 4-7 and 4-8 and Tables 4-17 to 4-19) in the Site 9 drainage ditch. Because of the depth of the water only one sample was collected at each location where water was present. Limited surface water flow was observed during the Round Two investigation and samples were obtained from ostensibly defined standing water locations along the drainage way. A sample could not be collected at location 9SW10 because the ditch was dry at this location.

No VOCs or SVOCs were detected in the three samples. However, nitramines were detected at all three sampling locations in the drainage way at Site 9. Four compounds were detected in sample 9SW08-01: 2,6 DNT (4J µg/L), 1,3,5 TNB (0.44NJ µg/L), 1,3 DNB (0.46 µg/L), and 2,4,6 TNT

(480 µg/L). The compound 2,4,6 TNT was also detected in sample 9SW09-01 at 110 µg/L and in sample 9SW11-01 at 25 µg/L. RDX was also identified in sample SW11-01 at 6 µg/L.

A single pesticide, heptachlor epoxide, was detected in sample 9SW08-01 at 0.08K µg/L. This pesticide is not believed to be site related.

Arsenic was detected in the surface water samples at Site 9. It was found at 4.6 µg/L in 9SW08-01, at 2.2 µg/L in 9SW09-01, and at 2.2 µg/L in 9SW11-01. Aluminum, barium, manganese, zinc, and cyanide (9SW08) were also detected in drainage way surface waters. With the exception of cyanide, concentrations of these constituents fall within background values for freshwater streams.

Sediment Investigation Results

During the Round Two RI VOCs and nitramines were not detected in any of the eight sediment samples collected at four locations at Site 9 (see Figures 4-9 and 4-10 and Tables 4-15 and 4-16). However, PAHs were identified at all four sampling locations in the drainage way from Building 10 to Lee Pond. In the shallow sediment sample 9SD08-01 five PAHs were found: benzo (a,h) anthracene (2,100 µg/Kg), benzo (b) fluoranthene (2,500 µg/Kg), benzo (a) pyrene (1200 µg/Kg), indeno (1,2,3-cd) pyrene (1,100 µg/Kg), and dibenzo (a,h) anthracene (210 µg/Kg). PAHs were not detected in the corresponding deep sediment samples.

PAHs were detected in both the shallow and deep samples collected at location 9SD09. Benzo (a) pyrene (560 µg/Kg) and dibenzo (a,h) anthracene (91J µg/Kg) were found in sample 9SD09-01. Five PAHs were detected in sample 9SD09-02: benzo (a) anthracene (2400J µg/Kg), benzo (b) fluoranthene (2,600 µg/Kg), benzo (a) pyrene (2,100 µg/Kg), indeno (1,2,3-cd) pyrene (1,300 µg/Kg), and dibenzo (a,h) anthracene (300J µg/Kg).

PAHs were not detected in the shallow sample 9SD10-10 and benzo(a)pyrene was the only PAH detected in the deep sample 9SD10-02 at 180J µg/Kg. Benzo(a)pyrene was also the sole PAH detected in sample 9SD11-01 at 480J µg/Kg. PAHs were not detected in the corresponding deep sample.

Inorganics, primarily arsenic and beryllium, were identified in all eight sediment samples. Arsenic levels ranged from 6.7J to 55.5J mg/Kg and beryllium levels ranged from 0.26 to 0.85 mg/Kg. One additional inorganic compound, chromium, was detected in sample 9SD09-02 at 47.3 mg/Kg. Arsenic concentrations detected in drainage way sediments exceeded background sediment concentrations for freshwater streams. Beryllium concentrations fell within background freshwater sediment values.

Biota Investigation Results

The biota investigation for the Round Two investigation included benthic macroinvertebrate sampling and fish population sampling. These results are presented in Section 7.0 (Ecological Risk Assessment).

4.2.2 Site 19 Investigation

The following sections present analytical results for the environmental samples collected during the Round Two RI at Site 19 by media.

4.2.2.1 Soil Investigation

This section presents analytical results from the soil investigation (surface and subsurface soil) at Site 19. Surface soil results are depicted on Figures 4-1 and 4-2; subsurface soil results are depicted on Figures 4-3 and 4-4. Tables 4-20 and 4-21 summarize surface soil results for Site 19, while Tables 4-22 to 4-25 summarize subsurface results.

Surface Soil Investigation Results

During the Round Two RI VOCs were not detected in any of the soil samples from Site 19. A single PAH, benzo (a) pyrene, was detected in two locations 19HA05 and 19HA07 at 95J and 140J respectively. Both of these sampling points were located at the rail end of the conveyor to Building 10.

Amino-DNTs (2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene) were identified in four samples from locations on the northwest side of the conveyor belt and at the lower end of the conveyor. Amino-DNTs were detected at concentrations of 1000 µg/Kg, 1500 µg/Kg, 1200 µg/Kg, and 2100 µg/Kg in samples 19HA01 (duplicate), 19HA03, 19HA04, and 19HA07, respectively. The presence of amino-DNTs is attributable to the reduction of 2,4,6-TNT over time. Relatively low levels of 2,4,6-TNT were detected in samples 19HA01 (150 NJ µg/Kg), 220 µg/Kg (19HA03), 250 µg/Kg (19HA04), 130 µg/Kg (19HA05), and 380 µg/Kg (19HA07).

Aluminum, chromium, copper, lead, vanadium, and zinc exceeded Station-wide and site-specific background values sporadically throughout Site 19. Of these constituents, aluminum is likely to be process related in that it occurs at maximum detected concentrations where 2,4,6-TNT and other explosive compounds were also detected. This is not unexpected because aluminum powder is added to high explosive formulations. At 19HA03 aluminum was identified at 59,300 mg/Kg; at 19HA04 it was identified at 90,600 mg/Kg; and at 19HA07 it was identified at 28,200 mg/Kg. These elevated levels of aluminum occur close to the conveyor belt. Arsenic was detected in surface soils at concentrations within Station-wide background values. Areas of higher arsenic concentrations were not detected at Site 19 in a manner similar to Site 9. Arsenic was, however, detected in sample 19HA07-02 at a concentration of 30.4 mg/Kg.

At two locations along the southeastern side of the conveyor, neither organic compounds nor site-related inorganics were detected.

Subsurface Soil Investigation Results

During the Round Two RI subsurface soil samples were collected from both hand auger locations and borings advanced for monitoring well installation. No VOCs or SVOCs were detected in the subsurface soil samples collected with the hand augers. No organic compounds or site-related inorganic compounds were found in the soil boring samples.

2,4,6-TNT was detected sporadically in shallow subsurface soil samples. Sample 19HA01-02 contained 1200 µg/Kg of 2,4,6-TNT. Other locations displaying relatively low levels of this

constituent include 19HA04-02 (110 J $\mu\text{g}/\text{Kg}$) and 19HA05-02D (210 $\mu\text{g}/\text{Kg}$). Amino DNTs were detected at two locations, 19HA03-02 and 19HA04-02 at 8,200 and 1,200 $\mu\text{g}/\text{Kg}$ respectively.

Inorganics detected above Station-wide background at Site 19 were limited to beryllium, chromium, and vanadium. Beryllium (0.97 mg/Kg) and vanadium (70 mg/Kg) were identified in sample 19HA01-02; beryllium (1.4 mg/Kg) was identified in sample 199HA02-02; beryllium (1.7 mg/Kg), chromium (52.4 mg/Kg), and vanadium (59.9 mg/Kg) were identified in sample 19HA06-02; and vanadium (74J mg/Kg) was identified in sample 19HA07-02. Arsenic was detected above Station-wide background in one subsurface soil sample (19B07-08) at 44.8 mg/Kg. A deeper subsurface soil sample was obtained from 19SB07 directly above the water table (19SB07-13) where arsenic was detected at 9.7 mg/Kg.

4.2.2.2 Groundwater Investigation Results

During the Round Two RI the existing wells were sampled and additional wells were installed (see Figures 4-5 and 4-6 and Tables 4-26 to 4-31). No VOCs or SVOCs were identified in the samples. However, nitramine compounds were detected at the upper and lower ends of the conveyor and between the conveyor and Lee Pond. RDX (0.77 $\mu\text{g}/\text{L}$) and amino DNTs (5.3 $\mu\text{g}/\text{L}$) were both detected at 19GW06 at the upper end of the conveyor. Three compounds were found at 19GW05 at the lower end of the conveyor: 1,3,5 TNB (5.8NJ $\mu\text{g}/\text{L}$), 2,4,6 TNT (38NJ $\mu\text{g}/\text{L}$) and amino DNTs (130 $\mu\text{g}/\text{L}$).

Nitramines were also detected at two locations between the conveyor and Lee Pond. At 19GW03 2,4,6 TNT was found at 4.2NJ $\mu\text{g}/\text{L}$ and amino DNTs at 6.7NJ $\mu\text{g}/\text{L}$ and at 19GW04 RDX was found at 1.1 $\mu\text{g}/\text{L}$, 1,3,5 TNB was found at 3.8NJ $\mu\text{g}/\text{L}$, and amino DNTs were found at 7.3 $\mu\text{g}/\text{L}$. It is possible that a source area exists under the belt. Additional samples will be obtained to determine potential belt-related 2,4,6-TNT contamination in support of the forth coming FS.

Total arsenic was identified at 19GW06 at 1.9L $\mu\text{g}/\text{L}$ and at 19GW05 at 3.6L $\mu\text{g}/\text{L}$. Total manganese was detected at 19GW03 at 2,850 $\mu\text{g}/\text{L}$. Eight different inorganics were found at 19GW04: aluminum (26400J $\mu\text{g}/\text{L}$), arsenic (37.6L $\mu\text{g}/\text{L}$), beryllium (2.7L $\mu\text{g}/\text{L}$), cadmium (4.4 $\mu\text{g}/\text{L}$), chromium (132J $\mu\text{g}/\text{L}$), lead (60.5 $\mu\text{g}/\text{L}$), manganese (1290 $\mu\text{g}/\text{L}$), and vanadium (258 $\mu\text{g}/\text{L}$).

Dissolved inorganic concentrations were much lower in filtered samples obtained from 19GW04. Of the eight total inorganic constituents detected in 19GW04 only manganese (13.8 µg/L) was detected in the dissolved sample.

4.3 Extent of Contamination

This section describes the extent to which contamination has migrated at Sites 9 and 19. Note that the discussion focuses on organic contamination. Inorganic contaminants were detected in all the media sampled as part of the Round Two investigation. The detected inorganic concentrations will be further evaluated in Sections 6.0 and 7.0 as part of the risk assessments.

4.3.1 Site 9

4.3.1.1 Surface and Subsurface Soil

Surface soil contamination was evaluated following the Round One RI, although subsurface contamination was not. Samples collected during the Round Two RI were focused on both surface and subsurface soil.

Surface Soil

Following an evaluation of data collected during the Round One RI, PAHs and nitramines were identified as the most prominent soil contaminants across Site 9. Some of the highest detections of nitramines were at sampling points located at the lower end of the drainage way from Building 10 to Lee Pond. Based upon these analytical results and the proximity of affected soils to hard waste, soils from this area were removed during the removal action.

Although contaminants were detected during the Round One RI, it was not clear whether PAHs and nitramines were wide spread across the site or confined to specific locations. Data collected during the Round Two RI were obtained to clarify this issue.

Round Two RI data indicate that PAH contamination in soils appears to be concentrated in the drainage way from Building 10 to Lee Pond. Benzo (a) pyrene was detected in six locations from

the northwestern corner of Building 10 to the bottom of the drainage way at levels ranging from 94J to 1,200 µg/Kg. Additional PAHs were detected at levels ranging from 130J to 2,200 µg/Kg.

Nitramine compounds were not detected in the soil samples collected at Site 9 during the Round Two RI. The most significant nitramine contamination at Site 9 was probably addressed during the removal action. Round Two RI results indicate that relatively low levels of nitramines were present in Site 9 surface soil samples obtained from the drainage way. Arsenic was also detected at relatively higher concentrations in drainage way surface soil samples. Despite somewhat elevated concentrations of inorganic constituents, Station-wide background concentrations were exceeded by select constituents (i.e., cadmium, vanadium, zinc). Arsenic concentrations did not exceed Station-wide background surface soil values.

Subsurface Soil

Results of the subsurface soil investigation at Site 9 mirrored the results of the surface soil investigation and supported the premise that the drainage way is the primary area of contamination. PAHs were detected at four locations within the drainage way; again benzo (a) pyrene was detected at each location at levels ranging from 160J to 1,700 µg/Kg. The highest concentrations of PAHs were detected at location 9HA06-01 near the end of the drainage way. The constituent 2,4,6-TNT was also detected at 33,000 µg/Kg. No organic compounds were detected in any of the soil borings advanced prior to well installation.

Arsenic did exceed Station-wide background concentrations for subsurface soils at location 9HA04-01 (54.7 mg/Kg). Other inorganic constituents including cadmium, vanadium, and zinc exceeded Station-wide subsurface soil concentrations.

4.3.1.2 Groundwater

This section addresses the extent of groundwater contamination at Site 9. Figures 4-6 illustrates the extent of contamination of groundwater by organics. Possible sources of groundwater contamination and potential migration of contamination are also evaluated.

During the Round One RI three HydroPunchs™ were installed at Site 9 to evaluate groundwater contamination. No VOCs or SVOCs were detected in the groundwater. However, nitramine compounds were detected at two of the three sampling locations. The highest levels of nitramine contamination were noted at location 9HP03.

During the Round Two RI monitoring wells were installed at Site 9 including a shallow and a deep well at locations 9GW02 and 9GW02A near the Round One location 9HP03.

Results of the Round Two RI supported those from Round One; VOCs or SVOCs were not detected in the groundwater. However, nitramines were again detected, primarily in the wells at 9GW02 and 9GW02A. In the shallow well 2,4,6-TNT was detected at 830µg/L and amino-DNTs were detected at 4400µg/L. Very low levels (0.79µg/L) of 1,3,5 TNB were detected in the corresponding deep well.

Shallow groundwater at Site 9 appears to be moving toward Lee Pond. However, since investigation of Lee Pond was not included as part of the investigation of Site 9 extent of potential migration of contaminants to the pond cannot be evaluated at this time.

4.3.1.3 Surface Water

During the Round One RI, VOCs and nitramines were detected in three samples collected in the drainage way at Site 9. Surface water samples collected during the Round Two RI were somewhat consistent with the Round One results; while VOCs and SVOCs were not detected in the surface water, nitramine compounds were detected. Five different nitramines were detected at levels ranging from 0.44NJ to 480 µg/L and were found in all three samples of surface water collected. Again, surface water results support the premise that the drainage way is the main area of contamination at Site 9.

4.3.1.4 Sediment

Seven sediment samples were collected at Site 9 during the Round One RI. While PAHs were detected in the sediments, no nitramine compounds were identified. Results of the Round Two RI confirmed these findings and again supported the contention that contamination is most prevalent

in the drainage way. Benzo(a)pyrene was found at each sampling location at levels ranging from 180J to 2,100 µg/Kg. Four additional PAHs were detected at levels ranging from 91J to 2,600 µg/Kg.

4.3.2 Site 19

This section describes the extent to which contamination has migrated at Site 19 and the potential for future migration of contaminants.

4.3.2.1 Soil

Surface soil contamination was evaluated following the Round One RI, although subsurface contamination was not. Samples collected during the Round Two RI were focused on both surface and subsurface soil.

Surface Soil

During the Round One RI, SVOCs and nitramines were detected in soils adjacent to and beneath the conveyor at Site 19. Results of the Round Two RI confirmed that the conveyor belt is the prime area of contamination in soil at Site 19. Amino-DNTs were detected in four soil samples collected from the northwest side of the conveyor at levels ranging from 1,000J to 2,100 µg/Kg. A single PAH, benzo (a) pyrene was detected in two locations at the rail end of the conveyor at 95J and 140J µg/Kg respectively.

Aluminum, chromium, copper, lead, vanadium, and zinc exceeded Station-wide background values. Of these constituents, aluminum is likely to be site related because aluminum powder was added to high explosives. Arsenic was detected at concentrations within Station-wide background values.

Subsurface Soil

During the Round Two RI subsurface soil samples were collected at both hand auger locations and in the borings advanced prior to well installation. No VOCs or SVOCs were detected in any of the hand auger samples; no organic compounds were detected in the soil borings at significant levels.

Amino-DNTs were detected at two locations at 1,200 and 8,200 µg/Kg. These two detections correspond to detections in the surface soil. Arsenic was detected at concentrations in subsurface soil sample 19SB07-08 at 44.8 mg/Kg. A deeper sample obtained from this location contained arsenic at a concentration within Station-wide background values (19SB07-13 at 9.7 mg/Kg). Other inorganics including beryllium, chromium, and vanadium were detected at concentrations exceeding Station-wide background.

4.3.2.2 Groundwater

During the Round One RI three monitoring wells were installed and a single round of sampling was conducted. Two nitramines were identified in well 19GW03 at relatively low levels (1.3J and 5.1 µg/Kg). During the Round Two RI the existing wells were sampled and additional wells were installed. Samples collected and analyzed verified that nitramines were present at the upper and lower ends of the conveyor and between Site 19 and Site 9. Detections of nitramines diminished closer to Site 9.

4.4 References

Baker Environmental, Inc. 1995. Draft Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin, Naval Weapons Station Yorktown, Yorktown, Virginia. April, 1995.

United States Environmental Protection Agency. 1989. Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A) Interim Final. Office of Solid Waste and Emergency Response. Washington, D.C. December 1989. EPA/540/1-89-002.

SECTION 4.0 TABLES

**TABLE 4-1
DATA QUALIFIER DEFINITIONS AND NOTES
SITES 09, and 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

QUALIFIER DEFINITIONS

(NO CODE) = Confirmed identification.

B = Not detected substantially above the level reported in laboratory or field blanks.

J = Analyte present. Reported value may not be accurate or precise.

K = Analyte present. Reported value may be biased high. Actual value is expected lower.

L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.

N = Tentative identification. Consider present. Special methods may be needed to confirm its presence or absence in future sampling efforts.

R = Unreliable result. Analyte may or may not be present in the sample. Supporting data necessary to confirm result.

U = Not detected. The associated number indicates approximate sample concentration necessary to be detected.

UJ = Not detected. Quantitation limit may be inaccurate or imprecise.

UL = Not detected. Quantitation limit is probably higher.

NOTES

mg/kg = milligrams per kilogram.

mg/l = milligrams per liter.

ug/kg = micrograms per kilogram.

ug/l = micrograms per liter.

NA = Not analyzed.

TABLE 4-2

STATION-WIDE AND SITE-SPECIFIC BACKGROUND INORGANIC
CONCENTRATIONS DETECTED IN SURFACE AND SUBSURFACE SOILS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Station-Wide Surface	Station-Wide Subsurface	Site-Specific Surface
Aluminum	1,960 - 19,200	2,710 - 28,200	3,560 - 8,380
Antimony	9.2L - 11L	8.5L - 31.3L	ND
Arsenic	0.46L - 63.9	0.23J - 42.7	0.97 - 2.1
Barium	4.2J - 80.2	10.6J - 66.9	18.5 - 37.2
Beryllium	0.23J - 0.93J	0.3J - 9.8	0.31 - 0.55
Cadmium	1.3K - 1.5	ND	ND
Chromium	2.6 - 18.3	5.2L - 33.5	4.1K - 6.9K
Cobalt	1J - 6.7J	0.97J - 156	1.3 - 4.5
Copper	1.2J - 24.4	2J - 15	1.7 - 3.4
Cyanide	NA	0.6K	ND
Iron	1,440 - 19,900	1,385 - 51,100J	3,040 - 5,790J
Lead	6.4 - 43.1	3.6L - 25.5L	12.7K - 19.3K
Magnesium	61.5J - 1,610	136J - 2,870	174 - 247
Manganese	7.6L - 491	3.5J - 2,940	106 - 188
Mercury	ND	ND	0.14K
Nickel	3.8J - 11.9	4.2J - 145	2.5 - 4.8
Potassium	398J - 1,640J	3,92J - 2,560	135 - 210
Selenium	0.26L - 0.55L	0.26L - 0.75L	0.35
Silver	1J - 2.1J	1.1J - 2.4J	0.51 - 0.59
Sodium	13.9J - 115J	17.2J - 2,180	9.4 - 23.6
Thallium	ND	0.44K	ND
Vanadium	6.1J - 34.7	7.8J - 70.3K	9.6 - 16.2
Zinc	3.2KJ - 48.4	3.6J - 330	7.0 - 22.9

Notes:

- All values in mg/kg (parts-per-million)
- Site-specific values obtained from locations 9HA90-00, 19HA08-00, 19HA09-00 and 19HA09-00D (Duplicate of HA09-00).

TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9HA01-00	9HA01-00D	9HA02-00	9HA03-00	9HA04-00	9HA05-00
DATE SAMPLED	09/10/95	09/10/95	09/10/95	09/10/95	09/10/95	09/10/95
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
PH	6.0	6.0	6.8	7.2	6.5	NA
ANALYTES (mg/kg)						
ALUMINUM	5030	5940	7520	5490	7750	6720
ARSENIC	15.7 K	15.5 K	16 K	20 K	23.3 K	17.2 L
BARIUM	32.1	21	25.7	31.2	45.6	32
BERYLLIUM	0.3 U	0.28 U	0.38 U	0.36 U	0.35 U	0.37 UL
CADMIUM	0.81 K	0.69 U	1.5 K	1.6 K	1.8 K	0.7 U
CALCIUM	1030 J	1010 J	2080 J	2580 J	2810 J	1840
CHROMIUM	12.7	12.7	19.7	20.8	29.8	24
COBALT	2.3	2	3.3	3.4	4.2	1.6
COPPER	5.7	5.2	12.7	18.7	26.1	15.4
IRON	10500	10700	14400	15400	18200	14000
LEAD	16	14.6 K	23.3 K	56.2	68.4	42.8 L
MAGNESIUM	299	332	396	422	509	377 J
MANGANESE	66.8	68.5	92	125	204	53.6
NICKEL	3.7	4.4	4.2	7.6	11	5.2 L
POTASSIUM	370	412	495	379	430	450
SELENIUM	0.34 UL	0.31 UL	0.38 UL	0.44 UL	0.47 L	0.43 K
SODIUM	24.2	29.6	35	33	28.5	40
VANADIUM	21.8	22.6	27	46.3	62.4	38.7 J
ZINC	28.6	28.9	55	112	128	80.8

Refer to Table 4-1 for data qualifiers and notes.

**TABLE 4-3
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

LOCATION	9HA06-00	9HA07-00	9HA08-00	9HA08-00D
DATE SAMPLED	09/10/95	09/10/95	09/07/95	09/07/95
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'
PH	NA	NA	NA	NA
ANALYTES (mg/kg)				
ALUMINUM	5810	4060	3160	4880
ARSENIC	22 L	15.9 L	1.6	1.1
BARIUM	38.8	19	23.4	28.1
BERYLLIUM	0.36 UL	0.37 UL	0.47	0.38
CADMIUM	1.1	0.69 U	0.65 U	0.66 U
CALCIUM	4430	2820	266	216
CHROMIUM	21.6	9.1 L	6.7 K	6.9 K
COBALT	3.3	2.1	2.7	3.2
COPPER	21.4	5.2	2.4	2.6
IRON	20200	18300	5650	5080
LEAD	53.8 L	15.3 L	9.7 K	10.2 K
MAGNESIUM	612 J	252 J	172	261
MANGANESE	179	153	141	152
NICKEL	6 L	3.6 L	2.6	4.1
POTASSIUM	598	347	149	216
SELENIUM	0.47 U	0.4 K	0.31 U	0.32 U
SODIUM	80.6	26.6	13.6	15
VANADIUM	68.6 J	24.8 J	12.5	11.9
ZINC	133	23.9	10.6	13.1

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-4
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9HA01-00	9HA01-00D	9HA02-00	9HA03-00	9HA04-00	9HA05-00
DATE SAMPLED	09/10/95	09/10/95	09/10/95	09/10/95	09/10/95	09/10/95
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
SEMIVOLATILES (ug/kg)						
DIMETHYLPHTHALATE	390 U	400 U	460 U	870	410 U	450 U
ACENAPHTHYLENE	390 U	400 U	460 U	58 J	410 U	450 U
ACENAPHTHENE	390 U	400 U	460 U	69 J	410 U	450 U
DIBENZOFURAN	390 U	400 U	460 U	49 J	410 U	450 U
FLUORENE	390 U	400 U	460 U	75 J	410 U	450 U
PHENANTHRENE	91 J	130 J	180 J	1100	530	350 J
ANTHRACENE	390 U	400 U	460 U	230 J	100 J	58 J
CARBAZOLE	390 U	400 U	460 U	140 J	79 J	47 J
DI-N-BUTYLPHTHALATE	210 J	240 J	250	240	230	1000
FLUORANTHENE	180 J	250 J	360 J	1400	780	630
PYRENE	200 J	260 J	470	1800	1100	510
BUTYLBENZYLPHTHALATE	390 U	400 U	460 U	470 U	410 U	450 U
BENZO(A)ANTHRACENE	87 J	110 J	200 J	850	500	270 J
CHRYSENE	140 J	180 J	290 J	1100	660	370 J
BIS(2-ETHYLHEXYL)PHTHALATE	390 U	200	460 U	85	94	48 J
BENZO(B)FLUORANTHENE	160 J	190 J	330 J	1100	740	430 J
BENZO(K)FLUORANTHENE	77 J	90 J	130 J	520	290 J	210 J
BENZO(A)PYRENE	94 J	120 J	190 J	830	500	270 J
INDENO(1,2,3-CD)PYRENE	74 J	88 J	150 J	550	390 J	260 J
DIBENZO(A,H)ANTHRACENE	390 U	400 U	460 U	130 J	86 J	55 J
BENZO(G,H,I)PERYLENE	74 J	84 J	150 J	530	330 J	220 J
PESTICIDE/PCBs (ug/kg)						
HEPTACHLOR EPOXIDE	1.6 J	1.6 J	3.7 J	2.3 U	2.1 U	2.3 U
4,4'-DDE	2.4 J	2 J	5.1	4.7 U	4.1 U	4.5 U
4,4'-DDT	4 U	5.6 J	2.8 J	4.7 U	4.1 U	3.2 NJ
EXPLOSIVES (ug/kg)						
2,4,6-TNT	120 U	120 U	210	430	540	290
AMINO-DNTS	200 U	200 U	210	230	1500	200 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-4
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED DEPTH	9HA06-00 09/10/95 0-0.5'	9HA07-00 09/10/95 0-0.5'	9HA08-00 09/07/95 0-0.5'	9HA08-00D 09/07/95 0-0.5'
SEMIVOLATILES (ug/kg)				
DIMETHYLPHTHALATE	520 U	420 U	350 U	350 U
ACENAPHTHYLENE	520 U	420 U	350 U	350 U
ACENAPHTHENE	120 J	420 U	350 U	350 U
DIBENZOFURAN	77 J	420 U	350 U	350 U
FLUORENE	120 J	420 U	350 U	350 U
PHENANTHRENE	1600	420 U	350 U	76 J
ANTHRACENE	310 J	420 U	350 U	350 U
CARBAZOLE	250 J	420 U	350 U	350 U
DI-N-BUTYLPHTHALATE	1200	1600	1200	750
FLUORANTHENE	2200	65 J	350 U	160 J
PYRENE	2000	66 J	35 J	120 J
BUTYLBENZYLPHTHALATE	55	100 J	88	310
BENZO(A)ANTHRACENE	1100	420 U	350 U	350 U
CHRYSENE	1200	43 J	350 U	75 J
BIS(2-ETHYLHEXYL)PHTHALATE	130 J	420 U	350 U	350 U
BENZO(B)FLUORANTHENE	2200	58 J	350 U	63 J
BENZO(K)FLUORANTHENE	190 J	420 U	350 U	350 U
BENZO(A)PYRENE	1200	420 U	350 U	350 U
INDENO(1,2,3-CD)PYRENE	170 J	420 U	350 U	350 U
DIBENZO(A,H)ANTHRACENE	160 J	420 U	350 U	350 U
BENZO(G,H,I)PERYLENE	770	420 U	350 U	350 U
PESTICIDE/PCBs (ug/kg)				
HEPTACHLOR EPOXIDE	2.6 U	2.1 U	1.8 U	1.8 U
4,4'-DDE	5.2 U	4.2 U	3.5 U	3.5 U
4,4'-DDT	5.2 U	4.2 U	3.5 U	3.5 U
EXPLOSIVES (ug/kg)				
2,4,6-TNT	530 NJ	120 U	120 U	120 U
AMINO-DNTS	200 U	200 U	200 U	200 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-5
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9HA01-01	9HA02-01	9HA03-01	9HA04-01	9HA05-01	9HA05-01D
DATE SAMPLED	09/10/95	09/10/95	09/10/95	09/10/95	09/10/95	09/10/95
DEPTH	0.5-1'	0.5-1'	0.5-1'	0.5-1'	0.5-1'	0.5-1'
ANALYTES (mg/kg)						
ALUMINUM	3220	7100	4980	12900	7780	10100
ANTIMONY	3.4 UL	4.5 UL	5.3 L	5.1 L	4.2 UL	4.9 UL
ARSENIC	13.6 K	19.1 K	12.9 K	54.7 K	6.7 L	30.8 L
BARIUM	13.1	25.5	24.2	119	36.3	47.5
BERYLLIUM	0.28 U	0.37 U	0.35 U	0.35 U	0.35 UL	0.41 UL
CADMIUM	0.88 K	1.3 K	1.2 K	1.5	0.65 U	0.76 U
CALCIUM	577 J	1310 J	1760 J	2840 J	2610	2360
CHROMIUM	14.2	17.5	17.6	26.7	23.1	23
COBALT	1.8	2.9	3.2	5.9	2.6	2.4
COPPER	3.3	8	12.4	11.7	11.3	13.3
IRON	10600	14400	12600	30000	15600	18200
LEAD	10.7	20.4	41.6	39.3	20.1 L	30.9 L
MAGNESIUM	165	325	333	785	334 J	366 J
MANGANESE	48.6	109	61	214	29.8	33.8
NICKEL	2.7	6	6.3	10.2	4.1 L	3.3 L
POTASSIUM	285	338	354	867	510	404
SELENIUM	0.28 UL	0.31 UL	0.39 L	0.41 UL	0.66 K	0.86 K
SODIUM	18.1	32.6	31.4	54.7	39.9	51.7
VANADIUM	20.5	26	35.6	43.8	34.6 J	38.7 J
ZINC	20.1	40.9	74.4	82	75.3	75.5

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-5
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9HA06-01	9HA07-01	9HA08-02	9SB01-01	9SB01-01D	9SB01-05
DATE SAMPLED	09/10/95	09/10/95	09/07/95	09/10/95	09/10/95	09/10/95
DEPTH	0.5-1'	0.5-1'	2-4'	1-3'	1-3'	9-11'
ANALYTES (mg/kg)						
ALUMINUM	12100	5910	5510	8220	5680	8000
ANTIMONY	7.3 UL	3.2 UL	3.5 R	3.1 U	3.5	3.7 U
ARSENIC	29.3 L	37.2 L	0.84	4.5	2.2	3.6
BARIUM	78	18.9	52.2	43.8	38.1	21.5
BERYLLIUM	0.61 UL	0.68 L	0.83	0.26	0.37	1
CADMIUM	4.5	0.61	0.71 U	0.62 U	0.69 U	0.75 U
CALCIUM	7000	1750	122	458	366	1410
CHROMIUM	44	20.3	5.8 K	15.4	10.7	30.5
COBALT	7.3	7.2	6.9	4.8	6.1	14.6
COPPER	81.9	4.9	1.7	1.9	1.6	5
IRON	31600	49600	4450	10100	8200	38800
LEAD	124 L	11.5 L	5.2 K	8.5	6.6	8.6
MAGNESIUM	902 J	345 J	251	528	362	1830
MANGANESE	183	376	244	75.7	97.5	380
NICKEL	25.2	6.1 L	5.3	5.7	4.3	11.5
POTASSIUM	641	297	163	440	248	2360
SELENIUM	1.5 K	0.37 U	0.3 U	0.28 U	0.3 U	0.35 U
SODIUM	97.5	31.1	10.7	21.4	26.1	37
VANADIUM	219 J	29.6 J	8.5	21.6	15	25.5
ZINC	400	38	9.9	14.3	11.1	48.4

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-5
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9SB02-01	9SB02-05	9SB03-01	9SB03-04	9SB03-04D	9SB04A-01
DATE SAMPLED	09/11/95	09/11/95	09/12/95	09/12/95	09/12/95	09/10/95
DEPTH	1-3'	9-11'	1-3'	7-9'	7-9'	1-3'
ANALYTES (mg/kg)						
ALUMINUM	7970	8040	5790	7350	10600	8150
ANTIMONY	3.4 UL	3.3 UL	3.3 UL	3.8 UL	3.4 UL	4.1 U
ARSENIC	19.4	5.5	8.3	29.5	18.3	8.9
BARIUM	29.4	29.9	23.9 J	17.2 J	27.2 J	19.3
BERYLLIUM	0.63 L	0.28 UL	0.32 L	1.2 L	1 L	0.34 U
CADMIUM	0.53 U	0.52 U	0.68 U	1.1	0.85	0.86
CALCIUM	1040	349	771	916	531	337
CHROMIUM	18.2	9.3 L	18.3	20.7	34.9	18.6
COBALT	6.4	1.7	1.9	6.7	5.2	3.1
COPPER	4.5	2.6	4.5	5.5	6.1	2.7
IRON	39800	9640	29400	74300	57000	19100
LEAD	12.8	7.8	9.4 L	9.3 L	8.5 L	10
MAGNESIUM	481	422	295	348	507	300
MANGANESE	281	66.9	134 J	755 J	144 J	18.5
NICKEL	5.4 L	2.1 UL	2.3 L	7.5 L	5.5 L	3.7
POTASSIUM	559	320	402	488	615	454
SELENIUM	0.5 L	0.31 UL	0.3 UL	0.33 UL	0.37 UL	0.29
SODIUM	29.8	26.5	23.3	29.4	32.5	25.4
VANADIUM	32.4 J	20 J	32.5	37.5	41.7	37.9
ZINC	31.2 J	9.7 J	16.7	55.6	58.7	10.4

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-5
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9SB04A-05
DATE SAMPLED	09/10/95
DEPTH	9-11'

ANALYTES (mg/kg)	
ALUMINUM	17000
ANTIMONY	4.2 U
ARSENIC	40
BARIUM	54.2
BERYLLIUM	4.1
CADMIUM	2.1
CALCIUM	154
CHROMIUM	46.5
COBALT	41.4
COPPER	10.1
IRON	97000
LEAD	16
MAGNESIUM	1420
MANGANESE	343
NICKEL	41.9
POTASSIUM	1590
SELENIUM	0.36 U
SODIUM	33.2
VANADIUM	66.7
ZINC	128

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-6
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9HA01-01	9HA02-01	9HA03-01	9HA04-01	9HA05-01	9HA05-01D
DATE SAMPLED	09/10/95	09/10/95	09/10/95	09/10/95	09/10/95	09/10/95
DEPTH	0.5-1'	0.5-1'	0.5-1'	0.5-1'	0.5-1'	0.5-1'
VOLATILES (ug/kg)						
ACETONE	11 U	13 U	14 U	14 U	14 U	15 U
SEMIVOLATILES (ug/kg)						
NAPHTHALENE	380 U	430 U	450 U	440 U	460 U	500 U
ACENAPHTHENE	380 U	430 U	54 J	44 J	460 U	500 U
DIBENZOFURAN	380 U	430 U	65 J	440 U	460 U	500 U
2,4-DINITROTOLUENE	380 U	430 U	450 U	47 J	460 U	500 U
FLUORENE	380 U	430 U	140 J	440 U	460 U	500 U
PHENANTHRENE	380 U	72 J	1300	590	220 J	370 J
ANTHRACENE	380 U	430 U	170 J	100 J	460 U	62 J
CARBAZOLE	380 U	430 U	150 J	85 J	460 U	53 J
DI-N-BUTYLPHTHALATE	570	210	230	200	720	1200
FLUORANTHENE	45 J	140 J	1300	810	380 J	610
PYRENE	54 J	180 J	1500	910	320 J	530
BUTYLBENZYLPHTHALATE	380 U	430 U	450 U	440 U	340	500 U
BENZO(A)ANTHRACENE	380 U	68 J	690	510	150 J	270 J
CHRYSENE	48 J	110 J	760	610	200 J	350 J
BIS(2-ETHYLHEXYL)PHTHALATE	380 U	430 U	77	440 U	73 J	500 U
BENZO(B)FLUORANTHENE	59 J	110 J	860	660	270 J	460 J
BENZO(K)FLUORANTHENE	380 U	64 J	270 J	250 J	130 J	200 J
BENZO(A)PYRENE	380 U	72 J	580	460	160 J	290 J
INDENO(1,2,3-CD)PYRENE	380 U	53 J	480	350 J	160 J	290 J
DIBENZO(A,H)ANTHRACENE	380 U	430 U	110 J	91 J	460 U	51 J
BENZO(G,H,I)PERYLENE	380 U	58 J	450	310 J	140 J	240 J
PESTICIDE/PCBs (ug/kg)						
HEPTACHLOR EPOXIDE	1.9 UL	2.2 J	2.2 U	2.2 U	2.3 U	2.5 U
4,4'-DDE	3.8 UL	6.5	4.4 J	3.6 J	2.7 J	4 J
ENDRIN	3.8 UL	4.3 U	4.4 UJ	4.5 UJ	4.6 U	5.1 U
4,4'-DDD	3.8 UL	4.3 U	4.4 U	4.5 U	4.1 J	7.1
4,4'-DDT	3.8 UL	3 J	4.4 U	4.5 U	5	3 NJ
EXPLOSIVES (ug/kg)						
2,4,6-TNT	850	140	120 U	7100 NJ	400	400
AMINO-DNTS	200 U	70 J	200 U	42000 NJ	200 U	200 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-6
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9HA06-01	9HA07-01	9HA08-02	9SB01-01	9SB01-01D	9SB01-05
DATE SAMPLED	09/10/95	09/10/95	09/07/95	09/10/95	09/10/95	09/10/95
DEPTH	0.5-1'	0.5-1'	2-4'	1-3'	1-3'	9-11'
VOLATILES (ug/kg)						
ACETONE	22 U	13 U	10 U	12 U	11 U	12 U
SEMIVOLATILES (ug/kg)						
NAPHTHALENE	86 J	420 U	340 U	370 U	350 U	380 U
ACENAPHTHENE	140 J	420 U	340 U	370 U	350 U	380 U
DIBENZOFURAN	110 J	420 U	340 U	370 U	350 U	380 U
2,4-DINITROTOLUENE	740 U	420 U	340 U	370 U	350 U	380 U
FLUORENE	160 J	420 U	340 U	370 U	350 U	380 U
PHENANTHRENE	2600	87 J	340 U	370 U	350 U	380 U
ANTHRACENE	370 J	420 U	340 U	370 U	350 U	380 U
CARBAZOLE	370 J	420 U	340 U	370 U	350 U	380 U
DI-N-BUTYLPHTHALATE	1500	1800 J	1100	340 J	210 J	530
FLUORANTHENE	3500	370 J	340 U	370 U	350 U	380 U
PYRENE	3700	430 J	340 U	370 U	350 U	380 U
BUTYLBENZYLPHTHALATE	91	260 J	380	370 U	350 U	380 U
BENZO(A)ANTHRACENE	1700	200 J	340 U	370 U	350 U	380 U
CHRYSENE	1900	240 J	340 U	370 U	350 U	380 U
BIS(2-ETHYLHEXYL)PHTHALATE	410 J	420 U	340 U	55 J	160 J	200 J
BENZO(B)FLUORANTHENE	2500	290 J	340 U	370 U	350 U	380 U
BENZO(K)FLUORANTHENE	980	120 J	340 U	370 U	350 U	380 U
BENZO(A)PYRENE	1700	210 J	340 U	370 U	350 U	380 U
INDENO(1,2,3-CD)PYRENE	1000	150 J	340 U	370 U	350 U	380 U
DIBENZO(A,H)ANTHRACENE	270 J	420 U	340 U	370 U	350 U	380 U
BENZO(G,H,I)PERYLENE	1000	140 J	340 U	370 U	350 U	380 U
PESTICIDE/PCBs (ug/kg)						
HEPTACHLOR EPOXIDE	3.7 U	2.1 U	1.7 U	1.9 U	1.8 U	2 U
4,4'-DDE	7.4 U	4.2 U	3.4 U	3.8 U	3.6 U	3.9 U
ENDRIN	7.4 U	4.2 U	3.4 U	3.8 U	3.6 U	3.9 U
4,4'-DDD	7.4 U	4.2 U	3.4 U	3.8 U	3.6 U	3.9 U
4,4'-DDT	7.4 NJ	4.2 U	3.4 U	3.8 U	3.6 U	3.9 U
EXPLOSIVES (ug/kg)						
2,4,6-TNT	33000	120 U	120 U	120 U	120 U	120 U
AMINO-DNTS	200 U	200 U				

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-6
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9SB02-01	9SB02-05	9SB03-01	9SB03-04	9SB03-04D	9SB04A-01
DATE SAMPLED	09/11/95	09/11/95	09/12/95	09/12/95	09/12/95	09/10/95
DEPTH	1-3'	9-11'	1-3'	7-9'	7-9'	1-3'
VOLATILES (ug/kg)						
ACETONE	11 U	120	11 U	100 J	71 J	11 U
SEMIVOLATILES (ug/kg)						
NAPHTHALENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
ACENAPHTHENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
DIBENZOFURAN	360 U	380 U	370 UJ	380 UJ	380 U	380 U
2,4-DINITROTOLUENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
FLUORENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
PHENANTHRENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
ANTHRACENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
CARBAZOLE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
DI-N-BUTYLPHTHALATE	490	410	1600 J	1200 J	570	210 J
FLUORANTHENE	54 J	380 U	370 UJ	380 UJ	380 U	380 U
PYRENE	63 J	380 U	370 UJ	380 UJ	380 U	380 U
BUTYLBENZYLPHTHALATE	360 U	380 U	40 J	380 UJ	380 U	380 U
BENZO(A)ANTHRACENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
CHRYSENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
BIS(2-ETHYLHEXYL)PHTHALATE	360 U	110 J	120 J	230 J	340 J	380 U
BENZO(B)FLUORANTHENE	39 J	380 U	370 UJ	380 UJ	380 U	380 U
BENZO(K)FLUORANTHENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
BENZO(A)PYRENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
INDENO(1,2,3-CD)PYRENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
DIBENZO(A,H)ANTHRACENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
BENZO(G,H,I)PERYLENE	360 U	380 U	370 UJ	380 UJ	380 U	380 U
PESTICIDE/PCBs (ug/kg)						
HEPTACHLOR EPOXIDE	1.8 U	1.8 U	1.8 U	1.9 U	1.9 U	1.9 U
4,4'-DDE	3.6 U	3.7 U	3.7 U	3.8 U	3.8 U	3.8 U
ENDRIN	3.6 U	2.6 J	3.7 U	3.8 U	3.8 U	3.8 U
4,4'-DDD	3.6 U	3.7 U	3.7 U	3.8 U	3.8 U	3.8 U
4,4'-DDT	3.6 U	4.1 NJ	3.7 U	3.8 U	3.8 U	3.8 U
EXPLOSIVES (ug/kg)						
2,4,6-TNT	120 U	120 U				
AMINO-DNTS	200 U	200 U				

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-6
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9SB04A-05
DATE SAMPLED	09/10/95
DEPTH	9-11'
VOLATILES (ug/kg)	
ACETONE	13 U
SEMIVOLATILES (ug/kg)	
NAPHTHALENE	440 U
ACENAPHTHENE	440 U
DIBENZOFURAN	440 U
2,4-DINITROTOLUENE	440 U
FLUORENE	440 U
PHENANTHRENE	440 U
ANTHRACENE	440 U
CARBAZOLE	440 U
DI-N-BUTYLPHTHALATE	380 J
FLUORANTHENE	440 U
PYRENE	440 U
BUTYLBENZYLPHTHALATE	440 U
BENZO(A)ANTHRACENE	440 U
CHRYSENE	440 U
BIS(2-ETHYLHEXYL)PHTHALATE	230 J
BENZO(B)FLUORANTHENE	440 U
BENZO(K)FLUORANTHENE	440 U
BENZO(A)PYRENE	440 U
INDENO(1,2,3-CD)PYRENE	440 U
DIBENZO(A,H)ANTHRACENE	440 U
BENZO(G,H,I)PERYLENE	440 U
PESTICIDE/PCBs (ug/kg)	
HEPTACHLOR EPOXIDE	2.2 U
4,4'-DDE	4.4 U
ENDRIN	4.4 U
4,4'-DDD	4.4 U
4,4'-DDT	4.4 U
EXPLOSIVES (ug/kg)	
2,4,6-TNT	120 U
AMINO-DNTS	200 U

Refer to Table 4-1 for data qualifiers and notes.

**TABLE 4-7
DEEP SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

LOCATION DATE SAMPLED DEPTH	9SB01-07 09/10/95 13-15' 8.2	9SB02B-06 09/11/95 11-13' 5.4	9SB03-06 09/12/95 11-13' 7.9	9SB04A-09 09/10/95 17-19' NA
ORGANICS (mg/kg)				
ARSENIC	5350	7380	8500	2770
BARIUM	8.1	2.3	12.9	4.4
BORON	21.7	20.7	13.8 J	27.4 J
BROMINE	1	0.54 U	0.86 U	0.83 U
CHLORINE	34500	429	184	96500
COPPER	26	10.5 L	13.7	16.1
CADMIUM	4.7	1.1	0.51 U	2.9
CHROMIUM	3.7	2.2	4.9	3.1
COBALT	17900	9990	14300	12000
COBALT	5.5	8.4	11.8 L	4.3 L
CHROMIUM	2310	342	360	1500
MANGANESE	208	35.3	21.2 J	53.7 J
NICKEL	10.1	2.2 UL	2.7 UL	4.3 L
POTASSIUM	2250	447	678	1040
SODIUM	302	24.6	37.1	843
RADIUM	16	25.8 J	29.5	9.6
ZINC	35.9	7.3 J	10.6	24

Refer to Table 4-1 for data qualifiers and notes.

**TABLE 4-8
DEEP SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

LOCATION	9SB01-07	9SB02B-06	9SB03-06	9SB04A-09
DATE SAMPLED	09/10/95	09/11/95	09/12/95	09/10/95
DEPTH	13-15'	11-13'	11-13'	17-19'
VOLATILES (ug/kg)				
ACETONE	14 U	54 J	44 J	12 U
SEMIVOLATILES (ug/kg)				
PENTACHLOROPHENOL	1100 U	920 U	1000 U	1000 J
DI-N-BUTYLPHTHALATE	240 J	520	730	1300 J
BIS(2-ETHYLHEXYL)PHTHALATE	63 J	370 U	41 J	400 UJ

Refer to Table 4-1 for data qualifiers and notes.

**TABLE 4-9
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
TOTAL INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

LOCATION DATE SAMPLED	9GW01-01 10/03/95	9GW02-01 10/03/95	9GW02-01D 10/03/95	9GW03-01 10/04/95
ANALYTES (ug/L)				
ALUMINUM	858	97.1	74	11800 J
ARSENIC	1.8 U	27.6	28.4	3.1 L
BARIUM	41.3	408	432	57.7
CALCIUM	115000	84200	87600	115000
CHROMIUM	3.8 U	3.8 U	3.8 U	34.3 J
COBALT	1.1 U	8.6	8.6	4.5
COPPER	2.3 U	2.3 U	2.3 U	6.8
IRON	1030	40600	42500	27000
LEAD	1.4 K	8.9	8.4	11.6 K
MAGNESIUM	2290	21500	22800	3820
MANGANESE	58.9	396	415	230
NICKEL	4.8 U	5.5	7.2	11.1 U
POTASSIUM	1460	32900	34500	2790
SODIUM	7380	25400	26800	5210
VANADIUM	1.5 U	1.5 U	1.5 U	41.2
ZINC	6.8	378	402	39.9
CYANIDE	10 U	246	277	10 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-10
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	9GW01F-01 10/03/95	9GW02F-01 10/03/95	9GW02F-01D 10/03/95	9GW03F-01 10/04/95
ANALYTES (ug/L)				
ALUMINUM	21.4	12.5 U	12.5 U	18.1 U
ARSENIC	1.8 U	25.6	25.9	1.8 R
BARIUM	38.7	419	391	29
CALCIUM	113000	88000	81900	109000
COBALT	1.1 U	8.4	7.5	3.4 U
COPPER	2.3 U	2.3 U	5.2	2.4
IRON	455	37300	36700	95.9
MAGNESIUM	2410	21900	21300	2950
MANGANESE	73.7	413	388	193
NICKEL	4.8 U	6.1	4.8 U	12.3
POTASSIUM	1600	34400	32000	1780
SODIUM	8010	27700	24800	5070
ZINC	4.3	402	368	5.3

Refer to Table 4-1 for data qualifiers and notes.

**TABLE 4-11
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

LOCATION DATE SAMPLED	9GW01-01 10/02/95	9GW02-01 10/03/95	9GW02-01D 10/03/95	9GW03-01 10/04/95
SEMIVOLATILES (ug/L)				
2,4-DINITROTOLUENE	10 U	2 J	2 J	10 U
BIS(2-ETHYLHEXYL)PHTHALATE	3 J	10 U	10 U	10 U
EXPLOSIVES (ug/L)				
AMINO-DNTS	0.25 U	4400	4200	0.2 U
2,4,6-TNT	0.16 U	830	880	0.13 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-12
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
TOTAL INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

ANION	9GW02A-01 10/03/95	9GW04A-01 10/05/95
CHLORIDE	214	94.7 J
SULFATE	1.8 U	2.2 L
NITRATE	27.1	82.3
AMMONIUM	70300	103000
PHOSPHATE	30	668
ARSENIC	3030	4030
CADMIUM	4.1	54.2
COBALT	2290	2550
COPPER	8090	6570
IRON	12.8	3.2 U
MANGANESE	10.5	10 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-13
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9GW02AF-01	9GW04AF-01
DATE SAMPLED	10/03/95	10/05/95
ANALYTES (ug/L)		
ALUMINUM	140	18.1 U
ARSENIC	1.8	1.8 R
BARIUM	22.9	78.8
CALCIUM	55500	98500
COPPER	2.3 U	7.2
IRON	29.2	132
MAGNESIUM	3050	3870
MANGANESE	2	51.8
POTASSIUM	2410	1980
SODIUM	8630	6490
VANADIUM	12	3.2 U
ZINC	6.8	3.1 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-14
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	9GW02A-01	9GW04A-01
DATE SAMPLED	10/03/95	10/05/95
VOLATILES (ug/L)		
CHLOROFORM	11	10 U
SEMIVOLATILES (ug/L)		
PHENOL	44	10 U
BIS(2-ETHYLHEXYL)PHTHALATE	10	10 U
EXPLOSIVES (ug/L)		
1,3,5-TRINITROBENZENE	0.79	0.11 U
AMINO-DNTS	2.6	0.18 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-15
SEDIMENT - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED DEPTH	9SD08-01 09/07/95 0-4" 7.1	9SD08-02 09/07/95 4-8" 7.2	9SD09-01 09/06/95 0-4" 7.2	9SD09-02 09/06/95 4-8" 7.3	9SD10-01 09/06/95 0-4" 8	9SD10-02 09/06/95 4-8" 7.6
ANALYTES (mg/kg)						
ALUMINUM	4260	4460	3700	5490	1690	2000
ARSENIC	49.4 J	55.5 J	9 J	8.5 J	6.7 J	22.4 J
BARIUM	22.6 J	16.2 J	54.9 J	26.5 J	7.2 J	9.4 J
BERYLLIUM	0.51	0.35	0.54	0.85	0.26	0.33
BISMUTH	1.9 K	0.77 U	0.95 U	1.7	0.94 U	1 K
CADMIUM	10100 J	2100 J	17500 J	1640 J	7420 J	6090 J
CROMIUM	17.6	21.1	18.6	47.3	8.7	17.5
COPPER	4.1	2.3	2.7	5.2	1.6	2
COPPER	22	8.6 L	4.9 L	9 L	1.3 L	2 L
COPPER	23400	25300	24200	54400	11100	21200
COPPER	45.5	21.2 J	13.3 J	109	7.9 J	12.9 J
COPPER	369	227	432	282	610	332
COPPER	62.7	83.6	51.5	52.4	52.6	64.3
COPPER	6.1	2.7	3.2	4.6	1.5	2.4
COPPER	245	267	429	355	99.7	142
COPPER	0.84 U	0.5 U	0.66	0.58 U	0.61 U	0.56 U
COPPER	73.5	19.7	164	20.1	58	53
COPPER	23.5	17.5	43.4	33.7	13.1	28.6
COPPER	147	56.9	51.3	133	30.8	34.2

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-15
SEDIMENT - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

CATION	9SD11-01	9SD11-01D	9SD11-02
DATE SAMPLED	09/06/95	09/06/95	09/06/95
DEPTH	0-4"	0-4"	4-8"
	7.1	7.2	7.2
ALYTES (mg/kg)			
ALUMINUM	2730	4100	6320
ARSENIC	9.2 J	9.7 J	5.7 J
BARIUM	22.1 J	23.7 J	38.6 J
BERYLLIUM	0.33	0.37	0.61
BISMUTH	0.85 U	0.82 K	1.2 K
CADMIUM	4270 J	3220 J	16400 J
COPPER	11.1	14.7	19.9
CHROMIUM	2.3	3.1	5.1
COBALT	8.6 L	7.5 L	7.7 L
COPPER	15600	15400	19400
LEAD	18.9	22.5 J	11.4 J
MAGNESIUM	251	491	994
MANGANESE	74.6	73.4	85.5
MERCUY	4	3.9	9
POTASSIUM	204	585	864
SILVER	0.55 U	0.51 U	0.7 U
SODIUM	71.4	41.2	64.1
ZINC	28.9	26.6	33.7
CHLORIDE	94.8	107	59.7

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-16
SEDIMENT - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED DEPTH	9SD08-01 09/07/95 0-4"	9SD08-02 09/07/95 4-8"	9SD09-01 09/06/95 0-4"	9SD09-02 09/06/95 4-8"	9SD10-01 09/06/95 0-4"	9SD10-02 09/06/95 4-8"
NONVOLATILES (ug/kg)						
BENZENE	36	20 J	54 J	20 J	13 U	13 U
1,2-DICHLOROBENZENE	18 U	4 J	13 U	3 J	13 U	13 U
1,4-DICHLOROBENZENE	18 U	14 U	13 U	13 U	13 U	13 U
SEMIVOLATILES (ug/kg)						
1,2-DICHLOROETHANE	150 J	460 U	440 U	77 J	420 U	440 U
1,2,3,4-TETRACHLOROBENZENE	220 J	460 U	440 U	130 J	420 U	440 U
1,2,3,4-TETRACHLOROPENTHANE	190 J	460 U	440 U	50 J	420 U	440 U
1,1-DICHLOROETHANE	590 U	460 U	440 U	3700	420 U	440 U
1,1-DICHLOROETHANE	420 J	460 U	52 J	150 J	420 U	440 U
1-METHYLNAPHTHENE	3200 J	130 J	1000	2600 J	57 J	260 J
1,2,3,4-TETRACHLOROPENTHANE	510 J	460 U	190 J	750 J	420 U	54 J
1,2,4-TRICHLOROBENZENE	180 J	460 U	160 J	250 J	420 U	440 U
1,2,4-TRICHLOROPENTHANE	290	200 J	300 J	300	200	220
1,2,4-TRICHLOROPENTHANE	4600	250 J	1500	4000	79 J	420 J
1,2,4-TRICHLOROPENTHANE	3300	200 J	1400	2900 J	76 J	270 J
1,2,4-TRICHLOROPENTHANE	590 U	460 U	440 U	430 UJ	420 U	440 U
1,2,4-TRICHLOROPENTHANE	2100	100 J	710	2400 J	42 J	180 J
1,2,4-TRICHLOROPENTHANE	2600	150 J	900	2400 J	54 J	210 J
(2-ETHYLHEXYL)PHTHALATE	61	460 U	440 U	430 UJ	420 U	440 U
1,2,4-TRICHLOROPENTHANE	2500	460 U	790	2600	60 J	240 J
1,2,4-TRICHLOROPENTHANE	940	460 U	380 J	970	420 U	110 J
1,2,4-TRICHLOROPENTHANE	1200	460 U	560	2100	46 J	180 J
1,2,4-TRICHLOROPENTHANE	1100	83 J	400 J	1300	420 U	130 J
1,2,4-TRICHLOROPENTHANE	210 J	460 U	91 J	300 J	420 U	440 U
1,2,4-TRICHLOROPENTHANE	850	66 J	300 J	1000	420 U	100 J
EXPLOSIVES (ug/kg)						
2,4,6-TRINITROPHENOL	320	1100	200 U	2300	420	200 U
2,4,6-TRINITROPHENOL	280	170	120 U	620	120 U	120 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-16
SEDIMENT - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED DEPTH	9SD11-01 09/06/95 0-4"	9SD11-01D 09/06/95 0-4"	9SD11-02 09/06/95 4-8"
VOLATILES (ug/kg)			
BENZENE	130 J	19 J	220 J
ACETANONE	31 J	15 U	59 J
TOLUENE	2 J	15 U	15 U
NONVOLATILES (ug/kg)			
1-NAPHTHYLENE	550 U	500 U	490 U
2-NAPHTHENE	550 U	500 U	490 U
2-ENZOFURAN	550 U	500 U	490 U
1-DINITROTOLUENE	550 U	500 U	490 U
1-IORENE	70 J	500 U	490 U
1-ENANTHRENE	720	540	490 U
1-THRACENE	170 J	110 J	490 U
1-BAZOLE	100 J	72 J	490 U
1-BUTYLPHTHALATE	1900	500	390 J
1-ORANTHENE	950	870	73 J
1-RENE	1000	660	67 J
1-XYLBENZYLPHTHALATE	660	500 U	490 U
1-IZO(A)ANTHRACENE	550	420 J	490 U
1-RYSENE	620	520	490 U
1-(2-ETHYLHEXYL)PHTHALATE	660	65 J	490 U
1-IZO(B)FLUORANTHENE	730	600	490 U
1-IZO(K)FLUORANTHENE	290 J	260 J	490 U
1-IZO(A)PYRENE	480 J	390 J	490 U
1-ENO(1,2,3-CD)PYRENE	440 J	320 J	490 U
1-ENZO(A,H)ANTHRACENE	88 J	68 J	490 U
1-IZO(G,H,I)PERYLENE	370 J	250 J	490 U
EXPLOSIVES (ug/kg)			
2,4-DINITRO	260	220	200 U
2,6-TNT	200	120	290

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-17
SURFACE WATER - POSITIVE DETECTION SUMMARY
TOTAL INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	9SW08-01 09/07/95	9SW09-01 09/06/95	9SW11-01 09/06/95	9SW11-01D 09/06/95
ANALYTES (ug/L)				
ALUMINUM	200	84.9	19.3	15.4
ARSENIC	4.6	2.2	2.2	3.4
BARIUM	48.1	48.6	39.4	38.3
CALCIUM	81800	89200	101000	99300
COBALT	2	1.1 U	2	1.1 U
IRON	2960	589	677	649
LEAD	1.4 UL	1.4 UL	1.4 UL	3.6 K
MAGNESIUM	3030	2230	1680	1650
MANGANESE	231	88.7	130	130
POTASSIUM	1980	1960	922	843
SODIUM	7160	7570	7530	7580
VANADIUM	1.5 U	3.3	1.5 U	1.5 U
ZINC	9.8	8.1	5.5	4.6
CYANIDE	27.7	10 U	10 U	10 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-18
SURFACE WATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	9SW08-01F 09/07/95	9SW09-01F 09/06/95	9SW11-01DF 09/06/95	9SW11-01F 09/06/95
ANALYTES (ug/L)				
ARSENIC	1.8 U	1.8 U	1.8 U	2.1
BARIUM	43.5	45.3	36	35.6
CALCIUM	79300	85900	97600	96100
CHROMIUM	3.8 U	5.6	3.8 U	3.8 U
COBALT	1.1 U	2.6	1.1 U	1.1 U
COPPER	2.3 U	8.3	2.3 U	6.1
IRON	15.4	9.3	4.6 U	4.6 U
LEAD	1.4 UL	1.4 UL	1.4 K	1.4 UL
MAGNESIUM	2920	2170	1620	1610
MANGANESE	218	109	127	129
POTASSIUM	1810	2030	788	812
SODIUM	6900	7190	7350	7340
VANADIUM	1.5 U	4.5	1.5 U	1.5 U
ZINC	5.6	10.7	8.9	6.3

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-19
SURFACE WATER - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 09
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	9SW08-01 09/07/95	9SW09-01 09/06/95	9SW11-01 09/06/95	9SW11-01D 09/06/95
HALOGENATED AROMATIC HYDROCARBONS (ug/L)				
CHLOROBENZENE	10 U	10 U	3 J	3 J
HALOGENATED AROMATIC HYDROCARBONS (ug/L)				
CHLOROBENZENE	10 U	10 U	3 J	3 J
SEMI-VOLATILES (ug/L)				
DINITROTOLUENE	4 J	2 J	10 U	10 U
DINITROTOLUENE	6 J	10 U	10 U	10 U
2-ETHYLHEXYLPHTHALATE	10 U	2 J	10 U	1
PESTICIDES/PCBs (ug/L)				
DICHLOR EPOXIDE	0.08 K	0.05 U	0.05 U	0.05 U
PHENOLS (ug/L)				
4-CRESOL	0.51 U	0.71 U	6	6.1
2,4-DINITROBENZENE	0.44 NJ	0.17 U	0.11 U	0.15 R
DINITROBENZENE	0.46 NJ	0.16 U	0.1 U	0.15 U
NO-DNTS	1000	520	97	110
2,4-DNTS	100 U	150 U	9.1 U	14
2,4,6-TNT	480	110	25	25

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-20
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19HA01-00	19HA01-00D	19HA02-00	19HA03-00	19HA04-00	19HA05-00
DATE SAMPLED	09/08/95	09/08/95	09/08/95	09/09/95	09/09/95	09/09/95
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
PH	6.3	6	5.6	7.1	6.6	6.8
ANALYTES (mg/kg)						
ALUMINUM	13300	7480	5880	59300	90600	14400
ANTIMONY	4.3 R	4.3 R	3.8 R	5.6 L	4.7 R	3.7 UL
ARSENIC	14 K	4.6 K	4.3 K	4.8 K	2.1 U	7.3 J
BARIUM	47.1	50.7	19.1	48	44.9	42.2 J
BERYLLIUM	0.37	0.5	0.29	0.37	0.37	0.31 U
CADMIUM	0.87 UL	0.87 UL	0.78 UL	0.97 UL	2.2	0.96 K
CALCIUM	1860	1350	592	1380	1110	1550 J
CHROMIUM	31.3	27.4	12.9	26.7	27.5	19.5 J
COBALT	4.8	3.8	1.8	1.9	2.5	3.7
COPPER	7.8	10.2	10.7	22	28.9	9.6
IRON	48700	27200	19600	12900	12300	33600 J
LEAD	79.7	136 J	45.5 J	182 J	392 J	84.9 J
MAGNESIUM	563	361	356	742	553	369
MANGANESE	25.8	42.7	112	52.5	133	110 J
MERCURY	0.09 U	0.1 K	0.11 U	0.11 U	0.14 U	0.1 U
NICKEL	6.4	4.2	2.6	4.3	6.8	3.5
POTASSIUM	532	240	275	626	278	382
SODIUM	21.7	17	5.9	18	16.5	25.8
VANADIUM	53.1	45	26.3	35	24.6	44 J
ZINC	45.6 J	89.3 J	34.4 J	231 J	365 J	90.7

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-20
SURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19HA06-00	19HA07-00
DATE SAMPLED	09/09/95	09/09/95
DEPTH	0-0.5'	0-0.5'
PH	5.7	6.4
ANALYTES (mg/kg)		
ALUMINUM	9920	28200
ANTIMONY	4.3 UL	4 UL
ARSENIC	13.6 J	0.68 J
BARIUM	31.7 J	29 J
BERYLLIUM	0.73	0.33 U
CADMIUM	1.3 K	1.4 K
CALCIUM	1200 J	1360 J
CHROMIUM	28.5 J	12.6 J
COBALT	5.6	3.5
COPPER	41.6	24.2
IRON	33600 J	16700 J
LEAD	174 J	48.3 J
MAGNESIUM	487	511
MANGANESE	80.5 J	119 J
MERCURY	0.11 U	0.1 U
NICKEL	7.4	6.2
POTASSIUM	594	451
SODIUM	30.3	25.1
VANADIUM	37.4 J	22.7 J
ZINC	316	119

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-21
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19HA01-00	19HA01-00D	19HA02-00	19HA03-00	19HA04-00	19HA05-00
DATE SAMPLED	09/08/95	09/08/95	09/08/95	09/09/95	09/09/95	09/09/95
DEPTH	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'	0-0.5'
VOLATILES (ug/kg)						
1,1,1-TRICHLOROETHANE	12 U	12 U	8 J	14 U	14 U	13 U
SEMIVOLATILES (ug/kg)						
DIMETHYLPHTHALATE	400 U	390 U	370 U	56 J	1100	420 U
PHENANTHRENE	400 U	390 U	370 U	450 U	440 U	210 J
ANTHRACENE	400 U	390 U	370 U	450 U	440 U	45 J
DI-N-BUTYLPHTHALATE	360	300	540	610	1700	660
FLUORANTHENE	46 J	62 J	370 U	450 U	47 J	370 J
PYRENE	400 U	67 J	370 U	450 U	44 J	180 J
BENZO(A)ANTHRACENE	400 U	390 U	370 U	450 U	440 U	130 J
CHRYSENE	400 U	39 J	370 U	450 U	440 U	120 J
BIS(2-ETHYLHEXYL)PHTHALATE	400 U	390 U	370 U	450 U	46 J	420 U
BENZO(B)FLUORANTHENE	400 U	43 J	370 U	450 U	440 U	170 J
BENZO(K)FLUORANTHENE	400 U	390 U	370 U	450 U	440 U	51 J
BENZO(A)PYRENE	400 U	390 U	370 U	450 U	440 U	95 J
INDENO(1,2,3-CD)PYRENE	400 U	390 U	370 U	450 U	440 U	62 J
BENZO(G,H,I)PERYLENE	400 U	390 U	370 U	450 U	440 U	53 J
PESTICIDE/PCBs (ug/kg)						
HEPTACHLOR EPOXIDE	2 U	1.9 U	1.9 U	2.2 U	2.2 U	2.1 U
4,4'-DDE	4 U	3.9 U	3.7 U	4.5 U	3.1 J	4.2 U
4,4'-DDT	4 U	3.9 U	3.7 U	4.5 U	9.4 J	2.9 J
ENDRIN KETONE	4 U	3.9 U	3.7 U	4.5 U	4.5 U	4.2 U
ENDRIN ALDEHYDE	4 U	3.9 U	3.7 U	4.5 U	4.5 U	4.2 U
GAMMA-CHLORDANE	2 U	1.9 U	1.9 U	2.2 U	2.2 U	2.1 U
EXPLOSIVES (ug/kg)						
2,4,6-TNT	150 NJ	290 NJ	120 U	220	250	130
AMINO-DNTS	620 J	1000 J	200 U	1500	1200	350

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-21
SURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19HA06-00	19HA07-00
DATE SAMPLED	09/09/95	09/09/95
DEPTH	0-0.5'	0-0.5'
VOLATILES (ug/kg)		
1,1,1-TRICHLOROETHANE	12 U	13 UJ
SEMIVOLATILES (ug/kg)		
DIMETHYLPHTHALATE	400 U	420 U
PHENANTHRENE	400 U	75 J
ANTHRACENE	400 U	420 U
DI-N-BUTYLPHTHALATE	250	410
FLUORANTHENE	400 U	190 J
PYRENE	400 U	210 J
BENZO(A)ANTHRACENE	400 U	88 J
CHRYSENE	400 U	140 J
BIS(2-ETHYLHEXYL)PHTHALATE	400 U	430
BENZO(B)FLUORANTHENE	400 U	230 J
BENZO(K)FLUORANTHENE	400 U	100 J
BENZO(A)PYRENE	400 U	140 J
INDENO(1,2,3-CD)PYRENE	400 U	130 J
BENZO(G,H,I)PERYLENE	400 U	96 J
PESTICIDE/PCBs (ug/kg)		
HEPTACHLOR EPOXIDE	2 U	12 NJ
4,4'-DDE	4 U	5
4,4'-DDT	4 U	9.1
ENDRIN KETONE	4 U	3.7
ENDRIN ALDEHYDE	4 U	2.1 NJ
GAMMA-CHLORDANE	2 U	2.9
EXPLOSIVES (ug/kg)		
2,4,6-TNT	120 U	380
AMINO-DNTS	200 U	2100

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-22
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19HA01-02	19HA02-02	19HA03-02	19HA04-02	19HA05-02	19HA05-02D
DATE SAMPLED	09/08/95	09/08/95	09/09/95	09/09/95	09/09/95	09/09/95
DEPTH	2-4'	2-4'	2-4'	2-4'	2-4'	2-4'
PH	5.1	5.2	11.1	8.8	5.6	6
ANALYTES (mg/kg)						
ALUMINUM	14000	12400	6640	8610	6380	7640
ARSENIC	37.2 K	22.1 K	15 K	6 K	9.1 J	18.8 J
BARIUM	22.9	34.3	15.4	30.3	23.6 J	26.4 J
BERYLLIUM	0.97	1.4	0.28	0.32	0.37	0.63
CADMIUM	0.82 UL	0.7 UL	0.82 UL	0.76 UL	0.59 K	0.58 K
CALCIUM	441	1280	495	16600	5530 J	18500 J
CHROMIUM	36.9	25.6	25	23.5	17.2 J	22.1 J
COBALT	6.7	8.3	1.6	2.6	2.4	7.6
COPPER	5.8	6.5	2.8	4.3	14.9	5.3
IRON	46800	55900	14000	18400	34700 J	37200 J
LEAD	16.3	11.2	12	14.3 K	15.5	10.7
MAGNESIUM	712	832	405	688	487	963
MANGANESE	26.6	294	12	65.4	112 J	216 J
MERCURY	0.12 U	0.11 U	0.11 U	0.11 K	0.11 U	0.12 U
NICKEL	7.8	10.3	1.1 U	3.1	8.7	11.2
POTASSIUM	578	960	489	587	748	943
SELENIUM	0.38 UL	0.33 UL	0.49 L	0.42 UL	0.3 UL	0.36 UL
SODIUM	9.9	23.7	8.6	143	53.5	169
VANADIUM	70	49	36.2	45.6	31.8 J	28.1 J
ZINC	27.8 J	37.9 J	12.1 J	13.7 J	30	39.4

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-22
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19HA06-02	19HA07-02	19SB01-01	19SB01-01D	19SB03A-01	19SB03A-05
DATE SAMPLED	09/09/95	09/09/95	09/08/95	09/08/95	09/08/95	09/08/95
DEPTH	2-4'	2-4'	1-3'	1-3'	1-3'	9-11'
PH	8.3	8.1	5.9	N/A	N/A	N/A
ANALYTES (mg/kg)						
ALUMINUM	11200	13900	5260	5910	6560	5760
ARSENIC	9.5 J	30.4 J	1.3	1.8	4.3 L	3.5 L
BARIUM	21.5 J	22.5 J	30.4	33.3	30	45.4
BERYLLIUM	1.7	0.35 U	0.44	0.4	0.36	1.1
CADMIUM	0.99 K	0.73 K	0.67 U	0.63 U	0.63 UL	0.83 UL
CALCIUM	1360 J	2320 J	190	473	61600 J	30000 J
CHROMIUM	52.4 J	34 J	7.4 K	9 K	7.3 L	21.6
COBALT	8.4	1.1	3.4	3	1.5	6.4
COPPER	7.4	6.5	2.5	2.3	5.9	3
IRON	68600 J	42300 J	7640	10200	6130	24500
LEAD	11.7	10.6	9.2	9.5	7.6	6.2
MAGNESIUM	1340	613	237	251	1390	1160
MANGANESE	141 J	29.5 J	103 J	77.5 J	99.1	276
MERCURY	0.11 U	0.1 U	0.1 U	0.08 U	0.085 U	0.1 U
NICKEL	14.4	2.7 U	3.2	3.2	4.3	10.3
POTASSIUM	1720	812	203	247	116 L	913
SELENIUM	0.36 UL	0.68 L	0.27 UL	0.26 UL	0.3 UL	0.27 UL
SODIUM	49.8	36.3	13.2	11.1	7.4	262
VANADIUM	59.9 J	74 J	13.5	18.1	14	20.3
ZINC	58.2	14.3	8.9	7.8	40.8	39.1

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-22
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19SB04-01	19SB05-01	19SB05-05	19SB05-05D	19SB06-01	19SB07-01
DATE SAMPLED	09/09/95	09/08/95	09/08/95	09/08/95	09/09/95	09/07/95
DEPTH	1-3'	1-3'	9-11'	9-11'	1-3'	1-3'
PH	N/A	N/A	N/A	N/A	N/A	N/A
ANALYTES (mg/kg)						
ALUMINUM	5640	8380	2450	4200	5790	5490
ARSENIC	4.7 L	7.9 L	5.5 L	5.3 L	3.4	0.8
BARIUM	33.3	20	24.5	29.5	40.5	28.9
BERYLLIUM	0.66	0.53	0.33	0.4	0.47	0.34
CADMIUM	0.67 UL	0.83 UL	0.91 UL	0.85 UL	0.76 U	0.76 U
CALCIUM	246 J	1610 J	181000 J	179000 J	412	295
CHROMIUM	12.6	29.6	11.9	16.1	8.8	6.3 K
COBALT	6.4	1.5	1.9	1.2	7.3	3.8
COPPER	1.7	4.4	2.8	2.5	1.7	1.5
IRON	16800	36300	10500	11800	10400	6450
LEAD	11	12.9	4.7	4.2	9.5	7.3
MAGNESIUM	335	331	1900	2440	346	274
MANGANESE	85	42	99.8	107	114	71.6 J
MERCURY	0.1 U	0.11 U	0.12 U	0.1 U	0.11 U	0.08 U
NICKEL	4.6	1.8	4.6	4.9	5.8	3.2
POTASSIUM	191 L	276 L	869	1460	197	178
SELENIUM	0.33 UL	0.67 L	0.37 UL	0.39 UL	0.27 U	0.24 UL
SODIUM	4.9	12	1650	1590	22.6	18
VANADIUM	17.9	40.7	6.8	11	14.9	11.6
ZINC	15.1	8.5	23.8	23.3	11.4	6.2

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-23
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19HA01-02	19HA02-02	19HA03-02	19HA04-02	19HA05-02	19HA05-02D
DATE SAMPLED	09/08/95	09/08/95	09/09/95	09/09/95	09/09/95	09/09/95
DEPTH	2-4'	2-4'	2-4'	2-4'	2-4'	2-4'
VOLATILES (ug/kg)						
ACETONE	13 U	12 U	12 U	13 U	13 U	13 U
1,1,1-TRICHLOROETHANE	13 U	11 J	12 U	13 U	13 U	13 U
SEMIVOLATILES (ug/kg)						
DI-N-BUTYLPHTHALATE	330	600	400	1100	250	280
BUTYLBENZYLPHTHALATE	430 U	420 U	390 U	430 U	440 U	430 U
BIS(2-ETHYLHEXYL)PHTHALATE	430 U	420 U	390 U	430 U	440 U	430 U
PESTICIDE/PCBs (ug/kg)						
HEPTACHLOR EPOXIDE	2.2 U	2.1 U	2 U	2.2 U	2.2 U	2.1 U
EXPLOSIVES (ug/kg)						
2,4,6-TNT	1200	120 U	120 U	110 J	120 U	210
AMINO-DNTS	400	200 U	8200	1200	200 U	310

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-23
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19HA06-02	19HA07-02	19SB01-01	19SB01-01D	19SB03A-01	19SB03A-05
DATE SAMPLED	09/09/95	09/09/95	09/08/95	09/08/95	09/08/95	09/08/95
DEPTH	2-4'	2-4'	1-3'	1-3'	1-3'	9-11'
VOLATILES (ug/kg)						
ACETONE	14	12 U	11 U	11 U	11 U	12 U
1,1,1-TRICHLOROETHANE	13 U	12 U	11 U	11 U	11 U	12 U
SEMIVOLATILES (ug/kg)						
DI-N-BUTYLPHTHALATE	350	650	1100	1200	200	190
BUTYLBENZYLPHTHALATE	430 U	410 U	370 U	46 J	380 U	400 U
BIS(2-ETHYLHEXYL)PHTHALATE	430 U	410 U	110	98	59 J	320 J
PESTICIDE/PCBs (ug/kg)						
HEPTACHLOR EPOXIDE	2.1 U	1.6 J	1.8 U	1.8 U	1.9 U	1.9 U
EXPLOSIVES (ug/kg)						
2,4,6-TNT	120 U	120 U	120 U	120 U	490 NJ	120 U
AMINO-DNTS	200 U	200 U	200 U	200 U	200 U	200 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-23
SHALLOW SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19SB04-01	19SB05-01	19SB05-05	19SB05-05D	19SB06-01	19SB07-01
DATE SAMPLED	09/09/95	09/08/95	09/08/95	09/08/95	09/09/95	09/07/95
DEPTH	1-3'	1-3'	9-11'	9-11'	1-3'	1-3'
VOLATILES (ug/kg)						
ACETONE	11 U	12 U	13 U	13 U	11 U	11 U
1,1,1-TRICHLOROETHANE	11 U	12 U	13 U	13 U	11 U	11 U
SEMIVOLATILES (ug/kg)						
DI-N-BUTYLPHTHALATE	300	200	260	240	310 J	1200
BUTYLBENZYLPHTHALATE	360 U	380 U	440 U	430 U	350 U	350 U
BIS(2-ETHYLHEXYL)PHTHALATE	86 J	82 J	440 U	430 U	41 J	330
PESTICIDE/PCBs (ug/kg)						
HEPTACHLOR EPOXIDE	1.8 U	1.9 U	2.2 U	2.2 U	1.8 U	1.7 U
EXPLOSIVES (ug/kg)						
2,4,6-TNT	120 U	120 U	1800 NJ	2100 NJ	120 U	120 U
AMINO-DNTS	200 U	200 U	200 U	200 U	200 U	200 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-24
DEEP SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19SB01-07	19SB01-10	19SB03A-09	19SB04-07	19SB04-12	19SB05-08
DATE SAMPLED	09/08/95	09/08/95	09/09/95	09/09/95	09/09/95	09/08/95
DEPTH	13-15'	19-21'	17-19'	13-15'	23-25'	15-17'
PH	5	7.8	8.2	8.6	8.7	8.3
ANALYTES (mg/kg)						
ALUMINUM	11100	3770	8500	3850	935	7990
ARSENIC	23.8	5.1	14.1	4.1 L	14.3 L	17.9 L
BARIUM	45.2	34.8	33.1	25	25.4	33.5
BERYLLIUM	2	0.96	0.43 U	0.44	0.27 U	0.65
CADMIUM	0.78 U	0.84 U	1 U	0.77 UL	3.4 UL	0.93 UL
CALCIUM	361	184000	24100	176000 J	341000 J	36500 J
CHROMIUM	38.2	17.4	25.6	16.3	3.5 UL	26.4
COBALT	28.9	5.1	7.1	3.6	1 U	5.5
COPPER	8.1	3.9	7.7	2.9	2.1 U	7.2
IRON	86300	35100	19800	14900	9440	20700
LEAD	11.7	5.4	11.1	3	4.1	11.1
MAGNESIUM	776	2280	2940	2370	1460	3020
MANGANESE	610 J	118 J	90.3	82.4	126	99.7
NICKEL	22.2	11.9	13.9	5.1	4.4 U	11.4
POTASSIUM	944	670	2100	1440	76.1 UL	2110
SILVER	0.51 U	0.95	0.74 U	0.5 L	2.2 UL	0.6 UL
SODIUM	21	1580	86.8	1470	2620	318
VANADIUM	54.1	21.7	17.3	11.9	6.7	16.3
ZINC	69.9	30.5	48.3	20.4	9.5	43.8

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-24
DEEP SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19SB06-07	19SB06-10	19SB07-08	19SB07-13
DATE SAMPLED	09/09/95	09/09/95	09/06/95	09/06/95
DEPTH	13-15'	19-21'	15-17'	25-27'
PH	4.9	8.4	5	7.3
ANALYTES (mg/kg)				
ALUMINUM	7920	3920	11700	4670
ARSENIC	16.3	4.1	44.8	9.7
BARIUM	26.9	27.6	65.6	19.8
BERYLLIUM	0.73	0.35 U	3.5	0.63
CADMIUM	0.85	1.1	0.81 U	0.99 U
CALCIUM	113	89800	287	2160
CHROMIUM	23.9	19.6	45	25.8
COBALT	7.4	2.3	57.7	3.5
COPPER	3.8	2.8	10.3	4.3
IRON	26600	12800	114000	17500
LEAD	6.7	4.1	10.2	4.6
MAGNESIUM	1520	2160	914	1890
MANGANESE	112	64.7	685 J	83.1 J
NICKEL	11.5	5.3	37	8.8
POTASSIUM	1560	1880	1070	2110
SILVER	0.48 U	0.61 U	0.53 U	0.64 U
SODIUM	27.6	800	28.6	30.9
VANADIUM	23.2	11.8	72.6	14.7
ZINC	43.8	24.7	100	33.3

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-25
DEEP SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19SB01-07	19SB01-10	19SB03A-09	19SB04-07	19SB04-12	19SB05-08
DATE SAMPLED	09/08/95	09/08/95	09/09/95	09/09/95	09/09/95	09/08/95
DEPTH	13-15'	19-21'	17-19'	13-15'	23-25'	15-17'
VOLATILES (ug/kg)						
ACETONE	19	13 U	15 U	12 U	11 U	13 J
SEMIVOLATILES (ug/kg)						
DI-N-BUTYLPHthalate	1200	1700	410 J	260	220	260
BUTYLBENZYLPHthalate	450 U	100 J	500 U	380 U	370 U	480 U
BIS(2-ETHYLHEXYL)PHthalate	680	1200	100 J	120 J	99 J	310 J
EXPLOSIVES (ug/kg)						
2,4,6-TNT	120 U	120 U	2200	120 U	120 U	1000 NJ
AMINO-DNTS	200 U	200 U	1800	200 U	200 U	1000

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-25
DEEP SUBSURFACE SOIL - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19SB06-07	19SB06-10	19SB07-08	19SB07-13
DATE SAMPLED	09/09/95	09/09/95	09/06/95	09/06/95
DEPTH	13-15'	19-21'	15-17'	25-27'
VOLATILES (ug/kg)				
ACETONE	12 U	13 U	13 U	14 U
SEMIVOLATILES (ug/kg)				
DI-N-BUTYLPHthalate	340 J	310 J	830	290
BUTYLBENZYLPHthalate	390 U	440 U	440 U	460 U
BIS(2-ETHYLHEXYL)PHthalate	48 J	440 U	47	73
EXPLOSIVES (ug/kg)				
2,4,6-TNT	120 U	120 U	120 U	120 U
AMINO-DNTS	200 U	200 U	200 U	200 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-26
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
TOTAL INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	19GW01-02 09/06/95	19GW01-02D 09/06/95	19GW02-02 09/07/95	19GW03-02 09/06/95	19GW04-01 10/04/95	19GW04-01D 10/04/95
ANALYTES (ug/L)						
ALUMINUM	12.5 U	12.5 U	49.9	32	26400 J	28000 J
ARSENIC	1.8 U	1.8 U	1.8 U	1.8 U	37.6 L	41.8 L
BARIUM	49.2 J	50.2 J	45.5 J	40.3 J	216	211
BERYLLIUM	0.3 U	0.3 U	0.3 U	0.3 U	2.7 L	2.3 L
CADMIUM	3.7 U	3.7 U	3.7 U	3.7 U	4.4	2.1 U
CALCIUM	114000	116000	136000	158000	961000	925000
CHROMIUM	3.8 U	3.8 U	3.8 U	3.8 U	132 J	129 J
COBALT	1.1 U	1.1 U	1.1 U	1.1 U	38.4	35.8
COPPER	2.3 U	2.3 U	9.4	9.3	24.3	21.9
IRON	445	455	337	12	160000	153000
LEAD	1.4 U	1.4 U	1.4 U	1.4 U	60.5	59.5
MAGNESIUM	1650	1700	1890	4720	10700	10700
MANGANESE	28	28.1	13.1	2850	1290	1220
NICKEL	4.8 U	4.8 U	4.8 U	5.5	46.3	63
POTASSIUM	770	788	676	917	7040	6580
SODIUM	5160	5230	5220	8730	13600	13300
VANADIUM	1.5 U	1.5 U	1.5 U	1.5	258	257
ZINC	5	2.5 U	2.5 U	5.4	155	143

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-26
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
TOTAL INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	19GW05-01 10/04/95	19GW06-01 10/05/95
ANALYTES (ug/L)		
ALUMINUM	1330 J	1270 J
ARSENIC	3.6 L	1.9 L
BARIIUM	29.6	33.5
BERYLLIUM	1 UL	1 UL
CADMIUM	2.1 U	2.1 U
CALCIUM	101000	107000
CHROMIUM	5.4 J	5.5 J
COBALT	3.4 U	3.4 U
COPPER	1.5 U	1.9
IRON	3280	2620
LEAD	1.8 L	1.9 L
MAGNESIUM	1610	1500
MANGANESE	13.6	167
NICKEL	11.1 U	11.1 U
POTASSIUM	849	873
SODIUM	9800	9870
VANADIUM	3.2 U	3.2 U
ZINC	12.2	9.5

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-27
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	19GW01-02DF 09/06/95	19GW01-02F 09/06/95	19GW02-02F 09/07/95	19GW03-02F 09/06/95	19GW04F-01 10/04/95	19GW04F-01D 10/04/95
ANALYTES (ug/L)						
ALUMINUM	12.8	12.5 U	12.5 U	14.8	18.1 U	18.1 U
BARIUM	49.7 J	50 J	43 J	39.5 J	29.3	28.5
CALCIUM	115000	115000	131000	154000	130000	126000
CHROMIUM	3.8 U	3.8 U	3.8 U	3.8 U	2.1 U	2.1 U
COPPER	2.3 U	2.3 U	17	10.1	7.8	1.5 U
IRON	433	448	40	6.8	30	78.2
MAGNESIUM	1670	1680	1840	4630	2120	2040
MANGANESE	28.9	29.1	17.7	2820	13.8	11.1
NICKEL	4.8 U	4.8 U	4.8 U	6.4	11.1 U	11.1 U
POTASSIUM	822	762	715	872	1450	1010
SODIUM	5140	5150	5260	8570	6400	6140
ZINC	2.5 U	2.5 U	8.1	4.2	5	5.2

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-27
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	19GW05F-01 10/04/95	19GW06F-01 10/05/95
ANALYTES (ug/L)		
ALUMINUM	18.1 U	18.1 U
BARIUM	23.6	33.2
CALCIUM	98200	106000
CHROMIUM	2.1 U	2.5 J
COPPER	2.7	1.8
IRON	9.7 U	9.7 U
MAGNESIUM	1200	1300
MANGANESE	2.5	165
NICKEL	11.1 U	11.1 U
POTASSIUM	895	787 U
SODIUM	9760	10000
ZINC	3.1 U	3.1 U

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-28
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	19GW01-02 09/06/95	19GW01-02D 09/06/95	19GW02-02 09/07/95	19GW03-02 09/06/95	19GW04-01 10/04/95	19GW04-01D 10/04/95
VOLATILES (ug/L)						
CHLOROFORM	10 U	10 U	10 U	10 U	2 J	10 U
SEMIVOLATILES (ug/L)						
BIS(2-ETHYLHEXYL)PHTHALATE	10 U	10 U	10 U	10 U	10 U	4 J
EXPLOSIVES (ug/L)						
RDX	0.85 U	1.1 U	0.8 U	0.39 U	1.1	0.99 NJ
1,3,5-TRINITROBENZENE	0.21 U	0.27 U	0.19 U	0.095 U	3.8 NJ	3.1 NJ
2,4,6-TNT	0.2 U	0.26 U	0.18 U	4.2 NJ	1.7	1.5
2,4-DNT/2,6-DNT	0.32 U	0.42 U	0.3 U	0.15 U	0.66 NJ	0.36 NJ
AMINO-DNTS	0.32 U	0.42 U	0.3 U	6.7 NJ	7.3 NJ	6.1

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-28
SHALLOW GROUNDWATER - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION DATE SAMPLED	19GW05-01 10/04/95	19GW06-01 10/04/95
VOLATILES (ug/L)		
CHLOROFORM	12	6 J
SEMIVOLATILES (ug/L)		
BIS(2-ETHYLHEXYL)PHTHALATE	10 U	6 J
EXPLOSIVES (ug/L)		
RDX	0.8 U	0.77 NJ
1,3,5-TRINITROBENZENE	5.8 NJ	0.16 U
2,4,6-TNT	38 NJ	0.15 U
2,4-DNT/2,6-DNT	0.3 U	0.24 U
AMINO-DNTS	130	5.3

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-29
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
TOTAL INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19GW03A-01
DATE SAMPLED	10/05/95
ANALYTES (ug/L)	
BARIUM	74.9
CALCIUM	101000
IRON	1910
LEAD	1.9 L
MAGNESIUM	3610
MANGANESE	60.2
POTASSIUM	2080
SODIUM	6050

Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-30
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
DISSOLVED INORGANICS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION 19GW03AF-01
DATE SAMPLED 10/05/95

ANALYTES (ug/L)	
CHLORIDE	69.6
CALCIUM	99500
AMMONIUM	1370
MAGNESIUM	3510
MANGANESE	57.9
POTASSIUM	1710
SODIUM	5940

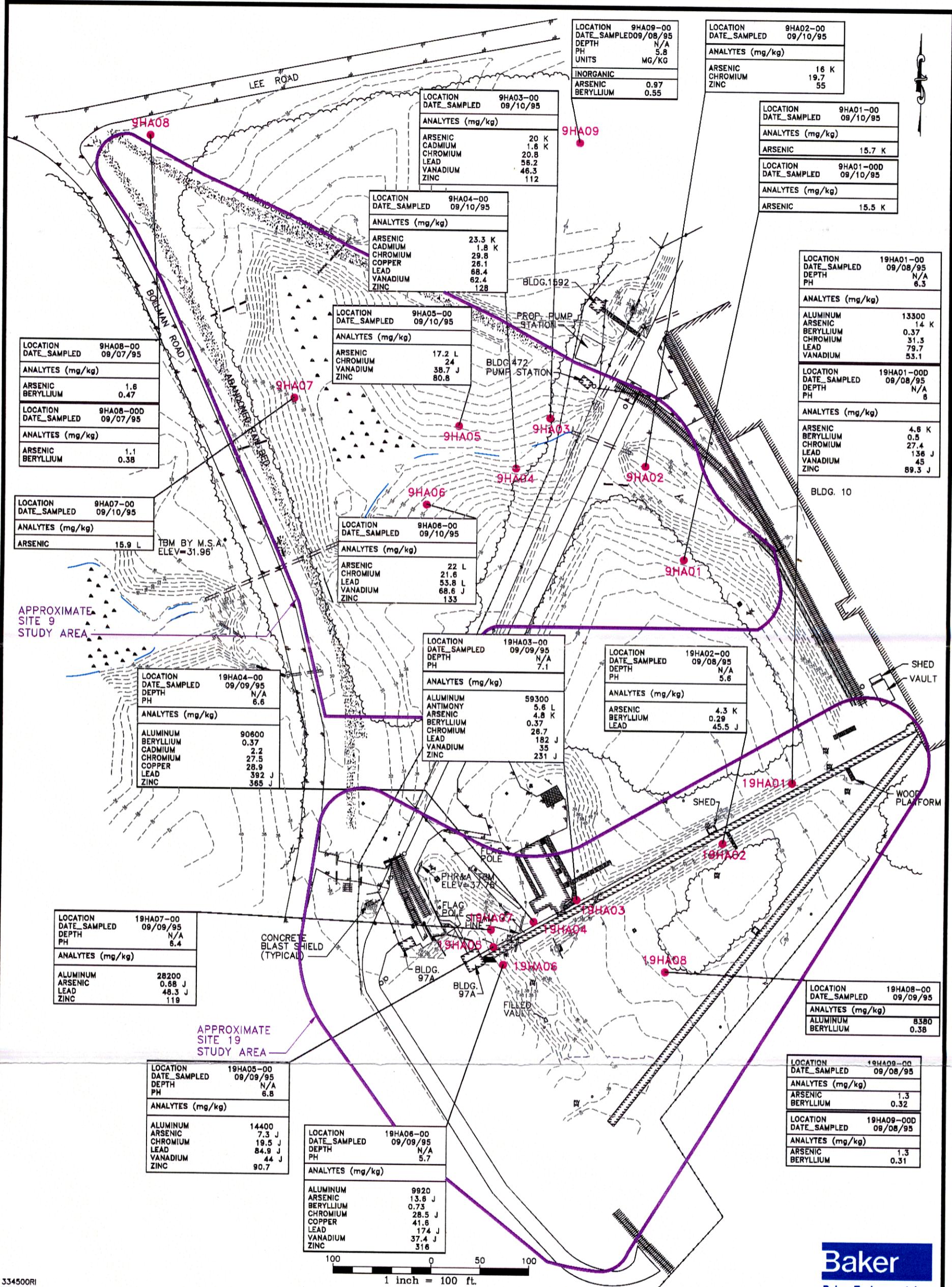
Refer to Table 4-1 for data qualifiers and notes.

TABLE 4-31
DEEP GROUNDWATER - POSITIVE DETECTION SUMMARY
ORGANIC COMPOUNDS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

LOCATION	19GW03A-01
DATE SAMPLED	10/05/95
VOLATILES (ug/L)	
CHLOROFORM	23
SEMIVOLATILES (ug/L)	
PHENOL	7 J

Refer to Table 4-1 for data qualifiers and notes.

SECTION 4.0 FIGURES



LOCATION	9HA08-00
DATE_SAMPLED	09/07/95
ANALYTES (mg/kg)	
ARSENIC	1.6
BERYLLIUM	0.47
LOCATION	9HA08-00D
DATE_SAMPLED	09/07/95
ANALYTES (mg/kg)	
ARSENIC	1.1
BERYLLIUM	0.38

LOCATION	9HA07-00
DATE_SAMPLED	09/10/95
ANALYTES (mg/kg)	
ARSENIC	15.9 L

LOCATION	19HA04-00
DATE_SAMPLED	09/09/95
DEPTH	N/A
PH	6.6
ANALYTES (mg/kg)	
ALUMINUM	90600
BERYLLIUM	0.37
CADMIUM	2.2
CHROMIUM	27.5
COPPER	28.9
LEAD	392 J
ZINC	365 J

LOCATION	19HA07-00
DATE_SAMPLED	09/09/95
DEPTH	N/A
PH	6.4
ANALYTES (mg/kg)	
ALUMINUM	28200
ARSENIC	0.68 J
LEAD	48.3 J
ZINC	119

LOCATION	19HA05-00
DATE_SAMPLED	09/09/95
DEPTH	N/A
PH	6.8
ANALYTES (mg/kg)	
ALUMINUM	14400
ARSENIC	7.3 J
CHROMIUM	19.5 J
LEAD	84.9 J
VANADIUM	44 J
ZINC	90.7

LOCATION	19HA06-00
DATE_SAMPLED	09/09/95
DEPTH	N/A
PH	5.7
ANALYTES (mg/kg)	
ALUMINUM	9920
ARSENIC	13.6 J
BERYLLIUM	0.73
CHROMIUM	28.5 J
COPPER	41.6
LEAD	17.4 J
VANADIUM	37.4 J
ZINC	316

LOCATION	19HA03-00
DATE_SAMPLED	09/09/95
DEPTH	N/A
PH	7.1
ANALYTES (mg/kg)	
ALUMINUM	59300
ANTIMONY	5.6 L
ARSENIC	4.8 K
BERYLLIUM	0.37
CHROMIUM	26.7
LEAD	182 J
VANADIUM	35
ZINC	231 J

LOCATION	19HA02-00
DATE_SAMPLED	09/08/95
DEPTH	N/A
PH	5.6
ANALYTES (mg/kg)	
ARSENIC	4.3 K
BERYLLIUM	0.29
LEAD	45.5 J

LOCATION	19HA08-00
DATE_SAMPLED	09/09/95
ANALYTES (mg/kg)	
ALUMINUM	8380
BERYLLIUM	0.38

LOCATION	19HA09-00
DATE_SAMPLED	09/08/95
ANALYTES (mg/kg)	
ARSENIC	1.3
BERYLLIUM	0.32

LOCATION	19HA09-00D
DATE_SAMPLED	09/08/95
ANALYTES (mg/kg)	
ARSENIC	1.3
BERYLLIUM	0.31

LOCATION	9HA03-00
DATE_SAMPLED	09/10/95
ANALYTES (mg/kg)	
ARSENIC	20 K
CADMIUM	1.6 K
CHROMIUM	20.8
LEAD	56.2
VANADIUM	46.3
ZINC	112

LOCATION	9HA04-00
DATE_SAMPLED	09/10/95
ANALYTES (mg/kg)	
ARSENIC	23.3 K
CADMIUM	1.8 K
CHROMIUM	29.8
COPPER	26.1
LEAD	68.4
VANADIUM	62.4
ZINC	128

LOCATION	9HA05-00
DATE_SAMPLED	09/10/95
ANALYTES (mg/kg)	
ARSENIC	17.2 L
CHROMIUM	24
VANADIUM	38.7 J
ZINC	80.8

LOCATION	9HA06-00
DATE_SAMPLED	09/10/95
ANALYTES (mg/kg)	
ARSENIC	22 L
CHROMIUM	21.6
LEAD	53.8 L
VANADIUM	68.6 J
ZINC	133

LOCATION	9HA09-00
DATE_SAMPLED	09/08/95
DEPTH	N/A
PH	5.8
UNITS	MG/KG
INORGANIC	
ARSENIC	0.97
BERYLLIUM	0.55

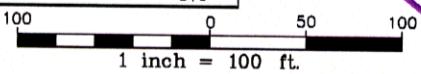
LOCATION	9HA02-00
DATE_SAMPLED	09/10/95
ANALYTES (mg/kg)	
ARSENIC	16 K
CHROMIUM	19.7
ZINC	55

LOCATION	9HA01-00
DATE_SAMPLED	09/10/95
ANALYTES (mg/kg)	
ARSENIC	15.7 K

LOCATION	9HA01-00D
DATE_SAMPLED	09/10/95
ANALYTES (mg/kg)	
ARSENIC	15.5 K

LOCATION	19HA01-00
DATE_SAMPLED	09/08/95
DEPTH	N/A
PH	6.3
ANALYTES (mg/kg)	
ALUMINUM	13300
ARSENIC	14 K
BERYLLIUM	0.37
CHROMIUM	31.3
LEAD	79.7
VANADIUM	53.1

LOCATION	19HA01-00D
DATE_SAMPLED	09/08/95
DEPTH	N/A
PH	6
ANALYTES (mg/kg)	
ARSENIC	4.6 K
BERYLLIUM	0.5
CHROMIUM	27.4
LEAD	136 J
VANADIUM	45
ZINC	89.3 J

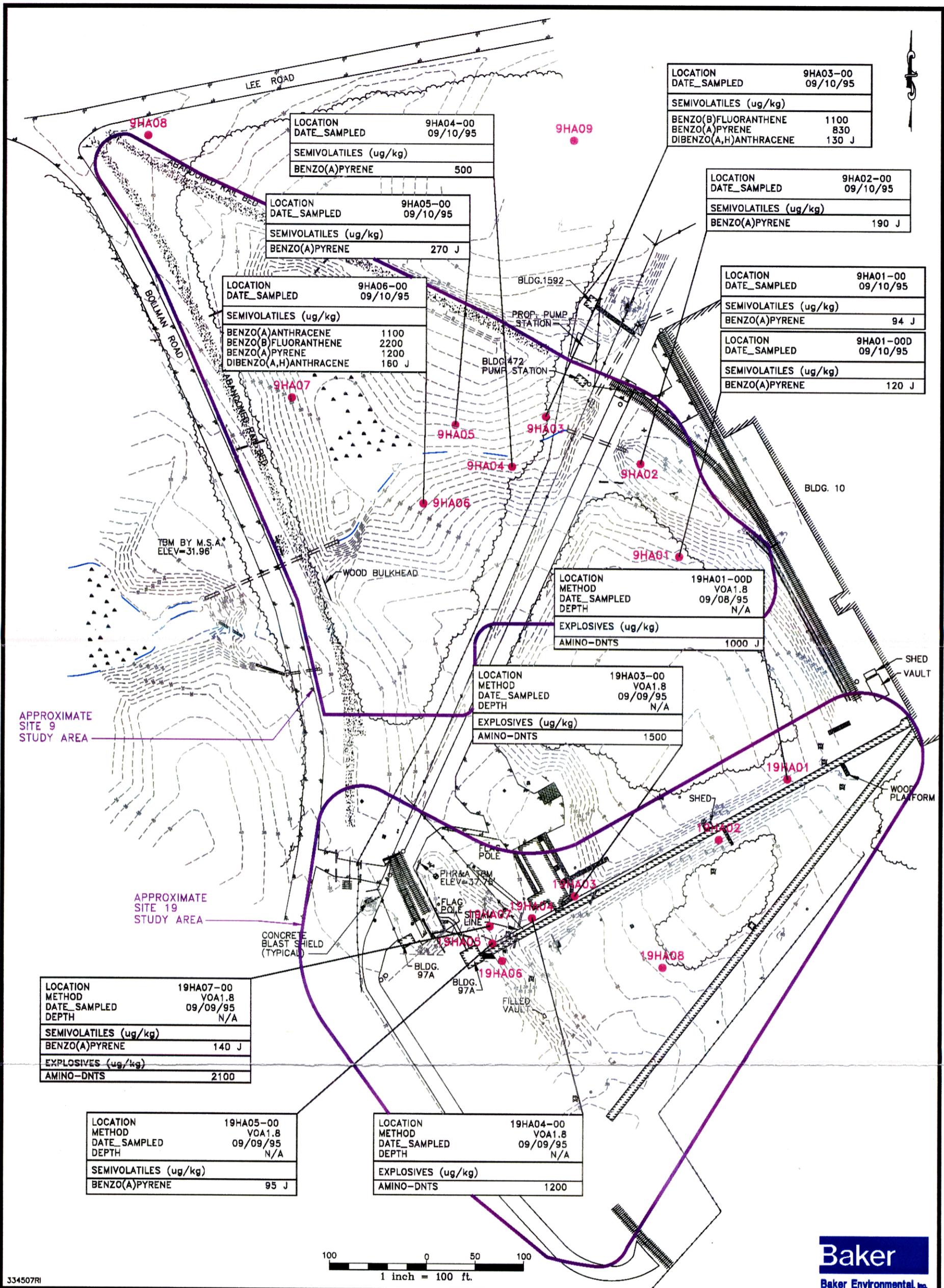


LEGEND
 ● 9HA09 - SURFACE SOIL SAMPLING LOCATION (HAND AUGERED)

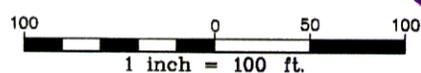
FIGURE 4-1
ROUND TWO RI
POSITIVE DETECTIONS OF SELECT INORGANIC
ANALYTES IN SURFACE SOIL
SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

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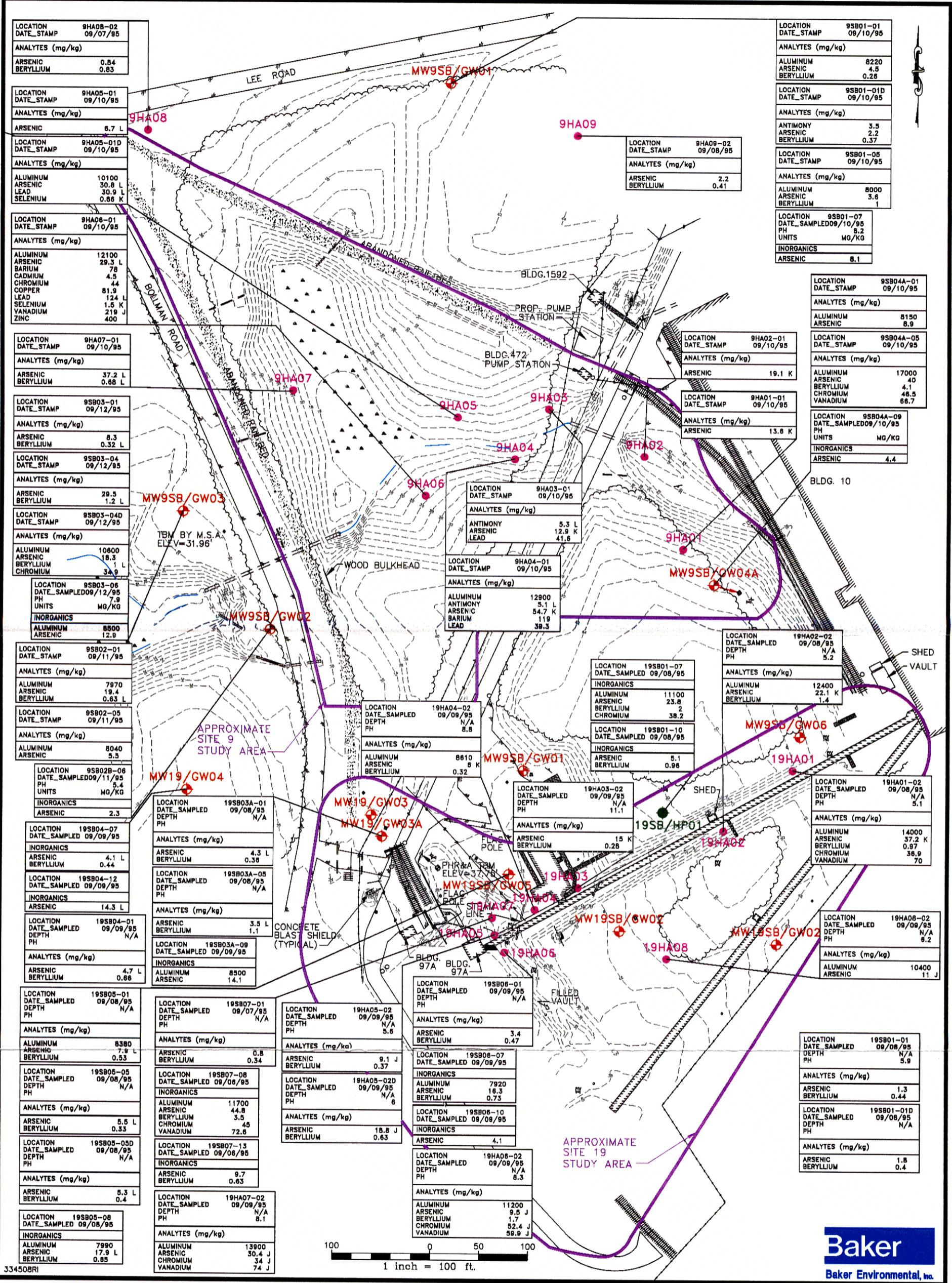
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LEGEND

9HA09 - SURFACE SOIL SAMPLING LOCATION (HAND AUGERED)

**FIGURE 4-2
 ROUND TWO RI
 POSITIVE DETECTIONS OF SELECT ORGANIC
 ANALYTES IN SURFACE SOIL
 SITES 9 AND 19**



LEGEND

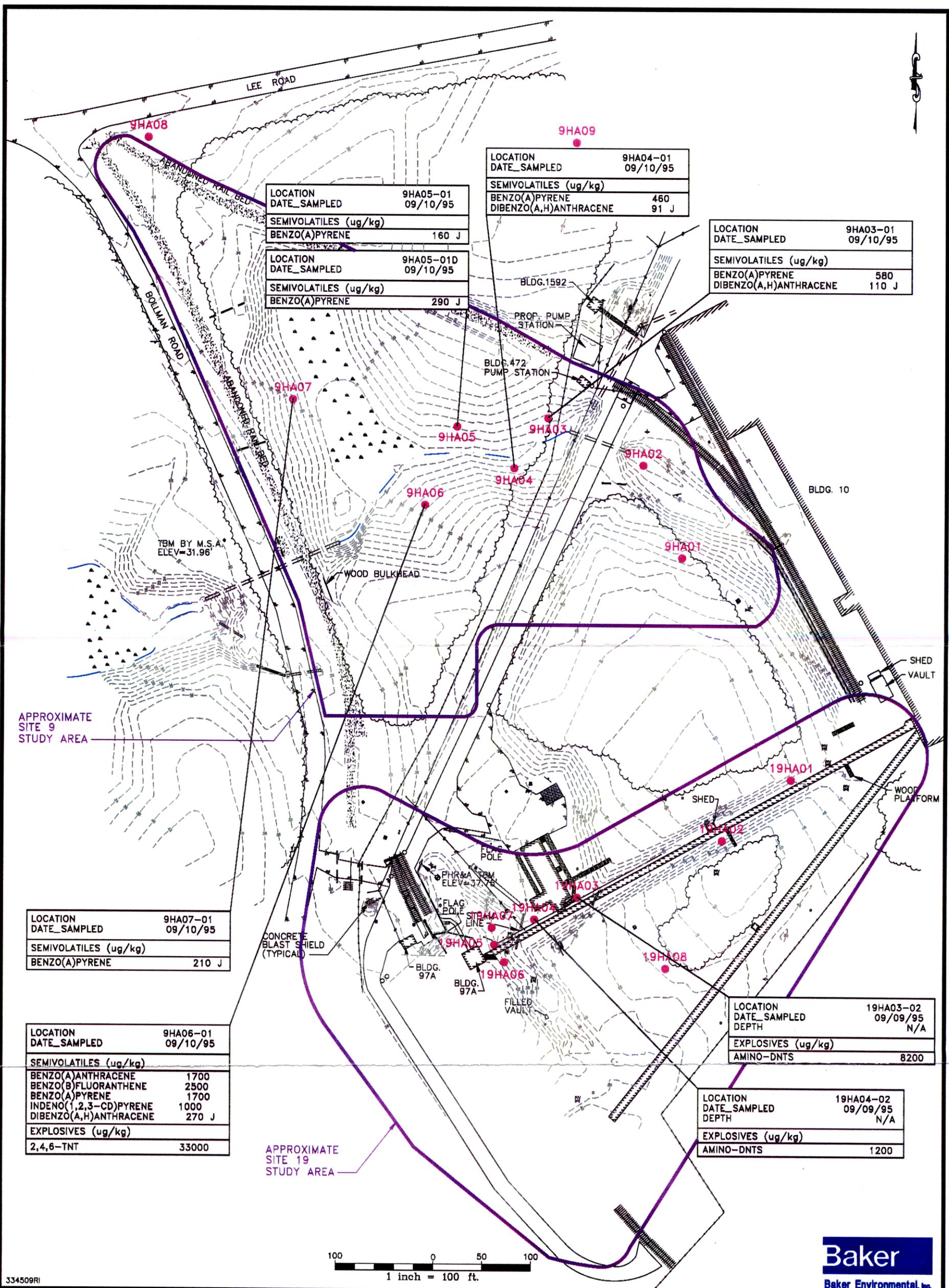
● 9HA09 - SURFACE SOIL SAMPLING LOCATION (HAND AUGERED)

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

FIGURE 4-3
ROUND TWO RI
POSITIVE DETECTIONS OF SELECT INORGANIC
ANALYTES IN SUBSURFACE SOIL
SITES 9 AND 19

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA





LOCATION	9HA04-01
DATE_SAMPLED	09/10/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	460
DIBENZO(A,H)ANTHRACENE	91 J

LOCATION	9HA05-01
DATE_SAMPLED	09/10/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	160 J

LOCATION	9HA05-01D
DATE_SAMPLED	09/10/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	290 J

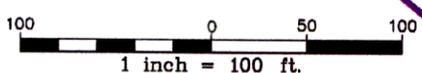
LOCATION	9HA03-01
DATE_SAMPLED	09/10/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	580
DIBENZO(A,H)ANTHRACENE	110 J

LOCATION	9HA07-01
DATE_SAMPLED	09/10/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	210 J

LOCATION	9HA06-01
DATE_SAMPLED	09/10/95
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	1700
BENZO(B)FLUORANTHENE	2500
BENZO(A)PYRENE	1700
INDENO(1,2,3-CD)PYRENE	1000
DIBENZO(A,H)ANTHRACENE	270 J
EXPLOSIVES (ug/kg)	
2,4,6-TNT	33000

LOCATION	19HA03-02
DATE_SAMPLED	09/09/95
DEPTH	N/A
EXPLOSIVES (ug/kg)	
AMINO-DNTS	8200

LOCATION	19HA04-02
DATE_SAMPLED	09/09/95
DEPTH	N/A
EXPLOSIVES (ug/kg)	
AMINO-DNTS	1200



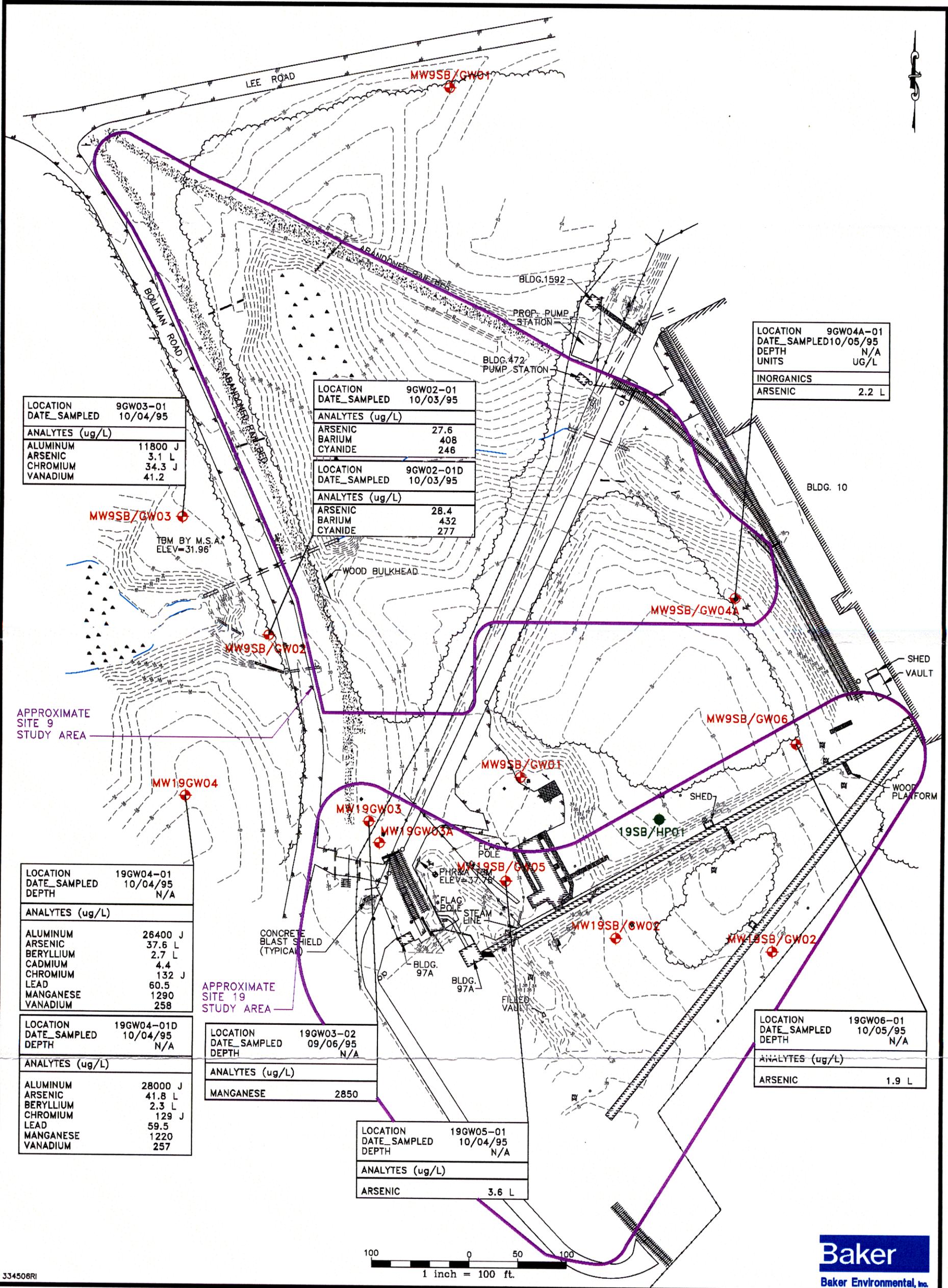
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9HA09 - SURFACE SOIL SAMPLING LOCATION (HAND AUGERED)

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

FIGURE 4-4
ROUND TWO RI
POSITIVE DETECTIONS OF SELECT ORGANIC
ANALYTES IN SUBSURFACE SOIL
SITES 9 AND 19

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



334508R1

LEGEND

- 19SB/HP01 - SOIL BORING/GROUNDWATER MONITORING WELL LOCATION
- MW9SB/GW04A - SOIL BORING/HYDROPUNCH LOCATION

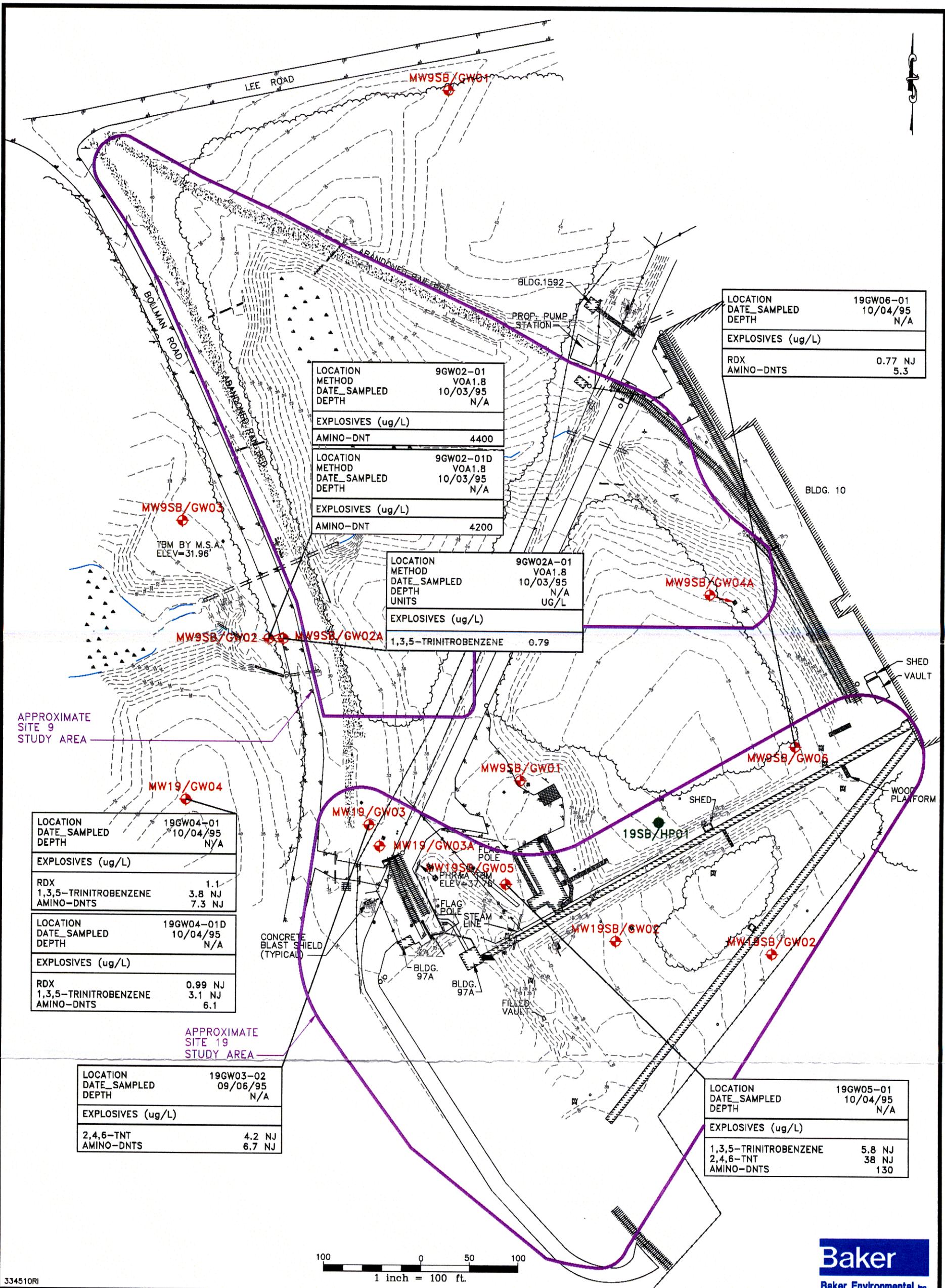
**FIGURE 4-5
POSITIVE DETECTIONS OF SELECT INORGANIC
ANALYTES IN GROUNDWATER
SITES 9 AND 19**

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

NAVAL WEAPONS STATION YORKTOWN

YORKTOWN, VIRGINIA





LOCATION	19GW06-01
DATE_SAMPLED	10/04/95
DEPTH	N/A
EXPLOSIVES (ug/L)	
RDX	0.77 NJ
AMINO-DNTS	5.3

LOCATION	9GW02-01
METHOD	VOA1.8
DATE_SAMPLED	10/03/95
DEPTH	N/A
EXPLOSIVES (ug/L)	
AMINO-DNT	4400

LOCATION	9GW02-01D
METHOD	VOA1.8
DATE_SAMPLED	10/03/95
DEPTH	N/A
EXPLOSIVES (ug/L)	
AMINO-DNT	4200

LOCATION	9GW02A-01
METHOD	VOA1.8
DATE_SAMPLED	10/03/95
DEPTH	N/A
UNITS	UG/L
EXPLOSIVES (ug/L)	
1,3,5-TRINITROBENZENE	0.79

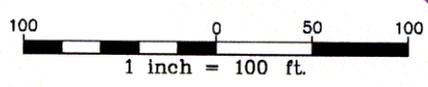
LOCATION	19GW04-01
DATE_SAMPLED	10/04/95
DEPTH	N/A
EXPLOSIVES (ug/L)	
RDX	1.1
1,3,5-TRINITROBENZENE	3.8 NJ
AMINO-DNTS	7.3 NJ

LOCATION	19GW04-01D
DATE_SAMPLED	10/04/95
DEPTH	N/A
EXPLOSIVES (ug/L)	
RDX	0.99 NJ
1,3,5-TRINITROBENZENE	3.1 NJ
AMINO-DNTS	6.1

LOCATION	19GW03-02
DATE_SAMPLED	09/06/95
DEPTH	N/A
EXPLOSIVES (ug/L)	
2,4,6-TNT	4.2 NJ
AMINO-DNTS	6.7 NJ

LOCATION	19GW05-01
DATE_SAMPLED	10/04/95
DEPTH	N/A
EXPLOSIVES (ug/L)	
1,3,5-TRINITROBENZENE	5.8 NJ
2,4,6-TNT	38 NJ
AMINO-DNTS	130

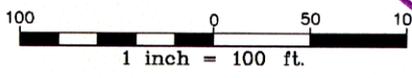
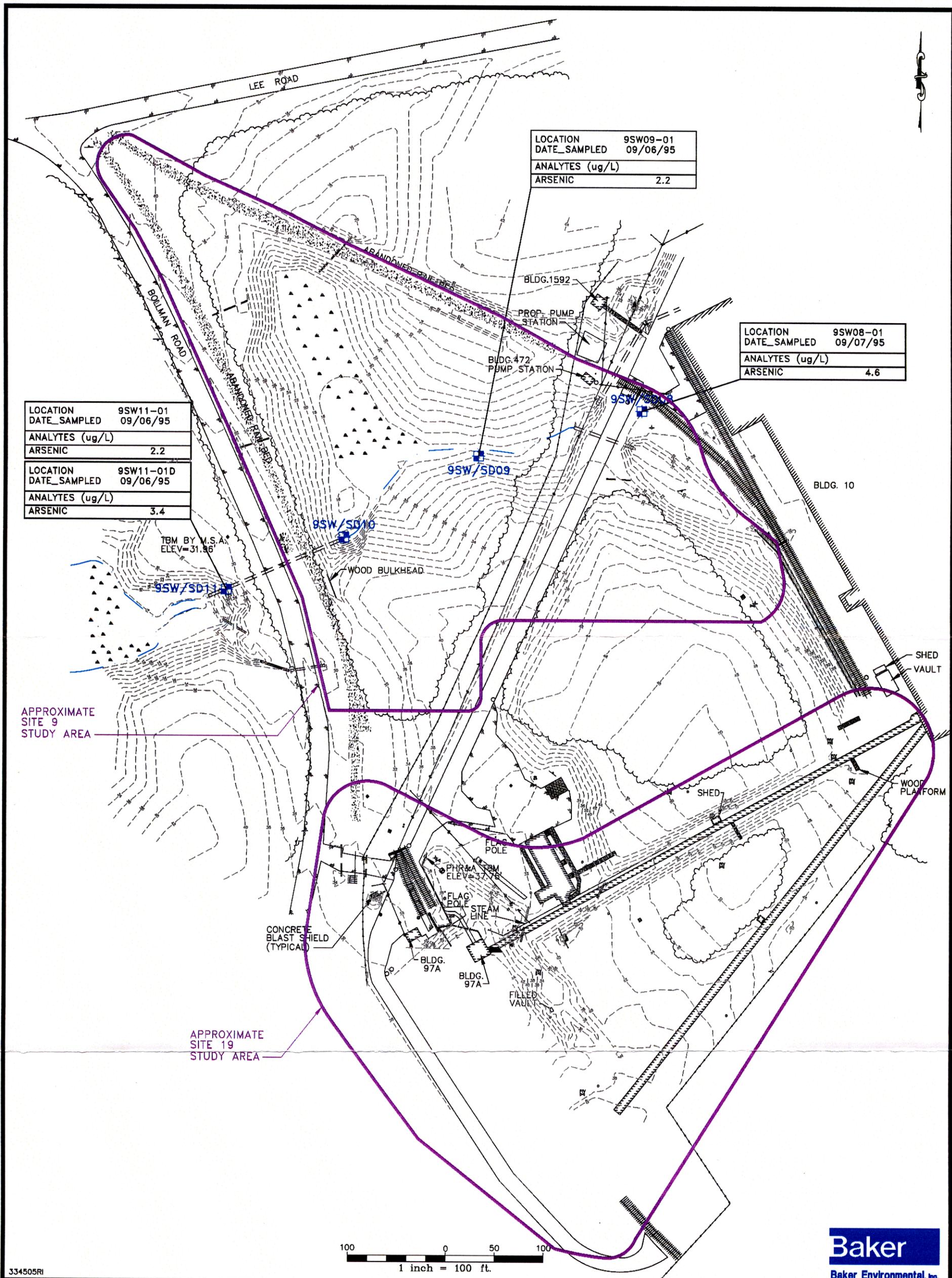
334510RI



LEGEND

- 19SB/HP01 - SOIL BORING/GROUNDWATER MONITORING WELL LOCATION
- ⊕ MW9SB/GW04A - SOIL BORING/HYDROPUNCH LOCATION

**FIGURE 4-6
POSITIVE DETECTIONS OF SELECT ORGANIC
ANALYTES IN GROUNDWATER
SITES 9 AND 19**

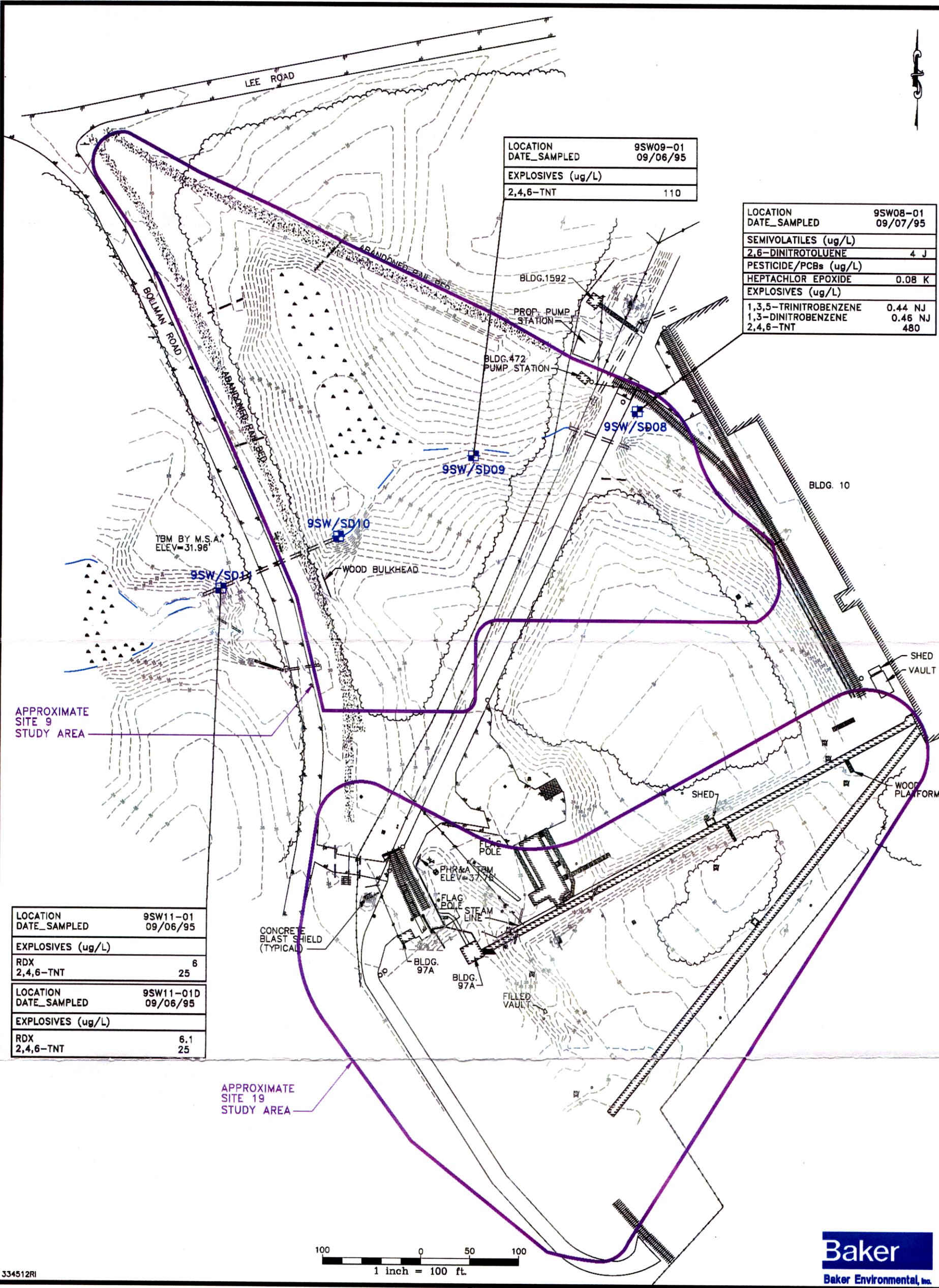


334505RI

LEGEND

9SW/SD09 - SURFACE WATER, SEDIMENT, AND BENTHIC SAMPLING LOCATION

FIGURE 4-7
ROUND TWO RI
POSITIVE DETECTIONS OF SELECT INORGANIC
ANALYTES IN SURFACE WATER
SITES 9 AND 19

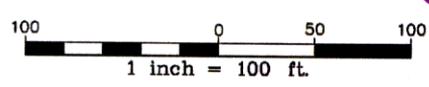


LOCATION	9SW09-01
DATE_SAMPLED	09/06/95
EXPLOSIVES (ug/L)	
2,4,6-TNT	110

LOCATION	9SW08-01
DATE_SAMPLED	09/07/95
SEMIVOLATILES (ug/L)	
2,6-DINITROTOLUENE	4 J
PESTICIDE/PCBs (ug/L)	
HEPTACHLOR EPOXIDE	0.08 K
EXPLOSIVES (ug/L)	
1,3,5-TRINITROBENZENE	0.44 NJ
1,3-DINITROBENZENE	0.46 NJ
2,4,6-TNT	480

LOCATION	9SW11-01
DATE_SAMPLED	09/06/95
EXPLOSIVES (ug/L)	
RDX	6
2,4,6-TNT	25

LOCATION	9SW11-01D
DATE_SAMPLED	09/06/95
EXPLOSIVES (ug/L)	
RDX	6.1
2,4,6-TNT	25

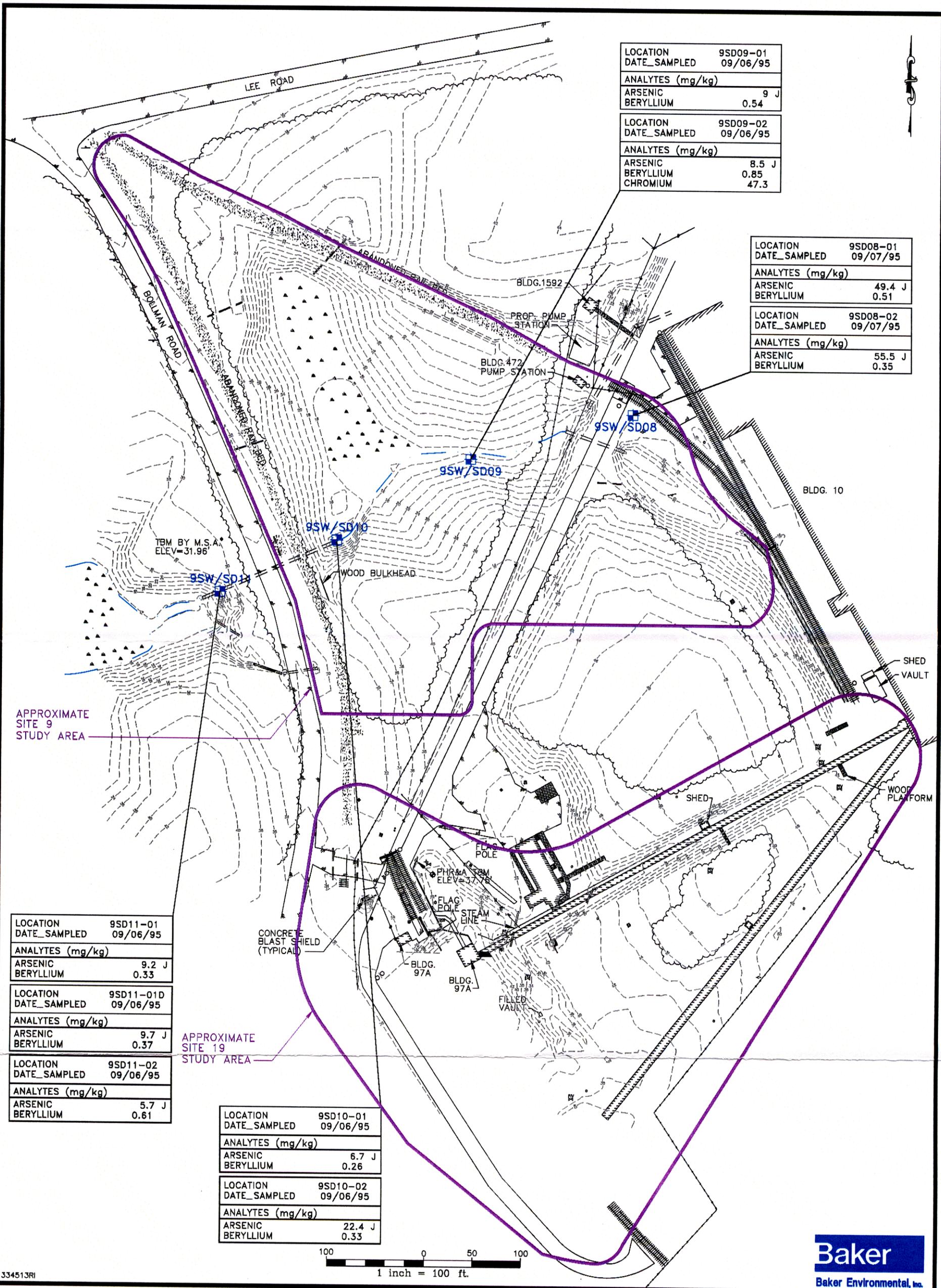


LEGEND	
	9SW/SD09 - SURFACE WATER, SEDIMENT, AND BENTHIC SAMPLING LOCATION

**FIGURE 4-8
ROUND TWO RI
POSITIVE DETECTIONS OF SELECT ORGANIC
ANALYTES IN SURFACE WATER
SITES 9 AND 19**

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995



LOCATION	9SD09-01
DATE_SAMPLED	09/06/95
ANALYTES (mg/kg)	
ARSENIC	9 J
BERYLLIUM	0.54

LOCATION	9SD09-02
DATE_SAMPLED	09/06/95
ANALYTES (mg/kg)	
ARSENIC	8.5 J
BERYLLIUM	0.85
CHROMIUM	47.3

LOCATION	9SD08-01
DATE_SAMPLED	09/07/95
ANALYTES (mg/kg)	
ARSENIC	49.4 J
BERYLLIUM	0.51

LOCATION	9SD08-02
DATE_SAMPLED	09/07/95
ANALYTES (mg/kg)	
ARSENIC	55.5 J
BERYLLIUM	0.35

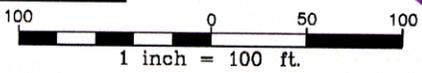
LOCATION	9SD11-01
DATE_SAMPLED	09/06/95
ANALYTES (mg/kg)	
ARSENIC	9.2 J
BERYLLIUM	0.33

LOCATION	9SD11-01D
DATE_SAMPLED	09/06/95
ANALYTES (mg/kg)	
ARSENIC	9.7 J
BERYLLIUM	0.37

LOCATION	9SD11-02
DATE_SAMPLED	09/06/95
ANALYTES (mg/kg)	
ARSENIC	5.7 J
BERYLLIUM	0.61

LOCATION	9SD10-01
DATE_SAMPLED	09/06/95
ANALYTES (mg/kg)	
ARSENIC	6.7 J
BERYLLIUM	0.26

LOCATION	9SD10-02
DATE_SAMPLED	09/06/95
ANALYTES (mg/kg)	
ARSENIC	22.4 J
BERYLLIUM	0.33



LEGEND
 9SW/SD09 - SURFACE WATER, SEDIMENT, AND BENTHIC SAMPLING LOCATION

**FIGURE 4-9
 ROUND TWO RI
 POSITIVE DETECTIONS OF SELECT INORGANIC
 ANALYTES IN SEDIMENT
 SITES 9 AND 19**

LOCATION	9SD09-01
DATE_SAMPLED	09/06/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	560
DIBENZO(A,H)ANTHRACENE	91 J

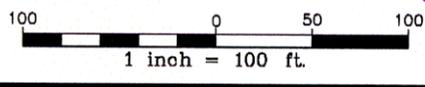
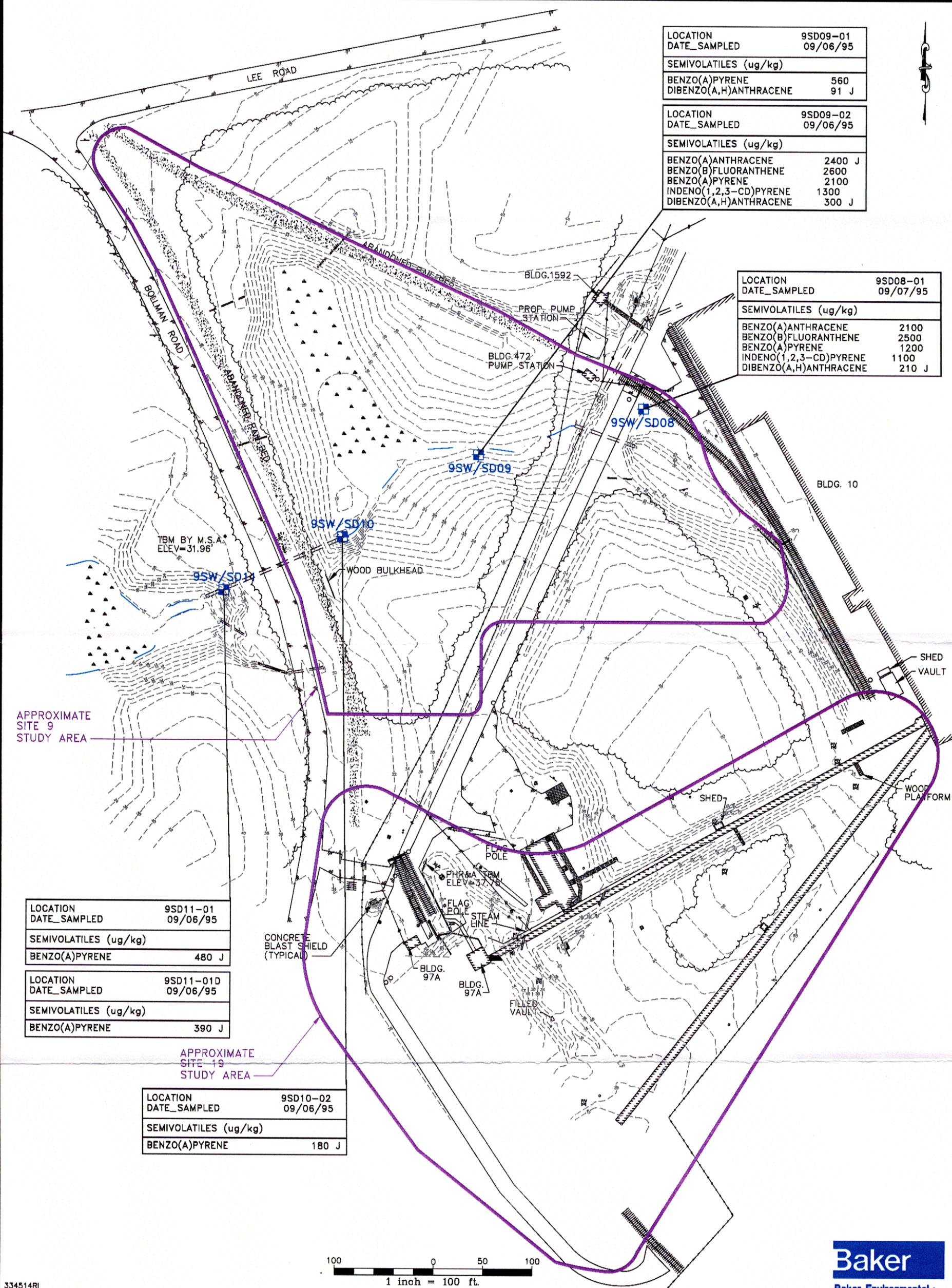
LOCATION	9SD09-02
DATE_SAMPLED	09/06/95
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	2400 J
BENZO(B)FLUORANTHENE	2600
BENZO(A)PYRENE	2100
INDENO(1,2,3-CD)PYRENE	1300
DIBENZO(A,H)ANTHRACENE	300 J

LOCATION	9SD08-01
DATE_SAMPLED	09/07/95
SEMIVOLATILES (ug/kg)	
BENZO(A)ANTHRACENE	2100
BENZO(B)FLUORANTHENE	2500
BENZO(A)PYRENE	1200
INDENO(1,2,3-CD)PYRENE	1100
DIBENZO(A,H)ANTHRACENE	210 J

LOCATION	9SD11-01
DATE_SAMPLED	09/06/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	480 J

LOCATION	9SD11-01D
DATE_SAMPLED	09/06/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	390 J

LOCATION	9SD10-02
DATE_SAMPLED	09/06/95
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	180 J



334514RI

LEGEND

9SW/SD09 - SURFACE WATER, SEDIMENT, AND BENTHIC SAMPLING LOCATION

**FIGURE 4-10
ROUND TWO RI
POSITIVE DETECTIONS OF SELECT ORGANIC
ANALYTES IN SEDIMENT
SITES 9 AND 19**

5.0 CONTAMINANT FATE AND TRANSPORT

This section contains a general discussion on the various physical and chemical properties, potential mobility, and persistence of contaminants detected at Sites 9 and 19 that could potentially determine the fate and transport of the contaminants in the environment. The nature and extent of potential contamination at Sites 9 and 19 was presented in Section 4.0.

5.1 Chemical and Physical Properties

The potential for a contaminant to migrate and persist in environmental media is an important factor in evaluating risk to human health and the environment. The general environmental mobility of a chemical is influenced by its physical and chemical properties, the physical characteristics of the site, and the site chemistry. This section evaluates the properties of the contaminants detected at Sites 9 and 19 with emphasis on potential environmental mobility and persistence.

Table 5-1 presents the physical and chemical properties that determine a contaminant's general environmental mobility and fate for the organic contaminants detected at the sites. These properties include:

- Specific gravity
- Vapor pressure
- Water solubility
- Octanol/water partition coefficient
- Bioconcentration factor
- Soil/sediment adsorption coefficient
- Henry's Law constant
- Mobility index

Oxidation/Reduction potential (Redox), pH, cation exchange capacity, and other physical/chemical properties affecting general inorganic constituent mobility will also be discussed in this section.

A discussion of the environmental significance of each property follows.

Specific gravity is the ratio of a given column of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a contaminant will have a tendency to float or sink (as an immiscible liquid) in water if it exceeds its corresponding water solubility.

Vapor pressure provides an indication of the rate at which a chemical may volatilize. It is of primary significance at environmental interfaces such as surface soil/air and surface water/air. Volatilization is not as important when evaluating groundwater and subsurface soil as it is when evaluating surface soil or surface water.

Vapor pressures for monocyclic aromatics and chlorinated volatiles such as TCE are generally higher than vapor pressures for PAHs. Contaminants with high vapor pressures will enter the atmosphere at a quicker rate than the contaminants with lower vapor pressures.

The rate at which a contaminant is leached from soil by infiltrating precipitation is proportional to its water solubility. More soluble contaminants are usually more readily leached than less soluble contaminants. The water solubilities indicate, for example, that the volatile organic contaminants including monocyclic aromatics are usually several orders-of-magnitude more soluble than pesticides.

The octanol/water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of contaminants between octanol and water. A linear relationship between octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor - BCF) has been established (Lyman et al., 1982). The coefficient also is useful in characterizing the sorption of compounds by organic soil where experimental values are not available.

The organic carbon adsorption coefficient (K_{oc}) indicates the tendency of a chemical to adhere to soil particles of organic carbon. Contaminants with high soil/sediment adsorption coefficients generally have low water solubilities and vice versa. For example, contaminants such as pesticides are relatively immobile in the environment and are preferentially bound to the soil. The compounds while bound, are not subject to aqueous transport to the extent of compounds with higher water

solubilities. It is, however, important to note that contaminants bound to soil may in time desorb to the water column until an equilibrium is reached. This equilibrium is governed by contaminant water solubility and soil characteristics including the percent of organic carbon in the soil microenvironment. Erosional properties of soils may enhance the mobility of these bound soil contaminants.

Both vapor pressure and water solubility are of use in determining volatilization from surface water bodies and from groundwater. These two parameters can be used to estimate an equilibrium concentration of a contaminant in the water phase and in the air directly above the water. This can be expressed as Henry's Law Constant.

A quantitative assessment of mobility has been developed that uses water solubility (S), vapor pressure (VP), and organic carbon partition coefficient (K_{oc}) (Laskowski, et al., 1983). This value is referred to as the Mobility Index (MI). It is defined as:

$$MI = \log((S*VP)/K_{oc})$$

A scale to evaluate MI is presented by Ford and Gurba (1984) below:

Relative MI	Mobility Description
>5	Extremely mobile
0 to 5	Very mobile
-5 to 0	Slightly mobile
-10 to -5	Immobile
<-10	Very immobile

Relative MI values and mobility descriptions are included on Table 5-1. Similar mobility descriptions are presented in Roy and Griffin (1985).

Numerous factors have been suggested as influencing mobility of elements in soils. Among these are: physical factors of the soil (structure and texture); biological factors (aerobic and anaerobic

microbial activities); and chemical factors (pH, redox potential, cation exchange capacity). Under appropriate conditions any of these factors can become dominant and exert controlling influences on inorganic mobility. In general, the following will usually be the most significant factors affecting inorganic constituent mobility:

- Particle size distribution (soil texture)
- Porosity (soil structure)
- pH
- Redox Potential
- Cation Exchange Capacity
- Soil organic matter

The following paragraphs present a brief discussion of each of the aforementioned factors potentially affecting inorganic mobility.

Many studies of inorganic constituent mobility indicate that attenuation is significantly correlated with particle size distribution, porosity, and the amount of extractable iron, probably dominated by hydrous oxides of Fe. In general, the smaller the particle size distribution, the higher the porosity, thus the greater the relative potential for attenuation. This is because fine-textured soil materials generally have a greater total volume of pore space than coarser soil materials. However, pores in fine-textured soil materials are usually much smaller than pores in coarse-textured soil materials. Because water in soil pore spaces is the vehicle in which soluble constituents move, the pore size has a profound influence on inorganic constituent migration. In general, small pore spaces restrict the movement of water through the soil which in turn allows more time for contaminants to react chemically, biologically, or physically in the environment. Table 5-2 presents general particle size, porosity, and bulk density information for various soil materials observed at WPNSTA Yorktown.

pH is expressed as the negative log of H^+ in moles/liter and is the measure of the concentration of protons available in solution. The lower the pH, the greater the number of available H^+ . The Redox potential or Eh refers to the presence or absence of electrons in solution. Similar to pH, Eh can be expressed as the measure of pH^- activity in solution. In general, positive Eh indicates oxidizing conditions and negative Eh indicates reducing conditions. Because electrons neutralize protons,

most naturally occurring reactions in solution are both Eh-pH dependent. Not surprisingly, the potential migration of inorganic constituents in the environment is Eh-pH dependent.

In general, attenuation of inorganic constituents may be expected in soils of neutral to alkaline (pH>7) conditions. Also, oxidizing conditions generally favor inorganic attenuation more so than reducing conditions. Reducing conditions are usually found in environments lacking free molecular oxygen. Chemical or biological demand for oxygen may consume more oxygen than can be brought into the system. Microorganisms find a substitute for O₂ in metabolic processes such as nitrates (NO₃⁻) or sulfates (SO₄²⁻). Reducing conditions generally favor the increased mobility of inorganic contaminants such as arsenic, beryllium, copper, nickel, selenium, vanadium, and zinc.

The carbon exchange capacity (CEC) of a soil can also affect the potential mobility of inorganic constituents. CEC is defined as the milliequivalents of monovalent cations that can be exchanged per unit weight of soil. CEC should be considered as conditional, varying with soil conditions, pH, and Eh, but, in general, the higher the CEC of a soil the greater the attenuation of inorganic contaminants. Clays typically exchange cations because of the presence of negatively charged sites on the mineral, resulting from the substitution of an atom of lower oxidation number for one of higher number for example, magnesium for aluminum.

CEC is the mechanism by which potassium, calcium, and magnesium are made available to plants. It is, therefore, not surprising that the concentration of organic matter in soils plays a role in the attenuation of inorganic contaminant mobility. Organic matter in soils has a general decelerating influence on trace inorganic contaminant mobility. Organic acids and bases can form complexes by ion-exchange, surface absorption, chelation, complex coagulation, and peptide reactions. Microbial activity can also be responsible for the production of organic chelating substances and thus play an important role in inorganic contaminant mobility.

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Sites 9 and 19 the following general potential contaminant transport pathways have been identified:

- Off-site atmospheric deposition of windblown dust
- Surface soil runoff
- Sediment migration
- Leaching of sediment contaminants to surface water
- Migration of contaminants in surface water
- Leaching of soil contaminants to groundwater
- Migration of groundwater contaminants offsite
- Groundwater discharge to surface water body

Contaminants released to the environment may undergo the following during transportation:

- Physical transformations: volatilization, precipitation, chelation
- Chemical transformations: photolysis, hydrolysis, oxidation, reduction, ion exchange
- Biological transformation: biodegradation
- Accumulation in one or more media

The behavior of relevant contaminant groups (VOCs, nitramine compounds, etc.) in each transport pathway, under these conditions is outlined in Section 5.3. The following paragraphs describe the transport pathways listed above.

5.2.1 Off-Site Atmospheric Deposition of Windblown Dust

Wind can act as a contaminant transport agent by eroding exposed soil and exposed sediment and blowing it off site. This is influenced by wind velocity, the grain size/density of the soil/sediment particles, and the amount of vegetative cover over the soil or sediment.

Most of the study area for Site 9 and Site 19 is covered by grass and tall trees. This would limit potential airborne migration of site contaminants. During the investigation of Sites 9 and 19, blowing dust was not noticeable and vehicle traffic was limited to the concrete and asphalt covered roads. Vehicle traffic at Sites 9 and 19 is limited because loading operations have ceased. However,

off-site deposition of dust may occur in the event of building demolition or any activities that might change future land use at Sites 9 and 19.

5.2.2 Surface Soil Runoff

Water can erode exposed soil and sediment particles during precipitation events. This is influenced by site topography, the amount of precipitation, soil/sediment particle size/density and cohesion, and vegetative cover.

The open areas of Sites 9 and 19 are primarily flat and grass covered, except for the berms around the buildings. Wooded areas are present around and within these open areas which would reduce the potential for surface soil runoff. Surface water runoff of potentially contaminated soil from the upper portions of Site 9 is expected in the drainage way and the tributary to Lee Pond. Although no distinct source area remains at the upper end of the drainage way the presence of PAHs and amino-DNTs in drainage way soils and sediments could be attributable to past operations at Site 9. Arsenic was also detected in surface soil samples of the drainage way. The elevated concentrations of arsenic present in the drainage way may not simply be associated with surface soil runoff. In poorly drained soils that become waterlogged, reducing conditions may make arsenic more soluble and mobile than oxidized forms (USEPA, 1977). Higher concentrations of arsenic in drainage ditch soils may be due to the solubilizing of naturally occurring arsenic from native soils and vegetative matter and poorly drained soils acting as a sink. These soils were moist, and water was encountered at a depth of approximately 3 feet in the drainage way.

5.2.3 Sediment Migration

Sediment can be transported mechanically through the drainage ditches by surface water erosion. This is influenced by drainage ditch slope, rate of surface water flow, sediment size/density and particle cohesion, and vegetative cover.

The lack of vegetative cover on the floor of the drainage way at Site 9 exposes sediment to erosion during periods of heavy precipitation. Sediment sample analytical results suggest that there may have been some migration of contaminants through the drainage ditches based on the presence of

PAHs detected at sediment locations at Site 9. Arsenic was also detected in the Site 9 drainage way sediments, with highest detected concentrations observed at locations SD08 (upgradient) and SD10 (downgradient) at concentrations of 50 mg/Kg and 22 mg/Kg, respectively. Higher concentrations were detected in deeper sediment samples which could be a function of arsenic solubility under reducing conditions often associated with deeper sediments.

5.2.4 Leaching of Sediment Contaminants to Surface Water

When in contact with surface water, contaminants attached to sediment particles can desorb from the sediment particle and partition into the surface water. Hydrophobic contaminants such as PAHs present in surface water can also be removed from the water column by sediment. Typically, an equilibrium between sediment concentrations and surface water concentrations is established in an aquatic system over time. The rate at which equilibrium is reached is influenced by the physical and chemical properties of the contaminant, the physical and chemical properties of the sediment particle, and the physical and chemical properties of the surface water.

Surface water and sediment sample analytical results suggest that PAHs are associated with the sediment and not the surface water. While the more water soluble nitramines were detected in the surface water samples, arsenic was detected in both surface water and sediment samples. These detected concentrations are likely dependent on pH, Eh, and other factors affecting potential inorganic constituent mobility. As such, arsenic detections in surface water and sediment samples obtained from the Site 9 drainage way are a snapshot of this surface water feature and are subject to change as the microenvironment changes with time.

5.2.5 Migration of Contaminants in Surface Water

Contaminants leaching from soil to surface water can migrate as dissolved constituents in surface water in the direction of surface water flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: (1) movement caused by the flow of surface water, (2) movement caused by irregular mixing of water, and (3) chemical mechanisms occurring during the movement of surface water. As stated earlier, sediment particles can disassociate from

the sediment particle into surface water and migrate in one of the aforementioned methods. These processes are discussed in more detail in Subsection 5.2.7.

Migration pathways associated with surface water and sediment from the drainage way at Sites 9 to Lee Pond include the transport of contaminants via surface water movement, adsorption/desorption process from surface water to sediment, and discharge to or from groundwater. Contaminants that could migrate in the drainage way include nitramines and inorganics such as arsenic which were detected in either surface water samples, sediment samples, or both. It does not appear that PAHs are moving by adsorption/desorption mechanisms at this time. The adsorption/desorption process, from surface water to sediment, can create a contaminant "sink" and this appears to be the case with PAHs. Adsorption/desorption mechanisms also involve complex chemical and biochemical reactions. For example, as chemicals are desorbed from sediment, they may be available for uptake by receptors from the water column.

5.2.6 Leaching of Soil Contaminants to Groundwater

Contaminants in the site soil can leach and migrate vertically to the groundwater with infiltrating precipitation. This is influenced by the physical and chemical properties of the soil, the physical and chemical properties of the contaminant, the amount of precipitation, and the depth to the water table.

Nitramine compounds including 2,4,6-TNT, RDX, 1,3,5-trinitrobenzene, and amino-DNTs were detected in the surface soil, subsurface soil, and the shallow groundwater at Sites 9 and 19 indicating that despite mobility data to the contrary, these contaminants are mobile in environmental media at the sites. Amino-DNTs are constituents formed by the reduction of a nitro-group (NO_2^-) on 2,4,6-TNT to an amine (NH_2^-). Because water solubility data are not available for amino-DNTs it is difficult to predict the overall affect on environmental mobility when 2,4,6-TNT is reduced to amino-DNTs. In general, NH_2^- is less relatively mobile than NO_2^- . Therefore, amino-DNTs may be less relatively mobile in environmental media than the parent 2,4,6-TNT compound.

5.2.7 Migration of Groundwater Contaminants Offsite

In general, organic contaminants detected in Sites 9 and 19 groundwater are dissolved in that detected concentrations do not exceed contaminant water solubility values. The presence of inorganic constituents in Site 9 and 19 groundwater appears to be associated with solids present in the water column as indicated by the difference between filtered versus unfiltered groundwater sample results. The following paragraphs discuss the potential migration of organic and inorganic contaminants in the groundwater medium.

Three general processes govern the migration of dissolved contaminants caused by the flow of groundwater: (1) advection, movement caused by flow of groundwater; (2) dispersion, movement caused by irregular mixing of waters during advection; and (3) chemical mechanisms such as adsorption/desorption which occur during advection.

5.2.7.1 Advection

Advection is the process which most strongly influences the migration of organic and inorganic contaminants. Groundwater generally flows from regions of the subsurface where the water level is high to regions where the water level is low. Hydraulic gradient is the term used to describe the magnitude of this force or the relative slope of the water table. In general, the gradient usually follows the topography for uniform sandy aquifers (unconfined or water table aquifers) which are commonly found in coastal regions. An average hydraulic gradient for the shallow aquifer (Cornwallis Cave aquifer) was calculated to be 0.016 feet/feet. The average flow velocity of shallow groundwater flow at Sites 9 and 19 was calculated in Section 3.3.1 as 3.6 ft/day.

Based on site history, it is likely that groundwater contaminants in the shallow aquifer have reached Lee Pond. A conservative travel time of 21 days can be derived using the average flow velocity (3.6 ft/day) and a distance of 75 feet (measured from well location MW9GW02) to Lee Pond proper. Inorganic contaminants such as aluminum and arsenic, which appear to be associated with the presence of solids in the sample, may take longer to reach Lee Pond because particles do not normally move as quickly in groundwater as do solubilized contaminants. However, aluminum and arsenic could be solubilized based on the chemistry (pH, Eh, CEC) of the shallow water bearing unit.

5.2.7.2 Dispersion

Dispersion results from two basic processes, molecular diffusion and mechanical mixing. The kinetic activity of dissolved solutes results in diffusion of solutes from a zone of high concentration to a lower concentration. Dispersion and spreading during transport results in the dilution of contaminants (maximum concentration of contaminant decreases with distance from the plume). For simple hydrogeologic systems, the spreading is believed to be proportional to the flow rate. Furthermore, dispersion in the directions transverse (perpendicular) to the flow also occurs. In the absence of detailed studies to determine dispersive characteristics at Sites 9 and 19, longitudinal and transverse dispersion must be estimated based on similar hydrogeological systems (Mackay, et al., 1985).

5.2.7.3 Chemical Mechanisms

Some dissolved contaminants may interact with the aquifer solids (i.e., subsurface soil) encountered along the flow path through adsorption/desorption, partitioning, CEC, and other processes. The interactions result in the contaminant's distribution between the aqueous phase and the aquifer solids, diminution of concentrations in the aqueous phase, and retardation of the movement of the contaminant relative to groundwater flow. The higher the fraction of the contaminant sorbed, the more retarded its transport (Mackay, et al., 1985). The sorption of certain halogenated organic solvents is affected by hydrophobicity (antipathy for dissolving in water) and the fraction of solid organic matter in the aquifer solids (organic carbon content).

Organic contaminants can be transformed into other organic compounds by a complex set of chemical and biological mechanisms. The principle classes of chemical reactions that can affect organic contaminants in water are hydrolysis and oxidation. However, it is believed that most chemical reactions occurring in the groundwater zone are likely to be slow compared with transformations mediated by microorganisms. Certain organic groundwater contaminants can be biologically transformed by microorganisms attached to solid surfaces within the aquifer. Factors which affect the rates of biotransformation of organic compounds include: water temperature and pH, the number of species of microorganisms present, the concentration of substrate, presence of microbial toxicants and nutrients, and the availability of electron acceptors (Mackey, et al., 1985).

The interaction of non-ionic organic compounds with solid phases can be used to predict the fate of the contaminant. Sorptive binding is a function of the organic content of the sorbent. Sorption of non-ionic organic compounds can be attributed to an active fraction of the soil organic matter. The uptake of neutral organics by soil results from their partitioning and a function of the aqueous solubility of the chemical and its liquid-liquid (e.g., octanol-water) partition coefficient (Chiou, 1979). Organic matrices in natural systems that have varying origins, degrees of humification, and degrees of association with inorganic matrices exhibit dissimilarities in their ability to sorb non-ionic organic contaminants.

Soil also contains surface-active mineral and humic constituents that are involved in reactions that affect inorganic contaminant retention. The surfaces of fine-grained soil particles are very active chemically; surface sites are negatively or positively charged or they are electronically neutral. Oppositely charged ions from solutions in soil are attracted to these charged surfaces. The relative proportions of ions attracted to these various sites depend on the Eh, pH, and temperature of the microenvironment, the mineralogical composition of the soil, and on its content of organic matter. In addition to these adsorption reactions, precipitation of new mineral phases also may occur if the chemical composition of the soil solution becomes supersaturated with respect to the insoluble precipitates. Of the probable precipitates, the most important of these phases are hydroxides, carbonates (under aerobic conditions), and sulfides (under anaerobic conditions).

5.3 Fate and Transport Summary

The following section summarizes the contaminant fate and transport data for some potential COPCs at Sites 9 and 19.

5.3.1 Volatile Organic Compounds

Volatile organic compounds were not detected at Sites 9 and 19.

5.3.2 Semivolatile Organic Compounds

PAHs were detected during investigations at Sites 9 and 19 primarily in soils and sediments. The majority of PAHs detected at Sites 9 and 19 are generally immobile to very immobile in environmental media. Low water solubilities and high K_{ow} and K_{oc} values indicate a strong tendency to adsorb to soils and sediments. Data obtained at Site 9 in the drainage way and mobility indices presented in Table 5-1 support the environmental immobility of these contaminants. Their mobility indices indicate that they are relatively immobile from a physical-chemical standpoint.

5.3.3 Nitramine Compounds

Nitramine compounds were detected during investigations at Sites 9 and/or 19 in surface soil, subsurface soil, shallow groundwater, and surface water. The primary nitramines detected were 4-amino-2,6-dinitrotoluene and 2,4,6-TNT.

Nitramines tend to be slightly mobile to very immobile in environmental media. Low water solubilities indicate a tendency to adsorb to soil. Despite relatively low water solubilities, analytical data obtained at both Sites 9 and 19 indicate that these constituents are mobile in environmental media. The presence of 2,4,6-TNT, 1,3,5-trinitrobenzene, RDX, and amino-DNTs in various environmental media (i.e., groundwater, surface water, soils) suggests that these contaminants have moved from potential source areas to deeper soils, groundwater, and possibly surface water and sediments over time. Groundwater data indicate that these constituents will likely continue to migrate in the direction of groundwater flow to Lee Pond, where shallow groundwater interacts with surface water.

Biotransformation has been identified as an important fate process for nitramines in the aquatic environment. Hydrolysis, oxidation, and abiotic reduction were not considered major transformation processes for these compounds, nor were volatilization, sediment sorption, and biosorption. The presence of amino-DNTs in various media indicate that biotransformation of chemical processes that can reduce 2,4,6-TNT is at work at Sites 9 and 19.

The migration of HMX and RDX in soil exhibits a pattern similar to that of TNT. Migration varies with soil type and is considered greatest in coarse, loamy soil. The low solubility of these compounds in water slows its migration potential through soil and produces a low concentration in groundwater (Roberts and Hartley, 1992).

5.3.4 Inorganics

Inorganics were detected during investigations at Sites 9 and 19 in all media. The primary inorganics detected were arsenic and beryllium. Aluminum occurred in conjunction with explosives in soils at Site 19.

Inorganics can be found as solid complexes at ambient temperature and pressure in soil at the sites. Inorganic ions exist in pure solutions as hydrated ions. Groundwater, as opposed to a pure solution, is a highly complex chemical system that is heavily influenced by the mineralogy of the substrate. Factors affecting the transport of inorganics in saturated soil are interactive and are often more complex and numerous than those affecting the transport of organic contaminants.

The most complicated pathway for inorganic contaminants is migration in subsurface soil and groundwater, where Eh and pH play critical roles. Table 5-3 presents a general assessment of relative inorganic environmental mobilities as a function of Eh and pH. Soil at WPNSTA Yorktown is relatively neutral to slightly acidic; therefore, inorganics such as lead, chromium and beryllium in the subsurface soil should be relatively immobile. Inorganics including zinc, copper and arsenic should be relatively mobile under these conditions.

Transport of inorganic species in groundwater is mainly a function of soil structure and the Eh, pH, CEC, and organic content of the soil/groundwater microenvironment. Generally, dynamic and reversible processes control solubility and transport of the inorganics. Such processes include precipitation/dissolution, adsorption/desorption, and ion exchange.

Inorganics could be sorbed onto colloidal materials, theoretically increasing their inherent mobility in saturated porous media. It is important to note, however, that most colloids themselves are not mobile in most soil/water systems.

The inorganic constituent arsenic may be more relatively mobile in surface and shallow subsurface soils of the Site 9 drainage way. Poorly drained soils in the drainage way and sediments therein displayed relatively high concentrations of arsenic. Reducing conditions in these soils could be mobilizing naturally occurring arsenic from native soils and vegetative matter in the ditch area where poorly drained soils and sediment act as a sink. This may also explain the presence of arsenic in surface water samples obtained from standing water in the drainage way. Although arsenic was detected in Site 9 and Site 19 soil, concentrations were generally within Station-wide background values. Arsenic concentrations in soils obtained from directly above the water table did not appear to be elevated, suggesting that Site 9 and 19 soils are not currently acting as potential source areas of arsenic to groundwater.

5.4 References

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SECTION 5.0 TABLES

TABLE 5-1

**ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Chemical	Vapor Pressure (mmHg)	Water Solubility (mg/L)	Octanol/Water Coefficient (log K_{ow})	Sediment Partition (log K_{oc})	Specific Gravity (g/cm ³)	Henry's Law Constant (atm-m ³ /mole)	Mobility Index	Comments
<i>Semivolatiles:</i>								
Benzo(a)Anthracene	5.00E-09	0.014	5.61	5.34	1.274	1.00E-06	-15.5	Very Immobile
Benzo(b)Fluoranthene	1.00E-11 to 1.00E-06	0.009	6.57	6.26	--	1.22E-05	-14.3	Very Immobile
Benzo(a)Pyrene	5.00E-09	0.0038	6.04	5.72	1.351	4.90E-07	-16	Very Immobile
Dibenzo(a,h)anthracene	1.00E-10	0.0005	6.86	6.38	--	7.33E-09	-19.7	Very Immobile
Indeno(1,2,3-cd)Pyrene	1.00E-10	0.0034	6.30	5.87	--	2.96E-20	-18.3	Very Immobile
<i>Nitramines:</i>								
Dinitrobenzene	3.90E-03	369	--	--	1.571	--	--	--
2-Amino-4,6-Dinitrotoluene	--	--	--	--	--	--	--	--
4-Amino-2,6-Dinitrotoluene	--	--	--	--	--	--	--	--
2,6-Dinitrotoluene	1.80E-02	300	2.00	1.79	--	2.17E-07	-1.1	Slightly Mobile
RDX	1.00E-09	38.4	0.87	1.80	1.816	1.20E-05	-9.2	Immobile
1,3,5-Trinitrobenzene	3.20E-06	0.03	--	--	--	--	--	--
2,4,6-Trinitrotoluene	1.99E-04	130	2.20	3.04	1.600	4.57E-07	-4.6	Slightly Mobile

TABLE 5-2

TEXTURE AND STRUCTURE DATA FOR VARIOUS SOIL MATERIALS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Material	Particle Size (mm)	Porosity (%)	Bulk Density (g/cm ³)	Permeability (cm ²)
Clay (colloidal)	10 ⁻⁴ - 0.01	40	1.49	10 ⁻¹² to 10 ⁻⁹
Sand	0.05 - 0.25	31	1.70	10 ⁻¹⁰ to 10 ⁻⁶
Silt	0.005 - 0.05	46	1.40	10 ⁻¹² to 10 ⁻⁸
Coarse Sand	0.5 - 2.0	39	1.75	10 ⁻⁹ to 10 ⁻⁵

TABLE 5-3

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Relative Mobility	Environmental Conditions			
	Oxidizing	Acidic	Neutral/Alkaline	Reducing
Very High			Se	
High	Se, Zn	Se, Zn, Cu, Ni, Hg, Ag		As, Be, Cr, Cu, Fe, Zn, Se
Medium	Cu, Ni, Hg, Ag, As, Cd	As, Cd	As, Cd	
Low	Pb, Ba, Se	Pb, Ba, Be	Pb, Ba, Be	Cd
Very Low	Fe, Cr	Cr	Cr, Zn, Cu, Ni, Hg, Ag	Ni, Hg, Pb, Ba, Ag

Notes:

As = Arsenic	Fe = Iron
Ag = Silver	Hg = Mercury
Ba = Barium	Ni = Nickel
Be = Beryllium	Pb = Lead
Cd = Cadmium	Se = Selenium
Cr = Chromium	Zn = Zinc
Cu = Copper	

Sources: Swartzbaugh, et al. "Remediating Sites Contaminated with Heavy Metals." Hazardous Materials Control, November/December 1992.

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6.0 HUMAN HEALTH RISK ASSESSMENT

A baseline human health risk assessment (RA) was performed, as part of the Round Two RI for Sites 9 and 19 at WPNSTA Yorktown to evaluate the potential risks associated with exposure to environmental media resulting from existing conditions at the site if no additional remedial action is undertaken. The baseline RA considers the most likely routes of potential human exposure for both current and future risk scenarios and was conducted in accordance with the Risk Assessment Guidance for Superfund (RAGS), Part A, Human Health Evaluation Manual (USEPA, 1989b), and the most recent updates.

This baseline RA is comprised of eight sections: Section 6.1 presents an overview of the historical information for Sites 9 and 19 pertinent to the technical approach the risk assessment. Section 6.2 presents the selection of chemicals of potential concern (COPCs). Sections 6.3 and 6.4 present the exposure assessment and toxicity assessment, respectively. The risk characterization is presented in Section 6.5; while Section 6.6 presents sources of uncertainty inherent in the estimation of inferential potential human health effects. A summary of the baseline RA is provided in Section 6.7; and total site risk to each potential human receptor is presented therein. Section 6.8 presents the references. A complete discussion of the previous investigations and history of Sites 9 and 19 is included in Section 1.0; therefore, only a brief description is presented in the section below.

6.1 Overview

Site 9 is a discharge area which had been used as a drainage way for Plant 1 (Building 10) nitramines/nitroaromatics (explosives)-contaminated wastewater and possibly for organic solvents. The drainage area was reportedly used from the late 1930s to 1975. In 1975, a carbon adsorption tower was installed to treat the contaminated wastewater prior to discharge to the drainage way. Based on estimated discharges, 5,200 pounds of TNT and RDX and 1,600 pounds of HMX may have been discharged to the site. Solvents such as TCE may also have been discharged from the plant. Contaminants from Plant 1 may have migrated via surface water into Lee Pond or across the upper soil via overland flow in the area of the pond near Building 10. In 1986, the discharge from the treatment tower was diverted to the sanitary sewer and ultimately to the HRSD. Site 9 is topographically downgradient from Site 19.

Site 19 is the conveyor belt between Buildings 10 and 98 that carried TNT powder packaged in containers across a depression into the loading building. The conveyor belt is completely enclosed with corrugated metal, but holes are visible along the floors and walls. Fine particles of explosives-related compounds may have been released to the soil in the vicinity of the conveyor belt during explosives loading operations. The conveyor and walls/floors were sprayed with water to control dust; this rinse water may have dripped onto the ground surface below. TNT-contaminated soil has been reported in the vicinity of the conveyor belt. Soil beneath the belt was removed in 1973 and 1974, but later tests indicated the presence of RDX and TNT.

There are no drinking water wells at WPNSTA Yorktown; the coastal plain aquifer and other shallower aquifers are not used as drinking water sources. Drinking water is supplied by the City of Newport News. There are, however, five supply wells at WPNSTA Yorktown, located at Buildings 120, 352, 304, and 28 (all for fire-fighting purposes), and Gate 13. Due to the poor water quality, the wells located at Buildings 120, 352, and 304 have been decommissioned and capped; a fourth well at Building 28 was abandoned and filled with cement. The remaining well at Gate 13, which is located in the deeper Yorktown aquifer, is a newer well that supplies water to the toilet facilities associated with the weigh station. This well is approved by the Virginia Department of Health for potable use; however, drinking water is supplied in the form of bottled water. Gate 13 is located in the western portion of WPNSTA Yorktown, several miles from Sites 9 and 19.

6.2 Identification of Chemicals of Potential Concern

The selection of COPCs was based on the information provided in the USEPA Region III Technical Guidance on Selecting Exposure Routes and Contaminants of Concern, by Risk-Based Screening (SCCRBS), dated January 1993 (USEPA, 1993a) and USEPA's Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A), Interim Final, December 1989 (USEPA, 1989b). COPC selection was completed for each environmental medium and area of concern using analytical data obtained during this RI.

A discussion of laboratory analytical results and nature and extent of constituent contamination is presented in Section 4.0 of this report. Chemicals detected in environmental media sampled during the RI were reevaluated in this section to select COPCs for quantitative evaluation in the baseline

RA. Chemicals selected as COPCs that could not be quantitatively evaluated, are discussed in the uncertainties section (Section 6.6) of the baseline RA.

6.2.1 COPC Selection Criteria

The primary criterion used in selecting a chemical as a COPC at Sites 9 and 19 included comparing the maximum detected concentration to the USEPA Region III Chemicals of Concern (COC) Screening Table (USEPA, 1994a), in accordance with USEPA Region III SCCRBS guidance (USEPA, 1993a).

In conjunction with concentration comparisons to the USEPA Region III COC screening table (COC values), a comparison to concentrations detected in field and laboratory blanks was conducted, to ensure that only site-related contaminants were evaluated in the quantitative estimation of human health effects (refer to Table 6-1). The prevalence of a chemical detected in a given environmental medium, as well as the history of site-related activities were other important criteria applied in selecting COPCs at Sites 9 and 19. Those constituents considered to be essential nutrients (which have relatively low toxicity) were not evaluated in this baseline RA.

Furthermore, in conjunction with concentration comparisons to USEPA Region III COC Screening Concentrations (COC values) and evaluations of chemical prevalence, site history, the assessment of essential nutrients, and comparisons of groundwater, surface water, and sediment to available Commonwealth and Federal standards and criteria were conducted to determine whether chemicals eliminated by a direct comparison to COC values should be re-included as COPCs. Each of the aforementioned criteria is discussed in the paragraphs that follow.

USEPA Region III COC Screening Concentrations - Risk-Based COC Screening Concentrations (COC screening concentrations) were derived by USEPA Region III in January of 1993, and provided in tabular format to support selection of COPCs and address two major limitations in the COPC selection process presented in RAGS. First, using COC screening concentrations prioritizes chemical toxicity and focuses the risk assessment on those COPCs and potential exposure routes. Second, using the COC screening concentrations provides an absolute comparison of potential risks associated with the presence of a COPC in a given medium.

COC screening concentrations were derived using conservative, USEPA-promulgated, default values and the most recent toxicological criteria available. COC screening concentrations for potentially carcinogenic and noncarcinogenic chemicals were individually derived based on a target incremental lifetime cancer risk (ICR) of 1×10^{-6} and a target hazard quotient (HQ) of 0.1, respectively. For potential carcinogens, the toxicity criteria applicable to the derivation of COC screening concentrations are chronic oral and inhalation cancer slope factors; for noncarcinogens, they are oral and inhalation reference doses. These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. Therefore, the use of toxicity criteria in the derivation of COC screening concentrations requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria.

In March of 1994, the USEPA Region III published a second COC Screening Table (COC values) which was also based on an ICR of 1×10^{-6} and a target HQ of 0.1. Subsequent publications of the table (i.e., Risk-Based Concentrations [RBCs]) have included an ICR of 1×10^{-6} but an HQ of 1.0, rather than 0.1. However, since the RBCs are derived using similar equations and USEPA promulgated default exposure assumptions that were used to derive the original set of COC screening concentrations (USEPA, 1993a) and COC values (USEPA, 1994a), updated COC values can be obtained by using the carcinogenic RBCs issued semi-annually by USEPA Region III and dividing the accompanying noncarcinogenic RBCs by a factor of 10. An updated set of COC values can, therefore, be obtained each time the RBC Tables are updated. The COC values used in this baseline RA were derived from the RBC values issued by the USEPA Region III for January to June 1996 (USEPA, 1996b).

Region III COC screening values used in this baseline RA include those derived for tap water (based on ingestion and inhalation pathways) and soil (based on the ingestion pathway residential and industrial land use scenarios). Both the residential and industrial soil COC screening values are presented in this baseline RA; however, in text, the residential values were actually used in selecting COPCs, since they are lower, and consequently, more conservative than the industrial values. Industrial COC screening values are presented since future land use at Sites 9 and 19 is expected to remain industrial. Only residential COC screening values are presented and used as a secondary criterion for the selection of sediment COPCs (secondary to the more conservative sediment screening values, which are discussed in the next paragraph). Tap water COC screening values

presented in this baseline RA were used for selecting groundwater COPCs, as well as for selecting surface water COPCs, in conjunction with ambient water quality criteria.

Sediment Screening Values - At present, promulgated sediment COC values or quality criteria do not exist to protect human health. However, sediment screening values (SSVs) have been published (Long, et al., 1995) for evaluating the potential for chemical constituents in sediment to cause adverse biological effects. This screening method was developed through evaluation of biological effects data for aquatic (marine and freshwater) organisms that were obtained through equilibrium partitioning calculations, spiked-sediment bioassays, and concurrent biological and chemical field surveys. For each constituent having sufficient data available, the concentrations causing adverse biological effects were arrayed and the lower 10 percentile (called an Effects Range-Low, or ER-L) and the median (called an Effects Range-Median, or ER-M) were determined. If contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable.

According to USEPA Region III, exceedences of the ER-M would constitute a chemical's retention as a COPC. Therefore, constituents detected in the sediment at Site 9 were compared to the SSV ER-Ms to determine if any criteria were exceeded.

Blank Concentrations - If a chemical is detected in both the environmental sample and a blank sample, it may not be retained as a COPC in accordance with RAGS depending on the concentration of the chemical in the media. Therefore, blank data were compared with results from environmental samples. If the blanks contained detectable results for common laboratory contaminants (i.e., acetone, 2-butanone, methylene, chloride, toluene, and phthalate esters), environmental sample results were considered as positive results only if they exceed 10 times the maximum amount detected in the associated blank. If the chemical detected in the blank(s) is not a common laboratory contaminant, environmental sample results were considered as positive results only if they exceeded five times the maximum amount detected in the associated blank(s). Furthermore, the elimination of an environmental sample result would directly correlate to a reduction in the prevalence of the contaminant in that media.

When assessing soil and sediment concentrations, the Contract Required Quantitation Limits (CRQLs) and percent moisture are accounted for in order to correlate solid and aqueous quantitation limits. For example, when assessing semivolatile, pesticide, PCB, and nitramine contaminants the

CRQL for solid samples is 33 to 66 times (depending on the contaminant) that of the aqueous samples; this correction is not necessary for the evaluation of volatile COPCs. Therefore, in order to assess contaminant levels in solid samples using an aqueous blank concentration, the concentration was multiplied by 5 or 10 (noncommon or common laboratory contaminants, respectively) and then multiplied by 33 to correct for the variance in the CRQL. Accounting for multipliers greater than 33 or the percent moisture was not necessary for this data set. Associated blanks for Sites 9 and 19 included: field blanks, trip blanks, and rinsate blanks. Table 6-1 provides a summary of the maximum detected blank data and the concentrations used for comparison to environmental sample results. It is important to note that the aforementioned methodologies for evaluating blanks are usually implemented during third party analytical data validation prior to the selection of COPCs in the RA.

Essential Nutrients - Despite their inherent toxicity, certain inorganic constituents are essential nutrients. Essential nutrients need not be considered further in the baseline RA if they are present in relatively low concentrations (i.e., slightly elevated above naturally occurring levels), or if the constituent is toxic at doses much higher than those which could be assimilated through exposures at the site. Elements evaluated as essential nutrients include calcium, iron, magnesium, potassium and sodium.

Prevalence - The prevalence of a chemical in an environmental medium can be described by the frequency and concentration with which it is detected. A detection frequency greater than, or equal to 5 percent (e.g., 1 positive detection in 20 samples) was considered the minimum criteria for the selection of a COPC in data sets comprised of 20 or more samples. Data sets with fewer than 20 samples were evaluated for any positive detections to determine whether the chemical should be included as a COPC.

6.2.2 Re-inclusion of Chemicals as COPCs

Chemicals can be re-included as COPCs for quantitative evaluation in the baseline RA, despite having been eliminated as such from a comparison to COC values (or other aforementioned criteria). For example, a chemical that was detected with a frequency of less than five percent, at concentrations below the corresponding COC value, may be re-included as a COPC if a chemical

is considered a Class A carcinogen (human carcinogen), or if it is reasonable to assume that the chemical could be site-related (especially if it has been detected in other media of concern).

Chemicals may also be re-included as COPCs if detected concentrations exceed the following Federal/Commonwealth standards or criteria.

Maximum Contaminant Levels (MCLs) - MCLs are potentially enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs have been adopted as enforceable standards for public drinking water systems and apply to drinking water supplies consumed by a minimum of 25 persons. They have been developed for the prevention of human health effects associated with lifetime exposure (70 year lifetime) of an average adult (70 kg) consuming 2 liters of water per day. MCLs also consider the technical and economic feasibility of removing the constituent from a public water supply (USEPA, 1995a).

Virginia Drinking Water Standards - Virginia Drinking Water Standards are the maximum contaminant level (MCL) concentrations of a contaminant in water delivered to the users of a public water system. With the exception of nitrate, all inorganic chemical contaminant levels are based on potential adverse health effects resulting from long term exposure to the contaminant in drinking water. The maximum contaminant levels for organics apply to community water supplies; the volatile organics also apply to nontransient, noncommunity water systems.

Virginia Water Quality Standards (WQS) for the Protection of Human Health - The WQSs are Commonwealth-enforceable standards used for identifying the potential for human health risks. WQSs are protective of human health and consider potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day), or from ingestion of water alone (2 liters/day). Commonwealth WQSs available for the protection of human health from potential carcinogenic substances are derived based on an incremental lifetime cancer risk of one additional case of cancer in an exposed population of 100,000 persons (i.e., 1×10^{-5}).

Federal Ambient Water Quality Criteria (AWQC) - AWQC are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic organisms

for surface water bodies. AWQCs consider acute and chronic effects in both freshwater and saltwater aquatic life, and potential carcinogenic and noncarcinogenic health effects in humans from ingestion of both water (2 liters/day) and aquatic organisms (6.5 grams/day) or from ingestion of organisms alone (6.5 grams/day). The AWQCs for protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 persons (i.e., the 1.0×10^{-07} to 1.0×10^{-05} range). The AWQCs used for comparison in this baseline RA included the human health recalculated values for water and organisms and for organisms only. Published criteria were used in the absence of recalculated values.

6.2.3 Selection of COPCs

Four environmental media (soil, groundwater, sediment, and surface water) were investigated at Site 9 while two environmental media (soil and groundwater) were investigated at Site 19. The selection of soil COPCs was stratified to correspond to the surface soil (0- to 6-inches bgs) and the subsurface soil (greater than 6-inches bgs to 11-feet bgs) depth intervals. Tables 6-2 through 6-9 present the selection of COPCs for each environmental medium based on the criteria discussed previously in Sections 6.2.1 through 6.2.3. Information is presented in these tables only for those constituents detected at least once, in the medium of interest. Furthermore, calcium, iron, magnesium, potassium, and sodium, which were detected in almost every sample regardless of the medium, were considered to be essential nutrients and were therefore, not retained as COPCs in any medium under investigation at Sites 9 and 19.

The following paragraphs present the rationale for selection of COPCs. Sample locations, analytical results, and corresponding figures are presented in previous sections of this RI report.

6.2.3.1 Surface Soils - Site 9 and 19

Site 9

Surface soil samples were collected from the 0- to 6-inch interval and analyzed for VOCs, SVOCs, pesticides/PCBs, nitramine compounds, and inorganics. The sample set included ten samples (8

environmental and 2 duplicate samples). The listing of the samples included in this set is presented in Appendix K. The COPC selection summaries for surface soils at Site 9 are presented in Table 6-2 and discussed below.

VOCs were not detected in the surface soils at Site 9; therefore, VOCs were not retained as surface soil COPCs.

Twenty-one SVOCs, namely phthalate esters, polynuclear aromatic hydrocarbons (PAHs), and dibenzofuran were detected in the Site 9 surface soil samples. Of these twenty-one constituents, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene exceeded their respective residential COC values. However, since PAHs occur as mixtures, three additional carcinogenic PAHs (cPAHs), benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were also retained as surface soil COPCs. One cPAH (carbazole); eight noncarcinogenic PAHs (nPAHs) (anthracene, acenaphthylene, acenaphthene, benzo(g,h,i)perylene, fluoranthene, fluorene, phenanthrene, and pyrene); four phthalate esters (butylbenzylphthalate, dimethylphthalate, di-n-butylphthalate and bis(2-ethylhexyl)phthalate); and dibenzofuran were also detected in the Site 9 surface soil samples. However, carbazole, the nPAHs, phthalates, and dibenzofuran did not exceed their respective residential soil COC values and were therefore, not retained as surface soil COPCs.

Three pesticides, heptachlor epoxide, 4,4'-DDE, and 4,4'-DDT were detected in the Site 9 surface soils; however, none exceeded their residential soil COC values. Therefore, no pesticides were retained as surface soil COPCs. PCBs were not detected in the surface soils at Site 9.

Two nitramines, 2,4,6-trinitrotoluene (TNT) and amino-DNTs, were detected in the Site 9 surface soils; the amino-DNTs did not exceed the COC value for 2,6-DNT and 2,4,6-TNT did not exceed its respective COC value, but each was retained as a COPC since their presence can be associated with the history of the site.

Inorganics were detected in each of the surface soil samples collected. Detected concentrations of arsenic, beryllium, and vanadium exceeded their corresponding Region III residential COC values; therefore, they were retained as surface soil COPCs for quantitative evaluation in the baseline RA. Several of the detected concentrations also exceeded the COC value for iron; however, iron is considered to be an essential nutrient and was not retained as a surface soil COPC.

Site 19

Surface soil samples at Site 19 were collected from the 0- to 6-inch interval and analyzed for VOCs, SVOCs, pesticides/PCBs, nitramine compounds, and inorganics during the Round Two investigation. The sample set included eight samples (seven environmental and one duplicate sample). The COPC selection summary for surface soils at Site 19 is presented in Table 6-3 and discussed below.

One VOC, 1,1,1-trichloroethane (which was also detected in associated blanks), was detected in one Site 19 surface soil sample. However, 1,1,1-trichloroethane did not exceed its respective residential COC value and was therefore, not retained as a surface soil COPC.

Fourteen SVOCs, namely phthalate esters and PAHs were detected in the Site 19 surface soil samples. Of these fourteen constituents, only benzo(a)pyrene exceeded its respective residential COC value. However, since PAHs occur as mixtures, five additional cPAHs, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene were also retained as surface soil COPCs. Five nPAHs (anthracene, benzo(g,h,i)perylene, fluoranthene, pyrene, and phenanthrene) and three phthalates (dimethyl-phthalate, di-n-butylphthalate and bis(2-ethylhexyl) phthalate) were also detected in the Site 19 surface soil samples. However, the nPAHs and the phthalates did not exceed their respective residential soil COC values and were therefore, not retained as surface soil COPCs.

Six pesticides, heptachlor epoxide, 4,4'-DDE, 4,4'-DDT, endrin ketone, endrin aldehyde, and gamma-chlordane, were detected in the Site 19 surface soils; however, none exceeded their residential soil COC values. Therefore, no pesticides were retained as surface soil COPCs. PCBs were not detected in the surface soils at Site 19.

Two nitramines, 2,4,6-TNT and amino-DNTs, were detected in the Site 19 surface soils; the amino-DNTs did not exceed the COC value for 2,6-DNT and 2,4,6-TNT did not exceed its respective COC value, but both were retained as COPCs since their presence can be associated with the history of the site.

Inorganics were detected in all the surface soil samples collected at Site 19. Detected concentrations of aluminum, antimony, arsenic, and beryllium exceeded their corresponding Region III residential COC values; therefore, they were retained as surface soil COPCs for quantitative evaluation in the baseline RA. Several of the detected concentrations also exceeded the COC value for iron; however, iron is considered to be an essential nutrient and was not retained as a surface soil COPC.

6.2.3.2 Shallow Subsurface Soil - Sites 9 and 19

Three subsurface soil samples were collected from each soil boring location. These samples were collected from the 1- to 3-foot (bgs) interval, a midpoint interval between ground-surface and the water table, and an interval just above the water table. However, if elevated PID readings or visible contamination were noted, the affected interval and the 2-foot interval below the affected layer, were selected in lieu of the 1- to 3-foot and midpoint samples, respectively. Additionally, two shallow subsurface soil samples were collected by hand augering. The sampling intervals were 0- to 6- inches and either 6- to 18-inches or 2- to 4-feet. For the purposes of the baseline RA, only samples collected in the 6-inch to 11-foot intervals (shallow subsurface) were assessed; the 0- to 6-inch interval was used in the assessment of surface soils. Samples collected beyond 11-feet (deep subsurface) were considered to be inaccessible to potential human receptors (this rationale will be further explained in the exposure assessment section).

Site 9

Ten shallow subsurface soil samples (eight environmental and two duplicates) were obtained as soil boring samples and nine shallow subsurface soil samples (eight environmental and one duplicate) were obtained from the hand auger samples. In total, nineteen samples (the sum of the soil boring and hand auger subsurface samples) were available for consideration in the baseline RA. Each sample was analyzed for VOCs, SVOCs, pesticides/PCBs, nitramine compounds, and inorganics. The COPC selection summaries for shallow subsurface soil at Site 9 are presented in Table 6-4.

One VOC, acetone, was detected in the shallow subsurface soil samples. However, the maximum concentration of acetone (also a common laboratory contaminant) did not exceed its respective residential soil COC value, or ten times the maximum detected value in associated blanks, and was therefore, not retained as a shallow subsurface soil COPC.

Twenty SVOCs, namely phthalate esters, PAHs, and dibenzofuran were detected in the Site 9 shallow subsurface soil samples. Of these twenty constituents, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, and dibenzo(a,h)anthracene exceeded their respective residential COC values. However, since PAHs occur as mixtures, two additional cPAHs, benzo(k)fluoranthene and chrysene were also retained as surface soil COPCs. One cPAH (carbazole); eight nPAHs (anthracene, acenaphthene, benzo(g,h,i)perylene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene); three phthalate esters (butylbenzylphthalate, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate); and dibenzofuran were also detected in the Site 9 shallow subsurface soil samples. However, the cPAH, nPAHs, phthalates, and dibenzofuran did not exceed their respective residential soil COC values and were therefore, not retained as shallow subsurface soil COPCs.

Five pesticides, heptachlor epoxide, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and endrin, were detected in the Site 9 shallow subsurface soils; however, none exceeded their residential soil COC values. Therefore, no pesticides were retained as shallow subsurface soil COPCs. PCBs were not detected in the shallow subsurface soils at Site 9.

Nitramine compounds, 2,4-dinitrotoluene, 2,4,6-TNT, and amino-DNTs were detected in the Site 9 shallow subsurface soils; the amino-DNTs exceeded the COC value for 2,6-DNT and were retained as shallow subsurface soil COPCs. 2,4,6-TNT also exceeded its COC value and was retained as a shallow subsurface soil COPC. 2,4-DNT did not exceed its respective COC value but was retained as a COPC since its presence can be associated with the history of the site and is considered to be degradation product of TNT.

Inorganics were detected in all shallow subsurface soil samples collected at Site 9. Detected concentrations of aluminum, antimony, arsenic, beryllium, cadmium, chromium, and vanadium exceeded their corresponding residential COC values; therefore, they were retained as shallow subsurface soil COPCs for quantitative evaluation in the baseline RA. Several of the detected concentrations also exceeded the COC value for iron; however, iron is considered an essential nutrient and was not retained as a shallow subsurface soil COPC.

Site 19

Ten shallow subsurface soil samples (eight environmental and two duplicates) were obtained as soil boring samples and eight shallow subsurface soil samples (seven environmental and one duplicate) were obtained from the hand auger samples. In total, eighteen samples (the sum of the soil boring and hand auger subsurface samples) were available for consideration in the baseline RA. Each sample was analyzed for VOCs, SVOCs, pesticides/PCBs, nitramine compounds, and inorganics. The COPC selection summaries for shallow subsurface soil at Site 19 are presented in Table 6-5.

Two VOCs, acetone and 1,1,1-trichloroethane, were detected in the shallow subsurface soil samples. However, acetone and 1,1,1-trichloroethane concentrations did not exceed their respective residential soil COC values, or ten and five times the maximum blank concentration, respectively. As a result acetone was qualified as a common laboratory contaminant and 1,1,1-trichloroethane was qualified as a nonlaboratory contaminant, according to the USEPA guidance presented in RAGS (USEPA, 1989b), and not retained as shallow subsurface soil COPCs.

Three SVOCs (di-n-butylphthalate, butylbenzylphthalate, and bis(2-ethylhexyl)phthalate) and one pesticide (heptachlor epoxide) were detected in the shallow subsurface soil at Site 19; however, none of the aforementioned constituents exceeded their respective residential soil COC values and were therefore, not retained as shallow subsurface soil COPCs.

Nitramine compounds, 2,4,6-TNT and amino-DNTs, were detected in the shallow subsurface soil at Site 19; the amino-DNTs exceeded the residential soil COC value for 2,6-DNT and were retained as a shallow subsurface soil COPC. 2,4,6-TNT did not exceed its respective COC value but was retained as a COPC since its presence can be associated with the history of the site; it has been detected in other media at the site; and the aforementioned amino-DNTs are considered to be degradation products of TNT. PCBs were not detected in the shallow subsurface soils at Site 19.

Inorganics were detected in all shallow subsurface soil samples collected at Site 19. Detected concentrations of aluminum, arsenic, beryllium, chromium, and vanadium exceeded their corresponding Region III COC values; therefore, they were retained as shallow subsurface soil COPCs for quantitative evaluation in the baseline RA. Several of the detected concentrations also exceeded the COC value for iron; however, iron is considered to be an essential nutrient and was not retained as a shallow subsurface soil COPC.

6.2.3.3 Groundwater - Sites 9 and 19

Shallow and deep groundwater samples were analyzed for VOCs, SVOCs, nitramine compounds, pesticides/PCBs, unfiltered (total) and filtered (dissolved) inorganics. A discussion of the selection of COPCs in groundwater is presented below.

Site 9 Shallow Groundwater

Table 6-6A summarizes the COPC selections performed for constituents detected in the shallow groundwater samples collected from Site 9. The sample set included three environmental samples and one duplicate sample.

VOCs were not detected in the shallow groundwater samples collected from Site 9; therefore, none were retained as shallow groundwater COPCs for quantitative evaluation in the baseline RA. One SVOC, bis(2-ethylhexyl)phthalate, was detected in the groundwater. However, bis(2-ethylhexyl)phthalate did not exceed the tapwater COC value or ten times the maximum blank concentration; as a result, it was not retained as a Site 9 shallow groundwater COPC. PCBs were not detected in the shallow groundwater at Site 9.

Three nitramine compounds were detected in the shallow groundwater at Site 9. They included amino-DNTs, 2,4-DNT, and 2,4,6-TNT. The amino-DNTs and 2,4,6-TNT exceeded their respective Region III tap water COC values. 2,4-DNT did not exceed the tapwater COC value but was re-included as a shallow groundwater COPC since its presence can be associated with site history and it is a degradation constituent of 2,4,6-TNT.

Of the unfiltered (total) inorganics detected in the groundwater at Site 9, only aluminum, arsenic, barium, chromium, vanadium, and cyanide were retained because of exceedances of the COC value, or, one or more of the available criteria. Dissolved arsenic and barium also exceeded one or more criteria and were retained as filtered (dissolved) groundwater COPCs for quantitative evaluation in the baseline RA. Several of the detected total and dissolved iron shallow groundwater concentrations also exceeded the corresponding COC value; however, iron is considered an essential nutrient and was not retained as a shallow groundwater COPC.

Site 9 Deep Groundwater

Table 6-6B summarizes the COPC selections performed for constituents detected in the deep groundwater samples collected from Site 9. The sample set included two environmental samples.

One VOC, chloroform, was detected in the deep groundwater at a concentration exceeding the tap water COC value. However, chloroform did not exceed the Federal MCL value or five times the maximum blank concentration; as a result, it was not retained as a Site 9 deep groundwater COPC.

Two SVOCs, bis(2-ethylhexyl)phthalate and phenol, were detected in the deep groundwater at Site 9. Phenol did not exceed its tap water COC value or five times the maximum blank concentration and was not retained as a deep groundwater COPC. Bis(2-ethylhexyl)phthalate exceeded its tap water COC value but did not exceed ten times the maximum blank concentration; as a result, it was qualified as lab contaminant and was not retained as a deep groundwater COPC. PCBs were not detected in the deep groundwater at Site 9.

Nitramine compounds, 1,3,5-trinitrobenzene and amino-DNTs, were detected in the deep groundwater at Site 9. Both of the aforementioned constituents exceeded their respective Region III tap water COC values and were retained as deep groundwater COPCs.

Of the unfiltered (total) inorganics detected in the deep groundwater at Site 9, only arsenic was retained since the one detected concentration exceeded the corresponding tapwater COC value. Dissolved arsenic also exceeded the Region III COC value and was retained as a filtered (dissolved) groundwater COPC for quantitative evaluation in the baseline RA. Several of the concentrations of detected total and dissolved iron in the shallow groundwater also exceeded the corresponding COC value for iron; however, iron is considered to be an essential nutrient and was not retained as a shallow groundwater COPC.

Site 19 Shallow Groundwater

Table 6-7A summarizes the COPC selections performed for constituents detected in the shallow groundwater samples collected from Site 19. The sample set included eight samples (six

environmental and two duplicates). A discussion of the selection of COPCs in shallow groundwater is presented below.

One VOC, chloroform, was detected in the shallow groundwater samples collected from Site 19. Chloroform did not exceed the Federal MCL but did exceed its respective tapwater COC value; however, the maximum detected concentration was below five times the maximum blank concentration. As a result, it was qualified as a nonlaboratory contaminant according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not retained as a shallow groundwater COPC.

One SVOC, bis(2-ethylhexyl)phthalate, was detected in the shallow groundwater at Site 19 at a concentration greater than the tapwater COC value. However, this constituent was detected at a concentration below ten times the maximum blank concentration. As a result, it was qualified as common laboratory contaminant according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not retained as a shallow groundwater COPC. PCBs were not detected in the shallow groundwater at Site 19.

Five nitramine compounds were detected in the shallow groundwater at Site 19. They included: RDX; 1,3,5-trinitrobenzene (TNB); 2,4,6-TNT; 2,4/2,6-DNT; and amino-DNTs. Four of these constituents (RDX; 1,3,5-TNB; 2,4,6-TNT; and amino-DNTs) exceeded their respective Region III tap water COC values and were retained as shallow groundwater COPCs. Furthermore, 2,4/2,6-DNT was also retained as a shallow groundwater COPC (even though it did not exceed the tapwater COC value for 2,6-DNT) since its presence can be associated with the history of the site, it has been detected in other media at the site, and the aforementioned constituents (excluding RDX) are considered to be degradation products of TNT.

Of the unfiltered (total) inorganics detected in the shallow groundwater at Site 19, aluminum, arsenic, beryllium, cadmium, chromium, lead, manganese, and vanadium were retained because of exceedances of the COC value and/or one or more of the other groundwater criteria. Dissolved manganese also exceeded its tapwater COC value and was retained as a filtered (dissolved) groundwater COPC for quantitative evaluation. Several of the detected concentrations of total iron in shallow groundwater also exceeded the corresponding COC value; however, iron is considered an essential nutrient and was not retained as a shallow groundwater COPC.

Site 19 Deep Groundwater

Table 6-7B summarizes the COPC selections performed for constituents detected in the deep groundwater samples at Site 19. The sample set included one environmental sample. A discussion of the selection of COPCs in deep groundwater is presented below.

One VOC, chloroform, was detected in the deep groundwater sample collected from Site 19. Chloroform did not exceed the Federal MCL but did exceed its respective tapwater COC value; however, the maximum detected concentration was below five times the maximum blank concentration. As a result, it was qualified as a nonlaboratory contaminant according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not retained as a shallow groundwater COPC.

One SVOC, phenol, was detected in the deep groundwater at Site 19 at a concentration below its corresponding tapwater COC value; therefore, it was not retained as a deep groundwater COPC.

Pesticides, PCBs, and nitramine compounds were not detected in the deep groundwater at Site 19; therefore, none were retained as deep groundwater COPCs for Site 19.

None of the unfiltered (total) inorganics and filtered (dissolved) inorganics detected in the deep groundwater at Site 19 exceeded the applicable criteria except for iron; however, iron is considered to be an essential nutrient and was not retained as a deep groundwater COPC. Therefore, inorganics were not retained as deep groundwater COPCs.

6.2.3.4 Surface Water - Site 9

Table 6-8 summarizes the COPC selections performed for constituents detected in the Site 9 surface water. The sample set included four samples (three environmental and one duplicate) that were analyzed for VOCs, SVOCs, pesticides/PCBs, and nitramine compounds, as well as for filtered (dissolved) and unfiltered (total) inorganics.

One VOC, chloroform, was detected in the surface water samples collected from Site 9. Chloroform did not exceed the Federal WQC (organisms only) or the Virginia Water Quality Standards, but did exceed its respective tapwater COC value and the Federal WQC for water and organisms; however,

the maximum detected concentration was below five times the maximum blank concentration. As a result, it was qualified as a nonlaboratory contaminant according to the USEPA guidance presented in RAGS (USEPA, 1989b) and not retained as a surface water COPC.

One SVOC, bis(2-ethylhexyl)phthalate, was detected in the surface water at Site 9 at a concentration below its corresponding tapwater COC value; therefore, it was not retained as a surface water COPC.

One pesticide, heptachlor epoxide, was detected at a concentration that exceeded the available criteria; therefore, it was retained as a surface water COPC. PCBs were not detected in the surface water at Site 9.

Eight nitramine compounds, 2,4-DNT; 2,6-DNT; amino-DNTs; 1,3-dinitrobenzene; 1,3,5-TNB; 2,4,6-TNT; HMX; and RDX were detected in the surface water samples at Site 9. Each of the aforementioned nitramines (excluding HMX) exceeded its respective Region III tapwater COC values and was retained as surface water COPCs. Furthermore, since HMX can be associated with site history, it was re-included as a surface water COPC.

Inorganics were detected in a majority of the surface water samples collected at Site 9. Detected concentrations of arsenic and manganese in the total (unfiltered) and dissolved (filtered) inorganic samples, exceeded one or more of the evaluation criteria; therefore, they were retained as Site 9 surface water COPCs for quantitative evaluation in the baseline RA.

6.2.3.5 Sediment - Site 9

Nine sediment samples (eight environmental and one duplicate) were collected from the sediment at Site 9. A listing of these samples is presented in Appendix K. The samples were collected from the 0- to 4-inch and 4- to 8-inch intervals, respectively. All sediment samples were analyzed for VOCs, SVOCs, pesticides/PCBs, nitramine compounds, and inorganics. The COPC selection summaries for sediment are presented in Table 6-9.

Three VOCs, acetone, 2-butanone, and toluene, were detected in the Site 9 sediment samples. Acetone, 2-butanone, and toluene did not exceed their evaluation criteria or the maximum concentration detected in associated blanks; therefore, they were not retained as sediment COPCs.

Twenty SVOCs, namely PAHs, phthalate esters, and dibenzofuran were detected in the Site 9 sediment samples. Of these twenty constituents, only phenanthrene, pyrene, benzo(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(a)pyrene exceeded their respective residential COC values. However, since PAHs do occur as mixtures, two additional cPAHs, chrysene and benzo(k)fluoranthene were also retained as sediment COPCs. One cPAH (carbazole); six nPAHs (acenaphthylene, acenaphthene, anthracene, benzo(g,h,i)perylene, fluoranthene, and fluorene); three phthalates (butylbenzylphthalate, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate); and dibenzofuran were also detected in the Site 9 sediment samples. However, carbazole, the nPAHs, phthalates, and dibenzofuran did not exceed either the ER-M or the residential soil COC value and were therefore, not retained as sediment COPCs. PCBs were not detected in the sediment at Site 9.

Nitramine compounds (2,4-DNT; amino-DNTs; and 2,4,6-TNT) were detected in the sediment samples at Site 9. 2,4-DNT; amino-DNTs; and 2,4,6-TNT did not exceed their respective COC values but were re-included as sediment COPCs because of site history and their presence in other media at the site.

Inorganics were detected in all of the sediment samples collected. Detected concentrations of arsenic, beryllium, and chromium exceeded their respective residential COC values and were retained as sediment COPCs for quantitative evaluation in the baseline RA.

6.2.4 Summary of COPCs

Table 6-10 presents the summary of COPCs by medium for Site 9. Table 6-11 presents the summary of COPCs by medium for Site 19.

6.3 Exposure Assessment

The exposure assessment addresses each potential current and future exposure pathway in soil, groundwater, surface water, sediment, and air. To determine whether human exposure could occur at Sites 9 and 19 in the absence of remedial action, an exposure assessment was conducted to identify potential exposure pathways and receptors. The following four elements were considered to ascertain whether a complete exposure pathway was present (USEPA, 1989b):

- A source and potential mechanism of chemical release
- An environmental retention or transport medium
- A point of potential human contact with the contaminated medium
- An exposure route (e.g., ingestion) at the contact point

The exposure scenarios presented in the following sections are used to estimate individual risks. The reasonable maximum exposure (RME) was evaluated for each scenario utilized in this baseline RA. Relevant equations for assessing intakes and exposure factors were obtained from RAGS (USEPA, 1989b), Exposure Factors Handbook (USEPA, 1989a), Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992a), and Standard Default Exposure Factors, Interim Final (USEPA, 1991a). The central tendency (CT) exposure was evaluated for those scenarios in which the RME exposure exceeded either the target risk range, or unity. Unless otherwise noted, all the statistical data associated with the factors used in the dose evaluation equations for assessing exposure were obtained from the Exposure Factors Handbook (USEPA, 1989b) and the accompanying guidance manuals.

As a result, the exposure scenarios presented in this baseline RA include both RME and CT assumptions, where applicable, for the input parameters in the dose evaluation equations. Thus, for each chemical, under each applicable exposure scenario, a range of chemical intakes is calculated that is defined by the CT and RME assumptions. However, it should be noted that the availability of USEPA-established CT assumptions is somewhat limited; therefore, for parameters having no established CT assumptions, the same value used for the RME scenario was applied.

WPNSTA Yorktown, will continue to function as one of the key Naval ordnance installations on the East Coast for the foreseeable future. Station housing for enlisted personnel is limited to areas around the golf course; Mason Row (senior officers quarters), which overlooks the York River; and cottage-style homes scattered throughout the Station. Housing for most enlisted personnel at WPNSTA Yorktown is situated in the Skiffes Creek area south of the Station and Highway 143. There is currently no Station housing of enlisted personnel at Sites 9 and 19.

The Station has been divided by the Navy into three basic land use areas: (1) explosive/ordnance storage, (2) ordnance production/maintenance, and (3) non-explosive and support functions

(DoN, 1991). Categorized from an "explosives" standpoint, two general land use patterns emerge: real estate encumbered by the Explosive Safety Quantity Distance (ESQD) arc and that which is not encumbered. Sites 9 and 19 are situated inside an area encumbered by the ESQD arc; and therefore, cannot be developed for Station housing of enlisted personnel. In addition, physical access restrictions are currently in place around both Sites 9 and 19 in the form of a security fence. The fence is in place on all sides of both sites, except for a portion of the Site 9 perimeter along Bollman Road, next to Lee Pond. Also, any individuals attempting to gain access to the sites must first enter through the main gate, which is equipped with a lock, and then must sign in at Building 10.

Therefore, current human receptors potentially exposed to COPCs detected in surface soil at Site 9 are limited to adult civilian workers on an infrequent basis. At Site 19, current human receptors potentially exposed to surface soil, surface water, and sediment COPCs are limited to on-site adult commercial workers. Although future residential development of Sites 9 and 19 is highly unlikely, future exposure to surface soil and groundwater by potential resident adult and child receptors was evaluated as a conservative approach. Future child and adult residents were considered to be potentially exposed to organic and dissolved inorganic COPCs in the groundwater. Total inorganic results were not evaluated since dissolved inorganic results are considered to be more representative of drinking water conditions at the tap. Future child and adult residents were also considered to potentially contact surface water and sediments at Site 9. Finally, future construction workers performing excavation and housing construction activities at Sites 9 or 19 were also evaluated as potential human receptors.

Section 5.0 presented a discussion of the chemical fate and transport and migration routes for the detected analytes at Sites 9 and 19; therefore, an additional discussion will not be presented here.

6.3.1 Potential Human Receptors

The potential human receptors and exposure routes evaluated at Sites 9 and 19 were selected considering current and future potential land use in accordance with the Master Plan for WPNSTA Yorktown (DoN, 1991). The following paragraphs present the rationale for the selection of potential exposure pathways for human receptors at Sites 9 and 19.

Based on information available regarding the physical features, site setting, site historical activities, the location of the site within the restricted area of the Station, and current and expected land uses, five potential human receptors are proposed for evaluation. These include:

- current on-site adult commercial workers (Site 19)
- current adult civilian workers (Site 9)
- future resident children (1-6 years old) (Sites 9 and 19)
- future resident adults (Sites 9 and 19)
- future adult construction workers (Sites 9 and 19)

Currently, there are no facilities located at Sites 9 and 19 for personnel housing. The area will not be developed for personnel housing in the future because of the Station's mission and the incumbrance of the ESQD arc. The most likely current receptor to COPCs in environmental media at Site 9 is the civilian adult who works in the area on an infrequent (as-needed) basis. These individuals are expected to visit the site over the course of the year for environmental management purposes. The most likely current receptor to COPCs in environmental media at Site 19 is the commercial adult who works within the confines of the fence surrounding the Site 19 area. These personnel could include the current on-site workers within Building 10 or periodic maintenance personnel who maintain the grounds. Potential exposure to COPCs and media of concern for the current adult civilian and on-site commercial workers includes accidental ingestion, dermal contact, and inhalation of fugitive dusts from the surface soils at Sites 9 and 19. The adult civilian worker could also contact surface water and sediment within the Site 9 drainage area, via accidental ingestion and dermal contact.

Despite the unlikely nature of residential development by the military or general public, future exposure by resident children and adults will be evaluated. In this scenario it is assumed that the future resident adult and child receptors could potentially be exposed to COPCs in the surface soils and groundwaters at Sites 9 and 19, via ingestion and dermal contact. Inhalation exposures to volatilized organics from groundwater used for domestic purposes were not considered for the future adult resident since volatile COPCs were not selected for groundwater. It was also assumed that future resident adult and child receptors could potentially be exposed to COPCs in the sediment and surface water in the Site 9 drainage area, through accidental ingestion and dermal contact.

Potential exposure to COPCs at Sites 9 and 19 could occur in the future if utilities or buildings in the area are constructed or existing buildings and utilities are removed. The future construction worker will therefore be evaluated for accidental ingestion, dermal contact, and inhalation of fugitive dust during excavation of the Site 9 and Site 19 shallow subsurface soils (soils from a 6-inch to 11-foot depth). Surface soil pathways were not considered significant for construction worker exposures relative to the shallow subsurface soil pathways, and therefore, were not evaluated for this receptor.

In summary, the following potential human exposure receptors and exposure pathways are being retained for quantitative evaluation in this baseline RA.

- Current civilian adult workers (Site 9):
 - ▶ Accidental ingestion of surface soil
 - ▶ Dermal contact with surface soil
 - ▶ Inhalation of fugitive dust
 - ▶ Accidental ingestion of surface water
 - ▶ Dermal contact with surface water
 - ▶ Accidental ingestion of sediment
 - ▶ Dermal contact with sediment

- Current on-site commercial adult workers (Site 19):
 - ▶ Accidental ingestion of surface soil
 - ▶ Dermal contact with surface soil
 - ▶ Inhalation of fugitive dust

- Future on-site adult and young child (1-6 years old) residents (Sites 9 and 19):
 - ▶ Accidental ingestion of surface soil
 - ▶ Dermal contact with surface soil
 - ▶ Ingestion of groundwater used as drinking water
 - ▶ Dermal contact with groundwater while bathing
 - ▶ Accidental ingestion of surface water
 - ▶ Dermal contact with surface water
 - ▶ Accidental ingestion of sediment

- ▶ Dermal contact with sediment
- Future on-site adult construction workers (Sites 9 and 19):
 - ▶ Accidental ingestion of subsurface soil
 - ▶ Dermal contact with subsurface soil
 - ▶ Inhalation of fugitive dust

6.3.2 Conceptual Site Model

Development of a conceptual site model of potential exposure is critical in evaluating all potential exposures for the aforementioned human receptors. The conceptual site model describes the area of concern in terms of potential sources of contamination, affected media, and all potential routes of migration of the contaminants present. Conceptual site models for Sites 9 and 19 are presented in Figures 6-1 and 6-2, respectively.

The primary source of contamination for Site 19 is the conveyor belt between Buildings 10 and 98 that carried TNT-powder, packaged in containers across a depression into the loading building, which may have been released to the soil below during loading operations. For Site 9, the primary source of contamination is the drainage way from Plant 1 (Building 10) which received discharges of TNT, RDX, and HMX wastewaters from the late 1930s to 1975, until a carbon adsorption tower was installed to treat the wastewater prior to discharge. Therefore, it is assumed that the primary release mechanisms are volatile emissions to air, surface runoff, and contaminant migration through the subsurface soil to groundwater. Fugitive dust generation from surface soil is not considered to be a significant potential release mechanism at Sites 9 and 19 since the site is covered to a great extent by vegetation, covered roadways, and buildings. However, as a conservative measure, potential exposures resulting from fugitive dusts emanating from surface soil were evaluated for current on-site workers at Sites 9 and 19.

6.3.3 Quantification of Exposure

The chemical concentrations used in the estimation of chronic daily intakes (CDIs) and dermally absorbed doses (DADs) for each medium are considered to be representative of the types of potential exposure encountered by each receptor. For this baseline RA, only data acquired during the Round Two sampling investigation (fall of 1995) were used to quantify potential intakes and not data

acquired during the Round One investigation (1992). At this writing, the Round One data are almost four years old and may not have been acquired in a manner consistent with current sampling protocols (i.e., 0-2 feet versus 0-6 inch surface soil samples). In addition, the use of Round One data would not yield a set of exposure concentrations that could be considered representative of the current and future exposure conditions being evaluated in this baseline RA. However, it should be noted that the analytical results acquired during Round One investigation, along with those acquired during the Round Two investigation, were used in discussing the nature and extent of contamination (Section 4.0) of Sites 9 and 19.

Exposure can occur discretely or at a number of sampling locations depending on the type of scenario considered for a given receptor. Furthermore, certain environmental media such as groundwater and surface water are migratory and chemical concentrations detected in these media change frequently over time. Soil and sediment are, by nature, less transitory. The manner in which environmental data are represented also depends on the number of samples and sampling locations available for a given area and a given medium.

To quantify exposure, analytical data must be evaluated to determine its distributional nature. In general, two types of distributions are applied to environmental data; these are the normal and log-normal distributions. For example, most large data sets from soil sampling are log-normally distributed rather than normally distributed. The geometric mean is the best estimator of central tendency for a log-normal data set (USEPA, 1992d). However, most Agency health criteria are based on the long-term average exposure which is expressed as the sum of all daily intakes divided by the total number of days in the averaging period. The geometric mean of a set of sampling results may not adequately represent random exposure and the cumulative intake that would result from long-term contact with site contaminants.

Potential exposure to soil, groundwater, surface water, and sediment at Sites 9 and 19, regardless of location, is considered as having an equal probability of occurrence as an individual moves randomly across the site. Therefore, for these media, the exposure point concentration for a constituent in the intake equation can be reasonably estimated as the arithmetic average concentration of site sampling data. USEPA supplemental risk assessment guidance (USEPA, 1992d) states that the average concentration is an appropriate estimator of the exposure concentration for two reasons: 1) carcinogenic and chronic noncarcinogenic toxicity criteria are

based on lifetime average exposures; and 2) the average concentration is most representative of the concentration that would be contacted over time. However, uncertainty is inherent in the estimation of the true average constituent concentration at the site.

In order to account for this uncertainty and to be health protective, USEPA risk assessment guidance (USEPA, 1989b) requires the use of an upper bound estimate of the arithmetic mean concentration to calculate the CDI. This estimate, which should be in the high end of the concentration frequency distribution, is called the reasonable maximum exposure (RME) concentration. The RME concentration is defined as the highest concentration that could reasonably be expected to be contacted via a given pathway over a long-term exposure period.

A conservative estimate that best represents the RME is the 95-percent upper confidence limit of the arithmetic mean concentration (95% UCL). In order to estimate the 95% UCL for soil, groundwater, surface water, and sediment data sets, a normal distribution was assumed to represent the occurrence of all COPC-detected concentrations for sample data sets greater than or equal to five. Therefore, since the size of the data sets for shallow groundwater, deep groundwater and surface water at Site 9 was less than five samples, the concentration term for these data sets will be represented by the maximum detected concentration. Furthermore, if the 95% UCL of the arithmetic mean exceeded the maximum detected concentration in a given data set, the maximum detected concentration also was used to represent the concentration term for that COPC.

The USEPA recommended use of the 95%UCL (normal or lognormal) as the RME concentration (in addition to RME assumptions) is designed to overestimate actual risks expected to result from "real-world" exposures. The W-Test (Gilbert, 1987) was performed on all data sets of the draft report in order to determine the underlying distribution (normal or lognormal)of each data set, and consequently, to determine whether the normal or lognormal 95%UCL would be more appropriate to use as an exposure concentration. The results of the W-Test, which are presented in Appendix K, indicate that some data sets consist of normally distributed data; some are lognormally distributed data; some data sets could be described by both distributions; while others could be described by neither distribution. As can be seen in Appendix K, the lognormal 95%UCLs are generally greater in value than the normal 95%UCLs. The normal 95%UCL was used as the exposure concentration, rather than the lognormal 95%UCL, in order to further reduce the potential for the overestimation of risks. Therefore, in this risk assessment, the use of the normal 95%UCL

reduces the uncertainty resulting from overestimation of actual exposures assumed to occur randomly across Sites 9 and 19.

The 95% UCL was calculated using the following equation (USEPA, 1992d):

$$95\% \text{ UCL} = \bar{x} + t(s/\sqrt{n})$$

Where:

\bar{x} = mean

t = Student t-statistic (Gilbert, 1987)

s = standard deviation

n = number of samples

In addition to the RME risk descriptor, which is represented by the maximum and/or 95%UCL concentration for the selected COPC, the CT risk descriptor was also used for data sets when the RME concentration term showed a potential risk to human health. The CT concentration term was utilized by estimating the arithmetic mean of the data concentrations (CT concentrations); detected concentrations as well as half-detection limit values were utilized in the calculation of the mean. The CT concentrations were then utilized to calculate chemical intakes for the CT-case scenarios.

For shallow groundwater at Sites 9 and 19, a plume was not evident; therefore, the RME- and CT-case exposure scenarios were utilized to represent the exposure potential for selected receptors. Furthermore, the RME concentration term utilized for Site 9, already accounts for the maximum detected concentration in the shallow groundwater, which is also represented by the groundwater well containing the highest concentration of nitramine contamination within the shallow groundwater. A "plume" also was not evident in the deep groundwater samples collected at Site 9; therefore, only the maximum detected concentration and CT concentration will be utilized to represent the upper bound and average-case scenarios for deep groundwater conditions at the site.

Frequency of detection as well as maximum detected values are presented in Appendix K; 95% UCL values and mean values, derived for the selected COPCs at Sites 9 and 19, are also presented in Appendix K. The equations for estimating the potential exposure to receptors from site-related

chemicals, for the various identified exposure pathways are presented in Appendix L. Site-specific risk summary tables for each potential pathway and receptor, are presented in Appendix M.

For results reported as "nondetect" (i.e., results flagged with the following validation qualifiers: U, UJ, UL, and UK), a value of one half of the sample-specific detection limit was used to calculate the 95% UCL. A value of half the detection limit was assigned to nondetects when estimating the 95% UCL because the actual value could be between zero and a value just below the detection limit. Ninety-five percent UCLs were calculated only for the constituents detected in at least one sample collected from the environmental medium of interest. Estimated concentrations also were used to calculate the 95% UCL, such as "J"-qualified (estimated), "L"-qualified (estimated, biased low) and "K"-qualified (estimated, biased high) data. "N"-qualified (tentatively identified) data were also used to estimate the exposure concentration. Reported concentrations qualified with an "R" (rejected) were not used in the statistical evaluation.

According to the Region III Modifications to the National Functional Guidelines (NFGs), reported organic and inorganic concentrations that were qualified with a "B" were evaluated against the available field and laboratory blanks. For constituents considered by RAGS to be common laboratory blanks, chemicals were deemed positive detects only if their concentration exceeded 10 times the maximum blank concentration. For constituents not considered to be laboratory blanks, chemicals were considered as positive detects only if their concentration exceeded 5 times the maximum blank concentration.

6.3.4 Exposure Factors Used To Derive Chronic Daily Intakes

Tables 6-12 through 6-15 present the exposure factors used in the estimation of potential CDIs or DADs for the COPCs retained for each receptor identified below. USEPA promulgated exposure factors are used in conjunction with USEPA standard default exposure factors for both the CT and RME exposure scenarios; however, the CT exposure scenario will be utilized only when the RME exposure scenario indicates a risk to human health. Furthermore, when USEPA exposure factors are not available, best professional judgment and site-specific information are used to derive a conservative and defensible value. The following paragraphs present the rationale for the selection of RME exposure factors for each receptor group evaluated in the baseline RA.

6.3.4.1 Current Adult Civilian Workers

Table 6-12 presents the exposure factors used in the estimation of potential CDIs/DADs for the current adult civilian worker. This scenario assumes that a civilian adult working in the areas of Site 9 could potentially be exposed to COPCs in the surface soil via accidental ingestion, dermal contact, and inhalation of fugitive dust, during cutting/clearing of tall grasses and trees or other general maintenance activities. It also was assumed that the on-site civilian adult could contact surface water and sediment, via accidental ingestion and dermal contact, on an infrequent basis as part of the aforementioned activities.

Surface Soil

For potential inhalation exposure to surface soil fugitive dusts, a respiration rate of 20 m³/day or 0.83 m³/hour (USEPA, 1991a) for a 70 kg adult (USEPA, 1989b) was assumed for 14 days/year (based upon conversations with current civilian personnel) over a 25 year period, for eight hours per day (USEPA, 1991a). The adult skin surface area available for dermal contact with surface soil was estimated to be 5,300 cm² (USEPA, 1992a), representing the skin surface area available for contact assuming an adult wears a short-sleeved shirt, short pants, and shoes. The ingestion rate was assumed to be 100 mg/day (USEPA, 1989b) with a soil to skin adherence factor of 1 mg/cm² for clay mineral kaolin (USEPA, 1992c) and a 100 percent fraction ingested rate (USEPA, 1989b). The experimentally-derived dermal absorption values were 3 percent (0.03) for arsenic (Webster, et al., 1993), with default values of 10 percent (0.1) for SVOCs and pesticides, and 1.0 percent (0.01) for inorganics (Ryan, et al., 1987). The averaging time of 9,125 days for noncarcinogens and 25,550 days for carcinogens (USEPA, 1989b), respectively, also were used.

Surface Water

For the adult civilian worker, equations and chemical-specific permeability constants (K_p) presented by the USEPA (USEPA, 1992a and 1992b) were used to estimate the absorption of COPCs by skin exposed to surface water. The ingestion rate was 0.05 L/hour (USEPA, 1989b) while the exposure time was estimated to be 2 hours/day. The exposure frequency, exposure duration, surface area, body weight, and averaging times were the same as those used for the surface soil scenario.

Sediment

The ingestion rate was assumed to be 100 mg/day (USEPA, 1991a), with a soil to skin adherence factor of 1 mg/cm² for clay mineral kaolin (USEPA, 1992c) and a 50 percent fraction ingested rate. Experimentally derived dermal absorption values of 0.03 for arsenic (Webster, et al., 1993), as well as default values of 0.1 for SVOCs and pesticides, and 0.01 for inorganics (Ryan, et al., 1987), also were used to estimate sediment exposures. The surface area, exposure duration, exposure frequency, averaging times, and body weight were the same as those presented for the surface water scenario.

6.3.4.2 Current Adult On-Site Commercial Workers

Table 6-13 presents the exposure factors used in the estimation of potential CDIs/DADs for the current adult on-site commercial worker. This scenario assumes that an on-site adult commercial worker at Site 19 could potentially be exposed to COPCs in the surface soil via accidental ingestion and dermal contact. Furthermore, an on-site adult commercial worker could also inhale fugitive dust, during grounds/general maintenance activities.

Surface Soil

For potential exposure to shallow soil a respiration rate of 20 m³/day or 0.83 m³/hour (USEPA, 1991a) for a 70 kg adult (USEPA, 1989b) was assumed for 250 days/year (USEPA, 1991a) over a 25 year period, for eight hours per day (USEPA, 1991a). The adult skin surface area available for dermal contact with surface soil was estimated to be 4,100 cm² (USEPA, 1992a), representing the skin surface area available for contact assuming an adult wears a sleeveless shirt, long pants, and shoes. The ingestion rate was assumed to be 100 mg/day (USEPA, 1989b) with a soil to skin adherence factor of 1 mg/cm² for clay mineral kaolin (USEPA, 1992c) and a 100 percent fraction ingested rate (USEPA, 1989b). The experimentally-derived dermal absorption values were 0.03 for arsenic (Webster, et al., 1993), with default values of 0.1 for SVOCs and pesticides, and 0.01 for inorganics (Ryan, et al., 1987). The averaging time of 9,125 days for noncarcinogens and 25,550 days for carcinogens (USEPA, 1989b), respectively, also were used.

6.3.4.3 Future Child and Adult Residents

Table 6-14 presents the exposure factors used in the estimation of potential CDIs/DADs for the future child and adult residents. Values enclosed by parentheses represent the CT exposure factors. The CT exposure factors were selected from two main sources, the USEPA's Draft Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure (USEPA, 1993b) and the USEPA's Interim Dermal Exposure Assessment: Principles and Applications (USEPA, 1992a). The values discussed in the following paragraphs represent the RME exposure factors selected for this baseline RA; the CT exposure factors are not discussed the following paragraphs, but are identified in Table 6-14.

In the current Master Plan for WPNSTA Yorktown, future residential development of Sites 9 and 19 is not projected (DoN, 1991). However, for the sake of conservatism, the potential exposure pathways associated with future potential residential development were estimated. Future adult and young child (ages 1-6 years) residents were evaluated for potential exposures via ingestion and dermal contact with COPCs surface soil, and in groundwater when used as a potential potable water source. Future adult and child residents also were evaluated for potential exposures from accidental ingestion and dermal contact with surface water and sediment at Site 9.

Surface Soil

The ingestion rate was assumed to be 200 mg/day (USEPA, 1991a) for a 15 kg child and 100 mg/day for a 70 kg adult with a fraction ingested rate of 100 percent or 1.0 (USEPA, 1989b). The exposure frequency was considered to be 350 days per year (USEPA, 1989b). The adult skin surface area (SA) available for dermal contact with surface soil was estimated to be 5,300 cm², representing 25 percent of the total body surface area available for contact (USEPA, 1992a). A skin SA value of 2,006 cm² was used to represent 25 percent of the total body surface area available for contact (USEPA, 1992a). The soil to skin adherence factor of 1 mg/cm² for clay mineral kaolin (USEPA, 1992c) and experimentally derived dermal absorption values of 0.03 for arsenic and default values of 0.1 for SVOCs and pesticides, and 0.01 for inorganics (Ryan, et al., 1987) also were used to estimate soil exposures. The exposure duration assumed for the adult was 24 years, the child exposure duration was assumed to be 6 years. The noncarcinogenic averaging times were 8,760 days for a 70 kg adult and 2,190 days for a 15 kg child; the carcinogenic averaging time was 25,550 days (USEPA, 1989b).

Groundwater

The adult skin SA available for dermal contact with groundwater during bathing was estimated to be 20,000 cm², representing total body exposure (USEPA, 1992a). The exposure frequency was assumed to be 350 days/year at 0.2 hours (12 minutes) a day (USEPA, 1989a). Equations and chemical-specific Kp presented by USEPA (USEPA, 1992a and 1992b) were used to estimate the absorption of COPCs by skin exposed to groundwater. The exposure duration assumed for the adult was 24 years, with an ingestion rate of 2 L/day (USEPA, 1991a). The averaging time and body weight were the same as those presented for the surface soil medium.

A skin SA value of 8,023 cm² was used to represent the 95th percentile whole body surface area of a young child (USEPA, 1992a). The exposure frequency, exposure time, and respiration rate are the same as the adult's, however the exposure duration was assumed to be 6 years with an ingestion rate of 1 L/day (USEPA, 1991a). Equations and chemical-specific Kp presented by USEPA (USEPA, 1992a and 1992b) were used to estimate the absorption of COPCs by skin exposed to groundwater. The averaging times were 2,190 days for the noncarcinogens and 25,550 days for the carcinogens.

Surface Water

The adult skin SA available for dermal contact with surface water was estimated to be 5,300 cm², representing 25 percent of the total body surface area available for contact (USEPA, 1992a). The exposure frequency was assumed to be 40 days/year (assuming one weekend/month for 9 months with an average of 4.3 weekends/month/year) at 2.6 hours a day (USEPA, 1989b), for 24 years (USEPA, 1991a). Equations and chemical-specific Kp values were used to estimate the absorption of COPCs by skin exposed to surface water. An ingestion rate of 0.05 L/day was also used. The averaging times were 8,760 days for the noncarcinogens and 25,550 days for the carcinogens.

A skin SA value of 2,006 cm² was used to represent 25 percent of the total body surface area available for contact for a young child (1-6 years) (USEPA, 1992a). The exposure frequency, ingestion rate, and exposure time are the same as the adult's, however the exposure duration was assumed to be 6 years. As with the adult, equations and chemical-specific Kp were used to estimate the absorption of COPCs by skin exposed to surface water. The averaging times were 2,190 days for the noncarcinogens and 25,550 days for the carcinogens.

Sediment

The ingestion rate was assumed to be 200 mg/day for the child and 100 mg/day for the adult for 40 days per year. The fraction ingested was assumed to be 50 percent. The soil to skin adherence factor of 1 mg/cm² for clay mineral kaolin (USEPA, 1992c) and experimentally derived dermal absorption values of 0.03 for arsenic, and default values of 0.1 for SVOCs and pesticides, and 0.01 for inorganics (Ryan, et al., 1987) were also used to estimate sediment exposures. The exposure duration, averaging time, and body weight were the same as those presented for the surface water medium.

6.3.4.4 Future Adult Construction Workers

Table 6-15 presents the exposure factors used in the estimation of potential CDIs/DADs for the future adult construction workers. Potential exposure to shallow subsurface soil COPCs may occur to construction workers while performing soil excavation and construction activities. Exposure pathways evaluated include accidental ingestion, dermal contact, and inhalation of fugitive dust. Exposure was assumed to occur for 8 hours per day, 250 days per year, for a construction period of 1 year. A USEPA default value soil ingestion rate of 480 mg/day with a fraction ingested rate of 100 percent or 1.0 (USEPA, 1989b) and a respiration rate of 30 m³/day or 1.25 m³/hour (USEPA, 1991a), also were assumed for a 70 kg construction worker. A skin surface area of 4,100 cm² (USEPA, 1992a) was evaluated for dermal contact with shallow subsurface soil. The soil to skin adherence factor of 1 mg/cm² for clay mineral kaolin (USEPA, 1992c) and experimentally derived dermal absorption values of 0.03 for arsenic, 0.1 for SVOCs and pesticides, and 0.01 for inorganics also were used to estimate soil exposures

6.4 Toxicity Assessment

Section 6.3 presented potential exposure pathways and receptors for this baseline RA. This section will review the available toxicological information for COPCs retained for quantitative evaluation.

An important component of the RA process is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse

health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. Standard reference doses (RfDs) and/or carcinogenic slope factors (CSFs) have been developed for many of the COPCs. This section provides a brief description of these parameters.

6.4.1 Reference Doses

The RfDs and Reference Concentrations (RfCs for inhalation) are developed for chronic and/or subchronic human exposure to chemicals and are based solely on the noncarcinogenic effects of chemical substances. These values are defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of adverse effects during a lifetime. The RfD is expressed as dose (mg) per unit body weight (kg) per unit time (day). The RfC is expressed as dose (mg) per cubic meter of air (m³).

6.4.2 Carcinogenic Slope Factors

CSFs are used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989b). This factor is reported in units of (mg/kg/day)⁻¹ and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the 95% UCL.

CSFs can also be derived from USEPA promulgated unit risk values for air and/or water. CSFs derived from unit risks cannot, however, be applied to environmental media other than the medium considered in the unit risk estimate.

Slope factors are also accompanied by weight-of-evidence classifications which designate the strength of the evidence that the COPC is a potential human carcinogen.

Quantitative indices of toxicity and USEPA weight-of-evidence classifications are presented in Table 6-16 for the identified COPCs. The hierarchy (USEPA, 1989b) for choosing these values was:

- Integrated Risk Information System (IRIS) (USEPA, 1996a)

- Health Effects Assessment Summary Table (HEAST) (USEPA, 1995b)
- National Center for Environmental Assessment (NCEA) (USEPA, 1995d)

The IRIS data base is updated monthly and contains both verified RfDs, RfCs and CSFs. The USEPA has formed an RfD work group to review existing data used to derive RfDs and RfCs. Once this task has been completed the verified RfD appears in IRIS. Like the RfD Work Group, the USEPA has also formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work group to review and validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they also appear in the IRIS data base.

HEAST, on the other hand, provides both interim (unverified) and verified RfDs, RfCs and CSFs. This document is published quarterly and incorporates any applicable changes to its data base.

6.4.3 Dermal Absorption Efficiency

Many of the RfDs and CSFs are derived from oral toxicological studies based on administered dose and do not account for the amount of a substance that can penetrate exchange boundaries after contact (e.g., absorbed dose). As a result, there is very little information available regarding dermal toxicity criteria. Therefore, in order to account for a difference in toxicity between an administered dose and an absorbed dose, the RfDs and CSFs (that were based on an administered dose) were adjusted, as described by the USEPA (USEPA, 1989b), using experimentally-derived oral absorption efficiencies. The adjustment for the oral RfD that would correspond to a dermally absorbed dose is represented by multiplying the RfD by an oral absorption efficiency. The adjustment for the oral CSF that would correspond to the dermally absorbed dose is represented by dividing the CSF by an oral absorption efficiency. The oral absorption efficiencies were obtained from sources such as the NCEA, IRIS, ATSDR toxicological profiles, toxicology publications, toxicology references, and USEPA Regional Offices. In some instances, published information was not available to determine the absorption efficiency. On these occasions, adjustments to the toxicity value were conducted using the following USEPA Region IV default values:

- VOCs - 80%;
- SVOCs, Pesticides and PCBs - 50%; and
- Inorganics - 20%

The absorption efficiencies used in this baseline RA for Sites 9 and 19 are presented in Table 6-16.

6.5 Risk Characterization

The risk characterization combines COPCs, potential exposure, and toxicity, to produce a quantitative estimate of current and future potential human health risks associated with Sites 9 and 19. Excess incremental lifetime cancer risks (ICRs) and hazard indices (HIs) discussed in this section include those estimated for the following: potential current adult civilian worker at Site 9 who could be exposed to COPCs via dermal contact and accidental ingestion of surface soil, surface water, and sediment as well as inhalation of fugitive dusts; current on-site adult commercial workers who could be exposed to Site 19 surface soil COPCs via dermal contact, accidental ingestion, and inhalation of fugitive dusts; future adult construction worker who could be exposed to Site 9 and Site 19 shallow subsurface soil COPCs via dermal contact, accidental ingestion, and inhalation of fugitive dusts; and the future adult and child residents who could be exposed to COPCs via dermal contact and ingestion of surface soil at Sites 9 and 19, and surface water, sediment, and groundwater at Site 9.

6.5.1 Carcinogenic Compounds

Quantitative risk calculations for potentially carcinogenic compounds estimate inferentially (versus probabilistically) the potential ICR for an individual in a specified population. This unit of risk refers to a potential cancer risk that is above the background cancer risk in unexposed individuals. For example, an ICR of 1×10^{-6} indicates that an exposed individual has an increased probability of one in one million of developing cancer subsequent to exposure over the course of their lifetime.

The potential lifetime ICR for an individual was estimated from the following relationship:

$$ICR = \sum_{i=1}^n (CDI_i \text{ or } DAD_i) \times CSF_i$$

where the CSF_i is expressed as $(\text{mg/kg/day})^{-1}$ for compound i , and the CDI_i and dermally absorbed dose (DAD_i) is expressed as mg/kg/day for compound i . Since the units of CSF are $(\text{mg chemical/kg body weight-day})^{-1}$ and the units of intake or dose are $[\text{mg chemical/kg body weight-day}]$, the ICR value is dimensionless. The aforementioned equation was derived assuming that cancer is a nonthreshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

For quantitative estimation of risk, it is assumed that cancer risks from various exposure routes are additive. Estimated ICR values will be compared to 1×10^{-6} to 1×10^{-4} which represents the target risk range of ICR values considered by the USEPA to represent an acceptable (i.e., de minimis) risk (USEPA, 1990).

6.5.2 Noncarcinogenic Compounds

Noncarcinogenic compounds assume that a threshold toxicological effect exists. Therefore, the potential for noncarcinogenic effects is calculated by comparing (i.e., dividing) CDI_i or DAD_i levels with reference doses ($RfDs$) for each $COPC$.

Noncarcinogenic effects are estimated by calculating the hazard quotient (HQ) for individual chemicals and the hazard index (HI) for overall chemicals and pathways by the following equation:

$$HI = \sum_{i=1}^n HQ_i$$

where: $HQ_i = (CDI_i \text{ or } DAD_i) / RfD_i \text{ or } RfC_i$

A hazard quotient (HQ) is the ratio of the daily intake or absorbed dose to the reference dose (or reference concentration for inhalation exposure). CDI_i is the chronic daily intake (mg/kg/day) of contaminant i ; DAD_i is the dermally absorbed dose (mg/kg/day) of contaminant i ; and RfD_i is the

reference dose (mg/kg/day) of contaminant *i* over a prolonged period of exposure. RfC is the reference concentration used when determining exposure due to inhalation. Since the units of RfD are mg/kg-day and the units of CDI or DAD are mg/kg-day, the HQ and HI are dimensionless. To account for the additivity of noncarcinogenic risk following exposure to numerous chemicals, the HI, which is the sum of all the HQs, will be calculated. A ratio of 1.0 is used for examination of the HQ and HI. Ratios less than 1.0 indicate that adverse noncarcinogenic health effects are unlikely. Ratios greater than or equal to 1.0 indicate the potential for adverse noncarcinogenic health effects to occur at that exposure level and caution should be exercised. However, this does not mean that adverse effects will definitely be observed since the RfD incorporates safety and modifying factors to ensure that it is well below that dose for which adverse effects have been observed. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect.

6.5.3 Potential Human Health Effects

Because of site demographics and the position of Site 9 and Site 19 within the ESQD arc, current potential human receptors at Site 9 are limited to adult civilian workers at the Station; current potential human receptors at Site 19 are limited to on-site adult commercial workers. The ICR values derived for each of the current potential human receptors fell within the USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4} ; the HI values were below unity. Furthermore, calculations for future adult construction workers at Sites 9 and 19 also exhibited ICR values within the generally acceptable target risk range and HI values below unity. Risk calculations and summary tables presenting the ICR and HI values, by pathway and medium for the current adult civilian worker at Site 9, the current adult on-site commercial worker at Site 19, and the future adult construction worker at Sites 9 and 19, are presented in Appendices L and M, respectively. Tables 6-17 and 6-18 present the total site risk for potential current and future human exposure to COPCs in environmental media at Sites 9 and 19.

Conservative future residential use scenarios evaluated for Sites 9 and 19, resulted in unacceptable ICR values (i.e., greater than 1×10^{-4}) and HI values (i.e., greater than 1.0). The section that follows will focus on the aforementioned scenarios and those COPCs and environmental media which may require remediation.

6.5.3.1 Future Residential Use of Sites 9 and 19

The following subsections will describe the resultant risk values derived for potential future adult and child on-site residents from four environmental media, surface soil, groundwater, surface water, and sediment at Site 9, and two environmental media, surface soil and groundwater, at Site 19. Tables 6-19 through 6-21 summarize the ICR and HI values by pathway and medium for Sites 9 and 19, respectively.

Site 9 - Future Adult Residents

Surface Soil

As shown on Tables 6-19 and 6-20, an evaluation of potential risk subsequent to exposure via accidental ingestion and dermal contact with surface soils for the future adult resident resulted in HI values below 1.0, and ICR values within the USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4} for both the RME- and CT-case exposure scenarios.

Shallow Groundwater

An evaluation of potential risk to future on-site adult residents subsequent to the ingestion and dermal contact with shallow groundwater, using the RME concentration term (represented by the maximum concentration) and RME exposure assumptions, resulted in an HI value of 51 and an ICR value of 6.3×10^{-4} (using organic and dissolved inorganic results). The HI value derived exceeded the acceptable value of 1.0 due to the presence of 2,4,6-trinitrotoluene (targeting the liver), and dissolved arsenic (targeting the skin). 2,4,6-TNT accounted for 95 percent and dissolved arsenic accounted for 4.7 percent of the HI value, respectively, via the ingestion route of exposure. The ICR value for shallow groundwater (6.3×10^{-4}) exceeded the target risk range due to the presence of dissolved arsenic, which accounted for 58.3 percent of the ICR value, and 2,4,6-TNT, which accounted for 39.6 percent of the ICR value via the ingestion route of exposure.

Evaluation of the CT-case exposure scenario for the future adult resident resulted in an ICR value within the target risk range and an HI value of 12. The exceedence of the HI value is attributed to the presence of the 2,4,6-TNT in shallow groundwater, via the ingestion route of exposure.

Deep Groundwater

Potential exposure to COPCs in the deep groundwater at Site 9, via ingestion and dermal contact, resulted in ICR values within the USEPA's target risk range and HI values below 1.0 when evaluating the RME and CT exposure scenarios, respectively.

Surface Water

Potential exposure to COPCs in the surface water at Site 9 via accidental ingestion and dermal contact by future adult residents, resulted in ICR values within the USEPA's target risk range, and HI values below unity when evaluating the RME and CT exposure scenarios, respectively.

Sediment

An evaluation of potential risk subsequent to exposure to COPCs in the Site 9 sediments by the future adult resident, via accidental ingestion and dermal contact, resulted in HI values below 1.0 and ICR values within the USEPA's target risk range of 1×10^{-06} to 1×10^{-04} when evaluating the RME and CT exposure scenarios, respectively.

Site 9 - Future Child Residents

Surface Soil

As shown on Tables 6-19 and 6-20, an evaluation of potential risk subsequent to the accidental ingestion and dermal contact with surface soils for the future child resident resulted in HI values slightly greater than 1.0, when the ingestion and dermal routes of exposure were summed in the RME-case exposure scenario. This was due primarily to the presence of arsenic (targeting the skin) in the surface soils, which contributed 89.2 percent of the HI value via the ingestion route of exposure. The CT exposure scenario exhibited an HI value less than unity. The ICR values for both the RME and CT-case exposure scenarios, fell within the USEPA's generally acceptable target risk range of 1×10^{-06} to 1×10^{-04} .

Shallow Groundwater

As shown on Table 6-19, an evaluation of potential risk to future on-site child residents subsequent to the ingestion and dermal contact of groundwater used as drinking water, using the RME concentration for groundwater (represented by the maximum detected values), resulted in an HI value of 120 and an ICR value of 3.6×10^{-04} (using organic and dissolved inorganic results). The HI value exceeded the acceptable value of 1.0 due to the presence of 2,4,6-TNT (targeting the liver) and dissolved arsenic (targeting the skin). 2,4,6-TNT accounted for 95 percent and dissolved arsenic accounted for 4.7 percent of the HI value, respectively. The ICR value exceeded the USEPA's target risk range due primarily to the presence of 2,4,6-TNT and dissolved arsenic which accounted for 58.3 percent and 39.6 percent of the ICR value, respectively, via the ingestion route of exposure.

Evaluation of the potential for exposure by the future child resident to shallow groundwater using the CT-case exposure scenario, resulted in an ICR value of 1.5×10^{-04} and an HI value of 39, via the ingestion route of exposure. The exceedence of the ICR value is attributed to the presence of dissolved arsenic and 2,4,6-TNT. The exceedence of the HI value is attributed to the presence of 2,4,6-TNT in the shallow groundwater.

Deep Groundwater

As shown on Table 6-20, an evaluation of potential risk subsequent to the accidental ingestion and dermal contact with deep groundwater for the future child resident resulted in an HI value of 1.4, for the ingestion route of exposure, using the RME-case exposure scenario. However, the HI value below unity when evaluating the CT-case exposure scenario. The exceedence of the HI value is attributed to the presence of 1,3,5-TNB (targeting the spleen) and dissolved arsenic (targeting the skin) in the deep groundwater. The total ICR value fell within the USEPA's generally acceptable range of 1×10^{-06} to 1×10^{-04} when using either the RME- or CT-case exposure scenarios, respectively.

Surface Water

As shown on Tables 6-19 and 6-20, an evaluation of potential risk subsequent to the accidental ingestion and dermal contact with surface water for the future child resident resulted in an HI value

of 1.5, when the ingestion and dermal routes of exposure were summed in the RME-case exposure scenario. This was due to the presence of 2,4,6-TNT (targeting the liver) contributing 95.4 percent of the total HI value, via the ingestion route of exposure. The HI value was below unity when using the CT concentration term. The ICR values fell within the USEPA's generally acceptable target risk range of 1×10^{-06} to 1×10^{-04} when using either the RME- or CT-case exposure scenarios, respectively.

Sediment

An evaluation of potential risk subsequent to exposure to COPCs in the sediment for the future child resident, via accidental ingestion and dermal contact, resulted in an HI value below unity and an ICR value within the USEPA's target risk range of 1×10^{-06} to 1×10^{-04} when using either the RME- or CT-case exposure scenarios, respectively.

Site 19 - Future Adult Residents

Surface Soil

As shown on Table 6-21, an evaluation of potential risk to the future adult resident, subsequent to the accidental ingestion and dermal contact with Site 19 surface soils, resulted in a total HI value below 1.0, and a total ICR value within the USEPA's generally acceptable target risk range of 1×10^{-06} to 1×10^{-04} when using either the RME- or CT-case exposure concentrations, respectively.

Shallow Groundwater

An evaluation of potential risk subsequent to the ingestion and dermal contact of shallow groundwater by future on-site adult residents, using the RME concentration term, resulted in an HI value of 1.8 (using organic and dissolved inorganic results). The HI value derived exceeded 1.0 due to the presence of 1,3,5-TNB (targeting the spleen) and 2,4,6-TNT (targeting the liver). 1,3,5-TNB accounted for 63.1 percent of the HI value, and 2,4,6-TNT accounted for 25.9 percent of the HI value, via the ingestion route of exposure. The HI value derived using the CT-case scenario was less than unity. The total ICR value for shallow groundwater including the ingestion and dermal routes

of exposure, was within the USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4} when using either the RME- or CT-case exposure concentrations, respectively.

Site 19 - Future Child Residents

Surface Soil

As shown on Table 6-21, the ICR and HI values associated with direct contact of surface soil by future child residents, via accidental ingestion and dermal contact, using the RME-case scenario, resulted in an HI value of 1.7 and an ICR value within the USEPA's generally acceptable target risk range of 1×10^{-6} to 1×10^{-4} . Aluminum (information regarding target organ(s) is currently unavailable) and arsenic (targeting the skin) in the surface soil contributed 51.9 percent and 34.2 percent of the HI value, respectively, via the ingestion route of exposure; however, the individual HQs for aluminum and arsenic did not exceed unity. The ICR and HI values using the CT concentration term were within the target risk range and unity, respectively.

Shallow Groundwater

An evaluation of potential risk subsequent to the ingestion and dermal contact of shallow groundwater by future on-site child residents, using the RME-case scenario for shallow groundwater, resulted in an HI value of 6.4 and an ICR value of 4.2×10^{-6} (using organic and dissolved inorganic results). The HI value derived exceeded the acceptable value of 1.0 because of 1,3,5-TNB (targeting the spleen) and 2,4,6-TNT (targeting the liver). 1,3,5-TNB accounted for 63.1 percent of the HI and 2,4,6-TNT accounted for 28.9 percent of the HI value, via the ingestion route of exposure. An evaluation of exposure using the CT-case scenario also resulted in an ICR value within the USEPA's generally acceptable target risk range and an HI value greater than unity. The HI value derived exceeded the acceptable value of 1.0 because of 1,3,5-TNB and 2,4,6-TNT in shallow groundwater, via the ingestion route of exposure.

6.6 Sources of Uncertainty

Uncertainties are encountered throughout the process of performing a risk assessment. This section discusses the sources of uncertainty inherent in the following elements of the human health evaluation performed for Sites 9 and 19:

- Sampling and analysis
- Selection of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization

Uncertainties associated with this human health RA are discussed in the following paragraphs. Table 6-22 summarizes the potential effects of certain uncertainties on the estimation of human health risks.

6.6.1 Sampling and Analysis

The development of a RA depends on the reliability of, and uncertainties associated with, the analytical data available to the risk assessor. These, in turn, are dependent on the operating procedures and techniques applied to the collection of environmental samples in the field and their subsequent analyses in the laboratory. To minimize the uncertainties associated with sampling and analysis at Sites 9 and 19, USEPA approved sampling and analytical methods were employed. Data were generated following USEPA's Statement of Work for Contract Laboratory Program (CLP). Samples were analyzed for TCL volatile, semivolatile, and pesticides/PCBs (plus nitramine compounds), TAL inorganics, and cyanide. Samples were taken from locations specified in the approved Work Plan and the necessary QA/QC samples were collected.

Analytical data are limited by the precision and accuracy of the methods of analysis which are reflected by the Relative Percent Difference (RPD) of duplicate analyses and the percent (%) recovery of spikes, respectively. In addition, the statistical methods used to compile and analyze the data (mean concentrations, detection frequencies) are subject to the overall uncertainty in data measurement. Furthermore, chemical concentrations in environmental media fluctuate over time

and with respect to sampling location. Analytical data must be sufficient to consider the temporal and spatial characteristics of contamination at the site with respect to exposure.

6.6.2 Selection of COPCs

The selection of COPCs is performed in a risk assessment following the evaluation of data. Analytical data also must be comprehensive in order to address the COPCs associated with the site. Types of organic COPCs encountered at Sites 9 and 19 include SVOCs (in the surface soils at Sites 9 and 19, shallow subsurface soils at Site 9, and sediments at Site 9), pesticides (in the surface water at Site 9), and nitramines (in the surface soil, shallow subsurface soil, and shallow groundwater at Sites 9 and 19, in addition to the surface water and sediments at Site 9). Inorganic constituents were detected in every medium investigated. A summary of the COPC selection criteria is presented below.

- Soil COPCs were selected based on comparisons of the detected concentration with Region III residential soil COC values.
- Groundwater COPCs were selected based on comparisons of the detected concentrations with Region III tap water COC values, Federal MCLs, and Commonwealth groundwater standards.
- Surface water COPCs were selected based on comparisons of the detected concentrations to Federal and Commonwealth Water Quality Criteria as well as the Region III tap water COC value.
- Sediment COPCs were selected based on comparisons of the detected concentration to SSVs and Region III residential soil COC values.

Region III COC values are based on exposure assumptions and equations that are intended to introduce conservatism in the risk assessment process by changing the COPC screening method from a relative toxicity screen as presented in RAGS, to an absolute comparison of risk. However, the use of the Region III COC values which incorporate a set of non-site-specific assumptions in the selection of COPCs at Sites 9 and 19, adds conservatism to the baseline RA. Furthermore, the use

of SSV ER-Ms (which are intended for aquatic organisms) and residential soil COC values (which are intended for soils not sediments) in the selection of human health COPCs, provides a very conservative screening tool.

Currently, no Station closures are planned for WPNSTA Yorktown and future residential development of the land is not expected. The application of the residential COC values to soil and groundwater COPC selections would, therefore, tend to result in a list of COPCs that could be considered conservative for a military base. The use of conservative COPC selections in the baseline RA ensures the protection of public health in that the results of the baseline RA are incorporated into the determination of remedial alternatives and remedial action objectives in the FS.

6.6.3 Exposure Assessment

In performing exposure assessments, uncertainties arise from two main sources. First, uncertainties arise in estimating the fate of a compound in the environment, including estimating release and transport in a particular environmental medium. Second, uncertainties arise in the estimation of chemical intakes resulting from contact by a receptor with a particular medium. An example of uncertainty introduced by the latter source is the estimation of potential intakes to construction workers as a result of direct contact exposures to subsurface soil during excavation/construction activities. Here, the uncertainty lies in the assumption that the only medium of concern for this receptor is subsurface soil. Construction worker exposures to surface soil could also occur; however, it is assumed in this baseline RA that surface soil exposures are insignificant at an excavated construction site relative to subsurface soil exposures. Intakes from direct contact exposures to surface soil were estimated for the much more conservative residential scenario. The resulting residential risks are expected to be greater than those that would be estimated for the construction worker scenario and would most likely drive the surface soil remedial efforts.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of constituents by the receptor. Exposure factors have been generated by the scientific community and have undergone review by the USEPA. The USEPA has published an Exposure Factors Handbook (USEPA, 1989a) which contains the best and latest values. Regardless of the validity of these exposure factors, they have been derived from a range of values

generated by studies of limited numbers of individuals. In all instances, values used in this risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA.

The use of a RME approach, designed as not to underestimate daily intakes, was employed throughout this risk assessment. The use of 95% UCL estimates of the arithmetic mean versus maximum values as the concentration term in estimating the CDI or DAD for soil exposure scenarios at Sites 9 and 19, shallow groundwater exposure scenarios at Site 19, and sediment exposure scenarios at Site 9 reduces the potential for overestimating exposure. However, the use of the maximum detected concentration in the evaluation of the shallow and deep groundwaters and surface water at Site 9, tends to overestimate the exposure for future residents.

The USEPA recommended use of the 95%UCL (normal or lognormal) as the RME concentration (in addition to RME assumptions) is designed to overestimate actual risks expected to result from "real-world" exposures. The W-Test (Gilbert, 1987) was performed on all data sets of the draft report in order to determine the underlying distribution (normal or lognormal) of each data set, and consequently, to determine whether the normal or lognormal 95%UCL would be more appropriate to use as an exposure concentration. The results of the W-Test, which are presented in Appendix K, indicate that some data sets consist of normally distributed data; some are lognormally distributed data; some data sets could be described by both distributions; while others could be described by neither distribution. As can be seen in Appendix K, the lognormal 95%UCLs are generally greater in value than the normal 95%UCLs. As discussed in the previous paragraph, the 95%UCL for the arithmetic mean versus the maximum detected concentration was used for risk calculations (i.e., assuming all data sets are normally distributed) to reduce the potential for the overestimation of risks. Likewise, the normal 95%UCL was used as the exposure concentration, instead of the lognormal 95%UCL in order to reduce the potential for the overestimation of risks. Therefore, in this risk assessment, the use of the normal 95%UCL reduces the uncertainty resulting from overestimation of actual exposures assumed to occur randomly across Sites 9 and 19.

6.6.4 Toxicological Assessment

In making quantitative estimates of the toxicity for varying dosages of compounds to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are at all available. Human exposure data usually lack

adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used, and new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental subjects, high doses of a compound are often used. In this situation, a high dose means that high exposures are used in the experiment with respect to most environmental exposures. Therefore, when applying the results of the animal experiment to the human condition, the effects at the high doses must be extrapolated to approximate effects at lower doses. In extrapolating effects from high doses in animals to low doses in humans, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose-response calculations, the following factors are considered:

- Studies are preferred where the animal closely mimics human toxicokinetics.
- Studies are preferred where dose intake most closely mimics the intake route and duration for humans.
- Studies are preferred which demonstrate the most sensitive response to the compound in question.

For compounds believed to cause threshold effects (i.e., noncarcinogens) safety factors are employed in the extrapolation of effects from animals to humans and from high doses to low doses. In deriving carcinogenic potency factors, the 95% UCL value is promulgated by the USEPA to prevent underestimation of potential risk.

Further conservatism in the baseline RA is also introduced through the use of experimentally-derived oral absorption efficiencies to account for a difference in the degree of toxicity between an administered dose and an absorbed dose. Equating the absorption efficiency of the dermal bi-phasic barrier to the absorption efficiency of the gastrointestinal lining is a very conservative approach that tends to overestimate the potential risk to human health.

In summary, the use of conservative assumptions results in quantitative indices of toxicity that are not expected to underestimate potential toxic effects, but may overestimate these effects by an order of magnitude or more.

6.6.5 Toxicity Criteria for Evaluating the Dinitrotoluenes

Dinitrotoluene analyses were performed on environmental samples collected from Sites 9 and 19 since these compounds are common constituents of explosives that are present at the Station. The specific isomers of interest in this investigation were the 2,4- and 2,6-dinitrotoluenes, which usually occur in explosives as a mixture. Inconsistencies in the reporting of analytical data for these isomers resulted in the reporting of individual isomer concentrations of 2,4-dinitrotoluene and 2,6-dinitrotoluene in some data sets, and the reporting concentrations of the 2,4-/2,6-dinitrotoluene mixture in other data sets. Specifically, one detection of the 2,4-dinitrotoluene isomer was reported for Site 9 shallow subsurface soil; two detections of the 2,4-dinitrotoluene isomer were reported for Site 9 shallow groundwater; two detections of the 2,4-/2,6-dinitrotoluene isomer mixture were reported for Site 19 shallow groundwater; detections of both the individual 2,4-dinitrotoluene and 2,6-dinitrotoluene isomers were reported for Site 9 surface water; and one detection of the 2,4-dinitrotoluene isomer was reported for Site 9 sediment.

Toxicity criteria have been established for both the individual isomers, as well as for the isomer mixture. Since a reporting inconsistency occurred with regard to the detection of the 2,4- and 2,6-dinitrotoluenes, some uncertainty exists in the use of the appropriate criteria in evaluating these isomers in two portions of the baseline RA, namely the selection of COPCs and the risk calculation/characterization. During the selection of COPCs, the uncertainty in the use of the appropriate toxicity criteria is manifested in the application of the appropriate Region III COC screening values, which are derived using the toxicity criteria. However, since the dinitrotoluenes are considered to be site-related compounds in this risk assessment, it should be noted that any detection of an individual dinitrotoluene isomer(s) or mixture triggered inclusion of that compound(s) as a COPC(s) for quantitative risk evaluation. This minimizes uncertainties associated with the use of the appropriate COC screening values during the COPC selection process.

For this baseline RA, if the detection of only one isomer is reported for a given environmental medium (i.e., Site 9 shallow subsurface soil, shallow groundwater and sediment), then the toxicity criterion and COC screening value established for that isomer were applied in the COPC selection process and risk calculation/characterization. In this instance the toxicity criterion established for the mixture was not applied to the detected isomer, since all concentrations of the other isomer are

reported to be below detection, and the risk resulting from potential exposures to non-detectable concentrations of that isomer are considered to be insignificant.

In the case where detected concentrations of both individual isomers are reported for a given medium (i.e., Site 9 surface water), the isomers were screened during COPC selection using the isomer-specific COC screening values established for each compound. However, the toxicity criterion established for the mixture was incorporated into calculating the risks associated with the both dinitrotoluenes. In this manner, the individual isomeric risks could be summed to represent risks resulting from exposure to the mixture.

When detected dinitrotoluene concentrations are reported for the mixture (i.e., Site 19 shallow groundwater), then both the COC screening value and toxicity criterion established for the mixture were incorporated into the process of COPC selection and the calculation of risks, respectively.

6.6.6 Risk Characterization

The risk characterization bridges the gap between potential exposure and the possibility of systemic or carcinogenic human health effects, ultimately providing impetus for the remediation of the site or providing a basis for no remedial action.

Uncertainties associated with risk characterization include the assumption of chemical additivity and the inability to predict synergistic or antagonistic interactions between COPCs. These uncertainties are inherent in any inferential risk assessment. To account for this, USEPA-promulgated inputs to the quantitative risk assessment and toxicological indices are calculated to be protective of the human receptor and to err conservatively, so as to not underestimate the potential human health risks.

6.7 Summary of Risk Assessment Results

This section summarizes the results of the baseline human health RA and identifies environmental media and COPCs which could potentially pose human health risks and/or effects. Risk results from each logical exposure pathway were summed for each receptor to determine the total site risk posed

by Sites 9 and 19. The following paragraphs present the potential current and future exposure pathways and the subsequent potential total site risk to humans.

6.7.1 Current Potential Receptors

Potential current receptors to COPCs detected in environmental media at Sites 9 and 19 include:

- Current civilian adult workers (Site 9)
- Current on-site commercial adult workers (Site 19)

The total ICR values previously presented in Table 6-17 for the civilian adult workers at Site 19 and on-site commercial adult workers at Site 9, fall within the USEPA's target risk range of 1×10^{-06} to 1×10^{-04} . The target risk range represents the range of potential risks that USEPA generally believes to be acceptable. HI values also presented in Table 6-17 for current potential human receptors fall below 1.0, indicating that noncarcinogenic adverse human health risks will probably not occur subsequent to exposure.

6.7.2 Future Potential Receptors

Property use at Sites 9 and 19 will remain the same in the foreseeable future. Future residential development of Sites 9 and 19 is highly unlikely given its location within an area encumbered by the ESQD arc, which prohibits its development as Station housing. However for the sake of conservatism, future residential development and associated potential risks were evaluated. The potential human receptors evaluated for Sites 9 and 19 under the future scenarios were:

- Future residents (adult and child combined)
- Future adult construction workers

Table 6-18 previously presented the summary of the total ICR and HI values for the future receptors. A discussion of the results for each of these scenarios is presented below.

6.7.2.1 Future Residents

For the future residents (adult and child) it was assumed that exposure to COPCs in surface soil and groundwater could occur at Sites 9 and 19, while exposure to surface water and sediment could occur at Site 9. Future development of groundwater for potable purposes is unlikely even in the event of future residential development because of the availability of municipal water; however, potential potable exposure to COPCs in shallow and deep groundwater was evaluated for the sake of conservatism. Table 6-18 presents the total ICR and HI values for the future potential residential development of Sites 9 and 19. The total ICR and HI values for future residents are the sum of the resident adult and resident child HI and ICR values, respectively.

Site 9

The ICR value for the future residents (the sum total for children and adults) exceeded the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} when using both the RME- and CT-case exposure scenarios. This was due primarily to contaminants detected in shallow groundwater; the presence of dissolved arsenic and 2,4,6-TNT accounted for the exceedence of the target risk range.

The HI value derived using both the CT- and RME-case scenarios for future residents was greater than 1.0, suggesting that noncarcinogenic adverse health effects may occur subsequent to exposure. 2,4,6-TNT and dissolved arsenic in the shallow groundwater, were the main contributors to the total HI value (using organic and dissolved inorganic results). Furthermore, the presence of arsenic in the surface soil; 2,4,6-TNT and dissolved arsenic in the shallow groundwater; 1,3,5-TNB and dissolved arsenic in the deep groundwater; and 2,4,6-TNT in the surface water, also contributed to the exceedence of the total HI value when using the RME-case scenario. Comparisons of maximum detected site concentrations to Station background values and site-specific background values where applicable, yielded the following results:

- The maximum concentration of arsenic (23.3 mg/Kg) in the surface soils at Site 9 was less than the maximum Station (63.9 mg/Kg) background value but greater than the maximum site-specific (0.97 mg/Kg) background value.
- 2,4,6-TNT was not detected in the Station background groundwater wells for the Cornwallis Cave Aquifer; however, the maximum dissolved arsenic concentration

(25.9 µg/L) was below the maximum Station background concentration (36.4 µg/L), as reported for the Cornwallis Cave Aquifer.

- 1,3,5-TNB was not detected in the Station background deep groundwater well for the Yorktown Eastover Aquifer; however, the maximum detected dissolved arsenic concentration in the Yorktown Eastover Aquifer (5.5L µg/L) was greater than the maximum detected concentration (1.8 µg/L) for the deep groundwater at Site 9.
- 2,4,6-TNT was detected in the Site 9 surface water samples; however, the nitramines were not detected in the Station background surface water samples, as reported for freshwater streams.

Site 19

For the future residents (the sum total for children and adults), the total RME- and CT-case ICR values were within the USEPA's target risk range of 1×10^{-6} to 1×10^{-4} . The target risk range represents the range of potential risks that the USEPA generally believes to be acceptable. However, the total RME- and CT-case HI values were greater than 1.0. An HI value greater than 1.0 suggests that noncarcinogenic adverse health effects may occur subsequent to exposure. 2,4,6-TNT and 1,3,5-TNB in the shallow groundwater, were the main contributors to the total HI value (using organic and dissolved inorganic results). Furthermore, the presence of aluminum and arsenic in the surface soil also contributed to the exceedance of the total RME-case HI value. Comparisons of the maximum detected site concentrations to the maximum detected Station and site-specific background values, where applicable, yielded the following results:

- The maximum detected concentration of aluminum (90,600 mg/Kg) in the surface soils at Site 19 was greater than the maximum Station (19,200 mg/Kg) and site-specific (8,380 mg/Kg) background values. However, the maximum detected concentration of arsenic (14 mg/Kg) in the surface soils at Site 19 was less than the maximum detected Station (63.9 mg/Kg) background value, but greater than the site-specific (2.1 mg/Kg) background value.

- 2,4,6-TNT and 1,3,5-TNB which were detected in the shallow groundwater at Site 19, were not detected in the Station background wells as reported for the Cornwallis Cave Aquifer.

6.7.2.2 Future Adult Construction Worker

Sites 9 and 19

Future potential adult construction workers could be exposed to COPCs in shallow subsurface soil during future building/excavation activities at Sites 9 and 19. The total ICR value derived for the future adult construction worker was within the USEPA's target risk range; therefore, carcinogenic health effects would not be expected to occur. The HI value did not exceed unity; therefore, noncarcinogenic health effects are also not expected to occur subsequent to exposure. Table 6-18 presents the total ICR and HI values for this receptor.

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SECTION 6.0 TABLES

TABLE 6-1
SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituent	Maximum Concentration Detected in Blank (µg/L)	Type of Blank with Maximum Detected Value	Concentration for Comparison (Aqueous-µg/L)	Concentration for Comparison ⁽³⁾ (Solid-µg/kg)
Volatiles:				
Acetone	100	Field Blank	1,000 ⁽¹⁾	1,000
Benzene	6J	Field Blank	30 ⁽²⁾	30
2-Butanone	76	Rinsate Blank	760 ⁽¹⁾	760
1,1-Dichloroethene	3J	Rinsate Blank	15 ⁽²⁾	15
1,2-Dichloroethene (total)	7J	Rinsate Blank	70 ⁽²⁾	70
Chloroform	81	Field Blank	405 ⁽²⁾	405
Bromodichloromethane	7J	Field Blank	35 ⁽²⁾	35
Ethylbenzene	2J	Field Blank	10 ⁽²⁾	10
Toluene	14	Field Blank	140 ⁽¹⁾	140
1,1,1-Trichloroethane	7J	Field Blank	35 ⁽²⁾	35
Trichloroethene	12	Field Blank	60 ⁽²⁾	60
Xylene (total)	14	Field Blank	70 ⁽²⁾	70
Semivolatiles:				
bis(2-Ethylhexyl)phthalate	280	Rinsate Blank	2,800 ⁽¹⁾	92,400
Di-n-butylphthalate	25	Rinsate Blank	250 ⁽¹⁾	8,250
Diethylphthalate	12	Rinsate Blank	120 ⁽¹⁾	3,960
Naphthalene	4J	Field Blank	20 ⁽²⁾	660
Phenol	9J	Field Blank	45 ⁽²⁾	1,485
Nitramines:				
amino-Dinitrotoluenes	0.28	Rinsate Blank	1.4 ⁽²⁾	46
2,6-Dinitrotoluene	3J	Rinsate Blank	15 ⁽²⁾	495
RDX	23	Field Blank	115 ⁽²⁾	3,795
Tetryl	4NJ	Field Blank	20 ⁽²⁾	660
2,4,6-Trinitrotoluene	0.25NJ	Field Blank	1.25 ⁽²⁾	41

Notes:

- (1) Concentration is ten times the maximum detected concentration in a blank.
- (2) Concentration is five times the maximum detected concentration in a blank.
- (3) Concentration is five or ten times the maximum detected concentration in a blank; converted to µg/kg.

TABLE 6-2

SURFACE SOILS DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Soil Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Semivolatiles:							
Anthracene	61,000	2,300	4/10	0.058J-0.31J	0	0	No
Acenaphthylene	8,200*	310*	1/10	0.058J	0	0	No
Acenaphthene	12,000	470	2/10	0.069J-0.12J	0	0	No
Benzo(a)anthracene	7.8	0.88	7/10	0.087J-1.1	0	1	Yes
Benzo(a)pyrene	0.78	0.088	7/10	0.094J-1.2	3	7	Yes
Benzo(b)fluoranthene	7.8	0.88	9/10	0.058J-2.2	0	2	Yes
Benzo(k)fluoranthene	78	8.8	7/10	0.077J-0.52	0	0	Yes ⁽⁴⁾
Benzo(g,h,i)perylene	8,200*	310*	7/10	0.074J-0.77	0	0	No
Bis(2-ethylhexyl)phthalate	410	46	5/10	0.048J-0.20	0	0	No
Butylbenzylphthalate	41,000	1,600	4/10	0.055-0.31	0	0	No
Carbazole	290	32	4/10	0.047J-0.25J	0	0	No
Chrysene	780	88	9/10	0.043J-1.2	0	0	Yes ⁽⁴⁾
Dibenzo(a,h)anthracene	0.78	0.088	4/10	0.055J-0.16J	0	2	Yes
Dibenzofuran	820	31	2/10	0.049J-0.077J	0	0	No

TABLE 6-2 (Continued)

SURFACE SOILS DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Soil Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Di-n-butylphthalate	20,000	780	10/10	0.21J-1.6	0	0	No
Dimethylphthalate	100,000	78,000	1/10	0.87	0	0	No
Fluoranthene	8,200	310	9/10	0.065J-2.2	0	0	No
Fluorene	8,200	310	2/10	0.075J-0.12J	0	0	No
Indeno (1,2,3-cd) pyrene	7.8	0.88	7/10	0.074J-0.55	0	0	Yes ⁽⁴⁾
Phenanthrene	8,200*	310*	8/10	0.076J-1.6	0	0	No
Pyrene	6,100	230	10/10	0.035J-0.20	0	0	No
Pesticides:							
Heptachlor Epoxide	0.63	0.07	3/10	0.0016J-0.0037J	0	0	No
4,4'-DDE	17	1.9	3/10	0.002J-0.0051	0	0	No
4,4'-DDT	17	1.9	3/10	0.0028J-0.0056J	0	0	No
Nitramines:							
2,4,6-Trinitrotoluene	190	21	5/10	0.21-0.54	0	0	Yes ⁽⁴⁾
amino-Dinitrotoluenes ⁽²⁾	200	7.8	3/10	0.21-1.5	0	0	Yes ⁽⁴⁾
Inorganics:							
Aluminum	100,000	7800	10/10	3,160-7,750	0	0	No

TABLE 6-2 (Continued)

SURFACE SOILS DATA AND COPC SELECTION SUMMARY
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Soil Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Arsenic (care)	3.8	0.43	10/10	1.1-23.3K	8	10	Yes
Barium	14,000	550	10/10	19-45.6	0	0	No
Beryllium	1.3	0.15	2/10	0.38-0.47	0	2	Yes
Cadmium	100	3.9	5/10	0.81K-1.8K	0	0	No
Calcium+	--	--	10/10	216-4,430	--	--	No
Chromium (VI)	1,000	39	10/10	6.7K-29.8	0	0	No
Cobalt	12,000	470	10/10	1.6-4.2	0	0	No
Copper	8,200	310	10/10	2.4-26.1	0	0	No
Iron+	61,000	2300	10/10	5,080-20,200	0	10	No ⁽⁶⁾
Lead	--	400 ⁽⁷⁾	10/10	9.7K-68.4	0	0	No
Magnesium+	--	--	10/10	172-612J	--	--	No
Manganese	4,700	180 ⁽⁸⁾	10/10	53.6-204	0	1	Yes
Nickel	4,100	160	10/10	2.6-11	0	0	No
Potassium+	--	--	10/10	149-598	--	--	No
Selenium	1,000	39	3/10	0.4K-0.47L	0	0	No
Sodium+	--	--	10/10	13.6-80.6	--	--	No

TABLE 6-2 (Continued)

**SURFACE SOILS DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Contaminant ⁽¹⁾	Soil Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Vanadium	1,400	55	10/10	11.9-68.6J	0	2	Yes
Zinc	61,000	2,300	10/10	10.6-133	0	0	No

Notes:

- ⁽¹⁾ Organic concentrations converted from µg/kg to mg/kg, Inorganic concentrations reported in mg/kg.
- ⁽²⁾ COC = USEPA Region III COC screening value as derived from RBC Tables (USEPA, 1996b).
- ⁽³⁾ 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.
- ⁽⁴⁾ Retained as a COPC (refer to Section 6.2.3.1 in text).
- ⁽⁵⁾ COC value is for 2,6-dinitrotoluene.
- ⁽⁶⁾ Essential nutrient, not retained as a COPC.
- ⁽⁷⁾ Action level for residential soils (USEPA, 1994b).
- ⁽⁸⁾ COC value recalculated based on updated RfD for manganese.

-- = No criteria published

+ = Essential Nutrients

* = COC value for naphthalene used as a surrogate

TABLE 6-3

SURFACE SOILS DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Soil Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Volatiles:							
1,1,1-Trichloroethane	7,200	270	1/8	0.008J	0	0	No
Semivolatiles:							
Anthracene	61,000	2,300	1/8	0.045J	0	0	No
Benzo(a)anthracene	7.8	0.88	2/8	0.088J-0.13J	0	0	Yes ⁽⁴⁾
Benzo(a)pyrene	0.78	0.088	2/8	0.095J-0.14J	0	2	Yes
Benzo(b)fluoranthene	7.8	0.88	3/8	0.043J-0.23J	0	0	Yes ⁽⁴⁾
Benzo(k)fluoranthene	78	8.8	2/8	0.051J-0.1J	0	0	Yes ⁽⁴⁾
Benzo(g,h,i)perylene	8,200*	310*	2/8	0.053J-0.096J	0	0	No
Bis(2-ethylhexyl)phthalate	410	46	2/8	0.046J-0.43	0	0	No
Chrysene	780	88	3/8	0.039J-0.14J	0	0	Yes ⁽⁴⁾
Dimethylphthalate	100,000	78,000	2/8	0.056J-1.1	0	0	No
Di-n-butylphthalate	20,000	780	8/8	0.25-1.7	0	0	No
Fluoranthene	8,200	310	5/8	0.046J-0.37J	0	0	No
Indeno (1,2,3-cd) pyrene	7.8	0.88	2/8	0.062J-0.13J	0	0	Yes ⁽⁴⁾
Phenanthrene	8,200*	310*	2/8	0.075J-0.21J	0	0	No
Pyrene	6,100	230	4/8	0.044J-0.21J	0	0	No

TABLE 6-3 (Continued)

**SURFACE SOILS DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Contaminant ⁽¹⁾	Soil Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Pesticides:							
Heptachlor Epoxide	0.63	0.07	1/8	0.012NJ	0	0	No
4,4'-DDE	17	1.9	2/8	0.0031J-0.005	0	0	No
4,4'-DDT	17	1.9	3/8	0.0029J-0.0094J	0	0	No
Endrin Ketone ⁽⁵⁾	61	2.3	1/8	0.0037	0	0	No
Endrin Aldehyde ⁽⁵⁾	61	2.3	1/8	0.0021NJ	0	0	No
gamma-Chlordane	4.4	0.49	1/8	0.0029	0	0	No
Nitramines:							
2,4,6-Trinitrotoluene	190	21	6/8	0.13-0.38	0	0	Yes ⁽⁴⁾
amino-Dinitrotoluenes ⁽⁵⁾	200	7.8	6/8	0.35-2.1	0	0	Yes ⁽⁴⁾

TABLE 6-3 (Continued)

SURFACE SOILS DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Soil Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Inorganics:							
Aluminum	100,000	7800	8/8	5,880-90,600	0	6	Yes
Antimony	82	3.1	1/4	5.6L	0	1	Yes
Arsenic (care)	3.8	0.43	7/8	0.68J-14K	6	7	Yes
Barium	14,000	550	8/8	19.1-50.7	0	0	No
Beryllium	1.3	0.15	6/8	0.29-0.73	0	6	Yes
Cadmium	100	3.9	4/8	0.96K-2.2	0	0	No
Calcium+	--	--	8/8	592-1,860	--	--	No
Chromium (VI)	1,000	39	8/8	12.6J-31.3	0	0	No
Cobalt	12,000	470	8/8	1.8-5.6	0	0	No
Copper	8,200	310	8/8	7.8-41.6	0	0	No
Iron+	61,000	2300	8/8	12,300-48,700	0	8	No ⁽⁷⁾
Lead	--	400 ⁽⁹⁾	8/8	45.5J-392J	0	0	No
Magnesium+	--	--	8/8	356-742	--	--	No
Manganese	4,700	180 ⁽⁸⁾	8/8	25.8-133	0	0	No
Mercury	61	2.3	1/8	0.1K	0	0	No
Nickel	4,100	160	8/8	2.6-7.4	0	0	No
Potassium+	--	--	8/8	240-626	--	--	No

TABLE 6-3 (Continued)

**SURFACE SOILS DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Contaminant ⁽¹⁾	Soil Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detection (mg/kg)	No. of Positive Detects Above Industrial COC Value	No. of Positive Detects Above Residential COC Value	Selected as a COPC?
Sodium+	--	--	8/8	5.9-30.3	--	--	No
Vanadium	1,400	55	8/8	22.7J-53.1	0	0	No
Zinc	61,000	2,300	8/8	34.4J-365J	0	0	No

Notes:

- (1) Organic concentrations converted from µg/kg to mg/kg, Inorganic concentrations reported in mg/kg.
- (2) COC = USEPA Region III COC screening value as derived from RBC Tables (USEPA, 1996b).
- (3) 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.
N = Tentatively identified.
- (4) Re-included as a COPC (refer to Section 6.2.3.1 in text).
- (5) Endrin used as a surrogate
- (6) COC value is for 2,6-dinitrotoluene.
- (7) Essential nutrient, not retained as a COPC.
- (8) COC value recalculated based on updated RfD for manganese.
- (9) Action level for residential soils (USEPA, 1994b).

- = No criteria published
- + = Essential Nutrients
- * = Naphthalene was used as a surrogate for the COC value

TABLE 6-4

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Region III Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Volatiles:							
Acetone	20,000	780	3/19	0.018J-0.12	0	0	No
Semivolatiles:							
Naphthalene	8,200	310	1/19	0.086J	0	0	No
Acenaphthene	12,000	470	3/19	0.044J-0.14J	0	0	No
Dibenzofuran	820	31	2/19	0.065J-0.11J	0	0	No
Fluorene	8,200	310	2/19	0.14J-0.16J	0	0	No
Phenanthrene	8,200 ⁽⁵⁾	310 ⁽⁵⁾	7/19	0.072J-2.6	0	0	No
Anthracene	61,000	2300	4/19	0.062J-0.37J	0	0	No
Carbazole	290	32	4/19	0.053J-0.37J	0	0	No
Di-n-butylphthalate	20,000	780	19/19	0.2-1.8J	0	0	No
Fluoranthene	8,200	310	9/19	0.045J-3.5	0	0	No
Pyrene	6,100	230	9/19	0.054J-3.7	0	0	No
Butylbenzylphthalate	41,000	1600	5/19	0.04J-0.38	0	0	No
Benzo(a)anthracene	7.8	0.88	7/19	0.068J-1.7	0	1	Yes
Chrysene	780	88	8/19	0.048J-1.9	0	0	Yes ⁽⁴⁾
Bis(2-ethylhexyl)phthalate	410	46	11/19	0.055J-0.41J	0	0	No
Benzo(b)fluoranthene	7.8	0.88	9/19	0.039J-2.5	0	1	Yes

TABLE 6-4 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Region III Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Benzo(k)fluoranthene	78	8.8	7/19	0.064J-0.98	0	0	Yes ⁽⁴⁾
Benzo(a)pyrene	0.78	0.088	7/19	0.072J-1.7	1	6	Yes
Indeno(1,2,3-cd)pyrene	7.8	0.88	7/19	0.053J-1.0	0	1	Yes
Dibenzo(a,h)anthracene	0.78	0.088	4/19	0.051J-0.27J	0	3	Yes
Benzo(g,h,i)perylene	8,200 ⁽⁵⁾	310 ⁽⁵⁾	7/19	0.058J-1.0	0	0	No
Pesticides:							
Heptachlor Epoxide	0.63	0.07	1/19	0.0022J	0	0	No
4,4'-DDE	17	1.9	5/19	0.0027J-0.0065	0	0	No
Endrin	61	2.3	1/19	0.0026J	0	0	No
4,4'-DDD	24	2.7	2/19	0.0041J-0.0071	0	0	No
4,4'-DDT	17	1.9	5/19	0.003J-0.0074NJ	0	0	No
Nitramines:							
2,4-Dinitrotoluene	4,100	16	1/19	0.047J	0	0	Yes ⁽⁴⁾
amino-Dinitrotoluenes ⁽⁶⁾	200	7.8	2/19	0.070J-42NJ	0	1	Yes
2,4,6-Trinitrotoluene	190	21	6/19	0.14-33	0	1	Yes

TABLE 6-4 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Region III Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Inorganics:							
Aluminum	100,000	7,800	19/19	3,220-17,000	0	10	Yes
Antimony	82	3.1	3/18	3.5-5.3L	0	3	Yes
Arsenic (calc)	3.8	0.43	19/19	0.84-54.7K	16	19	Yes
Barium	14,000	550	19/19	13.1-119	0	0	No
Beryllium	1.3	0.15	10/19	0.26-4.1	1	10	Yes
Cadmium	100	3.9	10/19	0.61-4.5	0	1	Yes
Calcium+	--	--	19/19	122-7,000	--	--	No
Chromium	1,000	39	19/19	5.8K-46.5	0	2	Yes
Cobalt	12,000	470	19/19	1.7-41.4	0	0	No
Copper	8,200	290	19/19	1.6-81.9	0	0	No
Iron+	61,000	2300	19/19	4,450-97,000	2	19	No ⁽⁷⁾
Lead	--	400 ⁽⁸⁾	19/19	5.2K-124L	0	0	No
Magnesium+	--	--	19/19	165-1,830	--	--	No
Manganese	4,700 ⁽⁹⁾	180 ⁽⁹⁾	19/19	18.5-755J	0	8	Yes
Nickel	4,100	160	18/19	2.3L-41.9	0	0	No
Potassium+	--	--	19/19	163-2,360	--	--	No
Selenium	1,000	39	6/19	0.29-1.5K	0	0	No

TABLE 6-4 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Region III Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Sodium+	--	--	19/19	10.7-97.5	--	--	No
Vanadium	1,400	55	19/19	8.5-219J	0	2	Yes
Zinc	61,000	2,300	19/19	9.7-400	0	0	No

Notes:

- (1) Organic concentrations reported in $\mu\text{g}/\text{kg}$ and converted to mg/kg , Inorganic concentrations reported in mg/kg .
- (2) COC Value = USEPA Region III COC screening value as derived from RBC Tables (USEPA, 1996b).
- (3) J = Analyte was positively identified, value is estimated.
 K = Analyte was positively identified, value is biased high.
 L = Estimated value, biased low
 N = Tentatively identified.
- (4) Retained as a COPC (refer to Section 6.2.3.2 in text).
- (5) Naphthalene used as a surrogate
- (6) COC value is for 2,6-dinitrotoluene.
- (7) Essential nutrient, not retained as a COPC.
- (8) Action level for residential soils (USEPA, 1994b)
- (9) COC value recalculated based on updated RfD for manganese.

-- = No criteria published

+ = Essential Nutrients

TABLE 6-5

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Region III Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Volatiles:							
Acetone	20,000	780	1/18	0.014	0	0	No
1,1,1-Trichloroethane	7,200	270	1/18	0.011J	0	0	No
Semivolatiles:							
Di-n-butylphthalate	20,000	780	18/18	0.19-1.2	0	0	No
Butylbenzylphthalate	41,000	1600	1/18	0.046J	0	0	No
Bis(2-ethylhexyl)phthalate	410	46	8/18	0.041J-0.33	0	0	No
Pesticides:							
Heptachlor Epoxide	0.63	0.07	1/18	0.0016J	0	0	No
Nitramines:							
2,4,6-Trinitrotoluene	190	21	6/18	0.11J-2.1NJ	0	0	Yes ⁽⁴⁾
amino-Dinitrotoluenes ⁽⁵⁾	200	7.8	4/18	0.31-8.2	0	1	Yes
Inorganics:							
Aluminum	100,000	7,800	18/18	2,450-14,000	0	7	Yes
Arsenic (care)	3.8	0.43	18/18	0.8-37.2K	13	18	Yes

TABLE 6-5 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Region III Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Barium	14,000	550	18/18	15.4-45.4	0	0	No
Beryllium	1.3	0.15	17/18	0.28-1.7	2	17	Yes
Cadmium	100	3.9	4/18	0.58K-0.99K	0	0	No
Calcium+	--	--	18/18	190-181,000J	--	--	No
Chromium	1,000	39	18/18	6.3K-52.4J	0	1	Yes
Cobalt	12,000	470	18/18	1.1-8.4	0	0	No
Copper	8,200	310	18/18	1.5-14.9	0	0	No
Iron+	61,000	2300	18/18	6,130-68,600J	1	18	No ⁽⁶⁾
Lead	--	400 ⁽⁸⁾	18/18	4.2-16.3	--	0	No
Magnesium+	--	--	18/18	237-2,440	--	--	No
Manganese	4,700	180 ⁽⁷⁾	18/18	12-294	0	3	Yes
Mercury	61	2.3	1/18	0.11K	0	0	No
Nickel	4,100	160	16/18	1.8-14.4	0	0	No
Potassium+	--	--	18/18	116L-1,720	--	--	No
Selenium	1,000	39	3/18	0.49L-0.68L	0	0	No
Sodium	--	--	18/18	4.9-1,650	--	--	No

TABLE 6-5 (Continued)

SHALLOW SUBSURFACE SOIL DATA AND COPC SELECTION SUMMARY
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Region III Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	Industrial COC Value (mg/kg)	Residential COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above Industrial COC Value	Positive Detects Above Residential COC Value	Selected as a COPC?
Vanadium	1,400	55	18/18	6.8-74J	0	3	Yes
Zinc	61,000	2,300	18/18	6.2-58.2	0	0	No

Notes:

- ⁽¹⁾ Organic concentrations reported in $\mu\text{g}/\text{kg}$ and converted to mg/kg , Inorganic concentrations reported in mg/kg .
- ⁽²⁾ COC Value = USEPA Region III COC screening value as derived from RBC Tables (USEPA, 1996b).
- ⁽³⁾ J = Analyte was positively identified, value is estimated.
 K = Analyte was positively identified, value is biased high.
 L = Estimated value, biased low
 N = Tentatively identified.
- ⁽⁴⁾ Re-included as a COPC (refer to Section 6.2.3.2 in text).
- ⁽⁵⁾ COC value is for 2,6-dinitrotoluene.
- ⁽⁶⁾ Essential nutrient, not retained as a COPC.
- ⁽⁷⁾ COC value recalculated based on updated RfD for manganese.
- ⁽⁸⁾ Action level for residential soils (USEPA, 1994b)

-- = No criteria published
 + = Essential Nutrients

TABLE 6-6A

SHALLOW GROUNDWATER DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Semivolatiles:									
bis (2-Ethylhexyl)phthalate	--	4.8	--	1/4	3J	--	0	--	No
Nitramines:									
amino-Dinitrotoluenes ⁽⁵⁾	--	3.7	--	2/4	4,200-4,400	--	2	--	Yes
2,4-Dinitrotoluene	--	7.3	--	2/4	2J-2J	--	0	--	Yes ⁽⁴⁾
2,4,6-Trinitrotoluene	--	2.2	--	2/4	830-880	--	2	--	Yes
Inorganics (Total):									
Aluminum	--	3,700	--	4/4	74-11,800J	--	1	--	Yes
Arsenic (carc)	50	0.045	50	3/4	3.1L-28.4	0	3	0	Yes
Barium	2,000	260	1,000	4/4	41.3-432	0	2	0	Yes
Calcium+	--	--	--	4/4	84,200-115,000	--	--	--	No
Chromium	100	18	50	1/4	34.3J	0	1	0	Yes
Cobalt	--	220	--	3/4	4.5-8.6	--	0	--	No
Copper	1,300	150	--	1/4	6.8	0	0	--	No
Iron+	--	1,100	--	4/4	1,030-42,500	--	3	--	No ⁽⁶⁾
Lead	15	--	50	4/4	1.4K-11.6K	0	--	0	No
Magnesium+	--	--	--	4/4	2,290-22,800	--	--	--	No
Manganese	--	84 ⁽⁷⁾	--	4/4	58.9-415	--	3	--	Yes

TABLE 6-6A (Continued)

SHALLOW GROUNDWATER DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Nickel	100	73	--	2/4	5.5-7.2	0	0	--	No
Potassium+	--	--	--	4/4	1,460-34,500	--	--	--	No
Sodium+	--	--	--	4/4	5,210-26,800	--	--	--	No
Vanadium	--	26	--	1/4	41.2	--	1	--	Yes
Zinc	--	1,100	--	4/4	6.8-402	--	0	--	No
Cyanide (free)	200	73	--	2/4	246-277	2	2	--	Yes
Inorganics (Dissolved):									
Aluminum	--	3,700	--	1/4	21.4	--	0	--	No
Arsenic (calc)	50	0.045	50	2/3	25.6-25.9	0	2	0	Yes
Barium	2,000	260	1,000	4/4	29-419	0	2	0	Yes
Calcium+	--	--	--	4/4	81,900-113,000	--	--	--	No
Cobalt	--	220	--	2/4	7.5-8.4	--	0	--	No
Copper	1,300	150	--	2/4	2.4-5.2	0	0	--	No
Iron+	--	1,100	--	4/4	95.9-37,300	--	2	--	No ⁽⁶⁾
Magnesium+	--	--	--	4/4	2,410-21,900	--	--	--	No
Manganese	--	84 ⁽⁷⁾	--	4/4	73.7-413	--	3	--	Yes
Nickel	100	73	--	2/4	6.1-12.3	0	0	--	No
Potassium+	--	--	--	4/4	1,600-34,400	--	--	--	No

TABLE 6-6A (Continued)

SHALLOW GROUNDWATER DATA AND COPC SELECTION SUMMARY
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Sodium+	--	--	--	4/4	5,070-27,700	--	--	--	No
Zinc	--	1,100	--	4/4	4.3-402	--	0	--	No

Notes:

- (1) All concentrations reported in µg/L
- (2) Federal MCL - Federal Safe Drinking Water Act Maximum Contaminant Level (USEPA, 1996c; Drinking Water Regulations and Health Advisories)
 Virginia Drinking Water Standards - PMCLs - Primary Maximum Contaminant Levels (Bureau of National Affairs - December, 1994)
 COC values - USEPA Region III tapwater COC screening value as derived from RBC Tables (USEPA, 1996b).
- (3) J = Analyte was positively identified, value is estimated
 K = Value estimated; biased high
 L = Analyte was positively identified, value is biased low.
- (4) Re-included as a COPC (refer to Section 6.2.3.3 in text).
- (5) COC value is for 2,6-dinitrotoluene.
- (6) Essential nutrient, not retained as a COPC.
- (7) COC value recalculated based on updated RfD for manganese.

-- = No criteria published
 + = Essential Nutrient

TABLE 6-6B

DEEP GROUNDWATER DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Volatiles:									
Chloroform	100	0.15	--	1/2	11	0	1	--	No ⁽⁴⁾
Semivolatiles:									
Phenol	--	2,200	--	1/2	44	--	0	--	No
Bis(2-ethylhexyl)phthalate	--	4.8	--	1/2	10	--	1	--	No ⁽⁴⁾
Nitramines:									
1,3,5-Trinitrobenzene	--	0.18	--	1/2	0.79	--	1	--	Yes
amino-Dinitrotoluenes ⁽⁵⁾	--	3.7	--	1/2	2.6	--	0	--	Yes ⁽⁶⁾
Inorganics (Total):									
Aluminum	--	3,700	--	2/2	94.7-214	--	0	--	No
Arsenic (ars)	50	0.045	50	1/2	2.2L	0	1	0	Yes
Barium	2,000	260	1,000	2/2	27.1-82.3	0	0	0	No
Calcium+	--	--	--	2/2	70,300-103,000	--	--	--	No
Iron+	--	1,100	--	2/2	30-668	--	0	--	No
Magnesium+	--	--	--	2/2	3,030-4,030	--	--	--	No
Manganese	--	84 ⁽⁷⁾	--	2/2	4.1-54.2	--	0	--	No
Potassium+	--	--	--	2/2	2,290-2,550	--	--	--	No
Sodium+	--	--	--	2/2	6,570-8,090	--	--	--	No

TABLE 6-6B (Continued)

DEEP GROUNDWATER DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Vanadium	--	26	--	1/2	12.8	--	0	--	No
Cyanide(total)	200	73	--	1/2	10.5	0	0	--	No
Inorganics (Dissolved):									
Aluminum	--	3,700	--	1/2	140	--	0	--	No
Arsenic (calc)	50	0.045	50	1/1	1.8	0	1	0	Yes
Barium	2,000	260	1,000	2/2	22.9-78.8	0	0	0	No
Calcium+	--	--	--	2/2	55,500-98,500	--	--	--	No
Copper	1,300	150	--	1/2	7.2	0	0	--	No
Iron+	--	1,100	--	2/2	29.2-132	--	0	--	No
Magnesium+	--	--	--	2/2	3,050-3,870	--	--	--	No
Manganese	--	84 ⁽⁷⁾	--	2/2	2-51.8	--	0	--	No
Potassium+	--	--	--	2/2	1,980-2,410	--	--	--	No
Sodium+	--	--	--	2/2	6,490-8,630	--	--	--	No

TABLE 6-6B (Continued)

DEEP GROUNDWATER DATA AND COPC SELECTION SUMMARY
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Vanadium	--	26	--	1/2	12	--	0	--	No
Zinc	--	1,100	--	1/2	6.8	--	0	--	No

Notes:

- ⁽¹⁾ All concentrations reported in µg/L
- ⁽²⁾ Federal MCL - Federal Safe Drinking Water Act Maximum Contaminant Level (USEPA, 1996c; Drinking Water Regulations and Health Advisories)
 Virginia Drinking Water Standards - PMCLs - Primary Maximum Contaminant Levels (Bureau of National Affairs - December, 1994)
 COC values - USEPA Region III tapwater COC screening value as derived from RBC Tables (USEPA, 1996b).
- ⁽³⁾ J = Analyte was positively identified, value is estimated
 K = Value estimated; biased high
 L = Analyte was positively identified, value is biased low.
- ⁽⁴⁾ Constituent considered to be a common laboratory contaminant.
- ⁽⁵⁾ COC value is for 2,6-dinitrotoluene.
- ⁽⁶⁾ Re-included as a COPC (refer to Section 6.2.3.3 in text).
- ⁽⁷⁾ COC value recalculated based on an updated RfD for manganese.

-- = No criteria published
 + = Essential Nutrient

TABLE 6-7A

SHALLOW GROUNDWATER DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Volatiles:									
Chloroform	100	0.15	--	3/8	2J-12	0	3	--	No ⁽⁴⁾
Semivolatiles:									
bis(2-Ethylhexyl)phthalate	--	4.8	--	2/8	4J-6J	--	1	--	No ⁽⁴⁾
Nitramines:									
RDX	--	0.61	--	3/8	0.77NJ-1.1	--	3	--	Yes
1,3,5-Trinitrobenzene	--	0.18	--	3/8	3.1NJ-5.8NJ	--	3	--	Yes
2,4,6-Trinitrotoluene	--	2.2	--	4/8	1.5-38NJ	--	2	--	Yes
2,4/2,6-Dinitrotoluene ⁽²⁾	--	0.099	--	2/8	0.36-0.66NJ	--	2	--	Yes
amino-Dinitrotoluenes ⁽²⁾	--	3.7	--	5/8	5.3-130	--	5	--	Yes
Inorganics (Total):									
Aluminum	--	3,700	--	6/8	32-28,000J	--	2	--	Yes
Arsenic (calc)	50	0.045	50	4/8	1.9L-41.8L	0	4	0	Yes
Barium	2,000	260	1,000	8/8	29.6-216	0	0	0	No
Beryllium	4	0.016	--	2/8	2.3L-2.7L	0	2	--	Yes
Cadmium	5	1.8	10	1/8	4.4	0	1	0	Yes
Calcium+	--	--	--	8/8	101,000-961,000	--	--	--	No
Chromium	100	18	50	4/8	5.4J-132J	2	2	2	Yes

TABLE 6-7A (Continued)

SHALLOW GROUNDWATER DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Cobalt	--	220	--	2/8	35.8-38.4	--	0	--	No
Copper	1,300	150	--	5/8	1.9-24.3	0	0	--	No
Iron+	--	1,100	--	8/8	12-160,000	--	4	--	No ⁽⁸⁾
Lead	15	--	50	4/8	1.8L-60.5	2	--	2	Yes
Magnesium+	--	--	--	8/8	1,500-10,700	--	--	--	No
Manganese	--	84 ⁽⁷⁾	--	8/8	13.1-2,850	--	4	--	Yes
Nickel	100	73	--	3/8	5.5-63	0	0	--	No
Potassium+	--	--	--	8/8	676-7,040	--	--	--	No
Sodium+	--	--	--	8/8	5,160-13,600	--	--	--	No
Vanadium	--	26	--	3/8	1.5-258	--	2	--	Yes
Zinc	--	1,100	--	6/8	5-155	--	0	--	No
Inorganics (Dissolved)									
Aluminum	--	3,700	--	2/8	12.8-14.8	--	0	--	No
Barium	2,000	260	1,000	8/8	23.6-50J	0	0	0	No
Calcium+	--	--	--	8/8	98,200-154,000	--	--	--	No
Chromium	100	18	50	1/8	2.5J	0	0	0	No
Copper	1,300	150	--	5/8	1.8-17	0	0	--	No
Iron+	--	1,100	--	6/8	6.8-448	--	0	--	No

TABLE 6-7A (Continued)

SHALLOW GROUNDWATER DATA AND COPC SELECTION SUMMARY
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Magnesium+	--	--	--	8/8	1,200-4,630	--	--	--	No
Manganese	--	84 ⁽⁷⁾	--	8/8	2.5-2,820	--	2	--	Yes
Nickel	100	73	--	1/8	6.4	0	0	--	No
Potassium+	--	--	--	7/8	715-1,450	--	--	--	No
Sodium+	--	--	--	8/8	5,140-10,000	--	--	--	No
Zinc	--	1,100	--	4/8	4.2-8.1	--	0	--	No

Notes:

- (1) All concentrations reported in µg/L
- (2) Federal MCL - Federal Safe Drinking Water Act Maximum Contaminant Level (USEPA, 1996c; Drinking Water Regulations and Health Advisories)
 Virginia Drinking Water Standards - PMCLs - Primary Maximum Contaminant Levels (Bureau of National Affairs - December, 1994)
 COC values - USEPA Region III tapwater COC screening value as derived from RBC Tables (USEPA, 1996b).
- (3) J = Analyte was positively identified, value is estimated
 K = Value estimated; biased high
 L = Estimated value; biased low.
 N = Tentatively identified.
- (4) Analyte detected in associated blanks; concentration did not exceed 5 or 10 times the maximum blank contaminant concentration.
- (5) COC value is for 2,6-dinitotoluene.
- (6) Re-included as a COPC (refer to Section 6.2.3.3 in text).
- (7) COC value recalculated based on updated RfD for manganese.
- (8) Essential nutrient; not retained as a COPC.

-- = No criteria published

+ = Essential Nutrient

TABLE 6-7B

DEEP GROUNDWATER DATA AND COPC SELECTION SUMMARY
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Volatiles:									
Chloroform	100	0.15	--	1/1	23	0	1	--	No ⁽⁴⁾
Semivolatiles:									
Phenol	--	2,200	--	1/1	7J	--	0	--	No
Inorganics (Total):									
Barium	2,000	260	1,000	1/1	74.9	0	0	0	No
Calcium+	--	--	--	1/1	101,000	--	--	--	No
Iron+	--	1,100	--	1/1	1,910	--	1	--	No ⁽⁵⁾
Lead	15	--	50	1/1	1.9L	0	--	0	No
Magnesium+	--	--	--	1/1	3,610	--	--	--	No
Manganese	--	84 ⁽⁶⁾	--	1/1	60.2	--	0	--	No
Potassium+	--	--	--	1/1	2,080	--	--	--	No
Sodium+	--	--	--	1/1	6,050	--	--	--	No
Inorganics (Dissolved)									
Barium	2,000	260	1,000	1/1	69.6	0	0	0	No
Calcium+	--	--	--	1/1	99,500	--	--	--	No
Iron+	--	1,100	--	1/1	1,370	--	1	--	No ⁽⁵⁾
Magnesium+	--	--	--	1/1	3,510	--	--	--	No

TABLE 6-7B (Continued)

DEEP GROUNDWATER DATA AND COPC SELECTION SUMMARY
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Groundwater Criteria ⁽²⁾			Frequency/Range ⁽³⁾		Comparison to Criteria			COPC Selection
	Federal MCL (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Virginia PMCLs (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	No. of Detects Above MCL	No. of Detects Above COC Value	No. of Detects Above Virginia Criteria	Retained as a COPC?
Manganese	--	84 ⁽⁶⁾	--	1/1	57.9	--	0	--	No
Potassium+	--	--	--	1/1	1,710	--	--	--	No
Sodium+	--	--	--	1/1	5,940	--	--	--	No

Notes:

- ⁽¹⁾ All concentrations reported in µg/L
- ⁽²⁾ Federal MCL - Federal Safe Drinking Water Act Maximum Contaminant Level (USEPA, 1996c; Drinking Water Regulations and Health Advisories)
 Virginia Drinking Water Standards - PMCLs - Primary Maximum Contaminant Levels (Bureau of National Affairs - December, 1994)
 COC values - USEPA Region III tapwater COC screening value as derived from RBC Tables (USEPA, 1996b).
- ⁽³⁾ J = Analyte was positively identified, value is estimated
 K = Value estimated; biased high
 L = Estimated value; biased low.
- ⁽⁴⁾ Analyte detected in associated blanks; concentration did not exceed 5 or 10 times the maximum blank contaminant concentration.
- ⁽⁵⁾ Essential nutrient, not retained as a COPC.
- ⁽⁶⁾ COC value recalculated based on updated RfD for manganese.

-- = No criteria published
 + = Essential Nutrient

TABLE 6-8

**SURFACE WATER DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Contaminant ⁽¹⁾	Federal/Regional Criteria ⁽²⁾			Virginia Water Quality Standards ⁽³⁾		Frequency/Range ⁽⁴⁾		COPC Selection
	WQC Water and Organisms (µg/L)	WQC Organisms Only (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Public Water Supplies (µg/L)	All Other Surface Waters (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	Retained as a COPC?
Volatiles:								
Chloroform	5.7	470	0.15	57	4,700	2/4	3J-3J	No ⁽⁵⁾
Semivolatiles:								
Bis(2-ethylhexyl)phthalate	1.8	5.9	4.8	--	--	2/4	1-2J	No ⁽⁵⁾
Pesticides:								
Heptachlor Epoxide	0.00010	0.00011	0.0012	0.0021 ⁽⁶⁾	0.0021 ⁽⁶⁾	1/4	0.08K	Yes
Nitramines:								
2,6-Dinitrotoluene	0.11 ⁽⁶⁾	9.1 ⁽⁶⁾	3.7	1.1 ⁽⁷⁾	91 ⁽⁷⁾	2/4	2J-4J	Yes
2,4-Dinitrotoluene	0.11	9.1	7.3	1.1	91	1/4	6J	Yes
RDX	--	--	0.61	--	--	2/4	6-6.1	Yes
1,3,5-Trinitrobenzene	--	--	0.18	--	--	1/3	0.44NJ	Yes
1,3-Dinitrobenzene	--	--	0.37	--	--	1/4	0.46NJ	Yes
amino-Dinitrotoluenes	0.11 ⁽⁷⁾	9.1 ⁽⁷⁾	3.7 ⁽⁸⁾	1.1 ⁽⁷⁾	91 ⁽⁷⁾	4/4	97-1,000	Yes
HMX	--	--	180	--	--	1/4	14	Yes#
2,4,6-Trinitrotoluene	--	--	2.2	--	--	4/4	25-480	Yes

TABLE 6-8 (Continued)

SURFACE WATER DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Federal/Regional Criteria ⁽²⁾			Virginia Water Quality Standards ⁽³⁾		Frequency/Range ⁽⁴⁾		COPC Selection
	WQC Water and Organisms (µg/L)	WQC Organisms Only (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Public Water Supplies (µg/L)	All Other Surface Waters (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	Retained as a COPC?
Inorganics (Total):								
Aluminum	--	--	3,700	--	--	4/4	15.4-200	No
Arsenic (conc)	0.018	0.14	0.045	50	--	4/4	2.2-4.6	Yes
Barium	1,000	--	260	2,000	--	4/4	38.3-48.6	No
Calcium+	--	--	--	--	--	4/4	81,800-101,000	No
Cobalt	--	--	220	--	--	2/4	2-2	No
Iron+	300	--	--	300	--	4/4	589-2,960	No
Lead	50	--	--	15	--	1/4	3.6K	No
Magnesium+	--	--	--	--	--	4/4	1,650-3,030	No
Manganese	50	100	84 ⁽⁹⁾	50	--	4/4	88.7-231	Yes
Potassium+	--	--	--	--	--	4/4	843-1,980	No
Sodium+	--	--	--	--	--	4/4	7,160-7,580	No
Vanadium	--	--	26	--	--	1/4	3.3	No
Zinc	--	--	1,100	5,000	--	4/4	4.6-9.8	No
Cyanide (total)	700	220,000	73	700	215,000	1/4	27.7	No

TABLE 6-8 (Continued)

SURFACE WATER DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Federal/Regional Criteria ⁽²⁾			Virginia Water Quality Standards ⁽³⁾		Frequency/Range ⁽⁴⁾		COPC Selection
	WQC Water and Organisms (µg/L)	WQC Organisms Only (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Public Water Supplies (µg/L)	All Other Surface Waters (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	Retained as a COPC?
Inorganics (Dissolved):								
Arsenic (calc)	0.018	0.14	0.045	50	--	1/4	2.1	Yes
Barium	1,000	--	260	2,000	--	4/4	35.6-45.3	No
Calcium+	--	--	--	--	--	4/4	79,300-97,600	No
Chromium	170	3,400	18	170	3,400	1/4	5.6	No
Cobalt	--	--	220	--	--	1/4	2.6	No
Copper	1,300	--	150	1,300	--	2/4	6.1-8.3	No
Iron+	300	--	1,100	300	--	2/4	9.3-15.4	No
Lead	50	--	--	15	--	1/4	1.4K	No
Magnesium+	--	--	--	--	--	4/4	1,610-2,920	No
Manganese	50*	100*	84 ⁽⁹⁾	50	--	4/4	109-218	Yes
Potassium+	--	--	--	--	--	4/4	788-2,030	No
Sodium+	--	--	--	--	--	4/4	6,900-7,350	No

TABLE 6-8 (Continued)

**SURFACE WATER DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Contaminant ⁽¹⁾	Federal/Regional Criteria ⁽²⁾			Virginia Water Quality Standards ⁽³⁾		Frequency/Range ⁽⁴⁾		COPC Selection
	WQC Water and Organisms (µg/L)	WQC Organisms Only (µg/L)	USEPA Region III Tapwater COC Value (µg/L)	Public Water Supplies (µg/L)	All Other Surface Waters (µg/L)	No. of Positive Detects/No. of Samples	Concentration Range (µg/L)	Retained as a COPC?
Vanadium	--	--	26	--	--	1/4	4.5	No
Zinc	--	--	1,100	5,000	--	4/4	5.6-10.7	No

Notes:

- (1) All concentrations reported in µg/L
- (2) Water Quality Criteria (WQC) human health values (recalculated) using IRIS as of 1990, or published values if recalculated values are not available. COC value - USEPA Region III tapwater COC screening value as derived from RBC Tables (USEPA, 1996b).
- (3) Virginia Water Standards (Bureau of National Affairs - December 1994)
- (4) J = Analyte was positively identified, value is estimated
K = Value is estimated; biased high.
L = Value is estimated; biased low
N = Tentatively identified.
- (5) Analyte detected in associated blanks; concentration did not exceed 5 or 10 times the maximum blank contaminant concentration.
- (6) Heptachlor used as a surrogate.
- (7) 2,4-Dinitrotoluene used as a surrogate
- (8) COC value is for 2,6-dinitrotoluene.
- (9) COC value recalculated based on updated RfD for manganese.

- = No criteria published
- # = Re-included as a COPC (refer to Section 6.2.3.4 in text)
- + = Essential Nutrient
- * = Hardness dependent criteria (100 mg/L CaCO₃ used)

TABLE 6-9

**SEDIMENT DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Contaminant ⁽¹⁾	Sediment Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	SSV ER-M (mg/kg)	Residential Soil COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above ER-M	Positive Detects Above Residential COC Value	Retained as a COPC?
Volatiles:							
Acetone	--	780	7/9	0.019J-0.22J	--	0	No
2-Butanone	--	4,700	4/9	0.003J-0.059J	--	0	No
Toluene	--	1,600	1/9	0.002J	--	0	No
Semivolatiles:							
Acenaphthylene	0.64	310 ⁽⁵⁾	2/9	0.077J-0.15J	0	0	No
Acenaphthene	0.5	470	2/9	0.13J-0.22J	0	0	No
Dibenzofuran	--	31	2/9	0.05J-0.19J	--	0	No
Fluorene	0.54	310	4/9	0.052J-0.42J	0	0	No
Phenanthrene	1.5	310 ⁽⁵⁾	8/9	0.057J-3.2J	2	0	Yes
Anthracene	1.1	2,300	6/9	0.054J-0.75J	0	0	No
Carbazole	--	32	5/9	0.072J-0.25J	--	0	No
Di-n-Butylphthalate	--	780	9/9	0.2J-1.9	--	0	No
Fluoranthene	5.1	310	9/9	0.073J-4.6	0	0	No
Pyrene	2.6	230	9/9	0.067J-3.3	2	0	Yes
Butylbenzylphthalate	--	1,600	1/9	0.66	--	0	No
Benzo(a)anthracene	1.6	0.88	8/9	0.042J-2.4J	2	2	Yes
Chrysene	2.8	88	8/9	0.054J-2.6	0	0	Yes ⁽⁴⁾
bis(2-Ethylhexyl)phthalate	--	46	3/9	0.061-0.66	--	0	No

TABLE 6-9 (Continued)

SEDIMENT DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant ⁽¹⁾	Sediment Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	SSV ER-M (mg/kg)	Residential Soil COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above ER-M	Positive Detects Above Residential COC Value	Retained as a COPC?
Benzo(b)fluoranthene	1.6 ⁽⁶⁾	0.88	7/9	0.06J-2.6	2	2	Yes
Benzo(k)fluoranthene	1.6 ⁽⁶⁾	8.8	6/9	0.11J-0.97	0	0	Yes ⁽⁴⁾
Benzo(a)pyrene	1.6	0.088	7/9	0.046J-2.1	1	6	Yes
Indeno(1,2,3-cd)pyrene	1.6 ⁽⁶⁾	0.88	7/9	0.083J-1.3	0	2	Yes
Dibenzo(a,h)anthracene	0.26	0.088	5/9	0.068J-0.3J	1	3	Yes
Benzo(g,h,i)perylene ⁽⁵⁾	2.1	310	7/9	0.066J-1.0	0	0	No
Nitramines:							
2,4-Dinitrotoluene	--	16	1/9	3.7	--	0	Yes ⁽⁴⁾
amino-Dinitrotoluenes ⁽⁷⁾	--	7.8	6/9	0.022-2.3	--	0	Yes ⁽⁴⁾
2,4,6-Trinitrotoluene	--	21	6/9	0.12-0.62	--	0	Yes ⁽⁴⁾
Inorganics:							
Aluminum	--	7,800	9/9	1,690-6,320	--	0	No
Arsenic (cac)	70	0.43	9/9	5.7J-55.5J	0	9	Yes
Barium	--	550	9/9	7.2J-54.9J	--	0	No
Beryllium	--	0.15	9/9	0.26-0.85	--	9	Yes
Cadmium	9.6	3.9	5/9	0.82K-1.9K	0	0	No
Calcium+	--	--	9/9	1,640J-17,500J	--	--	No
Chromium	370	39	9/9	8.7-47.3	0	1	Yes
Cobalt	--	470	9/9	1.6-5.2	--	0	No

TABLE 6-9 (Continued)

**SEDIMENT DATA AND COPC SELECTION SUMMARY
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Contaminant ⁽¹⁾	Sediment Criteria ⁽²⁾		Contaminant Frequency/Range ⁽³⁾		Comparison to Criteria		COPC Selection
	SSV ER-M (mg/kg)	Residential Soil COC Value (mg/kg)	No. of Positive Detects/ No. of Samples	Range of Positive Detections (mg/kg)	Positive Detects Above ER-M	Positive Detects Above Residential COC Value	Retained as a COPC?
Copper	270	310	9/9	1.3L-22	0	0	No
Iron+	--	2,300	9/9	11,100-54,400	--	0	No
Lead	218	400 ⁽⁹⁾	9/9	7.9J-109	0	0	No
Magnesium+	--	--	9/9	227-994	--	--	No
Manganese	--	180 ⁽⁸⁾	9/9	51.5-85.5	--	0	No
Nickel	51.6	160	9/9	1.5-9	0	0	No
Potassium+	--	--	9/9	99.7-864	--	--	No
Silver	3.7	39	1/9	0.66	0	0	No
Sodium+	--	--	9/9	19.7-164	--	--	No
Vanadium	--	55	9/9	13.1-43.4	--	0	No
Zinc	410	2,300	9/9	30.8-147	0	0	No

Notes:

- (1) Organic concentrations reported in $\mu\text{g}/\text{kg}$ and converted to mg/kg , Inorganic concentrations reported in mg/kg .
- (2) SSV = Sediment Screening Value (Long, et al, 1995)
COC value = USEPA Region III COC screening value as derived from RBC Tables (USEPA, 1996b).
- (3) J = Analyte was positively identified, value is estimated.
K = Estimated value; biased high.
L = Estimated value, biased low
- (4) Re-included as a COPC (refer to Section 6.2.3.5 in text).
- (5) Naphthalene used as a surrogate.
- (6) Benzo(a)pyrene used as a surrogate.
- (7) COC value is for dinitrotoluene mixture.
- (8) COC value recalculated based on updated RfD for manganese.
- (9) Action level for residential soils (USEPA, 1994b)

-- = No criteria published
+ = Essential Nutrients

TABLE 6-10

SUMMARY OF COPCs
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

COPCs	Surface Soils	Shallow Subsurface Soil	Shallow Ground-water (total)	Shallow Ground-water (dissolved)	Deep Ground-water (total)	Deep Ground-water (dissolved)	Surface Water (total)	Surface Water (dissolved)	Sediment
Semivolatiles:									
Benzo(a)anthracene	X	X							X
Benzo(a)pyrene	X	X							X
Benzo(b)fluoranthene	X	X							X
Benzo(k)fluoranthene	X	X							X
Chrysene	X	X							X
Dibenzo(a,h)anthracene	X	X							X
Indeno(1,2,3-cd)pyrene	X	X							X
Phenanthrene									X
Pyrene									X
Pesticides:									
Heptachlor Epoxide							X	X	
Nitramines:									
1,3-Dinitrobenzene							X	X	
amino-Dinitrotoluenes	X	X	X	X	X	X	X	X	X
2,4-Dinitrotoluene		X	X	X			X	X	X
2,6-Dinitrotoluene							X	X	
2,4,6-Trinitrotoluene	X	X	X	X			X	X	X
1,3,5-Trinitrobenzene					X	X	X	X	
HMX							X	X	
RDX							X	X	

TABLE 6-10 (Continued)

SUMMARY OF COPCs
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

COPCs	Surface Soils	Shallow Subsurface Soil	Shallow Ground-water (total)	Shallow Ground-water (dissolved)	Deep Ground-water (total)	Deep Ground-water (dissolved)	Surface Water (total)	Surface Water (dissolved)	Sediment
Inorganics:									
Aluminum		X	X						
Antimony		X							
Arsenic	X	X	X	X	X	X	X	X	X
Barium			X	X					
Beryllium	X	X							X
Cadmium		X							
Chromium		X	X						X
Manganese	X	X	X	X			X	X	
Vanadium	X	X	X						
Cyanide (total)			X						

TABLE 6-11

SUMMARY OF COPCs
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

COPCs	Site 19 Surface Soil	Site 19 Shallow Subsurface Soil	Site 19 Shallow Groundwater (total)	Site 19 Shallow Groundwater (dissolved)	Site 19 Deep Groundwater (total)	Site 19 Deep Groundwater (dissolved)
Semivolatiles:						
Benzo(a)anthracene	X					
Benzo(a)pyrene	X					
Benzo(b)fluorathene	X					
Benzo(k)fluoranthene	X					
Chrysene	X					
Indeno(1,2,3-cd)pyrene	X					
Nitramines:						
RDX			X	X		
1,3,5-Trinitrobenzene			X	X		
2,4,6-Trinitrotoluene	X	X	X	X		
2,4/2,6-Dinitrotoluene			X	X		
amino-Dinitrotoluenes	X	X	X	X		

TABLE 6-11 (Continued)

SUMMARY OF COPCs
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

COPCs	Site 19 Surface Soil	Site 19 Shallow Subsurface Soil	Site 19 Shallow Groundwater (total)	Site 19 Shallow Groundwater (dissolved)	Site 19 Deep Groundwater (total)	Site 19 Deep Groundwater (dissolved)
Inorganics:						
Aluminum	X	X	X			
Antimony	X					
Arsenic	X	X	X			
Beryllium	X	X	X			
Cadmium			X			
Chromium		X	X			
Lead			X			
Manganese		X	X	X		
Vanadium		X	X			

TABLE 6-12

**EXPOSURE INPUT PARAMETERS
FOR CURRENT ADULT CIVILIAN WORKER AT SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Input Parameter	Media	Units	Current Receptor	Comments/Reference
			Adult Worker	
ED, Exposure Duration	All Media	years	25	USEPA, 1991a
EF, Exposure Frequency	All Media	days/year	14 ⁽¹⁾	Professional Judgment
ET, Exposure Time	Surface Water	hrs/day	2	Professional Judgment
	Soil	hrs/day	8	USEPA, 1991a
IR, Ingestion Rate	Soil/Sediment	mg/day	100	USEPA, 1991a
	Surface Water	L/day	0.05	USEPA, 1989b
SA, Exposed Surface Area	All Media	cm ² /day	5,300 ⁽²⁾	USEPA, 1992a
FI, Fraction Ingested	Soil	unitless	1.0	USEPA, 1989b
	Sediment	unitless	0.5	Professional Judgment
ABS, Dermal Absorption Factor	Soil/Sediment	unitless	Chemical-specific ⁽³⁾	USEPA, 1995c
PC, Permeability Constant	Surface Water	cm/hr	Chemical Specific	USEPA, 1992a
RR, Respiration Rate	Soil	m ³ /hr	1.25	USEPA, 1989a
AF, Adherence Factor	Soil/Sediment	mg/cm ²	1	USEPA, 1991a and 1992a
BW, Body Weight	All Media	kg	70	USEPA, 1989b
AT, Averaging Times				
AT _{nc} , noncarcinogens	All Media	days	9,125	USEPA, 1989b
AT _c , carcinogens	All Media	days	25,550	USEPA, 1989b

Notes: ⁽¹⁾ Based on conversations with civilian Station-personnel working in the area on an infrequent basis.

⁽²⁾ Skin surface area available for contact for an individual wearing a short-sleeved shirt, short pants, and shoes.

⁽³⁾ The following USEPA Region III default absorbance factors will be applied to estimate dermal intake of COPCs in soil (USEPA, 1995a):

SVOCs/Pesticides/PCBs	-	10%
Arsenic	-	3.2%
Inorganics	-	1%

NA - Not Applicable

TABLE 6-12 (Continued)

EXPOSURE INPUT PARAMETERS FOR
CURRENT ADULT CIVILIAN WORKER AT SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

References:

USEPA, 1995a. Assessing Dermal Exposure from Soil.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA, 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A). Interim Final.

TABLE 6-13

EXPOSURE INPUT PARAMETERS FOR
CURRENT COMMERCIAL ADULT ON-SITE WORKERS AT SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Input Parameter	Units	Current Receptor	Comments/References
		Adult Worker	
ED, Exposure Duration	years	25	USEPA, 1991a
IR, Ingestion Rate	mg/day	100	USEPA, 1991a
EF, Exposure Frequency	days/yr	250	USEPA, 1991a
AF, Adherence Factor	mg/cm ²	1.0	USEPA, 1991a and 1992b
ABS, Dermal Absorption Factor for Organics/Inorganics	unitless	Chemical-specific ⁽¹⁾	USEPA, 1995a
ET, Exposure Time	hrs/day	8	USEPA, 1991a
SA, Surface Area	cm ² /day	4,100 ⁽²⁾	USEPA, 1992a
FI, Fraction Ingested	unitless	1	USEPA, 1989b
BW, Body Weight	kg	70	USEPA, 1989b
RR, Respiration Rate	m ³ /hr	0.83	USEPA, 1991a
AT, Averaging Time			
AT _{nc} , noncarcinogens	days	9,125	USEPA, 1989b
AT _c , carcinogens	days	25,550	USEPA, 1989b

Notes:

- ⁽¹⁾ The following USEPA Region III default absorbance factors will be applied to estimate dermal intake of COPCs in soil (USEPA, 1995a):

SVOCs/Pesticides/PCBs	-	10%
Arsenic	-	3.2%
Inorganics	-	1%

- ⁽²⁾ Skin surface area available for contact assuming an adult wears a sleeveless shirt, long pants, and shoes.

TABLE 6-13 (Continued)

EXPOSURE INPUT PARAMETERS FOR
CURRENT COMMERCIAL ADULT ON-SITE WORKERS AT SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

References:

USEPA, 1995a. Assessing Dermal Exposure from Soil.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A) Interim Final.

TABLE 6-14

**REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY (CT) EXPOSURE
INPUT PARAMETERS FOR FUTURE RESIDENT CHILDREN AND ADULTS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Input Parameter	Media	Units	RME (CT)		Comments/References
			Child (1 to 6 years)	Adult	
ED, Exposure Duration	All Media	years	6 (NA)	24 (9)	USEPA, 1991a (USEPA, 1993b)
EF, Exposure Frequency	Soil/Groundwater	days/year	350 (234)	350 (234)	USEPA, 1991a (USEPA, 1993b)
	Sediment/ Surface Water	days/year	40 ⁽¹⁾ (NA)	40 ⁽¹⁾ (NA)	Professional Judgment
ET, Exposure Time	Surface Water	hrs/day	2.6 (NA)	2.6 (NA)	USEPA, 1989b
	Groundwater	hrs/day	0.2 (NA)	0.2 (NA)	USEPA, 1989a
IR, Ingestion Rate	Groundwater	L/day	1 (NA)	2 (1.4)	USEPA, 1991a (USEPA, 1993b)
	Soil/Sediment	mg/day	200 (100)	100 (50)	USEPA, 1989b (USEPA, 1993b)
	Surface Water	L/day	0.05 (NA)	0.05 (NA)	USEPA, 1989b
SA, Surface Area	Groundwater	cm ²	8,023 (6,978)	20,000 (20,000)	USEPA, 1992a (USEPA, 1992a)
	Soil/Sediment/ Surface Water	cm ²	2,006 ⁽²⁾ (1,745) ⁽³⁾	5,300 ⁽²⁾ (5,000) ⁽³⁾	USEPA, 1989a/1992a (USEPA, 1992a)
RR, Respiration Rate	Air	m ³ /hr	-- (--)	0.83 (NA)	USEPA, 1991a
FI, Fraction Ingested	Soil/Sediment	unitless	1.0 (NA)	1.0 (NA)	USEPA, 1989b/ Professional Judgment
ABS, Absorbance Factor	Soil/Sediment	unitless	Chemical Specific ⁽⁴⁾	Chemical Specific ⁽⁴⁾	USEPA, 1995a
AF, Adherence Factor	Soil/Sediment	mg/cm ²	1 (0.2)	1 (0.2)	USEPA, 1992b (USEPA, 1992a)
BW, Body Weight	All Media	kg	15 (NA)	70 (NA)	USEPA, 1989b
PC, Permeability Constant	Groundwater/ Surface Water	cm/hr	Chemical- Specific	Chemical- Specific	USEPA, 1992a

TABLE 6-14 (Continued)

REASONABLE MAXIMUM EXPOSURE (RME) AND CENTRAL TENDENCY (CT) EXPOSURE
 INPUT PARAMETERS FOR FUTURE RESIDENT CHILDREN AND ADULTS
 AT SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Input Parameter	Media	Units	RME (CT)		Comments/References
			Child (1 to 6 years)	Adult	
AT, Averaging Time AT _{nc} , noncarcinogens	All Media	day	2,190 (NA)	8,760 (3,285)	USEPA, 1989b/1991a (USEPA, 1993b)
AT _c , carcinogens	All Media	day	25,550 (NA)	25,550 (NA)	USEPA, 1989b

- Notes: (1) Assumes one weekend/month for 9 months with an average of 4.3 weekends/month/year which equates to approximately 40 days/year.
- (2) Represents 25% of total body surface area at the 95th percentile value.
- (3) Represents 25% of the total body surface area at the 50th percentile value.
- (4) The following USEPA Region III default absorbance factors will be applied to estimate dermal intake of COPCs in soil (USEPA, 1995a):

SVOCs/Pesticides/PCBs	-	10%
Arsenic	-	3.2%
Inorganics	-	1%

References:

- USEPA, 1995a. Assessing Dermal Exposure from Soil.
- USEPA, 1993b. Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure - Draft.
- USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.
- USEPA, 1992b. Interim Region IV Guidance.
- USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.
- USEPA, 1989a. Exposure Factors Handbook.
- USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A) Interim Final.

TABLE 6-15

**EXPOSURE INPUT PARAMETERS
FOR FUTURE ADULT CONSTRUCTION WORKERS AT SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Input Parameter	Units	Future Receptor	Comments/Reference
		Adult Construction Worker	
ED, Exposure Duration	years	1	USEPA, 1991a
EF, Exposure Frequency	days/year	250	USEPA, 1991a
ET, Exposure Time	hrs/day	8	USEPA, 1991a
IR, Ingestion Rate	mg/day	480	USEPA, 1991a
SA, Exposed Surface Area	cm ² /day	4,100 ⁽¹⁾	USEPA, 1992a
RR, Respiration Rate	m ³ /hr	1.25	USEPA, 1989a
FI, Fraction Ingested	unitless	1.0	Professional Judgment
ABS, Dermal Absorption Factor	unitless	Chemical-specific ⁽²⁾	USEPA, 1995a
AF, Adherence Factor	mg/cm ²	1	USEPA, 1991a and 1992a
BW, Body Weight	kg	70	USEPA, 1989b
AT, Averaging Times			
AT _{nc} , noncarcinogens	days	365	USEPA, 1989b
AT _c , carcinogens	days	25,550	USEPA, 1989b

Notes: (1) Skin surface area available for contact for an individual wearing a sleeveless shirt, long pants, and shoes.

(2) The following USEPA Region III default absorbance factors will be applied to estimate dermal intake of COPCs in soil (USEPA, 1995a):

SVOCs/Pesticides/PCBs	-	10%
Arsenic	-	3.2%
Inorganics	-	1%

NA - Not Applicable

TABLE 6-15 (Continued)

EXPOSURE INPUT PARAMETERS
FOR FUTURE ADULT CONSTRUCTION WORKERS AT SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

References:

USEPA, 1995a. Assessing Dermal Exposure from Soil.

USEPA, 1992a. Dermal Exposure Assessment: Principles and Applications - Interim Report.

USEPA, 1992b. Interim Region IV Guidance.

USEPA, 1991a. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors." Interim Final.

USEPA, 1989a. Exposure Factors Handbook.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (Part A). Interim Final.

TABLE 6-16

**HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Constituents	Oral CSF (mg/kg/day) ⁻¹	Inhalation CSFi (mg/kg/day) ⁻¹	Oral RfD (mg/kg/day)	Inhalation RfDi (mg/kg/day)	Adjustment for Absorption Efficiency	Toxicity Criteria Derivation					
						WOE	Target Organ	Critical Effect	LOAEL/NOAEL (mg/kg/day)	Uncertainty/Modifying Factors	References ⁽³⁾
SVOCs:											
Benzo(a)anthracene	7.30E-01 (e)	6.10E-01 (e)	--	--	50%	B2	--	--	--	--	USEPA 1984, 1990
Benzo(a)pyrene	7.3 (i)	6.1 (w)	--	--	50%	B2	--	--	--	--	Neal and Rigdon, 1967; Brune et al, 1981
Benzo(b)fluoranthene	7.30E-01 (e)	6.10E-01 (e)	--	--	50%	B2	--	--	--	--	USEPA 1984, 1990
Benzo(k)fluoranthene	7.30E-02 (e)	6.10E-02 (e)	--	--	50%	B2	--	--	--	--	USEPA 1984, 1990
Chrysene	7.30E-03 (e)	6.10E-03 (e)	--	--	50%	B2	--	--	--	--	USEPA 1984, 1990
Dibenzo(a,h)anthracene	7.3 (e)	6.1 (e)	--	--	50%	B2	--	--	--	--	USEPA 1984, 1990
Indeno(1,2,3-cd)pyrene	7.30E-01 (e)	6.10E-01 (e)	--	--	50%	B2	--	--	--	--	USEPA 1984, 1990
Phenanthrene ⁽¹⁾	--	--	4.00E-02 (w)	--	50%	D	--	--	--	--	USEPA 1990
Pyrene	--	--	3.00E-02 (i)	--	50%	D	Kidney	Adverse Effects	75/125	3000/1	USEPA 1989

TABLE 6-16 (Continued)

HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Constituents	Oral CSF (mg/kg/day) ⁻¹	Inhalation CSFi (mg/kg/day) ⁻¹	Oral RfD (mg/kg/day)	Inhalation RfDi (mg/kg/day)	Adjustment for Absorption Efficiency	Toxicity Criteria Derivation					
						WOE	Target Organ	Critical Effect	LOAEL/NOAEL (mg/kg/day)	Uncertainty/Modifying Factors	References ⁽²⁾
Pesticides:											
Heptachlor Epoxide	9.10 (i)	9.10 (i)	1.3E-05 (i)	--	70%	B2	Liver	Increased Relative Weight	none/0.0125	1000/1	Dow Chemical Co., 1958
Nitramines:											
1,3-Dinitrobenzene	--	--	1.00E-04 (i)	--	50%	D	Spleen	Increased Weight	None/0.40	3000/1	Cody, et al., 1981
amino-Dinitrotoluenes	--	--	--	--	--	--	--	--	--	--	--
2,4-Dinitrotoluene	--	--	2.00E-03 (i)	--	70%	B2	CNS/ Erythrocytes/ Biliary Tract	Neurotoxicity/ Heinz Bodies/ Hyperplasia	1.5/0.2	100/1	Ellis, et al., 1985
2,6-Dinitrotoluene	--	--	1.00E-03 (h)	--	60%	B2	Whole Body/ CNS/ Blood/ Bile Duct/ Kidney	Mortality/ Neurotoxicity/ Heinz Bodies/ Methemoglobinemia/ Hyperplasia/ Histopathology	None/4.0	3000/1	3 week - Dog Study
HMX	--	--	5.00E-02 (i)	--	--	D	Liver/CNS	Adverse Effects	150/50	1000/1	U.S. DoD, 1985a
RDX	1.10E-01 (i)	--	3.00E-03 (i)	--	100%	C	Prostate	Inflammation/ Hemosiderosis	1.5/0.3	100/1	U.S. DoD, 1983

TABLE 6-16 (Continued)

**HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Constituents	Oral CSF (mg/kg/day) ⁻¹	Inhalation CSFi (mg/kg/day) ⁻¹	Oral RfD (mg/kg/day)	Inhalation RfDi (mg/kg/day)	Adjustment for Absorption Efficiency	Toxicity Criteria Derivation					
						WOE	Target Organ	Critical Effect	LOAEL/NOAEL (mg/kg/day)	Uncertainty/Modifying Factors	References ⁽²⁾
1,3,5-Trinitrobenzene	--	--	5.00E-05 (i)	--	50%	D	Spleen	Increased Weight	8 ppm/ 0.51 mg/kg/day	10,000/1	Cody, et al., 1981
2,4,6-Trinitrotoluene	3.00E-02 (i)	--	5.00E-04 (i)	--	74%	C	Liver	Adverse Effects	0.5/none	1000/1	U.S. DoD, 1983
Inorganics:											
Aluminum	--	--	1.00 (e)	--	20%	--	--	--	--	--	--
Antimony	--	--	4.00E-04 (i)	--	20%	D	Whole Body/Blood	Increased Mortality/ Altered Chemistry	0.35/none	1,000/1	Schroeder et al., 1970
Arsenic	1.50 (i)	15.1 (i)	3.00E-04 (i)	--	95%	A	Skin	Keratosi/s/ Hyperpigmentation	0.014/ 0.0008	3/1	Tseng, 1977; Tseng et al., 1968
Barium	--	--	7.00E-02 (i)	1.43E-04 (a)	100%	D	Cardivascular System	Increased Blood Pressure	none/0.21	3/1	Wones et al., 1990; Brenniman and Levy, 1984
Beryllium	4.30 (i)	8.40 (i)	5.00E-03 (i)	--	1%	B2	--	None observed	none/0.54	100/1	Schroeder and Mitchner, 1975
Cadmium (water)	--	6.30 (i)	5.00E-04 (i)	--	5%	B1	Renal Cortex	Significant Proteinuria	none/ 0.005	10/1	USEPA, 1985

TABLE 6-16 (Continued)

**HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Constituents	Oral CSF (mg/kg/day) ⁻¹	Inhalation CSFi (mg/kg/day) ⁻¹	Oral RfD (mg/kg/day)	Inhalation RfDi (mg/kg/day)	Adjustment for Absorption Efficiency	Toxicity Criteria Derivation					
						WOE	Target Organ	Critical Effect	LOAEL/NOAEL (mg/kg/day)	Uncertainty/Modifying Factors	References ⁽²⁾
Cadmium (soil/sediment)	--	6.30 (i)	1.00E-02 (i)	--	2.5%	B1	Renal Cortex	Significant Proteinuria	none/0.01	10/1	USEPA, 1985
Chromium	--	42.0 (i)	5.00E-03 (i)	--	20%	A	--	None Observed	none/2.4	500/1	MacKenzie et al., 1958
Copper	--	--	3.71E-02 (h)	--	60%	D	Gastrointestinal System	Irritation	--	--	USEPA, 1987
Cyanide	--	--	2.00E-02 (i)	--	70%	D	Whole body/ Thyroid/ Nerve	Decreased Weight/ Thyroid Effects/ Myelin Degeneration	30/10.8	100/5	Howard and Hanzal, 1955; Philbrick et al., 1979
Lead	--	--	--	--	--	B2	--	--	--	--	USEPA, 1984
Manganese	--	--	2.4E-02 (i)	1.43E-05 (i)	5%	D	CNS/Lung	Adverse Effects	0.06/ 0.005	1/1	WHO, 1973; Schroeder et al., 1966
Vanadium	--	--	7.00E-03 (h)	--	20%	D	--	--	--	--	NA

Notes:

-) Toxicity value for naphthalene used as a surrogate.
-) Toxicity value for 2,6-Dinitrotoluene used as a surrogate.
-) References to related studies cited in IRIS, 1996a, HEAST, 1995b. Integrated Risk Information System (IRIS), 1996a.

TABLE 6-16 (Continued)

**HUMAN HEALTH RISK ASSESSMENT TOXICITY FACTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

otes (continued):

National Center for Environmental Assessment (NCEA) (as cited from the January to June, 1996 USEPA, Region III RBC Tables)
Health Effects Assessment Summary Tables (HEAST), May, 1995
HEAST Alternative Method, 1995
Withdrawn from IRIS or HEAST
Not Available

TABLE 6-17

**TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND
HAZARD INDEX (HI) VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Receptors	Site 9		Site 19	
	Total ICR	Total HI	Total ICR	Total HI
Adult Civilian Worker ⁽¹⁾	8.5 x 10 ⁻⁰⁶	0.09	--	--
Adult On-Site Commercial Worker ⁽²⁾	--	--	1.7 x 10 ⁻⁰⁵	0.26

Notes: ⁽¹⁾ Current adult civilian workers could potentially be exposed to COPCs by accidental ingestion and dermal contact of surface soils, surface water, and sediments as well as inhalation of fugitive dusts in surface soils.

⁽²⁾ Current on-site adult commercial workers could be potentially exposed to COPCs by accidental ingestion, dermal contact, and inhalation of fugitive dusts in surface soils.

TABLE 6-18

**TOTAL SITE LIFETIME INCREMENTAL CANCER RISK (ICR) AND
HAZARD INDEX (HI) VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Future Receptors	Site 9		Site 19	
	Total ICR	Total HI	Total ICR	Total HI
On-Site Residents ⁽¹⁾⁽²⁾ (RME and CT Values using shallow groundwater)	$1.2 \times 10^{-03(3)}$ (2.3×10^{-04})	227 ⁽³⁾ (52)	$6.7 \times 10^{-05(3)}$ (9.3×10^{-06})	5 ⁽³⁾ (3.3)
On-Site Residents ⁽¹⁾⁽²⁾ (RME and CT Values using deep groundwater)	$2.2 \times 10^{-04(4)}$ (3.3×10^{-05})	6 ⁽⁴⁾ (2.2)	NA	NA
Construction Workers ⁽⁵⁾	4.4×10^{-06}	0.81	2.1×10^{-06}	0.42

- Notes:
- (1) Residents could potentially be exposed to COPCs by dermal contact and accidental ingestion of surface soils and groundwater at Sites 9 and 19, and surface water and sediments at Site 9.
 - (2) Total HI and ICR values for residents are the sum total of the resident adult and resident child HI and ICR values, respectively.
 - (3) ICR and HI values are elevated because of the presence of 2,4,6-TNT (Sites 9 and 19), dissolved arsenic (Site 9), 1,3,5-TNB (Site 19), and amino-DNTs (Sites 9 and 19) in the shallow groundwater; aluminum and arsenic in the Site 19 surface soil; arsenic in the Site 9 surface soil; and the amino-DNTs and 2,4,6-TNT in the Site 9 surface water.
 - (4) ICR and HI values are elevated because of the presence of 1,3,5-TNB in the deep groundwater at Site 9; arsenic in the Site 9 surface soil; and the amino-DNTs and 2,4,6-TNT in the Site 9 surface water.
 - (5) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of shallow subsurface soils, as well as the inhalation of fugitive dusts during excavation activities.

TABLE 6-19

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
 FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
 RME AND CENTRAL TENDENCY VALUES USING SHALLOW GROUNDWATER
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
<u>Surface Soil</u>				
Ingestion	1.7 x 10 ⁻⁰⁵ (1.6 x 10 ⁻⁰⁶)	0.1 (0.03)	4.0 x 10 ⁻⁰⁵ (1.0 x 10 ⁻⁰⁵)	0.91 (0.23)
Dermal Contact	5.7 x 10 ⁻⁰⁵ (2.0 x 10 ⁻⁰⁶)	0.18 (0.02)	2.5 x 10 ⁻⁰⁵ (2.1 x 10 ⁻⁰⁶)	0.31 (0.03)
Subtotal	7.4 x 10 ⁻⁰⁵ (3.6 x 10 ⁻⁰⁶)	0.28 (0.05)	6.5 x 10 ⁻⁰⁵ (1.2 x 10 ⁻⁰⁵)	1.2 (0.26)
<u>Shallow Groundwater⁽¹⁾</u>				
Ingestion	6.3 x 10 ⁻⁰⁴ (6.8 x 10 ⁻⁰⁵)	51 (12)	3.6 x 10 ⁻⁰⁴ (1.5 x 10 ⁻⁰⁴)	120 (39)
Dermal Contact	1.6 x 10 ⁻⁰⁶ (2.8 x 10 ⁻⁰⁷)	0.15 (0.05)	7.7 x 10 ⁻⁰⁷ (3.0 x 10 ⁻⁰⁷)	0.28 (0.08)
Inhalation	--	--	NE	NE
Subtotal	6.3 x 10 ⁻⁰⁴ (6.8 x 10 ⁻⁰⁵)	51 (12)	3.6 x 10 ⁻⁰⁴ (1.5 x 10 ⁻⁰⁴)	120 (39)
<u>Surface Water⁽²⁾</u>				
Ingestion	2.1 x 10 ⁻⁰⁶ (4.3 x 10 ⁻⁰⁷)	0.2 (0.07)	2.4 x 10 ⁻⁰⁶ (1.3 x 10 ⁻⁰⁶)	0.96 (0.33)
Dermal Contact	3.4 x 10 ⁻⁰⁷ (9.4 x 10 ⁻⁰⁸)	0.29 (0.09)	1.5 x 10 ⁻⁰⁷ (1.0 x 10 ⁻⁰⁷)	0.51 (0.15)
Subtotal	2.4 x 10 ⁻⁰⁶ (5.2 x 10 ⁻⁰⁷)	0.5 (0.2)	2.6 x 10 ⁻⁰⁶ (1.4 x 10 ⁻⁰⁶)	1.5 (0.5)

TABLE 6-19 (continued)

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
 FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
 RME AND CENTRAL TENDENCY VALUES USING SHALLOW GROUNDWATER
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
<u>Sediment</u>				
Ingestion	3.3 x 10 ⁻⁰⁶ (7.8 x 10 ⁻⁰⁸)	0.02 (<0.01)	7.8 x 10 ⁻⁰⁶ (4.9 x 10 ⁻⁰⁷)	0.16 (<0.01)
Dermal Contact	1.1 x 10 ⁻⁰⁵ (3.0 x 10 ⁻⁰⁷)	0.03 (<0.01)	5.0 x 10 ⁻⁰⁶ (3.3 x 10 ⁻⁰⁷)	0.05 (<0.01)
Subtotal	1.4 x 10 ⁻⁰⁵ (3.8 x 10 ⁻⁰⁷)	0.05 (<0.01)	1.3 x 10 ⁻⁰⁵ (8.2 x 10 ⁻⁰⁷)	0.21 (<0.01)
TOTAL	7.2 x 10 ⁻¹⁴ (7.3 x 10 ⁻¹⁵)	52 (12)	4.4 x 10 ⁻¹⁴ (1.6 x 10 ⁻¹⁵)	123 (40)

Notes:

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

NE = Not Evaluated

() = Central tendency value

Shaded areas indicated exceedances of the USEPA's generally acceptable target risk range or unity, respectively.

TABLE 6-20

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
 FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
 RME AND CENTRAL TENDENCY VALUES USING DEEP GROUNDWATER
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
<u>Surface Soil</u>				
Ingestion	1.7 x 10 ⁻⁰⁵ (1.6 x 10 ⁻⁰⁶)	0.1 (0.03)	4.0 x 10 ⁻⁰⁵ (1.0 x 10 ⁻⁰⁵)	0.91 (0.23)
Dermal Contact	5.7 x 10 ⁻⁰⁵ (2.0 x 10 ⁻⁰⁶)	0.18 (0.02)	2.5 x 10 ⁻⁰⁵ (2.1 x 10 ⁻⁰⁶)	0.31 (0.03)
Subtotal	7.4 x 10 ⁻⁰⁵ (3.6 x 10 ⁻⁰⁶)	0.28 (0.05)	6.5 x 10 ⁻⁰⁵ (1.2 x 10 ⁻⁰⁵)	1.2 (0.26)
<u>Deep Groundwater⁽¹⁾</u>				
Ingestion	2.5 x 10 ⁻⁰⁵ (4.5 x 10 ⁻⁰⁶)	0.67 (0.31)	1.5 x 10 ⁻⁰⁵ (9.9 x 10 ⁻⁰⁶)	1.4 (1.93)
Dermal Contact	5.3 x 10 ⁻⁰⁸ (1.3 x 10 ⁻⁰⁸)	<0.01 (<0.01)	2.5 x 10 ⁻⁰⁸ (1.5 x 10 ⁻⁰⁸)	<0.01 (<0.01)
Inhalation	--	--	NE	NE
Subtotal	2.5 x 10 ⁻⁰⁵ (4.5 x 10 ⁻⁰⁶)	0.6 (0.28)	1.5 x 10 ⁻⁰⁵ (9.9 x 10 ⁻⁰⁶)	1.4 (0.93)
<u>Surface Water⁽²⁾</u>				
Ingestion	2.1 x 10 ⁻⁰⁶ (4.3 x 10 ⁻⁰⁷)	0.2 (0.07)	2.4 x 10 ⁻⁰⁶ (1.3 x 10 ⁻⁰⁶)	0.96 (0.33)
Dermal Contact	3.4 x 10 ⁻⁰⁷ (9.4 x 10 ⁻⁰⁸)	0.29 (0.09)	1.5 x 10 ⁻⁰⁷ (1.0 x 10 ⁻⁰⁷)	0.51 (0.15)
Subtotal	2.4 x 10 ⁻⁰⁶ (5.2 x 10 ⁻⁰⁷)	0.5 (0.2)	2.6 x 10 ⁻⁰⁶ (1.4 x 10 ⁻⁰⁶)	1.5 (0.5)

TABLE 6-20 (continued)

**INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES USING DEEP GROUNDWATER
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
<u>Sediment</u>				
Ingestion	3.3 x 10 ⁻⁰⁶ (7.8 x 10 ⁻⁰⁸)	0.02 (<0.01)	7.8 x 10 ⁻⁰⁶ (4.9 x 10 ⁻⁰⁷)	0.16 (<0.01)
Dermal Contact	1.1 x 10 ⁻⁰⁵ (3.0 x 10 ⁻⁰⁷)	0.03 (<0.01)	5.0 x 10 ⁻⁰⁶ (3.3 x 10 ⁻⁰⁷)	0.05 (<0.01)
Subtotal	1.4 x 10 ⁻⁰⁵ (3.8 x 10 ⁻⁰⁷)	0.05 (<0.01)	1.3 x 10 ⁻⁰⁵ (8.2 x 10 ⁻⁰⁷)	0.21 (<0.01)
TOTAL	1.2 x 10 ⁻⁰⁴ (9 x 10 ⁻⁰⁶)	1.4 (0.53)	9.6 x 10 ⁻⁰⁵ (2.4 x 10 ⁻⁰⁵)	4.3 (1.7)

Notes:

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

NE = Not Evaluated

() = Central tendency value

Shaded areas indicated exceedances of the USEPA's generally acceptable target risk range or unity, respectively.

TABLE 6-21

**INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
<u>Surface Soil</u>				
Ingestion	8.5 x 10 ⁻⁰⁶ (7.5 x 10 ⁻⁰⁷)	0.13 (0.03)	2.0 x 10 ⁻⁰⁵ (4.7 x 10 ⁻⁰⁶)	1.2 (0.24)
Dermal Contact	1.9 x 10 ⁻⁰⁵ (7.8 x 10 ⁻⁰⁷)	0.3 (0.02)	8.4 x 10 ⁻⁰⁶ (8.5 x 10 ⁻⁰⁷)	0.54 (0.04)
Subtotal	2.8 x 10 ⁻⁰⁵ (1.5 x 10 ⁻⁰⁶)	0.43 (0.05)	2.8 x 10 ⁻⁰⁵ (5.6 x 10 ⁻⁰⁶)	1.7 (0.28)
<u>Shallow Groundwater</u>				
Ingestion	7.2 x 10 ⁻⁰⁶ (6.6 x 10 ⁻⁰⁷)	2.8 (0.12)	4.2 x 10 ⁻⁰⁶ (1.5 x 10 ⁻⁰⁶)	6.4 (2.1)
Dermal Contact	3.1 x 10 ⁻⁰⁸ (4.4 x 10 ⁻⁰⁹)	0.02 (>0.01)	1.5 x 10 ⁻⁰⁸ (4.8 x 10 ⁻⁰⁹)	0.03 (0.01)
Inhalation	--	--	NE	NE
Subtotal	7.2 x 10 ⁻⁰⁶ (6.6 x 10 ⁻⁰⁷)	2.8 (0.88)	4.2 x 10 ⁻⁰⁶ (1.5 x 10 ⁻⁰⁶)	6.4 (2.1)
TOTAL	3.5 x 10 ⁻⁰⁵ (2.2 x 10 ⁻⁰⁶)	3.2 (0.93)	3.2 x 10 ⁻⁰⁵ (7.1 x 10 ⁻⁰⁶)	8.1 (2.4)

Notes:

Shaded areas indicated exceedances of the USEPA's generally acceptable target risk range or unity, respectively.

NE = Not Evaluated.

() = Central tendency values

TABLE 6-22

**SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE
HUMAN HEALTH RISK ASSESSMENT
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
<u>Environmental Sampling and Analysis</u>			
Sufficient samples may not have been taken to characterize the media being evaluated.			Moderate
Systematic or random errors in the chemical analysis may yield erroneous data.			Low
<u>Selection of COPCs</u>			
The use of USEPA Region III COC screening values in selecting COPCs in soil and groundwater.			Low
The use of USEPA Region III tapwater COC screening values and the Federal and Commonwealth water quality criteria in selecting COPCs in surface water for human health evaluation.	Moderate		
The use of SSVs and USEPA Region III residential COPC screening values in selecting COPCs in sediment for human health evaluation.	Moderate		
<u>Exposure Assessment</u>			
The standard assumptions regarding body weight, exposure period, life expectancy, population characteristics, and lifestyle may not be representative of the actual exposure situations.			Moderate
The use of the 95% UCL of the arithmetic mean in the estimation of the soil, groundwater, surface water and sediment exposure point concentrations.	Low		
Using one-half of the CRQL as a surrogate concentration in the derivation of the 95% UCL.			Moderate
Assessing future residential property use when the likelihood of residential development is low.	High		
The amount of media intake is assumed to be constant and representative of any actual exposure.			Low
Estimating construction worker intakes resulting from only subsurface soil, and not from surface soil exposures.		Low	

TABLE 6-22 (Continued)

SUMMARY OF UNCERTAINTIES IN THE RESULTS OF THE
HUMAN HEALTH RISK ASSESSMENT
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
<u>Toxicological Assessment</u>			
Toxicological indices derived from high dose animal studies, extrapolated to low dose human exposure.	Moderate		
Lack of promulgated toxicological indices for the inhalation pathway.		Low	
Adjusting toxicity values for a difference in toxicity between an administered dose and an absorbed dose.	Moderate		
<u>Risk Characterization</u>			
Assumption of additivity in the quantitation of cancer risks without consideration of synergism, antagonism, promotion and initiation.			Moderate
Assumption of additivity in the estimation of systemic health effects without consideration of synergism, antagonism, etc.			Moderate
Additivity of risks by individual exposure pathways (dermal, ingestion and inhalation)			Low

Notes:

Low - Assumptions categorized as "low" may effect risk estimates by less than one order of magnitude.

Moderate - Assumptions categorized as "moderate" may effect estimates of risk by between one and two orders of magnitude.

High - Assumptions categorized as "high" may effect estimates of risk by more than two orders of magnitude.

Source: Risk Assessment Guidance for Superfund, Volume 1, Part A: Human Health Evaluation Manual. USEPA, 1989b.

SECTION 6.0 FIGURES

FIGURE 6-1
CONCEPTUAL SITE MODEL
FOR SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

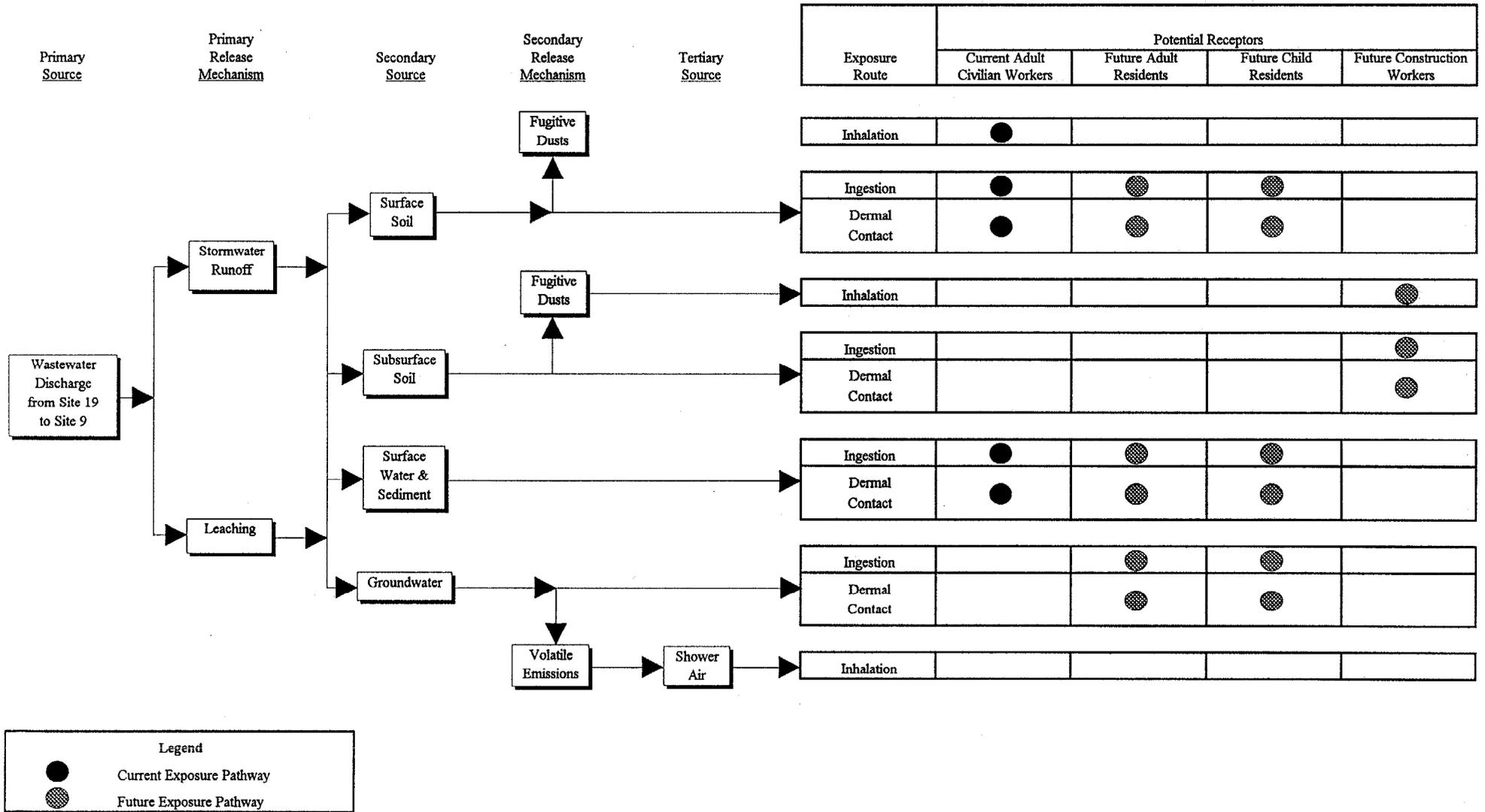
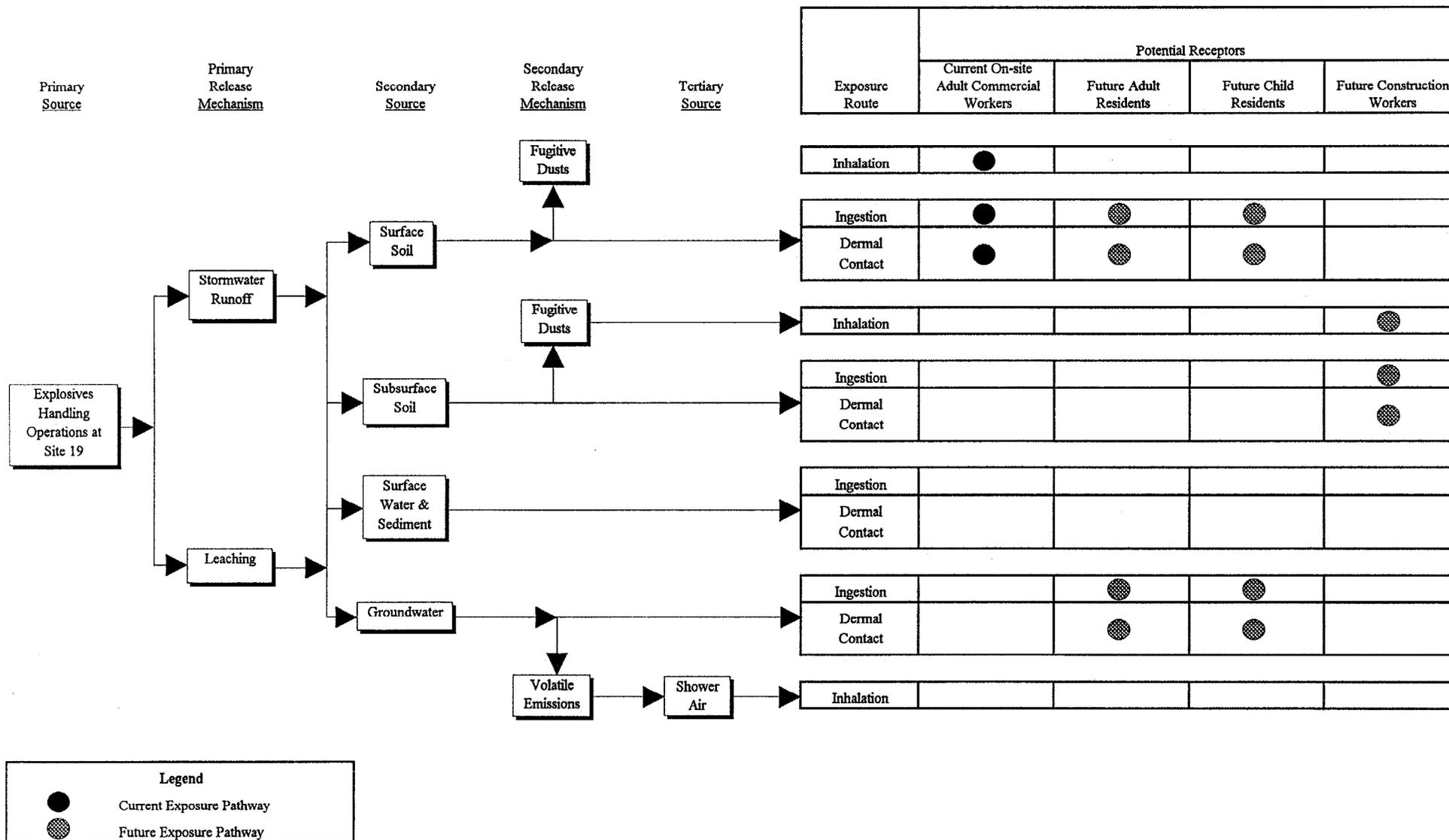


FIGURE 6-2
CONCEPTUAL SITE MODEL
FOR SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



7.0 ECOLOGICAL RISK ASSESSMENT

This section presents the Phase Two ecological risk assessment (RA) conducted at Sites 9 and 19 that addresses the potential impacts to ecological receptors from contaminants detected at the sites. Lee Pond which is located due west of Sites 9 and 19 will not be addressed in this ecological RA, but will be addressed in a future investigation. The objective of this ecological RA is to evaluate whether past site operations at Sites 9 and 19 have adversely affected the ecological integrity of the terrestrial and aquatic communities on or adjacent to the sites. The conclusions of the ecological RA will be used in conjunction with the human health RA (Section 6.0) to evaluate the appropriate remedial action for these sites to protect human health and the environment.

The ecological investigation of Sites 9 and 19 is divided into an aquatic assessment and a terrestrial assessment. An aquatic assessment was conducted on the surface water, sediment, fish, and benthic macroinvertebrates collected from the drainage way at Site 9. Two terrestrial assessments were conducted, one on the surface soil and surface water collected from Site 9 and one on the surface soil collected from Site 19. Data collected during the Round Two Remedial Investigation (RI) were compared to data collected from background locations representing regional conditions (Baker, 1995a).

As part of the Round Two RI, a Phase Two terrestrial and aquatic ecological risk assessment was conducted. The Phase Two RA consisted of an environmental screening of the sampled media concentrations to established screening levels to determine exceedances and to devise a list of ecological contaminants of concern (ECOCs) for each medium at each site. The aquatic assessment consisted of the calculation of quotient index (QI) ratios for ECOCs detected in surface water and sediment that exceeded screening levels to determine a quantitative risk to the aquatic environment. Using a weight of evidence approach, benthic macroinvertebrate and fish samples also were collected for the aquatic assessment. Benthic macroinvertebrate samples collected from the site were compared to background samples to determine differences between the two populations. Differences between the site benthic community and the background benthic community may indicate site-related affects to the aquatic environment. The fish population also was identified to verify expected populations for the aquatic environment at Site 9.

A modified Phase Two RA was conducted for the terrestrial portion of this RA. Surface soil ECOC concentrations were qualitatively compared to established toxicity values for surface soil flora and

fauna. In addition to a qualitative comparison, uptake modeling was conducted for potential terrestrial receptors at Sites 9 and 19.

Information used to evaluate sensitive environments was obtained from the Natural Heritage Inventory conducted at WPNSTA Yorktown by the Commonwealth of Virginia (Buhlman and Ludwig, 1992). In addition, a qualitative habitat evaluation was conducted at Sites 9 and 19 in 1994 to identify potential terrestrial and aquatic receptors (Baker, 1995b).

The risk assessment methodologies used in this evaluation were consistent with those outlined in the Ecological Risk Assessment Guidance for Superfund (USEPA, 1994a). In addition, information found in the following documents was used to supplement the USEPA guidance document:

- Framework for Ecological Risk Assessment (USEPA, 1992a)
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989b)
- Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (USEPA, 1990)
- Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Water (USEPA, 1993a)
- Region III Interim Ecological Risk Assessment Guidelines (USEPA, 1994b)

This ecological risk assessment for Sites 9 and 19 is organized in accordance with the recommended outline presented in the Region III Interim Ecological Risk Assessment Guidelines (USEPA, 1994b).

7.1 Problem Formulation

Problem formulation is the first step of an ecological RA and includes a preliminary characterization of exposure and effects. The problem formulation also includes a review of the Round One RI data (i.e., Phase One ecological RA). Based on the Phase One ecological RA, the Round Two field

investigation was conducted and included chemical analyses of soil, groundwater, surface water, and sediment collected from Sites 9 and 19 to evaluate the presence, concentrations, and variabilities of any contaminants. These data were used to select the ECOCs.

Ecological surveys also were conducted as part of the field activities during the Round Two RI. Based on these observations and evaluation of habitats in the vicinity of the site, potential ecological receptors were identified. Finally, toxicological information for the ECOCs detected in the media was obtained from available references and literature and used to evaluate the potential adverse ecological effects to the ecological receptors.

The components of this problem formulation stage include characterization of the Round One RI results, characterization of the Round Two RI results, identification of background, stressor characterization, ecosystems potentially at risk, ECOCs, endpoint selection, and a conceptual model. The following subsections discuss the components of the problem formulation and how they were evaluated in this ecological RA.

7.1.1 Round One Remedial Investigation

A summary of the analytical results and sampling locations for Sites 9 and 19 from the Round One RI is presented in Section 1.3. The Round One data indicated that surface soil, groundwater, surface water, and sediment potentially have been impacted by past site activities. Based on the review of these data and the habitat evaluation conducted at Sites 9 and 19, the Sampling and Analysis Plan for the Round Two RI was developed.

7.1.2 Round Two Remedial Investigation

The nature and extent of contaminants detected in the environmental media during the Round Two RI at Sites 9 and 19 are discussed in Section 4.2 of this report. Sampling locations were chosen based on historical information available for the site, results of the Round One RI, and a site visit to evaluate potential ecosystems and ecological receptors. Tables 4-3 through 4-31 summarize the contaminants that were detected in all media at Sites 9 and 19. Figures 4-1 through 4-10 provide a graphical description of the analytical results.

Contaminants in the subsurface soil and groundwater were not evaluated in this ecological RA. Some terrestrial species burrow in the soil and may contact the subsurface soil, and some microorganisms most likely exist in the groundwater. However, current guidance does not provide sufficient information to evaluate risk to these receptors.

7.1.3 Background Investigation

A background investigation was conducted for WPNSTA. The study included the chemical analyses of soil, surface water, and sediment. Surface soil and subsurface soil were collected on Station property across all soil associations and including anthropogenic data collected near railroad tracks. Surface water, sediment, fish and benthic macroinvertebrate were collected from freshwater ponds, freshwater streams, and tidal freshwater streams in relatively undisturbed areas within the York River Basin.

The background data is presented in the Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin, Naval Weapons Station, Yorktown, Virginia (Baker, 1995a). Background data collected from freshwater streams were used in this ecological RA to identify ECOCs and to evaluate site benthic and fish data.

7.1.3 Ecological Endpoints

Ecological endpoints were selected based upon the findings of the Round One RI and the habitat evaluation. These endpoints were used to focus ecological field studies. There are two primary types of ecological endpoints: assessment endpoints and measurement endpoints. Assessment endpoints are environmental characteristics, which, if they were found to be significantly affected, would indicate a need for remediation (e.g., decrease in sports fisheries). Measurement endpoints are quantitative expressions of an observed or measured effect of the ECOCs. Measurement endpoints may be identical to assessment endpoints (e.g., measurement of abundance of fish), or they may be used as surrogates for assessment endpoints (e.g., toxicity test endpoints). Both types of endpoints are used in the ecological risk evaluation and are discussed in the following sections.

7.1.3.1 Aquatic Endpoints

The assessment endpoints for the aquatic portion of this ecological RA are differences (compared to background) in the structure of benthic macroinvertebrate communities at Site 9 attributable to site-related contaminants and the reduction of an aquatic receptor population or subpopulation that is attributable to site-related contaminants. Measurement endpoints for the first aquatic assessment endpoint include lower species diversity and richness when compared to ecologically similar background locations and the dominance of contaminant-tolerant (opportunistic) species over contaminant-intolerant (equilibrium) species. Unsuitable, ecologically stressed benthic habitats tend to be dominated by opportunistic species; whereas, suitable benthic habitats tend to be dominated by equilibrium species. The measurement endpoints for the second aquatic assessment endpoint include exceedances of contaminant-specific surface water and sediment effect concentrations and the presence of gross external fish pathologies.

The benthic macroinvertebrate species were used to evaluate potential conditions in the sediment that may adversely impact the benthic community. Overall species richness is indicated by the number of species collected at each station. The number of species and the total number of individuals present at a site are highly sensitive to anthropogenic disturbances resulting from the introduction of contaminants. In addition, relatively undisturbed environments support communities having large numbers of species with no individual species present in overwhelming abundance. Species richness is usually directly proportional to an increase in water quality, habitat diversity, and/or habitat suitability. However, there are naturally occurring stresses to the benthic environment that will affect the domination of one benthic species over another (USEPA, 1990).

Diversity, richness, and species dominance are evaluated by comparing the type of species, the species diversity, the macroinvertebrate biotic index (MBI), and community similarity of the benthic macroinvertebrates collected at Site 9 to the appropriate off-site background stations. Appendix N provides a further detailed discussion of the aquatic ecological endpoints.

The assessment of gross external fish pathologies provides a relatively simple and rapid indication of how well fish live in their habitats. The pathologies are manifestations of biochemical and physiological alterations expressed at the organism level (USEPA, 1993a). Further, these observations can be useful in a weight-of-evidence approach in aquatic surveys (USEPA, 1989b).

Karr (1981) has used the percentage of physical anomalies in fish as one of the 12 metrics in the Index of Biotic Integrity. The frequency and intensity of neoplasms, cataracts, finrot, and other lesions observed in fish populations from the Elizabeth River, Virginia, have been correlated with the extent of sediment contamination (Van Veld, et al., 1990). Fish maintained in the laboratory in contact with sediment taken from the Elizabeth River exhibited several of the same gross external pathologies observed in the field populations.

7.1.3.2 Terrestrial Endpoints

The assessment endpoint for the terrestrial ecological RA is the reduction of a receptor population or subpopulation that is attributable to site-related contaminants. The measurement endpoints for the terrestrial ecological RA include exceedances of contaminant-specific soil effect screening levels and contaminant-specific effect doses. The contaminant-specific effect doses were used in the total daily intake (TDI) models for terrestrial species. The terrestrial species included in the model were selected based on receptor populations and subpopulations identified in the habitat evaluation or the importance of the species to natural resource management programs at the Station (i.e., rabbit, quail, and deer). In addition, the receptor populations were selected to include vertebrates representing predator-prey exposure (i.e., the fox). Finally, vertebrates were selected that have direct soil exposure, as well as vertebrates that are exposed to several environmental media (i.e., the raccoon).

7.1.4 **Criteria for Selecting Ecological Contaminants of Concern**

Quantifying risk for all positively identified contaminants may distract from the dominant risk-driving contaminants at the site. Therefore, the data set of all positively identified contaminants was reduced to a list of ECOCs. ECOCs are site-related contaminants used to estimate ecological exposures and associated potential adverse effects. It should be noted that historical information was not used as selection criteria for the ECOCs. However, historical information is incorporated into the risk assessment phase (Section 7.7) of this RA.

The criteria used in selecting the ECOCs from the contaminants detected during the field sampling and analytical phase of the investigation were:

- Prevalence
- Toxicity
- Comparison to background or naturally occurring levels
- Comparison to regional screening levels and other appropriate criteria
- Comparison to investigation-associated field and laboratory blank data

Each of these criteria is discussed in the following subsections.

7.1.4.1 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. Contaminants that were detected in 5 percent or fewer of the samples were not retained as ECOCs. The sample sets for Sites 9 and 19 were too small to use prevalence as selection criteria.

7.1.4.2 Toxicity

The potential toxicity of a contaminant is an important consideration when selecting ECOCs for further evaluation in the ecological RA. Several of the contaminants detected in the media at Sites 9 and 19 are prevalent. However, the inherent toxicity of some of the contaminants to ecological receptors is low; therefore, they were not retained as ECOCs. In addition, several of the contaminants have not been adequately studied to develop screening levels or accepted toxicological data does not exist with which to assess the contaminants. Contaminants that fell into this category were retained as ECOCs (if they were not eliminated based upon other criteria).

7.1.4.3 Comparison to Background Levels

Naturally occurring compounds common to the region were taken into consideration when selecting ECOCs. Analytical data collected from ecologically comparable background stations were used to eliminate contaminants from consideration as ECOCs. Background surface water, sediment, and biota were collected off-station in freshwater habitats similar to the study sites. Background surface soil data used in this assessment were collected at both Station-wide and site-specific (across all soil associations). The anthropogenic railroad data also were included in the calculation of surface soil

background concentrations. A contaminant was eliminated as an ECOC if the range of detection in Sites 9 and 19 media was within the range of detection in the background media.

7.1.4.4 Comparison to Screening Levels

The Biological Technical Assistance Group (BTAG) Screening Levels (BSLs) developed by USEPA Region III (1995a) were the primary source of surface soil, surface water, and sediment screening levels used in this ecological RA. Secondary soil screening levels were obtained from the Oak Ridge National Laboratory (ORNL) (Will and Suter, 1994a, b). ORNL has developed soil benchmark values that are used to evaluate potential ecological risks to terrestrial flora and fauna. These values, along with the BSLs, are referred to as Surface Soil Screening Levels (SSSLs) and are used as criteria for retaining surface soil ECOCs.

Secondary sources of screening levels for surface water were obtained from the Commonwealth of Virginia's Water Quality Standards for surface water (VSWCB, 1992) and the USEPA Ambient Water Quality Criteria (USEPA, 1992b). In addition, surface water screening levels for nitramine compounds were obtained from Bentley et al., (1977a, b) and Smock et al. (1976). These water quality screening levels will be referred to in this assessment as Surface Water Screening Levels (SWSLs).

Finally, secondary sources of screening levels for the sediment were obtained from: Long et al. (1995); Long and Morgan (1991); Apparent Effect Threshold (AET) values (TetraTech, 1986); and, the Wisconsin Department of Natural Resources interim guidance criteria for in-water disposal of dredged sediment (Sullivan et al., 1985). These sediment screening values will be referred to as Sediment Screening Levels (SSLs).

The SSSLs, SWSLs, and SSLs were used for comparative purposes to infer potential ecological risks. Contaminants that were detected at concentrations less than these screening levels were not retained as ECOCs since contaminants detected at concentrations less than these values were not expected to pose a significant risk to the ecological population.

A brief description of the reference values used in the ECOC selection is presented in Section 7.5 (Ecological Effects Characterization).

7.1.4.5 Comparison to Field and Laboratory Blank Data

In addition to the media samples, samples were collected for QA/QC analysis. These samples included field blanks, equipment rinsate blanks, and trip blanks. Common laboratory contaminants that were detected at concentrations of less than ten times the concentration in the blank sample or other constituents that were detected at concentrations of less than five times the concentration in a blank sample were not retained as ECOCs. Maximum concentrations of common laboratory contaminants detected in blanks are presented in Table 6-1.

7.1.5 **Selection of Ecological Contaminants of Concern**

In addition to the above-mentioned ECOC selection criteria, the physical and chemical characteristics of contaminants also were considered. The physical and chemical characteristics of contaminants may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioconcentration factors (BCFs), organic carbon partition coefficient (K_{oc}), octanol water partition coefficient (K_{ow}), plant transfer coefficients (B_v or B_r) and beef transfer coefficients (B_b). The physical and chemical characteristics of the selected ECOCs for Sites 9 and 19 are described in Appendix N.

The following sections present the selected ECOCs in each of the media using the selection criteria presented in Section 7.1.4. A summary of the ECOCs in each of the ecological media sampled at Sites 9 and 19 is presented in Table 7-1.

7.1.5.1 Site 9

Surface soil, surface water, and sediment collected at Site 9 were analyzed in this ecological RA. The following paragraphs present a discussion of the ECOCs selected in each of these media.

Surface Soil

SVOCs and inorganics were selected as surface soil ECOCs at Site 9. Table 7-2 summarizes the frequency and range of detections in surface soil and the selection criteria. Compounds that were

not retained as surface soil ECOs also are identified and the rationale for excluding them is presented in this table.

Surface Water

A pesticide, nitramines, and inorganic compounds were retained as surface water ECOs in the drainage way at Site 9. Table 7-3 presents the ECOs selected and the rationale for exclusion of the chemicals that were not retained.

Sediment

SVOCs, nitramines, and inorganic compounds were selected as ECOs in the sediment collected from the drainage way at Site 9. Frequency, range of positive detections, and selection criteria are summarized in Table 7-4. Compounds that were not retained as ECOs also are identified, and the rationale for excluding those that were not retained is presented.

7.1.5.2 Site 19

Only surface soil was collected from Site 19 during the Round Two investigation. One SVOC and several inorganic compounds were retained as surface soil ECOs at Site 19. Table 7-5 summarizes the frequency and range of detections in surface soil and selection criteria and identifies those contaminants that were retained for the ecological RA. A rationale for exclusion also is given for those chemicals that were not retained.

7.2 Ecological Receptor Characterization

Ecological receptors that may be potentially at risk from contaminants detected at Sites 9 and 19 were identified during the field investigation and a habitat evaluation (Baker, 1995b) and are discussed below. Specific details on the local ecology are presented in Section 1.25 of this report. Figure 1-11 shows the habitats present and their relationship to each other.

7.2.1 Site 9

Site 9 consists of a natural 600-foot drainage ditch east of Lee Pond and down slope of Site 19. During storm events, it appears that a great deal of water flows into the drainage way. Where the drain passes beneath the fence around Plant 1, debris in the fence indicates that water levels are several feet higher and several feet wider than the drainage channel.

Three different habitats are present in the vicinity of Site 9. The area around the buildings and along the fence line is open. Deciduous upland forest is present on the higher ground, although upland species are mixed with lowland species in the ecotones around the edges of the forested areas. Deciduous lowland forest is present along the drainage way itself.

Few species were noted in the open areas. Grasses are dominant in these areas and are kept closely mowed within the fence and roughly mowed outside of the fence. The mowed areas extend directly up to the forested areas without a shrub transition zone. Upland forest is present on the higher ground.

Birds, mammals, and amphibians were observed at Site 9. However, birds were not common, perhaps because overgrown fields and shrubby ecotones are not present and the wooded areas are relatively small. Signs of white-tailed deer, raccoon, opossum, fox, frogs, and peepers were observed at Site 9.

7.2.2 Site 19

Site 19 consists of a strip of soil beneath and around Building 10. Site 19 is connected to Site 9 via a concrete drainage channel. Three habitats are present at Site 19: open areas around the buildings and conveyor, a deciduous upland knoll, and an ecotone along the fence around buildings and the power line.

The open area is dominated by grass, which is kept closely mowed. The mowed grass extends up to the forested knoll and to the fence line. Woodchucks were observed in this open area. The upland knoll is dominated by deciduous trees with a sparsely vegetated forest floor. The ecotone at Site 19 appears to have been created when the area along the fence was cleared. Species in this area are

influenced by the upland forest. Limited avifauna was observed during the habitat evaluation of Site 19. Woodchucks, raccoons, and squirrels were observed at Site 19.

7.3 Exposure Pathways

A site-specific conceptual model diagrams the routes by which stressors might affect ecological components of the natural environment. It includes multiple exposure pathways that are considered during the ecological RA. Figure 7-1 presents the flowchart of potential exposure pathways and ecological receptors. For this risk assessment, the following pathways were initially considered: soil pathway, groundwater pathway, surface water pathway, sediment pathway, and air pathway.

To determine if ecological exposure via these pathways may occur in the absence of remedial actions, an analysis is conducted including the identification and characterization of the exposure pathways. The following four elements are examined to determine if a complete exposure pathway is present:

- A source and mechanism of chemical release
- An environmental transport medium
- A feasible receptor exposure route
- A receptor exposure point

The following sections discuss the potential exposure scenarios at Sites 9 and 19 including surface soil, groundwater, surface water, sediment, and air.

7.3.1 Surface Soil Exposure Pathway

Potential release sources to be considered in evaluating the soil pathway are surface or buried wastes and contaminated soil. Contaminated soil may be released via fugitive dust, leaching, and surface runoff. The potential routes to be considered for ecological exposure to the contaminated soil are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with the soil.

ECOCs were detected in the surface soil demonstrating a release from a source to the surface soil transport medium. Potential receptors that may be exposed to contaminants in surface soil at/or around the sites are deer, fox, raccoon, rabbits, birds, plants, and other terrestrial life.

Terrestrial receptors potentially are exposed to contaminants in the soil through ingestion, dermal contact, and/or direct uptake (for flora). The magnitude of the exposure depends on the feeding habits and the amount of time they reside at the contaminated soil area. In addition, terrestrial species may ingest organisms that have bioconcentrated contaminants from the soil. This exposure pathway is likely to occur at Sites 9 and 19 and will be retained for further analysis.

7.3.2 Groundwater Exposure Pathway

The potential release source to be considered in evaluating the groundwater pathway is contaminated soil. The release mechanism to be considered is leaching. The routes to be considered for ecological exposure to the contaminated groundwater are ingestion and dermal contact. Groundwater discharge to area surface water may represent a pathway for contaminant migration.

Subsurface biota (i.e., microorganisms) are the only ecological receptors expected to be directly exposed to groundwater. These biota will not be assessed in the ecological RA because current guidance does not provide sufficient information to evaluate risk. In addition, the groundwater to surface water exposure is accounted for in the surface water section of the ecological RA. Therefore, this exposure pathway will not be retained for further analysis.

7.3.3 Surface Water/Sediment Exposure Pathway

Potential release sources to be considered in evaluating the surface water pathway are contaminated surface soil and groundwater. The release mechanisms to be considered are groundwater seepage and surface runoff. The potential routes to be considered for ecological exposure to the contaminated surface water/sediment are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with the surface water on site or downgradient of the site.

ECOCs were detected in the surface water and sediment, demonstrating a release from a source to the surface water-sediment transport medium. Potential receptors that may be exposed to contaminants in surface water and sediment include invertebrates, fish, aquatic vegetation, reptiles, amphibians, birds, and mammals.

Aquatic receptors are exposed to contaminants in the surface water by ingesting water while feeding and by direct contact while feeding or swimming. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioconcentrated chemicals from the surface water and sediment. This exposure pathway is likely to occur at Sites 9 and 19 and is retained for further analysis.

Terrestrial faunal receptors potentially are exposed to contaminants in the surface water and sediment through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated water. In addition, terrestrial species may ingest organisms (i.e., fish, insects, plants) that have bioconcentrated contaminants from the surface water and sediment. These exposure pathways are likely to occur at Site 9. However, only the surface water exposure pathway will be retained for further analysis of terrestrial receptors, since sediment pathway sediment exposure criteria for terrestrial receptors have not been developed.

7.3.4 Air Exposure Pathway

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates and volatilization from surface soil, groundwater, and surface water. The potential exposure points for receptors are areas on or adjacent to the site. The air exposure pathway will not be evaluated in this ecological RA because current guidance does not provide sufficient information to evaluate risk.

7.4 Exposure Assessment

The exposure assessment evaluates the interaction of the stressor with the ecological environment. The Round Two RI involved collecting samples from five media; soil, groundwater, surface water, sediment, and biota.

Information on regional ecology of the coastal plain and the habitats present at Sites 9 and 19, as well as information on sensitive environments, wetlands, and endangered species is included in Section 1.0 of this report. The areas used as background stations include freshwater streams in Colonial National Historical Park and the headwaters to one tidal freshwater stream (Timberneck Creek, a tributary to the York River). It is noted that the background surface water, sediment, and biota stations used in this investigation are not ecologically similar to the Site 9 drainage way. The Site 9 drainage way is an intermittent water body. The amount of water present (if any) is dependent on the rain fall. However, the background stations, which are not intermittent, are similar to the Site 9 stations in that they are both freshwater streams with small channels and sandy substrate bottoms. Specific descriptions of the background areas can be found in the Summary of Background Constituent Concentrations and Characterization of the Biotic Community from the York River Drainage Basin, Naval Weapons Station, Yorktown, Virginia (Baker, 1995a).

Exposure of contaminants in the surface water and sediment to aquatic receptors was assumed to be equal to the contaminant concentration in the surface water and sediment. Exposure of contaminants in the surface soil to terrestrial flora and fauna was assumed to be equal to the contaminant concentration in the surface soil. It is noted in the uncertainty section (Section 7.8) of this ecological RA that all the contaminants in the surface water may not be bioavailable to the terrestrial flora and fauna. Exposure of contaminants in the surface water and surface soil to other terrestrial fauna (mammals, birds) was estimated using the total daily intake models presented in the next section of this ecological RA.

The following sections present the results of the ecosystem characterization including the surface water, sediment, and biological sampling, sampling site, and biotic community.

The biological samples collected at Site 9 consisted of benthic macroinvertebrates used to obtain population statistics and fish collected to verify the expected resident population present in the drainage way at Site 9.

Water quality measurements were collected during the sampling event prior to the surface water and sediment sample collection. These measurements consisted of temperature, pH, specific conductance, and dissolved oxygen. Table 7-6 and the Field Data Forms in Appendix F present the field chemistry results and characteristics of the sampling stations selected at Site 9. The station

locations (See Figure 4-8) and sampling procedures for collecting each of the environmental media are discussed in Section 2.0 of this report. The following subsections provide a description of the biotic community.

Due to the shallow and intermittent nature of the drainage way, only mosquito fish were collected with dip nets during the field investigation. The amount of water present in the drainage way is dependent on the season and the amount of rainfall. The drainage way is periodically dry or contains only pools of water. The fish stations sampled at Site 9 are presented on Figure 4-8. The fish community at Site 9 will be further characterized during the investigation of Lee Pond.

The aquatic species collected from Site 9 were compared to aquatic species collected at ecologically similar background stations (Baker, 1995a). Fish species collected from background stations are presented in Appendix O.

The benthic species collected at Site 9 were compared to benthic species collected in background freshwater stations. However, none of the background stations were intermittent streams as was the Site 9 drainage way. The background stations were similar to Site 9 stations in that they were small channeled streams located adjacent to roadways. Appendix O contains a list of all the benthic macroinvertebrate species collected per station and per replicate sample for Site 9 and background stations. Individual organisms were classified based on the specific genus or species classification, where possible. Appendix O also contains percent benthic species identified at each station.

Table 7-7 presents the freshwater benthic community identified in the drainage way at Site 9. The following phyla were identified in the drainage area: Arthropoda, Mollusca, and Annelida. The number of species collected at Site 9 stations ranged from five to twelve and the number of individuals collected ranged from 30 to 168. The majority of species collected were *Limnodrilus hoffmeisteri* and *Illoydrius templetoni*.

7.5 Ecological Effects Characterization

The ecological effects data that were used to assess potential risks to aquatic and/or terrestrial receptors in this ecological RA include the USEPA Region III BSLs for surface soil, surface water, and sediment. The terrestrial effects also were assessed by the use of available toxicity reference

values (TRVs). In addition to the BSLs used for screening ECOCs, various other criteria, reference values, and benchmark values also were utilized as SSSLs, SWSLs, and SSLs. The following paragraphs provide a brief description of the values used for ECOC selection and for overall risk characterization.

7.5.1 Surface Soil

Surface soil was evaluated in this ecological RA by the comparison of detected concentrations to established surface soil flora and fauna benchmark values for plants, earthworms, invertebrates, microorganisms, and microbial processes. In addition, surface soil was evaluated by the calculation of terrestrial TDI models. The following sections describe the use of the surface soil screening levels and TDI models to evaluate surface soil collected from Sites 9 and 19.

7.5.1.1 Comparison to Surface Soil Screening Levels and Literature Values

Toxicity values used for surface soil comparisons are benchmark values; therefore, these values represent a concentration at which no or low toxic effects are observed. It is noted that surface soil concentrations may exceed one or two benchmark values, but still support vigorous and diverse flora and fauna communities (Will and Suter, 1994a, b). Soil toxicity data cannot be used to evaluate potential risks to other terrestrial fauna (i.e., birds, deer, and rabbits) because the exposure doses for these species are different from the exposure doses for invertebrates and plants, which are in constant direct contact with the contaminants in the soil. In addition, the sensitivity of the organisms to the ECOCs may not be similar.

Site 9

At Site 9, SVOCs and several inorganic compounds exceeded SSSLs (see Table 7-2). In addition to the SSSLs used for ECOC screening, surface soil benchmark values for terrestrial flora and fauna also were used. The soil toxicity benchmark values for the ECOCs identified in the surface soil collected at Site 9 are provided on Table 7-8. Concentrations of SVOCs may be adversely impacting terrestrial flora and fauna as indicated by the exceedances of earthworm and invertebrate soil toxicity benchmark values. Surface soil concentrations of fluorene were detected below earthworm toxicity values. The highest numbers of toxicity value exceedances were from surface

soil concentrations of fluoranthene and pyrene. Butylbenzylphthalate, carbazole, and dibenzofuran were not evaluated because surface soil toxicity benchmark values are not available.

Surface soil concentrations of copper at Site 9 were detected below soil toxicity values, with the exception of the invertebrate toxicity value. However, the UCL concentration for copper was below this invertebrate toxicity value. The concentrations of iron detected in the surface soil at Site 9 were above all toxicity values. Lead concentrations were above plant toxicity values, but below earthworm, invertebrate, and microorganism values. In addition, the UCL calculated for lead was below all soil toxicity values. Soil concentrations of vanadium were detected above all soil toxicity values; however, the UCL for vanadium was calculated below the earthworm and invertebrate toxicity values.

Finally, the surface soil concentrations of zinc at Site 9 were above plant and microorganisms toxicity values, but below earthworm and invertebrate values. Also, the UCL for zinc was below the microorganisms value. The highest numbers of exceedances of the inorganic toxicity values were from concentrations of iron and vanadium.

Site 19

At Site 19, an SVOC and several inorganic compounds exceeded SSSLs (see Table 7-5). As depicted on Table 7-9, surface soil concentrations of phenanthrene, aluminum, and iron were above all soil toxicity benchmark values. Concentrations of mercury were detected below flora and fauna toxicity values; whereas, concentrations of copper and zinc were below all toxicity values, with the exception of the invertebrate value. Lead in the surface soil at Site 19 was detected below earthworm and microorganisms value, but above plant and invertebrate values. However, the UCL for lead was calculated below the invertebrate toxicity value.

7.5.1.2 Terrestrial Total Daily Intake Model

In addition to comparing soil concentrations to toxicity values for terrestrial invertebrates and plants, a terrestrial intake model was used to estimate the exposure of the ECOCs to terrestrial receptors (Scarano and Woltering, 1993). The following describes the procedures used to evaluate the

potential soil exposure to terrestrial fauna at Sites 9 and 19 by both direct and indirect exposure to ECOCs via soil, surface water, and foodchain transfer.

Based on the regional ecology and potential habitat at the site, the terrestrial indicator species used in this analysis are the white-tailed deer, cottontail rabbit, red fox, raccoon, and the bobwhite quail. The quail was used as a surrogate species for the pheasant that potentially inhabits Sites 9 and 19. The exposure points for these receptors are the surface soil, surface water, and prey items. The routes for terrestrial exposure to the ECOCs in the soil and water are drinking water and ingestion of incidental soil, vegetation (leafy plants, seeds, and berries), fish, and worms.

7.5.1.3 Derivation of Toxicity Reference Value

Total exposure of the terrestrial receptors to the ECOCs in the soil and surface water was determined by estimating the TDI dose and comparing this dose to TRVs representing acceptable daily doses in milligrams per kilogram per day (mg/kg/day). The TRVs were developed from no-observed-adverse-effect levels (NOAELs) or lowest-observed-adverse-effect levels (LOAELs) obtained from the Integrated Risk Information System (IRIS), Agency of Toxic Substances and Disease Registry Toxicological Profiles, mineral tolerance levels of domestic animals (Subcommittee on Mineral Toxicity in Animals, 1992), or other toxicological data available in the literature. Appendix P contains the methodology used in deriving the TRVs while Table 7-10 presents the TRV values for each of the surface soil and surface water ECOCs identified at Sites 9 and 19.

7.5.1.4 Calculation of Total Daily Intake

Total exposure of the terrestrial receptors to the ECOCs in the surface soil and surface water was determined by estimating the TDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. TDIs were estimated for the white-tailed deer, cottontail rabbit, quail, raccoon, and red fox at Sites 9 and 19. The estimated TDI dose for each model terrestrial receptor was determined using the equations presented in Appendix P.

Bioconcentration of the ECOCs to plants was calculated using the soil-to-plant transfer coefficient (B_v or B_r) for organics (Travis and Arms, 1988) and metals (Baes et al., 1984). The concentrations of the ECOCs in the soil (C_s) and surface water (I_w) used in the model were the 95% UCL or the

maximum concentration detected of each ECOC at Sites 9 and 19. The exposure parameters used in the TDI calculations are presented in Table 7-11.

7.5.2 Surface Water

Potential risks to aquatic receptors from contaminants detected in the surface water were evaluated by comparisons to SWSLs. USEPA Region III has compiled a list of SWSLs that are non-enforceable regulatory guidelines and are of primary utility in assessing the acute and chronic toxic effects in aquatic systems. SWSLs are provided for both freshwater and marine aquatic systems, and are reported as acute and/or chronic values (USEPA, 1995a). In addition, to the SWSLs, USEPA has promulgated Water Quality Standards (WQS) for states that have not developed their own standards. These WQS are based primarily on the USEPA Ambient Water Quality Criteria, with some of the values updated with more recent information. In addition, Virginia Water Quality Standards (Surface Water) also were used. These water quality standards are the concentrations of toxic substances that will not result in chronic and acute toxicity to aquatic life (VSWCB, 1992). Virginia WQS and USEPA criteria were used for contaminants that did not have BSLs. It is noted that an average hardness value detected in the surface water at Site 9 of 257 mg/L was used to calculate hardness dependent screening levels.

Site 9

Table 7-3 summarizes the SWSLs used to evaluate the surface water quality in the drainage way at Site 9. A pesticide, nitramines, and inorganic compounds were retained as ECOCs because they were above SWSLs and/or above background concentrations.

7.5.3 Sediment

Potential risks to aquatic receptors from contaminants detected in the sediment were evaluated by comparisons to SSLs and by comparison of benthic and fish communities to background locations. USEPA Region III has compiled a list of SSLs that are non-enforceable regulatory guidelines and are of primary utility in assessing toxic effects in aquatic systems. In addition, SSLs have been compiled for evaluating the potential for chemical contaminants in sediment to cause adverse biological effects (Long et al., 1995; Long and Morgan, 1991; and USEPA, 1995a). The lower ten

percentile (ER-L) and the median percentile (ER-M) of biological effects have been developed for various contaminants. The concentrations below the ER-L represent a minimal-effects range (adverse effects would be rarely observed). The concentration above the ER-L, but below the ER-M represents a possible-effects range (adverse effects would occasionally occur). Finally, the concentration above the ER-M represents a probable-effects range (adverse effects would probably occur) (Long et al., 1995). It is noted that the SSLs developed by the USEPA Region III are primarily ER-L values.

In addition to SSLs, AET sediment quality values have been developed for the Puget Sound (Tetra Tech, Inc., 1986). AETs are the concentrations of contaminants above which statistically significant biological effects always would be expected. Finally, the Wisconsin Department of Natural Resources has developed interim criteria for in-water disposal of dredged sediment (Sullivan et al., 1985). However, these criteria were established using background concentration data and were not based on toxicity data.

Site 9

Table 7-4 summarizes the SSLs used to evaluate the sediment quality in the drainage way at Site 9. SVOCs, nitramines, and inorganic compounds were retained as ECOCs because they were detected above SSLs and/or above background concentrations.

7.5.4 Biota Quality

The fish and benthic macroinvertebrate species collected at Site 9 were compared to fish and benthic macroinvertebrate species collected at background stations. A complete list of the biota collected at Site 9 and at the background stations is presented in Appendix O. Background stations were selected based on similar features with Site 9 stations, such as stream type and substrate. Substrate grain size analysis results for Site 9 sediment samples are summarized on Table 7-12.

Benthic macroinvertebrate and fish samples were collected from Site Stations 9BN08, 9BN09, and 9BN11. Benthic macroinvertebrate samples were not collected from Site Station 9BN10 because surface water was not present at this station. The benthic macroinvertebrate and fish samples

collected from the drainage way at Site 9 were compared to the following freshwater background samples: BGCPBN01, BGCPBN02, BGCPBN03, BGCPBN04, BGCPBN05, and BGTNBN06.

7.5.4.1 Fish Community

Due to the intermittent nature of the drainage way, the fish community at Site 9 was very limited. The surface water in the drainage way was present in pools interrupted by areas of mud. Mosquito fish were observed in several of the pools of water in the drainage way. It is noted that the fish community of Lee Pond (the downstream receptor of the drainage way) will be further assessed in future ecological investigations scheduled at WPNSTA Yorktown.

7.5.4.2 Benthic Macroinvertebrate Community

As displayed on Table 7-13, the number of taxa identified at two of the site stations was below background numbers. However, the number of taxa at one site station (9BN11) was within the range of taxa identified at background stations. The average number of taxa identified at Site 9 was below the average number of taxa identified in the freshwater background stations. The number of individuals and the densities calculated were within background values. However, the average calculations for the number of individuals and density were below the averages calculated for the background stations. At Site 9 stations, the species diversity indices (Brillioun's and Shannon-Wiener) were calculated higher than the background stations species diversities. Figure 7-2 presents the benthic station locations in addition to the densities, diversities, and MBI calculated for each station.

The MBI was used at the freshwater stations as a water quality indicator. The MBI values calculated for Site 9 stations ranged from 8.29 to 9.06 indicating poor water quality. The MBI in the background stations ranged from 4.33 (excellent) to 7.64 (fair). The average MBI for Site 9 stations indicates poor water quality; whereas, the average MBI for background stations indicates fair water quality. The tolerance values for the species collected at Site 9 are presented in Appendix O.

Community similarities were calculated for Site 9 stations compared to background freshwater stations. As displayed on Table 7-14, the samples collected from Site 9 were not similar to the samples collected from the background stations. The benthic community at the Site 9 stations

demonstrated a greater similarity among the other site stations than with background stations. The highest S_j values compared to background was calculated between 9BN08 and BGCPBN01. The S_s values were calculated highest compared to background between 9BN11 compared to BGCPBN03 and BGTNBN06.

7.6 Risk Characterization

The risk characterization is the final phase of an ecological RA. In risk characterization, the likelihood of adverse effects occurring as a result of exposure to a stressor is evaluated. This section evaluates the potential adverse effects on the ecological receptors at Sites 9 and 19 from contaminants identified at the sites. Quotient index (QI) ratios have been calculated for the surface soil, surface water, and sediment. These ratios are presented in the following subsections. A ratio greater than one indicates a potential risk, greater than ten indicates a moderately high potential risk, and above one hundred indicates an extreme risk to terrestrial or aquatic life (USEPA, 1994b).

7.6.1 Surface Soil

The QI approach was used to characterize the risk to terrestrial receptors by comparing the TDIs for each ECOC to the TRVs. The QI is calculated as follows:

$$QI = \frac{TDI}{TRV}$$

Where:

QI	=	Quotient Index
TDI	=	Total Daily Intake, mg/kg/day
TRV	=	Toxicity Reference Value, mg/kg/day

A QI of greater than one is considered to be indicative of potential risk. Such values do not necessarily indicate that an effect will occur but only that a lower threshold has been exceeded and that effects may occur. All ECOCs with terrestrial QIs greater than one are evaluated to determine if they are actually site-related. The risks characterized above provide insight into general effects upon animals in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

7.6.1.1 Site 9

Table 7-15 contains the terrestrial receptor QIs for the surface soil and surface water ECOCs at Site 9. The QIs calculated for the white-tailed deer and the bobwhite quail were below one, indicating that there is no risk to these species posed from the surface soil and surface water. A QI between one and ten was calculated for the red fox (5.59) and the cottontail rabbit (5.17), indicating that the ECOCs detected in the surface soil and surface water at Site 9 pose a potential for ecological effects to the fox and rabbit. The risk to the fox is driven by 2,4,6-trinitrotoluene and the risk to the rabbit is driven by 2,4,6-trinitrotoluene and vanadium.

The QI to the raccoon (233) was calculated greater than one hundred, indicating an extreme risk may be expected to the raccoon. The risk to the raccoon is driven by the pesticide, heptachlor epoxide. The calculations for Site 9 terrestrial models are presented in Appendix P.

7.6.1.2 Site 19

Table 7-16 contains the terrestrial receptor QIs for the surface soil ECOCs at Site 19. Surface water was not included in the calculation of the terrestrial receptor QIs because there is no surface water associated with this site. The QIs calculated for the white-tailed deer and the red fox were below one, indicating that there is no risk to these species posed from the surface soil. A QI between one and ten was calculated for the bobwhite quail (6.55), indicating that the ECOCs detected in the surface soil at Site 19 pose a potential for ecological effects to the quail. The risk to the quail is driven by aluminum.

The QIs for the raccoon (18.80) and the cottontail rabbit (12.00) were calculated between ten and one hundred, indicating a moderately high potential that greater exposures could result in adverse effects to the raccoon and rabbit. The risk to the raccoon is driven by aluminum and the risk to the rabbit is driven by aluminum, iron, and zinc. The calculations for Site 19 terrestrial models are presented in Appendix P.

7.6.2 Surface Water

The surface water collected in the drainage way at Site 9 was compared to SWSLs. Quotient index ratios were calculated for each station that exceeded screening levels. In addition, cumulative QIs using the average detected concentration for each surface water ECOC were calculated. It is noted that the UCL value could not be used in the cumulative QI calculation because of the small number of surface water samples collected. QI ratios for the SWSLs were calculated for each ECOC at Site 9.

$$QI = \frac{\text{Concentration in Sample / Average Concentration}}{SWSL}$$

Where:

QI = Quotient Index

SWSL = Surface Water Screening Level, $\mu\text{g/L}$

Site 9

As displayed on Table 7-17, surface water QIs calculated for Site 9 were greater than ten (indicating a moderately high potential for risk) for chronic heptachlor epoxide and greater than one, but less than ten (indicating a potential risk) for chronic 2,4,6-trinitrotoluene, acute and chronic cyanide, chronic iron, and chronic manganese. Table 7-18 represents overall ecological QI risk posed to the aquatic environment at Site 9. The overall surface water risk was calculated with average detected concentrations. The average QI values were greater than ten (indicating moderately high potential for risk) for chronic heptachlor epoxide and chronic amino-DNTs and between one and ten (indicating potential risk) for chronic 2,4,6-trinitrotoluene, acute and chronic cyanide, chronic iron, and chronic manganese. Based on the average concentrations, the surface water in the drainage way at Site 9 potentially is posing a risk to the aquatic environment. Cumulative QIs calculated for the surface water were 3.02 for acute and 54.81 for chronic.

7.6.3 Sediment

The sediment collected from the drainage way at Site 9 was compared to SSLs. A QI ratio of the detected values at each sampling station and the BSLs/ER-Ls, ER-Ms, or AETs was calculated for each ECOC at Site 9 that exceeded SSLs. In addition, cumulative QIs were calculated for each

ECOC in the sediment using the UCL concentrations. A QI greater than one for the ER-Ls indicates a possibility for adverse effects to aquatic life (Long, et al., 1995). A QI greater than one for the ER-Ms indicates a probable adverse effect to aquatic life (Long et al., 1995). The formula presented below was used to calculate the QI ratios.

$$QI = \frac{\text{Concentration in Sample}/95\% \text{ UCL}}{SSL}$$

Where:

QI = Quotient Index

UCL = Upper Confidence Limit

SSL = Sediment Screening Level, $\mu\text{g}/\text{kg}$ (organics) and mg/kg (inorganics)

Site 9

Table 7-19 presents QI ratios of the detected sediment ECOCs at each sampling station within the drainage way at Site 9 and Table 7-20 presents QI ratios using UCL values to calculate a cumulative sediment risk. Of the organic ECOCs, QI ER-L ratios calculated per station exceeded ten for acenaphthene, fluorene, phenanthrene, and 2,4,6-trinitrotoluene. In addition, the butylbenzylphthalate QI for the ER-M was greater than ten. QIs for the ER-Ms were calculated between one and three for benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. The ER-L QIs for the UCL values were calculated greater than ten for acenaphthene and fluorene. ER-M QIs for the UCL values for butylbenzylphthalate, indeno(1,2,3-cd)pyrene, and phenanthrene were calculated above one.

Of the inorganics, the ER-L QI for arsenic and the ER-M QI for iron were between one and ten. The QIs calculated with UCL concentrations were also greater than one for arsenic and iron. A QI for vanadium detected in the sediment was not calculated because SSLs are not available. The sediment in the drainage way at Site 9 may adversely impact the aquatic environment as indicated by a cumulative ER-L QI for the site of 79.19 (indicating a significant potential for risk) and an ER-M value of 15.36 (indicating a significant potential for risk).

7.6.4 Threatened and/or Endangered Species

The Commonwealth of Virginia prepared a Natural Heritage Resources Inventory for WPNSTA Yorktown in March 1992 (Buhlman and Ludwig, 1992). During this inventory, threatened, and endangered species and sensitive environments on the Station were identified. None of these species or environments were identified in the vicinity of Sites 9 and 19.

7.6.5 Wetlands

Site-specific wetland delineations were not conducted at Sites 9 and 19, although potential wetland areas were noted during the habitat evaluation. These wetlands were verified in the National Wetland Inventory maps. The wetland map for Sites 9 and 19 is presented on Figure 1-11.

Adverse impacts to the wetlands at Sites 9 and 19 may potentially occur as a result of the contaminants detected in the surface soil, surface water, and sediment samples collected within the wetland areas at Sites 9 and 19.

7.6.6 Other Sensitive Environments

Sensitive environments were evaluated as part of the Natural Heritage Resources Inventory at WPNSTA. Although sensitive environments were identified in the Kings Creek portion of the Station, they are not close enough to Sites 9 and 19 to be affected by site contaminants.

7.7 Risk Assessment

This section summarizes the overall risks to the natural environment at Sites 9 and 19. This information, to be used in conjunction with the human health RA, supports the evaluation of remedial action(s) for the site that are protective of human health and the environment.

7.7.1 Aquatic Assessment Endpoint

The first aquatic assessment endpoint for the drainage way at Site 9 is differences (compared to background) in the structure of benthic macroinvertebrate communities at Site 9 attributable to site-

related contaminants. Measurement endpoints for the assessment endpoint include lower species diversity and richness of the benthic community when compared to background locations and the dominance of contaminant-tolerant species over contaminant-intolerant species as calculated by the MBI.

The second aquatic endpoint for this ecological RA is the reduction of an aquatic receptor population or subpopulation that is attributable to contaminants from the site. Measurement endpoints for the second aquatic assessment endpoint include exceedances of contaminant-specific surface water and sediment effect concentrations and the presence of gross external fish pathologies.

The number of taxa and species richness calculated for the stations at Site 9 were lower than background values, with the exception of the number of taxa identified at Station 9BN11. The species densities at the Site 9 stations were within the range of background values. The diversities at Site 9 were higher than background diversities. However, the MBI calculated for Site 9 stations was indicative of poor water quality and the background MBI was indicative of fair to excellent water quality.

It is noted that the drainage way at Site 9 is not expected to be supportive of a vigorous population of equilibrium species of benthic macroinvertebrates. The intermittent nature of the drainage way is not a desirable habitat for most benthic species other than opportunistic species. Therefore, the number of taxa, the specie richness, and the MBI may be affected by the nature of the water body and not solely a result of site-related contamination.

Surface water concentrations of heptachlor epoxide, amino-DNTS, 2,4,6-trinitrotoluene, cyanide, iron, and manganese are potentially adversely impacting the aquatic environment in the drainage way at Site 9. Heptachlor epoxide was detected at a high concentration at one station (9SW08) in the drainage way adjacent to Building 10. This area was grassy with very little surface water. The heptachlor epoxide is probably a remnant of base-wide pesticide control and is not site-related.

The concentrations of 2,4,6-trinitrotoluene detected in the surface water in the drainage way at Site 9 were higher during the Round Two investigation than during the Round One investigation, indicating that surface soil runoff may be continually contaminating the surface water in the drainage way. The highest concentrations of the nitramines were detected at the same sampling

station in both the Round One and Round Two investigations at 9SW08. Dinitrotoluene and 2,4,6-trinitrotoluene released to surface water will most likely degrade by photolysis when exposed to sunlight. The half-life for 2,4,6-trinitrotoluene in surface water is a half hour to several hours in the presence of sunlight (Talmage, 1996).

Of the inorganics detected in the surface water at Site 9, iron was detected at higher concentrations during the Round One investigation than the Round Two investigation. In addition, the highest iron concentrations were detected in both the Round One and the Round Two investigations in the surface water adjacent to Building 10 (9SW08). Manganese concentrations were detected higher during the Round Two investigation than during the Round One investigation. It is noted that cyanide was not analyzed during the Round One investigation and was only detected in the Round Two investigation in the surface water at Station 9SW08.

Sediment concentrations of acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, butylbenzylphthalate, carbazole, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, nitramines, arsenic, iron, and vanadium may be adversely impacting sediment receptors in the drainage way based on exceedances of background and ER-L values. The majority of the high concentrations of SVOCs detected during the Round Two investigation were detected in the shallow sediment collected from the drainage way adjacent to Building 10 (9SD08) and in the deep sediment collected in the drainage way across the roadway from Building 10 (9SD09). High SVOCs also were detected in these two sample locations during the Round One investigation. SVOC concentrations compared to Round One data are higher in the Round Two investigation for sample 9SD08 and lower in the Round Two investigation for the sample 9SD09. Therefore, it appears that the SVOC concentrations are attenuating in the sediment in the drainage way across the road from Building 10; whereas, the sediment collected from drainage way adjacent to Building 10 appears to be continually affected by a source of contamination.

Concentrations of nitramines (amino-DNTs, 2,4-dinitrotoluene, and 2,4,6-trinitrotoluene) were detected in the sediment collected during the Round Two investigation. The highest concentrations of nitramines were detected in the deep sample at Station 9SD09. It is noted that nitramines have not been detected in sediment collected in the drainage way during any other previous investigations, indicating a recent source of nitramine contamination to the sediment is present.

The highest inorganic concentrations of arsenic and vanadium were detected at 9SD08. Arsenic concentrations were detected at higher concentrations during the Round Two investigation than during the Round One investigation. The concentrations of iron detected in the sediment during the Round Two investigation were within the range of Round One detections. Finally, vanadium was detected at higher concentrations during the Round One investigation than during the Round Two investigation.

7.7.2 Terrestrial Assessment Endpoint

The assessment endpoint selected for the terrestrial portion of this ecological RA was the reduction of a receptor population or subpopulation attributable to site-related contaminants. Two measurement endpoints were used to evaluate this assessment endpoint: exceedances of soil-effect concentrations and exceedances of contaminant-specific effect doses. Contaminant-specific effect doses were evaluated via TDI models.

7.7.2.1 Site 9

SVOCs and several inorganic compounds were retained as a terrestrial ECOCs at Site 9. Based on a comparison to literature toxicity values, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, dibenzofuran, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, copper, iron, lead, vanadium, and zinc are potentially adversely impacting terrestrial flora and fauna.

In addition to a qualitative literature comparison, potential adverse impacts to the terrestrial environment also are demonstrated in the terrestrial models. A QI between one and ten was calculated for the red fox (5.59) and the cottontail rabbit (5.17), indicating the surface soil at Site 9 poses a small potential risk to the fox and rabbit. The risks are driven by 2,4,6-trinitrotoluene and vanadium. Surface soil concentrations of vanadium are detected above flora and fauna toxicity values and are driving a risk in terrestrial models. Vanadium is a surface soil ECOC, but not a concern in the surface water. The nitramine 2,4,6-trinitrotoluene is a site-related contaminant;

however, it is noted that 2,4,6-trinitrotoluene is not a contaminant of concern in the surface soil. 2,4,6-trinitrotoluene was included in the terrestrial models because it is a surface water ECOC.

A QI of greater than one hundred was calculated for the raccoon (233) at Site 9, indicating an extreme risk may be expected to the raccoon. The risk to the raccoon model is driven by non-site-related heptachlor epoxide detected in one surface water sample and several surface soil samples. It is noted that heptachlor epoxide was not retained as a surface soil ECOC at Site 9 because the surface soil concentrations were detected below SSSLs.

7.7.2.2 Site 19

An SVOC and several inorganic compounds were retained as a terrestrial ECOCs at Site 19. Based on a comparison to literature toxicity values, phenanthrene, aluminum, copper, iron, lead, and zinc are potentially adversely impacting terrestrial flora and fauna. However, background concentrations of aluminum, copper, and iron also exceeded flora and fauna toxicity values.

In addition to a qualitative literature comparison, potential adverse impacts to the terrestrial environment also are demonstrated in the terrestrial models. A QI between one and ten was calculated for the bobwhite quail (6.55), indicating the surface soil at this site poses a small potential risk to the quail. The risk is driven by aluminum. However, aluminum also contributes to the risk to the quail model using background concentrations.

QIs between ten and one hundred were calculated for the raccoon (18.80) and the cottontail rabbit (12.00), indicating a moderate potential that greater exposures could result in adverse effects to the raccoon and the rabbit. The risk to the raccoon is driven by aluminum and the risk to the rabbit is driven by aluminum, iron, and zinc. The inorganic concentrations driving the terrestrial models also exceed the flora and fauna toxicity values. The inorganic concentrations may be site-related. However, risks were demonstrated in the raccoon and rabbit models as a result of background surface soil concentrations of aluminum.

7.8 Uncertainty

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The following discusses the uncertainty in this ecological

RA associated with the sampling methods, benthic macroinvertebrate interpretation, in use of background screening levels, assessment of nitramine effects on the environment, and terrestrial models.

7.8.1 Sampling Method

The Round Two ecological investigation consisted of one sampling effort. The results of this sampling only will provide a "snapshot in time" of the ecological environment. Because the biotic community can have a high amount of natural variability, the "snapshot in time" may not be an accurate representation of actual site conditions.

There is uncertainty in the sampling methods used to collect the benthic macroinvertebrates. A petite Ponar bottom grab sampler was used to collect these samples. The effectiveness of the Ponar depends upon the sediment type. The Ponar is less effective in hard, rocky sediment, or sediment containing organic debris that may prevent the Ponar from completely closing, than in soft mucky sediment. Because the sediment types varied among the stations, the effectiveness of the Ponar also would have varied.

7.8.2 Benthic Macroinvertebrate Interpretation

There is uncertainty in the interpretation of benthic macroinvertebrate data in attributing differences in species density, diversity, and similarities between stations and specific hazards. These differences may be the result of natural causes or qualities of the natural environment, such as stream velocity and sediment type.

The use of the MBI as a benthic index also has uncertainty associated with it. The MBI is based on benthic tolerance values developed by the NCDEHNR and the USEPA; therefore, the TVs used in this ecological RA to calculate the MBI were not specific values for the Commonwealth of Virginia. In addition, this ecological RA and the various studies establishing the TVs for benthics do not take into account influences from the aquatic environment (e.g. stream velocity) on tolerance levels.

7.8.3 The Use of Background Concentrations

There is uncertainty involved with the use of background data in the ecological RA. Surface soil, surface water, sediment, and biota samples from ecologically similar background areas were collected within the York River Basin to qualitatively assess contaminant concentrations detected at WPNSTA. Background areas were selected to be representative of regional conditions. Consideration was taken in the selection of background areas to select areas that appeared to be relatively unimpacted by surrounding land use. However, it is unrealistic to achieve background levels in the York River Basin that are completely uninfluenced by anthropogenic conditions. Therefore, background areas represent both the natural regional conditions, as well as any baseline anthropogenic conditions in the area.

The range of background detections was used in the selection of ECOCs which adds uncertainty to the risk. The use of the range for contaminant retention or elimination as an ECOC does not take into account the statistical distribution of the detected contaminants. Therefore, contaminants potentially may be incorrectly eliminated or retained. However, it is noted that this method of ECOC selection tends to be biased on the conservative side, retaining contaminants that statistically may be similar to background concentration detections.

7.8.4 Screening Levels

Potential adverse impacts to terrestrial flora and fauna were evaluated by comparing the ECOC concentrations to surface soil benchmark values obtained in the literature. There is uncertainty assessing the terrestrial environment using these benchmark values. Most of these studies do not take into account the soil type, which may have a great influence on the toxicity of the contaminants. For example, soil with high organic carbon content will tend to absorb many of the organic ECOCs, thus making them less bioavailable to terrestrial receptors. Also, various inorganic compounds in surface soil tend to have high degrees of variability. The variability of the inorganic concentrations in surface soil in turn magnifies the uncertainty associated with using the literature toxicity values to assess the risk posed to the terrestrial environment.

The benchmark values are based on both field and growth chamber studies; therefore, the reported toxic concentrations are not always equivalent to actual field conditions. In addition, the majority

of the benchmark values used for comparison purposes had low levels of confidence assigned to the values based on the low number of studies performed (less than ten studies) and the lack of diversity of species tested.

There is uncertainty in the ecological endpoint comparison. The surface water screening levels are established to be protective of a majority of the potential receptors. However, there will be some species not protected by the values because of their increased sensitivity to the chemicals. For example, the Ambient Water Quality Criteria developed by the USEPA in theory only protect 95 percent of the exposed species. Therefore, there may be some sensitive species present that may not be protected by the use of these criteria. In addition, most of the values are established using laboratory tests, where the concentrations of certain water quality parameters (pH, total organic carbon) that may influence toxicity are most likely at different concentrations than in the site water.

Potential adverse impacts to aquatic receptors from contaminants in the sediment were evaluated by comparing the ECOC concentration in the sediment to sediment screening levels. These SSLs have more uncertainty associated with them than do the SWSLs, since the procedures for developing them are not as established as those used in developing SWSLs. In addition, sediment type (pH, acid volatile sulfide, total organic carbon) has a significant impact on the bioavailability and toxicity of contaminants. The SSLs were developed using data obtained from freshwater, estuarine, and marine environments. Therefore, their applicability for use to evaluate potential effects to aquatic organisms from contaminants in freshwater habitats introduces uncertainty because of differences in both the toxicity of individual contaminants to freshwater and saltwater organisms, and the bioavailability of contaminants in the two aquatic systems.

The toxicity of chemical mixtures is not well understood. All the toxicity information used in the ecological RA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals due to synergistic or antagonistic effects. In addition, the species that were used to develop the toxicity data may not be present at the site, or have the potential to exist at the site. Depending on the sensitivity of the tested species to the species at the site, use of the toxicity values may overestimate or underestimate risk.

In addition, there is uncertainty associated with the detection limits used for the parameters tested in the RI. Some of the screening levels used for analytical constituents in the ecological RA were lower than the associated detection limit. Therefore, there is uncertainty in the ECOC selection process. Non-detected chemicals may actually be impacting the ecological environment. For this ecological RA, chemicals with at least one positive detection and with detection limits above the screening levels were incorporated into the QI calculation by using half of the detection limit.

7.8.5 Assessment of Nitramines in the Environment

There is uncertainty associated with the assessment of nitramines in the ecological environment. Because of the lack of sediment screening levels, not all of the nitramines detected have been calculated into the total site QI. Therefore, the risk presented in the sediment may be biased low.

7.8.6 Terrestrial Models

There are some differences of opinion found in the literature as to the effectiveness of using models to predict concentrations of contaminants found in terrestrial species. According to one source, the food chain models currently used incorporate simplistic assumptions that may not represent conditions at the site, bioavailability of contaminants, or site-specific behavior of the receptors. Simple food chain models can provide an effective means of initial characterization of risk; however, residue analyses, toxicity tests, and the use of biomarkers provide a better approach for assessing exposure (Menzie et al., 1993). In addition, there is uncertainty in the terrestrial models because sediment concentrations have not been incorporated into the models. In particular, the raccoon model may underestimate the actual risk to the species from ingestion and dermal contact with contaminated sediments. However, the current USEPA terrestrial uptake models are not designed to incorporate sediment concentrations.

There is uncertainty in the total daily intake models used to evaluate a reduction of receptor populations or sub-populations. Many of the input parameters are based on default values (i.e., ingestion rates) that may or may not adequately represent the actual values of the parameters. In addition, there is uncertainty in the level to which the indicator species will represent other species potentially exposed to ECOCs at the site. Finally, terrestrial species also will be exposed to contaminants by ingesting fauna that have accumulated contaminants. The modeling

biomagnification within a food web compounds the uncertainty associated with a single species model.

7.9 Interpretation

Overall, there is a potential for risk to occur to the aquatic environment in the drainage way at Site 9. In addition, terrestrial risks are demonstrated at both Sites 9 and 19, with Site 9 posing a greater risk to terrestrial receptors. The following subsections provide conclusions to the ecological RA for Sites 9 and 19.

7.9.1 Site 9

Both an aquatic and a terrestrial endpoint were addressed at Site 9. The following subsections provide an overview of any potential risk to the ecological environment identified at Site 9 during this assessment. Risks to the aquatic environment at Site 9 are demonstrated by the cumulative QI ratios calculated for both surface water and sediment greater than one. In addition, risks to the terrestrial environment are demonstrated by exceedances of soil toxicity values and risk exhibited in terrestrial TDI models.

7.9.1.1 Aquatic Ecosystem

Surface water concentrations of heptachlor epoxide, amino-DNTs, 2,6-dinitrotoluene, HMX, 1,3,5-trinitrobenzene, 2,4,6-trinitrotoluene, cyanide, iron, and manganese potentially adversely impact the aquatic environment in the drainage way at Site 9. Note, that the highest concentrations of heptachlor epoxide, nitramines, and cyanide were detected at Station 9SW08.

Cumulative QI ratios were calculated for the surface water at 3.02 for acute and 54.81 for chronic. The heptachlor epoxide detected in one surface water sample is most likely the result of base-wide pesticide control and not a site-related contaminant. Amino-DNTs were detected in every surface water sample collected at the site. These nitramines are a breakdown products of site-related 2,4,6-trinitrotoluene.

The benthic community in the drainage way may be adversely impacted by the contaminants detected in the sediment. The sediment contained elevated levels of PAHs, amino-DNTs, 2,4-dinitrotoluene, 2,4,6-trinitrotoluene, arsenic, and iron. The highest concentrations of SVOCs and inorganics were detected at Station 9SD08 and the highest concentrations of nitramines were detected in the deep sediment sample collected from Station 9SD09.

The risk to the aquatic community posed by the sediment is demonstrated by high cumulative QI values (78.04 for the ER-L and 16.51 for the ER-M). The concentrations detected in the sediment may be site-related contaminants. PAH concentrations in surface soil have been detected above soil screening levels in the vicinity of Site 9 and surface water concentrations also have exceeded surface water screening levels. The PAH exceedances of surface soil and surface water screening levels indicates that surface runoff may be contributing to the PAH concentrations detected in the sediment. It is noted that the nitramines detected in the sediment during this investigation (Round Two) have not been detected in any previous investigations in the drainage way, indicating that the surface water concentrations of nitramines are beginning to influence the quality of the sediment.

7.9.1.2 Terrestrial Ecosystem

Based on the data collected during the Round Two investigation and TDI modeling, there appears to be a potential risk to terrestrial receptors at Site 9. Soil flora and fauna toxicity values were exceeded for PAHs, copper, lead, vanadium, and zinc.

Risks to the terrestrial receptors are driven by heptachlor epoxide, 2,4,6-trinitrotoluene, and vanadium. It is noted that the heptachlor epoxide drives the risk in one model (raccoon). Because heptachlor epoxide is not a site-related contaminant, the removal of this concentration removes the risk to the raccoon. In addition, vanadium drives risk to the background rabbit. Therefore, concentrations of 2,4,6-trinitrotoluene are most likely the site-related contaminants contributing to terrestrial risk at Site 9. It is noted that heptachlor epoxide and 2,4,6-trinitrotoluene were not retained as soil ECOCs; however, due to the surface water contamination, these constituents were included in the models.

In conclusion, site-related contaminants of PAHs, nitramines, and inorganics are impacting the terrestrial environment at Site 9.

7.9.2 Site 19

Only the terrestrial ecosystem was assessed at Site 19. Overall, risk to the terrestrial environment is demonstrated by exceedances of soil toxicity values and risks demonstrated in the terrestrial TDI models. Concentrations of phenanthrene, aluminum, copper, iron, lead, and zinc exceeded surface soil toxicity values.

Terrestrial models demonstrated risks driven by aluminum, iron, and zinc. These inorganics driving the terrestrial model risk also exceed surface soil toxicity values. Aluminum poses only a moderate potential for risk to terrestrial ecological receptors including the raccoon and rabbit.

In conclusion, phenanthrene and inorganic compounds potentially are site-related contaminants that pose a slight potential to impact the terrestrial environment at Site 19.

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SECTION 7.0 TABLES

TABLE 7-1

**ECOLOGICAL CONTAMINANTS OF CONCERN PER MEDIA
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Analyte	Site 9			Site 19
	Surface Soil	Surface Water	Sediment	Surface Soil
Semivolatiles				
Acenaphthene	X		X	
Acenaphthylene			X	
Anthracene	X		X	
Benzo(a)anthracene	X		X	
Benzo(a)pyrene	X		X	
Benzo(b)fluoranthene	X			
Benzo(g,h,i)perylene	X		X	
Benzo(k)fluoranthene	X			
Butylbenzylphthalate	X		X	
Carbazole	X		X	
Chrysene	X		X	
Dibenz(a,h)anthracene	X		X	
Dibenzofuran	X			
Fluoranthene	X		X	
Fluorene	X		X	
Indeno(1,2,3-cd)pyrene	X		X	
Phenanthrene	X		X	X
Pyrene	X		X	
Pesticides/PCBs				
Heptachlor Epoxide		X		
Nitramines				
amino-Dinitrotoluene		X	X	
2,4-Dinitrotoluene			X	
2,4,6-Trinitrotoluene		X	X	
Inorganics				
Aluminum				X
Arsenic			X	
Copper	X			X
Cyanide, total		X		

TABLE 7-1 (Continued)

ECOLOGICAL CONTAMINANTS OF CONCERN PER MEDIA
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Analyte	Site 9			Site 19
	Surface Soil	Surface Water	Sediment	Surface Soil
Iron	X	X	X	X
Lead	X			X
Manganese		X		
Mercury				X
Vanadium	X		X	
Zinc	X			X

TABLE 7-2

FREQUENCY AND RANGE OF DETECTION COMPARED TO SURFACE SOIL SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Station-wide, Anthropogenic, and Site-Specific Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detects				
Semivolatile Organics (µg/kg)							
Acenaphthene	100	2/10	69J - 120J	1	ND	YES	
Acenaphthylene	100	1/10	58J	0	ND	NO	Below SSSL
Anthracene	100	4/10	58J - 310J	2	ND	YES	
Benzo(a)anthracene	100	7/10	87J - 1,100	6	44J - 240J	YES	
Benzo(a)pyrene	100	7/10	94J - 1,200	6	46J - 180J	YES	
Benzo(b)fluoranthene	100	9/10	58J - 2,200	7	66J - 500	YES	
Benzo(g,h,i)perylene	100	7/10	74J - 770	5	43J	YES	
Benzo(k)fluoranthene	100	7/10	77J - 520	5	120J - 130J	YES	
Bis(2-ethylhexyl)phthalate	NE	5/10	48J - 200	NA	ND	NO	Lab. Contaminant
Butylbenzylphthalate	NE	4/10	55 - 310	NA	ND	YES	
Carbazole	NE	4/10	47J - 250J	NA	ND	YES	
Chrysene	100	9/10	43J - 1,200	7	57J - 270J	YES	
Di-n-butylphthalate	200,000 ⁽¹⁾	10/10	210J - 1,600	0	810	NO	Below SSSL/ Lab. Contaminant
Dibenz(a,h)anthracene	100	4/10	55J - 160J	2	ND	YES	

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO SURFACE SOIL SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Station-wide, Anthropogenic, and Site-Specific Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Dibenzofuran	NE	2/10	49J - 77J	NA	ND	YES	
Dimethylphthalate	200,000 ⁽¹⁾	1/10	870	0	ND	NO	Below SSSL
Fluorene	100	2/10	75J - 120J	1	ND	YES	
Fluoranthene	100	9/10	65J - 2,200	8	91J - 430	YES	
Indeno(1,2,3-cd)pyrene	100	7/10	74J - 550	5	50J - 160J	YES	
Phenanthrene	100	8/10	76J - 1,600	6	42J	YES	
Pyrene	100	10/10	35J - 2,000	8	86J - 320J	YES	
Pesticides/PCBs(µg/kg)							
4,4'-DDE	<100	3/10	2J - 5.1	0	ND	NO	Below SSSL
4,4'-DDT	<100	3/10	2.8J - 5.6J	0	ND	NO	Below SSSL
Heptachlor Epoxide	<100	3/10	1.6J - 3.7J	0	ND	NO	Below SSSL

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO SURFACE SOIL SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Station-wide, Anthropogenic, and Site-Specific Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Nitramines (µg/kg) amino-Dinitrotoluene	80,000 ⁽²⁾	3/10	210 - 1,500	0	1,300J	NO	Below SSSL
2,4,6-Trinitrotoluene	30,000 ⁽³⁾	5/10	210 - 540	0	ND	NO	Below SSSL
Inorganics (mg/kg) Aluminum	1	10/10	3,160 - 7,750	10	1,960 - 24,100	NO	Background
Arsenic	328	10/10	1.1 - 23.3K	0	0.46L - 63.9	NO	Below SSSL/ Background
Barium	440	10/10	19 - 45.6	0	4.2J - 80.2	NO	Below SSSL/ Background
Beryllium	0.02	2/10	0.38 - 0.47	2	0.23J - 0.93J	NO	Background
Cadmium	2.5	5/10	0.81K - 1.8K	0	1.2J - 1.5	NO	Below SSSL
Calcium	NE	10/10	216 - 4,430	NA	39.4J - 7,820	NO	Low Toxicity/ Background
Chromium	0.0075	10/10	6.7K - 29.8	10	2.6 - 33.5	NO	Background
Cobalt	100	10/10	1.6 - 4.2	0	0.88J - 6.7J	NO	Below SSSL/ Background
Copper	15	10/10	2.4 - 26.1	4	1.2J - 24.4	YES	

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO SURFACE SOIL SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Station-wide, Anthropogenic, and Site-Specific Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detects				
Iron	12	10/10	5,080 - 20,200	10	1,440 - 46,400	YES	
Lead	0.01	10/10	9.7K - 68.4	10	2.1 - 43.1	YES	
Magnesium	NE	10/10	172 - 612J	NA	61.5J - 2,700	NO	Low Toxicity/ Background
Manganese	330	10/10	53.6 - 204	0	7.6L - 491	NO	Below SSSL/ Background
Nickel	2	10/10	2.6 - 11	10	5.8J - 12.5	NO	Background
Potassium	NE	10/10	149 - 598	NA	210 - 1,640J	NO	Low Toxicity/ Background
Selenium	1.8	3/10	0.4K - 0.47L	0	0.053L - 0.61L	NO	Below SSSL/ Background
Sodium	NE	10/10	13.6 - 80.6	NA	12J - 115J	NO	Low Toxicity/ Background

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO SURFACE SOIL SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Station-wide, Anthropogenic, and Site-Specific Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Vanadium	0.5	10/10	11.9 - 68.6J	10	5.2J - 64.7	YES	
Zinc	10	10/10	10.6 - 133	10	3.2KJ - 48.4	YES	

Notes:

NE Not Established

NA Not Applicable

ND Not Detected

(1) Will and Suter, 1994a,b and 1996

(2) Talmage, 1996 (plant and microbial process value)

(3) Talmage and Opresko, 1996a (plant value)

TABLE 7-3

**FREQUENCY AND RANGE OF DETECTION COMPARED TO FRESHWATER SCREENING LEVELS
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Analyte	Surface Water Screening Levels (SWSLs)		Contaminant Frequency/Range		No of Positive Detects Above SWSLs		Freshwater Background	Ecological Contaminant of Concern?	Reason for Exclusion
			No. of Positive Detects/No. of Samples	Range of Positive Detects	Acute	Chronic			
	Acute	Chronic							
Volatiles (µg/L)									
Chloroform	3,360 ⁽¹⁾	1,240	2/4	3J	0	0	ND	NO	Below SWSL
Semivolatiles (µg/L)									
Bis(2-ethylhexyl)phthalate	NE	NE	2/4	1 - 2J	NA	NA	ND	NO	Lab. Contaminant
Pesticides/PCBs (µg/L)									
Heptachlor Epoxide	0.52 ⁽²⁾	0.0038	1/4	0.08K	0	1	ND	YES	
Nitramines (µg/L)									
amino-Dinitrotoluene	350 ⁽³⁾	20 ⁽¹⁾	4/4	97 - 1,000	2	4	ND	YES	
1,3-Dinitrobenzene	1,200	NE	1/4	0.46NJ	0	NA	ND	NO	Below SWSL
2,4-Dinitrotoluene	330	230	1/4	6J	0	0	ND	NO	Below SWSL
2,6-Dinitrotoluene	330	230	2/4	2J - 4J	0	0	ND	NO	Below SWSL
HMX	3,800 ⁽⁴⁾	330 ⁽⁴⁾	1/4	14	0	0	ND	NO	Below SWSL

TABLE 7-3 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO FRESHWATER SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Water Screening Levels (SWSLs)		Contaminant Frequency/Range		No of Positive Detects Above SWSLs		Freshwater Background	Ecological Contaminant of Concern?	Reason for Exclusion
	Acute	Chronic	No. of Positive Detects/No. of Samples	Range of Positive Detects	Acute	Chronic			
RDX	1,400 ⁽⁵⁾	190 ⁽⁵⁾	2/4	6 - 6.1	0	0	ND	NO	Below SWSL/ Lab Contaminant
1,3,5-Trinitrobenzene	60 ⁽⁶⁾	14 ⁽⁶⁾	1/3	0.44NJ	0	0	ND	NO	Below SWSL
2,4,6-Trinitrotoluene	570 ⁽⁷⁾	130 ⁽⁷⁾	4/4	25 - 480	0	1	ND	YES	
Inorganics (µg/L)									
Aluminum	200*	87 ⁽²⁾	4/4	15.4 - 200	0	1	94.4J - 1,050	NO	Background
Arsenic	48 ⁽⁸⁾	874 ⁽⁹⁾	4/4	2.2 - 4.6	0	0	ND	NO	Below SWSL
Barium	10,000	NE	4/4	38.3 - 48.6	0	NA	30.4J - 41.5J	NO	Below SWSL
Calcium	NE	NE	4/4	81,800 - 101,000	NA	NA	13,000J - 97,300	NO	Low Toxicity/ Background
Cobalt	195 ⁽¹⁰⁾	3.06 ⁽¹⁰⁾	2/4	2	0	0	ND	NO	Below SWSL
Cyanide	22 ⁽²⁾	5.2	1/4	27.7	1	1	ND	YES	
Iron	NE	320	4/4	589 - 2,960	NA	4	630 - 2,500J	YES	
Lead	272 ⁽²⁾⁽¹¹⁾	1*	1/4	3.6K	0	1	1.6J - 15.9	NO	Background
Magnesium	NE	NE	4/4	1,650 - 3,030	NA	NA	1,380J - 2,460J	NO	Low Toxicity

TABLE 7-3 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO FRESHWATER SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Water Screening Levels (SWSLs)		Contaminant Frequency/Range		No of Positive Detects Above SWSLs		Freshwater Background	Ecological Contaminant of Concern?	Reason for Exclusion
	Acute	Chronic	No. of Positive Detects/No. of Samples	Range of Positive Detections	Acute	Chronic			
Manganese	1,470 ⁽¹⁰⁾	80.3 ⁽¹⁰⁾	4/4	88.7 - 231	0	4	15.4 - 85.9J	YES	
Potassium	NE	NE	4/4	843 - 1,980	NA	NA	1,740J - 3,210J	NO	Background/ Low Toxicity
Sodium	NE	NE	4/4	7,160 - 7,580	NA	NA	5,230 - 9,390	NO	Background/ Low Toxicity
Vanadium	10,000	NE	1/4	3.3	0	NA	4.5J	NO	Below SWSL/ Background
Zinc	246 ⁽²⁾⁽¹⁰⁾	30	4/4	4.6 - 9.8	0	0	11.9J - 59.3	NO	Below SWSL/ Background

Notes:

- NE Not Established
- NA Not Applicable
- * Value is hardness and/or pH dependent
- (1) ORNL, 1996
- (2) USEPA, 1992b and VSWCB, 1992
- (3) Talmage, 1996 (secondary value)
- (4) Maxwell and Opresko, 1996 (secondary value)
- (5) Talmage and Opresko, 1996b (secondary value)
- (6) Talmage and Opresko, 1996c (secondary value)
- (7) Talmage and Opresko, 1996a
- (8) Arsenic V level
- (9) Total Arsenic level
- (10) Suter and Mabrey, 1994
- (11) Value based on a hardness of 257 mg/L CaCO₃

TABLE 7-4

FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Sediment Screening Levels (SSLs)		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSL	Freshwater Stream Background	Ecological Contaminant of Concern?	Reason for Exclusion
	BSLs/ER-Ls	ER-Ms ⁽¹⁾	No. of Positive Detects/No. of Samples	Range of Positive Detections				
Volatile Organics (µg/kg)								
Acetone	NE	NE	7/9	19J - 220J	NA	9J - 250J	NO	Lab. Contaminant
2-Butanone	NE	NE	4/9	3J - 59J	NA	12J - 26J	NO	Lab. Contaminant
Toluene	NE	NE	1/9	2J	NA	ND	NO	Lab. Contaminant
Semivolatile Organics (µg/kg)								
Acenaphthene	16	500	2/9	130J - 220J	2	ND	YES	
Acenaphthylene	44	640	2/9	77J - 150J	2	ND	YES	
Anthracene	85.3	1,100	6/9	54J - 750J	5	ND	YES	
Benzo(a)anthracene	261	1,600	8/9	42J - 2,400J	5	ND	YES	
Benzo(a)pyrene	430	1,600	7/9	46J - 2,100	4	ND	YES	
Benzo(b)fluoranthene	NE	3,200 ⁽²⁾	7/9	60J - 2,600	0	ND	NO	Below SSL
Benzo(g,h,i)perylene	NE	670 ⁽²⁾	7/9	66J - 1,000	2	ND	YES	

TABLE 7-4 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO USEPA REGION III SEDIMENT SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Sediment Screening Levels (SSLs)		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSL	Freshwater Stream Background	Ecological Contaminant of Concern?	Reason for Exclusion
	BSLs/ER-Ls	ER-Ms ⁽¹⁾	No. of Positive Detects/No. of Samples	Range of Positive Detections				
Benzo(k)fluoranthene	NE	3,200 ⁽²⁾	6/9	110J - 970	0	ND	NO	Below SSL
Bis(2-ethylhexyl)phthalate	NE	1,300 ⁽²⁾	3/9	61 - 660	0	240J - 580	NO	Lab. Contaminant/ Below SSL
Butylbenzylphthalate	NE	63 ⁽²⁾	1/9	660	1	ND	YES	
Carbazole	NE	NE	5/9	72J - 250J	NA	ND	YES	
Chrysene	384	2,800	8/9	54J - 2,600	5	ND	YES	
Di-n-butylphthalate	NE	1,400 ⁽²⁾	9/9	200J - 1,900	1	ND	NO	Lab. Contaminant
Dibenz(a,h)anthracene	63.4	260	5/9	68J - 300J	5	ND	YES	
Dibenzofuran	NE	540 ⁽²⁾	2/9	50J - 190J	0	ND	NO	Below SSL/ Lab. Contaminant
Fluoranthene	600	5,100	9/9	73J - 4,600	5	ND	YES	
Fluorene	19	540	4/9	52J - 420J	4	ND	YES	
Indeno(1,2,3-cd)pyrene	NE	600 ⁽²⁾	7/9	83J - 1,300	2	ND	YES	
Phenanthrene	240	1,500	8/9	57J - 3,200J	6	ND	YES	
Pyrene	665	2,600	9/9	67J - 3,300	4	ND	YES	

TABLE 7-4 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO USEPA REGION III SEDIMENT SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Sediment Screening Levels (SSLs)		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSL	Freshwater Stream Background	Ecological Contaminant of Concern?	Reason for Exclusion
	BSLs/ER-Ls	ER-Ms ⁽¹⁾	No. of Positive Detects/No. of Samples	Range of Positive Detections				
Nitramines (µg/kg)								
amino-Dinitrotoluene	NE	NE	6/9	220 - 2,300	NA	ND	YES	
2,4-Dinitrotoluene	288 ⁽⁶⁾	NE	1/9	3,700	1	ND	YES	
2,4,6-Trinitrotoluene	520 ⁽⁶⁾	NE	3/9	170 - 620	1	ND	YES	
Inorganics (mg/kg)								
Aluminum	NE	NE	9/9	1,690 - 6,320	NA	482K - 17,700J	NO	Background
Arsenic	8.2	70	9/9	5.7J - 55.5J	7	0.27L - 5.4L	YES	
Barium	NE	500 ⁽⁴⁾	9/9	7.2J - 54.9J	0	2.3J - 84.8	NO	Below SSL/ Background
Beryllium	NE	0.36 ⁽⁴⁾	9/9	0.26 - 0.85	5	0.28J - 0.99J	NO	Background
Cadmium	5.1	9.6	5/9	0.82K - 1.9K	0	ND	NO	Below SSL
Calcium	NE	NE	9/9	1,640J - 17,500J	NA	74.9J - 44,000J	NO	Background/ Low Toxicity
Chromium	81	370	9/9	8.7 - 47.3	0	2.8 - 32.8	NO	Below SSL
Cobalt	NE	NE	9/9	1.6 - 5.2	NA	1.1J - 7.9J	NO	Background
Copper	34	270	9/9	1.3L - 22	0	1J - 6.3J	NO	Below SSL

TABLE 7-4 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO USEPA REGION III SEDIMENT SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Sediment Screening Levels (SSLs)		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSL	Freshwater Stream Background	Ecological Contaminant of Concern?	Reason for Exclusion
	BSLs/ER-Ls	ER-Ms ⁽¹⁾	No. of Positive Detects/No. of Samples	Range of Positive Detections				
Iron	NE	27,000 ⁽⁴⁾	9/9	11,100 - 54,400	1	329 - 27,700J	YES	
Lead	46.7	218	9/9	7.9J - 109	1	1.8L - 381L	NO	Background
Magnesium	NE	NE	9/9	227 - 994	NA	37.8J - 2,060	NO	Background/ Low Toxicity
Manganese	NE	230 ⁽⁴⁾	9/9	51.5 - 85.5	0	8.7 - 93.1	NO	Below SSL/ Background
Nickel	20.9	51.6	9/9	1.5 - 9	0	4.6K - 17.5K	NO	Below SSL/ Background
Potassium	NE	NE	9/9	99.7 - 864	NA	503J - 1,910	NO	Background/ Low Toxicity
Silver	1	3.7	1/9	0.66	0	ND	NO	Below SSL
Sodium	NE	NE	9/9	19.7 - 164	NA	12.2J - 323J	NO	Background/ Low Toxicity

TABLE 7-4 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO USEPA REGION III SEDIMENT SCREENING LEVELS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Sediment Screening Levels (SSLs)		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSL	Freshwater Stream Background	Ecological Contaminant of Concern?	Reason for Exclusion
	BSLs/ER-Ls	ER-Ms ⁽¹⁾	No. of Positive Detects/No. of Samples	Range of Positive Detections				
Vanadium	NE	NE	9/9	13.1 - 43.4	0	1.9J - 38.9	YES	
Zinc	150	410	9/9	30.8 - 147	0	3.2J - 143	NO	Below SSL

Notes:

- BSL USEPA Region III BTAG Screening Level
- ER-L Effects Range - Low
- ER-M Effects Range - Median
- NE Not Established
- NA Not Applicable

- (1) Long et al., 1995.
- (2) USEPA Region III sediment screening level (apparent effects threshold).
- (3) Benzo(a)pyrene screening level used.
- (4) Tetra Tech, Inc. 1986. (apparent effects threshold).
- (5) Value calculated using the following equation: $SQC = Foc * Koc * FCV / 1000000$

Where:

- Foc = Fraction of organic carbon in the sediments (used 13,711 mg/kg)
- Koc = Organic carbon partition coefficient (chemical specific)
- FCV = Final water chronic value (chemical specific)

- (6) Talmage and Opresko, 1996a.

TABLE 7-5

**FREQUENCY AND RANGE OF DETECTION COMPARED TO SURFACE SOIL SCREENING LEVELS
SITE 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Analyte	Surface Soil Screening Levels (SSSLs)	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Station-wide, Anthropogenic, and Site-Specific Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Volatile Organics (µg/kg)							
1,1,1-Trichloroethane	<300	1/8	8	0	ND	NO	Below SSSL
Semivolatile Organics (µg/kg)							
Anthracene	100	1/8	45J	0	ND	NO	Below SSSL
Benzo(a)anthracene	100	2/8	88J - 130J	1	120J - 240J	NO	Background
Benzo(a)pyrene	100	2/8	95J - 140J	1	140J - 180J	NO	Background
Benzo(b)fluoranthene	100	3/8	43J - 230J	2	230J - 500	NO	Background
Benzo(g,h,i)perylene	100	2/8	53J - 96J	0	ND	NO	Below SSSL
Benzo(k)fluoranthene	100	2/8	51J - 100J	0	120J - 130J	NO	Below SSSL/ Background
Bis(2-ethylhexyl)phthalate	NE	2/8	46J - 430	NA	ND	NO	Below SSSL
Chrysene	100	3/8	39J - 140J	2	150J - 270J	NO	Background
Di-n-butylphthalate	200,000 ⁽¹⁾	8/8	250 - 1,700	0	ND	NO	Below SSSL
Dimethylphthalate	200,000 ⁽¹⁾	2/8	56J - 1,100	0	ND	NO	Below SSSL
Fluoranthene	100	5/8	46J - 370J	2	120J - 430	NO	Background
Indeno(1,2,3-cd)pyrene	100	2/8	62J - 130J	1	160J	NO	Background
Phenanthrene	100	2/8	75J - 210J	1	ND	YES	
Pyrene	100	4/8	44J - 210J	2	160J - 320J	NO	Background
Pesticides/PCBs(µg/kg)							
gamma-Chlordane	<100 ⁽²⁾	1/8	2.9	0	ND	NO	Below SSSL
4,4'-DDE	<100	2/8	3.1J - 5	0	ND	NO	Below SSSL
4,4'-DDT	<100	3/8	2.9J - 9.4J	0	ND	NO	Below SSSL
Endrin Aldehyde	<100 ⁽³⁾	1/8	2.1NJ	0	ND	NO	Below SSSL

TABLE 7-5 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO SURFACE SOIL SCREENING LEVELS
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Station-wide, Anthropogenic, and Site-Specific Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Endrin Ketone	<100 ⁽³⁾	1/8	3.7	0	ND	NO	Below SSSL
Heptachlor Epoxide	<100	1/8	12NJ	0	ND	NO	Below SSSL
Nitramines (µg/kg)							
amino-Dinitrotoluene	80,000 ⁽⁵⁾	6/8	130 - 380	0	1,300J	NO	Below SSSL/ Background
2,4,6-Trinitrotoluene	30,000 ⁽⁴⁾	6/8	350 - 2,100	0	1,300J	NO	Below SSSL
Inorganics (mg/kg)							
Aluminum	1	8/8	5,880 - 90,600	8	1,960 - 24,100	YES	
Antimony	0.48	1/4	5.6L	1	9.2L - 11L	NO	Below SSSL/ Background
Arsenic	328	7/8	0.68J - 14K	0	0.46L - 63.9	NO	Background
Barium	440	8/8	19.1 - 50.7	0	4.2J - 80.2	NO	Below SSSL/ Background
Beryllium	0.02	6/8	0.29 - 0.73	6	0.23J - 0.93J	NO	Background
Cadmium	2.5	4/8	0.96K - 2.2	0	1.3K - 1.5	NO	Below SSSL
Calcium	NE	8/8	592 - 1,860	NA	39.4J - 7,820	NO	Low Toxicity/ Background
Chromium	0.0075	8/8	12.6J - 31.3	18	2.6 - 33.5	NO	Background
Cobalt	100	8/8	1.8 - 5.6	0	0.88J - 6.7J	NO	Below SSSL/ Background
Copper	15	8/8	7.8 - 41.6	4	1.2J - 24.4	YES	
Iron	12	8/8	12,300 - 48,701	8	1,440 - 46,400	YES	
Lead	0.01	8/8	45.5J - 392J	8	2.1 - 43.1	YES	
Magnesium	NE	8/8	356 - 742	NA	61.5J - 2,700	NO	Low Toxicity/ Background

TABLE 7-5 (Continued)

FREQUENCY AND RANGE OF DETECTION COMPARED TO SURFACE SOIL SCREENING LEVELS
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Surface Soil Screening Levels (SSSLs)	Contaminant Frequency/Range		No. of Positive Detects Above SSSL	Station-wide, Anthropogenic, and Site-Specific Background Surface Soil	Ecological Contaminant of Concern ?	Reason for Exclusion
		No. of Positive Detects/No. of Samples	Range of Positive Detections				
Manganese	330	8/8	25.8 - 133	0	7.6L - 491	NO	Below SSSL/ Background
Mercury	0.058	1/8	0.1K	1	0.05J	YES	
Nickel	2	8/8	2.6 - 7.4	8	2.5 - 12.5	NO	Background
Potassium	NE	8/8	240 - 626	NA	135 - 1,640J	NO	Low Toxicity/ Background
Sodium	NE	8/8	5.9 - 30.3	NA	9.4 - 115J	NO	Low Toxicity/ Background
Vanadium	0.5	8/8	22.7J - 53.1	8	5.2J - 64.7	NO	Background
Zinc	10	8/8	34.4J - 365J	8	3.2KJ - 48.4	YES	

Notes:

NE Not Established

NA Not Applicable

ND Not Detected

(1) Will and Suter, 1994a,b

(2) Screening level for total chlordane

(3) Screening level for endrin

(4) Talmage and Opresko, 1996a (plant value)

(5) Talmage, 1996 (plant and microbial process value)

TABLE 7- 6

SAMPLING STATION CHARACTERISTICS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Station	Temperature (degrees C)	pH (S.U.)	Specific Conductance (µmhos/cm)	Dissolved Oxygen (mg/L)	Stream Width (feet)	Stream Depth (feet)	Sediment Type
9SW08	20.4	6.81	492	2.50	2.5	1	Sand
9SW09	23.4	6.78	502	7.30	1	1	Sand
9SW10	NE	NE	NE	NE	12	NA	Sand
9SW11	22.3	6.87	535	5.70	3	2	Sand

Notes:

Surface water was collected at the surface only because the water column was less than three feet deep

NE Not Evaluated (no water present)
 NA Not Applicable
 S.U. Standard Unit
 µmhos/cm Microhoms per Centimeter
 mg/L Milligram per Liter

TABLE 7-7

**BENTHIC MACROINVERTEBRATE SPECIES
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Benthic Macroinvertebrate Species	Sampling Stations		
	9BN08	9BN09	9BN11
Mollusca			
Bivalvia			
Veneroida			
Sphaeriidae			
<i>Pisidium casertanum</i>			30
Anellida			
Oligochaeta			
Tubificida			
Tubificidae			
<i>Ilyodrilus templetoni</i>		17	37
<i>Limnodrilus hoffmeisteri</i>		25	45
Arthropoda			
Insecta			
Coleoptera			
Elmidae			
<i>Stenelmis</i> sp.		4	
Diptera			
Ceratopogonidae			
<i>Culicoides</i> sp.		1	1
Chironomidae			
<i>Chironomus</i> sp.	8	4	14
<i>Clinotanypus</i> sp.			4
<i>Paratendipes</i> sp.			5
<i>Procladius</i> sp.	11	2	16
<i>Psectrotanypus</i> nr. <i>dyari</i>	6		5

TABLE 7-7 (Continued)

BENTHIC MACROINVERTEBRATE SPECIES
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Benthic Macroinvertebrate Species	Sampling Stations		
	9BN08	9BN09	9BN11
<i>Tanytarsus</i> sp.			9
Tipulidae			
<i>Pilaria</i> sp.	2		
Ephemeroptera			
Baetidae			
<i>Baetis</i> sp.			1
Odonata			
Libellulidae			
<i>Libellula</i> sp.	3		1

TABLE 7-8

**CONTAMINANT DETECTIONS COMPARED TO SOIL FLORA AND FAUNA TOXICITY VALUES
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Contaminant	Soil Flora and Fauna Toxicity Values ⁽¹⁾				Range of Positive Detections	No. Exceedance / No. Detected	UCL
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes			
Semivolatiles (µg/kg)							
Acenaphthene	20,000 ⁽¹⁾	100 ⁽²⁾	100 ⁽²⁾	NE	69J - 120J	1/2	120*
Anthracene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	58J - 310J	2/4	228.86
Benzo(a)anthracene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	87J - 1,100	6/7	567.41
Benzo(a)pyrene	NE	100 ⁽²⁾	25,000	NE	94J - 1,200	6/7	588.03
Benzo(b)fluoranthene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	58J - 2,200	7/9	932.24
Benzo(g,h,i)perylene	NE	100 ⁽¹⁾	100 ⁽¹⁾	NE	74J - 770	5/7	398.90
Benzo(k)fluoranthene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	77J - 520	5/7	279.95
Butylbenzylphthalate	NE	NE	NE	NE	55 - 310	NA	230.02
Carbazole	NE	NE	NE	NE	47J - 250J	NA	207.51
Chrysene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	43J - 1,200	7/9	668.07
Dibenz(a,h)anthracene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	55J - 160J	2/4	160*
Dibenzofuran	NE	NE	NE	NE	49J - 77J	NA	77*
Fluoranthene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	65J - 2,200	8/9	1,018.15
Fluorene	NE	30,000	100 ⁽²⁾	NE	75J - 120J	1/2	120*
Indeno(1,2,3-cd)pyrene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	74J - 550	5/7	308.31
Phenanthrene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	76J - 1,600	6/8	739.66
Pyrene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	35J - 2,000	8/10	1,077.38
Inorganics (mg/kg)							
Copper	100	50	20	100	2.4 - 26.1	2/10	16.48
Iron	12 ⁽²⁾	NE	3,515	200	5,080	10/10	5,080*
Lead	50	500	300	900	9.7K - 68.4	3/10	43.82
Vanadium	2	58 ⁽²⁾	58 ⁽²⁾	20	11.9 - 68.6	10/10	45.15
Zinc	50	200	500	100	10.6 - 133	5/10	89.38

Notes:

⁽¹⁾ Will and Suter, 1996⁽²⁾ USEPA, 1995a (Region III BTAG Soil Screening Values for Soil Fauna)

UCL 95 percent Upper Confidence Level

NE Not established

* Maximum value

TABLE 7-9

CONTAMINANT DETECTIONS COMPARED TO SOIL FLORA AND FAUNA TOXICITY VALUES
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant	Soil Flora and Fauna Toxicity Values ⁽¹⁾				Range of Positive Detections	No. of Exceedances/ No. of Detects	UCL
	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes			
Semivolatiles (µg/kg)							
Phenanthrene	NE	100 ⁽²⁾	100 ⁽²⁾	NE	75J - 210J	1/2	210*
Inorganics (mg/kg)							
Aluminum	50	NE	NE	600	5,880 - 90,600	8/8	49,103.70
Copper	100	50	20	100	7.8 - 41.6	4/8	27.4
Iron	12 ⁽²⁾	NE	3,515	200	12,300 - 48,701	8/8	34,040.44
Lead	50	500	300	900	45.5J - 392J	6/8	218.93
Mercury	0.3	0.1	300	30	0.1K	0/1	0.1*
Zinc	50	200	500	100	34.4J - 365J	6/8	246.02

Notes:

- (1) Will and Suter, 1996
- (2) USEPA, 1995a (Region III BTAG Soil Screening Values for Soil Fauna)

UCL 95 Percent Upper Confidence Level
 NE Not established
 * Maximum value (UCL was higher than the maximum value)

TABLE 7-10
TOXICITY REFERENCE VALUES
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Chemical	Raccoon (mg/kg/day)	White-Tailed Deer (mg/kg/day)	Red Fox (mg/kg/day)	Bobwhite Quail (mg/kg/day)	Eastern Cottontail (mg/kg/day)
Semivolatile Organics					
Acenaphthene	6.94e+00	3.46e+00	7.45e+00	2.21e+01	1.16e+01
Anthracene	1.75e+01	8.71e+00	1.88e+01	5.57e+01	2.93e+01
Benzo(a)anthracene	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Benzo(a)pyrene	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Benzo(b)fluoranthene	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Benzo(k)fluoranthene	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Benzo(g,h,i)perylene	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Butylbenzylphthalate	6.31e+00	3.14e+00	6.77e+00	2.01e+01	1.06e+01
Carbazole	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Chrysene	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Dibenzofuran	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Dibenz(a,h)anthracene	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Fluorene	4.96e+00	2.47e+00	5.32e+00	1.58e+01	8.32e+00
Fluoranthene	2.19e+00	1.09e+00	2.35e+00	6.96e+00	3.67e+00
Indeno(1,2,3-cd)pyrene	1.75e-01	8.71e-02	1.88e-01	5.57e-01	2.93e-01
Phenanthrene	1.63e+01	8.10e+00	1.75e+01	5.18e+01	2.73e+01
Pyrene	1.31e+00	6.53e-01	1.41e+00	4.17e+00	2.20e+00
Pesticides/PCBs					
Heptachlor Epoxide	1.52e-04	7.55e-05	1.63e-04	4.82e-04	2.54e-04
Nitramines					
amino-Dinitrotoluene ⁽¹⁾	1.31e+00	6.53e-01	5.20e+00	4.17e+00	2.20e+00
2,4,6-Trinitrotoluene	1.59e-01	7.90e-02	6.50e-03	5.05e-01	2.66e-01

TABLE 7-10 (Continued)

TOXICITY REFERENCE VALUES
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Chemical	Raccoon (mg/kg/day)	White-Tailed Deer (mg/kg/day)	Red Fox (mg/kg/day)	Bobwhite Quail (mg/kg/day)	Eastern Cottontail (mg/kg/day)
Inorganics					
Aluminum	3.38e-01	6.51e+00	1.95e+01	1.42e+01	1.16e+01
Copper	7.27e+00	6.51e-01	7.79e+00	2.13e+01	1.16e+01
Cyanide	4.29e+00	2.13e+00	4.88e-01	6.40e+00	7.18e+00
Iron	1.73e+01	6.51e+00	1.86e+01	7.11e+01	2.90e+01
Lead	3.18e+00	1.95e-01	3.41e+00	3.49e+00	1.74e+00
Manganese	3.50e+00	1.30e+00	3.75e+00	1.42e+02	2.32e+01
Mercury	1.27e-01	1.30e-02	1.36e-01	1.42e-01	1.20e-01
Vanadium	2.58e-01	3.25e-01	2.77e-01	2.04e+01	5.80e-02
Zinc	6.35e+01	3.25e+00	1.30e+00	7.11e+01	2.90e+01

Notes:

⁽¹⁾ Values used for 2,6-dinitrotoluene

TABLE 7-11

TERRESTRIAL TOTAL DAILY INTAKE MODEL EXPOSURE PARAMETERS
 SITES 9 AND 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Raccoon	Small Mammal (Meadow Vole)
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 40% Fish 60%	Vegetation 100%
Feeding Rate	kg/d	1.6 ⁽²⁾	0.237 ⁽⁴⁾	0.0135 ⁽³⁾	0.6 ⁽³⁾	0.283 ⁽³⁾	0.112 ⁽³⁾
Incident Soil Ingestion	kg/d	0.019 ⁽¹⁾	0.0017 ⁽⁵⁾	0.001 ⁽³⁾	0.0168 ⁽⁵⁾	0.027 ⁽³⁾	0.00269 ⁽³⁾
Rate of Drinking Water Ingestion	L/d	1.1 ⁽²⁾	0.115 ⁽³⁾	0.019 ⁽³⁾	0.385 ⁽³⁾	0.462 ⁽³⁾	0.0652 ⁽³⁾
Rate of Vegetation Ingestion	kg/d	1.6	0.237	0.014	0.12	0.1132	0.112
Body Weight	kg	45.4 ⁽²⁾	1.189 ⁽³⁾	0.174 ⁽³⁾	4.54 ⁽³⁾	5.6 ⁽³⁾	0.3725 ⁽³⁾
Rate of Small Mammal Ingestion	kg/d	NA	NA	NA	0.48	NA	NA
Rate of Fish Ingestion	kg/d	NA	NA	NA	NA	0.17	NA
Rate of Invertebrate Ingestion	kg/d	NA	NA	NA	NA	NA	NA
Home Range Size	acres	454 ⁽²⁾	9.30 ⁽³⁾	26.24 ⁽³⁾	1,245 ⁽³⁾	257 ⁽³⁾	0.032 ⁽³⁾

Notes:

NA - Not Applicable

⁽¹⁾ Arthur and Alldridge, 1979

⁽²⁾ Dee, 1991

⁽³⁾ USEPA, 1993b

⁽⁴⁾ Opresko, 1993

⁽⁵⁾ Beyer, 1990

TABLE 7-12

SEDIMENT GRAIN SIZE ANALYSIS
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Stations	Percent Gravel	Percent Sand	Percent Silt	Percent Clay
9SD08-01	5	60.9	17.7	16.4
9SD08-02	NA	NA	NA	NA
9SD09-01	2.5	83.7	8.2	5.6
9SD09-02	5.1	85.3	3.9	5.7
9SD10-01	2.4	92.7	1.8	3.1
9SD10-02	1.5	85.2	8.3	5
9SD11-01	0.1	75.5	13.8	10.6
9SD11-02	1	65	17.1	16.9

Notes:

NA Not Analyzed

TABLE 7-13

**SUMMARY STATISTICS OF BENTHIC MACROINVERTEBRATE SPECIES
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Site 9 - Freshwater Stations

Station	Number of Taxon	Number of Individuals	Density (#/m ²)	Brillioun's Diversity	Shannon Wiener Diversity	MBI
9BN08	5	30	431.0	0.54	0.63	9.06
9BN09	6	53	761.5	0.51	0.57	8.92
9BN11	12	168	2,413.8	0.81	0.86	8.29
AVERAGE	7.7	83.7	1,202.1	0.62	0.69	8.76

Freshwater Background Stations

Station	Number of Taxon	Number of Individuals	Density (#/m ²)	Brillioun's Diversity	Shannon Wiener Diversity	MBI
BGCPBN01	10	29	416.67	0.61	0.76	7.64
BGCPBN02	7	43	617.82	0.53	0.62	7.03
BGCPBN03	7	35	502.87	0.56	0.66	7.18
BGCPBN04	10	102	1,465.52	0.66	0.72	7.51
BGCPBN05	8	400	5,747.13	0.39	0.40	6.69
BGTNBN06	20	711	10,215.52	0.71	0.73	4.33
AVERAGE	10.3	220.0	3,160.92	0.58	0.65	6.73

Notes:

Source: Baker, 1995a

BN Benthic Macroinvertebrate Sample

BGCP Colonial National Historical Park - freshwater streams background station

BGTN Timberneck Creek - tidal freshwater background station

MBI Macroinvertebrate Biotic Index

#/m² number of individuals per square meter

TABLE 7-14

RESULTS OF THE JACCARD COEFFICIENT (S_j) AND THE SØRENSEN INDEX (S_s)
 FOR COMMUNITY SIMILARITY BETWEEN SITE STATIONS AND
 BACKGROUND FRESHWATER STATIONS
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

S_j

Stations	9BN08	9BN09	9BN11	BGCPBN01	BGCPBN02	BGCPBN03	BGCPBN04	BGCPBN05	BGTNBN06
9BN08	NA	0.22	0.31	0.15	0	0	0	0	0.04
9BN09	0.36	NA	0.38	0	0	0	0	0	0.04
9BN11	0.47	0.56	NA	0.10	0	0.06	0	0	0.10
BGCPBN01	0.27	0	0.31	NA	0.06	0.13	0	0	0.03
BGCPBN02	0	0	0	0.12	NA	0.08	0.21	0.15	0.08
BGCPBN03	0	0	0.11	0.24	0.14	NA	0.06	0	0.08
BGCPBN04	0	0	0	0	0.35	0.12	NA	0.29	0.11
BGCPBN05	0	0	0	0	0.27	0	0.45	NA	0.12
BGTNBN06	0.08	0.08	0.18	0.07	0.15	0.15	0.20	0.21	NA

S_s

Notes:

- BN Benthic Macroinvertebrate Sample
- BGCP Colonial National Historical Park Sample
- BGTN Timberneck Creek Sample
- NA Not Applicable
- Values presented above "NA" are S_j values
- Values presented below "NA" are S_s values

TABLE 7-15

QUOTIENT INDEX RATIOS - TERRESTRIAL INTAKE MODEL
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant of Concern	Raccoon	White-Tailed Deer	Red Fox	Bobwhite Quail	Eastern Cottontail Rabbit
Acenaphthene	4.04×10^{-06}	4.02×10^{-06}	7.99×10^{-07}	3.06×10^{-05}	3.23×10^{-04}
Anthracene	2.25×10^{-06}	1.46×10^{-06}	4.04×10^{-07}	1.37×10^{-05}	1.15×10^{-04}
Benzo(a)anthracene	4.26×10^{-04}	1.04×10^{-04}	6.76×10^{-05}	1.85×10^{-03}	7.30×10^{-03}
Benzo(b)fluoranthene	6.63×10^{-04}	9.55×10^{-05}	1.04×10^{-04}	2.60×10^{-03}	5.86×10^{-03}
Benzo(a)pyrene	4.31×10^{-04}	8.52×10^{-05}	6.74×10^{-05}	1.79×10^{-03}	5.75×10^{-03}
Benzo(g,h,i)perylene	2.85×10^{-04}	4.28×10^{-05}	4.44×10^{-06}	1.13×10^{-03}	2.67×10^{-03}
Benzo(k)fluoranthene	2.04×10^{-04}	3.79×10^{-05}	3.18×10^{-05}	8.37×10^{-04}	2.52×10^{-03}
Butylbenzylphthalate	5.50×10^{-06}	2.65×10^{-06}	9.35×10^{-07}	2.92×10^{-05}	1.96×10^{-04}
Carbazole	1.52×10^{-04}	3.01×10^{-05}	2.39×10^{-05}	6.33×10^{-04}	2.03×10^{-03}
Chrysene	5.02×10^{-04}	1.22×10^{-04}	7.96×10^{-05}	2.19×10^{-03}	8.60×10^{-03}
Dibenz(a,h)anthracene	1.39×10^{-04}	2.08×10^{-05}	2.16×10^{-05}	5.47×10^{-04}	1.30×10^{-03}
Dibenzofuran	5.64×10^{-05}	1.12×10^{-05}	8.83×10^{-06}	2.35×10^{-04}	7.53×10^{-04}
Fluoranthene	7.04×10^{-05}	3.28×10^{-05}	1.20×10^{-05}	3.73×10^{-04}	2.51×10^{-03}
Fluorene	4.75×10^{-06}	3.87×10^{-06}	8.96×10^{-07}	3.23×10^{-05}	3.09×10^{-04}
Indeno(1,2,3-cd)pyrene	2.20×10^{-04}	3.29×10^{-05}	3.43×10^{-05}	8.68×10^{-04}	2.05×10^{-03}
Phenanthrene	7.80×10^{-06}	5.06×10^{-06}	1.40×10^{-06}	4.75×10^{-05}	3.98×10^{-04}
Pyrene	1.14×10^{-04}	3.79×10^{-05}	1.86×10^{-05}	5.39×10^{-04}	2.80×10^{-03}
Hepatchlor Epoxide	2.30×10^{-02}	2.75×10^{-02}	4.22×10^{-02}	3.41×10^{-02}	1.73×10^{-01}
amino-Dinitrotoluenes	5.41×10^{-01}	3.57×10^{-02}	1.53×10^{-02}	2.16×10^{-02}	8.92×10^{-02}

TABLE 7-15 (Continued)

QUOTIENT INDEX RATIOS - TERRESTRIAL INTAKE MODEL
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA

Contaminant of Concern	Raccoon	White-Tailed Deer	Red Fox	Bobwhite Quail	Eastern Cottontail Rabbit
2,4,6-Trinitrotoluene	1.85×10^{-02}	1.43×10^{-01}	5.47×10^{-03}	1.85×10^{-01}	1.41×10^{-03}
Copper	5.68×10^{-04}	5.32×10^{-03}	1.61×10^{-04}	7.12×10^{-03}	8.14×10^{-02}
Cyanide	7.28×10^{-04}	3.15×10^{-04}	4.82×10^{-03}	4.85×10^{-04}	3.73×10^{-04}
Iron	1.27×10^{-01}	2.95×10^{-02}	2.95×10^{-02}	3.51×10^{-01}	8.90×10^{-01}
Lead	2.68×10^{-02}	6.92×10^{-03}	4.21×10^{-04}	2.91×10^{-02}	1.85×10^{-01}
Manganese	7.71×10^{-02}	1.97×10^{-02}	7.11×10^{-03}	6.96×10^{-03}	2.40×10^{-01}
Vanadium	2.26×10^{-02}	1.45×10^{-03}	4.33×10^{-03}	3.44×10^{-03}	1.39×10^{-03}
Zinc	1.02×10^{-02}	2.13×10^{-02}	1.81×10^{-02}	3.85×10^{-02}	6.45×10^{-01}
Total	2.33×10^{-02}	2.80×10^{-01}	5.59×10^{-03}	6.91×10^{-01}	5.17×10^{-03}

TABLE 7-16

QUOTIENT INDEX RATIOS - TERRESTRIAL INTAKE MODEL
 SITE 19
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Contaminant of Concern	Raccoon	White-Tailed Deer	Red Fox	Bobwhite Quail	Eastern Cottontail Rabbit
Phenanthrene	2.44×10^{-06}	1.59×10^{-06}	4.39×10^{-07}	1.49×10^{-05}	1.25×10^{-04}
Aluminum	1.86×10^{-01}	6.28×10^{-02}	5.30×10^{-02}	5.50×10^{-00}	6.98×10^{-00}
Copper	9.91×10^{-04}	9.27×10^{-03}	2.80×10^{-04}	1.24×10^{-02}	1.42×10^{-01}
Iron	2.51×10^{-01}	4.36×10^{-02}	3.88×10^{-02}	7.62×10^{-01}	1.94×10^{-00}
Lead	9.11×10^{-03}	3.39×10^{-02}	1.74×10^{-03}	1.52×10^{-01}	9.69×10^{-01}
Mercury	1.86×10^{-04}	3.75×10^{-03}	1.42×10^{-04}	1.40×10^{-02}	1.12×10^{-01}
Zinc	2.38×10^{-03}	6.11×10^{-02}	5.04×10^{-02}	1.11×10^{-01}	1.89×10^{-01}
Total	1.88×10^{-01}	2.14×10^{-01}	1.44×10^{-01}	6.55×10^{-00}	1.20×10^{-01}

TABLE 7-17

SURFACE WATER QUOTIENT INDEX PER STATION
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Sample Number	Sample Concentration	Surface Water Quotient Index	
			Acute	Chronic
Pesticides/PCBs (µg/L)				
Heptachlor Epoxide	9SW08-01	0.08K	0.15	21.05
Nitraminess (µg/L)				
amino-Dinitrotoluene	9SW08-01	1,000	2.86	50.00
	9SW09-01	520	1.43	26.00
	9SW11-01	97	0.28	4.85
	9SW11-01D	110	0.31	5.50
2,4,6-Trinitrotoluene	9SW08-01	480	0.84	3.69
Inorganics (µg/L)				
Cyanide	9SW08-01	27.7	1.26	5.33
Iron	9SW08-01	2,960	NA	9.25
	9SW09-01	589	NA	1.84
	9SW11-01	677	NA	2.12
	9SW11-01D	649	NA	2.03
Manganese	9SW08-01	231	0.16	2.88
	9SW09-01	88.7	0.06	1.10
	9SW11-01	130	0.09	1.62
	9SW11-01D	130	0.09	1.62

Notes:

NA Not Applicable

TABLE 7-18

**SURFACE WATER QUOTIENT INDEX PER ECOLOGICAL
CONTAMINANT OF CONCERN
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Analyte	Detected Average Concentration	Average Surface Water Quotient Index	
		Acute	Chronic
Pesticides/PCBs (µg/L)			
Heptachlor Epoxide	0.08	0.15	21.05
Nitraminess (µg/L)			
amino-Dinitrotoluene	431.75	1.23	21.59
2,4,6-Trinitrotoluene	160.00	0.28	1.23
Inorganics (µg/L)			
Cyanide	27.7	1.26	5.33
Iron	1,218.75	NA	3.81
Manganese	144.93	0.10	1.80
Total QI		3.02	54.81

Notes:

NA Not Applicable
QI Quotient Index

TABLE 7-19

**SEDIMENT QUOTIENT INDEX PER STATION
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Analyte	Sample Number	Sample Concentration	Sediment Quotient Index	
			BSL/ER-L	ER-M
Semivolatile Organics ($\mu\text{g}/\text{kg}$)				
Acenaphthene	9SD08-01	220J	13.75	0.44
	9SD09-02	130J	8.13	0.26
Acenaphthylene	9SD08-01	150J	3.41	0.23
	9SD09-02	77J	1.75	0.12
Anthracene	9SD08-01	510J	5.98	0.46
	9SD09-01	190J	2.23	0.17
	9SD09-02	750J	8.79	0.68
	9SD11-01	170J	1.99	0.15
	9SD11-01D	110J	1.29	0.10
Benzo(a)anthracene	9SD08-01	2,100	8.05	1.31
	9SD09-01	710	2.72	0.44
	9SD09-02	2,400J	9.20	1.50
	9SD11-01	550	2.11	0.34
	9SD11-01D	420J	1.61	0.26
Benzo(a)pyrene	9SD08-01	1,200	2.79	0.75
	9SD09-01	560	1.30	0.35
	9SD09-02	2,100	4.88	1.31
	9SD11-01	480J	1.12	0.30
Benzo(g,h,i)perylene	9SD08-01	850	NA	1.27
	9SD09-02	1,000	NA	1.49
Butylbenzylphthalate	9SD11-01	660	NA	10.48
Carbazole	NA	NA	NA	NA
Chrysene	9SD08-01	2,600	6.77	0.93
	9SD09-01	900	2.34	0.32
	9SD09-02	2,400J	6.25	0.86
	9SD11-01	620	1.61	0.22
	9SD11-01D	520	1.35	0.19

TABLE 7-19 (Continued)

**SEDIMENT QUOTIENT INDEX PER STATION
SITE 9
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA**

Analyte	Sample Number	Sample Concentration	Sediment Quotient Index	
			BSL/ER-L	ER-M
Carbazole	NA	NA	NA	NA
Chrysene	9SD08-01	2,600	6.77	0.93
	9SD09-01	900	2.34	0.32
	9SD09-02	2,400J	6.25	0.86
	9SD11-01	620	1.61	0.22
	9SD11-01D	520	1.35	0.19
Dibenz(a,h)anthracene	9SD08-01	210J	3.31	0.81
	9SD09-01	91J	1.44	0.35
	9SD09-02	300J	4.73	1.15
	9SD11-01	88J	1.39	0.34
	9SD11-01D	68J	1.07	0.26
Fluoranthene	9SD08-01	4,600	7.66	0.90
	9SD09-01	1,500	2.50	0.29
	9SD09-02	4,000	6.66	0.78
	9SD11-01	950	1.58	0.19
	9SD11-01D	870	1.45	0.17
Fluorene	9SD08-01	420J	22.11	0.78
	9SD09-01	52J	2.74	0.10
	9SD09-02	150J	7.89	0.27
	9SD11-01	79J	4.16	0.15
Indeno(1,2,3-cd)pyrene	9SD08-01	1,100	NA	1.83
	9SD09-02	1,300	NA	2.16
Phenanthrene	9SD08-01	3,200J	13.33	2.13
	9SD09-01	1,000	4.17	0.67
	9SD09-02	2,600J	10.83	1.73
	9SD10-02	260J	1.08	0.17
	9SD11-01	720	3.00	0.48
	9SD11-01D	540	2.25	0.36

TABLE 7-19 (Continued)

SEDIMENT QUOTIENT INDEX PER STATION
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	Sample Number	Sample Concentration	Sediment Quotient Index	
			BSL/ER-L	ER-M
Nitramines (ug/kg)				
amino-Dinitrotoluene	NA	NA	NA	NA
2,4-Dinitrotoluene	9SD09-02	3,700	12.85	NA
2,4,6-Trinitrotoluene	9SD09-02	620	1.19	NA
Inorganics (mg/kg)				
Arsenic	9SD08-01	49.4J	6.02	0.71
	9SD08-02	55.5J	6.77	0.79
	9SD09-01	9J	1.10	0.13
	9SD09-02	8.5J	1.04	0.12
	9SD10-02	22.4J	2.73	0.32
	9SD11-01	9.2J	1.12	0.13
	9SD11-01D	9.7J	1.18	0.14
Iron	9SD09-02	54,400	NA	2.01
Vanadium	NA	NA	NA	NA

Notes:

BSL USEPA Region III BTAG Screening Level
 ER-L Effects Range - Low
 ER-M Effects Range - Median
 NA Not Applicable

TABLE 7-20

SEDIMENT QUOTIENT INDEX PER ECOLOGICAL CONTAMINANT OF CONCERN
 SITE 9
 NAVAL WEAPONS STATION YORKTOWN
 YORKTOWN, VIRGINIA

Analyte	UCL Concentration	Sediment UCL Quotient Index	
		BSL/ER-L	ER-M
Semivolatile Organics (µg/kg)			
Acenaphthene	247.03	15.44	0.49
Acenaphthylene	245.83	5.59	0.38
Anthracene	409.87	4.81	0.37
Benzo(a)anthracene	1,295.44	4.96	0.81
Benzo(a)pyrene	1,008.60	2.55	0.63
Benzo(g,h,i)perylene	579.20	NA	0.86
Butylbenzylphthalate	371.95	NA	3.90
Carbazole	NA	NA	NA
Chrysene	1,456.89	3.79	0.52
Dibenz(a,h)anthracene	235.25	3.71	0.90
Fluoranthene	2,473.42	4.12	0.48
Fluorene	272.92	14.36	0.51
Indeno(1,2,3-cd)pyrene	738.04	NA	1.23
Phenanthrene	1,680.95	7.00	1.12
Pyrene	1,855.96	2.79	0.71
Nitramines (µg/kg)			
amino-Dinitrotoluene	NA	NA	NA
2,4-Dinitrotoluene	1,341.85	4.66	NA
2,4,6-Trinitrotoluene	317.71	0.61	NA
Inorganics (mg/kg)			
Arsenic	31.54	3.85	0.45
Iron	31,121.00	1.15	NA
Vanadium	NA	NA	NA
Total QI		79.19	15.36

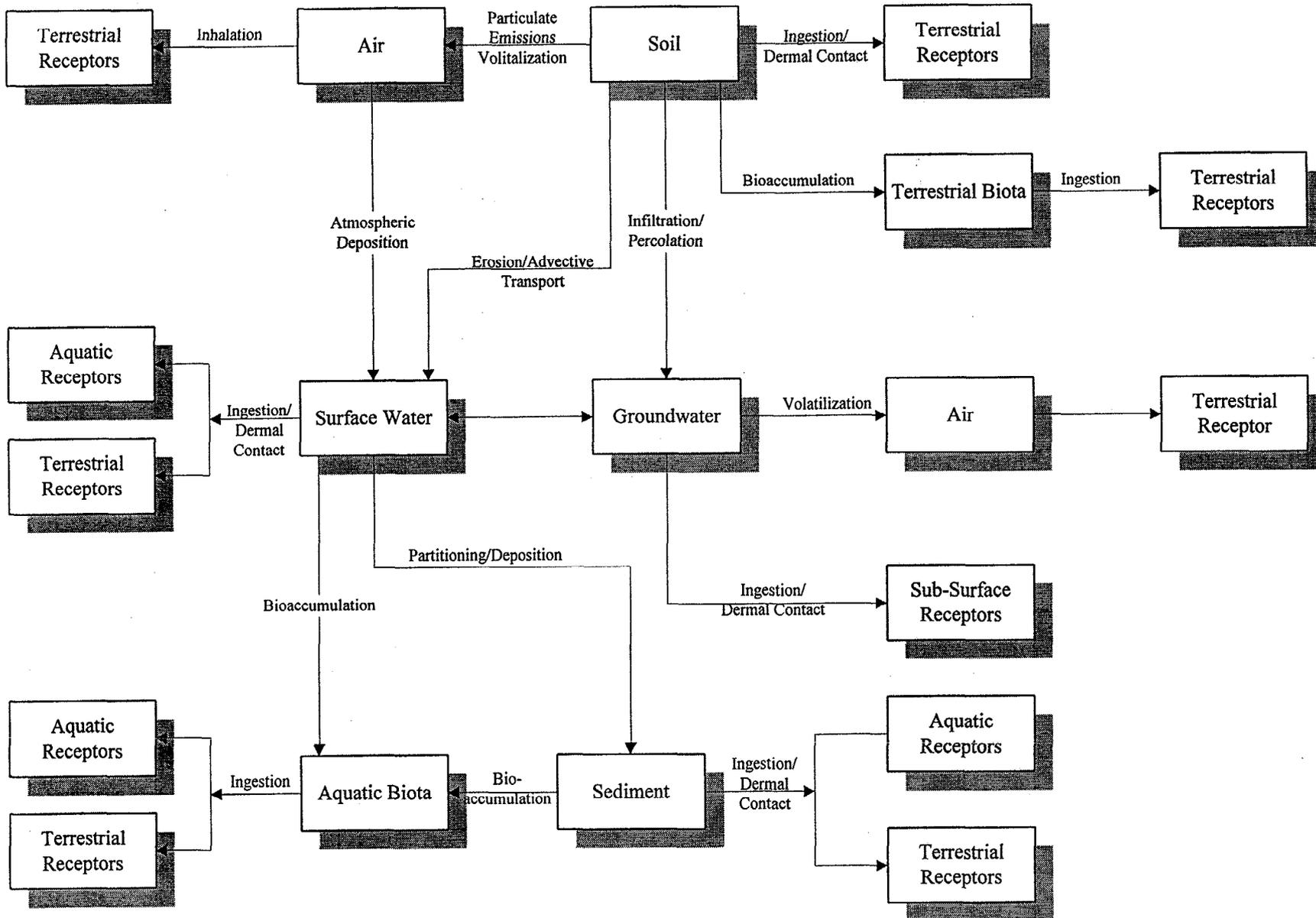
Notes:

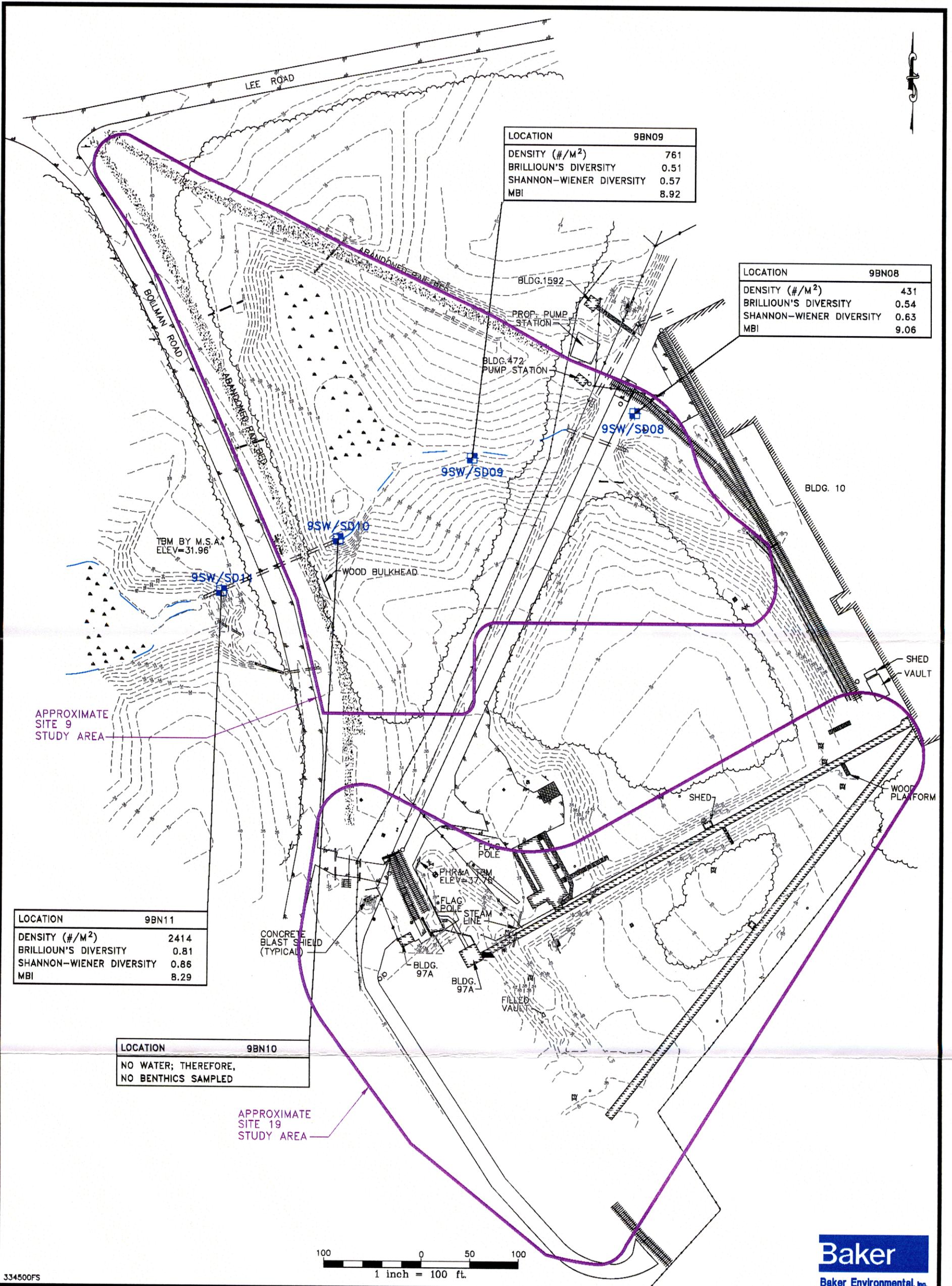
BSL USEPA Region III BTAG Screening Level
 ER-L Effects Range - Low
 ER-M Effects Range - Median
 NA Not Applicable

SECTION 7.0 FIGURES

FIGURE 7-1

POTENTIAL EXPOSURE PATHWAYS AND ECOLOGICAL RECEPTORS
SITES 9 AND 19
NAVAL WEAPONS STATION YORKTOWN
YORKTOWN, VIRGINIA



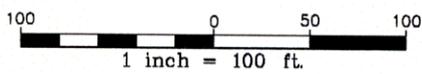


LOCATION	9BN09
DENSITY (#/M ²)	761
BRILLIOUN'S DIVERSITY	0.51
SHANNON-WIENER DIVERSITY	0.57
MBI	8.92

LOCATION	9BN08
DENSITY (#/M ²)	431
BRILLIOUN'S DIVERSITY	0.54
SHANNON-WIENER DIVERSITY	0.63
MBI	9.06

LOCATION	9BN11
DENSITY (#/M ²)	2414
BRILLIOUN'S DIVERSITY	0.81
SHANNON-WIENER DIVERSITY	0.86
MBI	8.29

LOCATION	9BN10
NO WATER; THEREFORE, NO BENTHICS SAMPLED	



334500FS

LEGEND

9SW/SD09 - SURFACE WATER, SEDIMENT, AND BENTHIC SAMPLING LOCATION

#/M² - NUMBER OF INDIVIDUALS PER SQUARE METER

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

FIGURE 7-2
ROUND TWO RI
SELECT BENTHIC
MACROINVERTEBRATE STATISTICS
SITE 9

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA

00889 B08V

8.0 SUMMARY AND CONCLUSIONS

The Round Two Remedial Investigation at Sites 9 and 19 was conducted to: (1) develop an RI report based on evaluation of Round One and Round Two field investigation results; (2) assess the nature and extent of contamination at each site and/or to identify data gaps preventing an adequate understanding of site conditions; and (3) assess potential human health and ecological risks associated with any contamination at Sites 9 and 19. To address data gaps from the Round One investigation, a second round of field investigation activities was carried out. These activities included installation of monitoring wells at both sites and collection of surface and subsurface soil, surface water, sediment, biota, and groundwater samples.

This section presents an itemized summary of the results of the Round Two RI for Sites 9 and 19. The summary is focused on the nature and extent of contamination at the sites in addition to the results of the baseline human health and ecological RAs. The significant findings of this investigation are presented in the following paragraphs. Following the summary are conclusions based on the results of the Round One and Round Two RIs and data obtained as part of the confirmation sampling conducted for the soil treatability study underway at WES. Limited conclusions have been made regarding Lee Pond; the scope for this investigation focused on source areas first. Investigations of Lee Pond will be undertaken at a later date.

8.1 Summary

8.1.1 Site 9

- PAHs and nitramines were detected in surface soil samples obtained near the drainage way that leads from Building 10 to Lee Pond. The highest levels of PAHs and nitramines were present at sample location 9HA06 at the bottom of the drainage way just above the area where debris and soil were removed in 1994. No VOCs were detected in surface soils at Site 9.

- PAHs were also detected in subsurface soil near the drainage way. Again, the highest levels were detected at location 9HA06. The nitramine compound 2,4,6-TNT was also detected at this particular location (33,000 µg/Kg) and other subsurface soil samples obtained near the Site 9 drainage way.
- PAHs were also detected in shallow and deep sediment samples obtained from the drainage way. These COPCs were present at concentrations similar to those detected in Site 9 surface soils.
- Nitramines were detected in the three surface water samples collected from the drainage way at Site 9. Five different nitramine compounds were detected at levels ranging from 0.44NJ (1,3,5-TNB) to 480 µg/L (2,4,6-TNT).
- During the Round Two RI, nitramines were detected in groundwater at location 9GW02 and 9GW02A. Compounds detected included 2,4,6-TNT (830 µg/L) and amino-DNTs (4400 µg/L) in the shallow well and 1,3,5-TNB (.79 µg/L) in the deep well.
- The total ICR values for the civilian adult workers at Site 9 fall within the target risk range the USEPA generally believes to be acceptable. HI values fall below 1.0, indicating that noncarcinogenic adverse human health risks will probably not occur.
- For the sake of conservatism, future residential development of Site 9 property and associated potential risks were evaluated. The ICR for the future residents (the sum total for children and adults) exceeded the USEPA's target risk range when using both the RME and central tendency (CT) exposure scenarios. This was primarily due to contaminants detected in shallow groundwater, particularly shallow well location 9GW02.
- The HI value derived using both the CT and RME for potential future residents at Site 9 was greater than 1.0, suggesting that noncarcinogenic adverse health effects may occur. Again, contamination in shallow groundwater detected at location 9GW02, was primarily responsible for the elevated HI value.

- Surface water concentrations of heptachlor epoxide; amino-DNTs; 2,6-DNT; HMX; 1,3,5-TNB; 2,4,6-TNB; cyanide; iron; and manganese have the potential to adversely impact the aquatic environment in the drainage way at Site 9. In addition, the benthic community in the drainage way may be adversely impacted by contaminants detected in the sediment. Sediment contaminants included PAHs; amino-DNT; 2,4-DNT; 2,4,6-TNT; arsenic; and iron. However, results of the aquatic survey at Site 9 are inconclusive because the drainage way is an intermittent stream. Apparent effects may reflect the natural stream conditions rather than site contaminants.
- Based on the data collected during the Round Two RI and the Terrestrial Daily Intake (TDI) modeling, there appears to be a potential risk to terrestrial receptors at Site 9. This risk is driven by the presence of PAHs, nitramines, and inorganics in surface soil samples.

8.1.2 Site 19

- The PAH benzo (a) pyrene and amino-DNTs were identified in surface soil samples collected at Site 19. Surface soil contamination was concentrated at the rail end of the conveyor and along the northwest side of the conveyor. Detections of aluminum above Station-wide background appear to correlate with the nitramine/nitroaromatic constituent detections in Site 19 surface soils.
- Amino-DNTs were detected in two subsurface soil locations at Site 19, both of which corresponded with surface soil detections of nitramines.
- Relatively low concentrations of nitramine compounds were detected in groundwater at the upper and lower ends of the conveyor and between the conveyor and Lee Pond. The highest concentrations were detected at location 19GW05 where amino DNTs were detected at 130 µg/L.

- The total ICR values for the on-site commercial adult workers fall within the target risk range the USEPA generally believes to be acceptable. HI values fall below 1.0, indicating that non-carcinogenic adverse human health risks will probably not occur.
- For the future residents, the total RME- and CT-derived ICR values were within USEPA's target risk range. The total RME- and CT-derived HI values were greater than 1.0 because of COPCs detected in samples obtained from well 19GW05. This suggests that noncarcinogenic adverse health effects may occur.
- The total ICR value derived for the future adult construction worker was within USEPA's generally acceptable target risk range. The HI value did not exceed unity; therefore, noncarcinogenic health effects are not expected to occur subsequent to exposure.
- Only the terrestrial ecosystem was addressed at Site 19. Overall, potential risk to the terrestrial environment is suggested by exceedences of soil toxicity values and results of the terrestrial uptake models.

8.2 Conclusions

8.2.1 Site 9

- At Site 9 contamination is confined to the drainage way from Building 10 to Lee Pond, based upon findings of the Round One and Round Two RIs and, to a lesser extent, the confirmation sampling for the treatability study (see Figure 8-1). Contaminants of concern include PAHs and nitramines found primarily in the soils. During the Round One RI, PAHs were detected at five out of six surface soil sampling locations at levels ranging from 19J $\mu\text{g}/\text{Kg}$ to 1,100 $\mu\text{g}/\text{Kg}$. Nitramines detected included 2,4,6-TNT; 2,4-DNT; and 1,3,5-TNB at levels ranging from 2,900 $\mu\text{g}/\text{Kg}$ to 2,100,000 $\mu\text{g}/\text{Kg}$.

During the Round Two RI, PAHs were detected in five surface soil sampling locations, all within the drainage way at levels ranging from 94J to 2,200 $\mu\text{g}/\text{Kg}$. The compound 2,4,6-TNT was detected in four of the five samples from locations within the drainage way at levels ranging from 210 to 540 $\mu\text{g}/\text{Kg}$.

The findings of the soil characterization study support this conclusion. During this study, composite samples were collected and analyzed for explosives. Two compounds, 2,4,6-TNT and amino-DNTs, were detected at relatively low levels ranging from 109 to 547 $\mu\text{g}/\text{Kg}$.

No discrete subsurface soil samples were collected during the Round One RI or the treatability study soil characterization. However, subsurface soil samples collected during the Round Two also show PAH and nitramine contamination (see Figure 8-2). PAHs were detected at levels ranging from 91J to 2,500 $\mu\text{g}/\text{Kg}$ in five samples of subsurface soil. Nitramines were detected in five samples; compounds included 2,4,6-TNT and amino-DNTs and were detected at levels ranging from 70J to 42,000NJ $\mu\text{g}/\text{Kg}$.

- Nitramines are also present in the surface water in the drainage way at Site 9. During the Round One RI, five nitramine compounds (HMX; RDX; 1,3,5-TNB; 2,4-DNT; 2,4,6-TNT) were detected at three locations in the drainage way at levels ranging from .29J to 370 $\mu\text{g}/\text{L}$. During the Round Two RI, nitramines were detected in all three surface water samples collected within the drainage way at levels ranging from 0.44 NJ to 480 $\mu\text{g}/\text{L}$. Surface water is probably not a primary source of contamination, but serves as a secondary source reflecting contamination by site soils. Because aquatic criteria are not available, it is difficult to quantify the effects of this surface water contamination.
- PAHs present in the sediments are probably site-related. PAH compounds were used during the loading process; in addition disposal of railroad ties in the drainage way may have contributed to PAH contamination. (These railroad ties have been removed.)

- Nitramines are present in the shallow groundwater at Site 9. This groundwater contamination could potentially be a result of past nitramine releases associated with loading operations in Building 10. Past practices may also explain the presence of nitramine contamination of surface and subsurface soils. Contamination of the shallow groundwater is driving the human health risk at Site 9.
- Ecological receptors at Site 9 could potentially be affected by PAHs, nitramines, and inorganics in the surface soils. Nitramines in the surface water may affect the aquatic environment. In addition, the drainage way is an intermittent stream. Apparent effects may actually reflect natural stream conditions.
- Because none of the site media could be excluded based on the results of the human health and/or ecological risk assessments, contamination in all media will be initially addressed in the Feasibility Study. Specifically, the FS at Site 9 will focus on PAH and nitramine contamination in soils and sediment and nitramine contamination in surface water and groundwater.

8.2.2 Site 19

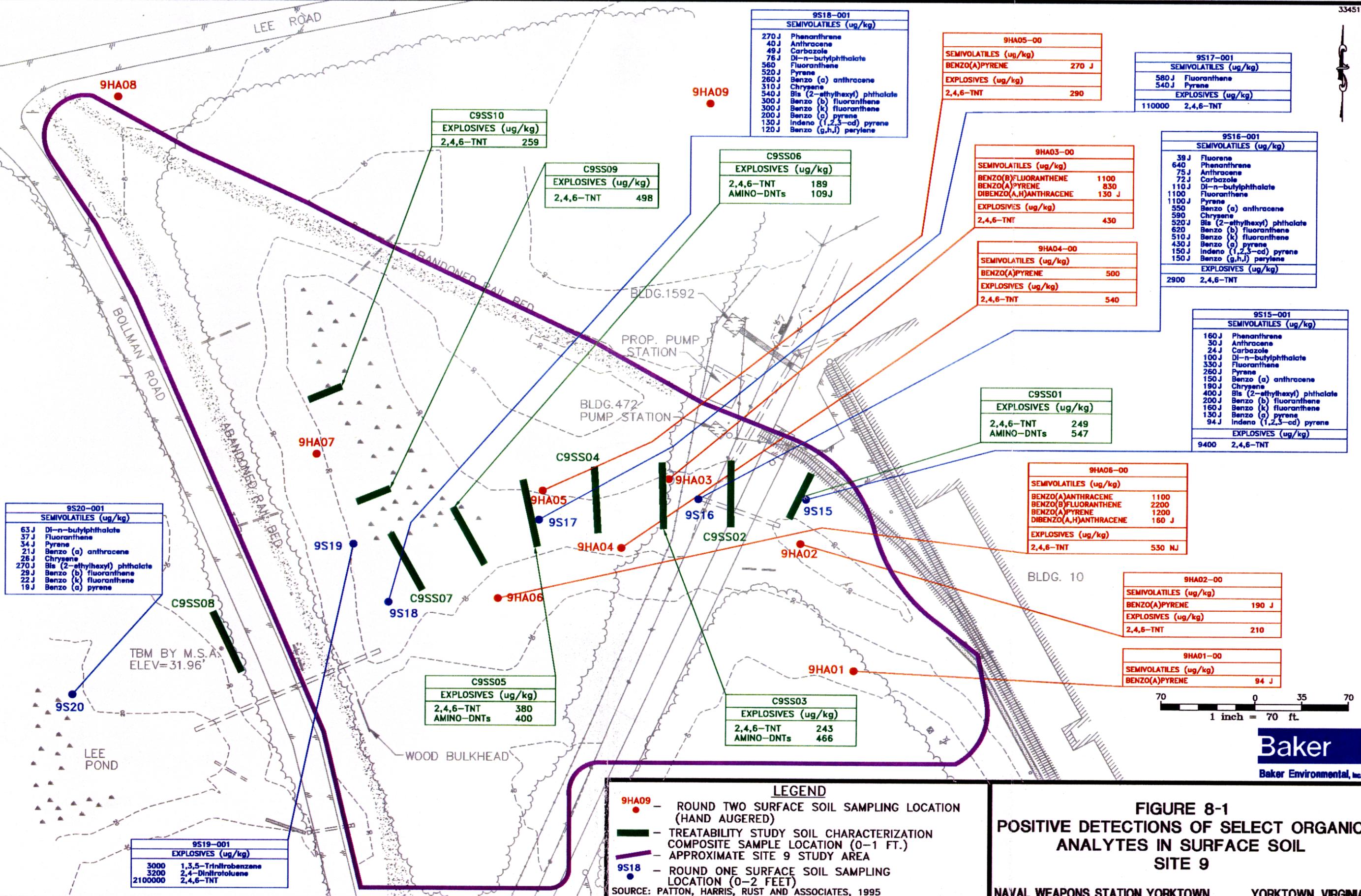
- Nitramines in the surface soils at Site 19 are the primary concern (see Figure 8-3). Nitramines are generally concentrated along the conveyor between the rail line and Building 10. During the Round One RI nitramines were detected in two locations. Four different compounds (1,3,5-TNB; 2,4,6-TNT; 2,4-DNT; and 2,6-DNT) were detected at levels ranging from 770J to 120,000 µg/Kg. Sampling locations for the Round Two RI were selected to provide additional information regarding nitramine contamination along the conveyor. Data from Round Two indicated that nitramines (2,4,6-TNT; amino-DNT) were found at five sampling locations at levels ranging from 130 to 2,100 µg/Kg. Soils collected during the characterization for the treatability study may provide the data most representative of site conditions. For this study, samples were collected across grids and composited. Three compounds

(2,4,6-TNT; HMX; amino-DNTs) were detected at levels ranging from 135 to 863,000 µg/Kg in 13 samples.

No discrete subsurface samples were collected at Site 19 during either the Round One RI or the characterization for the treatability study. However, subsurface soils were collected during the Round Two RI. Nitramines were detected in the subsurface soil at four locations. Two compounds were identified (2,4,6-TNT, amino-DNTs) at levels ranging from 1,000NJ to 8,200 µg/Kg.

- Nitramines may have migrated to the shallow groundwater from overlying soils. Nitramines were detected in one of the three samples obtained from monitoring wells installed at Site 19 during the Round One RI. The compounds 1,3,5-TNB and 2,4,6-TNT were detected at 1.3J µg/L and 5.1 µg/L respectively. During the Round Two RI, the existing wells were resampled and four new wells were installed. Nitramines were again detected in groundwater samples; samples from four wells exhibited nitramine compounds (TDX; amino-DNTs; 1,3,5-TNB; 2,4,6-TNT) at levels ranging from 0.77 to 130 µg/L. Nitramine contamination in the shallow groundwater is responsible for driving the future potential risk to residential receptors at Site 19.
- PAHs, nitramines, and inorganics may be affecting terrestrial ecological receptors at Site 19. Aquatic receptors are not present at the site.
- Because none of the site media could be excluded based on the results of the human health and/or ecological risk assessments, contamination in all media will be initially addressed in the Feasibility Study. Specifically, the FS at Site 19 will focus on nitramine contamination in soil and groundwater.

SECTION 8.0 FIGURES



9S20-001	
SEMIVOLATILES (ug/kg)	
63 J	Di-n-butylphthalate
37 J	Fluoranthene
34 J	Pyrene
21 J	Benzo (a) anthracene
26 J	Chrysene
270 J	Bis (2-ethylhexyl) phthalate
29 J	Benzo (b) fluoranthene
22 J	Benzo (k) fluoranthene
19 J	Benzo (a) pyrene

TBM BY M.S.A.
ELEV=31.96'

9S19-001	
EXPLOSIVES (ug/kg)	
3000	1,3,5-Trinitrobenzene
3200	2,4-Dinitrotoluene
2100000	2,4,6-TNT

C9SS05	
EXPLOSIVES (ug/kg)	
380	2,4,6-TNT
400	AMINO-DNTs

C9SS03	
EXPLOSIVES (ug/kg)	
243	2,4,6-TNT
466	AMINO-DNTs

C9SS10	
EXPLOSIVES (ug/kg)	
259	2,4,6-TNT

C9SS09	
EXPLOSIVES (ug/kg)	
498	2,4,6-TNT

C9SS06	
EXPLOSIVES (ug/kg)	
189	2,4,6-TNT
109 J	AMINO-DNTs

9S18-001	
SEMIVOLATILES (ug/kg)	
270 J	Phenanthrene
40 J	Anthracene
49 J	Carbazole
76 J	Di-n-butylphthalate
560	Fluoranthene
520 J	Pyrene
260 J	Benzo (a) anthracene
310 J	Chrysene
540 J	Bis (2-ethylhexyl) phthalate
300 J	Benzo (b) fluoranthene
300 J	Benzo (k) fluoranthene
200 J	Benzo (a) pyrene
130 J	Indeno (1,2,3-cd) pyrene
120 J	Benzo (g,h,i) perylene

9HA05-00	
SEMIVOLATILES (ug/kg)	
270 J	BENZO(A)PYRENE
290	EXPLOSIVES (ug/kg)
2,4,6-TNT	

9S17-001	
SEMIVOLATILES (ug/kg)	
580 J	Fluoranthene
540 J	Pyrene
110000	EXPLOSIVES (ug/kg)
2,4,6-TNT	

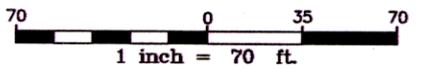
9S16-001	
SEMIVOLATILES (ug/kg)	
39 J	Fluorene
640	Phenanthrene
75 J	Anthracene
72 J	Carbazole
110 J	Di-n-butylphthalate
1100	Fluoranthene
1100 J	Pyrene
550	Benzo (a) anthracene
590	Chrysene
520 J	Bis (2-ethylhexyl) phthalate
620	Benzo (b) fluoranthene
510 J	Benzo (k) fluoranthene
430 J	Benzo (a) pyrene
150 J	Indeno (1,2,3-cd) pyrene
150 J	Benzo (g,h,i) perylene
2900	EXPLOSIVES (ug/kg)
2,4,6-TNT	

9S15-001	
SEMIVOLATILES (ug/kg)	
160 J	Phenanthrene
30 J	Anthracene
24 J	Carbazole
100 J	Di-n-butylphthalate
330 J	Fluoranthene
260 J	Pyrene
150 J	Benzo (a) anthracene
180 J	Chrysene
400 J	Bis (2-ethylhexyl) phthalate
200 J	Benzo (b) fluoranthene
160 J	Benzo (k) fluoranthene
130 J	Benzo (a) pyrene
94 J	Indeno (1,2,3-cd) pyrene
9400	EXPLOSIVES (ug/kg)
2,4,6-TNT	

9HA06-00	
SEMIVOLATILES (ug/kg)	
1100	BENZO(A)ANTHRACENE
2200	BENZO(B)FLUORANTHENE
1200	BENZO(A)PYRENE
160 J	DIBENZO(A,H)ANTHRACENE
530 NJ	EXPLOSIVES (ug/kg)
2,4,6-TNT	

9HA02-00	
SEMIVOLATILES (ug/kg)	
190 J	BENZO(A)PYRENE
210	EXPLOSIVES (ug/kg)
2,4,6-TNT	

9HA01-00	
SEMIVOLATILES (ug/kg)	
94 J	BENZO(A)PYRENE

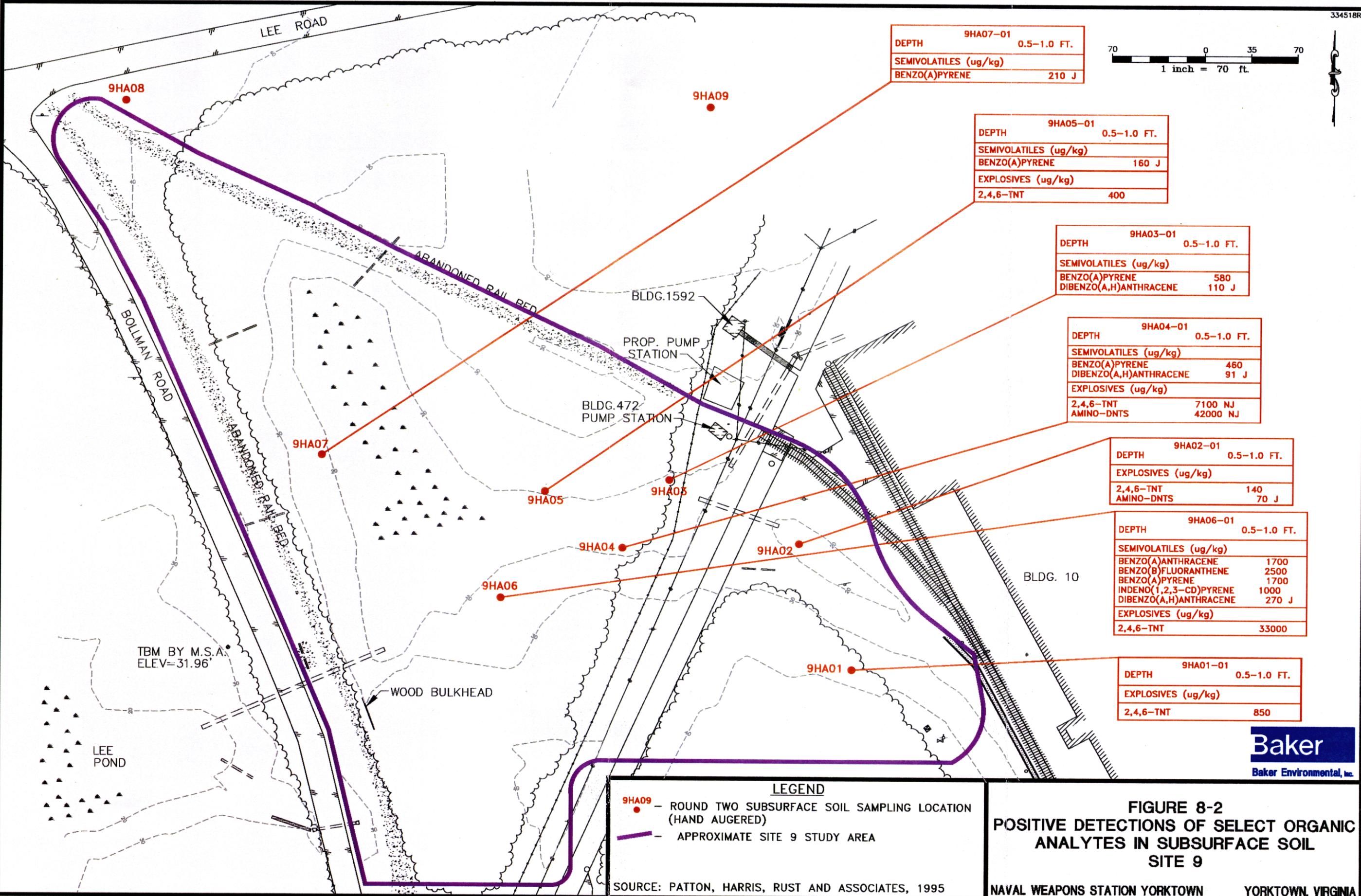


LEGEND

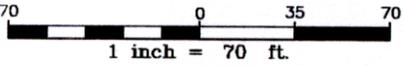
- 9HA09 - ROUND TWO SURFACE SOIL SAMPLING LOCATION (HAND AUGERED)
- █ - TREATABILITY STUDY SOIL CHARACTERIZATION COMPOSITE SAMPLE LOCATION (0-1 FT.)
- APPROXIMATE SITE 9 STUDY AREA
- 9S18 - ROUND ONE SURFACE SOIL SAMPLING LOCATION (0-2 FEET)

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

FIGURE 8-1
POSITIVE DETECTIONS OF SELECT ORGANIC ANALYTES IN SURFACE SOIL
SITE 9
 NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA



DEPTH	9HA07-01	0.5-1.0 FT.
SEMIVOLATILES (ug/kg)		
BENZO(A)PYRENE		210 J



DEPTH	9HA05-01	0.5-1.0 FT.
SEMIVOLATILES (ug/kg)		
BENZO(A)PYRENE		160 J
EXPLOSIVES (ug/kg)		
2,4,6-TNT		400

DEPTH	9HA03-01	0.5-1.0 FT.
SEMIVOLATILES (ug/kg)		
BENZO(A)PYRENE		580
DIBENZO(A,H)ANTHRACENE		110 J

DEPTH	9HA04-01	0.5-1.0 FT.
SEMIVOLATILES (ug/kg)		
BENZO(A)PYRENE		460
DIBENZO(A,H)ANTHRACENE		91 J
EXPLOSIVES (ug/kg)		
2,4,6-TNT		7100 NJ
AMINO-DNTS		42000 NJ

DEPTH	9HA02-01	0.5-1.0 FT.
EXPLOSIVES (ug/kg)		
2,4,6-TNT		140
AMINO-DNTS		70 J

DEPTH	9HA06-01	0.5-1.0 FT.
SEMIVOLATILES (ug/kg)		
BENZO(A)ANTHRACENE		1700
BENZO(B)FLUORANTHENE		2500
BENZO(A)PYRENE		1700
INDENO(1,2,3-CD)PYRENE		1000
DIBENZO(A,H)ANTHRACENE		270 J
EXPLOSIVES (ug/kg)		
2,4,6-TNT		33000

DEPTH	9HA01-01	0.5-1.0 FT.
EXPLOSIVES (ug/kg)		
2,4,6-TNT		850

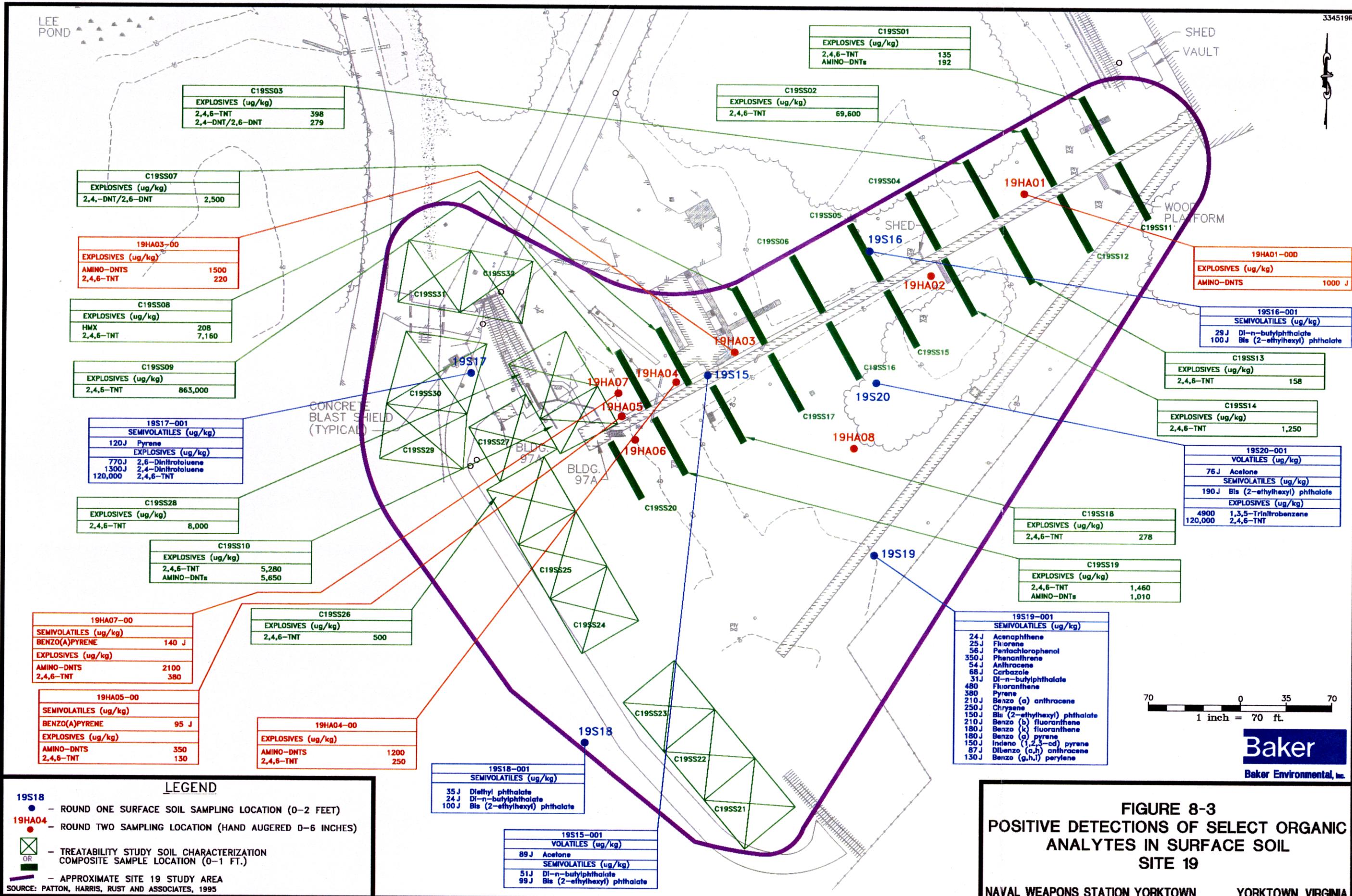
LEGEND
 ● 9HA09 - ROUND TWO SUBSURFACE SOIL SAMPLING LOCATION (HAND AUGERED)
 — APPROXIMATE SITE 9 STUDY AREA

FIGURE 8-2
POSITIVE DETECTIONS OF SELECT ORGANIC ANALYTES IN SUBSURFACE SOIL
SITE 9

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

NAVAL WEAPONS STATION YORKTOWN YORKTOWN, VIRGINIA





C19SS03	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	398
2,4-DNT/2,6-DNT	279

C19SS01	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	135
AMINO-DNTs	192

C19SS02	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	69,600

C19SS07	
EXPLOSIVES (ug/kg)	
2,4-DNT/2,6-DNT	2,500

19HA03-00	
EXPLOSIVES (ug/kg)	
AMINO-DNTs	1500
2,4,6-TNT	220

C19SS08	
EXPLOSIVES (ug/kg)	
HMX	208
2,4,6-TNT	7,160

C19SS09	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	863,000

19S17-001	
SEMIVOLATILES (ug/kg)	
120 J Pyrene	
EXPLOSIVES (ug/kg)	
770 J 2,6-Dinitrotoluene	
1300 J 2,4-Dinitrotoluene	
120,000 2,4,6-TNT	

C19SS28	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	8,000

C19SS10	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	5,280
AMINO-DNTs	5,650

19HA07-00	
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	140 J
EXPLOSIVES (ug/kg)	
AMINO-DNTs	2100
2,4,6-TNT	380

C19SS26	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	500

19HA05-00	
SEMIVOLATILES (ug/kg)	
BENZO(A)PYRENE	95 J
EXPLOSIVES (ug/kg)	
AMINO-DNTs	350
2,4,6-TNT	130

19HA04-00	
EXPLOSIVES (ug/kg)	
AMINO-DNTs	1200
2,4,6-TNT	250

19S18-001	
SEMIVOLATILES (ug/kg)	
35 J Diethyl phthalate	
24 J Di-n-butylphthalate	
100 J Bis (2-ethylhexyl) phthalate	

19S15-001	
VOLATILES (ug/kg)	
89 J Acetone	
SEMIVOLATILES (ug/kg)	
51 J Di-n-butylphthalate	
99 J Bis (2-ethylhexyl) phthalate	

C19SS18	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	278

C19SS19	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	1,460
AMINO-DNTs	1,010

19S19-001	
SEMIVOLATILES (ug/kg)	
24 J Acenaphthene	
25 J Fluorene	
56 J Pentachlorophenol	
350 J Phenanthrene	
54 J Anthracene	
68 J Carbazole	
31 J Di-n-butylphthalate	
480 Fluoranthene	
380 Pyrene	
210 J Benzo (a) anthracene	
250 J Chrysene	
150 J Bis (2-ethylhexyl) phthalate	
210 J Benzo (b) fluoranthene	
180 J Benzo (k) fluoranthene	
180 J Benzo (g) pyrene	
150 J Indeno (1,2,3-cd) pyrene	
87 J Dibenzo (a,h) anthracene	
130 J Benzo (g,h,i) perylene	

19HA01-000	
EXPLOSIVES (ug/kg)	
AMINO-DNTs	1000 J

19S16-001	
SEMIVOLATILES (ug/kg)	
29 J Di-n-butylphthalate	
100 J Bis (2-ethylhexyl) phthalate	

C19SS13	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	158

C19SS14	
EXPLOSIVES (ug/kg)	
2,4,6-TNT	1,250

19S20-001	
VOLATILES (ug/kg)	
76 J Acetone	
SEMIVOLATILES (ug/kg)	
190 J Bis (2-ethylhexyl) phthalate	
EXPLOSIVES (ug/kg)	
4900 1,3,5-Trinitrobenzene	
120,000 2,4,6-TNT	

LEGEND

- 19S18 ● - ROUND ONE SURFACE SOIL SAMPLING LOCATION (0-2 FEET)
 - 19HA04 ● - ROUND TWO SAMPLING LOCATION (HAND AUGERED 0-6 INCHES)
 - ⊗ - TREATABILITY STUDY SOIL CHARACTERIZATION COMPOSITE SAMPLE LOCATION (0-1 FT.)
 - OR
 - APPROXIMATE SITE 19 STUDY AREA
- SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

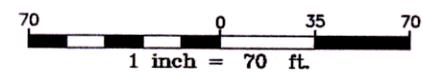
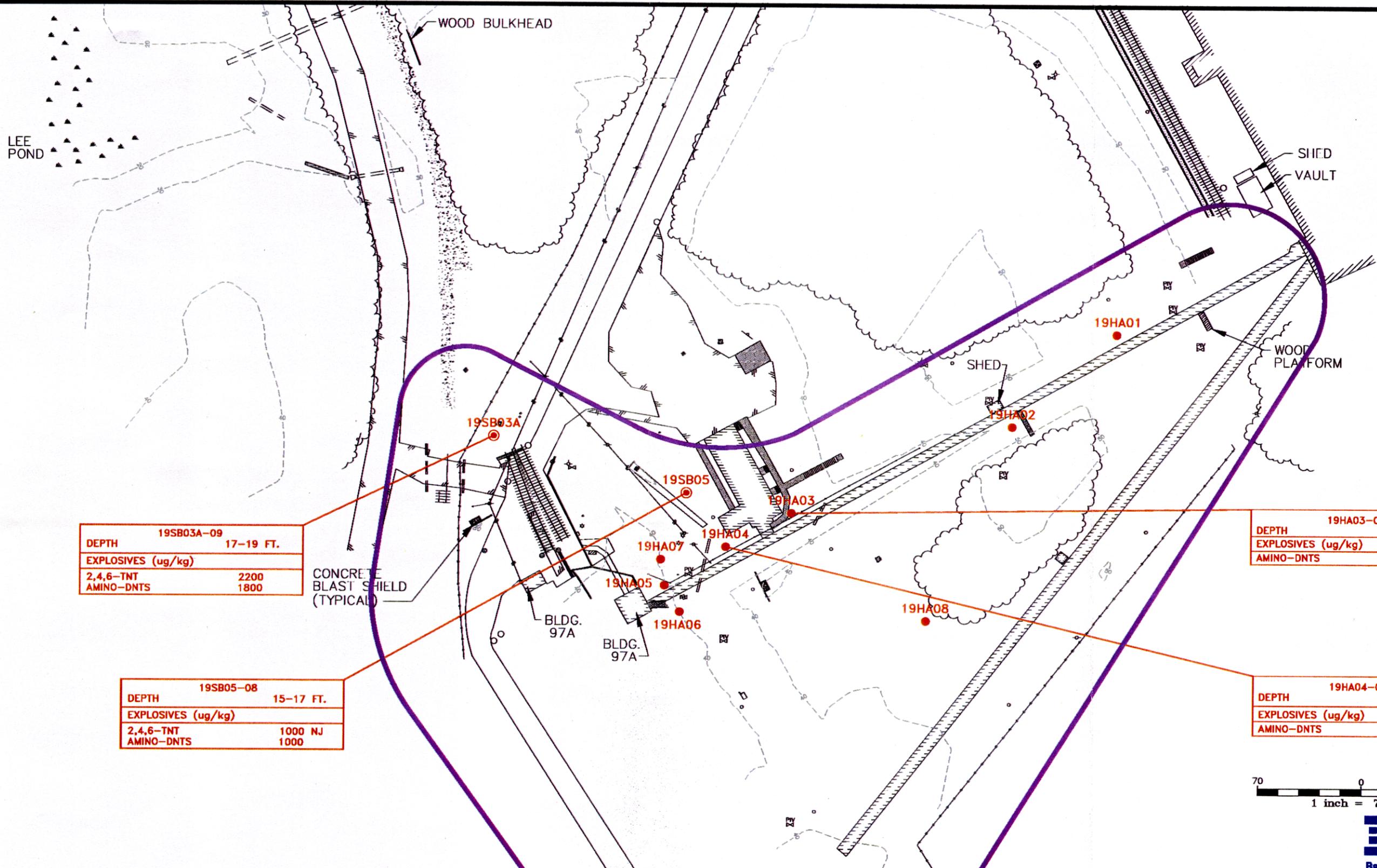


FIGURE 8-3
POSITIVE DETECTIONS OF SELECT ORGANIC ANALYTES IN SURFACE SOIL
SITE 19



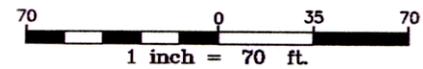
19SB03A-09	
DEPTH	17-19 FT.
EXPLOSIVES (ug/kg)	
2,4,6-TNT	2200
AMINO-DNTS	1800

CONCRETE BLAST SHIELD (TYPICAL)

19HA03-02	
DEPTH	2.0-4.0 FT.
EXPLOSIVES (ug/kg)	
AMINO-DNTS	8200

19SB05-08	
DEPTH	15-17 FT.
EXPLOSIVES (ug/kg)	
2,4,6-TNT	1000 NJ
AMINO-DNTS	1000

19HA04-02	
DEPTH	2.0-4.0 FT.
EXPLOSIVES (ug/kg)	
AMINO-DNTS	1200



- LEGEND**
- 19HA04 - ROUND TWO SUBSURFACE SOIL SAMPLING LOCATION (HAND AUGERED)
 - ⊙ 19SB03A - SOIL BORING/MONITORING WELL LOCATION
 - APPROXIMATE SITE 19 STUDY AREA

SOURCE: PATTON, HARRIS, RUST AND ASSOCIATES, 1995

FIGURE 8-4
POSITIVE DETECTIONS OF SELECT ORGANIC ANALYTES IN SUBSURFACE SOIL
SITE 19