Comprehensive Long-term Environmental Action Navy

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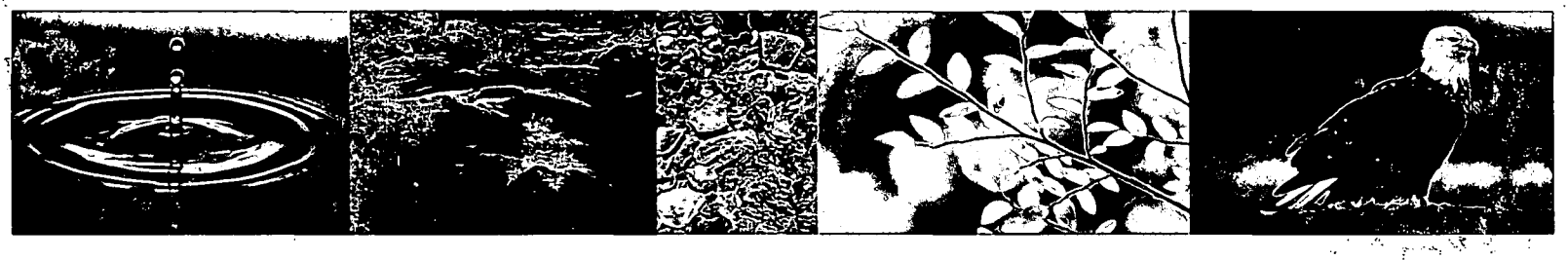

Rev. 0

Corrective Measures Proposal
for
Solid Waste Management Unit 3 (Ammunition Burning Grounds)

Volume I - Text

Naval Surface Warfare Center
Crane, Indiana

Contract Task Order 0311

July 2006

NAVFAC
Naval Facilities Engineering Command
Southeast
2155 Eagle Drive
North Charleston, South Carolina 29406

TETRA TECH NUS, Inc.

Plan copy

DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
300 HIGHWAY 361
CRANE INDIANA 47522-5001

IN REPLY REFER TO

5090/S4.7.5
Ser PRCR4/6193
4 AUG 2006

U.S. Environmental Protection Agency, Region V
Waste, Pesticides, & Toxics Division
Waste Management Branch
Corrective Action Section
77 West Jackson Blvd.
Chicago, IL 60604

Dear Mr. Ramanauskas:

Crane Division, Naval Surface Warfare Center submits the Draft Corrective Measures Proposal (CMP) for the Ammunition Burning Grounds (ABG), Solid Waste Management Unit 03. One copy is presented as enclosure (1) for your review. The permit required Certification Statement is provided as enclosure (2).

If you require any further information, my point of contact is Mr. Thomas J. Brent, Code PRCR4-TB, at 812-854-6160, email thomas.brent@navy.mil.

Sincerely,

J. M. Hunsicker
J. M. HUNSICKER
Environmental Site Manager
By direction of the Commanding Officer

Enclosures: 1. Draft ABG CMP
2. Certification Statement

Copy to:
ADMINISTRATIVE RECORD
SOUTHNAVFACENGCOM (Code ES31) (w/o encl)
IDEM (Doug Griffin)
TTNUS (Ralph Basinski) (w/o encl)
NAVFAC MW (Howard Hickey)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

James Hunsuck

SIGNATURE

Manager, Environmental Protection

TITLE

6/26/06

DATE

REVISION 0
JULY 2006

CORRECTIVE MEASURES PROPOSAL
FOR
SOLID WASTE MANAGEMENT UNIT 3
(AMMUNITION BURNING GROUNDS)

VOLUME I – TEXT

NAVAL SURFACE WARFARE CENTER, CRANE
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Naval Facilities Engineering Command
Southeast
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:
Tetra Tech NUS, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220

CONTRACT NUMBER N62467-94-D-0888
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July 2006

PREPARED UNDER THE SUPERVISION OF:

RALPH R. BASINSKI, QEP
TASK ORDER MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

APPROVED FOR SUBMITTAL BY:

DEBRA M. HUMBERT
PROGRAM MANAGER
TETRA TECH NUS, INC.
PITTSBURGH, PENNSYLVANIA

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ACRONYMS

°F	Degrees Fahrenheit
µg/L	Micrograms per liter
2A-DNT	2-amino-4,6-dinitrotoluene
4A-DNT	4-amino-2,6-dinitrotoluene
ABG	Ammunition Burning Grounds
AET	Apparent Effects Threshold
AUF	Area use factor
BC/BC	Big Clifty Sandstone/Beech Creek Limestone
bgs	Below ground surface
CAAA	Crane Army Ammunition Activity
CAC	Chromic aquatic criterion
CCCRA	Current Contamination Conditions Risk Assessment
CEC	Cation exchange capacity
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CM	Corrective Measure
CMP	Corrective Measures Proposal
COC	Chemical of concern
COPC	Chemical of potential concern
CTO	Contract Task Order
DBG	Dye Burial Grounds
DCE	Dchloroethene
DNT	2,4-dinitrotoluene
EDQL	Ecological Data Quality Level
EEQ	Ecological Effect Quotient
EMR	Environmental Monitoring Report
EPT	Ephemeroptera, Plecoptera, Trichoptera
ERA	Ecological Risk Assessment
Ft^3/s	Cubic feet per second
G-H	Golconda-Haney
gpm	Gallons per minute
HEAST	Health Effects Assessment Summary Table
HHRA	Human health risk assessment

HHRSE	Human health risk screening evaluation
HI	Hazard index
HMX	Cyclotetramethylenetetranitramine
IAC	Indiana Administrative Code
IAS	Initial Assessment Study
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
ILCR	Incremental Lifetime Cancer Risk
in/yr	Inches per year
IR	Installation Restoration
IRIS	Integrated Risk Information System
LSC	Little Sulfur Creek
LTM	Long-term monitoring
LUC	Land use control
MCL	Maximum Concentration Level
MCS	Media cleanup standard
mg/kg	Milligram(s) per kilogram
mph	Miles per hour
msl	Mean sea level
MTA	Main Treatment Area
NAD	Naval Ammunition Depot
NAVFAC EFD SOUTH	Naval Facilities Engineering Command, Engineering Field Division South
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No-Observable-Adverse-Effects Level
NPDES	National Pollution Discharge Elimination System
NPW	Net present worth
NSWC	Naval Surface Warfare Center
NTU	Nephelometric turbidity unit
NWSC	Naval Weapons Support Center
O&M	Operation and maintenance
OJT	Old Jeep Trail
OSWER	Office of Solid Waste and Emergency Response
PBT	Persistent, bioaccumulative, and toxic
PCA	Tetrachloroethane
PPE	Personal protective equipment

PRG	Preliminary Remediation Goal
QAPP	Quality Assurance Project Plan
RAB	Restoration Advisory Board
RBTL	Risk-based target level
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SDWA	Safe Drinking Water Act
SSL	Soil screening level
SVOCs	Semivolatile organic compounds
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCA	Trichloroethane
TCE	Trichloroethylene
TLSC	Terrestrial life cycle safe concentration
TNT	2,4,6-Trinitrotoluene
TOC	Total organic carbon
TtNUS	Tetra Tech NUS, Inc.
U.S. EPA	United States Environmental Protection Agency
U.S.	United States
USACE	United States Army Corps of Engineers
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UST	Underground storage tank
VOC	Volatile organic compound
WES	Water Experiment Station
WQBEL	Water quality-based effluent limitation
WQC	Water quality criteria
WQS	Water quality standard

1.0 INTRODUCTION

1.1 SCOPE AND OBJECTIVES

This Corrective Measures Proposal (CMP) Report was prepared for the solid waste management unit (SWMU) 3 [Ammunition Burning Grounds (ABG)] at the Naval Surface Warfare Center (NSWC) facility located in Crane, Indiana for the United States (U.S.) Navy Naval Facilities Engineering Command, Engineering Field Division South (NAVFAC EFD SOUTH) under Contract Task Order (CTO) 0311, of the Comprehensive Long-Term Environmental Action Navy (CLEAN) 3, Contract Number N62467-94-D-0888. For the purpose of this report, SWMU 3 consists of the Main Treatment Area (MTA), Old Jeep Trail (OJT), and Little Sulfur Creek (LSC).

This work is part of the Navy's Installation Restoration (IR) Program, which is designed to identify contamination of Navy and Marine Corps lands/facilities resulting from past operations and to institute corrective measures (CMs), as needed. There are typically four distinct phases. Phase 1 is the Preliminary Assessment [formerly known as the Initial Assessment Study (IAS)]. Phase 2 is a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA), which augments the information collected in the Preliminary Assessment). Phase 3 is the RCRA Facility Investigation (RFI)/CMP, which characterizes the contamination at a facility and develops options for remediation of the site. Phase 4 is the Corrective Measures Implementation, which results in the control or cleanup of contamination at the sites. This report has been prepared under Phase 3. The Indiana Department of Environmental Management (IDEM) is the lead oversight agency. However, under a work-sharing agreement, U.S. Environmental Protection Agency (U.S. EPA) Region 5 is responsible for the RFI/CMP phases at SWMU 3.

This work was conducted in accordance with the requirements of the Indiana State RCRA Hazardous Waste Permit for the facility (IN5170023498), which went into effect on October 18, 2001.

The submittal of a CMP is appropriate for SWMU 3 based upon the following:

- NSWC Crane is a fenced military installation controlled by the Navy.
- NSWC Crane was not included in the 2005 Base Realignment and Closure (BRAC) process and will remain a military installation for the indefinite future.

- Foreseeable land uses are military (i.e., industrial).

- Residential land uses occur only in very limited areas, none of which are located within or adjacent to SWMU 3.

The objectives of the CMP are as follows:

- Identify risk-based action levels that are protective of current human health receptors and the environment.
- Identify and screen corrective measures technologies.
- Develop CMs.

The MTA is permitted by U.S. EPA Region 5 as a treatment facility for hazardous waste munitions, explosives, and pyrotechnics and is subject to the groundwater monitoring and corrective action requirements of 40 Code of Federal Regulations (CFR) 264, Subpart F (i.e., the MTA is an active RCRA-permitted hazardous waste treatment facility). These regulations require corrective actions for any groundwater contamination resulting from the treatment operations. Additionally, all RCRA-permitted facilities are subject to RCRA closure requirements; therefore, at the end of the active life of the MTA, the MTA is required to either be clean closed or closed as a RCRA landfill. For the MTA, the CMP address risks to current receptors (i.e., site worker, construction worker, surface water, and trespasser).

RFI studies had been conducted by the U.S. Army Corps of Engineers (USACE) for groundwater, soils, and surface waters at the MTA. These studies recommended that corrective measures be considered to address explosives, chlorinated solvent, and metals contamination in soils, groundwater, and surface waters (Murphy, 1994; Murphy and Wade, 1998; Albertson et al., 1998).

The OJT portion of SWMU 3 is currently inactive. The RFI Report for the OJT and LSC recommended that a CMP be conducted to address explosives, chlorinated solvent, and metals contamination in groundwater and soils at the OJT (TtNUS, 2005a).

A draft Conceptual Site Model and Fieldwork Report was developed for SWMU 3 (TtNUS, 2005b). The Field Report portion of the Conceptual Site Model and Fieldwork Report describes and documents the site investigation activities conducted in April 2004 and presents the results and interpretation thereof for SWMU 3. The Conceptual Site Model portion of the draft Conceptual Site Model and Fieldwork Report describes the geology, hydrology, groundwater contamination sources, and fate and transport of

contamination and is the basis for developing, evaluating, and choosing the corrective measures presented in this CMP.

1.2 ORGANIZATION OF THE CMP

The CMP consists of four sections. Section 1.0 is this introduction. Section 2.0 provides a description of the current situation and presents the media cleanup standards (MCSs) for SWMU 3. Section 3.0 describes the CM recommendations. Section 4.0 provides the details of the CM evaluations for the CMs that were considered and the conclusions of the evaluations.

1.3 ACTIVITY BACKGROUND INFORMATION

1.3.1 Location

1.3.1.1 Facility

SWMU 3 is located in the eastern portion of NSWC Crane along LSC. NSWC Crane is located in a rural, sparsely populated region of south-central Indiana, approximately 75 miles southwest of Indianapolis and 71 miles northwest of Louisville, Kentucky (Figure 1-1) immediately east of Crane Village and Burns City. NSWC Crane encompasses 62,463 acres (approximately 98 square miles), most of which is located in the northern portion of Martin County. Smaller portions are located in Greene, Daviess, and Lawrence Counties. Most of NSWC Crane is forested, and the surrounding area is wooded or farmed land.

1.3.1.2 MTA, OJT, and LSC

SWMU 3 is located in the eastern portion of NSWC Crane (Figure 1-2). The MTA portion of the SWMU 3 is located at the headwaters of LSC (Figure 1-3). The OJT (Jeep Trail 25) area is located in the valley of LSC, approximately one-half mile south-southeast of the MTA (Figure 1-3).

1.3.2 Facility History

This section provides general information on the history of NSWC Crane and its activities.

1.3.2.1 History of Ownership and Operation

The NSWC Crane facility was commissioned on December 1, 1941 as the Naval Ammunition Depot (NAD), Burns City. Its initial mission was to prepare, load, renovate, receive, store, and issue all types of ammunition, including pyrotechnics and illuminating projectiles, and act as a principal supply source at a

critical time during the early days of World War II. In May 1943, the depot was renamed the Naval Ammunition Depot Crane, in honor of Commodore William Montgomery Crane, the Navy's first chief of the Bureau of Ordnance. The name changed again in 1975 to the Naval Weapons Support Center (NWSC) Crane to reflect the facility's growing involvement in high-technology weapons systems. In 1977, the Secretary of Defense combined all conventional ammunition acquisition under the responsibility of a single service. The ammunition production and storage function was given to the Army, and the Crane Army Ammunition Activity (CAAA) was established as a Crane tenant to accomplish this task for Naval ammunition. In 1992, the facility name was changed to NSWC Crane. Information regarding operations conducted at the ABG MTA and the OJT is provided in Sections 1.3.1.2 and 1.3.1.3.

1.3.2.2 MTA Operations

1.3.2.2.1 Historical and Present Day Operations

The MTA portion of SWMU 3 is used extensively to destroy unwanted materials contaminated with explosives and related materials. Several separate treatment units are located within the site (Figure 1-4). The largest quantities of materials were treated from 1956 to 1960, when 15,000 pounds per day of smokeless powder were flashed. In the same period, about 46,000 pounds per day of high explosives were burned.

Prior to the construction and use of clay-lined steel pans for open burning operations, explosives, propellants, and materials contaminated with explosives and propellants were spread and ignited on unlined pads or in pits. Many of these burn pads and pits were reportedly located in the area now occupied by the clay-lined steel burn pans (see Unit No. 3 on Figure 1-4). However, others were located throughout the MTA.

Three unlined surface impoundments were used to remove liquids from otherwise combustible sludges resulting from the blending and loading of munitions. In 1982, each impoundment was modified to include a liner and leachate collection system. Each of the impoundments was approximately 40 feet in diameter. Two impoundments held 2,4,6-trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and breakdown compounds in water from a facility munitions plant (Rockeye) and other locations within NSWC Crane. A third impoundment held phosphorus compounds. The three impoundments have been replaced by dewatering units (see Units 10 and 11 on Figure 1-4). The impoundments are now empty and are scheduled for closure.

Two empty underground storage tanks (USTs) were used to store runoff and leachate from the three former impoundments. One tank was located immediately east of the phosphorus impoundment. The other tank contained runoff from the two adjacent TNT and RDX impoundments. The tanks were removed in 1994.

The "ash pile" area (Figure 1-4) was the site of a former stockpile of burn residue. The pile, which consisted of approximately 12,290 pounds of burn residue, was removed between July 1986 and February 1987, pursuant to a RCRA closure plan.

Prior to approximately 1985, pink water sludge was placed and burned in an unlined pit in the location of the pink water tanks (see Unit Nos. 14 on Figure 1-4). The pink color of the water and sludge was caused by the presence of explosives and related chemicals. This flashing process was relocated to the burn pads in approximately 1985.

The former primer burn box was used for thermal treatment of ammunition components (for example, small impact-sensitive primers) and pyrotechnic munitions. The burn box has been decommissioned, and these activities are now performed at the primer pits and the incendiary cage (see Units Nos. 12 and 13, respectively, on Figure 1-4).

No treatment operations have taken place on the ground surface since the 1980s; all current treatment operations take place in containment facilities. The following operations currently occur at the MTA. The locations of many of these MTA activities are shown on Figure 1-4 as noted below.

- Solid bulk propellant and explosives are open burned in 18 clay-lined steel pans at the ABG Main Burn Pan Grid (Unit No. 3).

- The primer pit operation (Unit No. 12) involves treatment of small explosive components such as hand grenade fuses and cartridge primers.

- Solvents contaminated with propellants, explosives, and pyrotechnics are burned in one unlined steel pan (Unit No. 5).

- Waste scrap pyrotechnics, which have been desensitized in No. 2 fuel oil, are burned in a second unlined steel pan (Unit No. 7).

- A third pan is used to burn scrap black powder desensitized with water (Unit No. 8).

- Two sets of four pans each are used at Unit No. 6 for the treatment of a waste mixture containing red phosphorus and No. 2 fuel oil.

- The incendiary cage (Unit No. 13) is set up primarily to allow the open burning of pyrotechnic devices and components.

- The flashing and thermal treatment of suspect explosives-contaminated materials is carried out at three concrete-lined burn pads (Unit No. 9).

- Explosives- and pyrotechnic-contaminated sludges from production operations are treated at three sludge burning pans (Unit Nos. 10 and 11). Cyclotetramethylenetetranitramine (HMX)-contaminated sludge and phosphorus-contaminated sludge are currently burned at this unit.

1.3.2.2.2 Regulatory Status

In November 1988, the MTA was granted RCRA interim status. On December 23, 1989, the MTA RCRA interim status was terminated because the MTA RCRA operating permit went into effect.

The RCRA operating permit includes the following:

- Strict operating conditions including the requirement that treatment only take place in containment.
- Procedural requirements for inspection of the surrounding area as well as removal of any material generated during the open burning operations.
- Strict groundwater monitoring requirements.
- Upon suspension of operations, the MTA must undergo RCRA closure requirements.

The MTA RCRA operating permit closure requirements state that all hazardous wastes and hazardous constituents must be either:

- "Clean closed" (i.e., shipped off site to a permitted RCRA treatment, storage, and/or disposal facility) or

- "Closure in place" (i.e., the on-site containment of all the hazardous wastes in a RCRA landfill with ongoing groundwater monitoring of the site).

1.3.2.3 OJT

The OJT is an inactive area that is adjacent to and downstream in the LSC valley (south-southeast) of the MTA. Former operations at the OJT were directly associated with operations at the MTA. The OJT area was used to burn out bombs and flash powder from the mid-1970s through 1983. The area was also used to flash the residue from bombs and projectiles after they had been subject to melt-out or drill-out operations to remove the bulk of the explosives (Murphy, 1994). Materials were treated at two separate regions (the burn area and the burn pit). The term "pit" may be a misnomer because it is believed that the area was more of a natural topographic depression than an excavated pit. The approximate locations of these two areas are shown on Figure 1-5. At the burn area, bomb casings from which the bulk explosives had been removed were filled with initiating powder, tilted on-end toward a hillside east of the OJT, and flashed to complete the demilitarization process. Some munitions are thought to have been lashed to a horizontally positioned utility pole (that may have been creosote treated) prior to flashing.

The burn pit was a trench or natural depression, approximately 100 feet long, 30 feet wide, and 10 to 12 feet deep, located just south-southeast of the burn area (Figure 1-5). Powder was flashed and explosives-contaminated materials were burned in this pit. The contaminated material may have included cardboard, paper, wood, and metal packaging that may have come into contact with explosives, solvent-contaminated rags, and/or any other material that may have been contaminated with explosives. Some of the wooden packaging material may have contained pentachlorophenol. Small munitions items and components were also reportedly treated in the burn pits. The area has not been used for any operations since 1983 when it was filled with clean fill material and revegetated. The area is now overgrown with brush, trees, and grasses.

The exact sizes, shapes, and locations of the burn pit and the burn area are not known. Their approximate locations are indicated on Figure 1-5. Descriptions of the treatment areas in previous reports (Dunbar, 1982; Murphy, 1996) and interviews with base personnel during the OJT and LSC RFI field work (TtNUS, 2002) indicate that the treatment areas may have covered a larger area than just the burn area and the burn pit, extending from OJT westward to the LSC stream channel and southward as far as well 03-07 (see Figure 4-1). However, contaminants were not detected during sampling along the length of the OJT in areas where treatment reportedly took place. Although inactive as a treatment area, the OJT is still actively used as a vehicle route.

1.3.2.4 Groundwater Contamination Sources

Based on the above discussion of operations and the results of previous investigations at the MTA and OJT, the key operations and potential sources of groundwater contamination at the MTA and the OJT are identified in Section 2.0.

1.4 PHYSICAL CHARACTERISTICS OF SWMU 3 STUDY AREA

The MTA is approximately 20 acres in size; the OJT is approximately 6 acres in size. The MTA, OJT area, and LSC are located in the central-east portion of the facility. The site maps for the MTA and the OJT are presented as Figures 1-4 and 1-5, respectively.

1.4.1 Climate and Meteorology

The climate in the region of NSWC Crane can be described as temperate (NOAA, 1988). Precipitation is distributed evenly throughout the year, and there is no pronounced wet or dry season for this region. Rainfall in the spring and summer is produced mostly from showers and thunderstorms. A peak rainfall of about 2½ inches in a 24-hour period can be expected about once a year. Snowfalls of 3 inches or more occur on an average of two or three times per winter season. The annual mean monthly distribution of rain and snow for the area is shown in Table 1-1. Annual rainfall total is about 40 inches per year (in/yr), with the highest mean monthly totals occurring in the late spring and in the early summer period of May through July. Snowfall averages about 23 in/yr, with most occurring in the winter months of December through February.

Mean monthly air temperatures for the region are shown in Table 1-2. Temperatures range from a minimum of 27.9 degrees Fahrenheit (°F) in January to a maximum of 75.7°F in July. The mean annual temperature for the area is 52.6°F.

Relative humidity for the local area is generally highest in the early morning hours in June through September and generally ranges between 80 to 88 percent on average. The lowest values of relative humidity have historically occurred between March through October during the afternoon and evening hours when values average between 54 and 58 percent.

Long-term climatological records (NOAA, 1988) for the area indicate that the monthly prevailing wind direction is southwest during the months of April through December, then shifts to the northwest during the months of January through March. The annual prevailing wind direction for the region is from the southwest. The annual average wind speed for the area is about 9.6 miles per hour (mph).

1.4.2 Topography and Physical Features

1.4.2.1 NSWC Crane

NSWC Crane is in the unglaciated area of the Crawford Uplands Physiographic Province. This province is a rugged, highly vegetated, dissected plateau bounded by the Mitchell Plain Physiographic Province to the east and the Wabash Lowland Physiographic Province to the west (Murphy and Wade, 1988). The Mitchell Plain is a low dissected limestone plateau characterized by sinkholes and karst topographic features. The boundary between the Crawford Upland and the Mitchell Plain is marked by the highly irregular, eastern-facing Chester Escarpment. Springs, caverns, caves, and other solution weathering features can be found along this escarpment and on the eastern edge of the NSWC Crane facility. The boundary between the Crawford Upland and the Mitchell Plain near the western boundary of NSWC Crane is gradual (Murphy and Wade, 1988).

The terrain is predominantly rolling with moderately incised stream valleys throughout and occasional flat areas in the central and northern portions at NSWC Crane. The elevations across NSWC Crane range from about 500 feet above mean sea level (msl) at the southern drainageway to about 850 feet msl on the ridge in the west-central portion of the site. V-shaped drainageways in the north progress to 2,000-foot-wide floodplains in the south and rise to approximately 150 to 200 feet at the ridgelines (NEESA, 1983).

1.4.2.2 SWMU 3

The LSC watershed, which contains the MTA and OJT, is characterized by rugged relief, with ground surface elevations ranging from about 600 to 800 feet above msl in the headwaters. At the OJT, ground surface elevations range from approximately 550 to 800 feet above msl. The surface elevation is approximately 500 feet above msl where LSC exits the southern border of the installation.

The MTA is relatively flat and is within the northern headwater area of LSC. The MTA was formerly kept devoid of vegetation to minimize the potential for fires during open burning treatments. However, since the early 1990s, areas along LSC within SWMU 3 have been seeded with grass to minimize erosion of soil into LSC.

The OJT site is located in a gravel-covered area on the western side of the gravel access road (Jeep Trail 25), where the road widens in excess of 50 feet. The OJT and the remainder of the LSC valley are surrounded by wooded areas along the hillsides to the east and west, with miscellaneous natural ground vegetation under the tree canopy and along the creek banks.

1.4.3 Geology

Bedrock underlying the NSWC Crane facility consists of sedimentary rocks from the Lower Pennsylvanian age Mansfield Formation (Raccoon Creek Group) and the Upper Mississippian age Stephensport and West Baden Groups. Due to erosion and the moderate relief in the area, the Lower Pennsylvanian and Upper Mississippian rock units crop out on the ridgetops and along the stream valleys.

The USACE Waterways Experiment Station (WES), the Indiana Geological Survey, and Indiana University have been investigating the geology and hydrogeology of the LSC watershed since the early 1980s. The USACE WES understanding of the geologic units based on boring logs drilled to various depths throughout the LSC watershed, is presented in Appendix A of the draft Conceptual Site Model and Fieldwork Report.

1.4.4 Surface Water Hydrology

The surface drainage at NSWC Crane has formed a dense, dendritic pattern throughout the installation. Most of the major streams flow in a general southward or southwestward direction. Seven primary creeks in five drainage basins carry surface water off the installation, where they eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. Figure 1-3 shows the main drainage basins of NSWC Crane. SWMU 3 which includes the MTA and the OJT area lie within the Sulphur Creek drainage basin. LSC is a small stream whose headwaters originate in channels on the north, west, and south of the ABG. These ephemeral channels run through SWMU 3 and converge on the eastern side of the SWMU. From the MTA, a single channel meanders south-southeastward a distance of approximately 0.5 mile to the OJT area and then continues another 0.6 mile until it reaches the installation boundary. The Sulphur Creek basin drains approximately 30 percent of NWSC Crane.

LSC is approximately 4.6 miles long from its northernmost headwaters to its intersection with Sulphur Creek south of the installation. Several intermittent tributaries discharge into LSC from both sides of the stream, including the Johnson Hollow tributary, which intersects with LSC near the NSWC Crane boundary. The Dye Burial Grounds (SWMU 2) are located north of the OJT, and surface drainage from this site enters several ephemeral gullies that drain into LSC between MTA and OJT.

The LSC channel is usually dry north (upstream) of Spring C (see Figure 1-3). During dry periods of summer and fall, the flow rate in the creek between Springs A and C is typically less than about 50 gallons per minute (gpm). Downstream of where the discharge from Spring A enters LSC, the dry

weather flow in LSC is typically greater than 100 gpm. Flow rates in LSC were visually estimated on June 19, 2001 to be about 20 gpm. Downstream of Spring A, the flow rate in LSC can increase by two to three orders of magnitude, due in large part to the rapid increases in the flow rates of the springs along the creek.

From the installation boundary, LSC flows southward about 2 miles before it enters Sulphur Creek. Sulphur Creek then flows southward and empties into Indian Creek, which drains into the East Fork of the White River and then flows southwestward into the Wabash River.

1.4.5 Hydrogeology

1.4.5.1 NSWC Crane

USACE WES discussed regional groundwater trends pertaining to the unglaciated southwestern portion of Indiana. In general, groundwater is contained in joint openings of limestone and sandstone aquifers. Surficial unconsolidated aquifers are thin and have limited potential as water supplies.

Aquifers beneath NSWC Crane are considered to be vertically isolated from each other by interlayered shale beds that act as aquitards. Groundwater recharge in the unconsolidated surficial materials occurs through rainfall infiltration at the ground surface. Groundwater recharge in the underlying bedrock units can occur where aquifer units crop out or from vertical downward migration through joint openings from overlying units.

Local variations in bedding thickness and composition, dip, aquifer and aquitard thicknesses, presence or absence of fractures, incision by surface drainage, and karstic conditions cause local groundwater movement at NSWC Crane to differ from regional trends. Where erosion resulting from surface drainage has cut through aquifer units, groundwater discharge occurs as springs and seeps. Springs and seeps are prevalent at contacts between aquitards and overlying aquifers. Groundwater flowing from springs and seeps into surface water can potentially re-enter the groundwater system as recharge to a lower aquifer outcropping downstream below aquitards.

In the eastern portion of NSWC Crane, the karstic conditions are present primarily in major drainage valleys where erosion has cut into permeable sandstones overlying easily dissolved limestone units (USACE WES, 1998). Rapid infiltration in the Big Clifty Sandstone has caused dissolution and weathering of the underlying Beech Creek Limestone. The result of this occurrence has been the

creation of karst and collapse conditions along some of the major drainageways within the eastern part of NSWC Crane.

The upper soil materials on the tops and sides of ridges are generally unsaturated. The uppermost bedrock is composed of the Lower Pennsylvanian age Mansfield Formation consisting of irregular beds and lenses of sandstone, siltstone, and shale. Because of the irregularities in the extent and thickness of each lithologic unit and the variability in the permeability and yield of groundwater for each well, it is difficult to divide the Pennsylvanian age rocks into distinct aquifers or water-bearing units. In general, groundwater is likely moving along fractures, joints, and bedding planes and not through a porous matrix as is commonly the case with unconsolidated deposits.

1.4.5.2 SWMU 3

The complex hydrogeology associated with SWMU 3 is discussed in detail in Section 3 of the Groundwater Monitoring Plan of the renewal Part B Permit Application for the NSWC Crane OB/OD facilities (NSWC Crane, 2006). The following presents a brief summary of the hydrogeology of SWMU 3 as presented in the Groundwater Monitoring Plan.

1.4.5.2.1 Aquifers and Aquitards

Groundwater in the nonglaciated southwestern portion of Indiana is generally contained in fractures and joint openings of limestone and sandstone aquifers. Aquifers are generally isolated from one another vertically by less permeable shale and siltstone units. Groundwater enters the aquifers as infiltration in outcrop areas and flows by gravity down the dip of the strata or locally in directions controlled by the potentiometric gradients, which are in most cases influenced by topography and locations of stream channels (i.e., groundwater discharge areas).

Four primary aquifers in the LSC watershed have been identified in the Pennsylvanian and Upper Mississippian strata:

- Pennsylvanian sandstones
- Haney Limestone [also referred to as the Golconda-Haney (G-H) aquifer]
- Big Clifty Sandstone/Beech Creek (BC/BC) Limestone aquifer
- Beaver Bend Limestone

The Pennsylvanian sandstone aquifer is the uppermost aquifer and is present only along the tops of ridges at elevations above 615 feet above msl. The Glen Dean Limestone is present beneath the Pennsylvanian aquifer in isolated areas of the watershed. The Hardinsburg Shale is up to 50 feet thick and contains mostly shale with some low-permeability sandstone in the middle. This formation forms a nearly continuous, relatively impermeable barrier to groundwater flow between the Pennsylvanian sandstones above and the G-H Limestone below.

The G-H Limestone aquifer crops out on the sides of LSC and Johnson Hollow. This limestone aquifer is up to 20 feet thick. The Indian Springs Shale aquitard (the 20-foot-thick upper member of the Big Clifty Formation) underlies the G-H aquifer and minimizes vertical movement of groundwater downward into the Big Clifty Sandstone through most of the watershed. In places where the Indian Springs Shale and higher strata have been removed by post-Pennsylvanian erosion, surface recharge into the Big Clifty Sandstone is relatively rapid.

The Big Clifty Sandstone and the underlying Beech Creek Limestone are both permeable rock units and are in direct hydraulic communication with one another. Together, they form the most important aquifer unit in the watershed. The porosity and permeability of the Big Clifty Sandstone are due to intergranular pore spaces and to fractures (i.e., it has both primary and secondary permeability). The Beech Creek Limestone is very dense and well cemented; all of its permeability and porosity are due to vertical fractures, bedding-plane fractures, and solution openings along the fractures. The lithology, fracture patterns, and permeability characteristics of the Big Clifty Sandstone and the Beech Creek Limestone are detailed in reports by the USACE (Hunt, 1988; Murphy and Ciocco, 1990; Murphy, 1994) and the Indiana Geological Survey (Barnhill and Ambers, 1994). The BC/BC aquifer is exposed near the ground surface in the eastern half of SWMU 3, along the LSC valley, and in the lower elevation of Johnson Hollow. Beneath the ridges, the aquifer is approximately 60 feet thick and fracture flow is dominant in the limestone. Solution openings and cavities become larger and hydraulically more significant close to the stream valleys where conduit systems in the limestone have developed. Starting in the eastern half of SWMU 3 and continuing down the LSC valley to the facility property line, the dissolution of the Beech Creek Limestone was so extensive that, sometime in the geologic past, the overlying limestone collapsed; the Big Clifty Sandstone has also collapsed with the Beech Creek Limestone. The collapsed zones extend along the centers of the LSC valley and Johnson Hollow, are permeable, and form a hydraulic continuum within the BC/BC aquifer on both sides of the valleys.

The Elwren, Sample, and Reelsville Formations lie beneath the BC/BC aquifer and have a combined thickness of approximately 75 feet. The permeability of the shales in these formations is so low that a significant hydraulic head difference of about 46 feet exists between the BC/BC aquifer and the Beaver

Bend Limestone aquifer below (Baedke, 1998). The Beaver Bend Limestone is about 12 feet thick and forms an important aquifer below the Elwren-Sample-Reelsville aquiclude.

Karst System Monitoring

The MTA and OJT are underlain by two separate karst systems. Several studies of these karst systems have been conducted by the USACE WES and the Indiana University Department of Geological Sciences.

The karst systems show both temporal and spatial variation between diffuse-type and conduit-type groundwater flow. From highest to lowest, the three aquifer systems present at SWMU 3 are the G-H aquifer, the Beech Creek aquifer, and the Beaver Bend aquifer.

The solution openings and cavities (the karst system) in the Beech Creek Limestone have formed groundwater conduits that roughly trend north to south on both sides of the LSC valley. Based on the results of dye tracer studies, groundwater enters these karst conduits, which allow for rapid groundwater flow southward and roughly parallel to LSC to conduit outlets (i.e., springs). These conduits and springs along the valley walls south of the OJT area are discussed below.

1.4.5.2.2 Groundwater Flow Directions

In general, the shallow groundwater flow patterns mimic topography; highest groundwater elevations are typically found along ridge crests, and groundwater flow is toward the major stream or tributary valleys. Recharge to the shallow groundwater system generally occurs over most of the uplands and sideslopes. Groundwater moves downward and then laterally, where it discharges to the deeper stream valleys as springs, seeps, and baseflow.

The aquifers present in the LSC watershed consist primarily of sandstone and limestone. In the MTA area, groundwater in the G-H aquifer generally flows toward the MTA from the northern, western, and southern sides (Hunt, 1988; Murphy, 1994; Duwelius et al., 1995). When the groundwater reaches the cropline of this aquifer, the groundwater is apparently seeping near the ground surface through residual soils and weathered shale until it reaches the cropline of the Big Clifty Sandstone. There, it infiltrates into the Big Clifty Sandstone. No visible surface seeps or springs have been reported emanating from the G-H aquifer in the vicinity of the MTA.

The next lower aquifer, the BC/BC aquifer, has been more extensively studied than any of the other three aquifers. In general, the highest groundwater elevations (560 to 565 feet above msl) in this aquifer were found at the northern end of the LSC watershed (north of the MTA and in the vicinity of the DBG). Groundwater generally flows from north to south in the watershed, and also flows inward toward LSC (i.e., from the perimeter of the watershed toward the creek and Johnson Hollow). The elevation where groundwater discharges from Spring C was about 530 feet above msl (see Figure 1-2). The lowest groundwater elevations (about 510 to 515 feet above msl) were recorded at the southern end of the watershed at Spring A and well 03B10.

LSC is a losing stream between ABG and OJT and probably southward toward Spring C. In this section of the watershed, the streambed is usually dry, and groundwater flows either through the breccia zone materials parallel to the stream (i.e., underflow) or flows back into the bedrock valley wall. These localized flow directions (i.e., away from the Creek toward the northeast and southwest) are in contrast to the overall watershed flow directions, which are toward the stream valley. The apparent contradiction in flow directions can be explained by the presence of karst conduits that run in a north-south direction on both sides of the stream valley. The majority of groundwater in the OJT area is likely flowing toward the karst conduits.

Groundwater in the BC-BC aquifer and the conduits eventually discharges back into the LSC at Springs A, A', B, and C, smaller unnamed springs, and diffuse seepage through the streambed. All this discharge occurs at Spring C and south of Spring C, where the top of the Elwren Shale intersects the streambed and LSC becomes a gaining stream (i.e., flow of water is from the ground into the stream). LSC becomes a perennial stream at Spring C, where the flow of groundwater to the stream is sufficient to maintain flow in the stream continuously.

The Beaver Bend limestone is 10 to 12 feet thick and comprises the lowest aquifer that has been investigated in this watershed. Based on data from monitoring wells, the Beaver Bend is fully saturated and flowing southward at a very gentle gradient (Murphy, 1994). The Beaver Bend is considered to be isolated hydraulically from the BC-BC aquifer above.

1.4.5.2.3 Overview of Dye Trace Study

During early groundwater investigations in the LSC watershed, investigators (Hunt, 1988; Murphy and Ciocco, 1990) surmised that springs at the southern end of the watershed were linked to karst conduits originating to the north. Several dye tracer studies were performed to evaluate the pathways in these conduits and to estimate the velocity of travel. The first dye tracer investigation was performed by Murphy

and Ciocco (1990). The stream flow and spring flows were above average during the testing. The fluorescein dye persisted in these Springs A and A' for at least 5 days following injection. Based on a mean travel time of 16 hours and assuming a sinuous travel distance of about 8,000 feet, Murphy and Ciocco (1990) estimated a groundwater velocity of approximately 500 feet per hour through the conduit system. They detected a weak but inconclusive presence of dye in Springs B and C and in springs located north of ABG in another watershed. They attributed these weak detections possibly to background coloration of the water. Based on these results, it was clear that the ABG was directly linked to a karst conduit system that transfers water from the ABG south to Springs A and A' through the Beech Creek Limestone.

Indiana University initiated a second tracer test on the western side of LSC on May 3, 1997 (Baedke, 1998). Rhodamine WT dye and bromide ion were added to well 03C02P2 (see Figure 1-4). Eosin dye was injected into well 03C10. The springs and the stream were at relatively high flow rates because 2.5 inches of rain fell the previous day. Rhodamine WT dye was visually detected at Springs A and A' after injection at ABG. The bromide tracer appeared at the same time as the Rhodamine WT. Baedke (1998) calculated a travel velocity of 938 feet per hour between well 03C02P2 and Spring A, which is faster than the velocity calculated by Murphy and Ciocco (1990). Although the Rhodamine WT was detected at these two springs up to 4 days after injection, the bromide tracer dissipated quickly, presumably because the bromide ion does not sorb and is therefore flushed from the conduit system more quickly. Rhodamine WT was not detected during the entire test period in any other springs that were monitored. Eosin was not detected at all, even in Springs A and A'. Therefore, it does not appear that the portion of the BC/BC aquifer located near well 03C10 is directly connected to the conduit system feeding Springs A and A'.

On October 11, 2000, Rhodamine WT dye was again injected into well 03C02P2, but the flow rates in the stream and the springs were relatively low during this test (Krothe, 2002). Monitoring showed that the dye traveled from the well to Springs A and A'. This study concluded that the travel velocity was slower during dry weather conditions.

Previous dye tracer tests all showed that the ABG area does not seem to be hydraulically connected to Spring C, which is a major spring located on the eastern side of the creek, downstream of the OJT area. Groundwater elevations indicate a flow direction from the OJT burn pits to the east-northeast toward well 03-24 (see Figure 1-5). It was hypothesized that these solution channels might be linked to a conduit system that leads southward to Spring C, which is separate from but analogous to the conduit system investigated previously on the western side of the creek. Two dye tracer tests have been performed recently on the eastern side of LSC to determine whether there is a link between the OJT area and Spring

C (Jock and Krothe, 2002 and Hydrogeology, Inc., 2005). Fluorescein dye was injected into well 03-24 on May 24, 2002. The dye was first detected in Spring C 17 hours after injection. The dye concentration peaked 28 to 38 hours after injection. A second dye tracer test was conducted on December 2, 2004, using monitoring well 03-24 as the injection point and Springs A and C as monitoring points. This test resulted in 108 percent of the dye being recovered at Spring C. No dye was recovered at Spring A. Thus, the OJT area is linked to the Spring C conduit system in the vicinity of well 03-24. However, this conduit system does not seem to be as well developed, and travel velocities are not as fast as the conduit system on the western side of the creek feeding Springs A and A'.

1.4.5.2.4 Overview of Groundwater Discharge and Springs

The BC/BC aquifer discharges to the ground surface from both sides of the valley via numerous springs and baseflow in LSC downstream of Spring C. These springs and baseflow are forced to the ground surface because, at this point in the watershed, the stream has incised down to the underlying Elwren Shale. Springs A, A', B, and C are the largest in this area of the watershed. Springs A, A', and B are located on the western side of the valley, approximately 6,000 to 6,800 feet south of the MTA. Spring C is located on the eastern side of the creek, about 2,000 feet south of the OJT area. Presumably, Springs A, A', and B are draining the portion of the BC/BC aquifer west of the creek, and Spring C is draining the aquifer on the eastern side of the creek. These springs flow year round; however, flow rates fluctuate rapidly due to rainstorm or large snowmelt events.

In March and April 1996, continuous flow measurements were conducted for Springs A and C. During these measurements, the flow rates of the two springs rose rapidly in response to rain events and declined fairly rapidly within a few days. The peak flows in these two springs during the 2-month time period were approximately 10,000 gpm, or 22.3 cubic feet per second (ft^3/s). This is consistent with previous reports (e.g., Hunt, 1988; Murphy and Ciocco, 1990) that springs become turbid during high flow events and then clear up and return to normal flow within a day or two after a storm event. The flashiness of the spring flows and the fact that the discharge becomes turbid during a storm indicate that the springs are linked to conduit systems that take surface recharge and transfer it through the conduit systems quickly. The suspended solids contained in the discharge waters likely come from the areas of recharge and gradually move through the conduit system, primarily during storm events.

1.4.6 Water Supply

1.4.6.1 NSWC Crane

Seven primary creeks carry surface water off the installation and eventually drain into the East Fork of the While River, and then to the Wabash River to the southwest. The seven creeks that drain NSWC Crane are Furst Creek, Sulphur Creek, LSC, Boggs Creek, Turkey Creek, Indian Creek, and Seed Tick Creek (Figure 1-3). Also located within the installation are several small ponds and Lake Greenwood, an 800-acre, man-made, spring-fed lake in the northwestern portion of the installation. Lake Greenwood is the main source of drinking water at NSWC Crane, and it is also used for recreation.

1.4.6.2 SWMU 3

Groundwater at the MTA and OJT is not currently and is not anticipated to be used in the future as a potable drinking water source.

1.4.6.3 LSC

Groundwater in the BC/BC aquifer within the MTA flows southeast and into a karst conduit system and is then conveyed at a rapid velocity southeastward to Springs A and A'. Groundwater within the OJT area flows east-southeastward within collapse breccia material and discharges at Spring C into LSC. During most times of the year, the flow in LSC consists entirely of flow from Springs A, A', and C. LSC first becomes a perennial stream at Spring C. All surface water, sediments, and groundwater leaving the MTA and OJT areas eventually enter LSC.

Based on information from the United States Geological Survey (USGS), the closest public water intake is Shoals, which is located on the East Fork of the White River (see Figure 1-5).

1.4.7 Surrounding Land Use

NSWC Crane is situated in a rural area of south-central Indiana. The surrounding communities that form the region are in a period of transition from an economic base of agriculture, mining, and quarrying to an economy built on manufacturing and service industries. The patterns of settlement, population statistics, and median income are similar throughout the region.

There is no State or local planning within the vicinity of NSWC Crane. The only zoning and land use regulations are found in the municipalities within the region. None of these municipalities are close

enough to have an impact on NSWC Crane. None of the areas adjacent to NSWC Crane are zoned, and zoning is not anticipated in the near future. The MTA of SWMU 3 is approximately 1 mile west of the nearest NSWC Crane property boundary. There are no known current or likely future land use or community actions under consideration or proposed at this time for the off-base land in the vicinity of SWMU 3; however, LSC flows into Sulfur Creek which flows off base. SWMU 3 is contained completely within NSWC Crane and likely future land use at areas surrounding the SWMU is expected to be limited to industrial uses.

1.4.8 Ecological Setting

1.4.8.1 Facility Location

A biological characterization of NSWC Crane, including a listing of plants and animals found at the facility, was presented in the Installation Assessment (Army, 1978) and the IAS (NEESA, 1983), and is summarized in the Environmental Monitoring Reports (EMRs) (Halliburton NUS, 1992a and 1992b). A list of the species that may inhabit NSWC Crane and are protected under the U.S. Endangered Species Act, Indiana Department of Natural Resources Heritage Data Center, or the U.S. Fish and Wildlife Service is summarized in the RCRA Facility Permit (U.S. EPA, 1995). The following paragraphs briefly summarize the environmental setting at the installation.

Eighty percent of NSWC Crane's 63,000 acres are classified as Central Hardwoods Forest of the United States (NEESA, 1983). In addition, some agricultural fields are in various stages of succession. Openings on dry upland sites contain almost pure stands of grasses with some clumps of woody plants such as persimmon, sassafras, and sumac. Wetter sites have river birch, willow, sycamore, and cottonwood. Hillside communities have mostly hickory, white and black oak, red maple, sugar maple, tulip poplar, ash, and beech (NEESA, 1983).

The great variety of habitats at NSWC Crane (i.e., many stages of forest succession, streams, ponds, Lake Greenwood, grassy open spaces) has lead to a high diversity of animal species (NEESA, 1983). Some of these species include (but are not limited to) mammals such as white-tailed deer, beaver, coyote, hawks, red fox, rabbits, raccoons, mice; birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins; and various amphibians, reptiles, fish, and invertebrates.

The bird population includes a number of State or federal threatened, endangered, or species of special concern that use the installation as their home range. These species include the bald eagle, osprey, sharp-shinned hawk, red-shouldered hawk, broad-winged hawk, black and white warbler, hooded

warbler, and the worm-eating warbler (B&R Environmental, 1997). Also, the Indiana bat, a federal endangered species, is known to forage at NSWC Crane. Because of the bat and its potential habitat, the cutting of trees is restricted to certain times during the year, and the cutting of shagbark hickory trees is prohibited.

1.4.8.2 SWMU 3

Terrestrial Habitats: The most frequent tree species at SWMU 3 are mockernut hickory (*Carya tomentosa*), shagbark hickory (*Carya ovata*), sugar maple (*Acer saccharum*), tulip poplar (*Liriodendron tulipifera*), sassafras (*Sassafras albidum*), red oak (*Quercus rubra*), white oak (*Quercus alba*), and American beech (*Fagus grandifolia*). Common understory plants include flowering dogwood (*Cornus florida*) and sugar maple. Various tree seedlings, clubmosses, grasses, rushes, and forbs occur as groundcover at the site.

A total of 25 bird species were observed in the area of the SWMU during the 1995 biological survey. Commonly observed species included wild turkey (*Meleagris galopava*), whippoorwill (*Caprimulgus vociferus*), common crow (*Corvus brachyrhynchos*), common flicker (*Colaptes auratus*), American gold finch (*Spinus tristis*), chipping sparrow (*Spizella passerina*), and blue jay (*Cyanocitta crigtata*).

Aquatic Habitats: The channel of LSC has a riffle-and-pool structure, and standing water is limited to pooled areas during low-flow conditions such as during the 1995 biological survey. The 1995 survey included identification of fish and benthic macroinvertebrates in pools near two springs that flow into the creek. Spring A is located in the southern (most downstream) portion of SWMU 3. The water depth in the pool near Spring A was 6½ feet at the time of the 1995 survey. Spring C is located approximately 2,500 feet upstream of Spring A. The water level in the Spring C pool was 1½ feet during the survey. The LSC channel upstream of Spring C is generally dry except after rain events, resulting in the absence of permanent aquatic communities in most portions of the creek within SWMU 3.

Fish were captured for identification using an electrofishing backpack unit. In the pool near Spring A, the bluntnose minnow (*Pimenthales notatus*) was abundant, the gizzard shad (*Dorosoma cepedianum*) and creek chub (*Semotilis atromaculatus*) were common, and the largemouth bass (*Micropterus salmoides*) was uncommon. In the Spring C pool, the gizzard shad, silverjaw minnow (*Ericymba buccata*), and bluntnose minnow (*Pimenthales notatus*) were common, and the ribbon shiner (*Notropus fumeus*) and blacknose dace (*Rhinichthys atratulus*) were uncommon.

Benthic macroinvertebrates were collected using a D-frame kick net and preserved using 70-percent isopropanol. At the Spring A pool, 71 individuals in seven taxa were observed. The Ephemeroptera, Plecoptera, Trichoptera (EPT) Index was calculated to be 0.429, which is indicative of a relatively unpolluted stream. At the Spring C pool, 81 individuals in eight taxa were observed. The EPT Index was 0.375, indicative of a relatively unpolluted stream. For a riffle in LSC adjoining the Spring C pool, 40 individuals in four taxa were observed, and the EPT Index was 0.500, which is also indicative of a relatively unpolluted stream.

The waterbodies at SMWU 3 discharge directly to LSC. The designated State water uses for the Sulphur Creek-LSC waterbody segment are aquatic life support, fish consumption, and primary contact. This waterbody segment was assessed as part of the 2004 Indiana Integrated Water Quality Monitoring and Assessment Report to determine if the waterbody was supporting those uses (IDEM, 2004). The Sulphur Creek-LSC waterbody segment is fully supporting the aquatic life support and primary contact water uses; it was not assessed for the fish consumption water use (IDEM, 2004).

Threatened and Endangered Species: The Endangered Species Management Plan for NSWC Crane lists the federal and State threatened and endangered species and species of special concern potentially present at NSWC Crane. The Indiana bat and bald eagle are the only federally threatened or endangered species at NSWC Crane. Although the Indiana bat may be present at SWMU 3, the bald eagle is not likely present at SWMU 3 due to a lack of vast expanses of open water (i.e., the preferred hunting habitat for the Bald Eagle). In addition, a number of State endangered and federal and State species of concern have been listed.

LSC flows southward for about 2 miles before it enters Sulphur Creek. Sulphur Creek discharges off site to the East Fork of the White River. River otters, a State endangered species, are being reintroduced to Indiana. The otters are expanding from their original release sites into other watersheds including the East Fork of the White River (IDNR, 2000). Also, the East Fork of the White River is the site for an ongoing study of lake sturgeon populations, another State endangered species (IDNR, 2000). Finally, spotted darters, a State endangered species, has been found in the East Fork of the White River (IDNR, 2000). Other threatened, endangered, or special concern species also may be present in the water bodies just off site of Crane.

1.4.8.2.1 MTA

The MTA consists of an active treatment facility that is mostly clear of vegetation. Most terrestrial areas within the site support deciduous forest vegetation in varying stages of natural succession. Aquatic

habitats within the site consist of the surface waters and sediments of LSC. Terrestrial and aquatic habitats in areas surrounding the ABG, including the OJT, were characterized in detail in August and September 1995 as part of an Environmental Risk Assessment (ERA) completed in February 1999 (TtNUS, 1999). The following site description is based on information in that ERA.

Terrestrial Habitats: The authors of the 1995 biological survey noted that the noise, smoke, and other human activity at the MTA portion of the SWMU, as well as predation, may have reduced the diversity of wildlife in the surrounding area.

Aquatic Habitats: Springs A, A', and C, where aquatic habitats were observed during the 1995 biological survey, are located south (i.e., downstream) of the MTA.

The Sulphur Creek and LSC waterbody segment, which run through the MTA, is fully supporting the State-designated aquatic life support and primary contact water uses; it was not assessed for the fish consumption water use (IDEM, 2004).

1.4.8.2.2 OJT

The OJT consists of a portion of a narrow, forested stream valley centered on LSC. Most terrestrial areas within the site support deciduous forest vegetation in varying stages of natural succession. Aquatic habitats within the site consist of the surface waters and sediments of LSC. Terrestrial and aquatic habitats in areas surrounding the OJT were characterized in detail in August and September 1995 as part of an ERA completed in February 1999 (TtNUS, 1999).

Terrestrial Habitats: The forested habitats within and surrounding the OJT support numerous bird species (i.e., 25 bird species observed during the 1995 biological survey).

Aquatic Habitats: The OJT is upstream of Springs A and C, which are generally dry except after rain events, resulting in the absence of permanent aquatic communities in most portions of the creek within the OJT.

Threatened and Endangered Species: Although the Indiana bat may be present at the OJT, the bald eagle is not likely present due to a lack of vast expanses of open water (i.e., the preferred hunting habitat for the Bald Eagle).

TABLE 1-1

CLIMATOLOGICAL MEAN MONTHLY RAINFALL AND SNOWFALL AMOUNTS[1]
CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

Month	Mean Monthly Rainfall (inches)	Mean Monthly Snowfall (inches)
January	2.89	6.3
February	2.52	5.9
March	3.78	3.5
April	3.66	0.5
May	3.93	[2]
June	4.06	0
July	3.89	0
August	3.28	0
September	3.11	0
October	2.68	[2]
November	3.21	1.9
December	2.95	4.8
Annual	**39.98**	**23.0**

1 - Reference: National Oceanic and Atmospheric Administration (NOAA), 1988.
2 - Snowfall amounts less than 0.01 inch.

TABLE 1-2

CLIMATOLOGICAL MEAN MONTHLY TEMPERATURES[1]
CMP REPORT FOR SWMU 3 – AMMUNITION BURNING GROUNDS
NSWC CRANE,
CRANE, INDIANA

Month	Mean Monthly Temperature (°F)
January	27.9
February	30.6
March	40.3
April	52.0
May	62.5
June	71.7
July	75.7
August	73.6
September	66.8
October	55.3
November	42.0
December	31.8
Annual	**52.6**

1 - Reference: National Oceanic and Atmospheric Administration (NOAA), 1988.

°F - Degrees Fahrenheit.

DRAWN BY	DATE
J. LAMEY	3/9/00
CHECKED BY	DATE
V. PLACHY	03/27/06
COST/SCHEDULE-AREA	
SCALE	AS NOTED

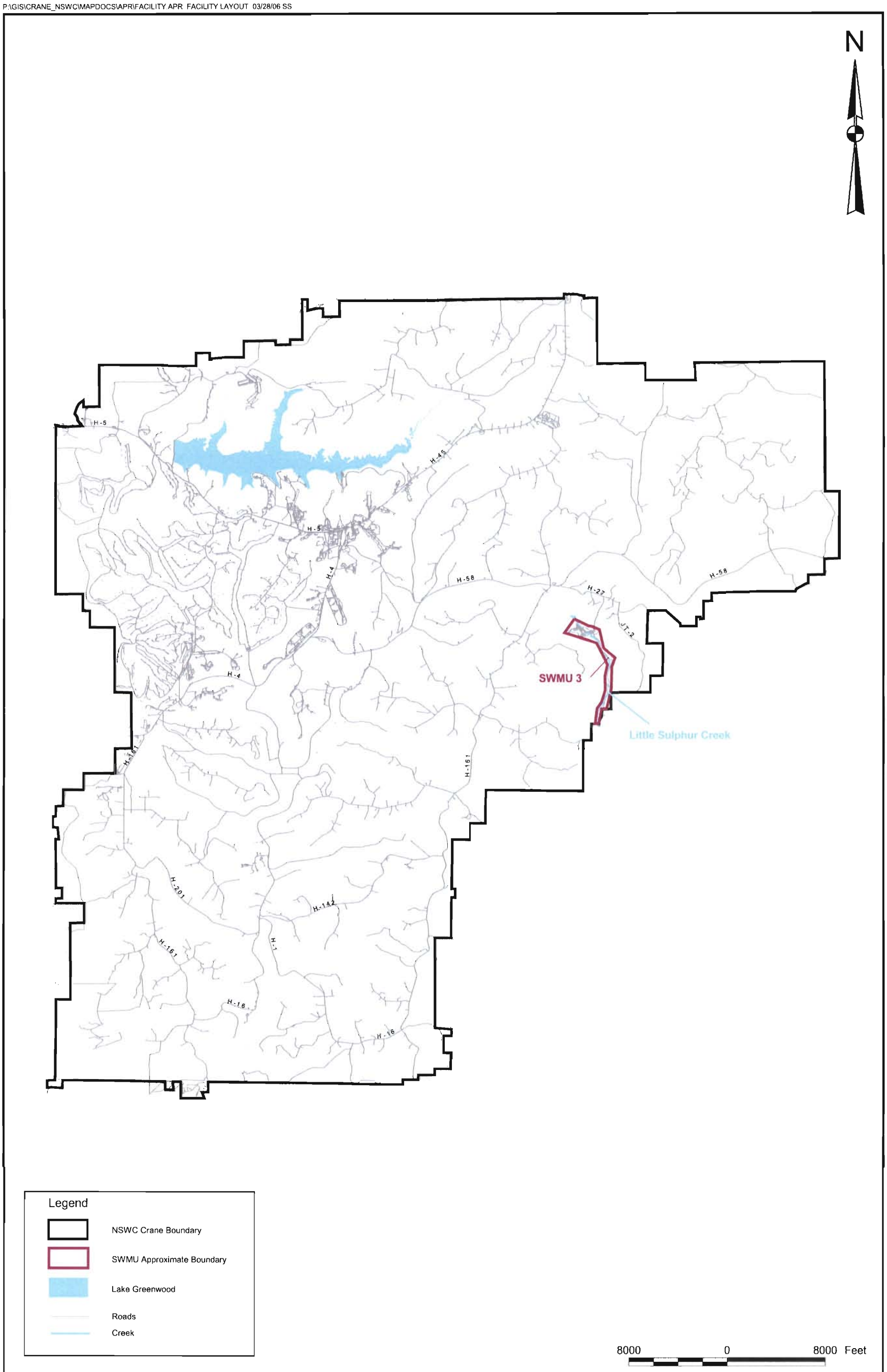
NAVFAC

LOCATION OF NSWC CRANE
CMP REPORT FOR
SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
CTO 0311	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 1 - 1	0

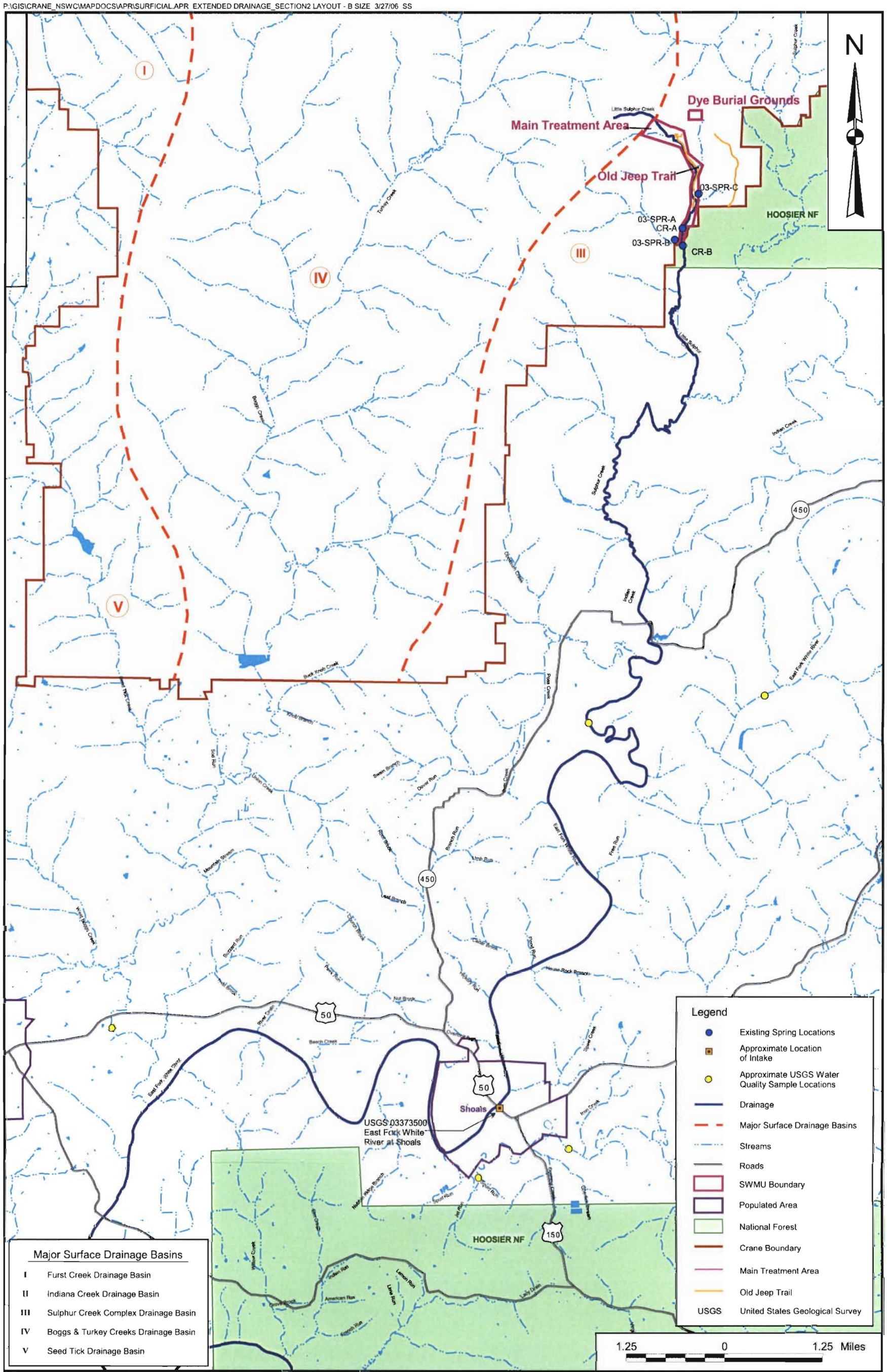
P:\GIS\NSWC_CRANE\APR\0087.APR GENERAL LOCATION MAP 03/29/06 SS

P:\GIS\CRANE_NSWC\MAPDOCS\APR\FACILITY.APR FACILITY LAYOUT 03/28/06 SS



DRAWN BY	DATE			CONTRACT NUMBER
A. JANOCHA	10/21/05		FACILITY LAYOUT	CTO 0311
CHECKED BY	DATE		CMP REPORT FOR	APPROVED BY / DATE
V. PLACHY	3/27/06		SWMU 3 - AMMUNITION BURNING GROUNDS	APPROVED BY / DATE
COST/SCHEDULE-AREA		NAVFAC	NSWC CRANE	DRAWING NO. / REV
SCALE			CRANE, INDIANA	FIGURE 1 - 2 / 0
AS NOTED				

P:\GIS\CRANE_NSWC\MAPDOCS\APR\SURFICIAL.APR EXTENDED DRAINAGE_SECTION2 LAYOUT - B SIZE 3/27/06 SS



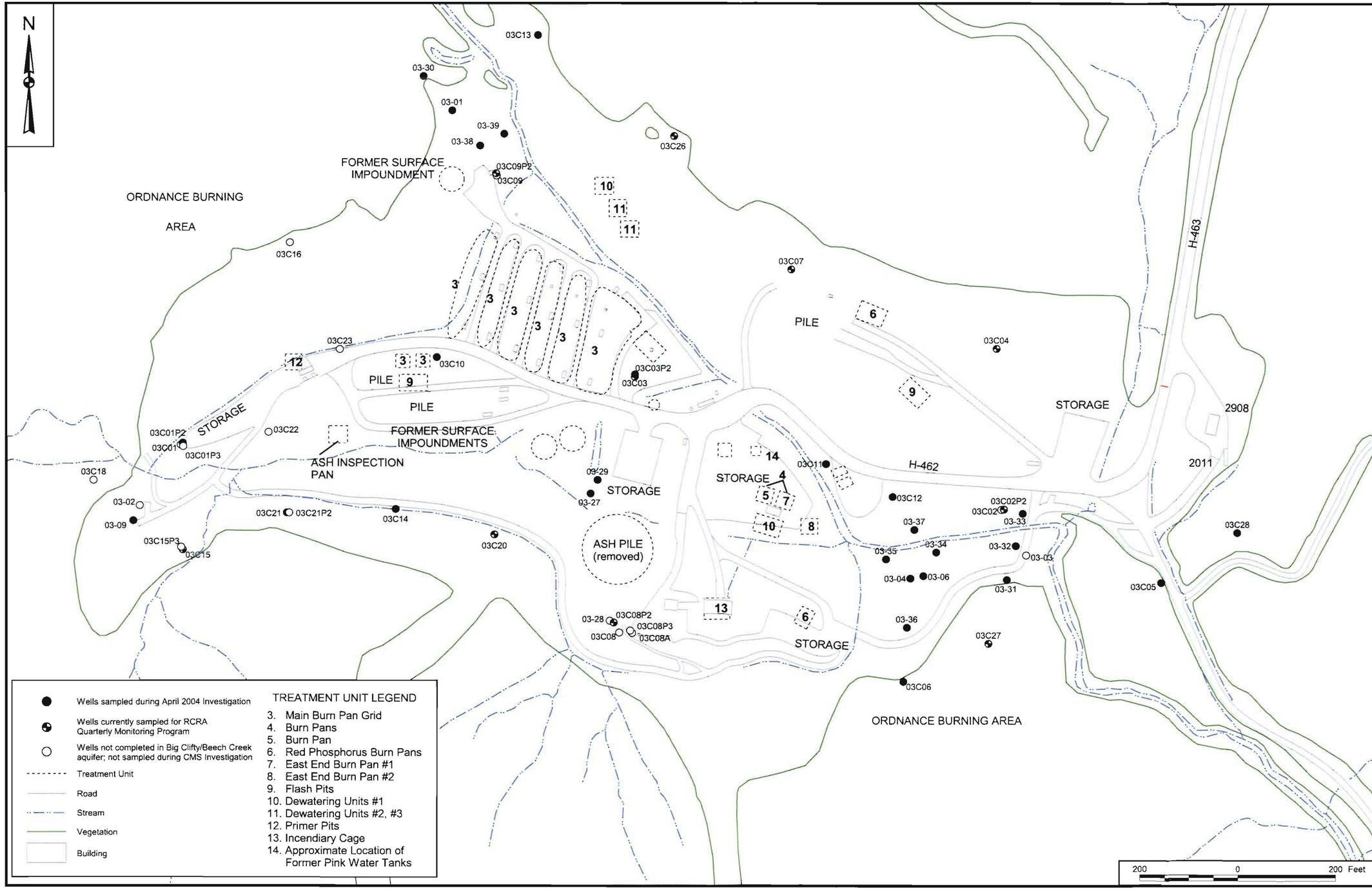
DRAWN BY	DATE
C. FOSTER	6/8/05
CHECKED BY	DATE
V. PLACHY	3/27/06
COST/SCHEDULE-AREA	
SCALE	AS NOTED

NAVFAC

SURFACE WATER FEATURES ASSOCIATED
WITH LITTLE SULPHUR CREEK
CMS REPORT FOR SWMU 03 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER CTO 0311	
APPROVED BY —	DATE —
APPROVED BY —	DATE —
DRAWING NO. FIGURE 1-3	REV 0

P:\GIS\NSWC_CRANE\APR\7651.APR ABG - CROSS SECTION LAYOUT 6/19/06 SP



CONTRACT NO. CTO 0311

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 1 - 4

REV 0

PHYSICAL FEATURES OF THE MTA PORTION OF THE ABG

CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS

NSWC CRANE

CRANE, INDIANA

NAVFAC

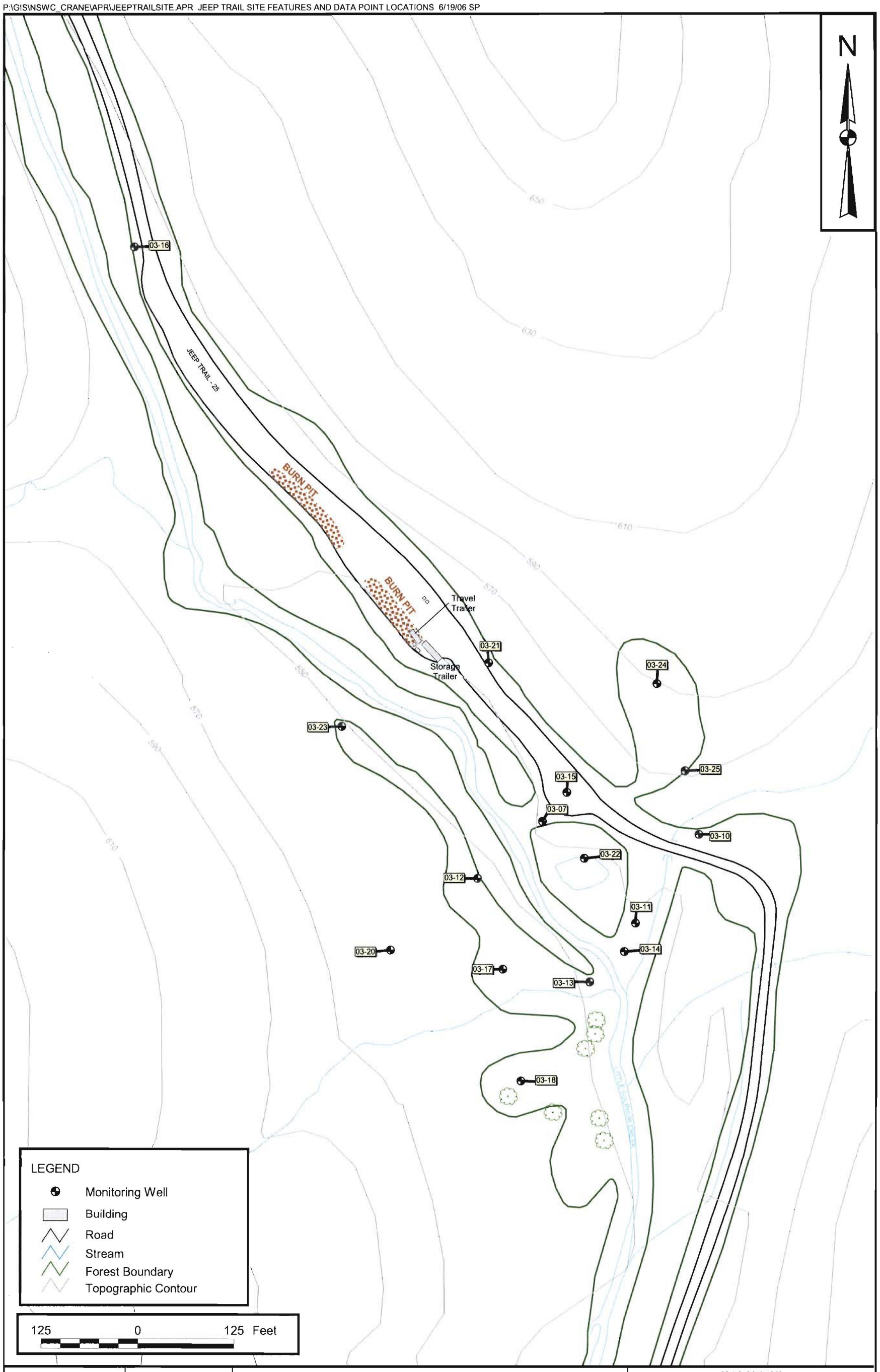
DRAWN BY A. JANOCHA DATE 3/03/04

CHECKED BY V. PLACHY DATE 6/19/06

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\JEEPTRAILSITE.APR JEEP TRAIL SITE FEATURES AND DATA POINT LOCATIONS 6/19/06 SP



DRAWN BY J. LAMEY	DATE 5/20/02	OLD JEEP TRAIL AREA / SITE MAP	CONTRACT NUMBER CTO 0311
CHECKED BY V. PLACHY	DATE 6/19/06	CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS	APPROVED BY — DATE —
COST/SCHEDULE-AREA		NSWC CRANE	APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC	CRANE, INDIANA	DRAWING NO. FIGURE 1 - 5 / REV 0

2.0 DESCRIPTION OF CURRENT CONDITIONS AT SWMU 3

Various historical investigations and risk assessments have been conducted at SWMU 3. As a result of these studies, the following have been identified as chemicals of potential concern (COPCs) for human health and ecological risk at the MTA, OJT, and LSC:

MTA

Soils (human health):

- Explosives (RDX)
- Volatile organic compounds (VOCs) [trichloroethylene (TCE)]
- Metals (barium, lead, and manganese)

Groundwater (human health):

- Explosives (RDX)
- VOCs [TCE, 1,1,2,2-tetrachloroethane (PCA), and 1,1,2-trichloroethane (TCA)]
- Metals (barium)

Sediments (ecological):

- Metals (barium, lead, and zinc)

OJT

Soils (human health):

- Explosives (RDX and TNT)
- Metals (lead)

Groundwater (human health):

- Explosives [RDX and TNT degradation product 2-amino-4,6-dinitrotoluene (2A-DNT)]
- VOCs (TCE and degradation products)

LSC

Surface Water (human health/ecological):

- Explosives [RDX and TNT degradation products 2A-DNT and 4-amino-2,6-dinitrotoluene (4A-DNT)]
- VOCs (TCE and degradation products)
- Metals (barium)

Sediments (ecological):

- Metals (barium, lead, and zinc)

Section 2.1 describes the historical investigations that have resulted in identification of these COPCs. Section 2.2 summarizes the results of the human health risk screening evaluation (HHRSE) for soils to determine whether risk exists for current human MTA receptors. Section 2.3 summarizes the MTA ERA conducted as part of this CMP. Section 2.4 summarizes the OJT human health risk assessment (HHRA) from the RFI Report (TtNUS, 2005a). Section 2.5 summarizes the OJT ERA. Section 2.6 summarizes the LSC alternative water quality criteria development. Section 2.7 presents the MCSs. Section 2.8 summarizes the Conceptual Site Model.

2.1 HISTORICAL INVESTIGATIONS

2.1.1 Surface/Subsurface Soil

2.1.1.1 MTA

2.1.1.1.1 USACE Phase III Study

Surface/Subsurface Soil

In 1993, the USACE collected surface soil grab samples (from depths of 1 to 30 inches) and subsurface soil samples (from depths of 30 to 60 inches and 60 to 90 inches) from locations across the ABG (Albertson et al., 1998). The soil samples were analyzed for explosive compounds, VOCs, semivolatile organic compounds (SVOCs), and metals.

The results of the soil analyses showed that VOCs were present in only a few locations, and only minor concentrations were typically detected (Albertson et al., 1998). The maximum concentrations of TCE, cis-1,2-dichloroethene (DCE), and trans-1,2-DCE were detected in boring 03/10-17.

HMX, RDX, trinitrobenzene, TNT, 2,4-dinitrotoluene (DNT), 2,6-DNT, 2A-DNT, and 4A-DNT were detected in surface and subsurface ABG soils. Locations where the highest concentrations of energetic compounds were detected included surface grab sample 03/10-61 and boring 03/10-35.

2.1.1.1.2 Current Contamination Conditions Risk Assessment

The Current Contamination Condition Risk Assessment was a field investigation and screening-level human health and environmental risk assessments that was conducted for the ABG, Old Rifle Range, and the Demolition Range (B&RE, 1997).

The following summarizes the screening-level human health and environmental risk assessments for soils:

- No unacceptable ecological risks from explosives, metals, or VOCs were identified
- No unacceptable human risks from explosives or VOCs were identified
- Zinc was identified as a human health chemical of concern (COC)

Because the CCCRA was a screening-level evaluation, further investigations were required to determine the actual risk to human and ecological receptors.

2.1.1.1.3 TtNUS CMS Field Investigation

A field investigation was conducted at the ABG by Tetra Tech NUS, Inc. (TtNUS) in April 2004 in an effort to fill data gaps identified during the early stage of CMP development. Groundwater underlying the MTA and OJT is contaminated with explosives (RDX) and chlorinated solvents (TCE) at concentrations greater than risk threshold levels and by metals (barium) at concentrations greater than screening levels. It was known that these contaminants were released to groundwater as the result of historical treatment practices, which occurred directly on the ground surface and released contaminants to the soils. In order to develop and estimate costs for effective remedial measures for soils, it was necessary to determine the locations and depths of soil contamination. It was also necessary to evaluate the relative ratios of contamination in soils versus contamination in bedrock to determine whether soil remediation would effectively reduce the contaminant sources. The historical data were inadequate to make these determinations.

To fill these data gaps, an additional investigation of MTA soils and groundwater was conducted during April 2004. A total of 223 soil samples were collected at 67 locations. All soil samples were analyzed for explosives, and selected soil samples were also analyzed for VOCs, RDX, TNT degradation products, Target Analyte List (TAL) metals, total organic carbon (TOC), pH, and cation exchange capacity (CEC). Sample depths were generally from 0 to 2 feet, 2 to 6 feet, 6 to 10 feet, and 10 to 14 feet or until refusal. Analytical results showing analytes detected in surface and subsurface soil are provided in Appendix A of the draft Draft Conceptual Site Model and Fieldwork Report (TtNUS, 2005b). Figure 2-1 summarizes the results for the most frequently detected explosives (RDX, HMX, and TNT) and the most frequently detected organic (TCE). Figure 2-2 summarizes the results for barium, the primary metal of concern.

All target explosives were detected in at least once in all surface soil samples. Most detections of explosives were less than 1.0 milligram per kilogram (mg/kg), with maximum explosives concentrations detected at 03SB120 [RDX (660 mg/kg), HMX (1,100 mg/kg), and TNT 400 (mg/kg)], which is the location of the former pink water tanks (Figures 1-4).

Surface Soil

Three HMX detections in surface soil (03SS088, 03SS119, and 03SS120) were greater than the soil-to-groundwater HMX soil screening level (SSL) level of 52.6 mg/kg. Five RDX detections in surface soil (03SS080, 03SS107, 03SS109, 03SS119, and 03SS120) were greater than the RDX SSL of 0.004 mg/kg. Seven detections for TNT in surface soil (03SS075, 03SS079, 03SS088, 03SS092, 03SS108, 03SS119, and 03SS120) were greater than the TNT SSL of 0.011 mg/kg. Surface soils were not analyzed for TCE.

Subsurface Soil

Six (HMX, RDX, TNT, 1,3,5-trinitrotoluene, 2A-DNT, and 4A-DNT) of the 11 target explosives were detected in subsurface soil. The maximum concentrations of HMX, RDX, and TNT were detected in soil borings 03SB119, 03SB120, and 03SB079, respectively.

None of the HMX detections in subsurface soil were greater than the HMX SSL of 52.6 mg/kg. Four of the RDX detections in subsurface soil (03SB061, 03SB080, 03SB119, and 03SB120) exceeded the RDX SSL of 0.004 mg/kg. Two of the TNT detections in subsurface soil (03SB079 and 03SB088) exceeded the TNT SSL of 0.011 mg/kg. Five of the TCE detections (03SB061 at two depths, 03SB102, 03SB103, and 03SB112) exceeded the TCE SSL of 0.057 mg/kg.

Based on these results, it was concluded that it is not possible to identify soil sources of COPCs that could account for the observed groundwater contamination.

2.1.1.2 Groundwater

2.1.1.2.1 USACE Phase III Groundwater Release Study and NSWC Crane Quarterly Monitoring

A Phase III RFI characterization for groundwater was conducted by the USACE WES (Murphy, 1994) at the MTA. A total of 98 borings and wells were drilled for this study. Seventy-two wells were sampled quarterly starting in 1987. Springs were also sampled. The RFI Report concluded that several wells within the MTA were contaminated. Contaminants included PCA, RDX, TCA, TCE, and barium. Other metals were detected less frequently. The occurrence of RDX in groundwater was confined to wells within the MTA and the mouth of Spring A.

The RFI recommended that a risk assessment be conducted to establish action levels and then to prepare a CMP.

2.1.1.2.2 Current Contamination Conditions Risk Assessment

The Current Contamination Condition Risk Assessment was a field investigation and screening-level human health and environmental risk assessments that was conducted for the ABG, Old Rifle Range, and the Demolition Range (B&RE, 1997).

The following summarizes the screening-level human health and environmental risk assessments for groundwater:

- RDX was identified as a human health COC
- TCE, vinyl chloride, TCA, and 1,1-DCE were identified as human health COCs
- Aluminum, antimony, arsenic, barium, chromium, manganese, and nickel were identified as human health COCs

Because the CCCRA was a screening-level evaluation, further investigations were required to determine the actual risk to human and ecological receptors.

2.1.1.2.3 RCRA Part B Permit Monitoring

The MTA is a RCRA-permitted treatment unit for the open burning of explosive materials in containment devices. The RCRA Part B Operating Permit requires quarterly monitoring of upgradient and downgradient wells in the BC/BC and Beaver Bend aquifers, the Spring A discharge point for contaminated MTA surface waters, and LSC. As part of RCRA quarterly monitoring at selected MTA wells, 12 Beech Creek aquifer monitoring wells have been sampled between 8 and 20 times since the fall of 1998. The samples have been analyzed for inorganics, VOCs, and explosives. Annually, samples from selected wells are analyzed for Appendix IX parameters. Nine rounds of monitoring were conducted to determine whether explosives and chlorinated solvents may be naturally attenuating. Analytical results are presented in annual monitoring reports, which also include statistical comparisons of downgradient wells to the upgradient well. Following is a summary of the conclusions regarding contaminants that have been detected in statistically significant concentrations and that also exceed risk-based target levels (RBTLs) established in the Operating Permit. Appendix A contains summary tables and conclusions from the annual monitoring reports for calendar years 2000, 2001, 2002, and 2003 (SAIC, 2002a, 2002b, 2003a, and 2003b, respectively)

Explosives: RDX is the primary explosive detected in downgradient wells, Spring A, and in LSC. 1,3,5-Tritnitrobenzene has been sporadically detected in two downgradient wells.

Metals: Barium (total and dissolved) is the primary metal that has been detected in downgradient wells and Springs A and C. Sporadically, exceedances have been observed for selenium, manganese, and zinc in one well (03C11).

VOCs: TCE and TCE degradation products have been consistently observed in several downgradient wells. Carbon tetrachloride has been consistently detected in two wells (03C09P2 and 03C10). Chloroform has been consistently detected in four wells (03C09P2, 03C10, 03C11, and 03C20). VOCs have rarely been rarely detected in Springs A and C and LSC.

2.1.1.2.4 TtNUS CMS Field Investigation

The field investigation conducted by TtNUS at the MTA in April 2004 included the collection of groundwater samples from 26 monitoring wells. All groundwater samples were analyzed for explosives, VOCs, and metals. Selected samples were also analyzed for perchlorates. In the case of metals, unfiltered samples were analyzed for total metals. If the turbidity of a groundwater sample was greater than 10 nephelometric turbidity units (NTUs), a filtered sample was collected and analyzed for dissolved

metals. Analytical results showing analytes detected in groundwater are provided in Appendix A of the Draft Conceptual Site Model and Fieldwork Report (TtNUS, 2005b).

The most frequently detected explosives in groundwater at the MTA were HMX and RDX. More than 80 percent of the detections were greater than 1 microgram per liter (µg/L), with concentrations at 11 locations (03-01, 03-31, 03-33, 03-38, 03-39, 03C03P2, 03C14, 03TW01, 03TW02, 03TW04, and 03TW05) exceeding the U.S. EPA Region 9 RDX Preliminary Remediation Goal (PRG) of 0.61 µg/L. None of the HMX detections in groundwater exceeded the HMX PRG of 1,800 µg/L.

In addition to RDX and HMX, one TNT detection (03-21) exceeded the PRG of 2.2 µg/L, three 4A-DNT detections (03TW05, 03-21, and 03C03P2) were greater than the PRG of 2.2 µg/L, and one 2A-DNT detection (03C03P2) exceeded the PRG of 2.2 µg/L.

There were 14 detections of TCE in groundwater at the MTA. Eleven TCE detections (03C03P2, 03C06, 03TW02, 03TW05, 03-38, 03-39, 03-01, 03-07, 03-12, 03-15, and 03-24) exceeded the PRG of 1.6 µg/L.

2.1.1.3 Sediment

2.1.1.3.1 Current Contamination Conditions Risk Assessment

The Current Contamination Condition Risk Assessment was a field investigation and screening-level human health and environmental risk assessment that was conducted for the ABG, Old Rifle Range, and the Demolition Range (B&RE, 1997).

The following summarizes the screening-level human health and environmental risk assessments for sediment:

- No unacceptable risks were identified for human receptors.
- No unacceptable risks were identified for ecological receptors.

2.1.2.2 OJT

2.1.2.2.1 2001 OJT/LSC RFI

Surface/Subsurface Soil

Forty-eight surface soil and 62 subsurface soil samples were collected from 48 soil borings at depths ranging from 1 to 15 feet below ground surface (bgs) at the OJT during the 2001 OJT/LSC RFI. The maximum RDX soil concentration was 4.4 mg/kg in soil boring 03SB24 on the western side of the burn pit. This and other soil RDX concentrations might account for the high RDX concentration detected in well 03-21. The burn pit was identified as the potential source area of energetics (i.e., RDX) and TCE contamination in groundwater. However, the levels of TCE detected in soil were not high enough to account for the TCE concentrations detected in well 03-07. Summaries of the analytical data for surface and subsurface soil samples collected during the 2001 OJT/LSC RFI are presented in Appendix A of the Draft Conceptual Site Model and Fieldwork Report (TtNUS, 2005b).

2.1.2.2.2 TtNUS CMS Field Investigation

Subsurface Soil

Four soil borings (03SB049, 03SB50, 03SB51, and 03SB52) were completed at the OJT during the April 2004 field investigation. All OJT surface and subsurface samples were analyzed for explosives and TAL metals. Selected sample depths were analyzed also for VOCs, RDX, TNT degradation products, and perchlorates. Analytical results showing analytes detected in groundwater are provided in Appendix A of the Draft Conceptual Site Model and Fieldwork Report (TtNUS, 2005b).

TNT and HMX were the only two explosives detections (both at 03SS050) in surface soil at the OJT. Only the TNT concentration exceeded the TNT soil-to-groundwater SSL of 0.011 mg/kg. There were no detections of explosives in subsurface soil.

There were no detections of TCE in OJT surface or subsurface soil samples.

2.1.2.2.3 USACE Groundwater Studies – 1981 to 1983 and 1994

Groundwater

The USACE installed 17 monitoring wells in the OJT area between 1981 and 1983 (Murphy, 1996). TCE concentrations in one well (03-07) exceeded 1,000 µg/L on several occasions, and reached a maximum of 19,000 µg/L in 1982.

In 1994, TCE and cis-1,2-DCE concentrations were 4,000 and 1,000 µg/L, respectively, in well 03-07 (Murphy, 1996); TCE contamination was also detected at lower concentrations in two wells to the northeast (03-15 and 03-24) and two wells to the southwest (03-12 and 03-20) of well 03-07. The highest RDX concentration (365 µg/L) was detected in well 03-21, located north of well 03-07 and southeast of the burn pit.

2.1.2.2.4 2001 OJT/LSC RFI

Groundwater

The OJT monitoring wells were resampled in 2001 during the OJT/LSC RFI. The TCE concentration in well 03-07 and the RDX concentration in well 03-21 decreased significantly compared to the 1994 concentrations. Analytical results for this study are provided in Appendix A of the Draft Conceptual Site Model and Fieldwork Report (TtNUS, 2005b).

2.1.2.2.5 TtNUS CMS Field Investigation

Groundwater

A total of six groundwater wells (03-07, 03-12, 03-15, 03-16, 03-21, and 03-24) were sampled during the field investigation conducted in April 2004. All samples were analyzed for VOCs, explosives, and metals, with the samples at locations 03-07 and 03-15 also being analyzed for perchlorates. Analytical results showing analytes detected in groundwater are provided in Appendix A of the Draft Conceptual Site Model and Fieldwork Report (TtNUS, 2005b).

Five explosives (2A-DNT, 4A-DNT, HMX, RDX, and TNT) were detected in all wells sampled during the investigation. The maximum detected concentrations of RDX and HMX were in samples from wells 03-21 and 03-12. One TNT detection (03-21) exceeded the PRG of 2.2 µg/L. All six wells had positive RDX detections that exceeded the PRG of 0.61 µg/L. None of the detected HMX concentrations exceeded the PRG of 1,800 µg/L.

2.2 HUMAN HEALTH RISK SCREENING EVALUATION

The MTA is an active, operating, RCRA-permitted hazardous waste treatment facility. NSWC Crane intends to conduct hazardous waste treatment operations at the MTA until the year 2050. All RCRA-permitted facilities are subject to RCRA closure requirements. At the end of the active life of the MTA, it will either be clean closed or closed as a RCRA landfill in accordance with RCRA closure regulations for hazardous waste treatment facilities. Therefore, human receptors and pathways of exposure evaluated for this CMP are limited to the existing land use scenario because future land use scenarios will be addressed in the closure plan. An (HHRSE) was conducted to determine whether risks exist to current receptors that must be addressed in the CMP. Appendix B contains the detailed HHRSE for soils. Following is a summary of the chemicals considered, potential receptors, exposures under current land use, and exposure pathways that were considered in the HHRSE:

Chemical Considered: Explosives, VOCs, and metals have been detected in surface and subsurface soils at the MTA.

On-Site Residents: Prohibited as long as the MTA is operated as a RCRA hazardous waste treatment facility (i.e., on-site residents are not a viable pathway under the current land use scenario).

Site Worker: Exposure occurs under current use of MTA as a RCRA hazardous waste treatment facility. Exposure is limited to surface soils because contaminated groundwater from the BC/BC aquifer is not withdrawn for drinking water (i.e., site worker exposure to surface soils is a viable pathway under the current land use scenario).

Construction Worker: Exposure may occur under current use of MTA as a hazardous waste treatment facility (i.e., construction worker exposure to surface soils is a potential pathway under the current land use scenario).

Trespasser: Exposure may occur under current use of MTA as a RCRA hazardous waste treatment facility. Exposure is limited to surface soils because contaminated groundwater from the BC/BC aquifer is not withdrawn for drinking water (i.e., trespasser exposure to surface soils is a viable pathway under the current land use scenario).

LSC Surface Waters for Recreational Use: LSC becomes a perennial stream downstream of Spring C (discharge point for contaminated OJT groundwater) and Springs A and A' (discharge points for

contaminated MTA groundwater) (i.e., LSC recreational use exposure is a viable pathway under the current land use scenario).

LSC Surface Waters as Drinking Water Source: Withdrawal of contaminated surface waters from LSC for use as drinking water is a viable exposure pathway under the current land use scenarios for the MTA (and OJT). However, under current land use scenarios and the anticipated future land use, this is only possible in areas of LSC beyond lands controlled by the Navy. Contaminated groundwater from the MTA discharges through the karst system into Springs A and A', which then discharges into LSC. LSC serves as a tributary to the East Fork of the White River, which is used as a drinking water source with the nearest intake at Shoals (Figure 1-3) (i.e., exposure to LSC surface waters as a drinking water source is a viable pathway under the current land use scenario).

Based on the above evaluation, an HHSRE was conducted for site workers, trespassers, and construction worker exposed to soils at the MTA and for off-site and on-site users of LSC surface waters. Therefore, for the MTA, the CMP will address excess risks to current SWMU 3 receptors (i.e., site worker, construction worker, and trespasser) and to users of LSC surface waters.

2.2.1 MTA Soils

This section is a summary of the results and conclusions of the HHRSE. Appendix B contains the detailed HHRSE.

The following constituents were evaluated in the HHSRE:

- Explosives
- Metals
- Chlorinated organic compounds

The HHSRE evaluated the following current receptors:

- Base personnel (typical SWMU workers) specifically assigned work tasks at the MTA
- Construction workers periodically assigned work at the MTA
- Trespassers

These receptors are typically exposed to soils via the following exposure pathways:

- Direct contact (i.e., incidental ingestion, and dermal contact)
- Inhalation of airborne soil particulates from the site

The risk characterization for COPCs in soils was conducted as follows:

- Except for lead, a simple risk-ratio technique was used estimates cancer and non-cancer risks based on the rationing of representative exposure point concentration to risk-based screening levels.

- For lead, qualitative comparisons of arithmetic mean lead concentrations in soils to U.S. EPA risk benchmarks for residential and industrial land use scenarios were used.

2.2.2 Summary and Conclusions for MTA Soils

The following conclusions were reached based upon the results of the HHRSE for MTA soils:

- Cancer risks developed for COPCs (explosives, chlorinated organics, and metals) detected in soils do not exceed the U.S. EPA target cancer risk range of $1x10^{-4}$ to $1x10^{-6}$ for the industrial worker, construction worker, or trespasser.

- Non-cancer risk estimates for COPCs (explosives, chlorinated organics, and metals) detected in soils for the industrial worker and trespasser are less than the U.S. EPA hazard index (HI) threshold of 1.

- Non-cancer risk estimates for construction worker exposure to soils are 10 for COPC concentrations in both surface and subsurface soils; the primary risk drivers are barium, lead, and manganese.

  - Barium is not recommended for further evaluation in the CMP for SWMU 3 because non-cancer risk estimates based on sub-chronic inhalation reference doses available in the Health Effects Assessment Summary Table (HEAST), but not in the Integrated Risk Information System (IRIS) database, indicated that construction worker exposure to on-site barium concentrations would not result in HIs exceeding 1. Therefore, barium in MTA soils will not be carried forward in this CMP for human receptors.

  - Manganese is not recommended for further evaluation in the CMP for SWMU 3 because the non-cancer risk estimates for the construction worker are based on a chronic inhalation reference dose (a sub-chronic inhalation reference dose is not available) developed using toxicity data reflective of a workers exposure to manganese oxide compounds in an occupational setting (not

incidental exposure to soils). Therefore, manganese in the MTA soils will not be carried forward in this CMP for human receptors.

- Lead is recommended for further evaluation in the CMP for SWMU 3.

- The area of concern for lead is a sub-area of the southeastern quadrant of the MTA that has arithmetic mean lead concentrations (681 mg/kg) exceeding the U.S. EPA Region 9 soil PRGs for residential and industrial land use scenarios, and the calculated site-specific screening level (550 mg/kg) for the construction worker (see Figure 2-3).

To ensure that no construction will occur in the area of concern for lead (e.g., the sub-area), land use controls (LUCs) will be implemented for this area of the MTA. Therefore, for the construction worker, LUCs will be addressed in this CMP Report as the recommended CM for the lead-contaminated sub-area of the MTA.

2.3 MTA ECOLOGICAL RISK ASSESSMENT

2.3.1 Surface Soils

Currently, and for the foreseeable future, open burning/open detonation operations will continue to occur at the active portion (MTA) of the ABG. Figure 2-4, an aerial photograph of the MTA, shows that the MTA consists of roads and other areas covered by gravel, pavement, concrete, etc., which is surrounded by mowed grass. The active area is surrounded by a heavily wooded area as seen in Figure 2-4. Because of the industrial nature of the site, with the exception of soil invertebrates, grass, and other herbaceous plants, few ecological receptors would be present in the active area except in passing. Therefore, there is not an ecologically significant ecological community that would be impacted by site contaminants. After activities cease at the site, a risk-based closure plan would need to be prepared, and risks to ecological receptors would be evaluated at that time for the uses designated in the closure plan.

Thus, surface soils associated with the MTA will not be carried forward in this CMP for ecological receptors.

2.3.2 Surface Water

Elevated levels of various compounds in surface water may have a potential adverse impact to wildlife at the site; however, impacts as a result of these COPCs would be very localized and unlikely to impact the viability of any one species at the site because of the availability of similar habitat in close proximity to these

locations. Population studies at SWMU 3 support this conclusion; animal, fish, macroinvertebrate, and vegetation species are diverse and abundant and are similar to those that would be expected to occur in non-impacted areas (TtNUS, 1999).

Therefore, surface water associated with the MTA will not be carried forward in this CMP for ecological receptors.

2.3.3 Sediments

The majority of ecological risks posed by COPCs at the MTA appear to be limited to aquatic habitats at the SWMU. Elevated levels of barium, lead, and zinc in sediments at the site may have slight adverse effects to wildlife; however, population studies and tissue samples for fish and macroinvertebrates did not show any evidence of adverse effects (TtNUS, 1999). Based upon the Current Contamination Conditions Risk Assessment (CCCRA), barium, lead, and zinc in the MTA should not be carried forward in this CMP for ecological receptors.

However, in further support of the elimination of barium as a COPC in sediments, an MTA ERA was conducted for barium (Appendix C). Barium was eliminated as an ecological COPC for sediments in LSC based on the following:

- Barium concentrations were greatest in samples collected within the MTA and decreased further downngradient, although they remained greater than the Apparent Effects Threshold (AET) and exceeded concentrations in samples collected upgradient of the MTA.

- Portions of LSC upgradient of Spring C are poor habitat for aquatic receptors, and significant impacts are unlikely because the number of receptors is limited by the poor habitat.

- Perennial portions of LSC (e.g., below Spring C) are currently supporting a variety of aquatic receptors, indicating that impacts from barium are not significant.

Therefore, based upon the CCCRA and the ERA, barium, lead, and zinc will not be carried forward in this CMP for ecological receptors.

2.4 OJT HUMAN HEALTH RISK ASSESSMENT

The human receptors evaluated for the OJT and LSC were the construction worker, maintenance worker, occupational worker, adolescent trespasser, off-site resident, off-site recreational user, and future adult and child residents. Human exposure pathways evaluated for the OJT and LSC were surface soil, subsurface soil, groundwater, surface water (high- and low-flow), and sediment (surface and deeper).

Two exposure units of different sizes were evaluated: the 1-acre exposure unit described in the Quality Assurance Project Plan (QAPP), which encompasses the burn area/burn pit, and the entire 6-acre OJT and LSC study area (TtNUS, 2001).

Based on evaluation of data obtained during the RFI investigation, consideration of site operational history, data generated during past investigations, results of the baseline HHRSE and ERA, and the QAPP decision rules for the OJT and LSC, the following conclusions were reached:

- The soil, groundwater, surface water, and sediment data collected during the RFI were adequate to support the development of baseline human health and ecological risk assessments for the OJT and LSC.

- Under current land use, no significant potential human health risks are expected for exposures to soil, sediment, surface water, or groundwater.

- Under future land use, non-carcinogenic risks exceeding an HI of 1.0 and/or Incremental Lifetime Cancer Risks (ILCRs) exceeding 1x10-4 were identified for on-site child and adult residents using surface water as a potable water source, mainly as a result of samples collected from location 03SWSD17. This location is downstream of Spring A, which is a direct conduit for groundwater contaminant transport from the MTA. 2A-DNT, 4A-DNT, and RDX were the major contributors to the elevated risks for surface water.

- Under future land use, non-carcinogenic risks exceeding an HI of 1.0 and/or ILCRs exceeding 1x10-4 were calculated for occupational workers, child recreational users, and on-site child and adult residents using groundwater as a potable water source. TCA, TCE, and 2A-DNT were the major contributors to the elevated risks for groundwater.

- Unacceptable risk due to exposure of the future on-site child resident to surface soils was identified, primarily as a result of high lead concentrations at surface soil sampling location 03SB24.

- A CMP should be implemented to evaluate remedial alternatives to reduce the identified unacceptable risks. This CMP should consider all sources of contamination at the MTA, OJT, and LSC because groundwater, surface water, and sediment flow from the MTA toward the OJT and LSC.

Therefore, risks from exposure to surface soil lead concentrations at sampling location 03SB024 for the OJT future child receptor will be addressed at closure.

Additionally, the following will be addressed in Section 2.6 of this CMP:

- Exposure to groundwater as a potable water source for future OJT occupational workers, child recreational users, and on-site child and adult residents based on risks from TCA, TCE, and 2A-DNT.

2.5 OJT ECOLOGICAL RISK ASSESSMENT

An ERA was conducted at the OJT and LSC (TtNUS, 2005a) in accordance with the approved QAPP for SWMU 3 (TtNUS, 2001). The ecological receptors evaluated in the assessment included the following:

- Those directly exposed to chemicals in surface water, sediment, and surface soil (i.e., plants, invertebrates in soil and sediment, and aquatic organisms).

- Those indirectly exposed to chemicals via the food chain (i.e., through the ingestion of plants, fish, and invertebrates).

Based on evaluation of the data obtained during the RFI investigation, consideration of site operational history, data generated during past investigations, and the QAPP requirements, the following conclusions were reached:

- Several chemicals were retained as COPCs in the initial ecological screening process in surface soil due to exceedances of direct contact, risk-based COPC screening levels, or because no current medium-specific Ecological Data Quality Levels (EDQLs) are available. During the Step 3a evaluation, no chemicals initially selected as COPCs were retained for further evaluation. The majority of elevated detections were found at locations 03SS22 and 03SS24. Both of these sample locations are in the southern burn pit/burn area along the fringe of the road where the habitat for plants and invertebrates is poor. Based on field sheets and boring logs, the surface soil sample (0 to 2 feet) from 03SS24 consisted of clayey silt, sand, gravel (top 1.5 feet) and silty clay (bottom

0.5 foot), and trace ash, and the surface soil sample (0 to 2 feet) from 03SS22 consisted of sand and gravel (top 0.4 foot) and clay with trace silt and sand (bottom 1.6 feet). Ash and burnt materials/cinders were found in the subsurface soil immediately below the surface soil samples. Therefore, it is not likely that a large earthworm population would inhabit this area because of the large amount of sand and gravel in the soil. It does not appear that plants are being adversely impacted because herbaceous plants are present along the road. Significant impacts to plants and invertebrates are therefore not expected because the poor habitat would limit the numbers of receptors, especially earthworms that would inhabit this area. Although risks to plants and invertebrates from COPCs in the soil are possible, the potential risks from chemicals initially selected as COPCs are not great enough to warrant further evaluation.

- Several chemicals were retained as COPCs in the initial ecological screening process in sediment and surface water due to exceedances of direct contact, risk-based COPC screening levels, or because no current medium-specific EDQLs are available. During the Step 3a evaluation, no chemicals initially selected as COPCs were retained for further evaluation. Currently, the highest contamination concentrations in LSC are in areas where the creek is intermittent and there is little viable aquatic habitat, and chemicals present in the perennial portion of LSC do not appear to be adversely impacting aquatic receptors. Various aquatic insects, fish, crayfish, frogs, and salamanders were observed in the perennial portion of LSC during a June 2004 site visit.

- Chemicals detected in surface soil, sediment, and surface water that are considered persistent, bioaccumulative, and toxic (PBT) were retained as COPCs for evaluation in terrestrial wildlife food chain models. During the Step 3a evaluation, no PBT chemicals were retained for further evaluation because No-Observable-Adverse-Effects Level (NOAEL)-based Ecological Effects Quotient (EEQs) using average exposure assumptions were near or less than 1.0. In the herbivorous/insectivorous models, only lead in the American robin model had a NOAEL EEQ of significance (EEQ = 24) using average exposure scenario; however, the exposure point concentration used in the model was elevated due to the maximum concentration detected at location 03SS24. This location is not likely to support earthworms due to the poor habitat in and surrounding the former burn pit. The NOAEL EEQ excluding location 03SS24 is 0.6. Several metals had NOAEL-based EEQs greater than 1.0 using the average exposure assumptions in the piscivorous mammal food chain model. However, LSC is small and is not likely capable of supporting 100 percent of the raccoon's diet, especially considering the large home range of this wildlife receptor. When an area use factor (AUF) of 10 percent is applied to the food chain models, NOAEL-based EEQs are less than 1.0.

Based upon the above information, the chemicals in surface water, sediment, and surface soil at SWMU 3 will not be carried forward in this CMP for OJT ecological receptors.

2.6 LSC ALTERNATIVE WATER QUALITY CRITERIA

The annual groundwater monitoring reports (SAIC, 2002a, 2002b, 2003a, and 2003b) identified RDX, TCE, and barium as the major constituents present in MTA groundwater in statistically significant concentrations greater than RBTLs. The RFI for the OJT/LSC (TtNUS, 2005a) identified excess risk resulting from ingestion of surface water containing RDX, 2A-DNT, and 4A-DNT for drinking water. The IDEM has established uses for all surface waters, including LSC. Protective criteria are established for various constituents to protect these uses. Based on the Indiana water quality standards (WQSs) for surface waters, concentrations of explosives including RDX, 2A-DNT, and 4A-DNT in LSC must be limited, at a minimum, to concentrations that would ensure maintenance of a balanced warm water aquatic community and that would protect public water supplies (at the point where water is withdrawn for drinking water or industrial use) for the most stringent of the two criterion. The concentration of RDX in LSC is the explosives risk driver because, typically, the combined concentrations of 2A-DNT and 4A-DNT are minimal (2A-DNT and 4A-DNT were not detected in the surface water samples collected in 2004) when compared to the RDX concentrations in LSC.

Indiana WQS regulations do not contain a list of protective criteria for RDX, 2A-DNT, or 4A-DNT. However, the regulations do contain a procedure for calculation of WQCs that are protective of human health and the environment. Following is summary of the process that was used to establish these criteria for SWMU 3. A detailed discussion of the methodology for the calculation of WQCs for these explosive compounds is contained in Appendix D.

As discussed in Section 1.4.4, the groundwater hydrology associated with SWMU 3 is complex. It has been determined that a karst system underlies part of the MTA that discharges groundwater from the BC/BC aquifer primarily at Springs A and A' and probably also at Spring B. Additionally, it has been determined that another karst system underlies part of the OJT that discharges groundwater from the BC/BC aquifer at Spring C, which is located upstream of Springs A, A', and B.

The surface water features of LSC and the streams into which it flows after it exits NSWC Crane property are shown on Figure 1-5. As previously discussed, LSC flows into Sulfur Creek; Sulfur Creek flows into Indian Creek; and Indian Creek flows into the East Fork of the White River.

In accordance with Indiana requirements, surface WQCs must be met at the location of the point of use. For protection of off-site receptors, these locations (see Figure 1-5) are defined as follows:

1. For warm water aquatic receptors, this location would be below Spring C, where LSC becomes a perennial stream.

2. For the full body contact recreational user (i.e., public health criterion, incidental water intake), this location would be LSC downstream of the location where Springs A, A', B, and C mix with LSC.

3. For protection of public water supplies, this location would be the closest location from which LSC surface waters are withdrawn for public water supply (i.e., Shoals Water Intake).

The following is a discussion of how WQCs were determined for barium, TCE, RDX, 2A-DNT, and 4A-DNT.

Barium

Barium has been detected in wells, springs, and surface waters in excess of the RBTL (3.9 µg/L) established in the RCRA Permit. The MCS for protection of human health is the Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL) (2,000 µg/L). Groundwater data for MTA monitoring wells and Spring A were evaluated to determine whether this MCL was exceeded. Appendix E includes the barium data from groundwater, spring, and surface water samples collected at the MTA since 1998. From 1998 through 2004, barium concentrations from MTA monitoring wells and Spring A ranged from 94.8 to 154 µg/L in unfiltered samples and from 96.2 to 142 µg/L for filtered samples. These concentrations are significantly less than the MCL of 2,000 µg/L.

Therefore, barium concentrations in groundwater and surface waters meet the MCL and will not be carried forward in this CMP for off-site human receptors.

RDX, 2A-DNT, and 4A-DNT

Alternative water quality criteria were developed for RDX, 2A-DNT, and 4A-DNT. Appendix E includes the data for these explosives in groundwater, spring, and surface water samples collected at the ABG since 1998.

Based on the Indiana WQCs for surface waters, RDX, 2A-DNT, or 4A-DNT concentrations in LSC must be limited to concentrations that would ensure maintenance of a balanced warm water aquatic community and that would protect public water supplies (at the point where water is withdrawn for drinking water or industrial use) for the most stringent of the two criterion. Applicable State and federal criteria, standards, and regulations are as follows:

- Under 327 Indiana Administrative Code (IAC) 2-1-6(a)(2)(C), Procedures for Calculation of Criteria, the RDX chronic aquatic criterion (CAC) was determined to by 3,070 µg/L, and the RDX terrestrial life cycle safe concentration (TLSC) was determined to be 2,800 µg/L.

- Springs A, A', B, and C can be considered to be equivalent to National Pollution Discharge Elimination System (NPDES) discharge points.

- The RDX water quality-based effluent limitation (WQBEL) established under 327 IAC 5-2-11.1 for public health criteria (incidental water intake only) was determined to be 120 µg/L.

- The 2A-DNT or 4A-DNT WQBELs established under 327 IAC 5-2-11.1 for public health criteria (incidental water intake only) were each determined to be 4,100 µg/L.

- The RDX public water supply point of intake criterion is 3 µg/L.

- The 2A-DNT and 4A-DNT WQBELs for public water supply intake were determined to be 68 µg/L for amino-dinitrotoluene compounds.

Using the USGS database for the closest water intake (Shoals), explosives concentrations at the nearest downstream gauging location (East Fork of the White River at Shoals) were calculated to be 0.0026 µg/L for RDX, 0.002 µg/L for 2A-DNT, and 0.0002 µg/L for 4A-DNT based upon the following assumptions (See Appendix D for the details):

- Spring C comprises the entire flow of LSC for 30 days.
- Spring C RDX concentrations are 63 µg/L, 2A-DNT concentrations are 70 µg/L, and 4A-DNT concentrations are 6.2 µg/L for 30 days.
- The LSC flow rate is 6 gpm for 30 days.
- The public water supply intake is located on the East Fork of the White River at Shoals.
- The monthly flow rate at Shoals is 142,279 gpm.

- No photolytic or biological degradation of RDX, 2A-DNT, or 4A-DNT occurs.

Based on these assumptions, the concentrations of RDX, 2A-DNT or 4A-DNT calculated for the Shoals intake are less than the applicable WQCs. Therefore, explosives in surface water will not be carried forward in this CMP for off-site human receptors.

PCA, TCA, AND TCE

No alternative water quality criterion were developed for PCA, TCA, or TCE. TCE and its degradation products are generally not detected or only detected at trace concentrations in springs and LSC surface waters. Appendix E includes the PCA, TCA, and TCE data for groundwater, spring, and surface water samples collected at SWMU 3 since 1998.

PCA, TCA, and TCE appear to be volatizing in the karst systems underlying the MTA and OJT, and any PCA, TCA, and TCE that would be present in the springs would volatize upon discharge to LSC.

Therefore, PCA, TCA, and TCE in groundwater will not be carried forward in this CMP for surface water.

2.7 MCS

Based on the results of the Risk Assessments presented in Sections 2.1 through 2.5, unacceptable risks to current and future receptors have been identified. The following identifies the constituents that present unacceptable risk to current and future human and ecological receptors:

MTA

Soils (human health):

- Explosives (Future Receptors)
- VOCs (Future Receptors)
- Metal (lead)(Current Receptors)

Groundwater (human health):

- Explosives (Current and Future Receptors)
- VOCs (Current and Future Receptors)

OJT

Soils (human health):

- Explosives (Future Receptors)
- VOCs (Future Receptors)
- Metals (Future Receptors)

Groundwater (human health):

- Explosives (RDX TNT, 2A-DNT) (Current and Future Receptors)
- VOCs (TCE and degradation products) (Current and Future Receptors)

LSC

Surface Water (human health/ecological):

- Explosives (RDX, TNT, 2A-DNT, and 4A-DNT)(Current Human Receptors)
- VOCs (TCE)(Current and Future Human Receptors)
- Metals (barium) (Current and Future Ecological Receptors)

Because future receptors will be addressed at closure, Table 2-1 presents the MCSs for SWMU 3 soil and surface water COCs for the current receptors. Groundwater usage will be prevented through the implementation of LUCs, therefore, MCSs have not been developed for groundwater COCs.

2.8 CONCEPTUAL SITE MODEL

Figure 2-5 is a schematic drawing of the Conceptual Site Model for the MTA. It shows that contaminants were released into surface/subsurface soils and migrated toward downgradient locations from those releases to deeper soils, groundwater, springs, and LSC. Appendix G presents the detailed Conceptual Site Model for the MTA. The following is a summary of the Conceptual Site Model for the MTA based on all information currently available:

- Groundwater underlying the MTA is contaminated with PCA, RDX, TCA, TCE, TNT, and degradation products of TNT and TCE in excess of risk-based concentrations. The presence of degradation products indicates that natural attenuation is occurring.

- The relative distribution of RDX and TCE contamination sources between the overburden, bedrock, and karst system is not known.

- The distribution of RDX and TCE contamination sources in the overburden soil, bedrock, and karst system appears to be heterogeneous in nature.

- Current practices (open burning in containment structures) have eliminated any current and future releases of contaminants to soils and groundwater; therefore, the contaminant source is being depleted through attenuation.

- MTA groundwater discharges through the karst system into LSC through Springs A and A'.

- TCE is volatized in the karst system and is not present in LSC surface waters.

- RDX concentrations in surface waters originating from Spring A discharges are less than applicable IDEM WQCs for public water supply and incidental contact with surface waters.

- The existing use for the MTA is industrial. Receptors associated with the existing use (military/industrial) include the site worker, construction worker, and trespasser.

- Contaminated groundwater underlying the MTA is not used and therefore does not present a risk under the industrial use scenario.

- Excess risk for existing use is present only for the construction worker resulting from exposure to lead.

- Excess risk for future use is present for future residents ingesting groundwater. Reasonable future uses for the MTA do not include residential housing.

- The industrial nature of the MTA (open burning operations, paved areas, etc.) eliminates ecological habit; therefore, ecological uses are not viable at the MTA.

Figure 2-6 is a schematic drawing of the Conceptual Site Model for the OJT. It shows that contaminants were released into surface/subsurface soils and migrated toward downgradient locations from those releases to deeper soils, groundwater, springs, and LSC. Exposure to the contaminants could result in

unacceptable health risks to humans. Appendix F presents the detailed draft Conceptual Site Model for SWMU 3 (TtNUS, 2005b). The following is a summary of the draft Conceptual Site Model for the OJT:

- Groundwater underlying the OJT is contaminated with RDX and TCE.
- RDX and TCE contamination sources appear to be distributed among the overburden soil, bedrock, and karst system.
- The relative distribution of RDX and TCE contamination sources between the overburden, bedrock, and karst system is not known due to the heterogeneous distribution of contamination at the OJT.
- Open burning operations, which resulted in the release of contaminants, have not taken place since the 1980s; therefore, the contaminant source is being depleted through attenuation.
- OJT groundwater discharges through the karst system into LSC at Spring C.
- LSC becomes a perennial stream below the Spring C discharge point.
- RDX concentrations in surface waters originating from Spring C discharges are less than applicable IDEM WQCs for public water supply and incidental contact with surface waters.
- TCE is volatized in the karst system and is not present in LSC surface waters.
- The existing use for the OJT is industrial. Receptors associated with the existing use (military/industrial) include the site worker, construction worker, and trespasser.
- Contaminated groundwater underlying the OJT is not used and; therefore, does not present a risk under the industrial use scenario.
- Excess risk for future use is present for future residents ingesting groundwater. Reasonable future uses for the OJT do not include residential housing.
- No excess risk to ecological receptors at the OJT or in LSC has been identified.

TABLE 2-1

HUMAN HEALTH MEDIA CLEANUP STANDARDS FOR CURRENT RECEPTORS
CMP REPORT FOR SMWU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

COC	Media Cleanup Standards		
	Surface Soil (mg/kg)	Surface Water (µg/L)	Groundwater (µg/L)
MTA			
Construction Worker			
Lead	540	N/A	N/A
OJT			
SWMU Worker			
TCE	N/A	21	N/A
LSC			
Future Life-Long Resident			
RDX[1]	4.4	3	N/A
TCE	N/A	5	N/A
TNT[2]	N/A	10	N/A
Recreational User			
A-DNT[3]	N/A	1,359	N/A
RDX[1]	N/A	239	N/A
TNT[2]	N/A	84	N/A
Fence Line Concentration			
A-DNT[3]	N/A	2,380,000	N/A
RDX[1]	N/A	106,707	N/A
TNT[2]	N/A	1,303,000	N/A

1 - The RDX MSCs are based upon a public water supply point of intake criterion of 3 µg/L as presented in Appendix D.

2 - The TNT MSCs are based upon a public water supply point of intake criterion of 10 µg/L as presented in Appendix D.

3 - The A-DNT MSCs are based upon a public water supply point of intake criterion of 67 µg/L as presented in Appendix D.

µg/L - Micrograms per liter.
A-DNT - 2-Amino-4,6-dinitrotoluene/4-amino-2,6-dinitrotoluene.
COC - Chemical of concern.
LSC - Little Sulfur Creek.
MCS - Media cleanup standard.
mg/kg - Milligrams per kilogram.
MTA - Main Treatment Area.
N/A - Not applicable to this medium for this COC.
OJT - Old Jeep Trail.
RDX - Hexahydro-1,3,5-trinitro-1,3,5-triazine.
TCE - Trichloroethylene.
TNT - 2,4,6-Trinitrotoluene.

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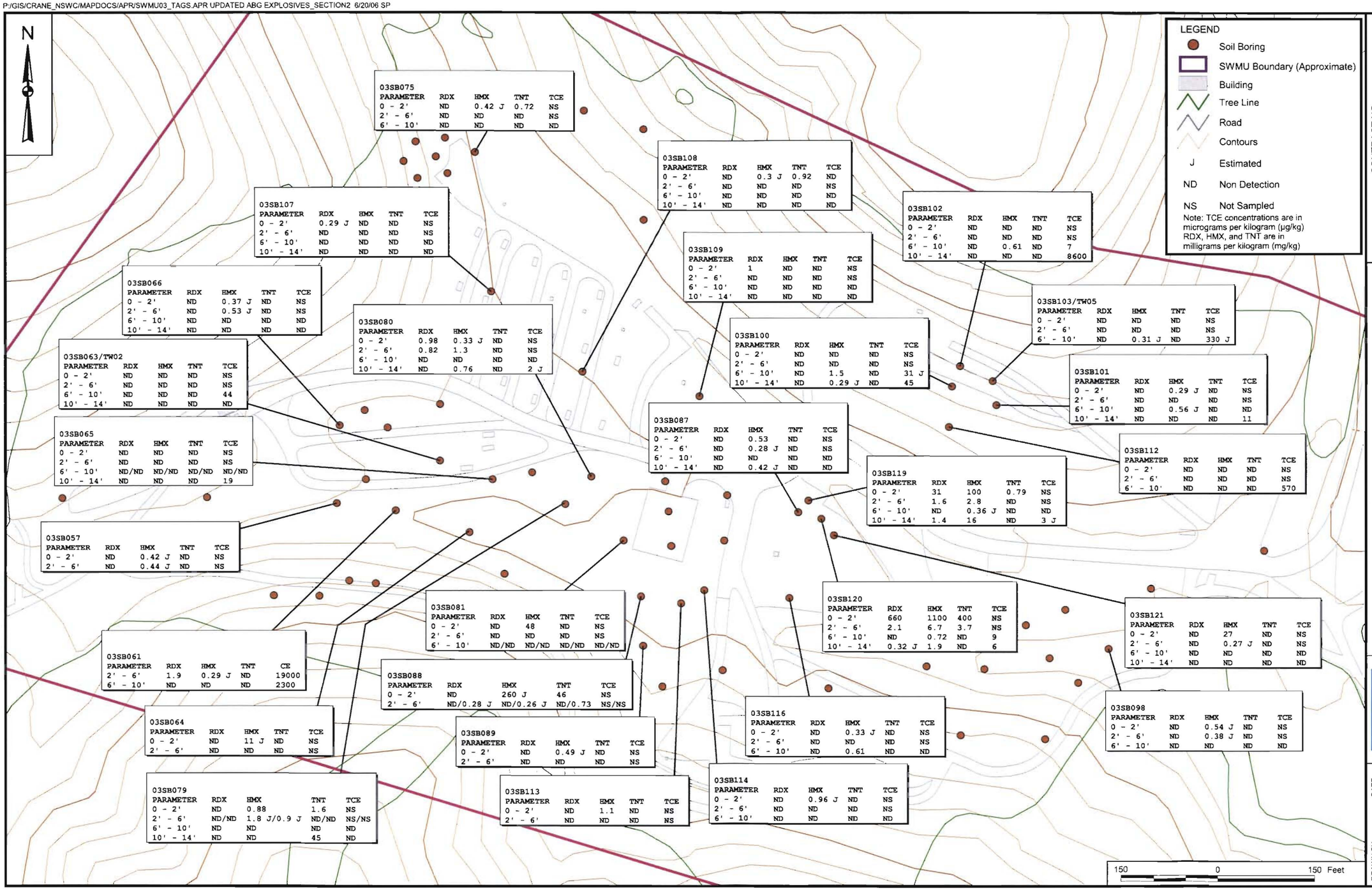

CONTRACT NO. CTO 0311

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 2-1

REV 0

PRIMARY ORGANIC CONTAMINANTS IN SURFACE AND SUBSURFACE SOILS
CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY V. PLACHY DATE 6/20/06

COST/SCHED-AREA

SCALE AS NOTED

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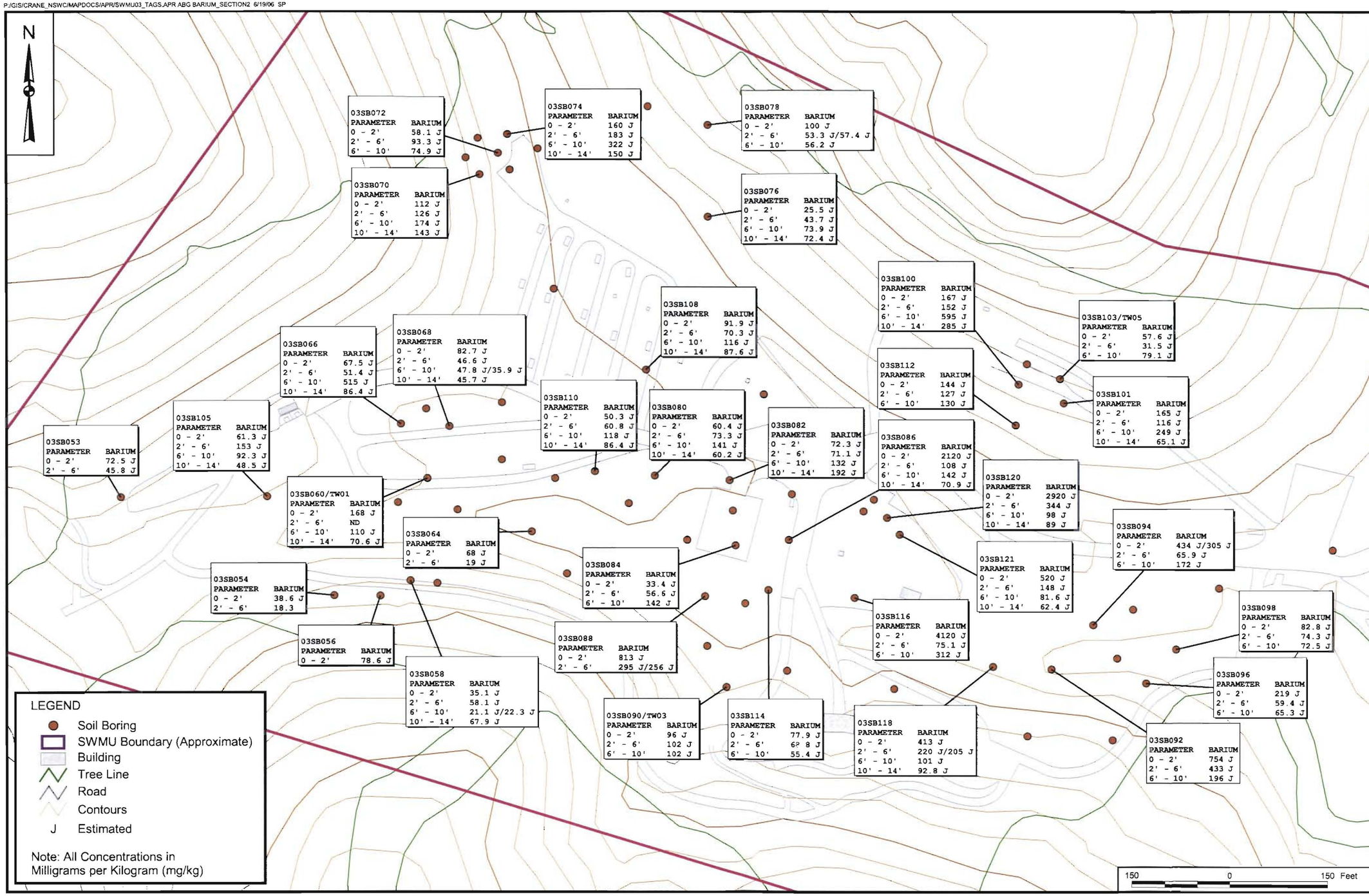

CONTRACT NO. CTO 0311

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 2-2

REV 0

BARIUM CONCENTRATIONS IN SURFACE AND SUBSURFACE SOILS

CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS (MAIN TREATMENT AREA)

NSWC CRANE

CRANE, INDIANA

NAVFAC

DRAWN BY A. JANOCHA DATE 9/14/04

CHECKED BY V. PLACHY DATE 6/19/06

COST/SCHED-AREA

SCALE AS NOTED

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CONTRACT NO.
CTO 0311

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 2 - 3

REV _

LEAD CONCENTRATIONS IN SURFACE SOILS (MG/KG)
CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
(MAIN TREATMENT AREA)
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY C. FOSTER DATE 7/20/05

CHECKED BY V. PLACHY DATE 6/20/06

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\SWMU3.APR SB 53-121 LOCATION_SECTION2 03/29/06 SS

CONTRACT NO.
CTO 0311

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 2-4 REV –

MAIN TREATMENT AREA AERIAL PHOTOGRAPH
SOIL BORING LOCATIONS
CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
CRANE NSWC
CRANE, INDIANA

NAVFAC

DRAWN BY C. FOSTER DATE 3/28/05

CHECKED BY V. PLACHY DATE 3/29/06

COST/SCHED-AREA

SCALE AS NOTED

FIGURE 2-5
CONCEPTUAL SITE MODEL SCHEMATIC DIAGRAM
MAIN TREATMENT AREA
CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA

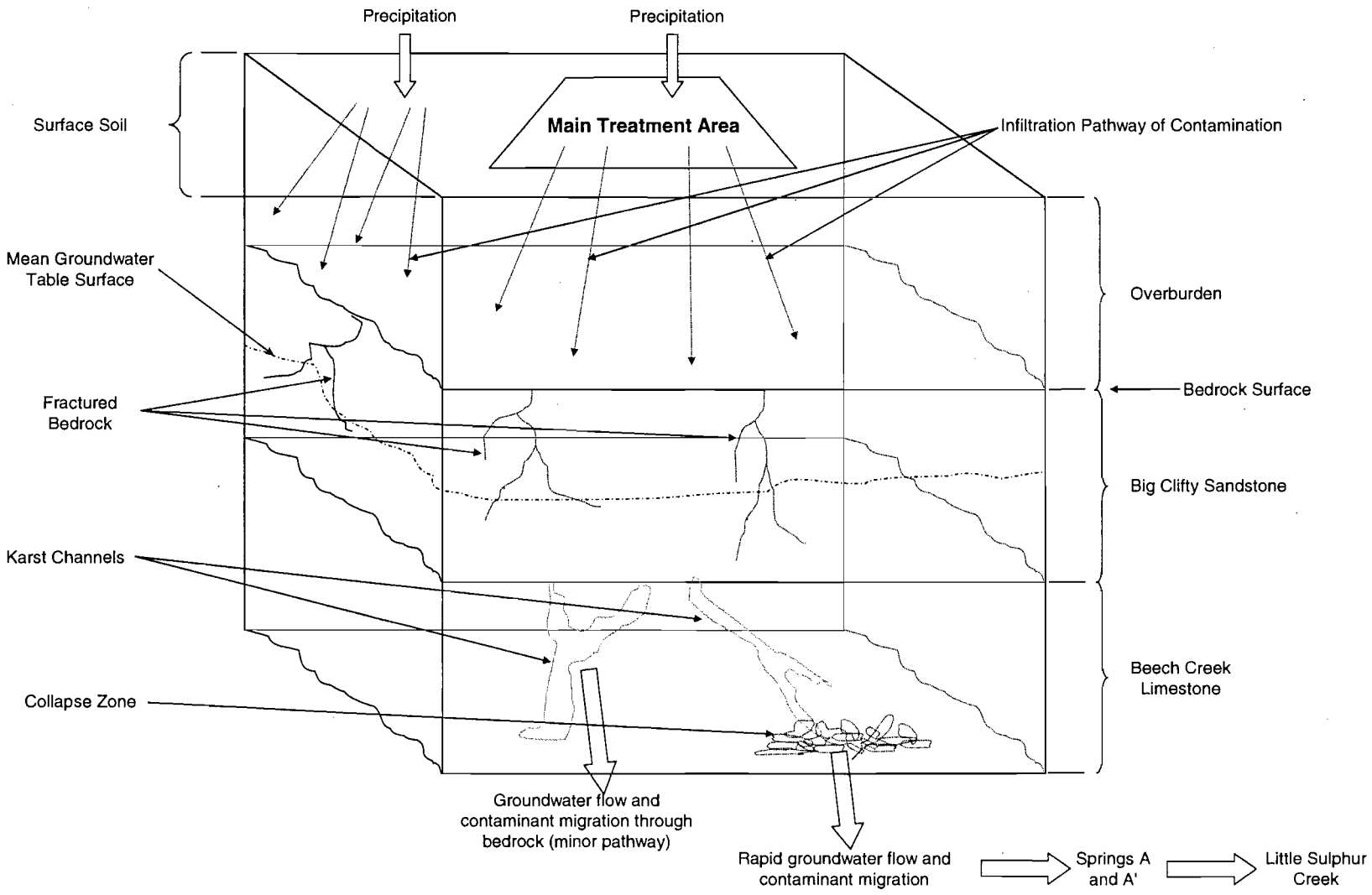
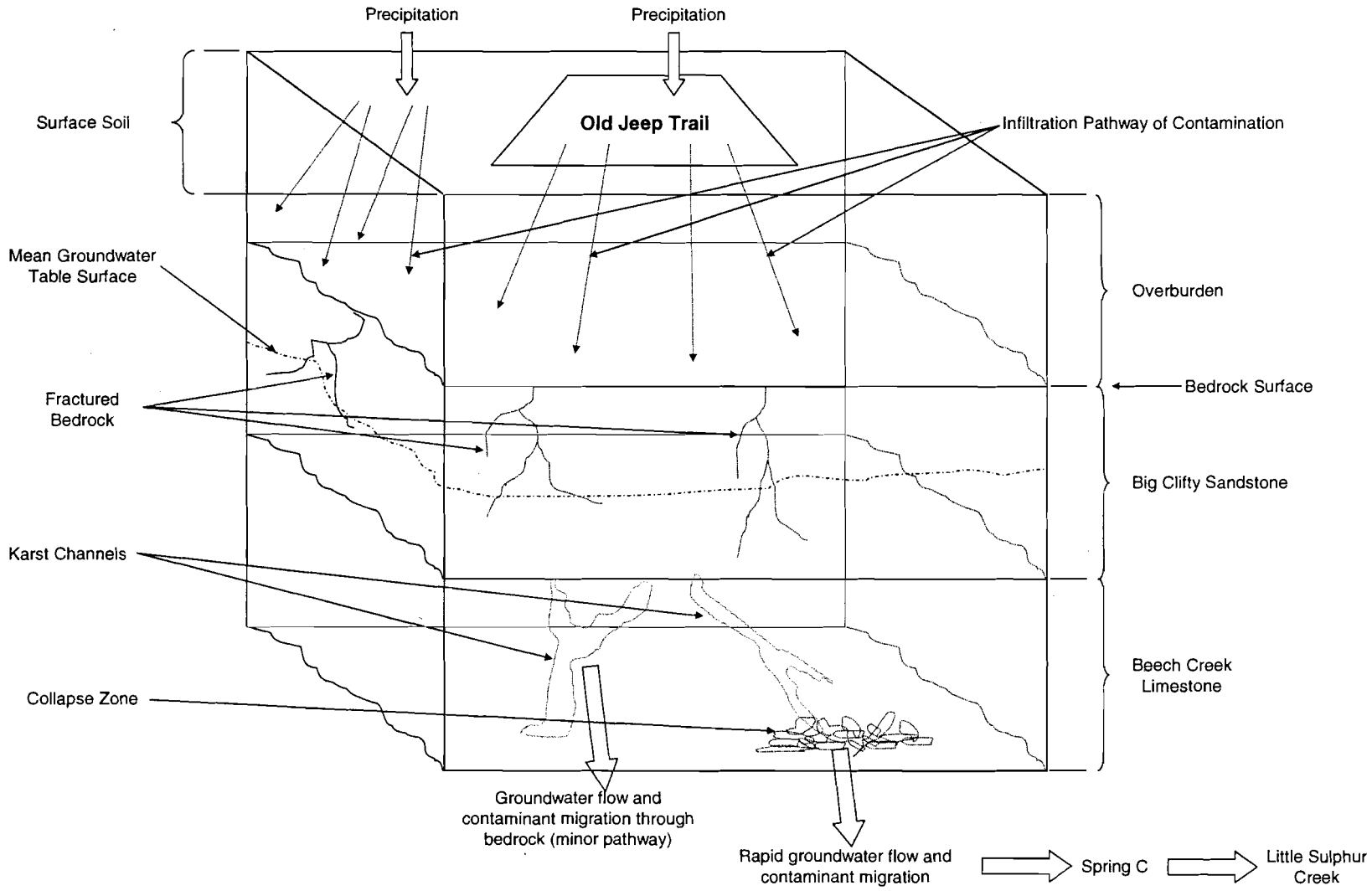


FIGURE 2-6
CONCEPTUAL SITE MODEL SCHEMATIC DIAGRAM
OLD JEEP TRAIL
CMP REPORT FOR SWMU 3 - AMMUNITION BURNING GROUNDS
NSWC CRANE
CRANE, INDIANA



3.0 DEVELOPMENT OF CORRECTIVE MEASURES RECOMMENDATIONS

Based on the current and future uses of SWMU 3 that are described in Section 1.0 and the Conceptual Site Model presented in Section 2.0, the following CM recommendations are made. Tables 3-1, 3-2, and 3-3 depict the process to arrive at these recommendations for the MTA, OJT, and LSC, respectively.

3.1 CORRECTIVE MEASURES

3.1.1 Soil

3.1.1.1 MTA

As part of the CMP process, an HHRSE was conducted for SWMU 3 risks to current MTA receptors (i.e., site worker, construction worker, and trespasser) from soils (Appendix B) and an ERA was conducted for SWMU 3 (Appendix C). Soil CMs were developed based upon the HHRSE. The following summarizes the soil CMs for the MTA at SWMU 3:

Two CMs will be considered for explosives, VOCs, and metals in soils at the MTA:

- No Action, designated as Alternative MTA-S1

- Limited Action, consisting of LUCs, designated as Alternative MTA-S2, to:
  - Prevent residential land use
  - Prevent construction at locations impacted by metals

3.1.1.2 OJT

As part of the RFI process a health risk assessment (HRA) and ecological risk assessment (ERA) was conducted for current and future OJT receptors (TtNUS, 2005). Soil CMs were developed based on the HRA. The following summarizes the soil CMs for the OJT at SWMU 3.

Two CMs to control exposure risks for future land use will be considered for explosives, VOCs, and metals in soils at the OJT:

- No Action, designated as Alternative OJT-S1

- Limited Action, consisting of LUCs, designated as Alternative OJT-S2, to:
  - Prevent residential land use

3.1.1.3 LSC

CMs for soils do not apply to LSC.

3.1.2 Groundwater

3.1.2.1 MTA

As part of the current contaminations risk assessment process a screening health risk assessment (Current Contaminations Conditions Risk Assessment (CCCRA) was conducted for current and future receptors for groundwater underlying the MTA. As part of the CMP development process, off-site receptors' (public water supply and recreational users) alternative WQC for explosives [RDX, TNT, and A-DNTs (2-amino-4,6-dinitrotoluene/4-amino-2,6-dinitrotoluene)] was developed. Water CMs for off-site receptors were developed based upon the alternative explosives WQCs that were developed as part of this CMP (Appendix D) and RFI Report (TtNUS, 2005b). The following summarizes the CMs for SWMU 3 groundwater.

Two CMs will be considered for explosives and VOCs in groundwater at the MTA:

- No Action, designated as Alternative MTA-GW1

- Limited Action, consisting of LUCs and Long-Term Monitoring (LTM), designated as Alternative MTA-GW2, to:
  - Prevent groundwater use
  - Determine whether explosives are naturally attenuating
  - Determine whether TCE is naturally attenuating

3.1.2.2 OJT

As part of the RFI process, a HRA was conducted for current and future receptors for groundwater underlying the OJT (TtNUS, 2005). As part of the CMP development process, the alternative explosives WQCs for off-site receptors (public water supply and recreational users) were developed for groundwater discharging to Spring C. Water CMs for off-site receptors were developed based upon the alternative

explosives WQCs as part of this CMP (Appendix D). The following summarizes the CMs for SWMU 3 groundwater.

Two CMs will be considered for explosives and VOCs in groundwater at the OJT:

- No Action, designated as Alternative OJT-GW1

- Limited Action, consisting of LUCs and LTM, designated as Alternative OJT-GW2, to:
  - Prevent groundwater use
  - Determine whether explosives are naturally attenuating
  - Determine whether TCE is naturally attenuating

3.1.3 Surface Water

3.1.3.1 LSC

Groundwater underlying the MTA and OJT discharge into LSC through Springs A and C, respectively. As part of the CMP process, off-site receptors' (public water supply and recreational users) alternative WQCs were developed for explosives (RDX, TNT, and A-DNTs) as part of this CMP (Appendix D). Water CMs for off-site receptors were developed based upon the alternative explosives WQCs. Two CMs will be considered for metals (barium), explosives, and VOCs in surface water at the LSC:

- No Action, designated as Alternative LSC-SW1

- Limited Action, consisting of LTM and Evaluation of Public Water Supplies Upstream of the Shoals, Indiana Water Intake, designated as Alternative LSC-SW2, to:
  - Verify that barium concentrations remain less than the MCL
  - Verify that TCE concentrations remain less than the MCL
  - Verify that explosives concentrations remain less than their alternative WQC
  - Determine if any new surface water recreational uses have occurred on LSC
  - Determine if any new surface water intakes have been installed on LSC or the East Fork of the White River
    - For all new surface water intakes, verify that explosives concentrations remain less than alternative WQCs

TABLE 3-1

REMEDY EVALUATION PROCESS SUMMARY
SWMU 3 - AMMUNITION BURNING GROUND
MAIN TREATMENT AREA
NSWC CRANE
CRANE, INDIANA

INVESTIGATION PHASE				REMEDIAL ACTION EVALUATION PHASE		
Main Treatment Area	**Document**	**Findings / Evaluations**	**Conclusion**	**Considerations**	**Evaluation Conclusions**	**Remedy**
Soils (Human Health)						
Explosives (RDX)	USACE Phase III Study, Part 2	RDX, HMX, TNT detected in soils	Conduct further investigations	• Future uses (residences and park visitor) addressed at closure and not evaluated • Current uses / receptors (industrial / site and construction workers and trespasser) for soil • Unable to determine proportion of explosives source in overburden versus bedrock • Unable to determine whether soil remediation would remove significant portion of explosives source • Soils not evaluated for protection of groundwater because groundwater not used • MTA not evaluated for ecological impacts because use as OB unit eliminates ecological habitat	• No risk from explosives to current receptors was identified • NFA and LUC where the only remedial actions evaluated • No detailed screening evaluation - No risk was identified for current uses / receptors	• Recommended alternative: LUC to prevent non-military/industrial uses
	CCCRA	HHRA and ERA conducted	No explosives identified as COCs			
	CMS Field Investigation	RDX sporadically detected mostly in surface and near-surface soils	Unable to establish link between soil sources of explosives and groundwater contamination			
VOCs (TCE)	USACE Phase III Study, Part 2	Minor concentrations detected	Conduct further investigations	• Future uses (residences and park visitor) addressed at closure and not evaluated • Current uses / receptors (industrial / site and construction workers & trespasser) for soil were evaluated • Unable to determine proportion of VOCs source in overburden versus bedrock • Unable to determine whether soil remediation would remove significant portion of groundwater source • Groundwater not used and soils not evaluated for protection of groundwater • Not evaluated for ecological impacts because use as OB unit eliminates ecological habitat	• No risk to current receptors was identified • No detailed screening evaluation - No risk was identified for current uses / receptors • NA and LUC were the only remedial actions evaluated	• Recommended alternative: LUC to prevent non-military/industrial uses
	CMS Field Investigation	Detected in subsurface soils	Relationship established between soil sources of VOCs and groundwater			
	CCCRA	HHRA and ERA conducted	No VOCs identified as COCs			
Metals (barium, lead, manganese)	USACE Phase III Study, Part 2	Several metals found in excess of background concentrations	Coordinate with regulatory agencies	• Future uses (residences and park visitor) addressed at closure and not evaluated • Current uses / receptors (industrial / site and construction workers and trespasser) for soil were evaluated • Groundwater not used and not evaluated • Not evaluated for ecological impacts because use as OB unit eliminates ecological habitat	• Lead identified as COC for construction worker • No detailed screening evaluation - No risk was identified for current uses / receptors • NA and LUC only remedial actions evaluated	• Recommended alternative: LUC to prevent non-military/industrial use and to prevent construction at location impacted by lead
	CCCRA	HHRA and ERA conducted	Zinc identified as COC for human health			
	CMS Field Investigation	Various metals detected	Unable to establish link between soil sources of explosives and groundwater contamination			
Groundwater (Human Health)						
Explosives (RDX)	CMS Field Investigation	Detected	RDX detected	• Future uses (residences and park visitor) addressed at closure • Current uses / receptors (industrial / site and construction workers & trespasser) for soil • Groundwater not used	• No risk to current receptors was identified because groundwater is not used • No remedial actions evaluated – No risk was identified to current receptors	• Recommended alternative: LUC to prevent use of groundwater • Recommended alternative: LTM to determine if RDX is naturally attenuating
	Routine Groundwater Monitoring Program	Statistical comparisons to background and to RBTLs	Detected in statistically significant concentrations greater than RBTL			
	CCCRA	HRA conducted	RDX identified as COC			
	USACE Phase III Study	Explosives contamination found in groundwater	Conduct risk assessment to establish action levels and proceed to CMP			
VOCs (TCE)	CMS Field Investigation	Detected		• Future uses (residences and park visitor) addressed at closure • Current uses / receptors (industrial / site and construction workers & trespasser) for soil • Groundwater not used	• No risk to current receptors was identified because groundwater is not used • No remedial actions evaluated – No risk was identified to current receptors	• Recommended alternative: LUC to prevent use of groundwater • Recommended alternative: LTM to determine if TCE is naturally attenuating
	CCCRA	HHRA conducted	Various VOCs identified as COCs			
	USACE Phase III Study	VOC contamination found in groundwater	Conduct risk assessment to establish action levels and proceed to CMP			
	Routine Groundwater Monitoring Program	Detected in statistically significant concentrations greater than RBTLs				

TABLE 3-1

REMEDY EVALUATION PROCESS SUMMARY
SWMU 3 - AMMUNITION BURNING GROUND
MAIN TREATMENT AREA
NSWC CRANE
CRANE, INDIANA

INVESTIGATION PHASE				REMEDIAL ACTION EVALUATION PHASE		
Main Treatment Area	**Document**	**Findings / Evaluations**	**Conclusion**	**Considerations**	**Evaluation Conclusions**	**Remedy**
Groundwater (Human Health) (continued)						
Metals	Routine Groundwater Monitoring Program	Statistical comparisons to background and to RBTLs	Barium consistently detected in statistically significant concentrations greater than RBTLs Other metals only sporadically detected in statistically significant concentrations greater than RBTLs	• Barium concentrations compared to MCL • All barium concentrations less than MCL	NFA	None required
	CCCRA	HHRA conducted	Several metals (aluminum, antimony, arsenic, barium, chromium, manganese, and nickel) were identified as COCs			
	USACE Phase III Study	Barium contamination found in groundwater	Conduct risk assessment to establish action level and proceed to CMP			
Sediments (Ecological):						
Metals (barium, lead, and zinc)	CCCRA	• May have slight adverse effects to wildlife • Population studies and tissue samples for fish and macroinvertebrates did not show any evidence of adverse effects	Proceed to CMP	• ERA conducted as part of CMP determined no adverse ecological impacts to wildlife	NFA	None required

CCCRA – Current Contamination Conditions Risk Assessment.
CMS – Corrective Measures Study.
COC – Chemical of concern.
ERA – environmental risk assessment.
HHRA – Human Health Risk Assessment.
HHRSE – Human Health Risk Screening Evaluation.
HMX – Cyclotetramethylenetetranitramine.
LTM – Long term monitoring.
NFA – No Further Action.
OB – open burning.
RBTL – Risk based target level.
RDX – hexahydro-1,3,5-trinitro-1,3,5-triazine.
SWMU – Solid Waste Management Unit.
TCE – trichloroethylene.
TNT – 2,4,6-Trinitrotoluene.
USACE – United States Army Corps of Engineers.

Document

USACE Phase III Study, Part 2 — Albertson, P., J.H. May, J.S. Nohrstedt, R.W. Magee, and P. Payonk, 1998. Rinal Report: RCRA Facility Investigation, Part 2 Phase III Soils Study, Ammunition Burning Ground, SWMU 03/10, Naval Surface Warfare Center Crane, Indiana, prepared by U.S. Army Corps of Engineers, Waterways Experiment Station, Technical Report, GL-98-23, May.

CMS Field Investigation (April 2004) — TtNUS (Tetra Tech NUS, Inc.), 2004. Corrective Measures Study Field Investigation. April.

HHRSE — TtNUS, 2005. Human Health Risk Screening Evaluation for SWMU 3. Naval Surface Warfare Center Crane, NSWC Crane. October.

USACE Phase III Study — USACE (United States Army Corps of Engineers), 1994. Murphy, W.L.. Final Report, RCRA Facility Investigation, Phase III, SWMU 03/10, Ammunition Burning Ground, prepared by United States Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, Technical Report GL-94-15, May.

Groundwater Monitoring Program — SAIC, 2002a, 2002b, 2003a, and 2003b. Annual Groundwater Monitoring Reporting for Ammunition Burning Grounds, Old Rifle Range, and Demo Range, CY 2000 (December 16, 2002), CY 2001 (December 16, 2002), CY 2002 (October 31, 2003), and CY 2003 (October 31, 2003), respectively, Naval Surface Warfare Center, Crane Division, Crane, Indiana.

OJT/LSC RFI Report - TtNUS — TtNUS, 2005. Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for SWMU 03 – Old Jeep Trail/Little Sulphur Creek, Naval Surface Warfare Center, Crane Division, Crane, Indiana prepared by TtNUS for Southern Division, Naval Facilities Engineering Command, North Charleston, South Carolina, January.

CCCRA — B&RE (Brown and Root Environmental), 1997. Current Contamination Conditions Risk Assessment. SWMU #03/10 (Ammunition Burning Ground), SWMU #07/09 (Old Rifle Range), SWMU #06/09 (Demolition Range), November.

TABLE 3-2

REMEDY EVALUATION PROCESS SUMMARY
SWMU 3 - AMMUNITION BURNING GROUND
OLD JEEP TRAIL AREA
NSWC CRANE
CRANE, INDIANA

INVESTIGATION PHASE				REMEDIAL ACTION EVALUATION PHASE		
Old Jeep Trail	**Document**	**Findings / Evaluations**	**Conclusion**	**Considerations**	**Evaluation Conclusions**	**Remedy**
Soils (Human Health)						
Explosives (RDX and TNT)	OJT/LSC RFI Report – TtNUS	RDX and TNT identified as COCs for future residents	Proceed to CMP	• No risks identified for current uses / receptors (industrial / site and construction workers and trespasser) • NSWC Crane is military facility, and residential use will not occur • Base need for corrective measures on plausible uses	• No detailed screening evaluation - No risk was identified for current uses / receptors • NFA and LUCs were the actions only evaluated	• Recommended alternative: LUC to prevent residential use
VOCs (TCE and degradation product)	OJT/LSC RFI Report – TtNUS	No VOCs identified as COCs	NFA			
Metals (lead)	OJT/LSC RFI Report – TtNUS	Lead identified as COC for future residents	Proceed to CMP			
Soils (Ecological)						
Mammals and birds	OJT/LSC RFI Report – TtNUS	Surface soil and surface water evaluated	NFA	None required	NFA	NA
Terrestrial plants and invertebrates		Surface soils	NFA	None required	NFA	NA
Groundwater (Human Health)						
Explosives (RDX, TNT, 2A-DNT and 4A-DNT)	OJT/LSC RFI Report – TtNUS	RDX, TNT, 2A-DNT, and 4A-DNT identified as COCs for future residents	Proceed to CMP	• No risks identified for current uses / receptors (industrial / site and construction workers and trespasser) • NSWC Crane is military facility, and residential use will not occur • Base need for corrective measures on plausible uses	• No detailed screening evaluation - No risk was identified for current uses / receptors • NFA and LUC were the only remedial actions evaluated	• Recommended alternative: LUC to prevent residential use • Recommended alternative: LTM to determine if explosives and VOCs are naturally attenuating
VOCs (TCE and degradation product)	OJT/LSC RFI Report – TtNUS	TCE and degradation products identified as COCs for future residents	Proceed to CMP			
Metals	OJT/LSC RFI Report – TtNUS	No significant risk identified	NFA	NA	NFA	NA

2A-DNT – 2-amino-4,6-dinitrotoluene
4A-DNT – 4-amino-2,6-dinitrotoluene
CMP – Corrective Measures Proposal.
COC – Chemicals of concern.
LSC – Little Sulfur Creek.
LUC – Land use control.
NA – Not applicable.
NFA – No Further Action.
OJT – Old Jeep Trail.
RCRA – Resource Conservation and Recovery Act.
RDX – Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RFI – RCRA Facility Investigation.
TCE – Trichloroethylene
TNT – 2,4,6-Trinitrotoluene.
TtNUS – Tetra Tech NUS, Inc.
VOC – Volatile organic compound.

Document
OJT/LSC RFI Report - TtNUS TtNUS (Tetra Tech NUS, Inc.), 2005. Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for SWMU 03 – Old Jeep Trail/Little Sulphur Creek, Naval Surface Warfare Center, Crane Division, Crane, Indiana prepared by TtNUS for Southern Division, Naval Facilities Engineering Command, North Charleston, South Carolina, January.

TABLE 3-3

REMEDY EVALUATION PROCESS SUMMARY
SWMU 3 - AMMUNITION BURNING GROUND
LITTLE SULPHUR CREEK
NSWC CRANE
CRANE, INDIANA

INVESTIGATION PHASE				REMEDIAL ACTION EVALUATION PHASE		
Little Sulfur Creek	**Document**	**Findings / Evaluations**	**Conclusion**	**Considerations**	**Evaluation Conclusions**	**Remedy**
Surface Water (Human Health)						
Explosives (RDX, 2A-DNT and 4A-DNT)	USACE Phase II Study	Site-related contaminants (RDX, HMX, and 24-DNT) were detected	Conduct Phase III study	Development of alternate WQCs in accordance with IDEM water quality regulations	• All concentrations of explosives in LSC were less than the calculated criteria	• Recommended alternative: LTM in LSC to verify that concentrations of explosives remain less than the alternative WQC • Recommended alternative: Periodic reviews to determine whether new public water supply intakes are located upstream Shoals, Indiana • Recommended alternative: Periodic revives to verify that concentrations of explosives are less than applicable criteria at any new public supply intakes
	OJT/LSC RFI Report - TtNUS	RDX, (2A-DNT and 4A-DNT) identified as COCs for residents	Proceed to CMP			
	Routine Groundwater Monitoring Program	Statistical comparisons to background and to RBTLs	RDX detected in statistically significant concentrations greater than RBTLs at Springs A and C			
Springs (Human Health)						
VOCs (TCE and degradation products)	USACE Phase II Study	No significant detections	NFA	None	• TCE volatizes in karst system and is not present at Springs A or C	• Recommended alternative: LTM in LSC to verify that concentrations of TCE remain less than MCL
	OJT/LSC RFI Report - TtNUS	No significant detections	NFA			
	Routine Groundwater Monitoring Program	No significant detections	NFA			
Metals	US ACE Phase II Study	Site-related metals (aluminum, barium, manganese, magnesium, chromium, cadmium, copper, lead, and zinc) were detected	Conduct Phase III study	• MCL for barium of 2,000 µg/L established as cleanup goal	• Springs A and C and LSC barium concentrations were less than 2,000 µg/L	• Recommended alternative: LTM in LSC to verify that concentrations of barium remain less than MCL
	OJT/LSC RFI Report - TtNUS	No metals identified as COCs	NFA			
	Routine Groundwater Monitoring Program	Statistical comparisons to background and to RBTLs	• Barium consistently detected at statistically significant concentrations greater than RBTLs • Other metals only infrequently detected at statistically significant concentrations			
Surface Water/Sediments (Ecological)						
Aquatic Organisms	OJT/LSC RFI Report - TtNUS	Surface water and sediment evaluated	NFA	None required because no significant ecological risk was identified	NA	NA
Mammals and birds						

µg/L – Micrograms per liter.
2A-DNT – 2-amino-4,6-dinitrotoluene.
4A-DNT – 4-amino-2,6-Dinitrotoluene.
CMP – Corrective Measures Proposal.
COC – Chemical of concern.
HMX - Cyclotetramethylenetetranitramine.
IDEM – Indiana Department of Environmental Management.
LSC – Little Sulfur Creek.
LTM – Long term monitoring.
MCL –Maximum Concentration Level.
NA – Not applicable.
NFA – No Further Action.
OJT – Old Jeep Trail.
RBTL – Risk Based Target Limit.
RCRA – Resource Conservation and Recovery Act.
RDX – hexahydro-1,3,5-trinitro-1,3,5-triazine.
RFI – RCRA Facility Investigation.
TCE – Trichloroethylene.
TtNUS – Tetra Tech NUS, Inc.
USACE – United States Corps of Engineers.
VOC – Volatile organic compound.
WQC – Water quality criterion.

TABLE 3-3

REMEDY EVALUATION PROCESS SUMMARY
SWMU 3 - AMMUNITION BURNING GROUND
LITTLE SULPHUR CREEK
NSWC CRANE
CRANE, INDIANA

Document Acronym	Document
USACE Phase III Study, Part 2	Albertson, P., J.H. May, J.S. Nohrstedt, R.W. Magee, and P. Payonk, 1998. Rinal Report: RCRA Facility Investigation, Part 2 Phase III Soils Study, Ammunition Burning Ground, SWMU 03/10, Naval Surface Warfare Center Crane, Indiana, prepared by U.S. Army Corps of Engineers, Waterways Experiment Station, Technical Report, GL-98-23, May.
USACE Phase III Study	Murphy, W.L., 1994. Final Report, RCRA Facility Investigation, Phase III, SWMU 03/10, Ammunition Burning Ground, prepared by United States Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi, Technical Report GL-94-15, May.
Routine Groundwater Monitoring Program	SAIC, 2002a, 2002b, 2003a, and 2003b. Annual Groundwater Monitoring Reporting for Ammunition Burning Grounds, Old Rifle Range, and Demo Range, CY 2000 (December 16, 2002), CY 2001 (December 16, 2002), CY 2002 (October 31, 2003), and CY 2003 (October 31, 2003), respectively, Naval Surface Warfare Center, Crane Division, Crane, Indiana.
OJT/LSC RFI Report - TtNUS	TtNUS, 2005. Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for SWMU 03 – Old Jeep Trail/Little Sulphur Creek, Naval Surface Warfare Center, Crane Division, Crane, Indiana prepared by TtNUS for Southern Division, Naval Facilities Engineering Command, North Charleston, South Carolina, January.

4.0 CORRECTIVE MEASURES COMPARISON

This section evaluates the CMs presented in Section 3.0 and summarized in Tables 3-1, 3-2, and 3-3 for the MTA, OJT, and LSC, respectively. Section 4.4 presents the conclusions from the CMP.

As previously discussed, the MTA is an active RCRA-permitted hazardous waste treatment facility. Human receptors and pathways of exposure at the MTA portion of SWMU 3 are limited to the existing land use scenario (military/industrial) because future land use scenarios will be addressed in the closure plan.

Furthermore, NSWC Crane, including the MTA and the OJT, is a military facility; therefore, only current MTA and OJT receptors (i.e., site worker, construction worker, and trespasser) will be addressed in this CMP.

The alternatives were evaluated using the following criteria set forth in the draft Statement of Work for a Corrective Measures Proposal developed by U.S. EPA Region 5 (U.S. EPA, 2005b).

- Protection of human health and the environment
- Attainment of MCSs
- Control of release sources
- Compliance with applicable standards for waste management
- Other factors including:
  - Long-term reliability and effectiveness
  - Reduction in toxicity, mobility, or volume of wastes
  - Short-term effectiveness
  - Implementability
  - Cost

4.1 SOIL ALTERNATIVES

4.1.1 MTA

4.1.1.1 Alternative MTA-S1: No Action

Protection of Human Health and the Environment

Alternative MTA-S1 is considered primarily as a baseline for comparison to the other CMs. This alternative would not be protective of human health because of the lack of institutional controls. Although there are no current non-industrial users of land at SWMU 3 and thus no current unacceptable risks to human receptors, Alternative MTA-S1 would not ensure that the land use remained military/industrial (e.g., would not prevent future use of the land for residential development), which could result in unacceptable human health risks. Change in land use from military/industrial use could result in unacceptable human health risks.

Attainment of Media Cleanup Standards

The HHRSE concluded that there is no unacceptable human health risks associated with explosives and VOCs at SWMU 3 under the current site use scenario. However, for one localized area, the HHRSE identified unacceptable risk from lead contamination for the construction worker.

The No Action alternative (Alternative MTA-S1) would not be effective in meeting the MCSs.

Source Control

Alternative MTA-S1 does not provide for source control because it would leave the soils in place in the area where unacceptable lead contamination risk to construction workers is present, as well as explosives and VOC contamination risks to future land use receptors exists.

Compliance with Waste Management Standards

There are no removal actions to be implemented for Alternative MTA-S1 and therefore no waste would be generated.

Other Factors

Long-Term Reliability and Effectiveness

Alternative MTA-S1 would not be reliable and effective in the long term because no action would occur. The localized area of lead contamination would remain. The potential threat to human health would remain because there would be no controls to prevent future land use, or construction activities, and no monitoring to warn of potential contaminant migration.

Reduction in Toxicity, Mobility, and Volume

Alternative MTA-S1 would not reduce contaminant mobility.

Short-Term Effectiveness

Alternative MTA-S1 would not involve any action and therefore would not pose any risks to on-site workers during remedy implementation, and no environmental impacts would be expected.

Implementability

Because no action would occur, Alternative MTA-S1 would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost

There are no costs associated with No Action, Alternative MTA-S1.

4.1.1.2 Alternative MTA-S2: Limited Action - Land Use Controls

Protection of Human Health and the Environment

LUCs would protect human health by preventing current and future receptors' exposure to contaminated soils as long as lead concentrations remain unacceptable. LUCs would protect human health by preventing current and future receptors' exposure to contaminated soils as long as lead concentrations remain unacceptable.

Attainment of MCSs

The lead MCS would not be attained; however, LUCs would protect human health by preventing exposure of the construction workers and future land use receptors to lead contaminated soils.

Source Control

Alternative MTA-S2 does not provide for source control because it would leave the soils in place in the area where unacceptable lead contamination risk to construction workers is present, as well as explosives and VOC contamination risks to future land use receptors exists.

Compliance with Waste Management Standards

Alternative MTA-S2 would not involve any removal of contaminated soils; therefore, residues would not be generated.

Other Factors

Long-Term Reliability and Effectiveness

Alternative MTA-S2 would be reliable and effective in the long term for protection of human health from lead contamination. LUCs would reliably and effectively prevent potential current and future exposure to contaminated soils and ensure that the land use remains military/industrial.

Reduction in Toxicity, Mobility, and Volume

Alternative MTA-S2 would not reduce contaminant mobility, toxicity, or volume.

Short-Term Effectiveness

Alternative MTA-S2 would involve administration of LUCs. Implementation of this alternative would not result in any short-term threat to the surrounding community or to ecological receptors.

Implementability

Alternative MTA-S2 would be readily implementable. LUCs would be readily implementable because SWMU 3 is completely contained within NSWC Crane, and LUCs would be similar to those implemented at other environmental sites within NSWC Crane.

Cost

The following costs are estimated for Alternative MTA-S2:

Capital Cost:	$	3,000
30-Year Net Present Worth (NPW) of Operating and Maintenance (O&M) Costs:	$	36,000
30-Year NPW:	$	39,000

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates. Detailed cost estimates are provided in Appendix H-1.

4.1.2 OJT

4.1.2.1 Alternative OJT-S1: No Action

Protection of Human Health and the Environment

Alternative OJT-S1 is considered primarily as a baseline for comparison to other CMs. This alternative would not be protective of human health because of the lack of monitoring and institutional controls. Although there are no current non-industrial users of land at SWMU 3 and thus no current unacceptable risks to human receptors, Alternative OJT-S1 would not ensure that the land use remains military/industrial (e.g., would not prevent future use of the land for residential development), which could result in unacceptable human health risks.

Attainment of MCSs

The HHRSE concluded that there are no unacceptable human health risks associated explosives, metals, and VOCs contamination at with SWMU 3 under the current site use scenario.

No Action would not be effective in meeting the MCS because nothing would occur to ensure that the land use remains military/industrial (e.g., would not restrict future site development where unacceptable risk could occur from exposure to contaminated soil).

Source Control

Alternative OJT-S1 does not provide for source control because it would leave the soils in place in the area where unacceptable explosives, VOCs, and metals contamination risk to future land use receptors exists.

Compliance with Waste Management Standards

There are no actions to be implemented for Alternative OJT-S1 and therefore no waste would be generated.

Other Factors

Long Term Reliability and Effectiveness

Alternative OJT-S1 would not be reliable and effective in the long term because no action would occur. The potential threat to human health and the environment would remain because there would be no controls to prevent future land residential use or construction activities and no monitoring to warn of potential contaminant migration.

Reduction in Toxicity, Mobility, and Volume

Alternative OJT-S1 would not reduce contaminant mobility.

Short-Term Effectiveness

Alternative OJT-S1 would not involve any action and therefore would not pose any risks to on-site workers during remedy implementation, and no environmental impacts would be expected.

Implementability

Because no action would occur, Alternative OJT-S1 would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost

There are no costs associated with No Action, Alternative OJT-S1.

4.1.2.2 Alternative OJT-S2: Limited Action - Land Use Controls

Protection of Human Health and the Environment

Alternative OJT-S2 would be protective of human health and the environment. LUCs would protect human health by ensuring that land use remains military/industrial.

Attainment of MCSs

LUCs would protect human health by maintaining military/industrial land use as long as concentrations remained unacceptable.

Source Control

Alternative OJT-S2 does not provide for source control because it would leave the soil in place in the area where unacceptable explosives, VOCs, and metals contamination risk to future land use receptors exists.

Compliance with Waste Management Standards

Alternative OJT-S2 would not involve any removal of contaminated soils; therefore, residues would not be generated.

Other Factors

Long-Term Reliability and Effectiveness

Alternative OJT-S2 would be reliable and effective in the long term. LUCs would reliably and effectively prevent potential current and future exposure to contaminated soils and ensure that the land use remains military/industrial.

Reduction in Toxicity, Mobility, and Volume

Alternative OJT-S2 would not reduce contaminant toxicity, mobility, or volume.

Short-Term Effectiveness

Alternative OJT-S2 would involve administration of LUCs. Implementation of this alternative would not result in any short-term threat to the surrounding community or to ecological receptors.

Implementability

Alternative OJT-S2 would be readily implementable. LUCs would be readily implementable because SWMU 3 is completely contained within NSWC Crane, and LUCs would be similar to those implemented at other environmental sites within NSWC Crane.

Cost

The following costs are estimated for Alternative OJT-S2:

Capital Cost:	$	3,000
30-Year NPW of O&M Costs:	$	36,000
30-Year NPW:	$	39,000

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates. Detailed cost estimates are provided in Appendix H-2.

4.2 GROUNDWATER ALTERNATIVES

4.2.1 MTA

4.2.1.1 Alternative MTA-GW1: No Action

Protection of Human Health and the Environment

Alternative MTA-GW1 is considered primarily as a baseline for comparison to other CMs. This alternative would not be protective of human health because of lack of monitoring and institutional controls. Although there are no current users of groundwater at SWMU 3 and thus no unacceptable risks to human receptors, Alternative MTA-GW1 would not prevent future use of the aquifer as a drinking water source, which could result in unacceptable human health risks.

Although there is no current evidence that migration of groundwater contaminants to surrounding surface water has resulted in unacceptable human health or ecological risks, continued migration of the explosives plume could potentially lead to such unacceptable risks and, in the absence of LTM, there would be no warning of this.

Attainment of Media Cleanup Standards

Alternative MTA-GW1 would eventually attain the explosives and VOC MCSs through natural attenuation (i.e., dispersion, dilution, etc.) but, in the absence of LTM, this occurrence would not be verified.

Source Control

Alternative MTA-GW1 would not involve any source control because no action would be performed as part of this alternative and no sources of VOC or explosives contamination have been identified.

Compliance with Waste Management Standards

There are no actions to be implemented for Alternative MTA-GW1 and therefore no waste would be generated.

Other Factors

Long-Term Reliability and Effectiveness

Alternative MTA-GW1 would not be reliable and effective in the long term because no action would occur. Although VOC and explosives concentrations in groundwater are expected to decrease as a result of natural attenuation, the effectiveness of this process would not be verified through monitoring. The potential threat to human health and the environment would remain because there would be no controls to prevent future groundwater use and no monitoring to warn of potential contaminant migration.

Reduction in Toxicity, Mobility, and Volume

Alternative MTA-GW1 would not reduce contaminant mobility. Alternative MTA-GW1 would reduce the toxicity and volume of VOC and explosives through natural attenuation, but this would not be verified through monitoring.

Short-Term Effectiveness

Alternative MTA-GW1 would involve no action and therefore would not pose any risks to on-site workers during remedy implementation, and no environmental impacts would be expected.

Implementability

Because no action would occur, Alternative MTA-GW1 would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost

There are no costs associated with No Action, Alternative MTA-GW1.

4.2.1.2 Alternative MTA-GW2: Limited Action - Land Use Controls And Long Term Monitoring

Protection of Human Health and the Environment

LUCs would protect human health by preventing current and future receptors' usage of and exposure to contaminated groundwater. Natural attenuation would protect human health by reducing explosives and VOC concentrations in groundwater. LUCs would protect human health by preventing current and future receptor usage of and exposure to contaminated groundwater. Monitoring would protect human health and the environment by verifying the progress of groundwater natural attenuation and warning of potential contaminant migration.

Attainment of MCSs

Alternative MTA-GW2 would eventually attain the explosives and VOC MCSs through natural attenuation. Current site information does not allow the accurate prediction of the timeframe required for natural attenuation to attain MCSs.

Source Control

Alternative MTA-GW2 would not involve any source control because no sources of explosives or VOC contamination have been identified.

Compliance with Waste Management Standards

Alternative MTA-GW2 would not involve any removal or ex-situ treatment of contaminated groundwater; however, periodic sampling activities would generate some residues (e.g., purge water) that would have to be properly disposed. The volume of residues generated would be very small, and waste management regulations would be easily met.

Other Factors

Long-Term Reliability and Effectiveness

Alternative MTA-GW2 would be reliable and effective in the long term because natural attenuation would occur for explosives and VOCs and the effectiveness of this process would be verified through monitoring. Additionally, the potential threat to human health and the environment would be eliminated because there would be LUCs established to prevent future groundwater use.

Reduction in Toxicity, Mobility, and Volume

Alternative MTA-GW2 would not reduce contaminant mobility. This alternative would eventually reduce the toxicity and volume of VOCs and explosives through natural attenuation which would be verified through monitoring.

Short-Term Effectiveness

Alternative MTA-GW2 would involve administration of LUCs and implementation of LTM. The short-term human health risks associated with these limited remedial activities would be minimal. Sampling personnel would undergo site-specific health and safety training and wear appropriate personal protection equipment (PPE). Implementation of this alternative would not result in any short-term threat to the surrounding community or to ecological receptors.

Alternative MTA-GW2 would involve limited action. Because NSWC Crane has implemented similar LUCs and LTM at NSWC Crane, risks to on-site workers during remedy implementation and environmental impacts would be expected to be minimal.

Implementability

Alternative MTA-GW2 would be readily implementable. LUCs and LTM would be readily implementable because SWMU 3 is completely contained within NSWC Crane, and they would be similar those implemented at other environmental sites within NSWC Crane.

Alternative MTA-GW2 could be implemented within approximately 12 months. Current site information does not allow the accurate prediction of the timeframe required for natural attenuation to attain MCSs.

Cost

The following costs are estimated for Alternative MTA-GW2:

Capital Cost:	$	3,000
30-Year NPW of O&M Costs:	$	156,000
30-Year NPW:	$	159,000

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates. Detailed cost estimates are provided in Appendix H-3.

4.2.2 OJT

4.2.2.1 Alternative OJT-GW1: No Action

Protection of Human Health and the Environment

Alternative OJT-GW1 is considered primarily as a baseline for comparison to other CMs. This alternative would not be protective of human health because of lack of monitoring and institutional controls. Although there are no current users of groundwater at SWMU 3 and thus no unacceptable risks to human receptors, Alternative OJT-GW1 would not prevent future use of the aquifer as a drinking water source, which could result in unacceptable human health risks.

Although there is no current evidence that migration of groundwater contaminants to surrounding surface water has resulted in unacceptable human health or ecological risks, continued migration of the explosives plume could potentially lead to such unacceptable risks and, in the absence of monitoring, there would be no warning of this.

Attainment of Media Cleanup Standards

Alternative OJT-GW1 would eventually attain the explosives and VOC MCSs through natural attenuation but, in the absence of LTM, this occurrence would not be verified.

Source Control

Alternative OJT-GW-1 would not involve any source control because no action would be performed as part of this alternative and no source of explosives or VOCs has been identified.

Compliance with Waste Management Standards

There are no actions to be implemented for Alternative OJT-GW1 and therefore no waste would be generated.

Other Factors

Long-Term Reliability and Effectiveness

Alternative OJT-GW1 would not be reliable and effective in the long term because no action would occur. Although explosives and VOC concentrations in groundwater would decrease as a result of natural attenuation, the effectiveness of this process would not be verified through monitoring. The potential threat to human health and the environment would remain because there would be no controls to prevent future groundwater use and no monitoring to warn of potential contaminant migration.

Reduction in Toxicity, Mobility, and Volume

Alternative OJT-GW1 would not reduce contaminant mobility. Alternative OJT-GW1 would reduce the toxicity and volume of explosives through natural attenuation, but this would not be verified through monitoring.

Short-Term Effectiveness

Alternative OJT-GW1 would involve no action and therefore would not pose any risks to on-site workers during remedy implementation, and no environmental impacts would be expected.

Implementability

Because no action would occur, Alternative OJT-GW1 would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost

There are no costs associated with No Action, Alternative OJT-GW1.

4.2.2.2 Alternative OJT-GW2: Limited Action - Land Use Controls and Long Term Monitoring

Protection of Human Health and the Environment

LUCs would protect human health by preventing current and future receptors' usage of and exposure to contaminated groundwater. Natural attenuation would protect human health by reducing explosives and VOC concentrations in groundwater. LUCs would protect human health by preventing current and future receptors usage of and exposure to contaminated groundwater. Monitoring would protect human health and the environment by verifying the progress of groundwater natural attenuation and warning of potential contaminant migration.

Attainment of MCSs

Alternative OJT-GW2 would eventually attain the explosives and VOC MCSs through natural attenuation. Current site information does not allow the accurate prediction of the timeframe required for natural attenuation to attain MCSs.

Source Control

Alternative OJT-GW2 would not involve any source control.

Compliance with Waste Management Standards

Alternative OJT-GW2 would not involve any removal or ex-situ treatment of contaminated groundwater; however, periodic sampling activities would generate some residues (e.g., purge water) that would have to be properly disposed. The volume of residues generated would be very small, and waste management regulations would be easily met.

Other Factors

Long-Term Reliability and Effectiveness

Alternative OJT-GW2 would be reliable and effective in the long term because natural attenuation would occur for explosives and VOCs. The effectiveness of this process would be verified through LTM. The potential threat to human health and the environment would be reduced because there would be LUCs to prevent future groundwater use.

Reduction in Toxicity, Mobility, and Volume

Alternative OJT-GW2 would not reduce contaminant mobility. This alternative would eventually reduce the toxicity and volume of VOCs and explosives through natural attenuation, which would be verified through LTM.

Short-Term Effectiveness

Alternative OJT-GW2 would involve administration of LUCs and implementation of LTM. The short-term human health risks associated with these limited remedial activities would be minimal. Sampling personnel would undergo site-specific health and safety training and wear appropriate PPE. Implementation of this alternative would not result in any short-term threat to the surrounding community or to ecological receptors.

Alternative OJT-GW2 would involve limited action. Because NSWC Crane has implemented similar LUCs and LTM at NSWC Crane, risks to on-site workers during remedy implementation and environmental impacts would be expected to be minimal.

Implementability

Alternative OJT-GW2 would be readily implementable. LUCs would be readily implementable because SWMU 3 is completely contained within NSWC Crane, and LUCs would be similar to those implemented at other environmental sites within NSWC Crane.

Alternative OJT-GW2 could be implemented within approximately 12 months. Current site information does not allow the accurate prediction of the timeframe required for natural attenuation to attain MCSs.

Cost

The following costs are estimated for Alternative OJT-GW2:

Capital Cost:	$ 3,000
30-Year NPW of O&M Costs:	$ 163,000
30-Year NPW:	$ 166,000

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates. Detailed cost estimates are provided in Appendix H-4.

4.3 SURFACE WATER ALTERNATIVES

4.3.1 LSC

4.3.3.1 Alternative LSC-SW1: No Action

Protection of Human Health and the Environment

Alternative LSC-SW1 is considered primarily as a baseline for comparison to other CMs. This alternative would not be protective of human health because of lack of monitoring. Although there are no current users of surface water at SWMU 3, surface water does discharge from NSWC Crane via LSC into Sulfur Creek and the East Fork of the White River where potential human receptors exist. Alternative LSC-SW1 would not prevent or warn of changes in use of LSC for public water supply intake, which could result in unacceptable human health risks.

Although there is no current evidence of unacceptable human health or ecological risks, in the absence of LTM, there would be no warning of this.

Attainment of Media Cleanup Standards

Alternative LSC-SW1 would eventually attain the explosives and VOC MCSs through natural attenuation but, in the absence of LTM, this occurrence would not be verified.

Source Control

Alternative LSC-SW-1 would not involve any source control because no source control is required.

Compliance with Waste Management Standards

There are no actions to be implemented for Alternative LSC-SW1 and therefore no waste would be generated.

Other Factors

Long-Term Reliability and Effectiveness

Alternative LSC-SW1 may be reliable and effective in the long term. However, this could not be confirmed due to the lack of monitoring.

Reduction in Toxicity, Mobility, and Volume

Reduction in toxicity, mobility, and volume would not occur and is not required.

Short-Term Effectiveness

Alternative LSC-SW1 would involve no action and therefore would not pose any risks to on-site workers during remedy implementation, and no environmental impacts would be expected.

Implementability

Because no action would occur, Alternative LSC-SW1 would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost

There are no costs associated with No Action, Alternative LSC-SW1.

4.3.3.2 Alternative LSC-SW2: Limited Action – Long Term Monitoring and Usage Evaluation of Public Water Supplies Upstream of the Shoals, Indiana Water Intake

Protection of Human Health and the Environment

Alternative LSC-SW2 would be protective of human health and the environment by monitoring to verify that surface water RDX concentrations remain less than the MCS. Review of public water supplies upstream of the Shoals, Indiana water intake would ensure that the alternative RDX WQC remains valid for the uses of surface waters or would be used to determine when an updated alternative RDX WQC requires development.

Attainment of MCSs

Alternative LSC-SW2 would monitor surface water concentrations to verify that concentrations of RDX in surface water are less than the alternative RDX WQC of 3 µg/L at the water intake at Shoals (Appendix D). Historical data indicates that the concentrations of RDX decrease with increased surface water flowrate (Appendix F).

Source Control

Alternative LSC-SW2 would not involve any source control and no source control is required.

Compliance with Waste Management Standards

Alternative LSC-SW2 would not involve any removal or ex-situ treatment of contaminated surface water; however, periodic sampling activities would generate some residues that would have to be properly disposed. The volume of residues generated would be very small, and waste management regulations would be easily met.

Other Factors

Long Term Reliability and Effectiveness

Alternative LSC-SW2 would be reliable and effective in the long term, and the effectiveness would be verified through monitoring. The potential threat to human health and the environment would be reduced because there would be controls to evaluate changes in surface water recreational use and to evaluate future surface water intakes upstream of the Shoals, Indiana surface water intake.

Reduction in Toxicity, Mobility, and Volume

Alternative LSC-SW2 would not reduce contaminant mobility.

Short-Term Effectiveness

Alternative LSC-SW2 would involve implementation of LTM. The short-term human health risks associated with this limited remedial activity would be minimal. Sampling personnel would undergo site-specific health and safety training and wear appropriate PPE. Implementation of this alternative would not result in any short-term threat to the surrounding community or to ecological receptors.

Implementability

Alternative LSC-SW2 would be implementable because SWMU 3 is completely contained within NSWC Crane, and LUCs would be similar those implemented at other environmental sites within NSWC Crane. Evaluation of surface water usage upstream of the Shoals, Indiana water intake would be implementable through the development of public record review procedures.

Alternative LSC-SW2 could be implemented within approximately 12 months.

Cost

The following costs are estimated for Alternative LSC-SW2:

Capital Cost:	$	3,000
30-Year NPW of O&M Costs:	$	190,000
30-Year NPW:	$	193,000

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates. Detailed cost estimates are provided in Appendix H-5.

4.4 EVALUATION AND CONCLUSIONS

This section summarize conclusions regarding the development of the SWMU 3 CMP that are based on the Conceptual Site Model presented in Section 2.8 and focusing on existing and planned future uses for SWMU 3 (e.g., military/industrial).

4.4.1 Soil

- Screening and detailed evaluations of alternatives to address excess risk from exposure to explosives and VOCs in soils at the MTA are not necessary because the HHRSE conducted as part of this CMP has determined that there is no unacceptable risk for current receptors (Appendix B).

- Screening and detailed evaluations of alternatives to address excess risk from exposure to lead in soils at the MTA are not necessary because the HHRSE conducted as part of this CMP has determined the location associated with unacceptable risk for current receptors (Appendix B).

- Alternative MTA-S2 (LUCs) is the preferred alternative for soils at the MTA to prevent future residential land use and construction at locations impacted by metals.

- Screening and detailed evaluations of alternatives to address excess risk from exposure to explosives, VOCs, and metals in soils at the OJT are not necessary because the HHRA has determined that there is no unacceptable risk to current receptors (TtNUS, 2005a).

- Alternative OJT-S2 (LUCs) is the preferred alternative for soils at the OJT to prevent residential land use.

4.4.2 Groundwater

- Screening and detailed evaluations of alternatives to address excess risk from exposure to explosives, VOCs, and metals in groundwater at the MTA are not necessary because the HHRA has determined that there is no unacceptable risk for current receptors (TtNUS, 2005a).

- Alternative MTA-GW2 (LUCs and LTM) is the preferred alternative for groundwater at the MTA because it will prevent groundwater use, determine whether RDX and TCE are naturally attenuating, and alert if RDX and TCE are migrating.

- Alternative OJT-GW2 (LUCs and LTM) is the preferred alternative for groundwater at the OJT because it will prevent groundwater use and determine whether RDX and TCE are naturally attenuating, and alert if RDX and TCE are migrating.

4.4.3 Surface Water

- Screening and detailed evaluations of alternatives to address excess risk from exposure to explosives, VOCs, and metals in groundwater at the MTA are not necessary because the CMP has determined that there is no unacceptable risk for current receptors.

- Alternative LSC-SW2 (LTM and Usage Evaluation of Public Water Supplies Upstream of the Shoals, Indiana Water Intake) is the preferred alternative for surface water downstream and at SWMU 3 because it will verify that TCE concentrations remain less than the MCL, verify that explosives concentrations remain less than the alternative WQC, determine if any new surface water intakes have been installed upstream of the Shoals, Indiana water intake, and determine if any new recreational uses have occurred.

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