N00164.AR.000876
NSWC CRANE
5090.3a

Resource Conservation and Recovery Act Facility Investigation Report for Round 1 and Round 2 Field Work

at

Mine Fill B (SWMU 13) and Cast High Explosives Fill/ Building 146 Incinerator (SWMU 16)

VOLUME I - TEXT

Naval Surface Warfare Center Crane

Crane, Indiana

NAVFAC
Naval Facilities Engineering Command

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888
Contract Task Order 0279

July 2004

DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
300 HIGHWAY 361
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IN REPLY REFER TO:

5090/????
Ser RP3/4193

12 JUL 2004

U.S. Environmental Protection Agency, Region V
Waste, Pesticides, & Toxics Division
Waste Management Branch
Corrective Action Section
ATTN: Mr. Peter Ramanauskas (DW-8J)
77 West Jackson Blvd.
Chicago, IL 60604

Dear Mr. Ramanauskas:

Crane Division, Naval Surface Warfare Center submits two copies of the results of field work from Rounds 1 and 2 at Solid Waste Management Units (SWMUs) 13 and 16 (Mine Fill B and Building 146 Incinerator, respectively) as enclosure (1). Please note that this report is being submitted for information purposes only. Comments will be solicited and addressed with the Draft report following Round 3. 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 RP3-TB, at 812-854-6160, email brent_t@crane.navy.mil.

Sincerely,

JAMES M. HUNSICKER
Manager, Environmental Protection
By direction of the Commanding Officer

Encl:
(1) Rounds 1 and 2 Field Work Report for SWMUs 13 and 16
(2) Certification Statement

Copy to:
ADMINISTRATIVE RECORD
SOUTHNAVFACENGCOM (Code ES32) (w/o encl)
IDEM (Doug Griffin)
TTNUS (Ralph Basinski) (w/o encl)

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 M. Hunnicutt
SIGNATURE

Manager, Environmental Protection
TITLE

7/12/2004
DATE

REVISION 0
JULY 2004

RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION REPORT FOR ROUND 1 AND ROUND 2 FIELD WORK AT MINE FILL B (SWMU 13) AND CAST HIGH EXPLOSIVES FILL/BUILDING 146 INCINERATOR (SWMU 16)

NAVAL SURFACE WARFARE CENTER, CRANE
CRANE, INDIANA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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ACRONYM LIST

amsl	above mean sea level
ATSDR	Agency for Toxic Substances and Disease Registry
AVS/SEM	Acid Volatile Sulfide/Simultaneously Extracted Metals
B&R	Brown & Root
B146	Building 146
B165	Building 165
B174	Building 174
bgs	below ground surface
CAAA	Crane Army Ammunition Activity
CEC	cation exchange capacity
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm/sec	centimeter per second
CMS	Corrective Measures Study
COPC	Chemicals of Potential Concern
CTO	Contract Task Order
DI	deionized
DO	dissolved oxygen
DPT	Direct push technology
DRMO	Defense Reutilization and Marketing Office
EMR	Environmental Monitoring Report
EP	Extraction Procedure
EPD	Environmental Protection Department
FOL	Field Operations Leader
FTMR	Field Task Modification Report
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HSA	hollow-stem auger
IAC	Indiana Administrative Code
IAS	Initial Assessment Survey
ICS	initial characterization samples
ID	inside diameter
IDEM	Indiana Department of Environmental Management
IDW	investigation-derived waste

IMR	Interim Measures Report
Kh	hydraulic conductivity
MCLC	Mine Clearing Line Charges
MFB	Mine Fill B
MK	Morrison Knusdon
NAD	Naval Ammunition Depot
NAD27	1927 North American Dadum
NAVD88	1988 North American Vertical Datum
NAVFACEFDSOUTH	Naval Facilities Engineering Field Division South
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic and Atmospheric Administration
NSWC	Naval Surface Warfare Center
NTU	nephelometric turbidity unit
NWSC	Naval Weapons Support Center
OD	outside diameter
ORP	oxidation-reduction potential
PAH	polynucleararomatic hydrocarbon
PCB	polychlorinated biphenyl
Pdz	Pennsylvania deep water-bearing zone
PES	post-excavation sample
PETN	pentaerythritoltetranitrate
PID	photoionization detector
Piz	Pennsylvania bedrock
PPE	personal protective equipment
Psz	Pennsylvania shallow water-bearing zone
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RBC	risk-based criterion
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
RFI	RCRA Facility Investigation
RQD	rock quality designation
SCS	Soil Conservation Service
SERA	Screening Ecological Risk Assessment

SOP	Standard operating procedure
SVOC	semi-volatile organic compound
SWMU	Solid Waste Management Unit
TCE	trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedures
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TolTest	Toltest, Incorporated
TOM	Task Order Manager
TtNUS	Tetra Tech NUS, Inc.
U.S. EPA	United States Environmental Protection Agency
USACE WES	United States Army Corps of Engineers Waterways Experiment Station
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
VOC	volatile organic compound

1.0 INTRODUCTION

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Field Report for Mine Fill B (MFB) and the Cast High Explosives Fill/Building 146 (B146) Incinerator was prepared for the Naval Surface Warfare Center (NSWC) Crane facility, located in Crane, Indiana, through the Naval Facilities Engineering Field Division South (NAVFAC EFD SOUTH) under Contract Task Order (CTO) 0279 for the Comprehensive Long-Term Environmental Action Navy (CLEAN) III, Contract Number N62467-94-D-0888. MFB and the Cast High Explosives Fill/B146 Incinerator are also known as Solid Waste Management Units (SWMUs) 13 and 16, respectively.

MFB was used for the production of large mines, depth charges, rocket heads, aerial bombs, and projectiles. In the past, explosive powders were discharged from roof vents, accumulated on the roofs, and were washed down by rainwater to the ground resulting in the contamination of soils. In addition, wastewaters containing explosives were previously discharged into ditches. An interim removal action was conducted in which explosive-contaminated soils were removed and treated via bioremediation. Treated soils were then placed onto the areas from which the contaminated soils had been removed.

The Cast High Explosives Fill/B146 Incinerator consisted of Building 146 and three oil-fired, rotary kiln incinerators with fuel storage tanks. B146 is still in existence; it was previously used as an explosive fill and pressure washout facility. The incinerators and fuel storage tanks have been removed. During operation, incinerator ash was stored in waste piles adjacent to the incinerator. These ash piles have also been removed. In previous investigations, sumps receiving roof drain waters and process waters were found to contain trichloroethylene (TCE). These sumps discharged into ditches. After this discovery, a remedial action was conducted in which an air stripper was used to remove volatile organic compounds (VOCs) from the sumps and the roof drain waters were rerouted to a separate line discharging into a ditch. After TCE concentrations in the sump were reduced to acceptable levels, the sump drains were rerouted to the sanitary sewer system.

1.1 REPORT PURPOSE AND FORMAT

The purpose of this RFI Report is to describe the site investigation activities conducted at each SWMU and to present the results and interpretation thereof for MFB and the Cast High Explosives Fill/B146 Incinerator. This investigation provides information regarding concentrations of organic and inorganic chemicals measured in surface soils, subsurface soils, sediment, surface water, and ground water at MFB and the Cast High Explosives Fill/B146 Incinerator. In addition, human health and ecological risks

associated with MFB and the Cast High Explosives Fill/B146 Incinerator were evaluated by way of a baseline human health risk assessment (HHRA) and a screening ecological risk assessment (SERA). The risk assessments were performed using the data collected during the most recent investigation in 2003. However, previous investigation results are presented, as appropriate, to provide perspective on current data.

1.1.1 Project Objectives

The objective of this RFI was to conduct the site characterization and environmental sampling activities necessary to establish the nature and extent of contamination and to complete the environmental and human health risk assessments then draw conclusions concerning whether further activities are warranted at the site.

1.1.2 Project Problem Statement

Because of known or suspected operationally related chemical releases to environmental media at SWMUs 13 and 16, as described in Section 1.4, human and ecological receptors could be exposed to unacceptable risks. The risks are expected to be confined primarily to aqueous and solid media because only minimal airborne release pathways (e.g., occasional minor resuspension of dust or release of volatile chemicals) are anticipated.

The degree of risk to a human or ecological receptor is based on the nature of contamination and the frequency, duration, and nature of exposure to contaminants. Consequently, it is important to understand where receptors could be exposed to the contaminants. This requires that the extent of contamination be established in those SWMUs identified as exhibiting unacceptable levels of contamination. In this context, extent is established relative to numerical risk-based criteria (RBC). The risk evaluations conducted for contaminated areas of SWMUs 13 and 16 were designed to determine whether risks posed by exposure of those receptors to site contaminants are unacceptable. Plausible land use scenarios are considered when identifying the receptors that could be at risk.

1.1.3 Organization of the Report

This report was prepared using the following organizational format. Section 1.0 of the report is the introduction, including the project scope, objectives, background information, site geology, and hydrogeology. Section 2.0 contains information regarding Round 1 and Round 2 field sampling activities and procedures associated with the data collection as described in the approved Quality Assurance Project Plan (QAPP) [Tetra Tech NUS (TtNUS), 2003a] and the QAPP Addendum No. 1 (TtNUS, 2003b).

Section 3.0 is a summary of the data evaluation procedures and a summary of data quality for the data collected as part of this investigation. Section 4.0 describes the procedures and results for selection of the chemicals of potential concern (COPCs). Section 5.0 presents an evaluation of the nature and extent of contamination detected at SWMUs 13 and 16. Section 6.0 presents a discussion on the chemical fate and transport of the COPCs and other chemicals or parameters. Sections 7.0 and 8.0 present the human health and ecological risk evaluations, respectively. Section 9.0 presents the overall project conclusions and recommendations formulated after review of all the data collected at SWMUs 13 and 16. Supporting documentation for this report is attached as Appendices A through I.

1.2 NSWC CRANE BACKGROUND

1.2.1 Facility Location and Description

NSWC Crane is located in a rural, sparsely populated region of south-central Indiana, approximately 75 miles southwest of Indianapolis, 60 miles northwest of Louisville, Kentucky, and immediately east of Burns City and Crane Village, Indiana. A location map of the NSWC Crane facility is provided as Figure 1-1. NSWC Crane encompasses approximately 62,463 acres or approximately 98 square miles of the northern portion of Martin County and smaller portions of Greene, Daviess, and Lawrence Counties.

1.2.2 History of NSWC Crane Ownership and Operations

NSWC Crane provides materiel, technical, and logistical support to the Navy for equipment, weapons systems, and expendable and non-expendable ordnance items. Early in 1940, Congress passed the first supplemental National Defense Appropriation Act. This act provided $5 million for new inland ammunition production facilities, $3 million of which were earmarked to build a Navy ammunition depot at Burns City on the site of the White River Project. Factors weighing in favor of the Burns City site were a remote location that was free of congested areas, hilly terrain ideal for magazine construction and camouflage, Lake Greenwood that could supply water for the facility, and the distance from the eastern seaboard, which minimized the danger of enemy attack.

The 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 during the early days of World War II. In May 1943, the depot was renamed the NAD, 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 assigned 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, based on changing missions and alignment, the facility name was changed to NSWC Crane.

The Army has assumed ordnance production, storage, and related responsibilities under the single-service management directive. All environmental activities on the installation, including permitting activities, remain the responsibility of the Navy. Although ordnance production and storage still occur on base, Crane serves as a recognized leader in diverse and highly technical product lines such as microwave devices, acoustic sensors, small arms, microelectronics technology, and more. Along with the Army, other major branches of the Department of Defense, the United States Coast Guard (Department of Transportation), and Defense Reutilization and Marketing Office (DRMO) are major tenants on the base.

1.3 GENERAL CHARACTERISTICS OF NSWC CRANE

1.3.1 Physiography and Topography

NSWC Crane is located 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, 1995). 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 Wabash Lowland near the western boundary of NSWC Crane is gradual (Murphy and Wade, 1995). The terrain is predominantly rolling with moderately incised stream valleys throughout and occasional flat areas in the central and northern portions of NSWC Crane. The elevations across NSWC Crane range from about 500 feet above mean sea level (amsl) to about 850 feet amsl. Topographic relief in the Crawford Upland generally ranges from 100 to 350 feet. Greater relief exists in the eastern part of NSWC Crane near the Chester Escarpment (Murphy and Wade, 1995).

MFB and the Cast High Explosives Fill sites are located in the upland areas of the facility. Elevations at MFB range from approximately 718 feet amsl at the northeastern site boundary to approximately 650 feet amsl at the southwestern boundary of the site. Surface drainage is routed through storm sewers and

ditches that ultimately discharge into drainageways located along the northwestern and southeastern borders of the site. These ditches lead to larger drainageways that flow into Boggs Creek. Refer to Figure 1-3 for SWMU 13 site features.

The Cast High Explosives Fill/B146 Incinerator is located on a relatively flat area with slopes to the east, south, and west. SWMU 16 has an average elevation of approximately 760 feet amsl. Surface drainages are toward the west, south, and east along storm sewers and ditches that ultimately flow into Turkey Creek. Refer to Figure 1-4 for SWMU 16 site features.

The SWMU areas consist of buildings and related structures with either paved or gravel access roads. Each SWMU has associated parking and staging areas and is surrounded by grassy areas. Wooded areas surround each SWMU beyond the limits of the grassy areas.

1.3.2 Climate and Meteorology

NSWC Crane has a warm, temperate climate. In general, summers are warm and humid, and winters are mild with occasional short, cold periods. The temperature ranges from an average maximum July temperature of 89°F to an average minimum January temperature of 26°F. Precipitation is evenly distributed throughout the calendar year; the maximum precipitation occurs during the spring and early summer. The average annual precipitation at the facility is 44 inches and consists of 42 inches of rain and 15 inches of snow. The average relative humidity ranges from 40 to 90 percent in summer and 60 to 90 percent in winter. Long-term climatological records for the area indicate that the monthly prevailing wind direction is from the southwest from April through December and from the northwest during January through March [National Oceanic and Atmospheric Administration (NOAA), 1988]. The annual prevailing wind direction for the region is from the southwest, and the annual average wind speed for the area is about 9.6 miles per hour. Figure 1-5 is a wind rose summarizing the mean wind direction and wind speed distribution for the Indianapolis International Airport over a 5-year period (1985 to 1989).

1.3.3 Regional Geology and Stratigraphy

The geology at NSWC Crane is generally characterized by thin overburden deposits overlying bedrock. The overburden deposits generally range from the surface to 65 feet below ground surface (bgs) [United States Army Corps of Engineers Waterways Experiment Station (USACE WES), 1988]. These deposits generally consist of two types: Quaternary-age unconsolidated deposits and unconsolidated residual soil derived from the underlying bedrock. Bedrock underlying the facility consists of sedimentary rock from the Lower Pennsylvanian-age Raccoon Creek Group and the Upper Mississippian-age Stephensport and

West Baden Groups (Figures 1-6 and 1-7). The following subsections describe the unconsolidated deposits and bedrock at NSWC Crane in greater detail.

1.3.3.1 Regional Unconsolidated Deposits

The Quaternary-age deposits consist of alluvial and colluvial silt, sand, and gravel; lacustrine clay, silt, and sand; and loess deposits consisting of clay and silt.

Residual soils at NSWC Crane were derived from the underlying sedimentary rocks of the Lower Pennsylvanian Raccoon Creek Group and the Upper Mississippian Stephensport and West Baden Groups. These soils consist of clay, silt, sand, and fragmented and/or partially weathered bedrock.

Using the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) soil classification system (McElrath, 1988), the soil at NSWC Crane has been classified into 23 different soil series. Each of these soil series is defined by various soil characteristics (e.g., grain size, erosion, slope, drainage, parent material, depositional source, etc.). Within these soil series, various sub-classes or soil map units have been defined.

Soil types at NSWC Crane were further evaluated during a base-wide background soils investigation conducted by TtNUS in 2001 (TtNUS, 2001). The objectives of the investigation were to identify and characterize soils based on three factors, depositional environment, grain size, and depth. A total of 16 soil types were identified and evaluated in the report based on combinations of these three factors. Four depositional environments were identified based on the mapped geologic parent material (Figure 1-6). Three predominant grain sizes were identified (clay, silt, and sand), and the soils were divided into two depth ranges (surface and subsurface). Soil samples were collected to establish representative background metals concentrations. Statistical analyses, supported by geologic principals, allowed the 16 soil types to be consolidated into nine different soil groups. All soil types within a given group have similar native metal concentrations.

Based on the classification scheme developed in the base-wide background soil study (TtNUS, 2001), the soils encountered at SWMU 13 and SWMU 16 fall into three different soil groups. The surface soils (0 to 2 feet bgs) all belong to Group 3 (surface soils, undifferentiated). The subsurface soils (2 to 10 feet bgs) are all derived from weathered Pennsylvanian bedrock. These subsurface residual soils are classified as Group 8 soils (subsurface, residual Pennsylvanian bedrock, silt or silty clay) or Group 9 soils (same as Group 8 except coarser; primarily sand). These groupings are discussed further in Section 3.4.

1.3.3.2 Regional Bedrock

Bedrock underlying NSWC Crane consists of sedimentary rocks from the Lower Pennsylvanian-age Mansfield Formation (Raccoon Creek Group) and the underlying Upper Mississippian-age Stephensport and West Baden Groups (Figure 1-7). The Mansfield Formation (uppermost bedrock) consists primarily of alternating beds of shales (e.g., black shale and carbonaceous shale), sandstone, and siltstone but also includes thin discontinuous coal seams and limestone lenses. This formation is typically about 110 feet thick or more at NSWC Crane (USACE WES, 1991) (See Figure 1-7). The Stephensport Group, generally 130 to 190 feet thick, includes a number of sandstone and limestone units including the Big Clifty Sandstone and the Beech Creek Limestone (Figure 1-7). An erosional unconformity separates the Pennsylvanian strata above from the Stephensport strata below. Depending on the location at NSWC Crane, pre-Pennsylvanian erosion has removed a significant portion of the Stephensport strata. At these locations, the paleo valleys are filled with shales and sandstones of Pennsylvanian age (Figure 1-7).

The underlying West Baden Group also consists of limestone, shale, and sandstone units and is generally 60 to 140 feet thick.

NSWC Crane is located on the eastern edge of the Illinois Structural Basin, where the Pennsylvanian- and Mississippian-age bedrock dips to the west-southwest and southwest at approximately 30 to 35 feet per mile (USACE WES, 1982; Kvale, 1992). Locally however, the dip of the Mississippian bedrock can range from 0 to 15 feet per mile to as much as 100 feet per mile to the southwest (in Sulphur Creek) (Kvale, 1992).

1.3.4 Regional Hydrogeology

Ground water in the unglaciated southwestern portion of Indiana is generally contained in fractures and joint openings of limestone and sandstone aquifers. Aquifers are generally separated from one another vertically by less permeable shale and siltstone units. Ground water enters the aquifers as infiltration through outcrops and flows by gravity down the dip of the strata or locally in directions controlled by the locations of ground water discharge points (streams, seeps, springs).

Ground water is first encountered in the Lower Pennsylvanian Mansfield Formation (Raccoon Creek Group) bedrock in the higher elevations of NSWC Crane, which includes MFB and the Cast High Explosives Fill/B146 Incinerator. Ground water is not encountered in the overlying unconsolidated material at higher elevations because the soils are above the water table. The bedrock, which is comprised primarily of shale and sandstone, has alternating and interlayered beds of variable thickness. Coal seams may also be present in the Lower Pennsylvanian bedrock. In general, ground water travels

through the fracture and joint systems in the bedrock, with some minor flow through individual pore spaces of coarser materials such as sandstone. Ground water in the bedrock flows through this fracture-controlled system and along bedding planes, with less permeable units such as shales restricting vertical downward migration.

Four bedrock formations comprise three aquifers that lie beneath the Lower Pennsylvanian Mansfield Formation, the Golconda-Haney limestone (the upper aquifer), the Big Clifty sandstone/Beech Creek limestone (the middle aquifer), and the Beaver Bend limestone (the lower aquifer). The Golconda-Haney and Big Clifty/Beech Creek aquifers are interconnected and form the uppermost flow system.

Shallow ground water flow patterns mimic topography, with the highest ground water elevations typically found along ridge crests and ground water flow toward the major stream or tributary valleys. Recharge to the shallow ground water system occurs through precipitation infiltration over most of the uplands and sideslopes. Ground water moves downward and then laterally and discharges to surface water in the deeper stream valleys.

1.3.5 Surface Hydrology and Drainage System

The surface drainage at NSWC Crane forms 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 1-2 shows the basins and drainages of NSWC Crane. The two SWMUs lie within the Boggs and Turkey Creek Drainage Basin, which discharges into the East Fork of the White River, ultimately discharging into the Wabash River. The Boggs and Turkey Creek Drainage Basin drains roughly 50 percent of NSWC Crane.

1.3.6 Land Use and Demography

The economic base of communities surrounding NSWC Crane is in transition from agriculture, mining, and quarrying to manufacturing and service industries. The patterns of settlement, population statistics, and median income are similar throughout the region. Because most of the region is covered by vegetation, the area is classified as rural (TtNUS, 2000).

There is no State or local planning within the vicinity of NSWC Crane. The only zoning and land use regulations are in the municipalities in the region. None of the municipalities are close enough to impact NSWC Crane. None of the areas adjacent to NSWC Crane are zoned, and zoning is not anticipated in

the near future. No known land use or community actions are being considered or proposed at this time (TtNUS, 2000).

1.3.7 Ecology

NSWC Crane is a heavily forested facility situated within the Western Mesophytic Forest Region, Hill Section, and Beech-Maple Forest Region (Braun, 1950). Lindsey, et al. (1970) further subdivided the area of the installation into the south-central Oak and Mixed Woods Division, including the Beech-Maple and the Beech-Oak-Maple-Hickory sub-elements. Deam (1940) classified the portion of Martin County in which the facility is located as consisting of the Chestnut Oak Upland, based on the dominant floral components at that time. More recently, Kuchler (1964) mapped this portion of Indiana and classified it as belonging to two distinct vegetation classes, the Oak-Hickory and the Beech-Maple forest components of the Broadleaf Forest Classification. This latter classification most closely resembles the current floristic components observed at the facility.

NSWC Crane contains old agricultural fields in various stages of biological succession. Openings on dry upland sites contain almost pure stands of grasses with some clumps of woody plants such as persimmon, sassafras, and sumac. Areas that tend to be wetter have river birch, willow, sycamore, and cottonwood. Hillside communities include hickory, white and black oak, red maple, sugar maple, tulip poplar, ash, and beech [Naval Energy and Environmental Support Activity (NEESA), 1983]. Cleared areas at the facility have various stages of grassland, oldfield, and scrub/shrub vegetational forms present. Dominant tree species include black oak, white oak, pignut hickory, and yellow poplar. These stands are relatively young, with the average tree diameter ranging from 6 to 12 inches. No scrubs or shrubs are present in these areas, and leaf litter, limbs, and fallen saplings cover the understory.

The wildlife habitats and vegetation types present at NSWC Crane (including many stages of forest succession, streams, ponds, Greenwood Lake, and grassy open spaces) support a diverse terrestrial and aquatic fauna. The abundance of wildlife is mainly due to the mixture of landforms and vegetation types that occur over the installation. In addition, the lack of agricultural pressures has enhanced wildlife abundance and served to provide an installation-wide "wildlife enclosure" condition. There is an adequate amount of forage materials, concealment opportunities, and shelter locations to support a highly diverse wildlife community at the site.

Terrestrial habitats (i.e., wooded and grassy areas) near the sites may provide shelter and food sources for various species of mammals such as white-tailed deer, coyote, red fox, rabbits, raccoons, and mice and for birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins.

The white-tailed deer is the most conspicuous large, wild mammal at the installation. Other mammals include opossum, raccoon, rabbits, mice, bats, chipmunks, squirrels, beaver, groundhogs, gray fox, coyotes, and long-tailed weasel. Fox, coyotes, and hawks are carnivores whose presence indicates a healthy ecosystem with smaller mammals present to provide a food source (NEESA, 1983).

The birds at NSWC Crane are diverse. Previous studies identified over 100 species present at the facility during breeding seasons (Hengeveld, 1987). Because the facility is largely forested, the species found consist predominantly of those that frequent wooded habitat types. There are also species of waterfowl that use the facility, especially in the vicinity of Greenwood Lake (Figure 1-2). A large number of bird species frequent the non-forested grassland, oldfield, and scrub/shrub vegetation present over portions of NSWC Crane. The bird population includes a number of threatened, endangered, or species of special concern that use NSWC Crane 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 worm-eating warbler [Brown & Root (B&R) Environmental, 1997].

Previous studies conducted at NSWC Crane (Nelson, et al., 1987) identified 21 amphibian species and 22 reptilian species including skinks, lizards, snakes, and turtles.

A total of 46 distinct fish species were collected from the installation during a 1987 inventory of the fish fauna at NSWC Crane. Other than Greenwood Lake, the 1987 study observed that the greatest number of individual fish species were recorded from the largest stream, Boggs Creek, and that the smallest number of species were recorded from Turkey Creek. Boggs Creek contained 29 species, including eight species of fish characteristic of large river-type systems. This included long-nose gar, paddlefish, bowfin, gizzard shad, ribbon shiner, big mouth buffalo, channel catfish, and flathead catfish. By contrast, the Turkey Creek survey yielded 16 species of fish, none of which were unusual to the area.

1.4 DESCRIPTION OF SWMUs 13 AND 16

The information presented in this section includes a discussion of each SWMU's background and operational history, physical characteristics, topography, hydrology, geology, and hydrogeology.

1.4.1 SWMU 13 – Mine Fill B

1.4.1.1 Background Information/Operational History

The approximate size of MFB is 50 acres. All structures found at MFB are shown in Figure 1-3. MFB can be divided into two halves by a northwest to southeast trending line. Identical activities took place in each half. Operations at MFB began when NSWC Crane was commissioned in December 1941. Production of explosive ordnance occurred at MFB from 1941 until 1973. MFB originally had the capability to handle only 2,4,6-trinitrotoluene (TNT). Later, MFB was modified to handle Torpex, Minol, HBX, and Amatol. During the Vietnam War, TNT, Composition B, H-6, Tritonal, and Minol were used in mine-filling operations. Constituents of these explosives are Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), TNT, aluminum powder, ammonium nitrate, and wax. Fertilizers (ammonium nitrate) were also melted into bombs. Since 1973, the facilities at MFB have been used for renovation of ordnance and equipment.

Renovation facilities in Building 169 include one paint booth. The 1983 Operation Permit application contained information on these activities. The paint booth applies an enamel coating that contains 22 percent naphtha by weight and also applies a bituminous solvent-type coating that contains 30 percent naphtha by weight.

Loading of bullets also reportedly took place in Building 169 (Halliburton NUS, 1992a). Bullets were loaded with titanium tetrachloride and vanadium oxytrichloride or dummy loaded with sands and salts. As many as 15 gallons of titanium tetrachloride are reported to have been spilled at Building 169 and neutralized, and the residue was reportedly disposed in a sanitary landfill. These rounds are no longer loaded at Building 169. Most of the vanadium oxytrichloride and titanium dioxide puff round loading equipment has been removed from this facility. Building 169 is currently used primarily for inert loading and painting of projectiles.

Renovation of mortars and bullets reportedly takes place in Building 165 (B165). Renovation activities include rotary grit blasting, spray painting, propellant removal, and fuse and configuration changes. In 1998, CAAA removed the two paint booths from B165. A new building was constructed next to B165, and an extruder was installed in this new building (Building 2172). The B165 area is now used for extrusion of C-4 blocks for various military items. In this process, C-4 is received at the building and brought to the proper temperature. The C-4 is then moved to the extruder by a bucket conveyor and processed through the extruder and its associated die in a remote manner. The die cuts the C-4 into blocks, and a conveyor carries the material back to the packaging line in B165. The blocks are then inspected and packaged for shipment. This process is permitted under the Crane Title V Operating permit, although there are

relatively little air emissions. Building 173, formerly used to degrease mines, is no longer used. There are no records of historical spills in this area. Building 174 (B174) is currently used primarily for demilitarization jobs. The most recent job involved the repackaging of Mine Clearing Line Charges (MCLC). B174 contained a vapor degreaser, but this equipment was removed in 1993. A paint booth remains in the building, but it has not been used recently.

Building 3299, which has been recently constructed, is utilized by the Navy Ordnance Department to test small waterjet cutting systems. The building has a 6-inch curb and sealed floors, so no wastewater can exit the building.

Large quantities of TNT, Composition B, HBX-1, HBX-3, and H6 were reportedly collected in the sumps of MFB (Halliburton NUS, 1992a). These sumps released explosives-contaminated water directly to surface drainage channels that flow into the Boggs Creek Watershed. Widespread soils explosives contamination was reported at MFB (Halliburton NUS, 1992a).

It is assumed that polychlorinated biphenyl (PCB) oils were heated in the therminol boilers and then transported to the melt building where the oil was used as a heat-transfer medium in the melting of explosive mixtures. PCB oils are reported to have leaked or spilled from the boilers and conveyance system, thus contaminating soil (Halliburton NUS, 1992a). During the remediation of explosives-contaminated soil at the MFB, soil containing PCBs was removed. No specific remediation goal for PCBs was established. Confirmation sampling indicated that the remaining soils contained PCBs in excess of 10 mg/kg. Some residual PCB contamination still remained near Buildings 166 and 171 as of 1992 (Halliburton NUS, 1992a).

Asbestos, once a component of AVCO, is not a concern for this investigation because the asbestos fibers were entrained in the asphalt-like AVCO matrix. In that form, the asbestos is not hazardous [Agency for Toxic Substances and Disease Registry (ATSDR), 1997]. Contaminants that were considered likely to be present at this SWMU include explosives, semi-volatile organic compounds (SVOCs), dioxins, PCBs, and metals.

1.4.1.2 Topography/Hydrology

The topography at MFB consists of a ridge that runs along Highway 45 in a north-south orientation with gradual slopes to the northwest across MFB and steeper slopes to the southeast into adjacent stream valleys. The elevation of the ground surface rises to a maximum of approximately 718 feet amsl in the northeastern corner near 13MWT03 (Figure 1-8).

Several man-made ditch systems located in the southern, eastern, and northern portions of the site, labeled 1, 2, and 3 on Figure 1-8, convey surface water runoff away toward larger tributaries. Ditch systems 1 and 2 ultimately discharge into Turkey Creek located east of SWMU 13, and ditch system 3 conveys runoff water towards Boggs Creek located to the west. Intermittent streams originating in the central portion of the site flow westward towards stream systems 1, 2, 3, and 4, which ultimately drain into Boggs Creek. Intermittent stream systems 5 and 6, east of Highway 45, flow southeastward and convey water towards Turkey Creek. These ditch systems are man-made controls to divert surface water runoff.

Surface water flow estimates were made based on visual observations during surface water sample collection. It was estimated that naturally occurring stream systems flowed at rates of 1 to 50 gallons per minute (gpm), while this ditch systems flowed at rates of less than 1 to 5 gpm. Flow calculations for surface water can be found in Appendix C.2.

1.4.1.3 Site-Specific Geology

MFB is located on a flattened ridgetop with relatively steep slopes that lead down to stream channels located on the northwestern and southeastern sides of the ridge. The geology and hydrogeology of SWMU 13 were investigated during two recent field efforts. In March through May 2003 (Round 1 field effort), 26 monitoring wells were installed. In October and November 2003 (Round 2 field effort), 21 additional monitoring wells were installed. Thus, a total of 47 monitoring wells were installed on the top of the ridge or high on the sideslopes of the ridge. To date, no drilling or installation of monitoring wells has occurred in the valleys near the bottom of the ridge.

The subsurface materials that underlie the MFB ridge include fill, natural unconsolidated soils, and bedrock (Lower Pennsylvanian and Mississippian). A description of each subsurface material is included in the remainder of this subsection. The maximum depth of investigation to date for this SWMU was approximately 84 feet bgs (13MWT45). Figure 1-9 illustrates the locations of the hydrogeologic cross sections, including select borings, through SWMU 13. Figures 1-10, 1-11, and 1-12 show hydrogeologic cross sections A - A', B - B', and C - C', respectively.

Fill was encountered in various borings and extended to a maximum depth of 6 feet bgs in soil boring 13MWT20 (Figure 1-11). In some cases, the fill extended to the bedrock surface. Fill material was found in several borings installed near the railroad tracks in the western portion of the SWMU (e.g., 13MWT12 and 13MWT17), in borings located near buildings (e.g., 13MWT02), and in areas of past excavation (e.g., 13MWT19 and 13MWT20). The fill material included cinders, gravel, sand, and sandstone fragments.

Natural unconsolidated materials, referred to as residual soils of the Raccoon Creek Group (Figure 1-6), underlie the fill and exist at the ground surface where the fill is not present. The maximum thickness of residual soil (17.5 feet) was found in soil boring 13MWT28 (Figure 1-12). The residual soils on the ridgetop and sideslopes consist predominantly of fine materials, including varying amounts of clay, silt, and sand.

Pennsylvanian bedrock was encountered beneath natural unconsolidated materials and fill and consisted of discontinuous layers of siltstones, sandstones, shales, and coal seams. Most fractures found in the bedrock were horizontal bedding plane fractures. The top of the ridge is capped with sandstone and siltstone that is weathered and stained brown because of iron oxidation. These rock units extend to about 635 to 645 ft amsl (see Figures 1-10 through 1-12). When grouped together, the ridge-capping sandstone and siltstone units form what is termed the Pennsylvanian shallow water-bearing zone (Psz); this zone is discussed in greater detail in the following subsection. Of the 47 monitoring wells that have been installed at this site to date, 40 of the wells are screened in this upper bedrock zone (Table 1-1).

Beneath the upper sandstone and siltstone units lies a mudstone (siltstone/shale) unit that extends throughout the SWMU area. The shale is interlayered with discontinuous siltstone and sandstone lenses. The sandstone lenses are most prevalent in the northeastern portion of SWMU 13. The top of the siltstone/shale unit was encountered at approximately 635 to 645 feet amsl (Figures 1-10 through 1-12). The bottom of the siltstone/shale unit lies at about 605 to 615 feet amsl. The total thickness of the siltstone/shale unit is about 30 feet. This siltstone/shale unit is considered to be an aquitard for reasons presented in the next subsection.

A sandstone layer was the next lithologic unit encountered beneath the interlayered shale and siltstone unit. The top of this sandstone unit was encountered at approximately 605 to 615 feet amsl. Seven out of 27 monitoring wells were drilled down to this interface and penetrated as much as 10 feet into the underlying sandstone. None of these deeper monitoring wells penetrated through the sandstone (see Figures 1-10 through 1-12). As a result, it is not known how thick the sandstone unit is.

The elevation of the Pennsylvanian/Mississippian unconformity is estimated to be between 500 to 550 ft amsl near SWMU 13 (Barnhill, 1993), or roughly 168 to 218 feet bgs. This places the base of the Pennsylvanian rock at or below the elevation of the tributary stream on the northwestern side of SWMU 13. No drilling has penetrated through the Pennsylvanian/ Mississippian unconformity, so the depth of the Mississippian formation that underlies the unconformity at this particular location is not known.

1.4.1.4 Hydrogeology

The maximum thickness of overburden encountered on the ridgetop at MFB was 17.5 feet in soil boring 13MWT28 (Figure 1-12). Elsewhere, the overburden was generally 10 feet thick or less. While drilling through the overburden, no saturated conditions or flowing water was observed. Therefore, it is concluded that very little if any ground water is present at the interface between bedrock and overburden. Surface water located in drainage gullies is not hydraulically connected to the bedrock ground water; therefore, water elevations from staff gauges 13SG01, 13SG02, 13SG06 and 13SG07 were not considered during preparation of the potentiometric surface maps. The surface water at these locations is believed to be perched on top of the clayey residual soils on the bedrock surface.

In general, the shallow bedrock aquifer is recharged by downward infiltration through the residual soil and occurs more readily where it is thin or disturbed and supplanted with fill material.

During drilling activities, ground water was generally encountered in the shallow bedrock at approximately 7 to 22 feet bgs. Ground water elevations in completed wells then rose above the depth at which ground water was first encountered. During three rounds of water level measurements, the static depth to ground water in shallow bedrock ranged from 0.26 foot bgs at 13MWT07 to 18.88 feet bgs at 13MWT42. In January 2004, the shallow ground water elevations ranged from 640.19 feet amsl in well 13MWT39 to 711.12 feet amsl in well 13MWT03, with an average ground water elevation of 682.24 feet amsl. The potentiometric surface for the shallow bedrock water-bearing zone (Psz), measured on January 20, 2004, is presented in Figure 1-13. The highest ground water elevations form a ridge that lies along the main road and the railroad tracks that lie along the southeastern SWMU boundary. Shallow ground water on the northwestern side of this ridge flows to the northwest and west. Shallow ground water on the southeastern side of the ridge flows southeast. All shallow ground water flow is presumably discharging in the gullies that are incised on the northwestern and southeastern sides of the ridge. The hydraulic gradients in the Psz steepen as the sideslopes of the ridge are approached. The local mounding of shallow ground water at well 13MWT34 may be a result of recent excavation of the residual soils at the well location as part of a soil remediation project.

Ground water elevations measured on January 20, 2004 in the seven monitoring wells completed in the Pennsylvanian deep water-bearing zone (Pdz) ranged from 595.51 in monitoring well 13MWT46 to 625.92 feet amsl in monitoring well 13MWT28 (Table 1-1), with an average elevation of 610.64 feet amsl. These water levels were much lower (about 50 to 70 feet) than the water levels measured in the Psz, thus indicating that a significant downward vertical gradient exists between the two water-bearing zones. Based on the average head difference between the two portions of the aquifer, there is a very restricted

hydraulic connection between the upper and lower ground water flow units. The shale unit, encountered between about 610 to 640 feet amsl, appears to be an effective aquitard between the Psz and the Pdz.

A potentiometric surface map for ground water in the Pdz is presented in Figure 1-14. The deep ground water flows toward the west and most likely discharges to the deeply-incised gullies on the side of the ridge (see Figure 1-14).

The results of slug tests performed on select monitoring wells during Round 2 at SWMU 13 are presented in Table 1-3. The average hydraulic conductivities for the shallow monitoring wells ranged from 0.00345 to 13.95 feet per day (1.2E-6 to 4.9E-3 centimeters per second [cm/s]). The geometric mean hydraulic conductivity (K) for the shallow bedrock was approximately 0.212 feet per day (7.5×10^{-5} cm/s). Horizontal hydraulic gradients for the Psz across the site were calculated graphically from ground water elevations presented in Figure 1-13. The average hydraulic gradients across the southwestern and eastern parts of the site were estimated to be 0.094 and 0.0478, respectively. Assuming a fracture-related porosity of about 0.005 for the bedrock, average ground water velocities were calculated to be approximately 3.99 feet per day and 2.0 feet per day for the western and eastern parts of the site, respectively. Water level recovery plots and calculations based on the slug test data can be found in Appendix E.

The hydraulic conductivities for the deep monitoring wells ranged from 0.000137 to 7.76 feet per day (4.8E-8 to 2.7E-3 cm/s). The geometric mean K value for deep bedrock was approximately 0.00896 feet per day (3.2×10^{-6} cm/s). The horizontal hydraulic gradient across the site for the deep ground water, calculated graphically from ground water elevations presented in Figure 1-4, was estimated to be 0.0387. Assuming a fracture-related porosity of about 0.005 for the bedrock, average ground water velocities were calculated to be approximately 0.069 feet per day. Water level recovery plots and calculations based on the slug test data can be found in Appendix E.

1.4.2 SWMU 16 – Cast High Explosives Fill/B146 Incinerator

1.4.2.1 Background Information/Operational History

SWMU 16 is approximately 16 acres in size. B146 (Figures 1-4 and 1-15), the largest building at SWMU 16, covering approximately two-thirds of an acre, was an explosives fill and pressure washout facility. Most of SWMU 16 is covered with buildings and gravel parking lots, and most grassy areas are located southeast of B146. The building identification numbers for SWMU 16 reflect that the site is very old (low numbers). Sumps and drains in the buildings are potential contaminant sources. Although current

operations are known, it is likely that unknown operations once occurred at this site based on its age. Oil/water separator outfalls previously discharged to swales at the site. These outfalls have since been welded shut. Sewer lines to sumps have been rerouted to the sanitary sewer system. Downspouts have also been rerouted. There is only one sewer system at Crane, and it is a sanitary system.

SWMU 16 is intermittently active and is used for renovation, rework, and breakdown of munitions. It is also sometimes used for ammunition demilitarization operations. Nearby facilities include case filling, case preparation, lunch and locker, and sewage pumping station buildings to the north and fuse and detonator magazines to the south. Magazine and storage buildings are situated east of B146, and magazines for fuses, detonators, and high explosives lie east of the SWMU. Both Building 145, the case filling plant, and Building 148, the small arms repacking building, housed significant quantities of explosives and smokeless powder.

B146 was an explosives fill and pressure washout facility with two large and one prototype, oil-fed rotary kiln incinerators. Three nearby above-ground storage tanks supplied No. 2 fuel oil for the kilns. The storage tanks in the eastern and western bays each had an approximate capacity of 2,000 gallons, and the central storage tank feeding the prototype kiln had a 300- to 500-gallon capacity. Munitions entered the kilns at one end and were exposed to flame combustion, which resulted in the destruction of the energetics (propellants, explosives, pyrotechnics) contained within the munitions to demilitarize them through burning or detonation. Ash and slag residues from the incinerators were piled on the ground. The incinerators were closed in the early 1990s. A decision was made to remove the waste ash piles, and the piles were removed along with some obviously contaminated soil.

Site operations also included cast loading (melt pouring of TNT, RDX, and HBX explosives into projectiles), demilitarization and incineration of ammunitions (shotgun shells, fuses, detonators, boosters, tracers, flare candles, and smoke flares), and demilitarization and high-pressure washout. Steamout of Army ammunition and rockets containing TNT and Composition B was reportedly conducted between 1954 and 1956 (Halliburton NUS, 1992b). The latter was accomplished by drilling out and recovering approximately 5 pounds of powder from each projectile. An additional 3 pounds were then washed out, collected, and disposed at the burning ground. Prior to 1978, the generated wastewater was discharged through a storm drain to a ditch, with ultimate transport to Boggs Creek. After 1978, wastewaters generated at B146 were transported to the Rockeye Treatment Facility for treatment.

In 1995, CAAA, in conjunction with the Earth Conservancy, installed a washout system in B146. This system has been referred to as the WOMBAT system. The WOMBAT system is designed to use high-pressure water to wash out explosives-loaded projectiles. The washed-out explosives go through a

clarifier that separates the explosives from the water. The water is reused in the process, and the explosives are collected for packaging. The system has containment devices to ensure that explosives-contaminated wastewaters are not released to the environment. This system has been through several testing phases but has never been fully proven successful. Currently, the system is not being used.

Two sumps located on the northeastern and northwestern sides of B146 received discharges from floor drains in this building. These sumps were designed to drain through clay tile pipes into ditches in the woods. Both sumps were expected to contain explosives-contaminated sludge. However, it was found that the sumps contained significant quantities of TCE, with the western sump having the highest concentrations. The eastern sump was piped to the western sump, and an air stripper was installed. The clay tile discharge lines were plugged when the stripper was installed. Shortly after the air stripper was installed, it was found that stormwater draining from the roof of B146 was found to be flowing into the sumps and causing them to overflow. The roof drains were rerouted to separate discharge lines that discharge into ditches. The air stripper was operated until TCE levels were low enough to allow direct discharge of the sumps into the sanitary sewer system. After the TCE concentrations were low enough to be transferred to the sanitary sewer without treatment by the air stripper, permanent sump pumps were installed. The TCE source was never found. However, a degreaser was used in B146 during the 1980s. At the time that the TCE was found in the sumps, TCE was not in use in B146 and had not been used for several years.

Major contaminants from B146 loading and washout activities were TNT, RDX, HBX, Composition A, Composition B, and ammonium picrate. HBX is a mixture of RDX, TNT, aluminum, and wax. Composition A contains RDX and beeswax. Composition B is composed of RDX, TNT, and wax. The primary metals of concern associated with the incinerator operations are the heavy metals lead, barium, cadmium, chromium, and mercury. Potential combustion of fuels containing PCBs and contamination from PCB oxidation products have also been reported (Halliburton NUS, 1992b). Polynuclear aromatic hydrocarbons (PAHs) and undetonated explosives have also been detected in ash from the incinerators. The source emission testing data, which exceeded allowable particulate emission rates set by the Air Pollution Control Board of the State of Indiana, provide additional information concerning the potential particulate and gaseous releases, particularly those occurring prior to baghouse installation (Halliburton NUS, 1992b). Initially, incinerator ash was piled near B146; later, ash and residue from burning and baghouse dust were collected and transferred to the storage facility. Ash from B146 operations has been reported to be a RCRA hazardous waste (Halliburton NUS, 1992b). TCE has been detected at high concentrations at the sumps.

Potential historical contaminant migration pathways at B146 include air, surface water, and ground water. Air should no longer be a migration pathway of significance because the incinerators and ash piles have been removed. Release of contaminants from surface soil or sediments to surface water and ground water is still a possibility. For example, any ash pile residue remaining in surface soils could continue to release contaminants to surface soils, and these contaminants could migrate via percolation into the subsurface and dissolve or be suspended in the ground water.

Site drains were terra cotta, which are known for leakage potential. Therefore, subsurface soils may be contaminated.

Ground water may be contaminated, especially because of the high concentrations of TCE found in soil and ground water in the sumps. The site is small enough that it may be considered a single unit with regard to ground water sampling. Contaminants considered likely to be present at this SWMU at the beginning of the Phase III RFI are explosives, SVOCs, VOCs, dioxins, and metals.

1.4.2.2 Topography/Hydrology

The topography at SWMU 16 is relatively flat with slopes to the east, south, and west of the site. The elevation of the ground surface rises to a maximum of approximately 766 feet amsl in the south near WES-14-05-83 (see Figure 1-15). Ditch systems 1 and 2 (see Figure 1-15), located in the northern portion of the site, as well as drainage systems 3 and 4 located in the southern portion of the site were dry and only showed minor pooling during storm events. Surface runoff encountered during storm events flows across the site to the east and west and ultimately flows into the ditch systems, which discharge surface water into larger water bodies to the east and west.

1.4.2.3 Geology

The Cast High Explosives Fill/B146 Incinerator area (SWMU 16) is located on a flattened ridgetop with relatively steep slopes that lead down to stream channels located on the western, southern, and eastern sides of the ridge. The geology and hydrogeology of SWMU 16 was first investigated in the early 1980s when the USACE installed five monitoring wells in the area (16MW01 through 16MW05). The area has been investigated more recently for the RFI during two field efforts. In March through May 2003 (Round 1 field effort), six new monitoring wells were installed. In October and November 2003 (Round 2 field effort), 12 additional monitoring wells were installed; one of these wells has subsequently been abandoned. Thus, a total of 22 monitoring wells were installed on the top of the ridge or high on the

sideslopes of the ridge. To date, no drilling or installation of monitoring wells has occurred in the valleys near the bottom of the ridge.

The geologic materials that underlie the SWMU 16 ridge include natural unconsolidated soil materials and bedrock (Lower Pennsylvanian and Mississippian). A description of each geologic material is included in the remainder of this subsection. The maximum depth of investigation to date for this SWMU was approximately 105 feet bgs (16MWT18). Figure 1-16 illustrates the locations of the hydrogeologic cross sections, including select borings, through SWMU 16. Figures 1-17 and 1-18 show hydrogeologic cross sections A - A' and B - B', and C - C', respectively.

Natural unconsolidated materials on the ridgetop and sides of the ridge are residual soils formed as a result of weathering of the underlying Raccoon Creek Group. The residual soils consist predominantly of fine materials, including varying amounts of clay, silt, and sand. The maximum observed thickness of soils was 13 feet.

The bedrock found at the site consists of siltstones, sandstones, shales, and coal seams. The layers of siltstone and sandstone encountered are somewhat discontinuous. A number of shallow, discontinuous, and weathered sandstone layers (5 to 10 feet thick) were encountered near the top of the ridge at elevations of about 742 to 755 feet amsl (Figures 1-17 and 1-18). The sandstones are presumably capping the ridge and are resistant to erosion. Ground water was first encountered in these sandstones so they have been grouped together and are referred to as the shallow water-bearing zone (Psz), which will be discussed in Section 1.4.2.4.

Shale layers are somewhat continuous and interlayered with the shallow sandstones and lie beneath the shallow sandstone lenses down to about 735 to 740 feet amsl (Figures 1-17 and 1-18). This shale is irregular in thickness but appears to be an effective aquitard between the shallow sandstones (Psz) and the intermediate depth sandstones, as will be discussed in Section 1.4.2.4.

Slightly deeper, intermediate-depth sandstone lenses are classified as the intermediate water-bearing zone of the Pennsylvanian bedrock (Piz), as discussed below, and were encountered at approximately 735 to 740 feet amsl and extend to about 720 feet amsl. The location where the thickest intermediate-depth sandstone unit was encountered was in well 16MW01 (Figure 1-16), which is located on the southwestern side of SWMU 16. This sandstone unit extends east to west across the northern end of SWMU 16 (cross section A-A', Figure 1-17) and is interpreted to extend south to well 16MW01 (cross section B-B', Figure 1-17).

Beneath the intermediate-depth sandstone lenses (Piz) lie about 35 to 50 feet of shale, which is continuous across the site. The elevation of the shale ranges from about 675 to 725 feet amsl (Figures 1-17 and 1-18). Because of its thickness, this shale is acting as an aquitard beneath the intermediate-depth sandstone lenses described above (Piz) and the underlying interlayered sandstone and siltstone described below.

Below the thick shale unit lies an interlayered sandstone and siltstone unit, which also contains a coal seam near the top (Figures 1-17 and 1-18). Four monitoring wells have penetrated into this unit; however, none of them extend more than about 12 feet into it. Therefore, it is not possible to determine how thick this sandstone is and how its lithologic properties might change at greater depth. This interlayered sandstone and siltstone is considered to be the deep water-bearing zone in the Pennsylvanian bedrock (Pdz), which will be discussed in greater detail in Section 1.4.2.4.

The Pennsylvanian bedrock beneath SWMU 16 is estimated to be 122 to 134 feet in thickness. The Pennsylvanian/Mississippian unconformity at SWMU 16 is estimated to be 640 to 650 feet amsl, roughly 126 to 136 feet bgs (Barnhill, 1993).

1.4.2.4 Hydrogeology

Description of Water-Bearing Zones

The maximum thickness of overburden (i.e., residual soils) encountered on the ridgetop at SWMU 16 was 13 feet. Elsewhere, the residual soils were generally 10 feet thick or less. While drilling through the overburden, no saturated conditions or flowing water was observed. Therefore, it is concluded that very little if any ground water is perching at the interface between the bedrock and overburden. Water elevations measured at staff gauges located in drainage gullies indicate that water in these gullies is not hydraulically connected to the bedrock ground water, and these elevations were not considered during preparation of the potentiometric surface maps. The surface water at these locations is believed to be perched on top of the clayey residual soils or on the bedrock surface.

The Pennsylvanian bedrock encountered during the field investigations was divided into three water-bearing zones (Psz, Piz, and Pdz) based on stratigraphic sequences, differences in water-yielding properties, and differences in hydraulic potential that were encountered in each of the three zones. Shale units and occasional siltstone lenses separate the three water-bearing zones and appear to act as aquitards. The shallow, intermediate, and deep ground water potentiometric surfaces and flow patterns were determined based on water levels measured on January 24, 2004 (Table 1-2).

There are 12 monitoring wells installed across the site that are screened in the shallow water-bearing zone (Table 1-2 and Figure 1-19). The static depth to ground water ranges from 10.25 feet bgs at 16MWT02 to 22.05 feet bgs at 16MWT10. Shallow ground water elevations ranged from 742.38 feet amsl at well 16MWT10 to 753.03 feet amsl at well 16MWT04, with an average ground water elevation of 748.33 feet amsl. Monitoring wells 16MWT07 and 16MWT14 were installed in the same shallow depth interval as the other 10 wells. However, these two wells did not encounter any sandstone units and failed to produce water, demonstrating the discontinuous nature of the Psz.

In general, the shallow potentiometric surface (Figure 1-19) mimics the surface topography. The highest ground water elevations in the northern portion of the site were measured in monitoring wells 16MW02 and 16MWT17, which are located along a northwest to southeast orientation near the centerline of the ridge. Ground water to the west of the divide flows to the west and southwest across the site, ultimately discharging into gullies that drain surface water and ground water westward towards a tributary of Boggs Creek. Shallow ground water east of the divide flows to the northeast towards gullies on the eastern side of the site. Shallow ground water is also present in the east-central portion of the site and flows in a southeasterly direction towards gullies on the southeastern side of the site that convey water eastward and southeastward towards Turkey Creek (Figure 1-17).

The shallow water-bearing zone appears to be absent or dry throughout most of the west-central and southern portions and in a small northeastern area of this SWMU (Figure 1-19).

Monitoring well 16MWT01 was not used in developing the SWMU 16 shallow potentiometric surface map and is therefore not representative of SWMU 16 ground water elevations (see Figure 1-19). The potentiometric surface elevation for 16MWT01 was approximately 6.78 feet lower than 16MWT06 during the May 30, 2003 measurements, and the water level difference was 1.71 feet during the January 24, 2004 measurements. The ground water in this well appears to have a restricted hydraulic connection to the shallow ground water flow system at the site. An evaluation of fracturing during drilling activities showed that fewer fractures existed in 16MWT01 compared to 16MWT06 and other wells at the site. A lower ground water yield was also noted during purging and development of 16MWT01, which may be related to the lower water level elevations in this well.

There are seven monitoring wells screened in the intermediate water-bearing zone (Table 1-2 and Figure 1-20). The static depth to ground water ranged from 20.13 feet bgs at 16MWT12 to 32.93 feet bgs at 16MWT16 (Table 1-2). Intermediate ground water elevations ranged from 731.81 feet amsl at well

16MWT16 to 736.07 feet amsl at well 16MWT03, with an average ground water elevation of 734.74 feet amsl (see Figure 1-20).

Monitoring well 16MWT16 was not used in developing the SWMU 16 potentiometric surface map for the Piz (Figure 1-20). The potentiometric surface elevation for 16MWT16 was approximately 3 feet lower than the average water level for other monitoring wells screened in the intermediate water-bearing zone. It is surmised that this well may not have a strong hydraulic connection to the remainder of the intermediate ground water flow system at the site.

Ground water elevations are highest near the central portion of this SWMU (near B146), and ground water is flowing toward the southwestern, southern, and southeastern hillsides. When it reaches the hillsides, the ground water is most likely discharging to the ground surface, primarily where gullies are deeply incised into the ground surface. These gullies convey water to tributaries of Turkey Creek (Figure 1-20).

There are four monitoring wells screened in the deep water-bearing zone (Table 1-2 and Figure 1-21). Monitoring well 16MWT15 was not used in developing the potentiometric surface map for the deep water-bearing zone. The potentiometric elevation for 16MWT15 was approximately 40 feet higher than the average water level measured in the three other wells screened in this zone. This may indicate that the well is in an area of increased vertical fracturing and enhanced leakage from the overlying intermediate flow zone.

The static depth to deep ground water ranged from 53.23 feet bgs at 16MWT15 to 97.04 feet bgs at 16MWT08. Deep ground water elevations ranged from 664.53 at well 16MWT08 to 706.46 feet amsl at well 16MWT15 on January 24, 2004, with an average elevation of 676.93 feet amsl (Figure 1-21). Not using the data for monitoring well 16MWT15, the deep ground water elevations ranged from 664.53 to 668.94 feet amsl, and averaged about 667 feet amsl. This ground water elevation is about 68 feet and 81 feet deeper, respectively, than the average Piz and Psz water levels. Thus, there is a very significant downward vertical gradient/hydraulic separation between the three water-bearing zones.

The potentiometric surface measured for the Pdz on January 24, 2004 is presented in Figure 1-21. Ground water flow direction on the eastern side of the site is towards the northeast. The ground water is likely discharging to the ground surface on the northeastern side of the ridge. Most of this discharge is likely going into the deep gullies that have incised the hillsides. These gullies in turn are conveying water to tributaries of Turkey Creek (Figure 1-21).

Hydraulic Characteristics of Water-Bearing Zones

The results of slug tests performed on select monitoring wells at SWMU 16 are presented in Table 1-4.

Water level recovery plots and calculations based on the slug test data can be found in Appendix E.

The average hydraulic conductivities (k values) for the shallow monitoring wells ranged from 0.034 to 26.7 feet per day (1.2E-4 to 9.42E-3 cm/s) (Table 1-4). The geometric mean K for the shallow water-bearing zone was approximately 1.83 feet per day (5.9×10^{-4} cm/s). The horizontal hydraulic gradient for the shallow zone was calculated graphically from ground water elevations measured in the northern area on Figure 1-19. The calculated hydraulic gradient was estimated to be 0.0198. Assuming a fracture-related porosity of about 0.005 for the bedrock, the ground water velocity was estimated to be 7.3 feet per day.

For the east-central area of SWMU 16, the average hydraulic gradient for the site was estimated to be 0.0727. The same horizontal hydraulic conductivity (1.83 feet per day) and porosity (0.005) were used to estimate the seepage velocity to be 26.61 feet per day.

A single horizontal hydraulic conductivity value (0.611 foot/day, 2.16E-4 cm/s) was measured for the intermediate monitoring wells (Table 1-4). The horizontal hydraulic gradient for the site was calculated graphically from ground water elevations measured in the southern area, as shown on Figure 1-20. The hydraulic gradient for the site was estimated to be 0.0048. Assuming a fracture-related porosity of about 0.005 for the bedrock, the ground water velocity was approximated to be 0.61 foot per day.

A single horizontal hydraulic conductivity (0.004 foot per day, 1.4E-6 cm/s) was measured for the deep monitoring wells (Table 1-4). The hydraulic gradient for the site was calculated graphically from ground water elevations measured in the northeastern part of the site, as shown on Figure 1-21. The average hydraulic gradient for this area was estimated to be 0.02. Assuming a fracture-related porosity of about 0.005 for the bedrock, the ground water velocity was approximated to be 0.016 foot per day.

1.5 PREVIOUS INVESTIGATIONS/INTERIM REMEDIAL ACTION

Several environmental investigations have been conducted at MFB (SWMU 13) and the Cast High Explosive Fill/B146 Incinerator (SWMU 16). Much of the historical data [contained in the 1992 Environmental Monitoring Reports (EMR) for SWMU 13 and the 1997/1998 Interim Measures Reports (IMR) for SWMU 16] were collected through programs that did not require independent data validation.

Therefore, some of the data described in the following sections appear not to have undergone validation to the extent typically performed for use in a risk assessment. However, data from SWMU 13 representing soils after bioremediation have been validated [Morrison Knudson (MK) Corporation, 2000].

The following sections summarize the available historical data for each SWMU. A site investigative chronology for SWMUs 13 and 16 is presented in Table 1-5.

1.5.1 SWMU 13 – Mine Fill B

The major sources of contamination at MFB were washdown from buildings onto the ground and exhausts from ventilation systems. Also, therminol boilers located near Buildings 166 and 171 leaked PCB oils. The boilers and surrounding soil were removed in 1989, but subsequent soil samples collected near the boilers indicated that PCB concentrations were greater than 10 mg/kg.

Selected surface water samples were collected in drains and ditches in 1972, 1978, and 1979 by the Department of the Army (Halliburton NUS, 1992a). These samples were collected adjacent to and at various distances from the buildings. The explosives TNT, RDX, and HMX were detected in most samples, and concentrations in the samples collected nearer the buildings were greater than the concentrations in the more distant samples. In 1972, surface water samples collected in drains near Buildings 166, 167, 168, 171, 174, 2501, 2502, and 2503 were found to contain TNT, RDX, and HMX. The greatest concentrations were detected in the southern drain near Buildings 171, 174, 2501, and 2503. In 1978, drainage and runoff samples from the north and south contained TNT, RDX, and HMX. The greatest concentrations were detected in the southern runoff. Surface water samples were collected in ditches farther from the facilities in 1979. TNT was detected in one sample collected at a central ditch. RDX and HMX were detected in the south-central and central ditches.

Sediment samples were collected from ditches located farther from the buildings in 1979. TNT, RDX, and HMX were detected in sediment samples. Data from these sampling events exhibited the same pattern: samples from the northern ditch had no detectable explosives; samples from the central and south-central ditches had measurable concentrations of TNT, RDX, and HMX in both the aqueous and sediment fractions; and samples from the southern ditch had no detectable explosives in water but contained high levels of RDX and HMX in sediment.

Pilot test studies were conducted at three hand-dug wells located in the vicinity of MFB in 1972 (Kent, et al., 1972). Samples were collected from these wells; however, only one well contained detectable levels of explosives (at concentrations exceeding risk-based Drinking Water Health Advisories). The explosives

detected included TNT and RDX. Kent, et al. (1973) also reported detections of TNT and RDX in soil samples collected in ditches near Buildings 172 and 2501. The greatest concentrations were found in the soil collected from the ditch northeast of Building 2501.

A soil sample collected in 1985 around Building 169 was tested by the Extraction Procedure (EP) Toxicity Test for susceptibility of contaminants to leach. Concentrations of metals, methylene chloride, and PCBs were determined to be less than 1990 Toxicity Characteristic Leaching Procedures (TCLP) action levels. As part of the Initial Assessment Survey (IAS) for SWMU 13, eight soil samples were collected around Building 167 and Building 172 from core soil samples to a 20-inch depth and were analyzed for explosives (Halliburton NUS, 1992a). These samples had detections of TNT, HMX, and RDX.

Interim Remedial Action

In 2000, TolTest Incorporated (TolTest) performed sampling, excavation, on-site treatment through bioremediation (composting) of explosives-contaminated soil, and on-site backfilling of compost. On-site bioremediation of the high-explosives-contaminated soil was conducted using a windrow composting process. The scope of work included initial site characterization by sampling and analysis, excavation and screening of explosives-contaminated soil, transportation of screened soil to the bioremediation facility for treatment, process monitoring and confirmatory sampling of the compost windrows, disposal of treated soil, and site restoration. The analytes selected for evaluation in the initial characterization consisted of the following:

VOCs	Explosives	Metals	PCBs
methylene chloride	dinitrobenzene	aluminum	Aroclor 1242
acetone	HMX	arsenic*	Aroclor 1254
methyl ethyl ketone	RDX	barium	Aroclor 1260
methyl isobutyl ketone	nitrobenzene	cadmium	
toluene	pentaerythritoltetranitrate (PETN)	chromium	
xylenes	trinitrobenzene	lead	
chloroform*	Tetryl	mercury	
1,2-dichloroethane*	TNT	selenium	
1,1-dichloroethane*	dinitrotoluenes	silver	
	nitrotoluenes		
	aminodinitrotoluenes		

* Parameter is a TCLP parameter for waste characterization (not a chemical of concern).

The excavation and remediation of contaminated soil at SWMU 13 was documented in the Interim Measures Report for SWMU 13 (TolTest Inc., 2002) and is summarized below. Explosives-contaminated soil excavated from MFB was treated in the biofacility by composting to degrade the explosive compounds in the soil. Organic amendments (chicken manure and straw) were mixed with the contaminated soil to form the compost windrows. The chicken manure and straw in the compost served as a carbon source for the microorganisms in the material that were capable of degrading the explosives. The availability of organic material and inorganic nutrients (such as nitrogen and phosphorus), temperature, moisture content, pH, and oxygen availability in the compost were optimized to enhance the process. Microbial activity in the soil was stimulated by heat generated and contained in the compost matrix. A full description of the composting operation process is provided in the Full-Scale Operational Plan for Soil Bioremediation Facility (MK, 1998).

TolTest Inc. and MK obtained initial characterization samples (ICS) for the purpose of delineating the extent of contaminated soil requiring excavation. The locations of potentially contaminated areas were based on visual observations, with direction provided by personnel from the NSWC Crane Environmental Protection Department (EPD). Samples were obtained on blast-wall berms, in flat areas accepting runoff from the berms, under vents, and in drainage ditches. Grid sampling was performed around or near Buildings 165 through 168, 171 through 174, 2500, and 2501. The grid layout and boundaries were affected by the presence of buildings, railways, roadways, utilities, etc. A total of 281 grid points were initially marked. Of these initial 281 grid points, only 256 were actually sampled. The grid points not sampled were on blast-wall berms covered by a thick layer of gravel. Given the difficult nature of sampling through this gravel, several grid points were consolidated into a larger composite sample for the purpose of obtaining ICS.

Sampling in each grid point consisted of two composite samples and one grab sample. The composite samples were analyzed for explosives and metals, and the grab sample was analyzed for VOCs. The composite samples were collected at depths of 0 to 12 inches and 24 to 36 inches and the grab sample was collected from a depth of 12 inches. Field duplicates and other appropriate field quality control (QC) samples were also collected from selected locations.

Samples were analyzed by United States Environmental Protection Agency (U.S. EPA) SW-846 methods 8330 (explosives), 8260 (VOCs), and 6010/7470 (metals) for the constituents of concern. The analysis was performed to ensure that solvent-contaminated soil, or other potential RCRA characteristic wastes, were not transported to the biofacility for composting. Results of these parameters analyses were reported on a total concentration basis. The results were divided by an estimation factor of 20 and

compared with the TCLP regulatory limits. All results were significantly less than 20 times the TCLP limit so the material was classified as not exhibiting the RCRA hazardous waste characteristic of toxicity.

Grid points 137 and 258 through 261 at Building 171 were also analyzed for PCBs because this was an area of known PCB contamination. PCBs were detected in grid point 137 at 13 ppm but were not detected in grid points 258 through 261. Because the level in grid point 137 was less than 50 ppm, the soil was excavated, screened, and transported to the biofacility for composting.

Of the 256 grid points sampled, 110 grid points had samples that exceeded industrial cleanup objectives and required excavation. ICS analytical results are summarized in Tables E-1 (explosives), E-2 (metals), E-3 (VOCs), and E-4 (PCBs) in Appendix E of the IMR (MK, 2000).

After the ICS results were received, the horizontal boundaries of explosives contamination were delineated by grid points with no detectable levels of contamination or levels less than cleanup objectives or by buildings, roads, railroad tracks or other physical obstacles to excavation. No metals or VOCs were detected at concentrations greater than cleanup action levels for SWMU-specific contaminants of concern at any grid point that required excavation. Arsenic was present in samples at various levels that exceeded industrial cleanup goals. However, no action was taken because none of the total arsenic results, when divided by an estimation factor of 20, exceeded the TCLP regulatory limit (meaning that the material did not possess the hazardous waste characteristic of toxicity).

Excavated soil was loaded into mechanical soil screening equipment using a backhoe or tracked excavator. After screening, the fines were dropped from the screener onto the stacking conveyor and placed into a dump truck or a live-bottom truck bed for transport to the biofacility. Before entering the biofacility, each truck was weighed to determine the amount of soil being brought into the facility. Oversized material was separated into large rocks and soil clods mixed with gravel. The reject soil mixed with gravel was re-screened several times to remove as much soil as possible. The rocks were transported to the biofacility to be washed and were placed back into the open excavation at a later date.

The total quantity of soil excavated, screened, and transported to the biofacility from MFB was 22,951.73 tons, and the combined weight of soil plus reject rocks was 23,112.2 tons.

Soil samples were collected during excavation activities to assist in determining the extent of excavation required at each grid point. Field screening test kits were used to test RDX levels in the in-process soil samples to provide quick turnaround results. One composite sample was collected from the base of the excavation and one from each side wall (if a side wall was present). If the field screening indicated that

concentrations of RDX were greater than industrial cleanup levels, subsequent layers of contaminated soil were removed until field screening indicated acceptable concentrations of explosives (less than the industrial cleanup objectives) or physical impediments (buildings, railways, roadways, utilities, etc.) were encountered. The IMR identifies those grid points that were not excavated to cleanup goals and explains why no additional excavation was conducted.

Post-excavation samples (PESs) were collected following excavation and field screening to determine the levels of SWMU-specific contaminants remaining in the soil. PESs included one composite and one grab sample from the base of each grid point and one grab sample for each 20 feet of side wall. Samples were analyzed for all contaminants of concern. Appendices D, G, and H of the IMR (MK, 2000) provide details of the PES collected from each grid point.

A total of 104 windrows were formed to treat the contaminated soil excavated from MFB. All windrows successfully achieved industrial or residential cleanup goals for explosive compounds. According to the IMR, the excavated soil from MFB was mixed with 11,498.3 tons of chicken manure and 5,011.5 tons of straw, and the total weight of processed soil backfilled into the excavated areas was 39,730.75 tons.

1.5.2 SWMU 16 – Cast High Explosives Fill/B146 Incinerator

Analytical data for two ash pile samples collected in 1982 show that the ash from the rotary kiln furnaces was a RCRA hazardous waste. Barium, cadmium, and lead exceeded EP Toxicity limits (Halliburton NUS, 1992b).

Surface soil and sediment samples were collected around B146 in 1982 and 1985. The 1982 samples exceeded EP Toxicity action levels for cadmium and lead. These samples also contained trace levels of the explosives RDX and HMX. One sample collected in 1985 exceeded the EP Toxicity action level for lead. None of the 1985 samples contained detectable levels of explosives.

During some rerouting of drain lines, trenches were dug through the asphalt cover and into the soil. Samples were collected from the soil/asphalt mixture, and low concentrations of PCBs were detected in the samples.

Sediment samples collected from drainageways in the northern ditch into which B146 discharges contained TNT, RDX, and HMX (Department of the Army, 1980). Water samples collected in 1979 from the same areas revealed no detections of HMX; however, TNT and RDX were detected. No measurable concentrations or related detrimental effects were found in Turkey Creek, the ultimate receptor of the

B146 discharge. A 1972 water sample from B146 was reported to contain detectable levels of HMX and RDX, but the concentrations were not provided (Halliburton NUS, 1992b).

Soil samples were collected from the B146 incinerator bays as part of closure activities. Between October and December 1989, 133 soil samples were collected from 34 locations at depths between 0 and 2 feet bgs. The samples were analyzed for metals and PCBs. In March 1990, an additional 16 samples were collected from four locations to represent background conditions. The Indiana Department of Environmental Management (IDEM) determined that quality assurance/quality control (QA/QC) data for the PCB parameters were inadequate, and six locations were resampled from 0 to 2 feet bgs (IDEM, 1990). The analytical results for samples collected from below the incinerator bays indicated that concentrations of arsenic, cadmium, chromium, selenium, and silver exceeded background levels. Only the concentrations of selenium and silver were considered significant (Halliburton NUS, 1993), but concentrations were not provided. The PCB analytical data indicated that detectable levels of PCBs were not present in B146 sampling locations.

Four monitoring wells were installed near B146 in July 1983. Soil and ground water samples were collected and analyzed for metals and selected organic constituents. Based on a comparison of detected concentrations with average United States metal concentrations, the soils around B146 contained elevated concentrations of lead and zinc. Ground water samples around B146 exceeded drinking water regulations for lead, chromium, nickel, cadmium, mercury, and TCE, which was the only organic chemical detected in ground water. TCE was not detected in soil boring samples collected from 0 to 5 feet bgs at the same locations.

1.6 CONSTITUENTS OF INTEREST

Based on previous site investigations and interim remedial actions, a list of constituents of interests was assembled for SWMUs 13 and 16. Sections 1.6.1 and 1.6.2 provide a discussion of the constituents of interest for each medium being evaluated in this RFI.

1.6.1 SWMU 13 – Mine Fill B

The chemicals or chemical mixtures potentially released at SMWU 13 generally fall into four categories: metals, SVOCs (including PAHs), VOCs, and explosives. Sections 1.6.1.1 through 1.6.1.4, present discussions of the constituents of interest for surface/subsurface soil, surface water, sediment, and ground water, respectively.

1.6.1.1 Surface Soil/Subsurface Soil

Soil samples collected around Buildings 167 and 172 have reportedly had detections of the explosives TNT, HMX, and RDX, with the greatest concentrations occurring near Building 172. Soil samples collected from the area around Building 169 were tested by the EP Toxicity Test for susceptibility of contaminant leaching from soil to ground water. Concentrations of metals, methylene chloride, and PCBs were less than 1990 TCLP action levels.

The following constituents of interest are evaluated in this RFI for all surface/subsurface soil samples collected at MFB unless noted otherwise:

- Metals - Aluminum and other metals were included because of the potential for their release directly to surface or subsurface soils.

- VOCs - VOCs were included because of the potential for their release directly to surface or subsurface soils only near the therminol boilers.

- SVOCs - SVOCs including PAHs were included because of the potential for their release directly to surface and subsurface soils.

- PCBs - Existing evidence shows that soils only near the therminol boilers were still contaminated with PCBs at the start of the Phase III RFI.

- Dioxins and furans - These compounds are generated from the combustion of PCB oil and were included because of the potential for their release via air dispersion and deposited to the surface soil only near the therminol boilers.

- Total organic carbon (TOC), cation exchange capacity (CEC), and pH - These parameters were measured in selected samples to provide information for use in corroborating the absence or presence of contamination and in evaluating potential contaminant bioavailability.

- Depositional environment and grain size - The data provides information for potential use in the Corrective Measures Study (CMS) and for comparison to background concentrations (for naturally occurring inorganics)

1.6.1.2 Surface Water

Historical surface water sampling data for MFB indicates detections of TNT, RDX, and HMX in most samples. The concentrations in samples collected nearer the building had greater concentrations than more distant samples. In 1972, samples collected in drains near Buildings 166, 167, 168, 171, 174, 2501, 2502, and 2503 were also found to contain TNT, RDX, and HMX. In 1978, drainage and runoff samples from the buildings contained TNT, RDX, and HMX, with the greatest concentrations measured at the southern end of MFB. Surface water samples were also collected from ditches in 1979 and had detections of TNT, RDX, and HMX. It appears that most or all of these data were not validated.

The following constituents of interest are evaluated in this RFI for all surface water samples collected at MFB unless noted otherwise:

- Metals - Aluminum and other metals were included because of the potential for their release directly to surface or subsurface soils and migrated to surface waters.

- Explosives (SW-846 nitroaromatics/nitramines) - These compounds were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to surface water.

- SVOCs - SVOCs including PAHs were included because of the potential for their release directly to surface or subsurface soils and migrated to surface waters only near the location of the therminol boilers.

- General surface water quality parameters - Dissolved oxygen, oxidation-reduction potential (ORP), pH, specific conductance, temperature, turbidity, and flow rate were measured to evaluate the overall quality of surface water and to provide information on contaminant masses.

- Ammonia - Ammonia was included because of the potential for it to leach from bioremediated soils. This parameter is measured in all surface water samples.

- Nitrates - Nitrates are degradation products of certain explosives. Consequently, this parameter was measured in all surface water samples.

1.6.1.3 Sediment

Sediment samples collected from certain ditches located away from the buildings had detections of the explosives TNT, RDX, and HMX. Samples collected in the northern ditch had no detectable explosives. However, measurable concentrations of TNT, RDX, and HMX were detected from the central and south-central ditches in both the aqueous and sediment fractions. Samples collected in the southern ditch contained high levels of RDX and HMX.

The following constituents of interest are evaluated in this RFI for all sediment samples collected at MFB unless noted otherwise:

- Metals - Aluminum and other metals were included because of the potential for their release directly to surface or subsurface soils and migrated to surface water and sediment.

- Explosives - These compounds were included because of the potential for their release to surface or subsurface soils with subsequent migration to surface water and sediment.

- SVOCs - SVOCs including PAHs were included because of the potential for their release directly to surface or subsurface soils and migrated to surface waters and sediments only near the therminol boilers.

- TOC, CEC, and pH - These parameters were measured for selected samples to provide information for use in corroborating the absence or presence of contamination and in evaluating potential contaminant bioavailability.

- Depositional environment and grain size - These parameters were measured for all samples to provide information for potential use in the CMS and for comparison to background concentrations (for naturally occurring inorganics in sediment).

- Acid Volatile Sulfide/Simultaneously Extracted Metals (AVS/SEM) - These parameters were measured for selected samples to provide information for fate and transport assessment.

1.6.1.4 Ground Water

Historically, there were very limited ground water sampling data available for MFB. Samples had been collected from hand-dug wells near MFB. Only one well had concentrations of TNT and RDX that

exceeded U.S. EPA risk-based Drinking Water Health Advisories. The greatest concentrations of explosives were found in a ditch northeast of Building 2501.

The following constituents of interest are evaluated in this RFI for all ground water samples collected at MFB unless noted otherwise:

- Metals - Aluminum and other metals were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to ground water.

- Explosives - These compounds were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to ground water.

- VOCs - VOCs were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to ground water only near the therminol boilers.

- SVOCs - SVOCs including PAHs were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to ground water only near the therminol boilers.

- Ammonia - Ammonia was included because of the potential for it to leach from bioremediated soils with subsequent migration to ground water.

- Nitrates - Nitrates are degradation products of certain explosives that may have migrated to ground water.

1.6.2 SWMU 16 – Cast High Explosives Fill/B146 Incinerator

The chemicals or chemical mixtures potentially released at SMWU 16 generally fall into five categories: metals (aluminum, lead, cadmium, chromium, barium, mercury), PCBs, PCB oxidation products (dioxins and furans), VOCs, high explosives (Compositions A and B, HBX, and TNT), and potentially ammonium picrate. Sections 1.6.2.1 through 1.6.2.4 present a discussion of the constituents of interest for surface/subsurface soil, surface water, sediment, and ground water, respectively.

1.6.2.1 Surface/Subsurface Soil

Limited historical surface/subsurface soil data were available for SWMU 16. Surface soil samples collected around B146 contained elevated concentrations of lead and zinc and also exceeded EP Toxicity

action levels for cadmium and lead. In addition, these soil samples contained trace levels of the explosives RDX and HMX. Soil samples collected during drain rerouting had detections of PCBs. Subsurface soil samples collected below the incinerator bays had detections greater than background for arsenic, selenium, and silver.

The following constituents of interest are evaluated in this RFI for all surface/subsurface soil samples collected at SWMU 16 unless noted otherwise:

- Metals - Metals were included because of the potential for their release directly to surface or subsurface soils.

- Explosives - These compounds were included because of the potential for their release directly to surface or subsurface soils.

- Picrates - Picrates, ammonium picrate in particular, were included because of the potential for their release directly to surface or subsurface soils.

- VOCs - These contaminants were released to surface soils or to sumps in the 1980s and may have migrated deeper to subsurface soils.

- SVOCs - SVOCs including PAHs were included because of the potential for their release directly to surface or subsurface soils.

- PCBs - These compounds were included because of the potential for their release directly to surface or subsurface soils and were measured in selected samples.

- Dioxins and furans - These compounds were included because of the potential for their release directly to the air and settled on surface soil and were measured in selected samples.

- Depositional environment and grain size - These parameters provide information for potential use in the CMS and for comparison to background concentrations (for naturally occurring inorganics).

1.6.2.2 Surface Water

Limited historical surface water data were available for SWMU 16. Surface water samples collected near settling basins or sumps into which B146 floor drains discharge had detections for the explosives TNT, HMX, and RDX.

The following constituents of interest are evaluated in this RFI for all surface water samples collected at SWMU 16:

- Metals - Metals were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to surface water.

- Explosives - These compounds were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to surface water.

- Picrates - Picrates, ammonium picrate in particular, were included because of the potential for their release to surface and subsurface soil and may have migrated to surface water.

- SVOCs - SVOCs including PAHs were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to surface water.

- General surface water quality parameters - dissolved oxygen, ORP, pH, specific conductance, temperature, turbidity, and flow rate will be measured to evaluate the overall quality of surface water and provide information on contaminant masses.

- Nitrate - This test evaluates the impact of nitrates, which are degradation products of certain explosives.

1.6.2.3 Sediment

Contaminant concentrations in sediment samples collected around B146 exceeded EP Toxicity action levels for cadmium and lead, and these samples also contained trace levels of the explosives RDX and HMX. Sediment samples collected from drainageways near B146 contained TNT, RDX, and HMX.

The following constituents of interest are evaluated in this RFI for all sediment samples collected at SWMU 16 unless noted otherwise:

- Metals - Metals were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to sediments.

- Explosives - These compounds were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to sediments.

- Picrates - Releases of picrates, ammonium picrate in particular, may have migrated to sediment.

- SVOCs – SVOCs including PAHs were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to sediments.

- TOC, CEC, and pH - These parameters were measured for selected samples and provide information for use in corroborating the absence or presence of contamination and in evaluating potential contaminant bioavailability.

- AVS/SEM - These parameters were measured for selected samples and provide information for fate and transport.

1.6.2.4 Ground Water

Limited historical ground water sampling had been conducted at SWMU 16. Ground water samples collected near B146 contained elevated concentrations of lead and zinc and exceeded drinking water regulations for lead, chromium, nickel, cadmium, mercury, and TCE.

The following constituents of interest are evaluated in this RFI for all ground water samples collected at SWMU 16:

- Metals - Metals were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to ground water.

- Explosives - These compounds were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to ground water.

- Picrates - Releases of picrates, ammonium picrate in particular, to surface or subsurface soil may have migrated to ground water. In addition, picrates are relatively soluble in water and have a high migration potential.

- VOCs - These contaminants were released to soils or to sumps and may have migrated deeper to ground water.

- SVOCs - SVOCs including PAHs were included because of the potential for their release directly to surface or subsurface soils with subsequent migration to ground water.

- Nitrate - Nitrates are degradation products of certain explosives.

1.7 CONCEPTUALIZED HYDROLOGIC MODEL FOR CONTAMINANT MIGRATION IN THE WATERSHED

1.7.1 SWMU 13

Surface water runoff at SWMU 13 follows topography and is routed through storm sewers and ditches located along the northwestern and southeastern borders of the site. The ditches lead to larger drainageways that flow into the Boggs Creek and Turkey Creek Drainage Basin. Site-specific hydrogeologic information indicates that ground water flow patterns mimic topography, with high ground water elevations found along ridge crests and ground water flow toward the major stream or tributary valleys. Recharge to the shallow ground water system occurs over most of the uplands and sideslopes. Ground water moves downward and then laterally and discharges to surface water in the deeper stream valleys.

1.7.2 SWMU 16

The topography at SWMU 16 is relatively flat with slopes to the east, south, and west. Surface drainage is primarily toward the west, south, and east along storm sewers and ditches that ultimately flow into Turkey Creek. Site-specific hydrogeologic information indicates that ground water flow patterns mimic topography, with high ground water elevations found along ridge crests and ground water flow toward the major stream or tributary valleys. Recharge to the shallow ground water system occurs over most of the uplands and sideslopes. Ground water moves downward and then laterally and discharges to surface water in the deeper stream valleys.

TABLE 1-1

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 13 - MINE FILL B
NSWC CRANE
CRANE, INDIANA

Well Number	Installation Date	Northing (feet)	Easting (feet)	Ground Elevation (feet amsl)	Top of Riser Elevation (feet amsl)	Total Depth (feet bgs)[1]	Screened Interval				Water-Bearing Zone	May 5, 2003		May 11, 2003		January 20, 2004	
							Top (feet bgs)	Bottom (feet bgs)	Top (feet amsl)	Bottom (feet amsl)		Depth to Water (feet btor)	Ground Water Elevation (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation (feet amsl)
13MWT01	3/30/2003	1310541.574	3025015.943	713.10	715.34	15.00	5.00	15.00	708.10	698.10	Psz	6.21	709.13	5.82	709.52	7.55	707.79
13MWT02	3/29/2003	1310776.555	3024743.547	702.10	704.72	27.00	17.00	27.00	685.10	675.10	Psz	17.15	687.57	17.10	687.62	16.24	688.48
13MWT03	3/30/2003	1310240.946	3024891.661	718.34	721.10	15.00	5.00	15.00	713.34	703.34	Psz	8.79	712.31	8.88	712.22	9.98	711.12
13MWT04	3/30/2003	1310383.396	3024546.113	704.37	706.84	15.00	5.00	15.00	699.37	689.37	Psz	12.98	693.86	12.75	694.09	14.09	692.75
13MWT05	3/29/2003	1310758.927	3024380.025	693.61	696.44	16.00	6.00	16.00	687.61	677.61	Psz	5.42	691.02	4.13	692.31	5.78	690.66
13MWT06	4/7/2003	1309916.177	3024495.270	715.30	717.93	15.00	5.00	15.00	710.30	700.30	Psz	15.11	702.82	15.62	702.31	11.91	706.02
13MWT07	3/29/2003	1310539.322	3024094.128	684.38	687.22	15.00	5.00	15.00	679.38	669.38	Psz	3.12	684.10	3.10	684.12	4.21	683.01
13MWT08	3/30/2003	1310247.860	3024337.560	698.42	700.56	15.00	5.00	15.00	693.42	683.42	Psz	3.17	697.39	2.92	697.64	3.88	696.68
13MWT09	4/1/2003	1309662.066	3024049.030	703.29	705.90	20.00	10.00	20.00	693.29	683.29	Psz	7.74	698.16	7.40	698.50	8.77	697.13
13MWT10	3/27/2003	1309979.693	3024001.262	697.77	700.15	25.00	15.00	25.00	682.77	672.77	Psz	13.65	686.50	13.11	687.04	14.96	685.19
13MWT11	3/28/2003	1310233.721	3023750.087	679.76	682.29	15.00	5.00	15.00	674.76	664.76	Psz	7.87	674.42	7.00	675.29	8.76	673.53
13MWT12	3/27/2003	1310080.207	3023574.945	679.96	682.12	20.00	10.00	20.00	669.96	659.96	Psz	7.88	674.24	7.78	674.34	10.75	671.37
13MWT13	4/23/2003	1309441.270	3024163.605	699.28	701.98	19.00	8.00	18.00	691.28	681.28	Psz	3.62	698.36	3.18	698.80	4.93	697.05
13MWT14	3/31/2003	1309142.232	3024110.167	703.15	705.50	23.00	13.00	23.00	690.15	680.15	Psz	13.25	692.25	13.08	692.42	14.17	691.33
13MWT15	3/25/2003	1309565.518	3023717.803	694.27	696.65	25.00	15.00	25.00	679.27	669.27	Psz	12.88	683.77	12.63	684.02	14.59	682.06
13MWT16	3/27/2003	1309854.276	3023341.916	682.13	684.35	15.00	5.00	15.00	677.13	667.13	Psz	8.49	675.86	8.61	675.74	11.01	673.34
13MWT17	3/26/2003	1309605.272	3023123.966	690.68	693.01	18.00	8.00	18.00	682.68	672.68	Psz	8.70	684.31	8.09	684.92	8.89	684.12
13MWT18	3/26/2003	1309326.980	3023293.416	700.05	702.92	30.00	20.00	30.00	680.05	670.05	Psz	19.06	683.86	19.04	683.88	20.21	682.71
13MWT19	3/31/2003	1308893.971	3023834.565	703.10	705.82	19.00	9.00	19.00	694.10	684.10	Psz	8.31	697.51	6.80	699.02	10.96	694.86
13MWT20	4/1/2003	1309066.757	3023527.233	699.33	702.07	20.00	10.00	20.00	689.33	679.33	Psz	4.22	697.85	4.00	698.07	5.00	697.07
13MWT21	3/28/2003	1309391.009	3022916.218	688.37	690.74	15.00	5.00	15.00	683.37	673.37	Psz	7.69	683.05	7.34	683.40	9.09	681.65
13MWT22	3/28/2003	1308936.338	3022785.672	669.53	671.96	15.00	5.00	15.00	664.53	654.53	Psz	7.44	664.52	7.25	664.71	8.18	663.78
13MWT23	4/1/2003	1308708.016	3023245.117	696.66	699.14	22.00	11.50	21.50	685.16	675.16	Psz	7.45	691.69	7.17	691.97	8.50	690.64
13MWT24	4/1/2003	1308397.230	3022916.484	691.33	693.93	22.00	12.00	22.00	679.33	669.33	Psz	8.45	685.48	8.23	685.70	9.25	684.68
13MWT25	3/28/2003	1308625.618	3022677.444	678.87	681.57	15.00	5.00	15.00	673.87	663.87	Psz	16.00	665.57	16.61	664.96	7.05	674.52
13MWT26	3/28/2003	1308232.686	3022690.142	684.86	687.49	20.00	10.00	20.00	674.86	664.86	Psz	9.10	678.39	8.93	678.56	10.05	677.44

TABLE 1-1

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 13 - MINE FILL B
NSWC CRANE
CRANE, INDIANA

Well Number	Installation Date	Northing (feet)	Easting (feet)	Ground Elevation (feet amsl)	Top of Riser Elevation (feet amsl)	Total Depth (feet bgs)[1]	Screened Interval				Water-Bearing Zone	May 5, 2003		May 11, 2003		January 20, 2004	
							Top (feet bgs)	Bottom (feet bgs)	Top (feet amsl)	Bottom (feet amsl)		Depth to Water (feet btor)	Ground Water Elevation (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation (feet amsl)
13MWT27	11/5/2003	1309786.548	3023829.075	696.09	698.13	21.00	10.00	20.00	686.09	676.09	Psz	na	na	na	na	9.31	688.82
13MWT28	11/19/2003	1309678.623	3024066.666	703.54	705.55	88.00	78.00	88.00	625.54	615.54	Pdz	na	na	na	na	79.63	625.92
13MWT29	11/4/2003	1309538.755	3024290.715	698.10	700.44	20.00	9.00	19.00	689.10	679.10	Psz	na	na	na	na	5.82	694.62
13MWT30	11/6/2003	1309174.842	3024237.447	696.57	698.94	25.00	14.00	24.00	682.57	672.57	Psz	na	na	na	na	11.72	687.22
13MWT31	11/5/2003	1308631.827	3023583.849	693.56	696.21	20.00	10.00	20.00	683.56	673.56	Psz	na	na	na	na	10.65	685.56
13MWT32	10/29/2003	1308214.113	3023162.004	693.62	696.04	25.00	8.00	18.00	685.62	675.62	Psz	na	na	na	na	9.52	686.52
13MWT33	11/6/2003	1308749.271	3023868.766	700.14	701.97	20.00	10.00	20.00	690.14	680.14	Psz	na	na	na	na	10.63	691.34
13MWT34	11/11/2003	1309304.310	3023084.250	693.35	695.93	20.50	10.00	20.00	683.35	673.35	Psz	na	na	na	na	5.42	690.51
13MWT35	11/19/2003	1310254.914	3023773.290	679.51	681.73	69.00	57.00	67.00	622.51	612.51	Pdz	na	na	na	na	63.96	617.77
13MWT36	11/5/2003	1309053.391	3022677.863	664.91	667.21	26.00	15.00	25.00	649.91	639.91	Psz	na	na	na	na	19.26	647.95
13MWT37	10/24/2003	1309402.928	3022617.274	659.96	662.29	25.00	14.50	24.50	645.46	635.46	Psz	na	na	na	na	14.37	647.92
13MWT38	11/4/2003	1309376.761	3022619.525	659.03	661.04	80.00	55.00	65.00	604.03	594.03	Pdz	na	na	na	na	61.90	599.14
13MWT39	11/4/2003	1309804.482	3022589.032	652.42	654.44	25.00	14.00	24.00	638.42	628.42	Psz	na	na	na	na	14.25	640.19
13MWT40	10/23/2003	1309622.333	3022833.330	664.93	667.18	25.50	15.00	25.00	649.93	639.93	Psz	na	na	na	na	18.55	648.63
13MWT41	11/10/2003	1309645.205	3022818.998	663.65	665.67	66.00	55.00	65.00	608.65	598.65	Pdz	na	na	na	na	66.58	599.09
13MWT42	10/22/2003	1309862.275	3023113.220	668.05	670.31	25.00	11.00	21.00	657.05	647.05	Psz	na	na	na	na	21.14	649.17
13MWT43	11/6/2003	1310558.559	3023939.448	688.88	690.90	21.00	10.00	20.00	678.88	668.88	Psz	na	na	na	na	8.50	682.40
13MWT44	11/10/2003	1310621.143	3023530.333	682.11	683.82	88.00	73.00	83.00	609.11	599.11	Pdz	na	na	na	na	64.57	619.25
13MWT45	11/10/2003	1309373.683	3022901.377	688.76	690.59	84.00	70.00	80.00	618.76	608.76	Pdz	na	na	na	na	72.75	617.84
13MWT46	11/22/2003	1309812.022	3022565.944	651.64	653.61	68.00	55.00	65.00	596.64	586.64	Pdz	na	na	na	na	58.10	595.51
13MWT47	11/20/2003	1309389.470	3024437.454	675.41	677.23	21.00	8.00	18.00	667.41	657.41	Psz	na	na	na	na	7.32	669.91
STAFF GAUGES																	
13SG01[2]	3/29/2003	1310836.894	3024771.436	698.35	na	na	na	na	na	na	na	na	na	1.73	696.62	1.77	696.58
13SG02	3/29/2003	1310746.566	3024854.367	701.95	na	na	na	na	na	na	Psz	na	na	3.64	698.31	3.68	698.27
13SG03	3/29/2003	1309585.700	3024436.891	696.24	na	na	na	na	na	na	Psz	na	na	1.96	694.28	1.87	694.37
13SG04	3/29/2003	1309478.258	3024317.864	688.99	na	na	na	na	na	na	Psz	na	na	2.38	686.61	2.45	686.54
13SG05	3/29/2003	1309341.458	3024185.404	692.94	na	na	na	na	na	na	Psz	na	na	3.89	689.05	3.90	689.04

TABLE 1-1

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 13 - MINE FILL B
NSWC CRANE
CRANE, INDIANA

Well Number	Installation Date	Northing (feet)	Easting (feet)	Ground Elevation (feet amsl)	Top of Riser Elevation (feet amsl)	Total Depth (feet bgs)[1]	Screened Interval				Water-Bearing Zone	May 5, 2003		May 11, 2003		January 20, 2004	
							Top (feet bgs)	Bottom (feet bgs)	Top (feet amsl)	Bottom (feet amsl)		Depth to Water (feet btor)	Ground Water Elevation (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation (feet amsl)	Depth to Water (feet btor)	Ground Water Elevation (feet amsl)
13SG06[2]	3/29/2003	1308991.982	3023849.675	704.88	na	na	na	na	na	na	na	na	na	2.37	702.51	2.35	702.53
13SG07	3/29/2003	1308164.248	3022622.065	680.30	na	na	na	na	na	na	Psz	na	na	1.50	678.80	1.47	678.83
13SG08	3/29/2003	1308846.735	3022744.778	665.95	na	na	na	na	na	na	Psz	na	na	5.05	660.90	5.08	660.87
13SG09	3/29/2003	1309868.608	3023412.150	675.30	na	na	na	na	na	na	Psz	na	na	4.15	671.15	4.15	671.15
13SG10	3/29/2003	1310366.976	3023821.247	676.10	na	na	na	na	na	na	Psz	na	na	4.78	671.32	4.82	671.28
13SG11	1/19/2004	1309388.009	3024416.837	675.36	na	na	na	na	na	na	Psz	na	na	na	na	2.74	672.62

Notes:
1 = Total depth of boring, total depth of well may be less.
2 = Staff gauges contained perched water not hydraulically connected to the Pennsylvanian geologic unit.
bgs = Below ground surface.
btor = Below top of riser/reference point.
amsl = Above mean sea level (NAVD88).
na = Not applicable.
NAVD = North American Vertical Datum
Psz = Pennsylvanian shallow water-bearing zone
Pdz = Pennsylvanian deep water-bearing zone

TABLE 1-2

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Well Number	Installation Date	Northing (feet)	Easting (feet)	Ground Elevation (feet amsl)	Top of Riser Elevation (feet amsl)	Total Depth (feet bgs)[1]	Screened Interval				Water-Bearing Zone	May 5, 2003		May 30, 2003		January 24, 2004	
							Top (feet bgs)	Bottom (feet bgs)	Top (feet amsl)	Bottom (feet amsl)		Depth to Water (feet btor)	Ground Water Elevaton (feet amsl)	Dept to Water (feet btor)	Ground Water Elevaton (feet amsl)	Dept to Water (feet btor)	Ground Water Elevaton (feet amsl)
16MWT01	4/8/2003	1321193.488	3032881.285	762.02	764.50	24.00	14.00	24.00	748.02	738.02	Psz	25.19	739.31	22.7	741.80	19.12	745.38
16MWT02	4/11/2003	1321146.42	3032559.16	757.60	760.36	18.00	8.00	18.00	749.60	739.60	Psz	6.55	753.81	12.18	748.18	10.94	749.42
16MWT03	4/10/2003	1320946.968	3032644.291	761.95	764.41	35.00	25.00	35.00	736.95	726.95	Piz	27.20	737.21	28.07	736.34	28.34	736.07
16MWT04	4/9/2003	1321003.281	3032946.466	763.88	766.14	25.00	15.00	25.00	748.88	738.88	Psz	8.05	758.09	13.14	753.00	13.11	753.03
16MWT05	4/9/2003	1320741.793	3032812.772	764.50	766.88	40.00	29.00	39.00	735.50	725.50	Piz	29.77	737.11	30.39	736.49	31.44	735.44
16MWT06	4/24/2003	1321199.519	3032883.373	761.77	764.44	25.00	15.00	25.00	746.77	736.77	Psz	22.33	742.11	15.92	748.52	17.41	747.03
16MWT07	11/11/2003	1321176.931	3033001.574	760.54	762.87	25.50	15.00	25.00	745.54	735.54	Psz	na	na	na	na	dry	dry
16MWT08	11/9/2003	1321179.449	3033009.24	759.57	761.56	99.00	85.00	95.00	674.57	664.57	Pdz	na	na	na	na	97.03	664.53
16MWT09	11/8/2003	1321068.489	3033041.444	762.43	764.28	25.00	15.00	25.00	747.43	737.43	Psz	na	na	na	na	13.88	750.40
16MWT10	11/9/2003	1320936.048	3033074.741	761.93	764.43	25.00	14.00	24.00	747.93	737.93	Psz	na	na	na	na	22.05	742.38
16MWT11	11/11/2003	1320934.642	3033062.786	763.23	765.24	98.00	86.00	96.00	677.23	667.23	Pdz	na	na	na	na	96.3	668.94
16MWT12	11/7/2003	1320729.139	3033074.921	753.23	755.45	26.50	16.00	26.00	737.23	727.23	Piz	na	na	na	na	20.13	735.32
16MWT13	11/11/2003	1321125.775	3032562.405	757.62	759.57	19.00	8.00	18.00	749.62	739.62	Psz	na	na	na	na	10.25	749.32
16MWT14	11/7/2003	na	na	764.98	Abn	25.00	15.00	25.00	749.98	739.98	Psz	na	na	na	na	na	dry
16MWT15	11/9/2003	1321120.81	3032563.53	757.73	759.69	92.00	81.00	91.00	676.73	666.73	Pdz	na	na	na	na	53.23	706.46
16MWT16	11/9/2003	1321059.41	3032814.52	764.98	764.74	40.00	26.00	36.00	738.98	728.98	Piz	na	na	na	na	32.93	731.81
16MWT17	11/8/2003	1321235.88	3032675.07	764.79	766.53	24.00	14.00	24.00	750.79	740.79	Psz	na	na	na	na	15.35	751.18
16MWT18	1/18/2004	1321068.96	3032807.84	764.99	764.44	105.00	94.00	104.00	670.99	660.99	Pdz	na	na	na	na	96.65	667.79
WES-14-01-83	1983	1320638.353	3032713.383	763.87	766.67	50.70	35.80	45.30	728.07	718.57	Piz	31.00	735.67	31.00	735.67	31.94	734.73
WES-14-02-83	1983	1321319.899	3032647.27	763.69	766.54	25.80	11.35	20.39	752.34	743.30	Psz	14.23	752.31	14.56	751.98	15.36	751.18
WES-14-03-83	1983	1320816.004	3033018.495	761.51	763.93	35.40	20.88	29.99	740.63	731.52	Psz	18.80	745.13	19.83	744.10	20	743.93
WES-14-04-83	1983	1320572.345	3032960.959	760.42	762.99	46.00	31.38	40.47	729.04	719.95	Piz	26.80	736.19	27.27	735.72	28.39	734.60
WES-14-05-83	1983	1320584.051	3032850.321	766.60	769.40	50.70	35.80	45.25	730.80	721.35	Piz	32.59	736.81	33.05	736.35	34.18	735.22

Notes:
1 = Total depth of boring, total depth of well may be less.
bgs = Below ground surface.
btor = Below top of riser.
amsl = Above mean sea level (NAVD88).
Psz = Pennsylvanian shallow water-bearing zone
Piz = Pennsylvanian intermediate water-bearing zone
Pdz = Pennsylvanian deep water-bearing zone
na = not available
NAVD = North American Vertical Datum

TABLE 1-3

SLUG TEST HYDRAULIC CONDUCTIVITY RESULTS
SWMU 13 - MINE FILL B AREA
NSWC CRANE
CRANE, INDIANA

Water-Bearing Zone	Well Identification	Screened Interval Lithologic Type[3]	Falling Head Test (feet/day)	Rising Head Test (feet/day)	Average[1]	
					(feet/day)	(cm/sec)
Shallow	13MWT02	Sandstone	0.00388	0.00302	0.00345	1.2E-06
	13MWT08	Overburden/Siltstone	10.9	2.16	6.53	2.3E-03
	13MWT11	Overburden/Siltstone	0.389	0.159	0.274	9.7E-05
	13MWT14	Mudstone/Sandstone	1.67	1.26	1.465	5.2E-04
	13MWT15	Siltstone	0.195	0.128	0.1615	5.7E-05
	13MWT17	Overburden/Siltstone	10.6	17.3	13.95	4.9E-03
	13MWT20	Mudstone	0.135	0.131	0.133	4.7E-05
	13MWT26	Overburden/Siltstone	0.0186	0.0132	0.0159	5.6E-06
	13MWT30	Siltstone	0.0873	0.0607	0.074	2.6E-05
	13MWT32	Sandstone	0.303	0.231	0.267	9.4E-05
	13MWT33	Mudstone	na	0.0147	0.0147	5.2E-06
	13MWT34	Siltstone	0.199	0.163	0.181	6.4E-05
	13MWT37	Sandstone	1.37	1.03	1.2	4.2E-04
	13MWT42	Sandstone	na	0.0794	0.0794	2.8E-05
	13MWT47	Sandstone	0.375	0.349[2]	0.362	1.3E-04
				Geometric Mean =	**0.212**	**7.5E-05**
Deep	13MWT35	Mudstone/Sandstone	na	0.000895	0.000895	3.2E-07
	13MWT38	Sandstone	na	0.00678	0.00678	2.4E-06
	13MWT45	Siltstone	na	0.000137	0.000137	4.8E-08
	13MWT46	Sandstone	6.12	9.4	7.76	2.7E-03
				Geometric Mean =	**0.00896**	**3.2E-06**

1 Average of rising and falling head tests.
2 Two rising head tests were averaged for this value.
3 The overburden primarily consists of decomposed bedrock (clay, silt, and sand).
na - Not available.

TABLE 1-4

SLUG TEST HYDRAULIC CONDUCTIVITY RESULTS
SWMU 16 - CAST HIGH EXPLOSSIVES FILL/B146 INCINERATOR AREA
NSWC CRANE
CRANE, INDIANA

Water-Bearing Zone	Well Identification	Screen Interval Lithologic Type	Falling Head Test (feet/day)	Rising Head Test (feet/day)	Average[1] (feet/day)	Average[1] (cm/sec)
Shallow	16MWT02	Sandstone	5.090	3.370	4.230	1.49E-03
	16MWT04	Sandstone/Mudstone	1.090	1.050	1.070	3.77E-04
	16MWT09	Mudstone	0.267	0.413	0.340	1.20E-04
	16MWT10	Sandstone/Siltstone	na	26.7[2]	26.700	9.42E-03
	16MWT17	Sandstone/Mudstone	0.501	0.509	0.505	1.78E-04
				Geometric Mean =	**1.83**	**5.9E-04**
Intermediate	16MWT05	Mudstone	0.638	0.584	0.611	2.16E-04
				Geometric Mean =	**0.611**	**2.16E-04**
Deep	16MWT15	Siltstone	0.004	na	0.004	1.4E-06
				Geometric Mean =	**0.004**	**1.4E-06**

1 Average of rising and falling head tests.
2 Two rising head tests were averaged for this value.
na - Not available.

TABLE 1-5

SUMMARY OF PREVIOUS INVESTIGATIONS
SWMU 13 – MINE FILL B AND
SWMU 16 – CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

SWMU/Investigation	Summary/Conclusions
SWMU 13	
Mine Fill B NAVFAC, undated	• Boiler system in Buildings 166 and 171, which used PCB oils, released PCBs into nearby soil. Remedial action was taken but PCBs remain greater than 10 ppm.
Mine Fill B 1972 Soil Sample Study	• Soil samples collected from drainage ditches near Mine Fill B and a stream water sample near well W036 exhibited TNT and RDX contamination. • Soil samples from ditches near Building 172 in 1970 showed high explosives contamination. Contaminated soil was removed; however, subsequent sampling indicated that explosives contamination still existed.
RCRA Facility Investigation Phase II Release Assessment Work Plan (Never Implemented) 1992	**Soil** • Box Houses (Buildings 2174, 2175, 2176, and 2177): Samples were proposed to be analyzed for metals and explosives. • Shaker Houses (Buildings 167, 168, 172, and 173): Samples were proposed to be analyzed for explosives and metals. • Melt House and Shaker House Conveyor Lines: Samples were proposed to be analyzed for metals and explosives. • Paint Lockers (Building 193, 194, and 195): Samples were proposed to be analyzed for VOCs, metals, and PCBs. • Metals Buildings (Buildings 2502 and 2503): Samples were proposed to be analyzed for explosives and metals. • Former Thermanal Boilers: Samples were proposed to be analyzed for PCBs. • Valve Box near Building 2790: Samples were proposed to be analyzed for VOCs, metals, and PCBs. • Melt Houses (Buildings 166 and 171): Samples were proposed to be analyzed for explosives and metals. • Casing Preparation Building (Building 169) Dust Dropout: Samples were proposed to be analyzed for VOCs, metals, PCBs, and explosives. • Bag House Filter Drop Out: Samples were proposed to be analyzed for metals and explosives. • Building 169 Utility Pads: Samples were proposed to be analyzed for metals, PCBs, and explosives. • Nitrate Preparation Building: Samples were proposed to be analyzed for explosives and metals. • Former Compressor Location between Buildings 2790 and 2171: Samples were proposed to be analyzed for metals and PCBs. • Hazardous Waste Storage Lockers. Building 174, Cart Shelter/Washout, drainageways, and Settling Basins Overflow/Discharge: Samples were proposed to be analyzed for explosives and metals.

TABLE 1-5

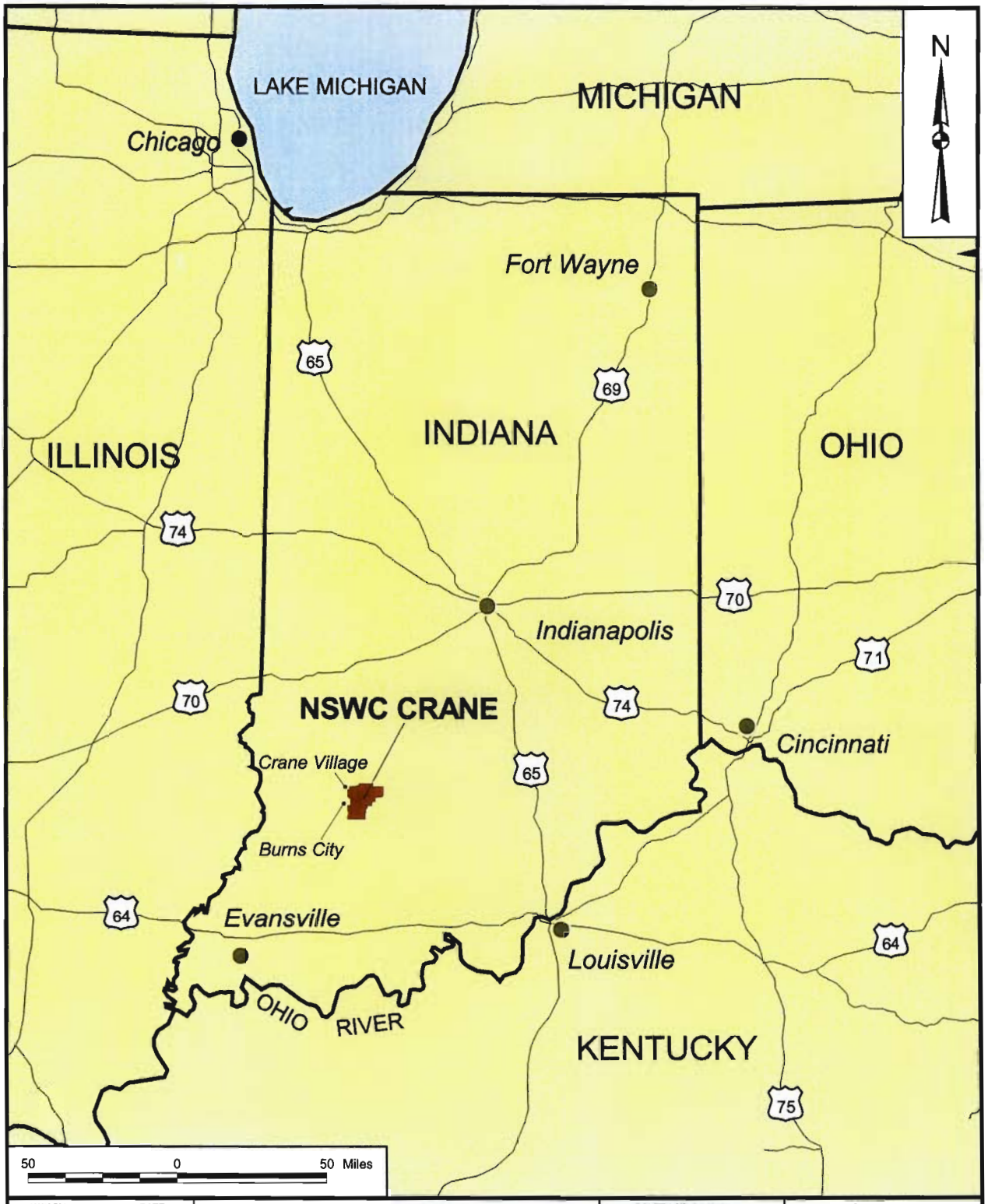
SUMMARY OF PREVIOUS INVESTIGATIONS
SWMU 13 – MINE FILL B AND
SWMU 16 – CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

SWMU/Investigation	Summary/Conclusions
RCRA Facility Investigation Phase II Release Assessment Work Plan (Never Implemented) 1992 (Continued)	**Surface Water** • Drainageways and Settling Basin Overflow/Discharge at exit of SWMU or confluence prior to exit: Samples were proposed to be analyzed for explosives and metals. **Ground Water** Install three ground water monitoring wells: Samples were proposed to be analyzed for SVOCs, metals, and explosives.
SWMU 16	
Building 146 Discharge Sampling	• 1972 discharge water samples contained detectable levels of HMX and RDX. • 1979 discharge water samples did not contain HMX.
1980 U.S. Army Water Quality Engineering Special Study	• Sediment samples collected at Building 146 drainageways contained TNT, RDX, and HMX.
Building 146 Rotary Furnace Emissions Testing (1980 and 1981)	• Results showed that the furnace could not comply with Indiana emission standards without a baghouse on line.
1982 Rotary Kiln Ash Pile Sampling	• Ash from the rotary kiln furnaces was determined to be a RCRA toxicity characteristic hazardous waste.
1982 and 1985 Building 146 Surface Soil/Sediment Sampling	• The 1982 samples from the southern surface water drainage ditch exceeded the EP Toxicity action levels for cadmium and lead and contained trace levels of explosives. • One 1985 sample exceeded the EP Toxicity action level for lead. • None of the 1985 samples contained detectable levels of explosives.
October to December 1989 Surface Soil Sampling at Building 146 Incinerator Bay	• Incinerator bay and background soil samples results showed detectable concentrations of arsenic, barium, cadmium, chromium, lead, selenium, and silver. • Arsenic, cadmium, chromium, selenium, and silver exceeded background concentrations. • Detectable levels of PCBs were not detected at Building 146.
Building 146 Monitoring Well Data	• Four wells (WES-14-1-83 through WES-14-4-83) were installed near Building 146 in July 1963. • Soils around Building 146 appeared to contain elevated levels of lead and zinc. • Lead and zinc detected in two wells were an order of magnitude greater than concentrations in the other two wells.

TABLE 1-5

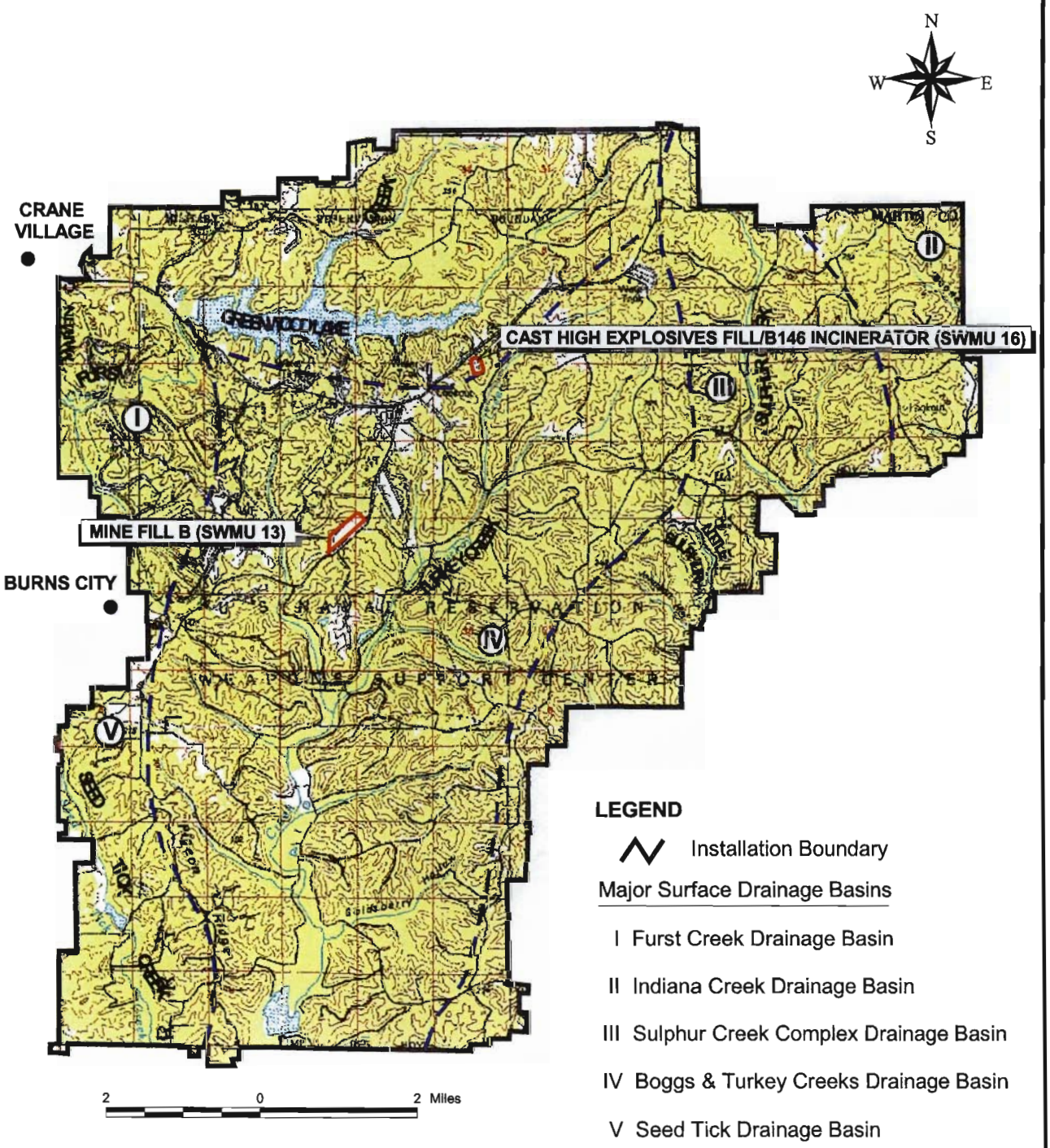
SUMMARY OF PREVIOUS INVESTIGATIONS
SWMU 13 – MINE FILL B AND
SWMU 16 – CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

SWMU/Investigation	Summary/Conclusions
RCRA Facility Investigation Phase II Release Assessment Work Plan (Never Implemented)	**Soil** • Collection of surface grab samples from within drainageways east and southwest of Building 146 were collected and were proposed to be analyzed for SVOCs, metals, explosives, and PCBs. • Above-ground fuel storage tanks: Samples were proposed to be analyzed for SVOCs, metals, explosives, and PCBs. • Within limits of former Incinerator Ash Pile samples were proposed to be analyzed for SVOCs, metals and explosives. **Surface Water** • Settling Basins northeast and northwest of Building 146: Samples were proposed to be analyzed for explosives, metals, VOCs, SVOCs, and chloride. **Sediment** • Samples at surface water sampling locations were proposed to be analyzed for explosives, metals, VOCs, and SVOCs. **Ground Water** • Five existing wells were proposed for sampling and analysis for explosives, VOCs, SVOCs, metals, and chloride.
Interim Measures Cleanup 1995	• Clean-up activities included removing, sampling, and disposing sludge from sumps and ash/slag piles; confirmation sampling of remaining soils; cleaning two sumps; and backfilling and restoring excavated areas. • Soil excavations during installation of new piping indicated low levels of PCBs.
Voluntary Interim Measures Report 1999	• TCE was getting into sumps. Interim measures were conducted from 1996 to 1998 to clean up TCE from water prior to discharge. Soil sampling was conducted near the sumps and revealed no detections of TCE. Roof drains were disconnected from the sumps and re-routed, and existing floor drains in Building 146 were abandoned. New piping was installed in 1997 connecting the eastern and western sumps to the sanitary sewer system.



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NO.
J. LAMEY	3/9/00		9060	CTO 279
CHECKED BY	DATE	GENERAL LOCATION MAP NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA	APPROVED BY	DATE
T. JOHNSTON	9/27/02		T. JOHNSTON	9/27/02
COST/SCHEDULE-AREA			APPROVED BY	DATE
			—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 1-1	1

P:\GIS\NSWC_CRANE\0087.APR GENERAL LOCATION MAP 7/22/03 AJ



LEGEND

Installation Boundary

Major Surface Drainage Basins

I Furst Creek Drainage Basin

II Indiana Creek Drainage Basin

III Sulphur Creek Complex Drainage Basin

IV Boggs & Turkey Creeks Drainage Basin

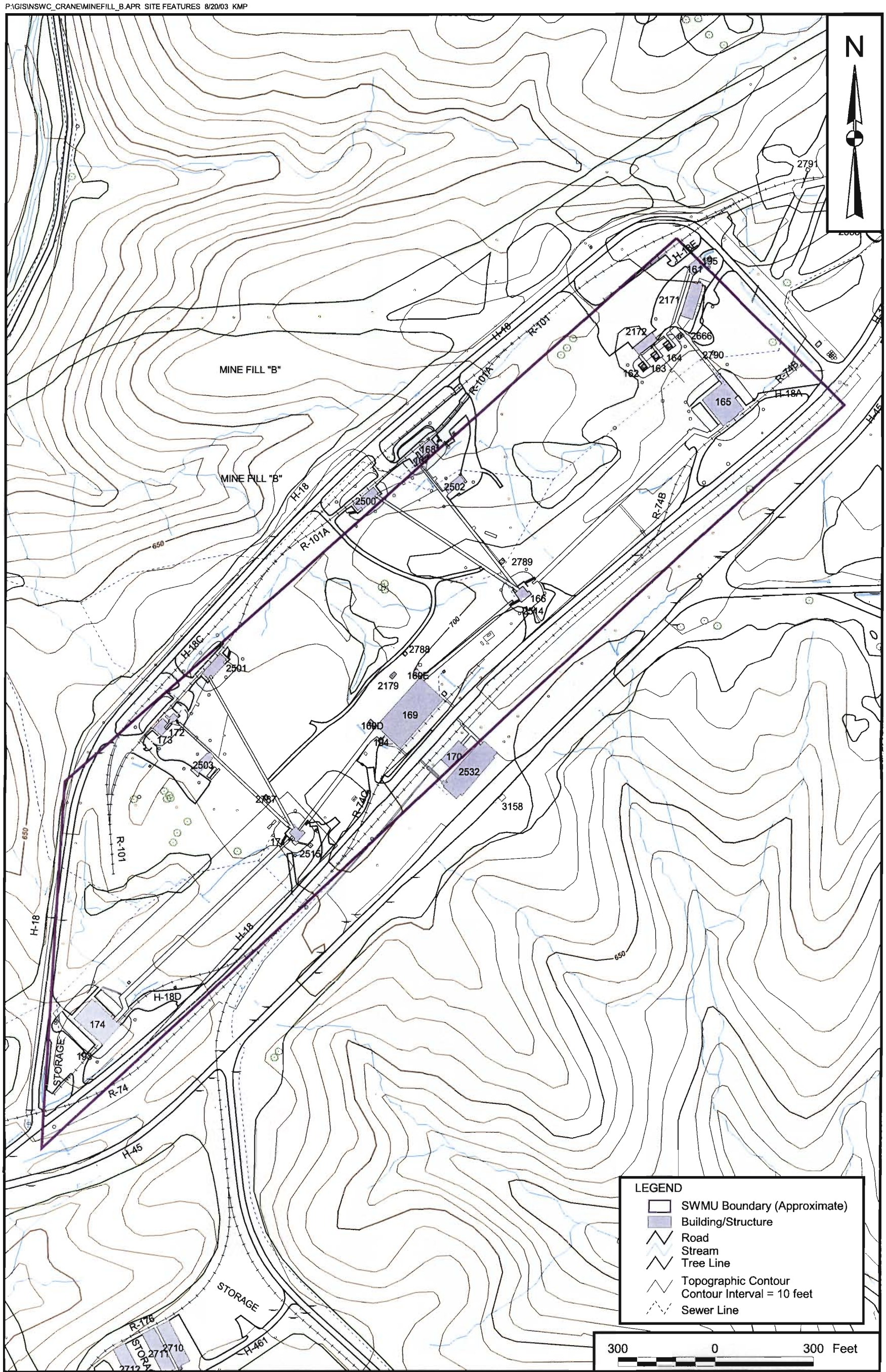
V Seed Tick Drainage Basin

SOURCE: "Initial Assessment of Study of Naval Weapons Support Center Crane, Indiana." Naval Energy and Environmental Support Activity, May 1983.

DRAWN BY J. LAMEY — DATE 8/27/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER 9060	OWNER NO. CTO 279
CHECKED BY B. BALKOVEC — DATE 7/22/03	SWMU LOCATIONS AND DRAINAGE BASINS SWMUs 13 AND 16 NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — DATE —	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1-2	REV 0

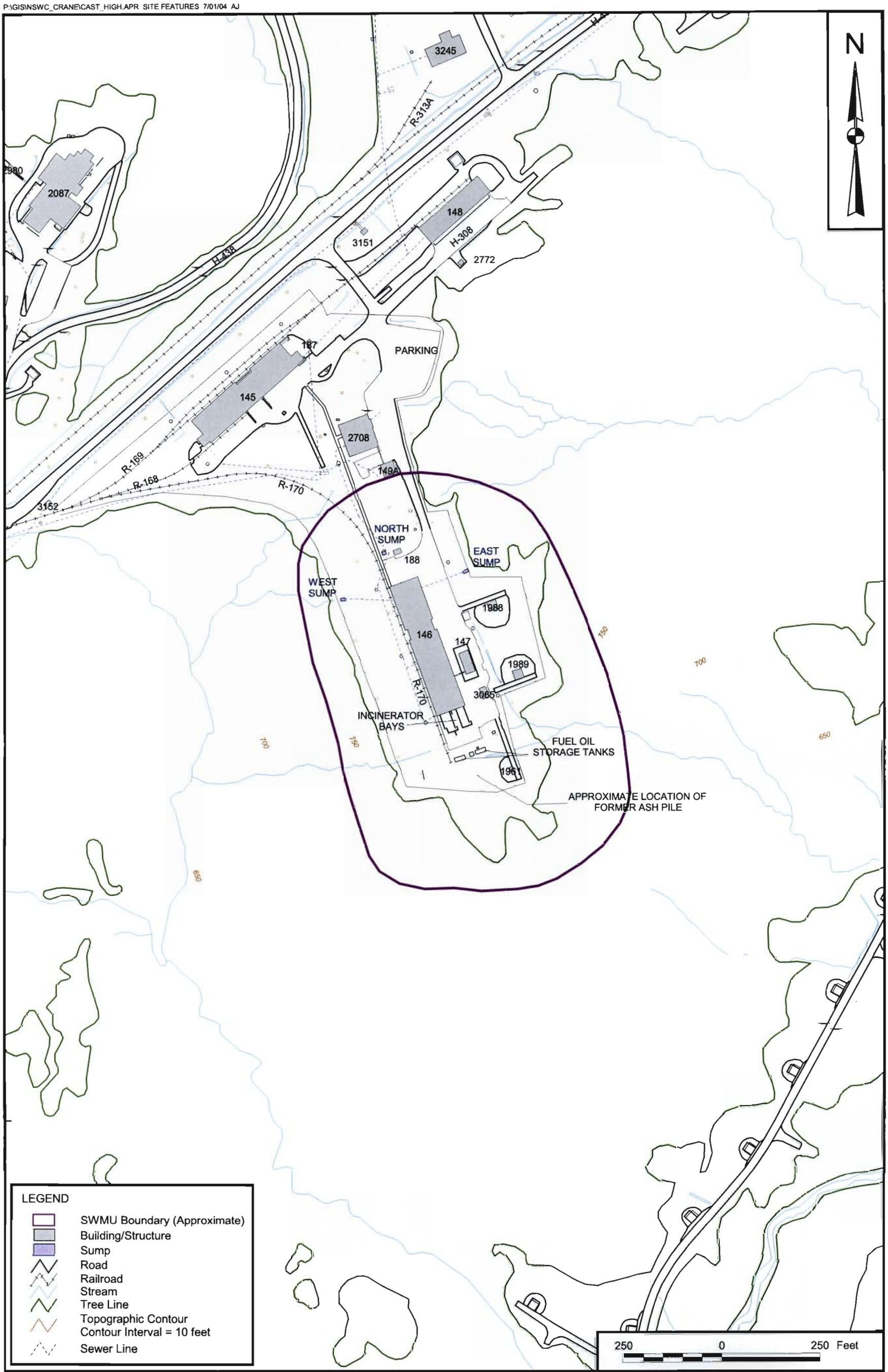
P:\GIS\NSWC_CRANE\MINEFILL_A.APR DRAINAGE BASINS 8/22/03 KMP

P:\GIS\NSWC_CRANE\MINEFILL_B.APR SITE FEATURES 8/20/03 KMP



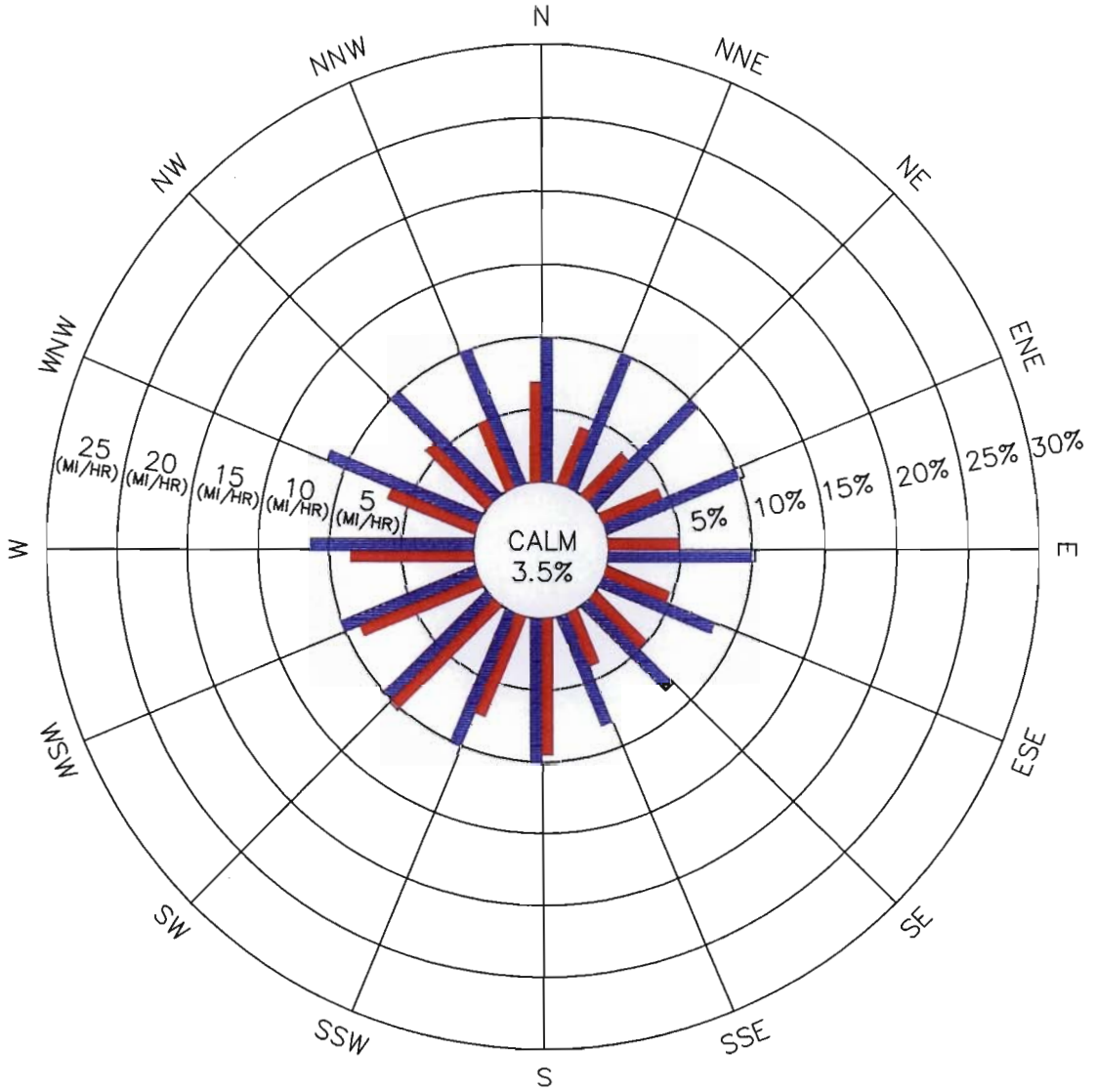
DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NUMBER
J. LAMEY	8/21/01		9060	CTO 279
CHECKED BY	DATE	SITE FEATURES MINE FILL B (SWMU 13) NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY	DATE
B. BALKOVEC	7/22/03		—	—
COST/SCHEDULE-AREA			APPROVED BY	DATE
			—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 1 - 3	0

P:\GIS\NSWC_CRANE\CAST_HIGH.APR SITE FEATURES 7/01/04 AJ



DRAWN BY	DATE	Tetra Tech NUS, Inc.	CONTRACT NUMBER	OWNER NUMBER
J. LAMEY	8/22/01		9060	CTO 279
CHECKED BY	DATE	SITE FEATURES	APPROVED BY	DATE
J. GOERDT	7/01/04	CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR (SWMU 16)	—	—
COST/SCHEDULE-AREA		NAVAL SURFACE WARFARE CENTER	APPROVED BY	DATE
		CRANE, INDIANA	—	—
SCALE			DRAWING NO.	REV
AS NOTED			FIGURE 1 - 4	0

ACAD: 9060KM02.dwg 08/21/03 DM PIT



LEGEND:

WIND DIRECTION FREQUENCY (PERCENT)
(DIRECTION FROM WHICH THE WIND IS BLOWING)

MEAN WIND SPEED (MI/HR)

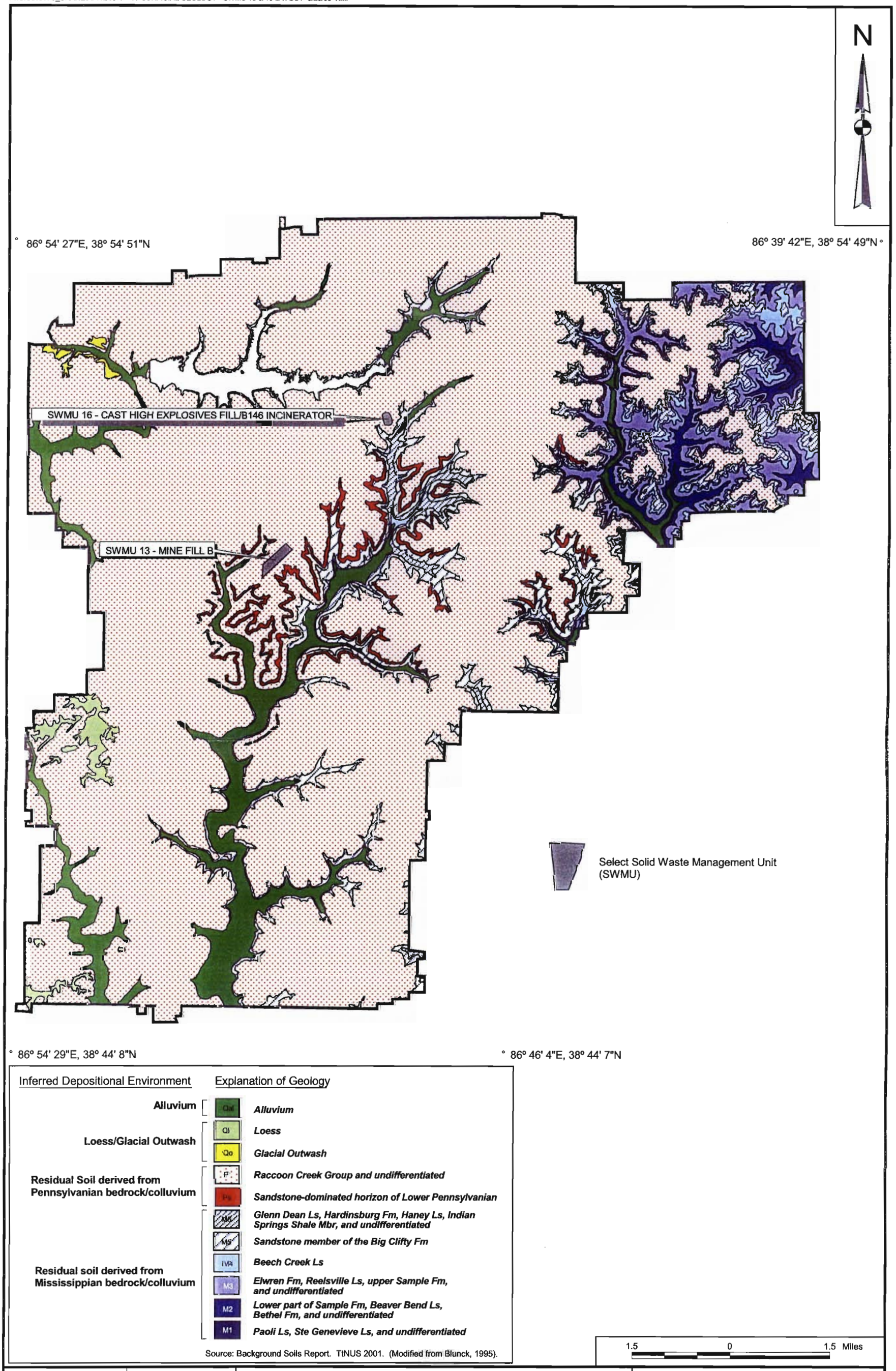
DATA SOURCE: INDIANAPOLIS, INDIANA AIRPORT

PERIOD OF RECORD: 1985–1989
43,824 OBSERVATIONS

DRAWN BY DM DATE 8/21/03	DEPARTMENT OF THE NAVY SOUTHERN DIV FACILITIES ENGINEERING COMD	FIVE-YEAR WIND ROSE SUMMARY FOR INDIANAPOLIS, INDIANA NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	CONTRACT NO. 9060
CHECKED BY DATE			APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-5 / REV. 1

FORM CADD NO. SDIV_AV.DWG - REV 0 - 1/20/98

P:\GIS\NSWC_CRANE\APR\0087.APR SURFICIAL GEOLOGY - SWMU 13 & 16 LAYOUT 8/20/03 KMP



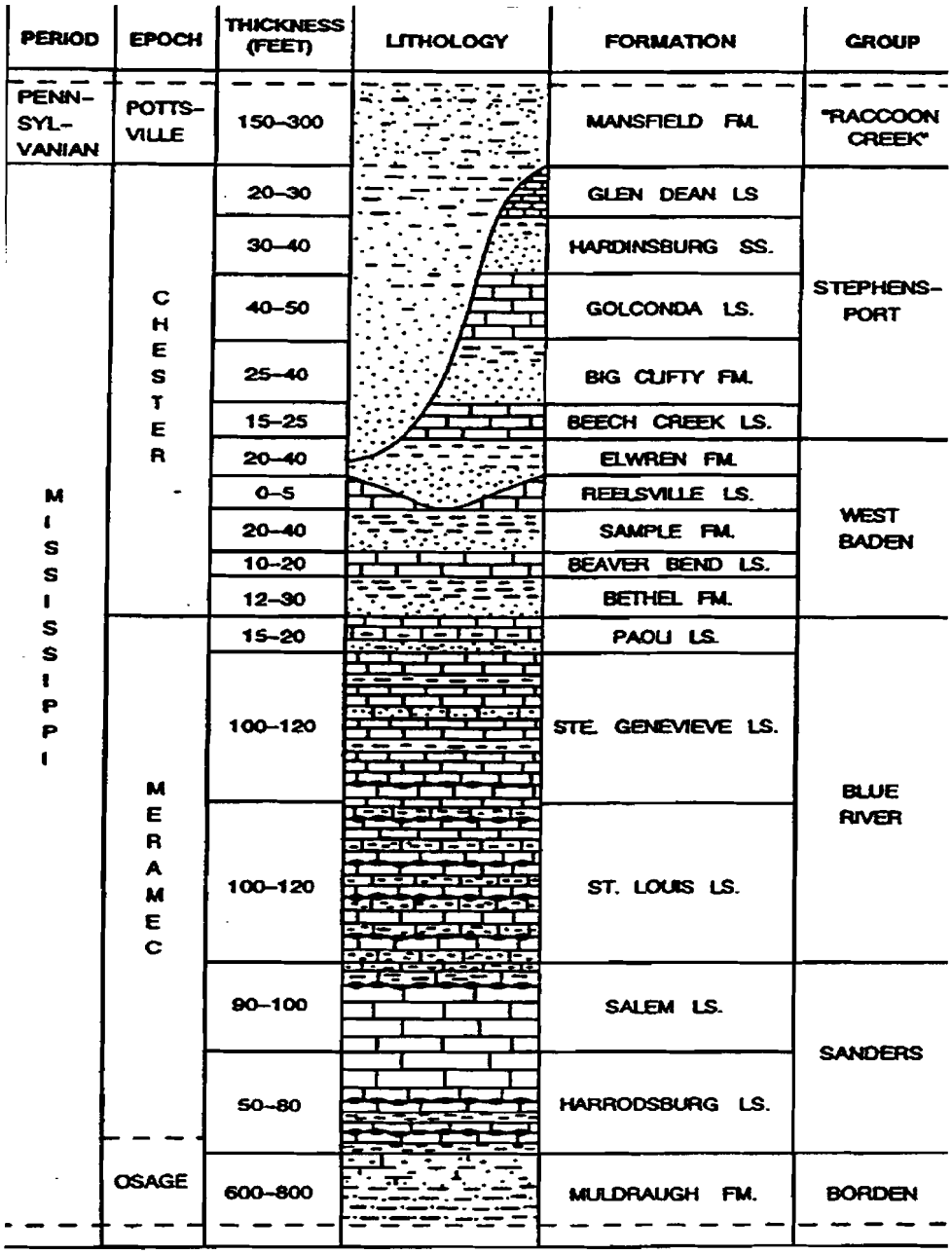
DRAWN BY	DATE
A. JANOCHA	7/09/03
CHECKED BY	DATE
B. BALKOVEC	7/09/03
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

SURFICIAL GEOLOGY AND DEPOSITIONAL ENVIRONMENTS

NSWC CRANE

CRANE, INDIANA

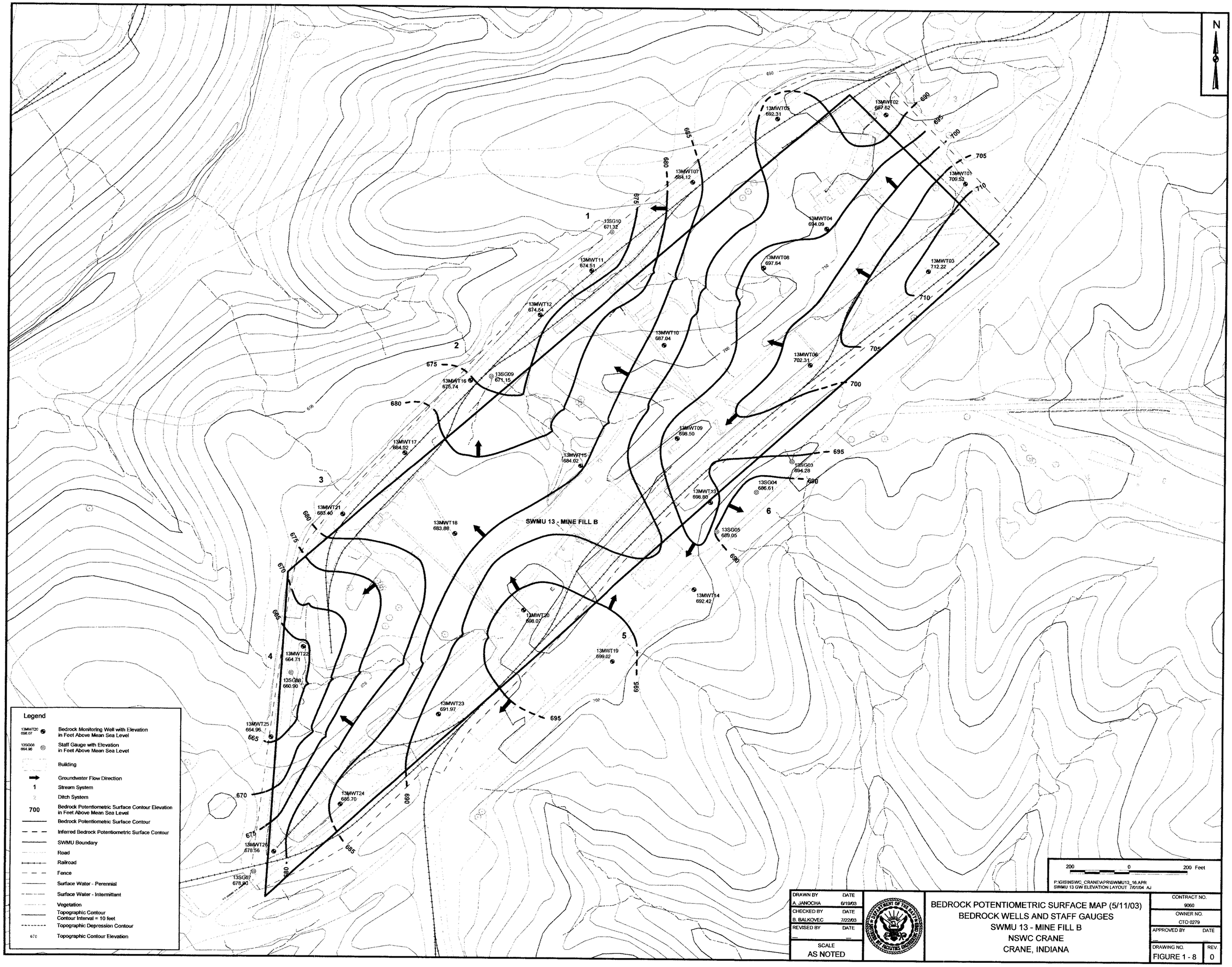
CONTRACT NUMBER	
9060	
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 1 - 6	0



Source: Draft Report, RCRA Facility Investigation
Phase II Groundwater Release Assessment, SWMU 06/09
Demolition Area and Phase III Release
Characterization SWMU 07/09 Old Rifle Range
November 1995 - Figure 13
by William L. Murphy and Roy Wade

DRAWN BY J. LAMEY DATE 8/28/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER 9060	OWNER NO. CTO 0279
CHECKED BY J. GOERDT DATE 7/01/04	STRATIGRAPHIC COLUMN FOR ROCK UNITS ENCOUNTERED AT THE NAVAL SURFACE WARFARE CENTER NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY — DATE —	
COST/SCHEDULE-AREA		APPROVED BY — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1 - 7	REV 0

P:\GIS\NSWC_CRANE\MINEFILL_A.APR STRATIGRAPHIC COLUMN 7/01/04 AJ


N
SWMU 13 - MINE FILL B
13MWT02 687.62
13MWT03 712.22
13MWT04 694.09
13MWT05 692.31
13MWT06 702.31
13MWT07 684.12
13MWT08 697.64
13MWT09 698.50
13MWT10 687.04
13MWT11 674.51
13MWT12 674.54
13MWT13 698.80
13MWT14 692.42
13MWT15 684.02
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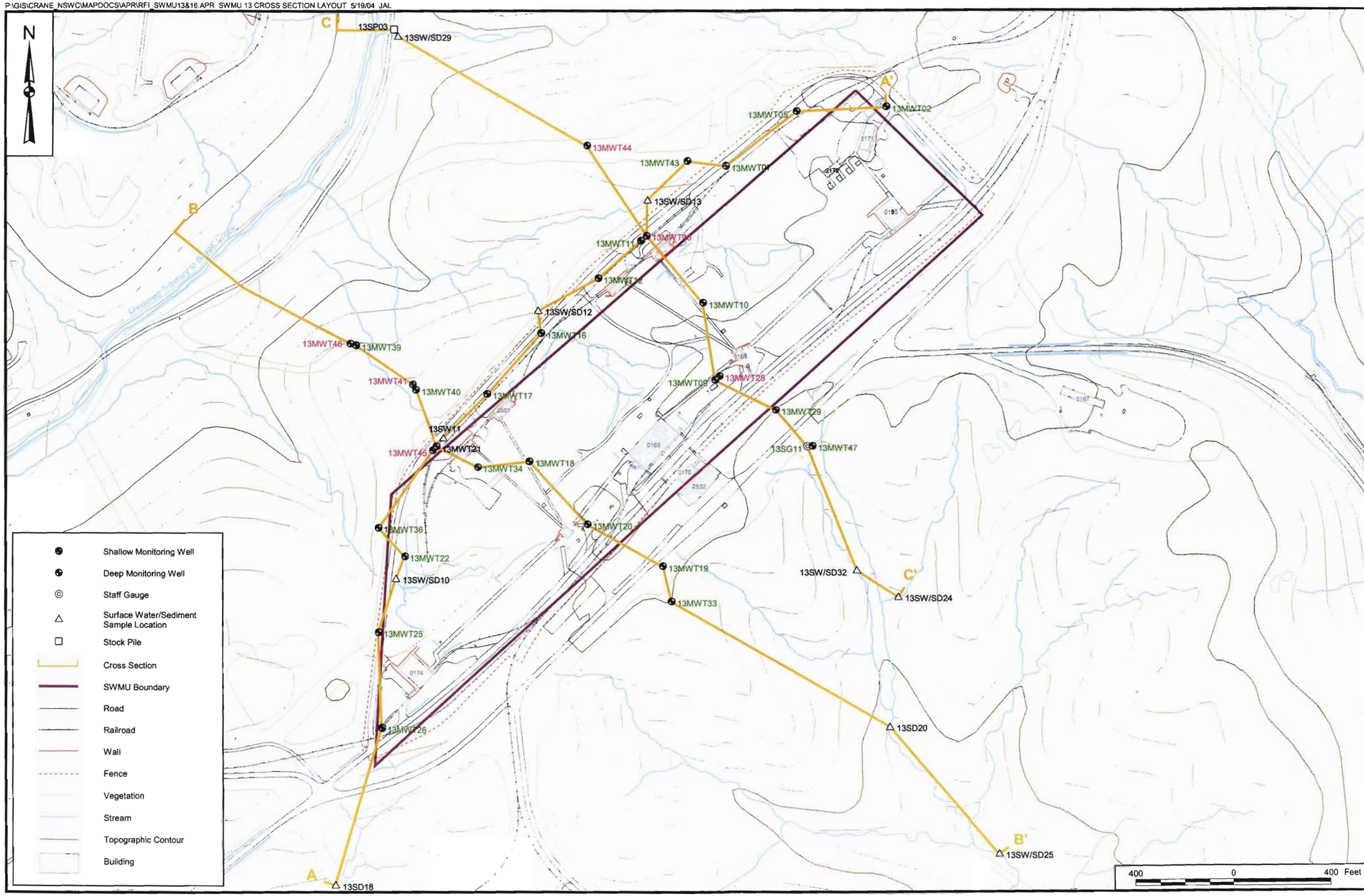
13MWT20 698.07
13MWT21 683.40
13MWT22 664.71
13MWT23 691.97
13MWT24 685.70
13MWT25 664.96
13MWT26 678.56
13SG03 694.29
13SG04 686.61
13SG05 689.05
13SG07 678.90
13SG08 660.90
13SG09 671.15
13SG10 671.32
1
2
3
4
5
6
Legend
13MWT20 698.07 Bedrock Monitoring Well with Elevation in Feet Above Mean Sea Level
13SG08 664.96 Staff Gauge with Elevation in Feet Above Mean Sea Level
Building
Groundwater Flow Direction
1 Stream System
Ditch System
700 Bedrock Potentiometric Surface Contour Elevation in Feet Above Mean Sea Level
Bedrock Potentiometric Surface Contour
Inferred Bedrock Potentiometric Surface Contour
SWMU Boundary
Road
Railroad
Fence
Surface Water - Perennial
Surface Water - Intermittant
Vegetation
Topographic Contour Contour Interval = 10 feet
Topographic Depression Contour
670 Topographic Contour Elevation
200 0 200 Feet
P:\GIS\NSWC, CRANE\APR\SWMU13_16.APR
SWMU 13 GW ELEVATION LAYOUT 7/01/04 AJ
DRAWN BY A. JANOCHA DATE 6/19/03
CHECKED BY B. BALKOVEC DATE 7/22/03
REVISED BY DATE
SCALE AS NOTED
BEDROCK POTENTIOMETRIC SURFACE MAP (5/11/03)
BEDROCK WELLS AND STAFF GAUGES
SWMU 13 - MINE FILL B
NSWC CRANE
CRANE, INDIANA
CONTRACT NO. 9060
OWNER NO. CTO 0279
APPROVED BY DATE
DRAWING NO. FIGURE 1 - 8
REV. 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\RFI_SWMU13&16.APR SWMU 13 CROSS SECTION LAYOUT 5/19/04 JAL



CONTRACT NO. CTO 0279

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 1 - 9

REV 0

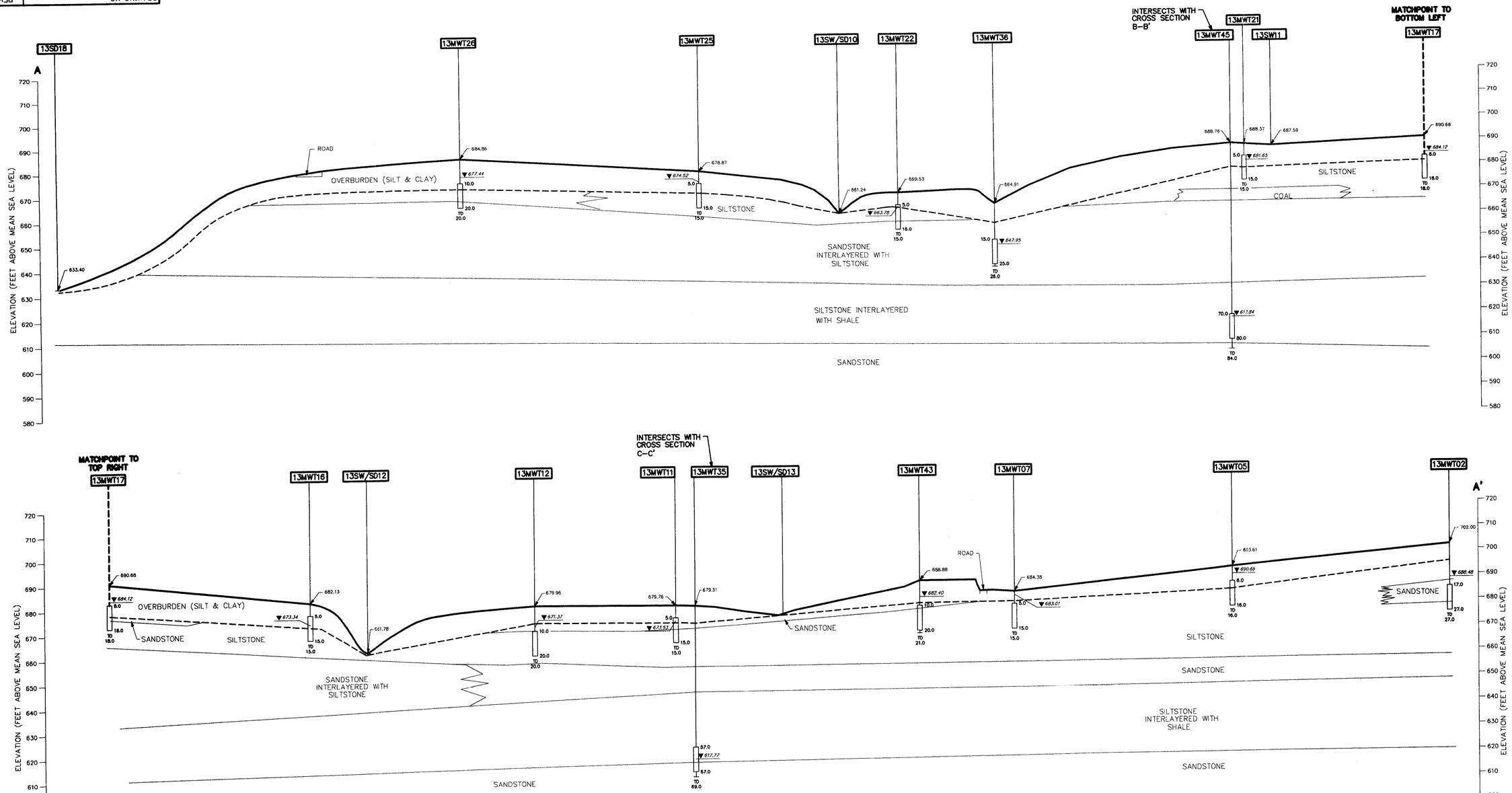
CROSS SECTION MAP
SWMU 13 - MINE FILL B
NSWC CRANE
CRANE, INDIANA

DRAWN BY A. JANOCHA DATE 3/10/04

CHECKED BY F. RAMSER DATE 3/17/04

COST/SCHED-AREA

SCALE AS NOTED



LEGEND:

MONITORING WELL OR BORING NUMBER — 13MWT25
GROUND SURFACE ELEVATION — 684.86
GROUND SURFACE
BEDROCK SURFACE
BEDROCK POTENTIOMETRIC SURFACE ELEVATION — 677.44
TOP OF MONITORED INTERVAL (FT BGS) — 10.0
LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS AND WHEN DASHED)
BOTTOM OF MONITORED INTERVAL (FT BGS) — 20.0
TOTAL DEPTH OF WELL OR BORING (FT BGS) — TD 20.0

0 80 160
HORIZONTAL SCALE IN FEET

0 20 40
VERTICAL SCALE IN FEET

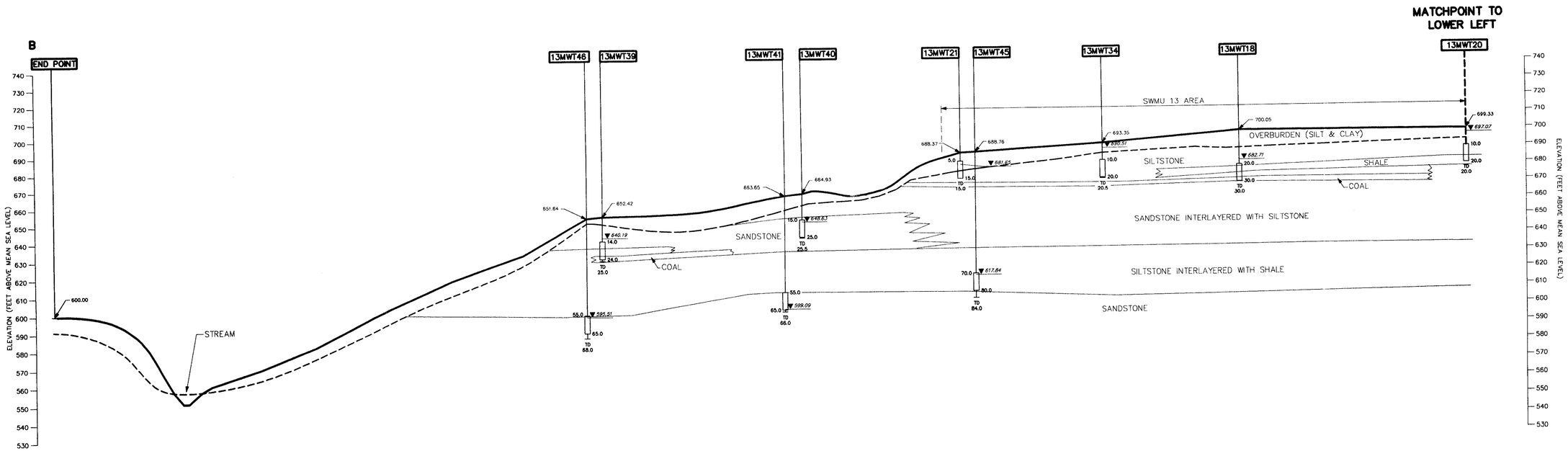
DRAWN BY HJB	DATE 2/17/04
CHECKED BY ----	DATE ----
REVISED BY ----	DATE ----
SCALE AS NOTED	

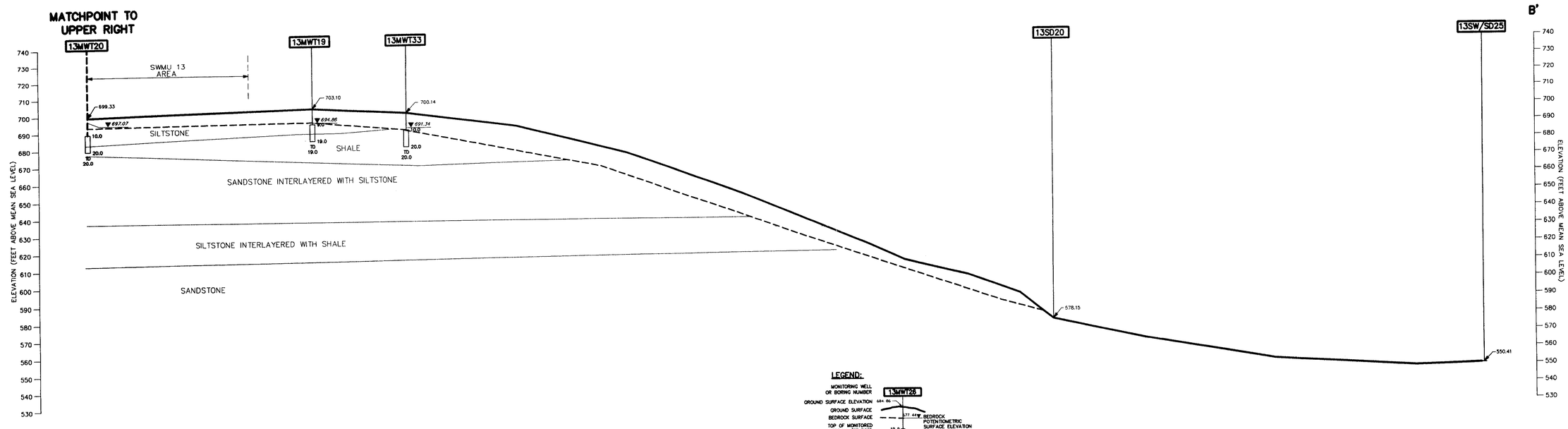
SWMU 13
GEOLOGICAL CROSS SECTION A–A'
NSWC CRANE
CRANE, INDIANA

CONTRACT NO. 9060
OWNER NO. ----
APPROVED BY DATE
DRAWING NO. FIGURE 1–10
REV. 0

ACAD:9060GX11.dwg 06/04/04 MF PIT

DRAWING NO. FIGURE 1–10 REV. 0





LEGEND:

- MONITORING WELL OR BORING NUMBER — 13MW128
- GROUND SURFACE ELEVATION — 684.86
- GROUND SURFACE
- BEDROCK SURFACE — 677.44 BEDROCK POTENTIOMETRIC SURFACE ELEVATION
- TOP OF MONITORED INTERVAL (FT BGS) — 10.0
- LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS AND WELL DASHED)
- BOTTOM OF MONITORED INTERVAL (FT BGS) — 20.0
- TOTAL DEPTH OF WELL OR BORING (FT BGS) — TD 20.0

0 80 160
HORIZONTAL SCALE IN FEET

0 30 60
VERTICAL SCALE IN FEET

DRAWN BY HJB	DATE 4/14/04	
CHECKED BY ----	DATE ----	
REVISED BY ----	DATE ----	
SCALE AS NOTED		

SWMU 13
GEOLOGICAL CROSS SECTION B–B'
NSWC CRANE
CRANE, INDIANA

CONTRACT NO.	9060
OWNER NO.	----
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DRAWING NO. FIGURE 1–11	REV. 0

ACAD: 9060GX12.dwg 06/04/04 MF PIT

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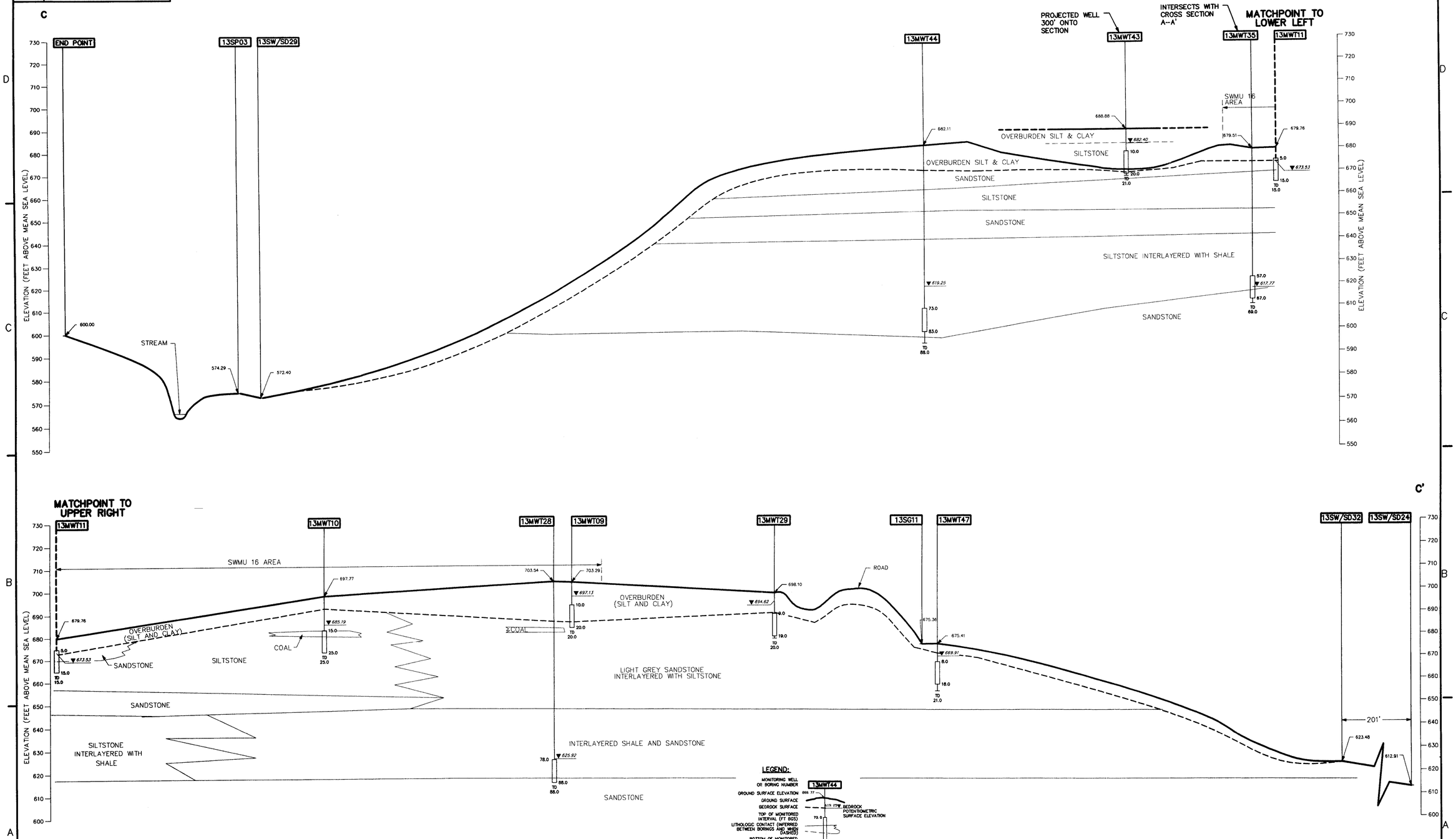

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REVISED BY ———	DATE ———		APPROVED BY / DATE
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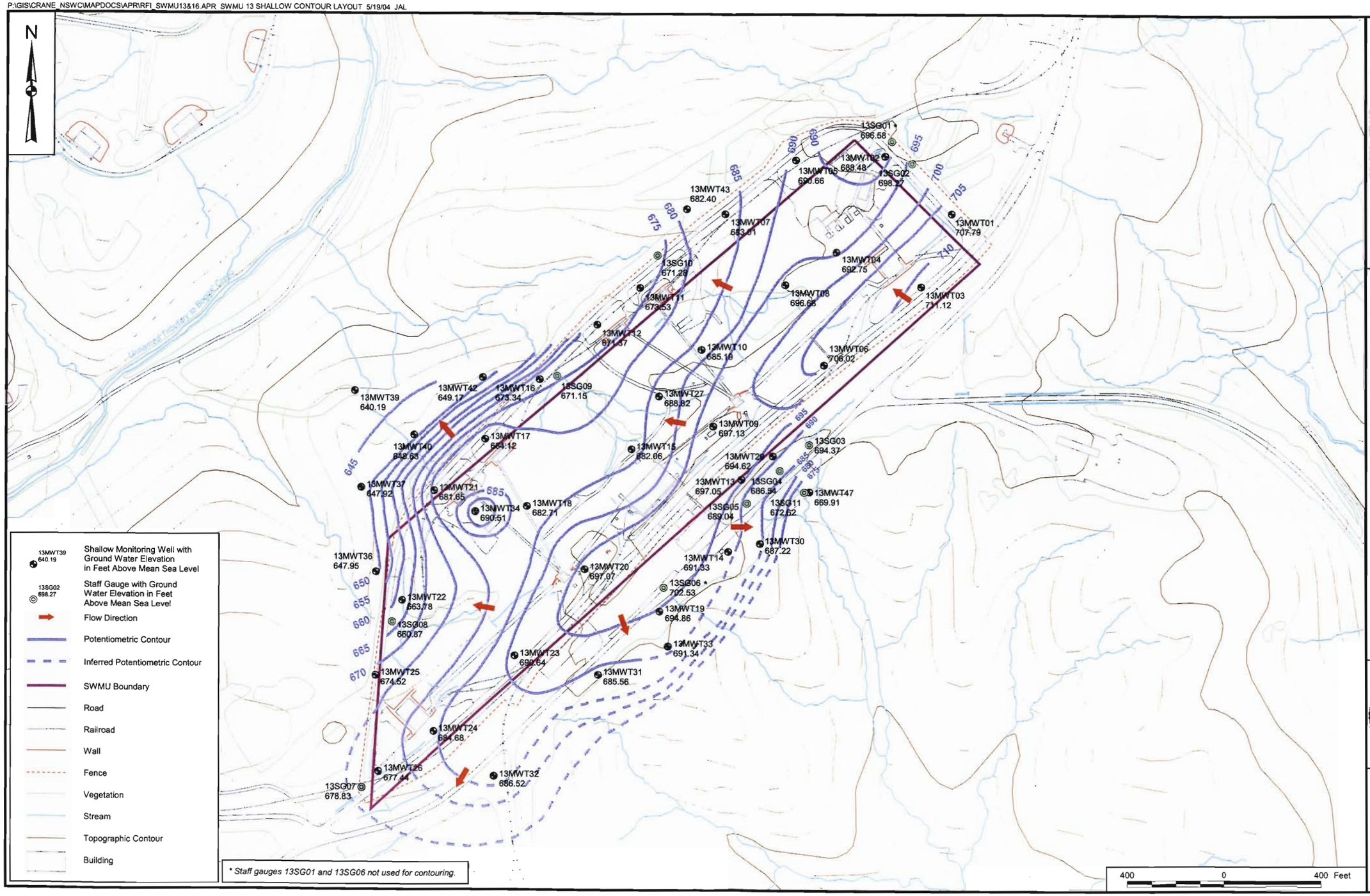

CONTRACT NO. CTO 0279

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

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REV 0

POTENTIOMETRIC SURFACE ELEVATION MAP
FOR SHALLOW WELLS - JANUARY 19 AND 20, 2004
SWMU 13 - MINE FILL B
NSWC CRANE
CRANE, INDIANA

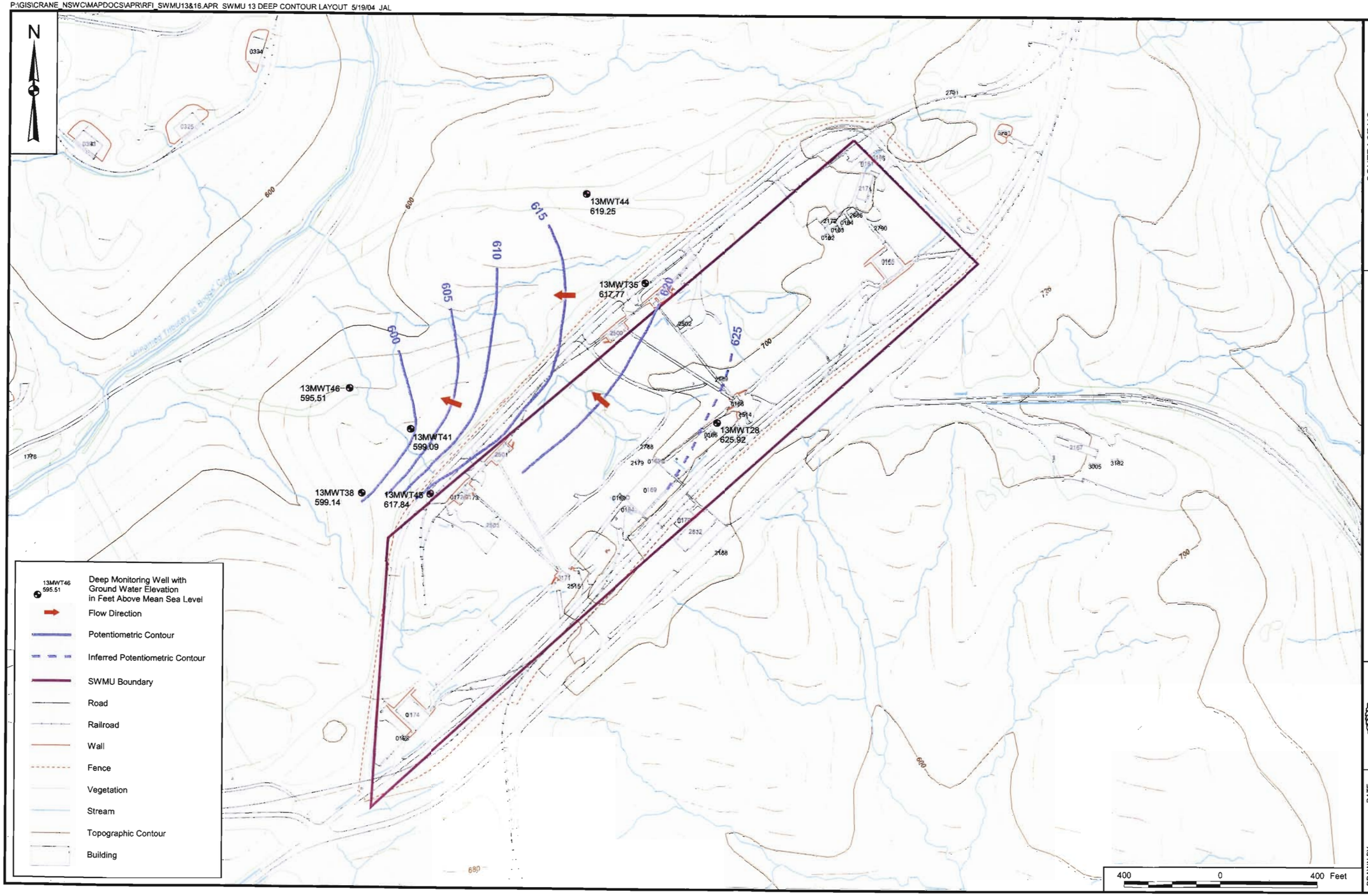
DRAWN BY A. JANOCHA DATE 2/23/04

CHECKED BY J. LUCAS DATE 5/13/04

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\CRANE_NSWC\MAPDOCS\APR\RFI_SWMU13&16.APR SWMU 13 DEEP CONTOUR LAYOUT 5/19/04 JAL



CONTRACT NO.
CTO 0279

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APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 1 - 14

REV 0

POTENTIOMETRIC SURFACE ELEVATION MAP
FOR DEEP WELLS - JANUARY 19 AND 20, 2004
SWMU 13 - MINE FILL B
NSWC CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY ★ SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMD ★

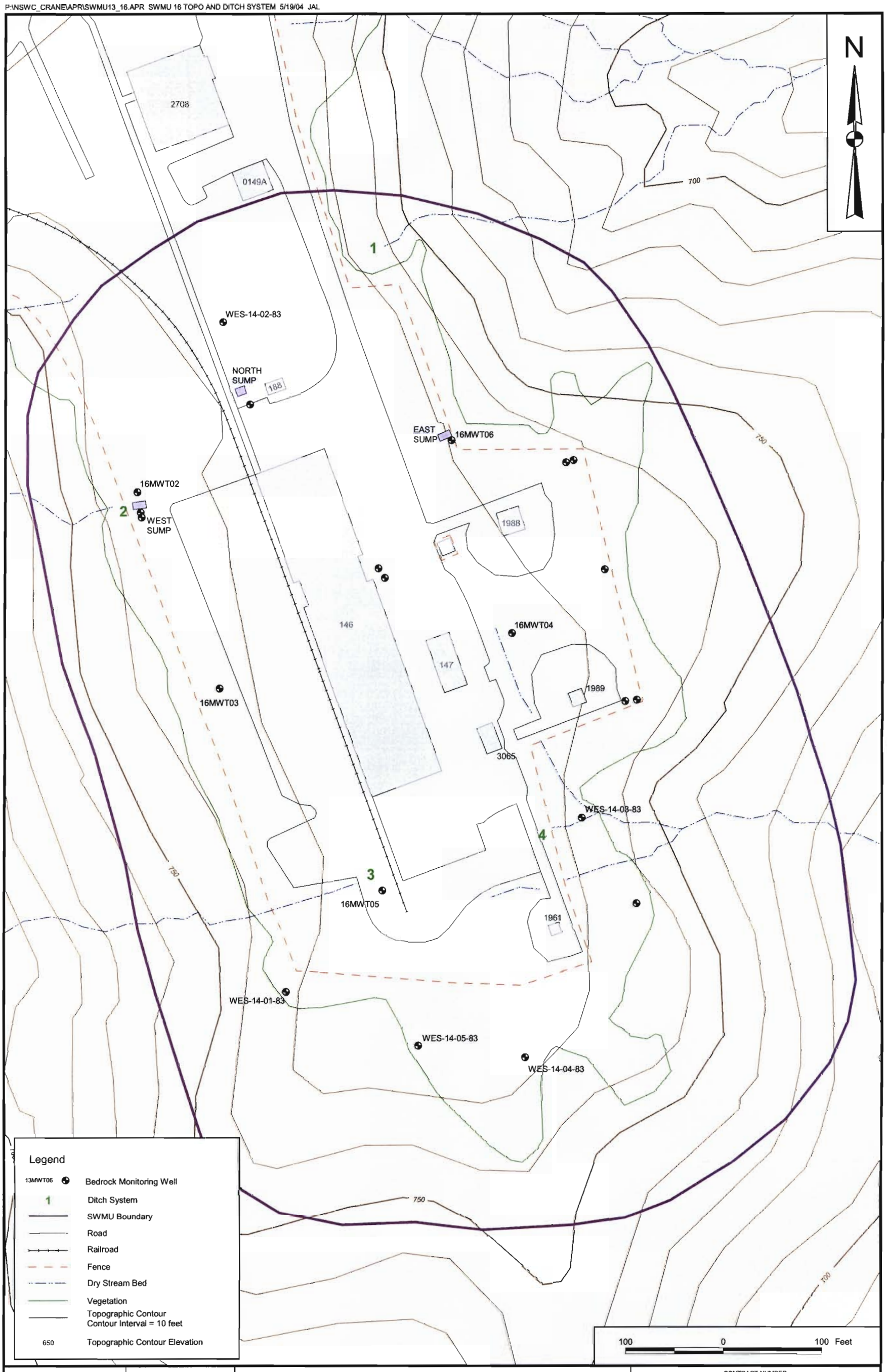
DRAWN BY A. JANOCHA DATE 2/23/04

CHECKED BY F. RAMSER DATE 3/17/04

COST/SCHED-AREA

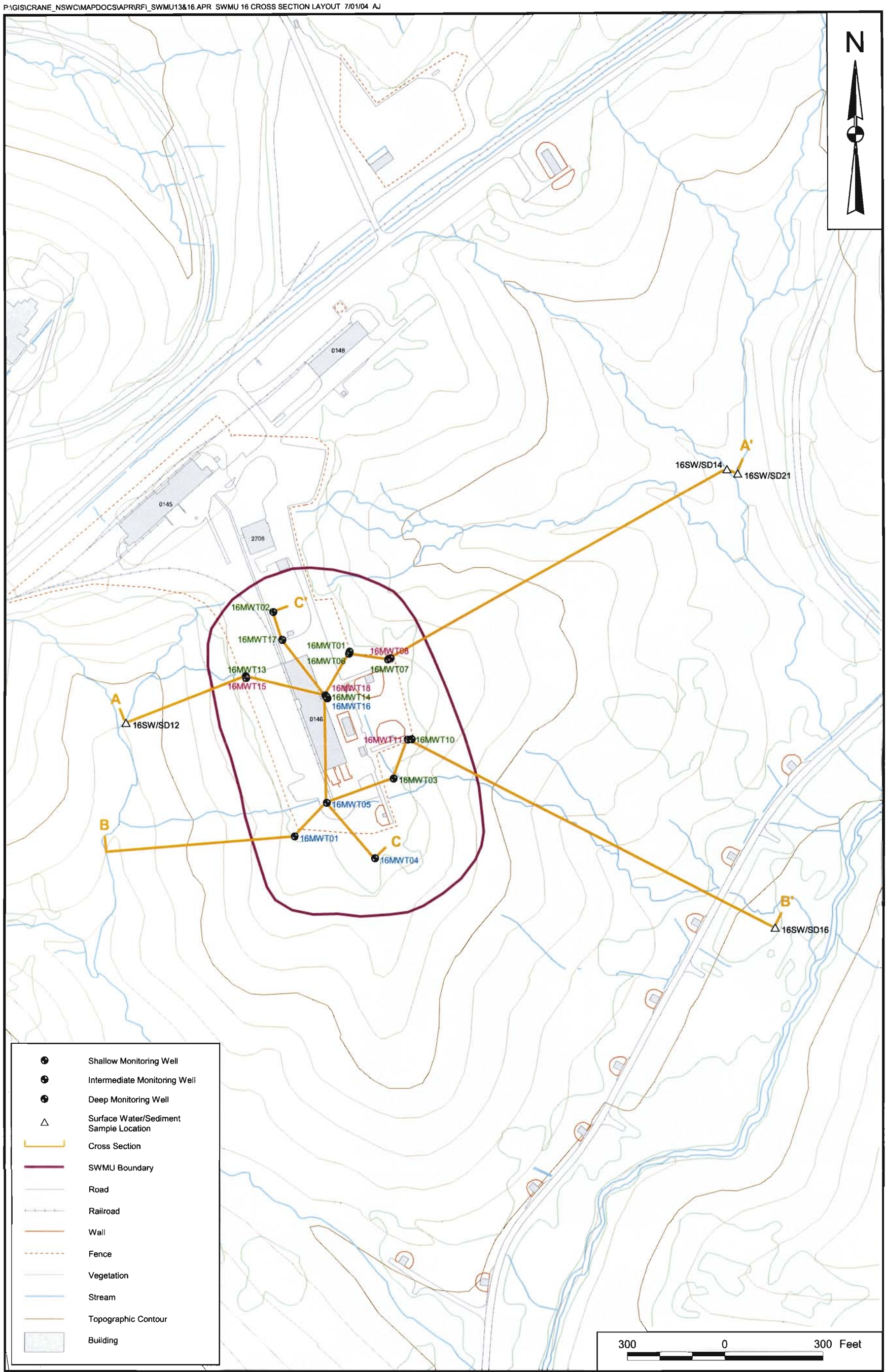
SCALE AS NOTED

P:\NSWC_CRANE\APR\SWMU13_16.APR SWMU 16 TOPO AND DITCH SYSTEM 5/19/04 JAL



DRAWN BY	DATE		CONTRACT NUMBER
M. KUHN	5/5/04	TOPOGRAPHY AND DITCH SYSTEMS	CTO 0279
CHECKED BY	DATE	B146 INCINERATOR/CAST HIGH EXPLOSIVES FILL (SWMU 16)	APPROVED BY / DATE
J. LUCAS	5/5/04	NSWC CRANE	APPROVED BY / DATE
COST/SCHEDULE-AREA		CRANE, INDIANA	DRAWING NO. FIGURE 1 - 15 / REV 0
SCALE AS NOTED			

P:\GIS\CRANE_NSWC\MAPDOCS\APR\RFI_SWMU13&16.APR SWMU 16 CROSS SECTION LAYOUT 7/01/04 AJ



DRAWN BY	DATE	CONTRACT NUMBER
A. JANOCHA	3/10/04	9060
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J. GOERDT	7/01/04	— / —
COST/SCHEDULE-AREA		APPROVED BY / DATE
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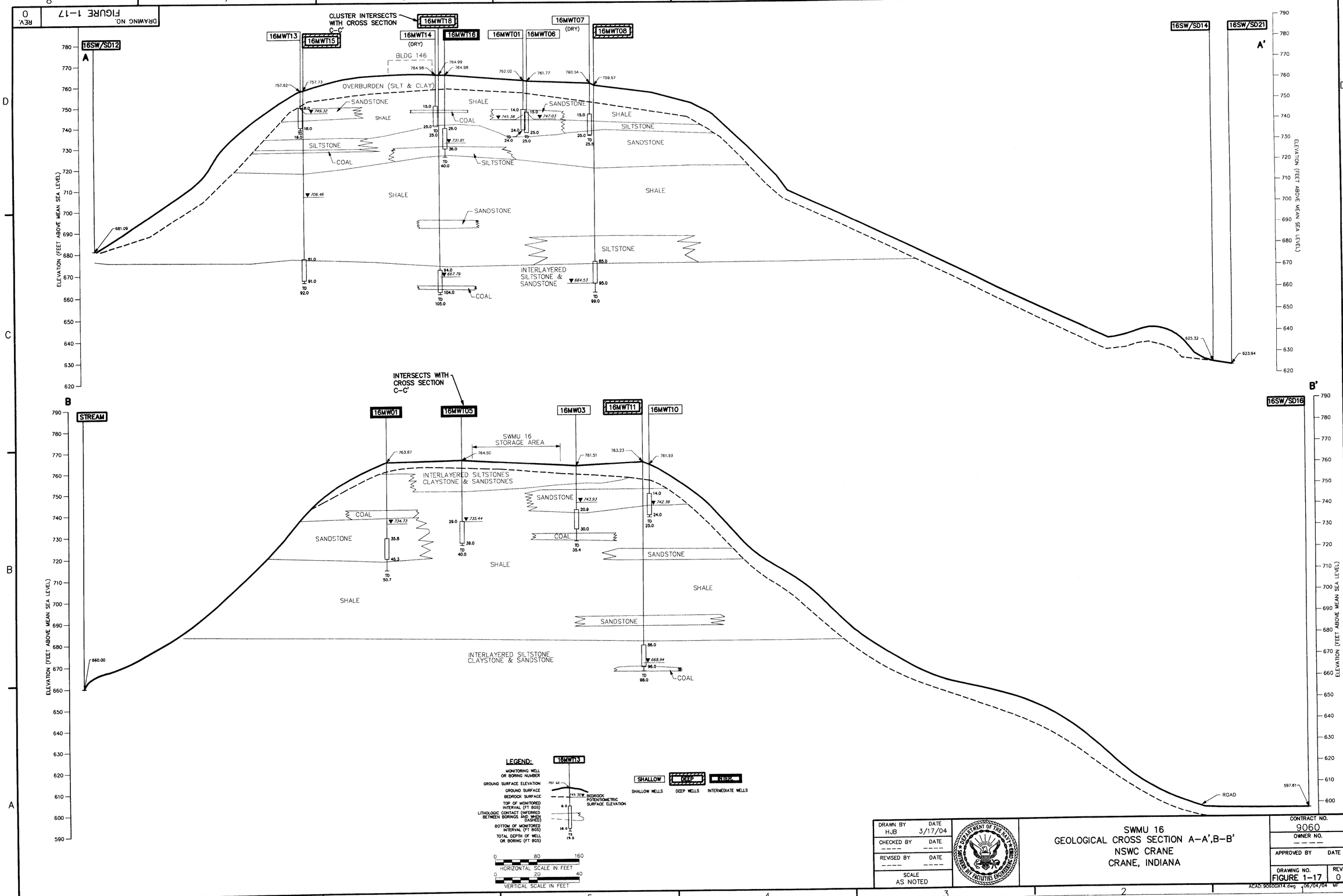
SCALE		DRAWING NO. / REV
AS NOTED		FIGURE 1 - 16 / 0

CROSS SECTION MAP

SWMU 16 - CAST HIGH EXPLOSIVES FILL/BUILDING 146 INCINERATOR

NSWC CRANE

CRANE, INDIANA



DRAWN BY HJB	DATE 3/17/04	SWMU 16 GEOLOGICAL CROSS SECTION A–A',B–B' NSWC CRANE CRANE, INDIANA
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SCALE AS NOTED		

CONTRACT NO.	9060
OWNER NO.	----
APPROVED BY	DATE
DRAWING NO.	FIGURE 1–17
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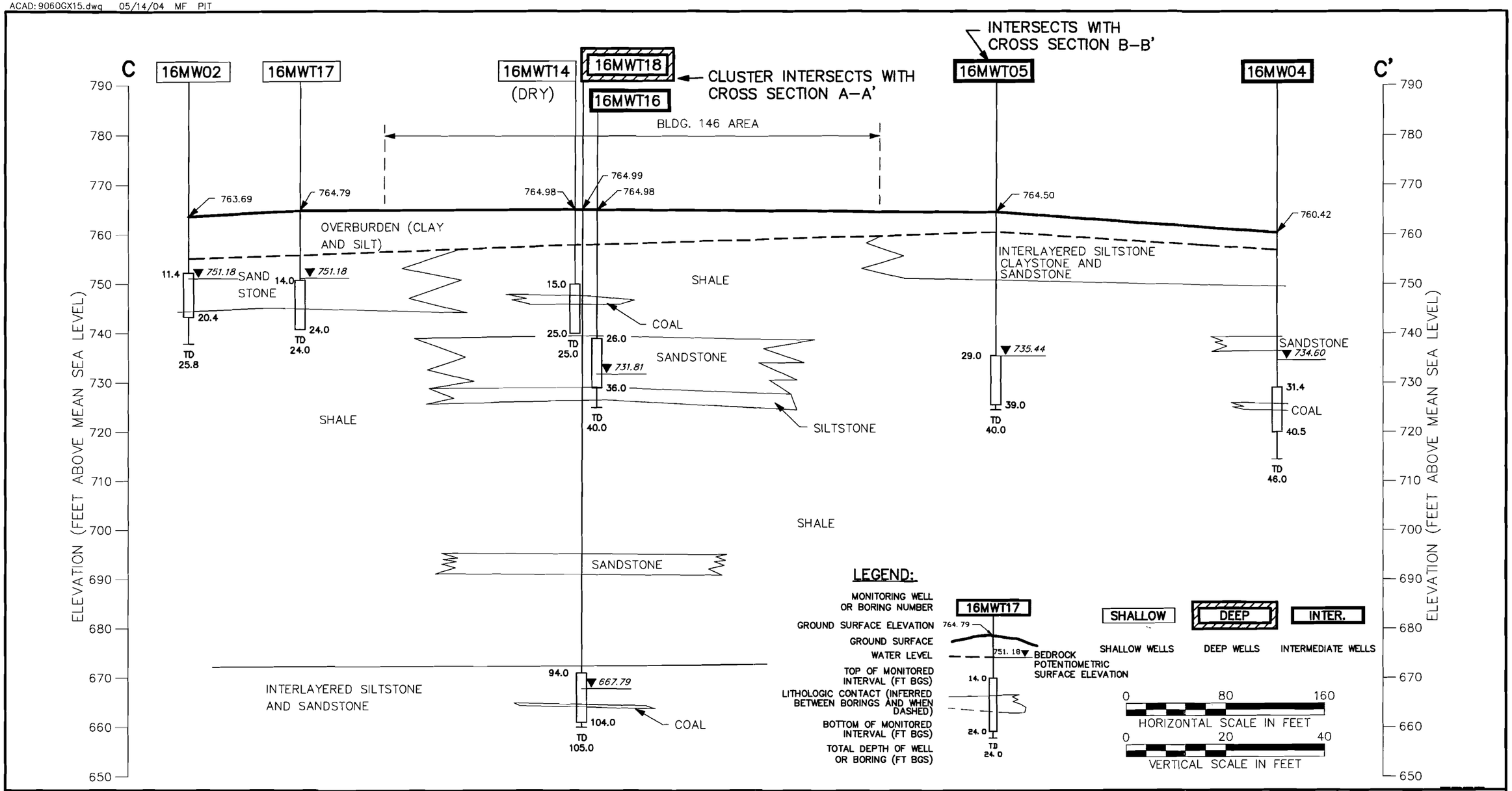
DRAWING NO. FIGURE 1–17 REV. 0

ACAD: 9060GX15.dwg 05/14/04 MF PIT



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJB DATE 2/19/04
CHECKED BY DATE
COST/SCHED–AREA
SCALE AS NOTED

DEPARTMENT OF THE NAVY ★ SOUTHERN DIV FACILITIES ENGINEERING COMD ★

SWMU 16
GEOLOGICAL CROSS SECTION C–C'
NSWC CRANE
CRANE, INDIANA

CONTRACT NO. 9060
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REV. 0

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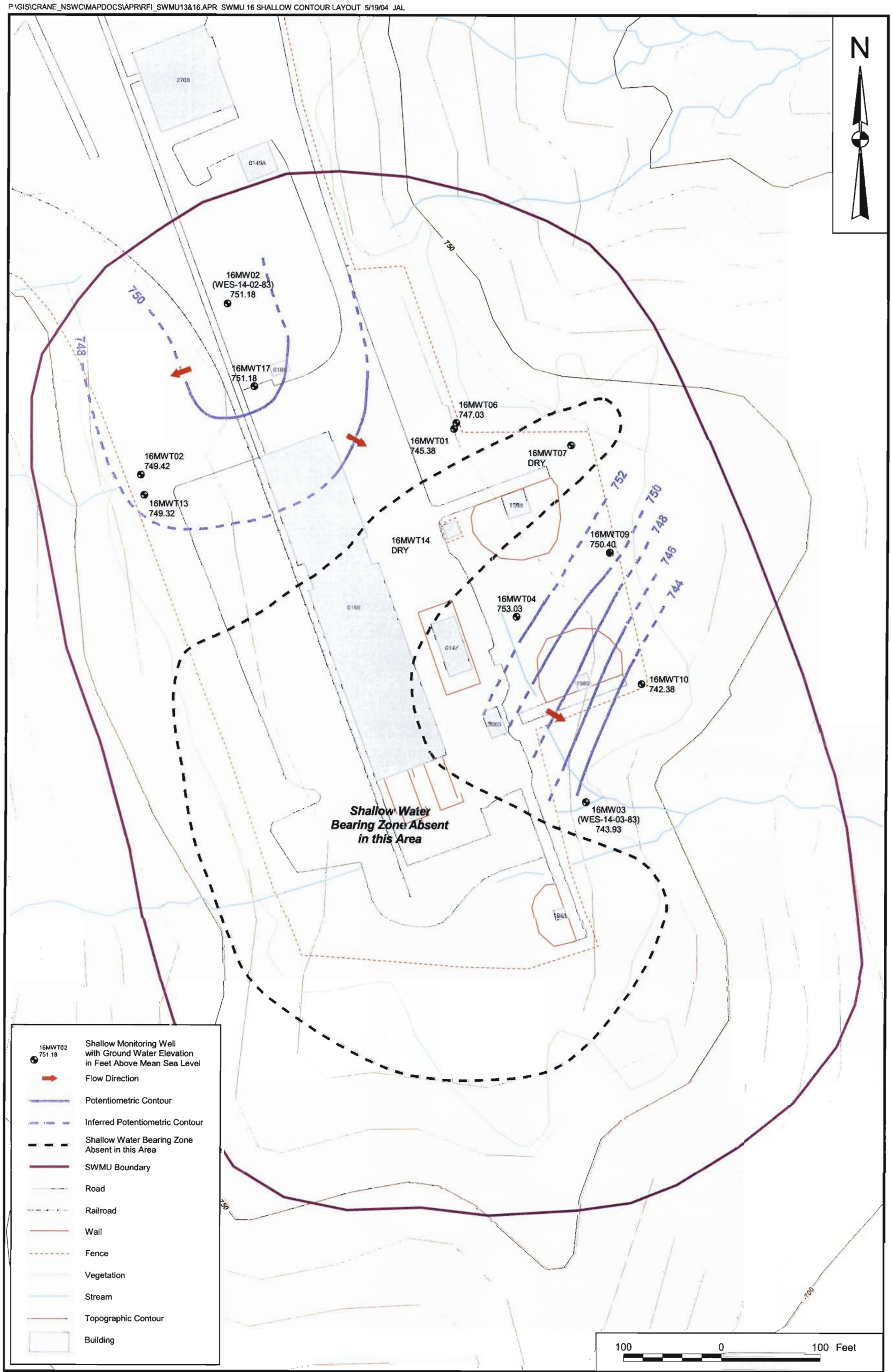

DRAWN BY A. JANOCHA	DATE 2/23/04	POTENTIOMETRIC SURFACE MAP FOR SHALLOW WELLS - JANUARY 24, 2004 SWMU 16 - CAST HIGH EXPLOSIVES FILL/BUILDING 146 INCINERATOR NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0279
CHECKED BY J. LUCAS	DATE 5/13/04		APPROVED BY — DATE —
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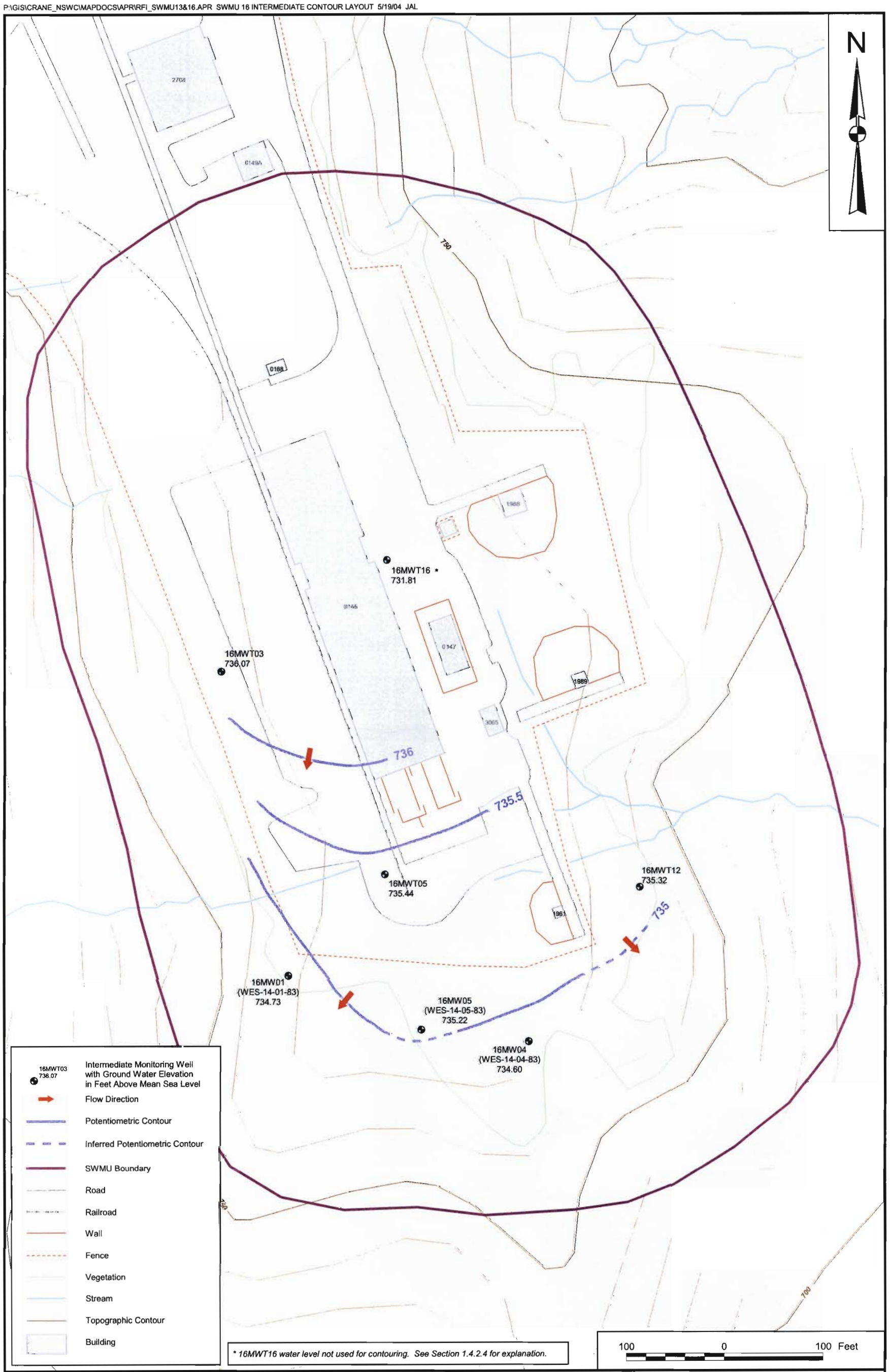
SCALE AS NOTED			DRAWING NO. FIGURE 1 - 19 REV 0

P:\GIS\CRANE_NSWC\MAPDOCS\APR\RFI_SWMU13&16.APR SWMU 16 INTERMEDIATE CONTOUR LAYOUT 5/19/04 JAL



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A. JANOCHA	2/23/04
CHECKED BY	DATE
J. LUCAS	5/13/04
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

POTENTIOMETRIC SURFACE MAP FOR
INTERMEDIATE WELLS - JANUARY 24, 2004
SWMU 16 - CAST HIGH EXPLOSIVES FILL/BUILDING 146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
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FIGURE 1 - 20	0

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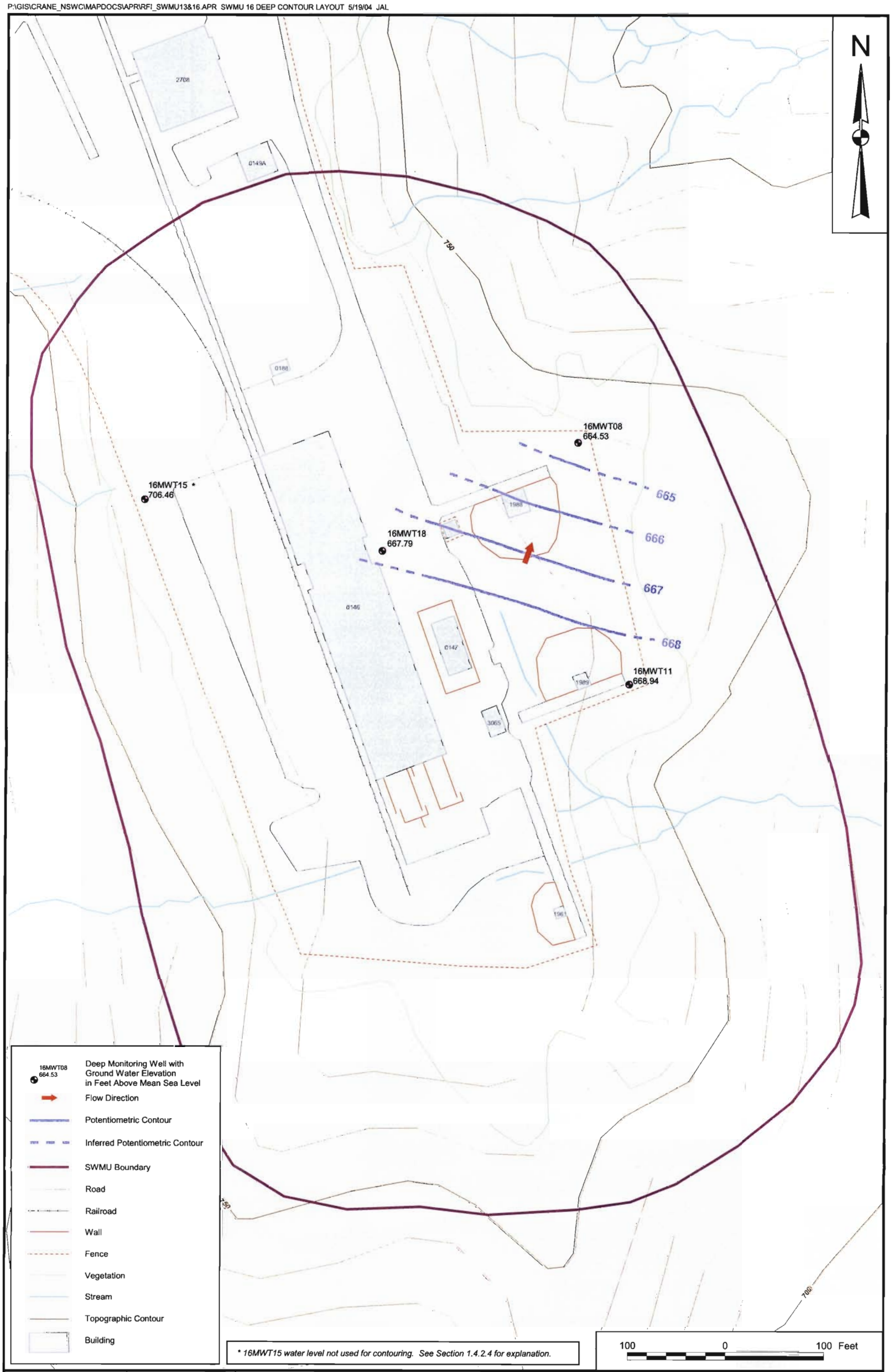

DRAWN BY A. JANOCHA	DATE 2/23/04	POTENTIOMETRIC SURFACE MAP FOR DEEP WELLS - JANUARY 24, 2004 SWMU 16 - CAST HIGH EXPLOSIVES FILL/BUILDING 146 INCINERATOR NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0279
CHECKED BY J. LUCAS	DATE 3/17/04		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1 - 21 REV 0

2.0 FIELD INVESTIGATION

This section presents sampling activities, procedures, and documentation utilized during Round 1 and Round 2 field operations performed in 2003 and 2004 for NSWC Crane SWMU 13 - MFB and SWMU 16 - Cast High Explosives Fill/B146 Incinerator.

2.1 OVERVIEW

RFI field activities were conducted from February through May 2003 (Round 1) and October 2003 through January 2004 (Round 2). All work performed for Round 1 was conducted in accordance with the procedures and methodologies described in the U.S. EPA-approved QAPP (TtNUS, 2003a). All work performed for Round 2 was done in accordance with the procedures and methodologies described in the Addendum No. 1 to the approved QAPP (TtNUS, 2003b). Standard operating procedures (SOPs) that governed the field work are included in Appendix H of the approved QAPP (TtNUS, 2003a), and Appendix E of the Addendum No. 1 to the approved QAPP (TtNUS, 2003b). Photographs and surveyed sample locations of SWMUs 13 and 16, copies of all field forms, records, and field logbooks associated with both Round 1 and Round 2 field investigations are provided in Appendices A through E of this document (Volume 2 of 2) as follows:

- Appendix A - Photographs of SWMU 13 and SWMU 16 and Surveyed Sample Locations
  - A.1 Figure A-1: Photograph Direction Markers and Survey Locations of SWMU 13
  - A.2 Figure A-2: Photograph Direction Markers and Survey Locations of SWMU 16

- Appendix B - Boring Logs, Monitoring Well Construction Diagrams, and Related Materials
  - B.1 SWMU 13 and SWMU 16 Boring Logs and Monitoring Well Construction Diagrams (Round 1 and Round 2)
  - B.2 SWMU 13 and SWMU 16 Digging Permits (Round 1 and Round 2)
  - B.3 SWMU 13 and SWMU 16 Monitoring Well Materials Certificates of Conformance (Round 1 and Round 2)

- Appendix C - Sample Log Sheets and Other Field Forms
  - C.1 SWMU 13 and SWMU 16 Soil and Sediment Sample Log Sheets (Round 1 and Round 2)
  - C.2 SWMU 13 and SWMU 16 Surface Water Sample Log Sheets (Round 1 and Round 2)
  - C.3 SWMU 13 and SWMU 16 Ground Water Sample Log Sheets (Round 1 and Round 2)
  - C.4 SWMU 13 and SWMU 16 Chain-of-Custody Records (Round 1 and Round 2)

- C.5 SWMU 13 and SWMU 16 Monitoring Well Inspection Sheets (Round 1 and Round 2)
- C.6 SWMU 13 and SMWU 16 Monitoring Well Development Records (Round 1 and Round 2)
- C.7 SWMU 13 and SWMU 16 Water Level Measurement Sheets (Round 1 and Round 2)
- C.8 SWMU 13 and SWMU 16 Field Task Modification Request Forms (Round 1 and Round 2)
- C.9 SWMU 13 and SWMU 16 Equipment Calibration Logs (Round 1 and Round 2)

- D Miscellaneous Field documentation
  - D.1 SWMU 13 and SWMU 16 Site Logbook (Round 1 and Round 2)
  - D.2 SWMU 13 and SWMU 16 Field Notebook (Round 1 and Round 2)
  - D.3 SWMU 13 and SWMU 16 Land Survey Data (Round 1 and Round 2)

- E Aquifer Characteristics, Calculations, and Records
  - E.1 SWMU 13 Slug Test Results and Calculations (Round 1)
  - E.2 SWMU 13 Slug Test Results and Calculations (Round 2)
  - E.3 SWMU 16 Slug Test Results and Calculations (Round 1)
  - E.4 SWMU 16 Slug Test Results and Calculations (Round 2)

2.2 MOBILIZATION / DEMOBILIZATION

Following approval of the QAPP, TtNUS began mobilization activities for Round 1. Following approval of the Addendum No. 1 to the approved QAPP, TtNUS began mobilization activities for Round 2. All field team members reviewed the approved QAPP (Round 1) and the Addendum No. 1 to the approved QAPP (Round 2), associated appendices, and the Health and Safety Plan (HASP) prior to the start of project activities. In addition, the Field Operations Leader (FOL) held field team orientation meetings to ensure that personnel were familiar with the scope of the field activities.

Prior to the initiation of fieldwork for each round, the FOL arrived at the site and began on-site mobilization activities. These activities included coordination with base personnel and utility clearance of all proposed boring locations through the NSWC Crane Publics Works Office. The equipment required for the field activities was shipped to the site. Field sampling activities, drilling activities, and site characterization work were performed from March to May 2003 for Round 1, and October 2003 through January 2004 for Round 2. At the conclusion of Round 1 and Round 2 field activities, the FOL completed the decontamination and demobilization of all equipment.

2.3 SUBSURFACE INVESTIGATION METHODOLOGIES AND PROCEDURES

2.3.1 Drilling

Round 1

The borings for soil sampling and monitoring well installation were drilled using direct-push technology (DPT), hand auger, Rotosonic, and hollow-stem auger (HSA) methods (see Table 2-1). DPT boring, hand augering, and Rotosonic drilling methods were used to install soil borings, and Rotosonic and HSA drilling techniques were used to install monitoring well borings. All borings were installed in accordance with SOP CTO166-04 and logged in accordance with SOPs CTO166-07 and CTO166-11. Boring logs can be found in Appendix B.

Round 2

Nineteen borings for soil sampling and 32 borings for monitoring well installation were drilled using hand auger, Rotosonic, and HSA methods (see Table 2-1). Hand augering was used to advance soil borings, and Rotosonic and HSA techniques were used to drill monitoring well borings. All borings were installed in accordance with SOP CTO166-04 and logged in accordance with SOPs CTO166-07 and CTO166-11. Boring logs can be found in Appendix B.

2.3.1.1 Direct-Push Technology Borings

The DPT method involves pushing sampling tools hydraulically and/or mechanically downward into the ground to the desired depth. Soil samples were collected from borings for chemical analyses and for lithologic logging. All samples obtained from the boreholes were screened with a photoionization detector (PID) immediately upon opening. All PID readings were recorded on the boring logs. Soil sample collection information is provided in Section 2.5.1.

SWMU 13

The DPT method was used to complete 12 soil borings at SWMU 13 during Round 1. Figure A-1 in Appendix A shows the locations of all soil borings completed as part of the RFI at SWMU 13. DPT soil borings at SWMU 13 were advanced to a total depth of 10 feet, to the water table, or to refusal. Actual sample depths for SWMU 13 soil samples are listed in Table 2-1. The DPT method was not used during Round 2 field activities at SWMU 13.

SWMU 16

The DPT method was used to complete 36 soil borings at SWMU 16 during Round 1. Figure A-2 in Appendix A shows the locations of all soil borings completed as part of the RFI at SWMU 16. DPT soil borings 16SB40 and 16SB41 at SWMU 16 were advanced to the bottom of their respective sumps (7 to 8 feet bgs). All other soil borings at SWMU 16 were advanced to refusal (1.5 feet to 6 feet). Actual sample depths for SWMU 16 soil samples during Round 1 are listed in Table 2-1. The DPT method was not used during Round 2 field activities.

2.3.1.2 Rotosonic Drilling

The Rotosonic drilling technique provided a viable alternative method to HSA and rotary drilling techniques for a number of reasons. Rotosonic drilling advances rapidly through all types of unconsolidated and some bedrock materials and provides 5- to 10-foot continuous core samples for accurate lithologic and hydrogeologic information. Drilling fluids and drill cuttings are also kept to a minimum with this technique. The Rotosonic technique combines vibrational and rotational forces to advance the drill stem. The high-frequency vibration generated in the drill head can be adjusted for various drilling conditions to optimize penetration rates. Photographs of the Rotosonic rig used at SWMU 13 and SWMU 16 are presented in Appendix A.

Where necessary, the borings were advanced using a temporary casing to prevent collapse during drilling. The drill bit was attached to the base of the 4-inch inside diameter (ID), 4.5-inch outside diameter (OD), 10-foot-long core barrel. The core barrel was connected to a drill pipe of the same ID. When the core barrel reached the desired depth, a larger 6-inch OD drill pipe was centered on the core barrel and advanced to the same depth to act as a temporary outer casing. Core runs were limited to 5 feet to maximize sample recovery. The inner core barrel and drill pipe were retrieved and the core was extruded from the inner core barrel using vibration and/or hydraulic pressure. Each core sample was extruded into a clear plastic sleeve. This technique facilitated lithologic classification, environmental sample collection, and vapor monitoring using a PID. All PID readings were recorded on the boring logs. This process was repeated to the termination point of each well boring. The remaining drill cuttings not retained for analytical or classification purposes were disposed in accordance with the approved QAPP (TtNUS, 2003a) and the Addendum No. 1 to the approved QAPP (TtNUS, 2003b) (see Section 2.14 for more information).

In borings where continuous sampling was not required, a 4-inch ID displacement bit was attached to the base of the core barrel. This technique used both vibration and water to ream through the overburden and bedrock.

Controlled amounts of water were added where necessary to remove cuttings from the borehole. Any excess water generated during this process was collected in a container and transported to and disposed at an NSWC Crane-approved sanitary sewer. Soil sample collection information is provided in Section 2.5.1.

SWMU 13

Twenty-five (Round 1) and 15 (Round 2) Rotosonic borings were converted into bedrock monitoring wells at SWMU 13. Appendix B contains boring logs, including those for wells drilled using Rotosonic techniques. In addition, Rotosonic techniques were used for collection of soil samples as listed in Table 2-1 for both Rounds 1 and 2. Actual sample depths for all borings at SWMU 13 where soil samples were collected for chemical analysis are listed in Table 2-1 for both Round 1 and Round 2.

Continuous rock cores were collected from 12 (Round 1) and 13 (Round 2) bedrock well borings at SMWU 13 for lithologic description purposes. Select cores that were retained were placed into labeled core boxes, photographed, and turned over to the NSWC Crane EPD for storage.

SWMU 16

Six (Round 1) and three (Round 2) Rotosonic borings were converted into bedrock monitoring wells at SWMU 16. Five borings (16SB26, 16SB32, 16SB33, 16SB34, and 16SB36) were drilled for the collection of soil samples during Round 1. Three Rotosonic borings were converted into bedrock monitoring wells during Round 2. Appendix B includes information about wells drilled using Rotosonic techniques. In addition, Rotosonic techniques were used for collection of soil samples as listed in Table 2-1 for both Round 1 and Round 2. Actual sample depths for SWMU 16 borings are listed in Table 2-1 for both Round 1 and Round 2.

Continuous rock cores were collected from five (Round 1) and three (Round 2) bedrock well borings for lithologic description purposes. Select cores that were retained were placed into labeled core boxes, photographed, and turned over to the NSWC Crane Environmental Protection Department for storage.

2.3.1.3 Hollow-Stem Augering

HAS drilling included the use of 4.25 ID HSAs, with split-spoon samplers used to obtain soil samples. Split-spoon samplers had a minimum ID of 2 inches and were 2 feet long. The split-spoon sampler was driven to the required depth with a rig-mounted hammer weighing 140 pounds and falling 30 inches. All soil samples obtained from boreholes drilled using the HSA method were screened with a PID immediately upon opening. All PID readings were recorded on the boring logs. Drill cuttings were disposed in accordance with the approved QAPP.

SWMU 13

One monitoring well boring was drilled at SWMU 13 using the HSA drilling method during Round 1 and seven during Round 2. The HSA drilling technique with split-spoon sampling was used at SMWU 13 to install 13MWT13. Soil samples were collected continuously from the ground surface to the bottom of this well for identification of lithologic characteristics only.

SWMU 16

One monitoring well boring was drilled at SWMU 16 using the HSA drilling method during Round 1 and eight during Round 2. The HSA technique at SWMU 16, used to install 16MWT06 during Round 1, did not require any continuous sampling because an adjacent well was previously installed with continuous sampling.

2.3.1.4 Hand Augering

The hand augering system consisted of a stainless steel bucket auger (6-½ inches long and 3-¼ inches in diameter) and a 4-foot-long stainless steel extension rod with a cross handle. The borings were augered to the desired depth or until refusal was encountered. Soil sample collection information is provided in Section 2.5.1. All samples obtained from the boreholes were screened with a PID immediately upon retrieval from the borehole. All PID readings were recorded on the boring logs.

SWMU 13

Two Round 1 (13SB14, 13SB15) and 10 Round 2 (13SB16 through 13SB25) soil borings were collected using the hand auger method only at SMWU 13.

SWMU 16

There were no soil borings collected at SWMU 16 during Round 1 using the hand auger method; however, nine soil borings were collected during Round 2 using the hand auger method (16SS42 through 16SB50).

2.3.2 Borehole and Sample Logging

A TtNUS geologist maintained a log for each boring in accordance with SOP CTO166-07 (Borehole and Soil Sample Logging) and SOP CTO166-11 (Drilling and Geologic Logging of Boreholes in Rock). At a minimum, the boring logs contain the following information:

- Well identification (where applicable)
- Boring identification
- Name of geologist logging the boring
- Name of drilling contractor
- Sample number and type
- Sample depth
- Sample recovery and sample interval
- Soil density or cohesiveness
- Soil color
- Unified Soil Classification System (USCS) material descriptions
- Rock type and description, recovery, and rock quality designation (RQD)
- Location of boring
- Drilling and/or well construction problems or deviations from the project-specific approved QAPP or the Addendum No. 1 to the approved QAPP.
- Date(s) of drilling
- Screening instrument readings

In addition, depths of changes in lithology, sample moisture observations, depth to water, organic vapor meter PID readings, drilling methods, and total depth of each borehole were included on each log, as well as any other pertinent observations. Logs for the borings drilled as part of the RFI are included in Appendix B of this document.

2.3.3 Borehole Abandonment

All DPT soil borings at both SWMUs were backfilled with bentonite chips and hydrated in accordance with the manufacturer's specifications. The ground surface at all boring locations was restored to its original condition.

Well 16MWT14 was abandoned during Round 2 field activities. The shale unit encountered during drilling yielded small amounts of ground water, and it was not known whether the borehole would yield sufficient water for monitoring purposes. The well was partially completed (all materials were installed except for the grout seal and protective casing). The well was periodically checked for the presence of ground water and found to be dry. Subsequently, the well was abandoned. The abandonment procedure consisted of knocking out the bottom of the well screen with drill rods and filling the well with a cement-bentonite mixture. The well riser pipe and screen were pulled from the boring, and the remaining annulus was filled to the ground surface with the cement-bentonite mixture.

2.4 MONITORING WELL INSTALLATION AND DEVELOPMENT

2.4.1 Well Installation

Monitoring wells were installed during Round 1 and Round 2 RFI field operations at both SWMU 13 and SWMU 16 in accordance with SOP CTO166-12. Tables 1-1 (SWMU 13) and 1-2 (SWMU 16) provide monitoring well construction details.

After each boring was drilled to the desired depth, a 2-inch-diameter polyvinyl chloride (PVC) Schedule 40 well screen and riser pipe was lowered into the boring through the steel isolation casing. All well screens were 10 feet in length with a slot size of 0.20 inch. After the screen and the riser pipe were in place, the annulus of the boring was backfilled with clean silica sand from the bottom of the boring to 1 to 2 feet above the top of the well screen. A bentonite seal was then installed either in pellet (shallow wells) or slurry form (deep wells), and the pellets allowed to hydrate in accordance with the manufacturer's recommendations. The remainder of the annulus of the borehole (from the bentonite seal to the ground surface) was filled with cement-bentonite grout to approximately 1 foot bgs.

The depth of the backfill materials was continuously monitored during the installation of the monitoring wells using a weighted steel tape measure to ensure that the sand pack or bentonite did not bridge during the installation process.

Indiana State well installation requirements in 310 Indiana Administrative Code (IAC) 16 were followed for all well installation activities. Well construction logs for Round 1 and Round 2 were completed for each well and are presented in Appendix B. Refer to Section 2.3.1 for the drilling methods. Monitoring well construction information and water level measurements are presented in Tables 1-1 (SWMU 13) and 1-2 (SWMU 16) for each round. Figures presented in Appendix B-1 and B-2 show well construction details.

SWMU 13

Round 1

Twenty-six monitoring wells (13MWT01 through 13MWT26) were installed at SWMU 13. Monitoring wells at SWMU 13 ranged in depth from 15 to 30 feet bgs (Table 1-1). See Figure A-1 in Appendix A for the SWMU 13 monitoring well locations.

Round 2

Twenty-one monitoring wells (13MWT27 through 13MWT47) were installed at SWMU 13. Monitoring wells at SWMU 13 ranged in depth from 20 to 88 feet bgs (Table 1-1). See Figure A-1 in Appendix A for the SWMU 13 monitoring well locations.

SWMU 16

Round 1

Six monitoring wells (16MWT01 through 16MWT06) were installed at SWMU 16. Monitoring wells at SWMU 16 ranged in depth from 18 to 40 feet bgs (Table 1-1). Monitoring well 16MWT06 was installed to replace 16MWT01 due to its extremely low ground water yield. Refer to the Ground Water Sample Log Sheet for 16MWT06 in Appendix C.6.1 for further detail. See Figure A-2 in Appendix A for the SWMU 16 monitoring well locations.

Round 2

Eleven monitoring wells (16MWT07 through 16MWT17) were installed at SWMU 16. Well 16MWT14 was subsequently abandoned due to lack of water (see Section 2.3.3). Deep monitoring wells 16MWT15 and 16MWT16 were only to be installed as contingency wells if ground water samples from corresponding shallow wells indicated that contamination was present. A decision was made to install well 16MWT15 at the same time as its corresponding shallow well (16MWT13) due to the overhead power lines near the well location needing to be shut down as a safety precaution for the drilling rig. Due to the abandonment

of well 16MWT14, well 16MWT16 was drilled as a shallow replacement well. A quick turnaround on sampling results for well 16MWT16 indicated that contamination was present in the well. Therefore, a corresponding deep well (16MWT18) was installed and sampled. Monitoring wells at SWMU 16 ranged in depth from 19 to 99 feet bgs (Table 1-1). See Figure A-2 in Appendix A for the SWMU 16 monitoring well locations.

2.4.2 Monitoring Well Protection

After each monitoring well was installed and the annulus grouted to the land surface, a 4-inch, square, steel protective casing with a locking cap was cemented in place over the riser pipe. This stick-up-type protective casing extended approximately 3 feet above and 2 feet below the ground surface. A drain hole was drilled into the protective casing approximately 6 inches above the ground surface. Pea gravel was used to fill the space between the outer protective casing and the riser pipe. A 4-foot-square and 6-inch-thick concrete apron was cemented in place around the protective casing, and four safety yellow barrier posts (nominal 4-inch-diameter, 5-foot-long steel pipes buried 2 feet deep and filled with concrete) were cemented just outside the four corners of the concrete apron. Stainless steel well plates indicating well ID, depth, date, etc. were installed on the outside of each protective well casing. To maintain well security, a locking cap was placed on each well.

2.4.3 Monitoring Well Repair and Development

SWMU 13

No existing wells were present at SWMU 13 at the initiation of the Round 1 investigation. However, during the Round 2 RFI activities, the 26 existing wells from Round 1 were inspected and sampled. Inspection reports are included in Appendix C.8 of this document. No significant repairs were necessary during Round 2.

SWMU 16

As part of the Round 1 investigation, five existing wells at SMWU 16 were inspected, repaired as needed, redeveloped, and sampled during RFI activities. During Round 2, the 11 existing wells at SWMU 16 were inspected, repaired as needed, redeveloped, and sampled during RFI activities. Inspection reports are included in Appendix C.8 of this document. The repairs made included the following:

- Replacing the rusted lock and fixing the locking latch at existing monitoring well location WES-14-03-83 (Round 1).
- Replacing the cement pad at monitoring well location WES-14-04-83 (Round 1).

Well Development

All newly installed monitoring wells were developed by surging and pumping methods no sooner than 24 hours after installation to remove fine material from around the well screen and the sand pack that surrounds the well screen. The period of development for each well was approximately 1 hour. If the well was pumped dry, TtNUS personnel typically waited 20 to 30 minutes, noted the rate of recharge, and then pumped the well dry at least three times in an effort to maximize the amount of fine material removed. Development continued and was considered complete when one of the following was achieved: the purge water was clear to the unaided eye, five well volumes were removed, or the well was pumped dry three times.

Wells were developed by up to three surging and purging techniques (a surge block with Whale® pump, a bailer, or a check valve method). The surge block/Whale® pump method consisted of inserting a 2-inch surge block into the well and surging over the length of the saturated screen for a minimum of 5 minutes. Immediately after surging, the Whale® pump was lowered into the well and was pumped in accordance with SOP CTO166-10. The bailer method consisted of purging the well over the length of the saturated screen and removing water and fines. The check valve method involved attaching a decontaminated foot valve to new dedicated ¾-inch polyethylene tubing, extending the tubing to the bottom of the well, and both surging and purging by moving the tubing in an up and down motion. On the downward stroke, the ball in the foot valve lifts and the tubing fills with water, and on the upward stroke, the ball is set and surged ground water is forced out of the tubing and into a purge bucket. Section 2.14 describes the disposal of all investigation-derived waste (IDW) including development fluids.

Water-quality parameters (pH, specific conductivity, temperature, DO, ORP, and turbidity), pumping rates, volumes of ground water removed, recharge rates, and water levels were recorded on monitoring well development records. Monitoring well development records for both Round 1 and Round 2 can be found in Appendix C of this document.

2.5 SAMPLING OPERATIONS

This section discusses the methodology for all soil, surface water, sediment, and ground water sampling activities and aquifer testing performed at SWMUs 13 and 16 at NSWC Crane, Indiana. All sample

locations for SWMU 13 are depicted on Figure A-1 of Appendix A, and all sample locations for SWMU 16 are depicted on Figure A-2. A summary of analyses is included in Tables 2-2 (Round 1) and 2-3 (Round 2).

2.5.1 Soil Sampling

During Round 1 of the RFI, a total of 95 soil samples were collected from 56 soil borings. During Round 2, a total of 28 soil samples were collected from 19 soil borings. Soil samples were collected in accordance with SOP CTO166-08. Soil sample log sheets for both Round 1 and Round 2 are included in Appendix C of this document.

2.5.1.1 Surface Soil Sampling

The surface soil samples were collected from the ground surface to a maximum depth of 2 feet bgs or until refusal was reached using DPT or Rotosonic methods (Round 1) and hand augering (Round 2). Upon retrieval, all samples were monitored for the presence of VOCs using a PID. The results of this screening were recorded on the boring logs and/or soil sample log sheets (found in Appendix B and Appendix C, respectively, of this document). Samples for VOC analyses were collected first from the 0.5- to 1.0- or 2.0-foot bgs interval that had the highest PID reading. Samples to be analyzed for VOCs were collected using 5-gram EnCore™ samplers. Sample aliquots for the other analyses were collected from the remaining soil core within the 0- to 2-foot depth interval and placed in the appropriate containers following homogenization.

SWMU 13

Round 1

Fifteen of the proposed 16 surface soil samples were collected at SWMU 13. One surface soil sample was collected from each of the 15 soil borings from the ground surface to a depth of 1 to 2 feet bgs using DPT methods, Rotosonic drilling, or hand augering. Surface soil sample 13SS16 was not collected during Round 1; however, it was collected during Round 2.

Round 2

Ten surface soil samples were collected at SWMU 13. One surface soil sample was collected from each of the 10 soil borings from the ground surface to a depth of 1 to 2 feet bgs using hand augering.

SWMU 16

Round 1

Thirty-nine proposed surface soil samples were collected from the 41 soil boring locations at SWMU 16. Two soil boring locations at SWMU 16 (16SB40 and 16SB41) did not require surface samples.

Round 2

Five surface soil samples were collected by hand augering from the nine soil boring locations at SWMU 16. Borings 16SB47 through 16SB50 did not require surface soil samples.

2.5.1.2 Subsurface Soil Sampling

Upon retrieval, all subsurface samples were monitored for the presence of VOCs using a PID. The results of this screening were recorded on the boring logs and/or soil sample log sheets. Samples for VOC analyses were collected first from the interval that had the highest PID reading using 5-gram EnCore™ samplers. The remaining soil core material was then homogenized, and soil to be analyzed for other parameters was placed into the required containers. Subsurface sample intervals for SWMU 13 and SWMU 16 are listed in Tables 2-1 and 2-2 for Round 1 and Round 2, respectively.

SWMU 13

Round 1

Fourteen of the proposed 16 subsurface soil samples were collected at SWMU 13. Proposed sample 13SB14 was not obtained due to refusal encountered before reaching the target depth for subsurface soil sample collection. Proposed sample 13SB16 was not collected during Round 1; however, it was collected during Round 2. Subsurface samples were collected from a 2-foot interval between 2 to 10 feet bgs using DPT methods, Rotosonic drilling, or hand augering.

Round 2

Nine subsurface soil samples were collected at SWMU 13. Refusal was encountered at soil boring 13SB20 before reaching the target depth for subsurface soil sample collection. Subsurface samples were collected from a 2-foot interval between 2 to 4 feet bgs using hand augering.

SWMU 16

Round 1

Twenty-five subsurface soil samples were collected from the proposed 41 soil boring locations at SWMU 16. Sixteen subsurface soil samples were not able to be collected due to refusal. Two subsurface samples were taken from both 16SB40 and 16SB41. All subsurface samples were collected from a 2-foot section between 2 to 8 feet bgs using DPT or Rotosonic methods.

Round 2

Four subsurface soil samples were collected from the nine soil boring locations at SWMU 16. The subsurface samples were collected from 2-foot sections between 1 to 5 feet bgs by hand augering.

2.5.2 Surface Water/Seep Sampling

Twenty surface water sample locations (including streams and sumps) were proposed for both SWMUs during Round 1, and 23 surface water sample locations and five seep sample locations were proposed during Round 2. All sample locations were marked with a labeled, wooden survey stake. Fluorescent flagging was tied to the stake and to a nearby tree (if available) to facilitate relocation of the sample location for surveying purposes. All Round 1 surface water samples that could be collected were collected in accordance with the approved QAPP (TtNUS, 2003a), and all Round 2 surface water samples were collected in accordance with Addendum No. 1 to the approved QAPP (TtNUS, 2003b). All pertinent field data, including water quality parameters, sampling method, and location were recorded on a surface water sample log sheet (see Appendix C). The samples that were proposed and collected are identified in Tables 2-2 (Round 1) and 2-3 (Round 2) along with the analyses that were proposed and conducted on the samples.

SWMU 13

Round 1

Thirteen proposed surface water samples were collected at SWMU 13. Photographs taken of selected surface water sampling locations at SWMU 13 are presented in Appendix A.

Round 2

Twenty-two of the 23 proposed surface water sample locations at SWMU 13 were collected. Sample 13SW2901 was not collected due to the absence of water at the time of sampling. Four of the five proposed seep samples were sampled during Round 2. The fifth seep sample was not collected due to dry conditions.

SWMU 16

Round 1

Three of the proposed seven surface water samples were collected at SWMU 16. Four surface water locations at SWMU 16 were dry and therefore, no samples were collected at those locations. These four locations were checked periodically, and no flow was observed at any time during the field investigation. Sump photographs taken at SWMU 16 and photographs of proposed surface water sample locations where surface water was not present for sample collection at SWMU 16 are presented in Appendix A; a minute amount of standing water at one location and dry drainage ditches at the remaining locations. The surface water sample location photographs show

Round 2

Three surface water samples were collected at SWMU 16 (16SW0102, 16SW0202, 16SW0702). All three were taken from sumps located within the SWMU 16 boundary. Four (16SW1501, 16SW1601, 16SW1901, and 16SW2201) of the 11 proposed surface water samples were not collected due to no available water at the time of sampling. Five seep samples were proposed for collection; however, no seeps were located at SWMU 16.

2.5.3 Sediment Sampling

Thirty-two sediment samples were collected from 34 locations in intermittent streams, drainage ditches, and surface runoff locations at both SWMUs during Round 1, and 20 sediment samples were collected from the proposed 20 locations in intermittent streams, drainage ditches, and surface runoff locations at both SWMUs during Round 2. Sediment samples were collected in depositional areas that contained predominantly fine (clay and silt) particles present in the streambeds or drainageways. Sediment samples were collected at a depth of 0 to 4 inches. All Round 1 sediment samples were collected in accordance with the approved QAPP (TtNUS, 2003a), and all Round 2 sediment samples were collected in accordance with Addendum No. 1 to the approved QAPP (TtNUS, 2003b). All locations were marked with

a labeled, wooden survey stake. Fluorescent flagging was tied to the stake and to a nearby tree (if available) to facilitate relocation of the sample location for surveying purposes. All pertinent field data, including sampling method, depth, description, and location were recorded on sediment sample log sheets (see Appendix C).

SWMU 13

Round 1

Twenty-three sediment samples were collected at SWMU 13. Originally, 22 locations were proposed; however, sample location 13SD23 was added based on field observations (an additional culvert located near the northern corner of the site was discovered and sampled during the field investigation).

Round 2

Nine sediment samples were collected at SWMU 13. Six of the nine new sampling locations were located in the drainage gullies southeast of SWMU 13, and three were located northeast of SWMU 13. These locations are all downgradient of the SWMU and were used to evaluate how far contaminants may have migrated from the site.

SWMU 16

Round 1

Nine of the proposed 11 sediment samples were collected at SWMU 16. Three sediment samples (16SD01, 16SD02, and 16SD07) were proposed to be collected from the bottom of the three on-site sumps; however, no sediment was found inside any of these sumps. Sediment location 16SD02, which was intended to be sampled from inside the East Sump, was relocated to a nearby drainage ditch (see Figure A-2 in Appendix A) just east of the sump. In the past, the aforementioned ditch received discharge from the sump; however, the discharge to the ditch has since been blocked and redirected to the sewer system. Sediment sampling locations 16SD01 and 16SD07 which were not sampled are associated with the North Sump and West Sump, respectively.

Round 2

Eleven sediment samples were collected at SWMU 16. The sample locations are all outside of the SWMU 16 boundary and are downgradient of the samples collected during the Round 1 investigation.

2.5.4 Ground Water Purging and Sampling

Purging and stabilization of wells prior to sampling was accomplished using low-flow techniques in accordance with SOP CTO166-16 and SOP CTO166-15. Sampling was accomplished in accordance with SOP CTO166-05.

Wells were purged prior to sampling using a peristaltic pump or bladder pump, depending on the static water level, well depth, and recharge information obtained during well development. In general, bladder pumps were used to sample wells with a static water level greater than 28 feet bgs, and peristaltic pumps were used to sample wells having a static water level less than 28 feet bgs. Disposable tubing was used with both pump types, and new, dedicated tubing was used for each well.

Ground water quality parameters including pH, specific conductance, temperature, dissolved oxygen (DO), and ORP were measured during purging at 5- to 10-minute intervals using a YSI Model 600 series multi-parameter water-quality meter and flow-through cell. Longer intervals were used for slower pumping wells. Turbidity readings were measured using a LaMotte 2020 turbidity meter. Water levels and pumping rates were also measured during purging at 5- to 10-minute intervals. Purging continued until a minimum of one well volume was removed and the above parameters stabilized or after 4 hours of purge time, in accordance with SOP CTO166-16, and SOP CTO166-15. Copies of the monitoring well low-flow purge data sheets and ground water sample log sheets for both Round 1 and Round 2 are provided in Appendix C of this document.

To the extent possible, the pumping rates were adjusted to prevent drawdown from exceeding 0.3 foot during purging. Well purging continued until all parameters stabilized and the minimum purge volume (stabilized well volume plus the extraction tubing volume) was removed. If the water quality parameters did not stabilize within 4 hours of purging, sampling was initiated and this information was recorded on the low-flow purge data sheet.

Monitoring wells were sampled with the same pump (peristaltic or bladder) and tubing used during well purging. Immediately following the purging process and before sampling, the temperature, pH, specific conductance, DO, ORP, and turbidity were measured and recorded on the ground water sample log sheet (included in Appendix C).

Sample containers were filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Samples for VOC analysis were collected by the straw method when using the peristaltic pump and were filled directly when using the bladder pump. These samples were

immediately sealed in 40-mL vials so that no headspace existed. Samples for SVOCs, explosives, explosive picrates, total metals, total mercury, ammonia, nitrate, dissolved metals, and dissolved mercury were collected next and in the order given (when applicable). Samples with turbidity values greater than 10 nephelometric turbidity units (NTUs) were field filtered for dissolved metals analyses prior to sample preservation using a 0.45 µm in-line filter.

During Round 2, several wells were also sampled for natural attenuation field parameters including DO, alkalinity, carbon dioxide, ferrous iron, hydrogen sulfide, sulfide, nitrite, and manganese.

SWMU 13

Round 1

Twenty-eight unfiltered and seven filtered ground water samples were collected at SWMU 13. Twenty-six new wells were sampled, and monitoring wells 13MWT09 and 13MWT20 were sampled twice for SVOCs only due to low surrogate recoveries encountered at the laboratory. Monitoring wells 13MWT06 and 13MWT25 were slow-recovering wells, and it took several days to fill the required containers. Refer to Appendix C for sampling details.

Round 2

Forty-eight unfiltered and 15 filtered ground water samples were collected at SWMU 13. Twenty-one new wells were installed in Round 2. Monitoring wells 13MWT06 and 13MWT45 were slow-recovering wells, and it took several days to fill the required containers. Monitoring well 13MWT28 went dry after purging and the collection of a 1-liter explosives sample. The remainder of the samples were collected the following day. Refer to Appendix C for sampling details.

SWMU 16

Round 1

Thirteen unfiltered and no filtered ground water samples were collected at SWMU 16. Originally, five new wells were proposed to be installed at SWMU 16; however, 16MWT06 was added adjacent to 16MWT01 due to that well not producing sufficient water for sampling. Six new wells were installed and one new well (16MWT06) was sampled twice. Five existing monitoring wells were sampled and one existing monitoring well location (WES-14-02-83) was sampled twice. Metals were resampled at location WES-14-02-83 for statistical background comparison, and SVOCs were resampled at this well due to low surrogate

recoveries encountered at the fixed-base laboratory. Monitoring well 16MWT06 was resampled for SVOCs only due to low surrogate recoveries encountered at the laboratory. Monitoring well 16MWT01 was a slow-recovering well, and it took 2 days to fill the required sample containers for this well. Refer to Appendix C for sampling details.

Round 2

A total of 22 ground water samples were collected at SWMU 16 from 11 existing wells and from 11 new wells installed during the Round 2 investigation. Monitoring wells 16MWT11 and 16MWT16 were slow-recovering wells; it took several days to fill the required containers for 16MWT16. Refer to Appendix C for sampling details.

2.6 FIELD SAMPLE DOCUMENTATION

Sample documentation consisted of the completion of boring logs, matrix-specific sample log sheets, sample bottle tags, chain-of-custody records, field task modification request (FTMR) forms, equipment calibration log sheets, field logbooks, and health and safety documentation. Field documentation was completed as per SOP CTO 166-03. The sample log sheets contain information such as sample location and sample ID, container requirements and analyses to be performed, sample type, time, date, and method of sample collection. Any unusual circumstances encountered during sample collection were noted on the form. Sample log sheets can be found in Appendix C of this document. Chain-of-custody records (see Appendix C.4) were used to track each sample from collection to receipt and analysis at the laboratory. FTMRs (see Appendix C.8) were used to document deviations from the approved QAPP and from the Addendum No. 1 to the approved QAPP. Equipment calibration log sheets are discussed in Section 2.9.1 and can be found in Appendix C.9 of this document. Upon completion of sample analyses, sample bottle tags were forwarded by laboratory personnel to the NSWC Crane Environmental Protection Department for storage.

2.7 SAMPLE HANDLING, PACKAGING, AND SHIPPING

Sample handling activities included the field-related considerations concerning the selection of sample containers, preservatives, allowable holding times, sample custody, and maintaining samples at the appropriate storage temperature. Sampling containers were sealed in Ziploc® plastic bags, and glass containers were wrapped in plastic bubble wrap to minimize the possibility of breakage during transport. The sample containers were then placed in a cooler lined with a large plastic garbage bag. The cooler was packed with a cushioning material (bubble wrap) to prevent container breakage. Samples were cooled immediately after collection with ice placed over the sample containers. A temperature blank was

placed in each cooler prior to shipment. The plastic garbage bag was sealed with a knot, and the chain-of-custody form was sealed in a Ziploc® bag and taped to the inside of the cooler lid. A signed and dated custody seal was applied to each end of the cooler and then covered with strapping tape to provide a tamper-evident seal. A Federal Express® airbill was applied to the shipping cooler. TtNUS maintained custody of the samples until they were relinquished to Federal Express®. The Federal Express® tracking number (airbill number) was recorded on the chain-of-custody form, and the sender's copy of the airbill was maintained for shipment tracking, if needed. All samples were shipped to the laboratories for overnight delivery and were received within sample holding times. Sample bottle tags were removed from each sample bottle by laboratory personnel and forwarded to the NSWC Environmental Protection Department.

2.8 QUALITY CONTROL SAMPLES

QA/QC samples were collected and generated during sampling activities to monitor both field and laboratory procedures. These procedures are detailed in the approved QAPP. QA/QC samples included field duplicates, equipment rinsate blanks, trip blanks, source water blanks, and temperature blanks. Field duplicate results are tabulated in Appendix F (Analytical Database) of this document. These types of QA/QC samples are briefly described below:

- Field Duplicates - Field duplicates consisted of two samples collected either independently at a sampling location at approximately the same time in the case of soil or sediment VOC samples, ground water, and surface water or as a single sample split into two portions in the case of non-VOC soil and sediment samples. Field duplicates were collected at the rate of 1 in 10 per medium and were used to assess the overall precision of the sampling and analysis program.

- Equipment Rinsate Blanks - Equipment rinsate blanks were obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through or over sample collection equipment after decontamination and before use. As a rule, 1 equipment rinsate blank per 10 samples per aqueous matrix and 20 samples per solid matrix was collected for each type of sampling equipment used (i.e., bladder pump) on a daily basis. However, when pre-cleaned, dedicated, or disposable sampling equipment was used (no decontamination was required), one equipment rinsate blank was collected as a batch blank. Additionally, bladder pump equipment rinsate blanks were collected at a rate of one equipment rinsate blank for every five samples (See the FTMR form in Appendix C.8). Equipment rinsate blanks were analyzed for the same chemical constituents as the associated environmental samples.

- Trip blanks - Trip blanks were used to determine whether contamination of the VOC samples had occurred during transit or storage. Trip blanks consisted of analyte-free water taken from the laboratory to the site and returned to the laboratory. One trip blank was submitted to the laboratory in each cooler that contained samples for VOC analyses and was analyzed for VOCs only.

- Source water blanks - Source water blanks were obtained by sampling the analyte-free water and potable water source(s) used for decontamination of sampling equipment. Source water blanks were used to determine whether analyte-free water or potable water (used for steam cleaning, etc.) contributed to sample contamination.

- Temperature blanks - Temperature blanks were used to determine if samples were adequately cooled during shipment. Temperature blanks consisted of analyte-free water poured into a clean sample container at the site or supplied by the fixed-based laboratory. One temperature blank was submitted to the laboratory in each cooler, and the temperature was checked upon receipt at the laboratory.

2.9 FIELD INSTRUMENT MEASUREMENTS

Field measurements taken and recorded during field sampling operations included water temperature, pH, specific conductance, ORP, DO, turbidity, and ground water level measurements. Ambient air measurements included monitoring of organic vapors in the breathing zone during intrusive field investigation activities and monitoring of organic vapors emanating from site sources such as soil samples and well casings. Several instruments were used during field activities to obtain these measurements including the following:

- PID
- YSI Model 6 series, multi-parameter water-quality meter
- LaMotte 2020 turbidity meter
- M-scope water-level indicator

2.9.1 Equipment Calibration

Instruments used in the field were calibrated daily prior to use according to manufacturers' requirements and in accordance with applicable SOPs. Equipment calibration logs can be found in Appendix C.9.

2.9.2 Field Investigation Preventive Maintenance Procedures/Schedule

The field instruments for this project included the PID, YSI water-quality meter, LaMotte 2020 turbidity meter, and water level indicator. The specific preventive maintenance procedures followed for field equipment were those recommended by the equipment manufacturers.

An appropriate maintenance check was performed daily on each piece of equipment. If damaged or defective parts were identified during the maintenance check, and it was determined that the damage could have an impact on the instrument's performance, the instrument was removed from service until the defective parts were repaired or replaced. Critical spare parts were kept on site to reduce downtime. Spare parts included batteries, a DO-probe membrane kit (membranes and a bottle of solution), and air particle filters for the PID. Back-up instruments and equipment were available on site or were shipped within 1 day via overnight courier to avoid delays in the field schedule.

2.10 SURVEYING

All new and existing monitoring wells, soil borings, surface water sample locations, sediment sample locations, staff gauges, and sumps were surveyed. The top of the riser pipe (where the uncapped well riser is marked), the top of the protective casing, and the ground surface elevation at each monitoring well location were surveyed to within 0.01-foot vertical accuracy. For all other locations, the ground surface elevation was surveyed to the nearest 0.10-foot. Staff gauge reference point elevations were also surveyed to the nearest 0.01 foot. Vertical elevations were referenced to the 1988 North American Vertical Datum (NAVD88). Existing survey monuments at NSWC Crane were used as reference points. Horizontal locations of samples, borings, wells, and sump pumps were surveyed to Indiana State Plane coordinates to the nearest 0.10 foot and referenced to the 1927 North American Datum (NAD27). All surveying was performed by a surveyor professionally licensed in the State of Indiana. Copies of the survey data can be found in Appendix D.3.

2.11 DECONTAMINATION

The nondedicated, nondisposable equipment involved in field sampling activities was decontaminated before beginning work, during drilling and sampling activities, and at the completion of the RFI activities in accordance with SOP CTO166-16. This equipment included drilling rigs, down-hole tools, augers, and soil and water sampling equipment.

2.11.1 Major Equipment

All down-hole equipment, including down-hole drilling tools, were steam cleaned with high-pressure hot water prior to beginning work, between borings, and at the conclusion of each shift of drilling.

Well riser pipe and screens were supplied at the site in certified clean packaging. All decontamination activities took place at a predetermined area within NSWC Crane.

2.11.2 Sampling Equipment

All nondedicated (reusable) equipment used for collecting samples was decontaminated both before field sampling, between sample collections, and at the end of each sampling event. This equipment included stainless steel trowels, stainless steel mixing bowls, bladder pumps, etc. The following decontamination steps were taken:

- Potable water and phosphate-free detergent wash (scrub if necessary)
- Potable water rinse
- Deionized (DI) water rinse
- Air dry (if possible)
- Wrap in aluminum foil (if not to be used immediately)

An isopropanol rinse was not necessary because no oily residue was evident on the sampling equipment.

Field analytical equipment such as pH, conductivity, and temperature probes were rinsed first with analyte-free water then with the sample prior to making measurements. Water level measurement devices were rinsed with DI water.

2.12 WATER LEVEL MEASUREMENTS AND AQUIFER TESTING

2.12.1 Ground Water Level Measurements

Water level measurements were obtained from each monitoring well prior to development and purging. In addition, two complete synoptic rounds of water levels were taken including all the wells at both sites. Each round of synoptic water level measurements was obtained within a 4-hour time period. Measurements were taken with an electrical water level indicator (M-scope), using the top of the riser pipe as the reference point to determine water depth for monitoring wells and using a surveyed mark for staff gauge measurements. All measurements were taken in accordance with SOP CTO 166-18 contained in

Appendix H of the approved QAPP (TtNUS, 2003a), and SOP CTO166-17 contained in Appendix E of the Addendum No. 1 to the approved QAPP (TtNUS, 2003b). A mark was placed at the top of the riser pipe to ensure that measurements were taken from a consistent reference point. Water level measurements and staff gauge measurements were recorded to the nearest 0.01 foot on ground water level measurement forms, provided in Appendix C of this document. Tables 1-1 (SWMU 13) and 1-2 (SWMU 16) contain water level/elevation data.

SWMU 13

Water level measurements were collected at SMWU 13 on May 5 and 11, 2003 (Round 1) and January 19 and 20, 2004, (Round 2). Staff gauges at SWMU 13 were measured on May 11, 2003 (Round 1) and January 19, 2004 (Round 2). Round 2 water level data were used to determine ground water flow directions.

SWMU 16

Water level measurements were collected at SWMU 16 on May 5 and 30, 2003 (Round 1) and January 24, 2004 (Round 2). The May 30 round of water level measurements was used to determine ground water flow direction for Round 1 because these measurements were considered more representative of static conditions based on the longer equilibrium time.

2.12.2 Staff Gauge Installation and Estimation of Stream Flow

Staff gauges were installed at the culverts of drainage ditches and intermittent streams where flowing water was observed. Marks were placed on these permanent structures denoting the point where measurements would be taken and the staff gauge number. Staff gauge measurements were collected at SWMU 13 on May 11, 2003 (Round 1) and January 19, 2004 (Round 2) in conjunction with monitoring well measurements. Staff gauges were not installed at SWMU 16 during Round 1 or Round 2 due to the lack of surface water

Ten staff gauges were installed at SWMU 13 on March 29, 2003 during Round 1 and one was installed on January 19, 2004 during Round 2. Refer to Figure A-1 in Appendix A for staff gauge locations at SWMU 13. Refer to Appendix A for photographs of surface water body features at SWMU 13.

Stream flow estimates were made based on visual observations and can be found in Appendix C. Due to shallow depths, dense grassy cover, and/or natural features interfering with adequate unrestricted stream/drainage ditch runs, stream flow measurement SOP CTO166-20 could not be followed.

2.12.3 Aquifer Testing

Slug tests were performed at SWMU 13 and SWMU 16 to determine the hydraulic characteristics of the formation in the immediate vicinity of the wells. Tables 1-3 (SWMU 13) and 1-4 (SWMU 16) provide slug test data evaluation results.

During slug testing, the change in water level in the wells was induced by withdrawing (rising head) or introducing (falling head) a solid PVC slug with a volume equivalent to approximately 2 to 3 feet of displacement in a 2-inch well. In some instances, one or two bailers (one bailer induces approximately 1.5 feet of displacement in a 2-inch well) were used to withdraw water to initiate the water level change. Monitoring wells with a water level below the top of the well screen were tested only using the rising head method and in most cases using a bailer to induce the water level change. Monitoring wells with 3 feet or less of standing water were not slug tested.

Prior to performing each slug test, the static water level in the monitoring well was measured using an electronic water-level indicator. Water levels were recorded with a pressure transducer at linear and logarithmic intervals of time via a programmed electronic data logger as the head returned to the original static water level. The time and the rate of change required for the water level to return to the original static water level are functions of the transmissivity and hydraulic conductivity of the aquifer. The resulting drawdown data from the slug tests were evaluated using the Hvorslev Method (Fetter, 1998). The geometric mean is the best measure of central tendency; therefore, the average hydraulic conductivity for the site is best presented as the geometric mean of the test results.

SWMU 13

Slug tests were performed in eight shallow monitoring wells at SWMU 13 during Round 1 and in seven shallow wells and four deep wells during Round 2 (see Appendix E for specific well locations).

SWMU 16

Slug tests were performed at two shallow wells and one intermediate well at SWMU 16 during Round 1 and in three shallow wells and one deep well during Round 2 (see Appendix E for specific well locations).

2.13 FIELD CORRECTIVE ACTION

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or "out of quality control" performance that can affect data quality, or modifying procedures to address unexpected/unusual field conditions encountered.

Corrective action in the field resulted when substantive changes were made to the sampling network (i.e., more/fewer samples collected, sampling locations other than those specified, etc.) and when sampling procedures or field analytical procedures required modification. For example, monitoring well 16MWT06 was installed to compensate for low-yielding monitoring well 16MWT01. Project personnel reported all suspected technical or QA nonconformance or suspected deficiencies of any activity or issued document to the FOL or designee. The Task Order Manager (TOM) was responsible for assessing the suspected problems in consultation with the project QA/QC Manager and for making a decision based on the potential for the situation to affect the quality of the data. If it was determined that the situation warranted a reportable nonconformance requiring corrective action, a nonconformance report was initiated by the TOM. No nonconformances or suspected deficiencies occurred during this field investigation; however, 14 deviations from the approved QAPP occurred during the Round 1 RFI activities, and one deviation from the Addendum No. 1 to the approved QAPP occurred during Round 2. These deviations were addressed using FTMR forms, copies of which are included in Appendix C.11.

2.14 INVESTIGATION-DERIVED WASTE HANDLING

The field investigations generated several types of potentially contaminated wastes including personal protective equipment (PPE), decontamination fluids from the drill rig, backhoe, and bulldozer, sampling equipment decontamination fluids, DPT plastic sleeves, development and purge water, and soil cuttings. Management of each residue was performed as follows:

PPE, Pump Tubing, and DPT Plastic Sleeves – All PPE, tubing, and plastic sleeves were decontaminated, double bagged, and placed in NSWC Crane trash receptacles (i.e., dumpsters).

Purge Water, Development Water, Drill and Sampling Equipment Decontamination Fluids – All well development and purge waters and equipment decontamination fluids were collected and discharged to the NSWC Crane permitted waste treatment plant.

Waste Cuttings and Rock Cores from Drilling Activities – For each boring, the cuttings produced were scanned for VOCs. VOC readings were at background levels for all borings, and cuttings were therefore

used as backfill if the boring terminated above the water table. Any remaining cuttings were spread on the ground in the immediate vicinity of the boring.

Additional requirements for IDW handling can be found in SOPs CTO166-15 contained in Appendix H of the approved QAPP (TtNUS, 2003a), and CTO166-14 contained in Appendix E of the Addendum No. 1 to the approved QAPP (TtNUS, 2003b).

2.15 SITE MANAGEMENT AND FACILITY SUPPORT

The FOL was designated as the lead in coordinating all day-to-day activities during the investigation. The FOL was responsible for ensuring that all field team members (including subcontractors) were familiar with the approved QAPP for Round 1, the Addendum No. 1 to the approved QAPP for Round 2, and the site-specific HASP. Additionally, the FOL was responsible for all sampling operations, QA/QC, field documentation requirements, and field change orders. The FOL reported to the TOM on a daily basis regarding the status of fieldwork.

All site preparation, mobilization/demobilization, and sampling activities were coordinated through NSWC Crane personnel.

2.16 RECORDKEEPING

Various hardcover, bound record books were maintained for each field activity in accordance with SOP CTO166-03. The Master Site Logbook served as the overall record of field activities. Information recorded daily in the Master Site Logbook included daily field activities, weather conditions, identity of and arrival and departure times of personnel, management issues, etc. Various field notebooks were also maintained. For example, the site geologist supervising monitoring well installation operations maintained a field notebook. Copies of field log books are included in Appendix D.

The FOL was responsible for the maintenance and security of all field records. Eventually, all field records, chain-of-custody forms, sample log sheets, field forms, logbooks, and notebooks were docketed and incorporated in the central project file for CTO 0279.

2.17 RESTORATION AND REVEGETATION

Round 1

At the conclusion of Round 1 field activities, TtNUS performed site restoration and revegetation on all areas impacted by drilling activities and/or heavy equipment (i.e. backhoe and bulldozer) operations at SWMUs 13 and 16.

Round 2

At the conclusion of Round 2 field activities, it was determined that the ground surface was too hard to perform site restoration and revegetation. Restoration was subsequently completed on April 15 and 16, 2004.

TABLE 2-1

INSTALLATION DATES AND DEPTHS OF MONITORING WELLS AND SOIL BORINGS, AND DEPTHS OF SOIL SAMPLES COLLECTED
SWMU 13 - MINE FILL B
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Boring or Well No.	Total Depth (feet bgs)	Drilling Method[1]	Date Drilled	Depth Interval(s) of Soil Samples (feet bgs)
SWMU 13 - Round 1				
13MWT01	15	RS	30-Mar-03	NS
13MWT02	27	RS	29-Mar-03	NS
13MWT03	15	RS	30-Mar-03	NS
13MWT04	15	RS	30-Mar-03	NS
13MWT05	16	RS	29-Mar-03	NS
13MWT06	15	RS	7-Apr-03	NS
13MWT07	15	RS	29-Mar-03	NS
13MWT08	15	RS	30-Mar-03	NS
13MWT09	20	RS	1-Apr-03	NS
13MWT10	25	RS	27-Mar-03	NS
13MWT11	15	RS	28-Mar-03	NS
13MWT12	20	RS	27-Mar-03	NS
13MWT13	19	HSA	23-Apr-03	NS
13MWT14	23	RS	31-Mar-03	NS
13MWT15	25	RS	25-Mar-03	NS
13MWT16	15	RS	27-Mar-03	NS
13MWT17	18	RS	26-Mar-03	NS
13MWT18	30	RS	26-Mar-03	NS
13MWT19	19	RS	31-Mar-03	NS
13MWT20	20	RS	1-Apr-03	NS
13MWT21	15	RS	24-Mar-03	NS
13MWT22	15	RS	28-Mar-03	NS
13MWT23	21.5	RS	1-Apr-03	NS
13MWT24	22	RS	1-Apr-03	NS
13MWT25	15	RS	28-Mar-03	NS
13MWT26	20	RS	28-Mar-03	NS
13SB01	4	DPT	25-Mar-03	0 - 2, 2 - 4
13SB02	4	DPT	25-Mar-03	0 - 2, 2 - 4
13SB03	4	DPT	25-Mar-03	0 - 2, 2 - 4
13SB04	4	DPT	25-Mar-03	0 - 2, 2 - 4
13SB05	4	DPT	25-Mar-03	0 - 2, 2 - 4
13SB06	4	DPT	25-Mar-03	0 - 2, 2 - 4
13SB07	10	DPT	26-Mar-03	0 - 2, 8 - 10
13SB08	8	RS	30-Mar-03	0 - 2, 6 - 8
13SB09	4	DPT	26-Mar-03	0 - 2, 2 - 4
13SB10	4	DPT	26-Mar-03	0 - 2, 2 - 4
13SB11	4	DPT	26-Mar-03	0 - 2, 2 - 4

TABLE 2-1

INSTALLATION DATES AND DEPTHS OF MONITORING WELLS AND SOIL BORINGS, AND DEPTHS OF SOIL SAMPLES COLLECTED
SWMU 13 - MINE FILL B
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Boring or Well No.	Total Depth (feet bgs)	Drilling Method[1]	Date Drilled	Depth Interval(s) of Soil Samples (feet bgs)
SWMU 13 - Round 1 (cont'd)				
13SB12	4	DPT	26-Mar-03	0 - 2, 2 - 4
13SB13	4	DPT	26-Mar-03	0 - 2, 2 - 4
13SB14	2	HA	10-Apr-03	0 - 2
13SB15	4	DPT	10-Apr-03	0 - 2, 2 - 4
SWMU 13 - Round 2				
13MWT27	21	RS	05-Nov-03	NS
13MWT28	88	RS	03-Nov-03	NS
13MWT29	20	HSA	04-Nov-03	NS
13MWT30	25	HSA	06-Nov-03	NS
13MWT31	20	HSA	05-Nov-03	NS
13MWT32	25	RS	10-Oct-03	NS
13MWT33	20	HSA	06-Nov-03	NS
13MWT34	20.5	HSA	11-Nov-03	NS
13MWT35	69	RS	19-Nov-03	NS
13MWT36	26	HSA	05-Nov-03	NS
13MWT37	25	RS	24-Oct-03	NS
13MWT38	80	RS	04-Nov-03	NS
13MWT39	25	RS	04-Nov-03	NS
13MWT40	25.5	RS	23-Oct-03	NS
13MWT41	66	RS	10-Nov-03	NS
13MWT42	25	RS	22-Oct-03	NS
13MWT43	21	RS	06-Nov-03	NS
13MWT44	88	RS	06-Nov-03	NS
13MWT45	84	RS	10-Nov-03	NS
13MWT46	68	RS	22-Nov-03	NS
13MWT47	21	RS	19-Nov-03	NS
13SB16	4	HA	8-Dec-03	0 - 2, 2 - 4
13SB17	4	HA	8-Dec-03	0 - 2, 2 - 4
13SB18	4	HA	8-Dec-03	0 - 2, 2 - 4
13SB19	3	HA	8-Dec-03	0 - 2, 2 - 3
13SB20	1	HA	8-Dec-03	0 - 1
13SB21	4	HA	8-Dec-03	0 - 2, 2 - 4
13SB22	4	HA	8-Dec-03	0 - 2, 2 - 4
13SB23	4	HA	8-Dec-03	0 - 2, 2 - 4
13SB24	3	HA	8-Dec-03	0 - 2, 2 - 3
13SB25	4	HA	8-Dec-03	0 - 2, 2 - 4

TABLE 2-1

INSTALLATION DATES AND DEPTHS OF MONITORING WELLS AND SOIL BORINGS, AND DEPTHS OF SOIL SAMPLES COLLECTED
SWMU 13 - MINE FILL B
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Boring or Well No.	Total Depth (feet bgs)	Drilling Method[1]	Date Drilled	Depth Interval(s) of Soil Samples (feet bgs)
SWMU 16 - Round 1				
16MWT01	24	RS	8-Apr-03	NS
16MWT02	18	RS	11-Apr-03	NS
16MWT03	35	RS	10-Apr-03	NS
16MWT04	25	RS	9-Apr-03	NS
16MWT05	40	RS	9-Apr-03	NS
16MWT06	25	RS	24-Apr-03	NS
16SB01	6	DPT	27-Mar-03	0 - 2, 4 - 6
16SB02	6	DPT	27-Mar-03	0 - 2, 4 - 6
16SB03	2	DPT	27-Mar-03	0 - 2
16SB04	2	DPT	27-Mar-03	0 - 2
16SB05	2	DPT	27-Mar-03	0 - 2
16SB06	2	DPT	27-Mar-03	0 - 2
16SB07	2	DPT	27-Mar-03	0 - 2
16SB08	2	DPT	27-Mar-03	0 - 2
16SB09	2	DPT	27-Mar-03	0 - 2
16SB10	2	DPT	27-Mar-03	0 - 2
16SB11	4	DPT	27-Mar-03	0 - 2, 2 - 4
16SB12	4	DPT	28-Mar-03	0 - 2, 2 - 4
16SB13	4	DPT	28-Mar-03	0 - 2, 2 - 4
16SB14	2	DPT	27-Mar-03	0 - 2
16SB15	2	DPT	27-Mar-03	0 - 2
16SB16	2	DPT	27-Mar-03	0 - 2
16SB17	4	DPT	27-Mar-03	0 - 2, 2 - 4
16SB18	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB19	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB20	2	DPT	28-Mar-03	0 - 2
16SB21	2	DPT	28-Mar-03	0 - 2
16SB22	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB23	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB24	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB25	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB26	4	RS	9-Apr-03	0 - 2, 2 - 4
16SB27	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB28	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB29	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB30	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB31	2	DPT	28-Mar-03	0 - 2

TABLE 2-1

INSTALLATION DATES AND DEPTHS OF MONITORING WELLS AND SOIL BORINGS, AND DEPTHS OF SOIL SAMPLES COLLECTED
SWMU 13 - MINE FILL B
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Boring or Well No.	Total Depth (feet bgs)	Drilling Method[1]	Date Drilled	Depth Interval(s) of Soil Samples (feet bgs)
SWMU 16 - Round 1 (cont'd)				
16SB32	4	RS	9-Apr-03	0 - 2, 2 - 4
16SB33	4	RS	9-Apr-03	0 - 2, 2 - 4
16SB34	3	RS	9-Apr-03	0 - 3
16SB35	2	DPT	28-Mar-03	0 - 2
16SB36	3	RS	9-Apr-03	0 - 2, 2 - 3
16SB37	2	DPT	28-Mar-03	0 - 2
16SB38	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB39	3	DPT	28-Mar-03	0 - 2, 2 - 3
16SB40	8	DPT	28-Mar-03	5 - 6, 6 - 8
16SB41	7	DPT	27-Mar-03	3 - 5, 5 - 7
SWMU 16 - Round 2				
16MWT07	25.5	HSA	11-Nov-03	NS
16MWT08	99	RS	9-Nov-03	NS
16MWT09	25	HSA	8-Nov-03	NS
16MWT10	25	HSA	9-Nov-03	NS
16MWT11	98	HSA	11-Nov-03	NS
16MWT12	26.5	HSA	7-Nov-03	NS
16MWT13	19	HSA	11-Nov-03	NS
16MWT14	25	HSA	7-Nov-03	NS
16MWT15	92	RS	9-Nov-03	NS
16MWT16	40	HSA	9-Nov-03	NS
16MWT17	24	HSA	8-Nov-03	NS
16MWT18	105	RS	18-Jan-04	NS
16SS42	2	HA	5-Dec-03	0 - 1, 1 - 2
16SS43	2	HA	5-Dec-03	0 - 1, 1 - 2
16SS44	2	HA	5-Dec-03	0 - 1, 1 - 2
16SS45	2	HA	5-Dec-03	0 - 1, 1 - 2
16SS46	2	HA	5-Dec-03	0 - 1, 1 - 2
16SB47	5	HA	5-Dec-03	0 - 1, 1 - 5
16SB48	3	HA	5-Dec-03	0 - 1, 1 - 3
16SB49	5	HA	5-Dec-03	0 - 1, 1 - 5
16SB50	3	HA	5-Dec-03	0 - 1, 1 - 3

1 HA = Hand Auger, DPT = Direct Push Technology, RS = Rotosonic, HSA = Hollow Stem Auger.
NS - Not sampled.

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
SWMU 13																			
Ground Water																			
13GWT0101						X		X	X	X	X								
13GWT0201						X		X	X	X	X								
13GWT0301						X		X	X	X	X								
13-GWT0301-F								X	X										
13GWT0401						X		X	X	X	X								
13GWT0501						X		X	X	X	X								
13GWT0501-F								X	X										
13GWT0601						X		X	X	X	X								
13GWT0601-F								X	X										
13GWT0701						X		X	X	X	X								
13GWT0801						X		X	X	X	X								
13GWT0901	X					X	X	X	X	X	X	X	X	X					
13GWT0902												X							
13GWT1001						X		X	X	X	X								
13GWT1101						X		X	X	X	X								
13GWT1201						X		X	X	X	X								
13GWT1201-F								X	X										
13GWT1301						X		X	X	X	X								
13GWT1401						X		X	X	X	X								
13GWT1501						X		X	X	X	X								
13GWT1601						X		X	X	X	X								
13GWT1701						X		X	X	X	X								
13GWT1801						X		X	X	X	X								
13GWT1801-F							X	X											
13GWT1901						X		X	X	X	X								
13GWT2001	U					X	U	X	X	X	X	U	U	U			U		
13GWT2001-F								X	X										
13GWT2002												X							
13GWT2101						X		X	X	X	X								
13GWT2201						X		X	X	X	X								
13GWT2301						X		X	X	X	X								
13GWT2401						X		X	X	X	X								
13GWT2501						X		X	X	X	X								
13GWT2501-F							X	X											

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
13GWT2601						X		X	X	X	X								
Totals																			
x	1	0	0	0	0	26	3	33	31	26	26	3	1	1	0	0	0	0	0
u	1	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	1	0	0
o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWMU 13																			
Subsurface Soil																			
13SB010204					X		X					X		X	X				
13SB020204					X		X					X		X	X				
13SB030204					X		X					X		X	X				
13SB040204					X		X					X		X	X				
13SB050204					X		X					X		X	X				
13SB060204	X				X		X					X	X	X	X				
13SB070810				X						O						X			X
13SB080608				X						O						X			X
13SB090204					X		X					X		X	X				
13SB100204					X		X					X		X	X				
13SB110204					X		X					X		X	X				
13SB120204					X		X					X		X	X				
13SB130204					X		X					X		X	X				
13SB14					O		O					O		O	O				
13SB150204	U				O		O					O	U	O	O				
13SB16					O		O					O		O	O				
Totals																			
x	1	0	0	2	11	0	11	0	0	0	0	11	1	11	11	2	0	0	2
u	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
o	0	0	0	0	3	0	3	0	0	2	0	3	0	3	3	0	0	0	0
SWMU 13																			
Sediment																			
13SD010004						X		X	X										
13SD020004			X	X		X		X	X							X		X	X
13SD030004						X		X	X										
13SD040004						X	X	X	X			X		X					
13SD050004			X	X		X	X	X	X			X		X		X		X	X
13SD060004						X	X	X	X			X		X					
13SD070004						X		X	X										

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
13SD080004			X	X		X		X	X							X		X	X
13SD090004						X		X	X										
13SD100004						X		X	X										
13SD110004			X	X		X		X	X							X		X	X
13SD120004						X		X	X										
13SD130004						X		X	X										
13SD140004			X	X		X		X	X							X		X	X
13SD150004						X		X	X										
13SD160004						X		X	X										
13SD170004			X	X		X		X	X							X		X	X
13SD180004						X		X	X										
13SD190004						X		X	X										
13SD200004			X	X		X		X	X							X		X	X
13SD210004						X		X	X										
13SD220004						X		X	X										
13SD230004						U		U	U										
Totals																			
x	0	0	7	7	0	22	3	22	22	0	0	3	0	3	0	7	0	7	7
u	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWMU 13																			
Surface Soil																			
13SS010002					X		X					X		X	X				
13SS020002					X		X					X		X	X				
13SS030002					X		X					X		X	X				
13SS040002					X		X					X		X	X				
13SS050002					X		X					X		X	X				
13SS060002	X				X		X					X	X	X	X				
13SS070002				X						O						X			X
13SS080002				X						O						X			X
13SS090002					X		X					X		X	X				
13SS100002					X		X					X		X	X				
13SS110002					X		X					X		X	X				
13SS120002					X		X					X		X	X				
13SS130002					X		X					X		X	X				
13SS140001					X		X					X		X	X				

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
13SS150002	U				O		O					O	U	O	O				
13SS16					O		O					O		O	O				
Totals																			
x	1	0	0	2	12	0	12	0	0	0	0	12	1	12	12	2	0	0	2
u	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
o	0	0	0	0	2	0	2	0	0	2	0	2	0	2	2	0	0	0	0
SWMU 13																			
Surface Water																			
13SW0101						X		X	X	X	X								
13SW0101-F								X	X										
13SW0201						X		X	X	X	X								
13SW0201-F								X	X										
13SW0301						X		X	X	X	X								
13SW0301-F								X	X										
13SW0401						X	U	X	X	X	X	U		U					
13SW0401-F								X	X										
13SW0501						X	U	X	X	X	X	U		U					
13SW0501-F								X	X										
13SW0601						X	U	X	X	X	X	U		U					
13SW0601-F								X	X										
13SW0701						X		X	X	X	X								
13SW0701-F								X	X										
13SW0801						X		X	X	X	X								
13SW0801-F								X	X										
13SW0901						X	O	X	X	X	X	O		O					
13SW0901-F								X	X										
13SW1001						X		X	X	X	X								
13SW1001-F								X	X										
13SW1101						X		X	X	X	X								
13SW1101-F								X	X										
13SW1201						X		X	X	X	X								
13SW1201-F								X	X										
13SW1301						X		X	X	X	X								
13SW1301-F								X	X										
Totals																			

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
x	0	0	0	0	0	13	0	26	26	13	13	0	0	0	0	0	0	0	0
u	0	0	0	0	0	0	3	0	0	0	0	3	0	3	0	0	0	0	0
o	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0
SWMU 16																			
Ground Water																			
16GW0101	X					X	X	X	X	X	X	X	X	X			X		
16GW0201	X					X	X	X	X	X	X	X	X	X			X		
16GW0202								X	X										
16GW0301	X					X	X	X	X	X	X	X	X	X			X		
16GW0401	X					X	X	X	X	X	X	X	X	X			X		
16GW0501	X					X	X	X	X	X	X	X	X	X			X		
16GWT0101	X												X						
16GWT0201	X					X	X	X	X	X	X	X	X	X			X		
16GWT0301	X					X	X	X	X	X	X	X	X	X			X		
16GWT0401	X					X	X	X	X	X	X	X	X	X			X		
16GWT0501	X					X	X	X	X	X	X	X	X	X			X		
16GWT0601	X					X	X	X	X	X	X	X	X	X			X		
16GWT0602												X							
Totals																			
x	11	0	0	0	0	10	10	11	11	10	10	11	11	10	0	0	10	0	0
u	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWMU 16																			
Subsurface Soil																			
16SB010406						X	X	X	X			X	X	X	X		X		
16SB020406				X		X	X	X	X			X	X	X	X	X	X		X
16SB03						O	O	O	O			O	O	O	O		O		
16SB04						O	O	O	O			O	O	O	O		O		
16SB05						O	O	O	O			O		O			O		
16SB06						O	O	O	O			O		O			O		
16SB07				O		O	O	O	O			O		O		O	O		O
16SB08						O	O	O	O			O		O			O		
16SB09						O	O	O	O			O		O			O		
16SB10						O	O	O	O			O		O			O		
16SB110204						X	X	X	X			X	X	X	X		X		

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
16SB120204				X		X	X	X	X			X	X	X	X	X	X		X
16SB130204						X	X	X	X			X	X	X	X		X		
16SB14						O	O	O	O			O		O			O		
16SB15						O	O	O	O			O		O			O		
16SB16						O	O	O	O			O		O			O		
16SB170204						X	X	X	X			X	X	X	X		X		
16SB180203				X		X	X	X	X			X	X	X	X	X	X		X
16SB190203						X	X	X	X			X	X	X	X		X		
16SB20						O	O	O	O			O		O			O		
16SB21						O	O	O	O			O		O			O		
16SB220203						X	X	X	X			X	X	X	X		X		
16SB230203						X	X	X	X			X		X			X		
16SB240203				X		X	X	X	X			X		X		X	X		X
16SB250203						X	X	X	X			X		X			X		
16SB260204						X	X	X	X			X		X			X		
16SB270203						X	X	X	X			X		X			X		
16SB280203						X	X	X	X			X		X			X		
16SB290203						X	X	X	X			X		X			X		
16SB300203						X	X	X	X			X		X			X		
16SB31				O		O	O	O	O			O		O		O	O		O
16SB320204						X	X	X	X			X		X			X		
16SB330204						X	X	X	X			X		X			X		
16SB340203						X	X	X	X			X		X			X		
16SB35						O	O	O	O			O	O	O			O		
16SB360203						X	X	X	X			X	X	X			X		
16SB37				O		O	O	O	O			O	O	O		O	O		O
16SB380203						X	X	X	X			X	X	X	X		X		
16SB390203						X	X	X	X			X	X	X	X		X		
16SB400506	X					X	X	X	X			X	X	X			X		
16SB400608	X					X	X	X	X			X	X	X			X		
16SB410305	X			X		X	X	X	X			X	X	X		X	X		X
16SB410507	X			X		X	X	X	X			X	X	X		X	X		X
Totals																			
x	4	0	0	6	0	27	27	27	27	0	0	27	16	27	11	6	27	0	6
u	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o	0	0	0	3	0	16	16	16	16	0	0	16	4	16	2	3	16	0	3

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
SWMU 16																			
Sediment																			
16SD01						O		O	O			O							
16SD020004		X	X	X		X	X	X	X			X		X		X	X	X	X
16SD030004						X	X	X	X			X		X			X		
16SD040004						X	X	X	X			X		X			X		
16SD050004						X	X	X	X			X		X			X		
16SD060004		X	X	X		X	X	X	X			X		X		X	X	X	X
16SD07						O		O	O			O							
16SD080004						X	X	X	X			X		X			X		
16SD090004		X	X	X		X	X	X	X			X		X		X	X	X	X
16SD100004						X	X	X	X			X		X			X		
16SD110004						X	X	X	X			X		X			X		
Totals																			
x	0	3	3	3	0	9	9	9	9	0	0	9	0	9	0	3	9	3	3
u	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o	0	0	0	0	0	2	0	2	2	0	0	2	0	0	0	0	0	0	0
SWMU 16																			
Surface Soil																			
16SS010002	X					X	X	X	X			X	X	X	X		X		
16SS020002	X			X		X	X	X	X			X	X	X	X	X	X		X
16SS030002	X					X	X	X	X			X	X	X	X		X		
16SS040002	X					X	X	X	X			X	X	X	X		X		
16SS050002	X					X	X	X	X			X	X	X	X		X		
16SS060002	X				X	X	X	X	X			X	X	X	X		X		
16SS070002	X			X	X	X	X	X	X			X	X	X	X	X	X		X
16SS080002	X				X	X	X	X	X			X	X	X	X		X		
16SS090002	X				X	X	X	X	X			X	X	X	X		X		
16SS100002	X				X	X	X	X	X			X	X	X	X		X		
16SS110002	X				X	X	X	X	X			X	X	X	X		X		
16SS120002	X			X	X	X	X	X	X			X	X	X	X	X	X		X
16SS130002	X				X	X	X	X	X			X	X	X	X		X		
16SS140002	X				X	X	X	X	X			X	X	X	X		X		
16SS150002	X				X	X	X	X	X			X	X	X	X		X		
16SS160002	X				X	X	X	X	X			X	X	X	X		X		
16SS170002	X				X	X	X	X	X			X	X	X	X		X		

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
16SS180002	X			X	X	X	X	X	X			X	X	X	X	X	X		X
16SS190002	X				X	X	X	X	X			X	X	X	X		X		
16SS200002	X				X	X	X	X	X			X	X	X			X		
16SS210002	X				X	X	X	X	X			X	X	X			X		
16SS220002	X				X	X	X	X	X			X	X	X			X		
16SS230002	X				X	X	X	X	X			X	X	X			X		
16SS240002	X			X	X	X	X	X	X			X	X	X		X	X		X
16SS250002	X				X	X	X	X	X			X	X	X			X		
16SS260002	X				X	X	X	X	X			X	X	X	X		X		
16SS270002	X				X	X	X	X	X			X	X	X	X		X		
16SS280002	X				X	X	X	X	X			X	X	X	X		X		
16SS290002	X				X	X	X	X	X			X	X	X	X		X		
16SS300002	X				X	X	X	X	X			X	X	X	X		X		
16SS310002	X			X	X	X	X	X	X			X	X	X	X	X	X		X
16SS320002	X				X	X	X	X	X			X	X	X	X		X		
16SS330002	X				X	X	X	X	X			X	X	X	X		X		
16SS340002	X					X	X	X	X			X	X	X			X		
16SS350002	X					X	X	X	X			X	X	X			X		
16SS360002	X					X	X	X	X			X	X	X			X		
16SS370002	X			X		X	X	X	X			X	X	X	X	X	X		X
16SS380002	X					X	X	X	X			X	X	X	X		X		
16SS390002	X					X	X	X	X			X	X	X	X		X		
Totals																			
x	39	0	0	7	28	39	39	39	39	0	0	39	39	39	30	7	39	0	7
u	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
o	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SWMU 16																			
Surface Water																			
16SW0101						X	X	X	X	U	X	X		X			X		
16SW0101-F								X	X										
16SW0201						X	X	X	X	U	X	X		X			X		
16SW0201-F								X	X										
16SW03						O		O	O		O	O							
16SW04						O		O	O		O	O							
16SW05						O		O	O		O	O							
16SW06						O		O	O		O	O							

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC
16SW0701						X	X	X	X	U	X	X		X			X		
16SW0701-F								X	X										
Totals																			
x	0	0	0	0	0	3	3	6	6	0	3	3	0	3	0	0	3	0	0
u	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
o	0	0	0	0	0	4	0	4	4	0	4	4	0	0	0	0	0	0	0
Field Duplicates																			
FD03250301					X		X					X		X	X				
FD03260301					X		X					X		X	X				
FD03270301	X				X	X	X	X	X			X	X	X	X		X		
FD03270302	X				X	X	X	X	X			X	X	X	X		X		
FD03280301	X				X	X	X	X	X			X	X	X			X		
FD03280302						X	X	X	X			X		X			X		
FD03280303	X					X	X	X	X			X	X	X			X		
FD03290301			X	X		X		X	X							X		X	X
FD03290302						X		X	X										
FD03290303						X		X	X	X	X								
FD03290303-F								X	X										
FD03300301				X												X			X
FD04010301						X	X	X	X			X		X			X		
FD04010302		X	X	X		X	X	X	X			X		X		X	X	X	X
FD04090301															X				
FD04090302	X					X	X	X	X			X	X	X	X		X		
FD04090303						X	X	X	X			X		X			X		
FD04100301						X	X	X	X	X	X	X		X			X		
FD04100301-F								X	X										
FD04240301	X					X	X	X	X	X	X	X	X	X			X		
FD04250301						X		X	X	X	X								
FD04280301	X					X	X	X	X	X	X	X	X	X					
FD05070301						X		X	X	X	X								
FD05090301												X							

TABLE 2-2

ROUND 1 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND
SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																		
	ALC	AVS	AVS/SEM	CEC	DIOX	EXP	HERB	HG	METALS	NH3	NTIA	SVOC	VOC	PAH	PCB	PH	PIC	SEM	TOC

X = Analyzed.
U = Unscheduled.
O = Omitted.
ALC - 1,4-dioxane, acetonitrile, isobutyl alcohol, propionitrile as determined by Method 8015B.
AVS - Acid volatile sulfide.
AVS/SEM - Acid volatile/simultaneously extracted metals.
CEC - Cation exchange capacity.
DIOX - Dioxins.
EXP - Explosives.
HERB - Herbicides.
HG - Mercury.
NH3 - Ammonia.
NTIA - Nitrite/nitrate.
SVOC - Semivolatile organic comounds.
VOC - Volatile organic compounds.
PAH - Polynuclear aromatic hydrocarbon.
PCB - Polychlorinated biphenyl.
PIC - Picrates, (picric acid, picrimic acid).
SEM - Simultaneously extracted metals.
TOC - Total organic carbon.
Water samples with a -F designation were filtered in the field prior to preparation.
Metals - U.S. EPA Contract Laboratory Program Target Analyte List Metals.

TABLE 2-3

ROUND 2 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample ID	Analytical Fraction										
	VOC	SIM	EXP	PCB	Metals	NTIA	NH3	S/C	MEE	TOC	MNA
SWMU 13											
Ground Water											
13GWT0102			X		X	X	X				
13GWT0202			X		X	X	X				X
13GWT0302			X		X	X	X			X	X
13GWT0302-F					X						
13GWT0402			X		X	X	X				
13GWT0502			X		X	X	X				X
13GWT0502-F					X						
13GWT0602			X		X	X	X				
13GWT0602-F					X						
13GWT0702			X		X	X	X				
13GWT0802			X		X	X	X				X
13GWT0802-F					X						
13GWT0903			X		X	X	X				X
13GWT1002			X		X	X	X			X	X
13GWT1102			X		X	X	X				X
13GWT1202			X		X	X	X				X
13GWT1302			X		X	X	X				X
13GWT1402			X		X	X	X				
13GWT1501									U		
13GWT1502			X		X	X	X			X	X
13GWT1502-F					X						
13GWT1602			X		X	X	X				
13GWT1702			X		X	X	X				X
13GWT1802			X		X	X	X				X
13GWT1802-F					X						
13GWT1902			X		X	X	X				
13GWT2003			X		X	X	X				X
13GWT2102			X		X	X	X				X
13GWT2202			X		X	X	X				X
13GWT2302			X		X	X	X				X
13GWT2402			X		X	X	X				X
13GWT2502			X		X	X	X				
13GWT2502-F					X						
13GWT2602			X		X	X	X				X
13GWT2701			X		X	X	X				
13GWT2801			X		X	X	X				X
13GWT2801-F					X						
13GWT2901			X		X	X	X				X
13GWT3001			X		X	X	X				
13GWT3101			X		X	X	X				

TABLE 2-3

ROUND 2 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample ID	Analytical Fraction										
	VOC	SIM	EXP	PCB	Metals	NTIA	NH3	S/C	MEE	TOC	MNA
Ground Water (cont'd)											
13GWT3201			X		X	X	X				
13GWT3301			X		X	X	X				
13GWT3301-F					X						
13GWT3401			X		X	X	X				X
13GWT3501			X		X	X	X				X
13GWT3501-F					X						
13GWT3601			X		X	X	X				X
13GWT3701			X		X	X	X				
13GWT3801			X		X	X	X				X
13GWT3801-F					X						
13GWT3901			X		X	X	X				
13GWT3901-F					X						
13GWT4001			X		X	X	X				
13GWT4101			X		X	X	X				
13GWT4101-F					X						
13GWT4201			X		X	X	X				
13GWT4201-F					X						
13GWT4301			X		X	X	X				
13GWT4401			X		X	X	X				
13GWT4501			X		X	X	X				
13GWT4501-F					X						
13GWT4601			X		X	X	X				
13GWT4701			X		X	X	X				
Sediment											
13SD240004			X		X						
13SD250004		X	X		X						
13SD260004			X		X						
13SD270004			X		X						
13SD280004			X		X						
13SD290004			X		X						
13SD300004			X		X						
13SD310004			X		X						
13SD320004		X									
Surface Soil											
13SS160002				X							
13SS170002				X							
13SS180002				X							
13SS190002				X							
13SS200002				X							
13SS210002				X							
13SS220002				X							

TABLE 2-3

ROUND 2 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample ID	Analytical Fraction										
	VOC	SIM	EXP	PCB	Metals	NTIA	NH3	S/C	MEE	TOC	MNA
Surface Soil (cont'd)											
13SS230002				X							
13SS240002				X							
13SS250002				X							
Subsurface Soil											
13SB160204				X							
13SB170204				X							
13SB180204				X							
13SB190203				X							
13SB200204				O							
13SB210204				X							
13SB220204				X							
13SB230204				X							
13SB240203				X							
13SB250204				X							
Surface Water											
13SW0702			X		X	X	X				
13SW0702-F					X						
13SW0802			X		X	X	X				
13SW0802-F					X						
13SW0902			X		X	X	X				
13SW0902-F					X						
13SW1002			X		X	X	X				
13SW1002-F					X						
13SW1102			X		X	X	X				
13SW1102-F					X						
13SW1202			X		X	X	X				
13SW1202-F					X						
13SW1302			X		X	X	X				
13SW1302-F					X						
13SW1401			X		X	X	X				
13SW1401-F					X						
13SW1501			X		X	X	X				
13SW1501-F					X						
13SW1601			X		X	X	X				
13SW1601-F					X						
13SW1801			X		X	X	X				
13SW1801-F					X						
13SW1901			X		X	X	X				
13SW1901-F					X						
13SW2001			X		X	X	X				
13SW2001-F					X						

TABLE 2-3

ROUND 2 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample ID	Analytical Fraction										
	VOC	SIM	EXP	PCB	Metals	NTIA	NH3	S/C	MEE	TOC	MNA
Surface Water											
13SW2201			X		X	X	X				
13SW2201-F					X						
13SW2401			X		X	X	X				
13SW2401-F					X						
13SW2501		X	X		X	X	X				
13SW2501-F					X						
13SW2601			X		X	X	X				
13SW2601-F					X						
13SW2701			X		X	X	X				
13SW2701-F					X						
13SW2801			X		X	X	X				
13SW2801-F					X						
13SW2901			O		O	O	O				
13SW3001			X		X	X	X				
13SW3001-F					X						
13SW3101			X		X	X	X				
13SW3101-F					X						
13SW3201		X									
Seep											
13SP0101			X		X	X	X				
13SP0101-F					X						
13SP0201			X		X	X	X				
13SP0201-F					X						
13SP0301			X		X	X	X				
13SP0301-F					X						
13SP0401			X		X	X	X				
13SP0401-F					X						
13SP0501			O		O	O	O				
SWMU 13 Total Samples	**0**	**4**	**80**	**19**	**120**	**72**	**72**	**0**	**1**	**3**	**24**
SWMU 16											
Ground Water											
16GW0102	X		X		X	X		X			
16GW0203	X		X		X	X		X	X	X	X
16GW0302	X		X		X	X		X	X		X
16GW0402	X		X		X	X		X			
16GW0502	X		X		X	X		X	X		X
16GWT0102	X		O		O	O		O			
16GWT0202	X		X		X	X		X			
16GWT0302	X		X		X	X		X			
16GWT0302-F					X						
16GWT0402	X		X		X	X		X	X	X	X

TABLE 2-3

ROUND 2 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample ID	Analytical Fraction										
	VOC	SIM	EXP	PCB	Metals	NTIA	NH3	S/C	MEE	TOC	MNA
Ground Water (cont'd)											
16GWT0502	X		X		X	X		X			
16GWT0603	X		X		X	X		X	X		X
16GWT0701	O		O		O	O		O	O		O
16GWT0801	X		X		X	O		O	O		O
16GWT0901	X		X		X	X		X			
16GWT1001	X		X		X	X		X	X		X
16GWT1101	X		X		X	O		O			
16GWT1101-F					X						
16GWT1201	X		X		X	X		X	U		U
16GWT1301	X		X		X	X		X	X		X
16GWT1301-F					X						
16GWT1401	O		O		O	O		O	O		O
16GWT1501	X		X		X	X		X	O	X	X
16GWT1501-F					X						
16GWT1601	X		X		X	O		O	O		O
16GWT1601-F					X						
16GWT1701	X		X		X	X		X			
Sediment											
16SD120004	X		X		X						
16SD130004	X		X		X						
16SD140004	X		X		X						
16SD150004	X		X		X						
16SD160004	X		X		X						
16SD170004	X		X		X						
16SD180004	X		X		X						
16SD190004	X		X		X						
16SD200004	X		X		X						
16SD210004	X		X		X						
16SD220004	X	X									
Surface Soil											
16SS420002					X						
16SS430002					X						
16SS440002					X						
16SS450002					X						
16SS460002					X						
Subsurface Soil											
16SB470405	X										
16SB480203	X										
16SB490405	X										
16SB500103	X										

TABLE 2-3

ROUND 2 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample ID	Analytical Fraction										
	VOC	SIM	EXP	PCB	Metals	NTIA	NH3	S/C	MEE	TOC	MNA
Surface Water											
16SW0102	U										
16SW0202	U										
16SW0702	U										
16SW1201	X		X		X	X					
16SW1201-F					X						
16SW1301	X		X		X	X					
16SW1301-F					X						
16SW1401	X		X		X	X					
16SW1401-F					X						
16SW1501	X		X		X	X					
16SW1501-F					X						
16SW1601	O		O		O	O					
16SW1701	X		X		X	X					
16SW1701-F					X						
16SW1801	X		X		X	X					
16SW1801-F					X						
16SW1901	O		O		O	O					
16SW2001	X		X		X	X					
16SW2001-F					X						
16SW2101	X		X		X	X					
16SW2101-F					X						
16SW2201	O	O									
Seep											
16SP0101	O		O		O	O					
16SP0201	O		O		O	O					
16SP0301	O		O		O	O					
16SP0401	O		O		O	O					
16SP0501	O		O		O	O					
SWMU 16 Total Samples	**46**	**1**	**37**	**0**	**54**	**24**	**0**	**16**	**8**	**3**	**9**
Field Duplicates											
13FD10220302			X		X						
13FD10220301			X		X	X	X				
13FD10220301-F					X						
13FD10220303			X		X	X	X				
13FD10220303-F					X						
13FD10240301	X		X		X						
13FD10270301		X	X		X	X	X				
13FD10270301-F					X						
13FD11050301					X						
13FD11100301			X		X	X	X				
13FD11230301			X		X	X	X				
13FD11230301-F					X						

TABLE 2-3

ROUND 2 - SUMMARY OF ENVIRONMENTAL SAMPLES AND LABORATORY ANALYSIS
SWMU 13 - MINE FILL B AND SWMU 16 - CAST HIGH EXPLOSIVES FILL/B146 INCINERATOR
NSWC CRANE
CRANE, INDIANA

Sample ID	Analytical Fraction										
	VOC	SIM	EXP	PCB	Metals	NTIA	NH3	S/C	MEE	TOC	MNA
Field Duplicates (cont'd)											
13FD11250301										X	
13FD12040301			X		X	X	X				
13FD12080301				X							
13FD12080302				X							
13FD12080303			X		X	X	X				
16FD10240302	X		X		X						
16FD10240301	X		X		X	X					
16FD10240301-F					X						
16FD10260301	X	X	X		X	X		X			
16FD11210301	X		X		X	X		X	X		
16FD12050301	X										
16FD12050302					X						
16FD12060301	X										

X = Analyzed.
U = Unscheduled.
O = Omitted.
VOC - Volatile organic compounds (Methods SW-846-8260B and SW-846-8015B).
SIM - Selected Ion Monitoring.
EXP - Explosives (Method SW-846-8330 and Misc. Explosives).
PCB - Polychlorinated biphenyl (Method SW-846-8082).
METALS - Total metals (Method SW-846-6020), and total mercury (Method SW-846-7470A).
Water samples with a -F designation were filtered in the field prior to preservation. Dissolved metals (Method SW-846-6020), and dissolved mercury (Method SW-846-7470A)
NTIA - Nitrite/nitrate (as N) EPA 353.2.
NH3 - Ammonia (as N) EPA 350.1.
S/C - Sulfate and Chloride
MEE - Methane, ethane, ethene.
TOC - Total organic carbon.
MNA - Monitored Natural Attenuation field parameters.

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