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Resource Conservation and Recovery Act Corrective Measures Study Report for SWMU 2 - Dye Burial Grounds

Naval Surface Warfare Center Crane Division

Crane, Indiana

NAVFAC
Naval Facilities Engineering Command

Southern Division Naval Facilities Engineering Command

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RESOURCE CONSERVATION AND RECOVERY ACT CORRECTIVE MEASURES STUDY REPORT FOR SWMU 2 - DYE BURIAL GROUNDS

NAVAL SURFACE WARFARE CENTER,
CRANE DIVISION
CRANE, INDIANA

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ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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ACRONYM LIST

ALPEC	Ammunition Loading and Production Engineering Center
AMSL	Above Mean Sea Level
ARARs	Applicable or Relevant and Appropriate Requirements
ASL	Air Screening Levels
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factor
BDAT	Best Demonstrated Available Technology
BGS	Below Ground Surface
CAA	Clean Air Act
CAAA	Crane Army Ammunition Activity
CAMU	Corrective Action Management Unit
CAO	Corrective Action Objective
CASCO	Central Ammunition Supply Control Office
CKD	Cement Kiln Dust
CLEAN	Comprehensive Long-Term Environmental Action Navy
CMA	Corrective Measures Alternatives
CMS	Corrective Measures Study
COC	Chemical Of Concern
COPC	Chemical Of Potential Concern
CTO	Contract Task Order
CWA	Clean Water Act
DOT	Department of Transportation
GAC	Granular Activated Carbon
GCL	Geosynthetic Clay Liner
HDPE	High-Density Polyethylene
HI	Hazard Indice
IAAQS	Indiana Ambient Air Quality Standards
IAS	Initial Assessment Study
IDEM	Indiana Department of Environmental Management
ILCR	Incremental Lifetime Cancer Risk
IR	Installation Restoration
IWQA	Indiana Water Quality Standards
KG	Kilogram

Koc	Organic Carbon Partition Coefficient
Kow	Octanol/Water Partition Coefficient
LDR	Land Disposal Requirement
LOAEL	Lowest Observed Adverse Effect Level
LTTD	Low-Temperature Thermal Desorption
LUC	Land Use Controls
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MCS	Media Cleanup Standard
MF	Modifying Factor
MG	Milligram
MK	Morrison Knudsen Corporation
NAAQS	National Ambient Air Quality Standards
NACIP	Navy Assessment and Control of Installation Pollutants
NAD	Naval Ammunition Depot
NAVFAC	Navy Southern Division Naval Facilities Engineering Command
NCP	National Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollutant Discharge Elimination System
NPW	Net Present Worth
NSWC	Naval Surface Warfare Center
NWSCC	Naval Weapons Support Center Crane
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Act
PEL	Permissible Exposure Level
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RISC	Risk Integrated System of Closure
SDWA	Safe Drinking Water Act
SERA	Screening Ecological Risk Assessment
SMCL	Secondary Maximum Contaminant Level
SSL	Soil Screening Level
SWMU	Solid Waste Management Unit

TAL	Target Analyte List
TBC	To Be Considered
TOC	Total Organic Carbon
TSD	Treatment, Storage, or Disposal
TSDF	Treatment, Storage, and Disposal Facility
TSS	Total Suspended Solid
UF	Uncertainty Factor
U.S. ACE	U.S. Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
VRP	Voluntary Remediation Program

EXECUTIVE SUMMARY

A Corrective Measures Study (CMS) Report has been prepared for the Naval Surface Warfare Center (NSWC) facility located in Crane, Indiana, for the United States Navy Southern Division Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) 0010, for the Comprehensive Long-Term Environmental Action Navy (CLEAN) 3, Contract Number N62467-94-D-0888. This CMS report addresses one solid waste management unit (SWMU) identified as SWMU 2 Dye Burial Grounds (DBG).

Interim corrective measures have been completed (consolidation of dye materials and construction of a cap). The RCRA Facility Investigation Report (RFI) (Tetra Tech NUS, Inc. [TtNUS], 2003) did not identify a need for further remedial activities based on current conditions. The objective of this CMS was to determine whether any additional corrective measures are required in order to provide long-term protection to human health and the environment, including an evaluation of clean closure.

SITE DESCRIPTION

Military smoke dyes and dye-contaminated materials were disposed at the site. Materials reportedly included magnesium, boxes, and rags contaminated with dyes, and open-topped drums of dye. Currently, the site is inactive (i.e., it is not used for waste disposal activities) and an interim-measures cap, which included permanent grass vegetation, has been installed. SWMU 2 is approximately 12.4 acres in area and consists of a grass-covered cap (4.2 acres), woods (7.8 acres), and one main gravel road (0.4 acre).

INTERIM MEASURE ACTIVITY

In 1995, an interim measures cap design was developed for the site to minimize potential threats to human health and the environment through mitigation of the migration of contaminants to ground water. The construction of the multi-layered cap began in 1996. During site preparation, dye-contaminated materials were found outside the planned limits of the cap. In 1997, a revised Work Plan for Interim Measures Cleanup at SWMU 2 was prepared to address the residual contamination found outside the planned cap limits. Excavation of dye-contaminated soils at the disturbed areas began in November 1996. Because no analytical method existed for dyes in media, no confirmatory samples were collected to verify that all residual contamination was removed from the disturbed areas.

In late 1997, during the construction of the foundation fill for the cap, seeps of dye-contaminated water were observed primarily in the northeastern and northwestern areas within the cap limits. A seepage collection system was constructed at the northeastern area and frac tanks were positioned at various

locations within the work area to hold dye-impacted water resulting from storm water runoff. In September 1998, the cap was completed at the Dye Burial Grounds.

PHASE III RFI

Various investigations have been performed at SWMU 2 to characterize site conditions, nature and extent of contamination, and evaluate human health and ecological risk. Initial studies conducted before construction of the cap determined that site disposal activities at Dye Burial Grounds did not present an immediate threat to human health and the environment. However, the site was recommended for further study to refine estimates of nature and extent. Most recently, soil (surface and subsurface), ground water, surface water, and sediment samples were collected from the DBG and analyzed for the presence of dyes and metals during the investigation phase of the DBG RFI (TtNUS, 2003). Previous studies had not analyzed soil or ground water samples for dyes because analytical methods were not available. Therefore, analytical methods for analysis of dyes in soil and ground water were developed by NSWC Crane. Also, reference doses and preliminary remediation goals were developed in order to complete the risk assessment included in the RFI report (TtNUS, 2003). The following discussion summarizes the nature and extent of contamination from the RFI at the SWMU 2:

- The soils, ground water, surface water, and sediment data collected during the RFI were adequate to support the development of baseline human health and screening-level ecological risk assessments for SWMU 2.

- Dyes, that were the primary constituents of concern at SWMU 2, were not detected in surface soil, ground water, surface water, or sediment. Two dyes, Acid Orange 10 and Acid Yellow 23, were detected infrequently in subsurface soil samples at concentrations that were below levels of concern.

SITE RISK

A baseline human health risk assessment was performed for SWMU 2 to characterize the potential risks to likely human receptors under current and potential future land use. The human receptors evaluated for SWMU 2 were the construction worker, adolescent trespasser, adult recreational user and future adult and child residents. The following conclusions resulted from the human health risk assessment:

- SWMU 2 incremental cumulative cancer risks for all human receptor pathways were estimated to be within, or less than, the EPA National Contingency Plan risk range of 10^{-6} to 10^{-4}; therefore, the Navy believes the risk is acceptable.

- Non-carcinogenic hazard estimates [hazard indices (HIs)] calculated for all human receptors were less than unity which is the threshold value for non-carcinogenic hazard, for all exposure pathways other than ground water exposure pathway for SWMU 2.

- Non-carcinogenic hazard estimates all human receptors for the ground water exposure pathway were greater than unity for SWMU 2. However, the exposure point concentrations were primarily influenced by one ground water sample that exhibited an unusually low pH (3.7). The elevated metals concentrations in this particular sample were due to the increased solubility of geologic materials in the acidic environment. The well (02C11P3) where this pH was observed is the most down gradient of the capped area. Intervening wells did not exhibit acid pH. The acidic conditions at this location are believed to be attributable to the geology of this well location. Therefore, the elevated metals concentrations are not attributable to the disposal of materials at the DBG.

A screening ecological risk assessment (SERA) was performed for the DBG. The ecological receptors evaluated in the screening assessment included receptors directly exposed to chemicals in the surface water and surface soil (i.e., plants and soil invertebrates), and indirectly exposed to chemicals via the food chain (i.e., through the ingestion of plants and invertebrates) and via the aquatic invertebrates that could be exposed to chemicals in the surface water and sediment in streams. The following conclusions resulted from the SERA:

- Risks to terrestrial plants and invertebrates from organic and inorganic chemicals in the surface soil in DBG were estimated to be low to negligible.

- Risk to aquatic receptors from organic and inorganic chemicals in surface water and sediments were estimated to be low to negligible.

REMEDIAL ALTERNATIVES

Three corrective measure alternatives were developed for the dye materials underlying the cap. These alternatives include the following:

Alternative No. 1 – No Action. The No Action alternative maintains the site as is and is retained to provide a baseline for comparison to other alternatives.

Alternative No. 2 – Institutional Controls/Ground Water Monitoring. This alternative includes two major components: (1) Institutional Controls and (2) Ground Water Monitoring. Institutional controls would include limitation of land use to industrial purposes and prohibition of aquifer use as a drinking water supply. These controls would eliminate or reduce pathways of exposure to contaminants at the site. Institutional controls would also consist of installing and maintaining a fence to control site access and maintaining the existing cap. As part of the Corrective Measures Design (CMD), the details of the controls would be developed. The controls would be implemented during the corrective measures implementation phase to insure that, prior to any future development at SWMU 9, adequate measures would be taken to minimize adverse human health and environmental effects. In particular, LUCs would prevent future site development for residential purposes.

Alternative No. 3 – Excavation/Off-site Disposal. This alternative includes two major components: (1) excavation and (2) off-base transportation and disposal. Soil contaminated with concentrations of chemicals of concern (COCs) in excess of the media cleanup standards (MCSs) would be excavated, including all of the existing landfill cap and the contaminated soil and landfill material beneath that cap. An area approximately 1.6 acres in size would be excavated to a depth of 6 to 12 feet bgs. This corresponds to a total volume of approximately 39,000 yd^2 of material to be excavated, including approximately 16,000 yd^3 of cap material, 15,000 yd^3 of contaminated soil and landfill material beneath the cap, and 8,000 yd^3 of over-excavated soil. The 39,000 yd^3 of excavated soil is expected to include 20,000 yd^3 of clean soil and 19,000 yd^3 of contaminated soil. The excavated soil would be transported to an off-base permitted treatment, storage, and disposal facility (TSDF) for disposal. It is assumed that the excavated soil would be non-hazardous and would be disposed in a RCRA Subtitle D type landfill. Samples of the excavated soil would be collected and analyzed to ensure that it complies with the TSDF landfill permit.

RECOMMENDED CORRECTIVE ACTION

Alternative 1 would not be sufficiently protective of human health and the environment because it would not provide for continued maintenance of the existing cap, prevent potential future exposure to contaminated soil, or warn of potential migration of soil COCs to ground water. Alternative 2 is recommended for use at SWMU 2 because it provides the best long term assurance that the cap will be maintained and that the dye is not migrating to ground water. Alternative 3 would remove the dye materials from the site. However, the dye materials would not be destroyed. Rather, the dye would only be transferred to another location. In addition, Alternative 3 would be difficult to implement because it would require excavation and off-base transportation and disposal of a relatively large volume of soil, which would require extra handling because of the presence of dyes.

1.0 INTRODUCTION

1.1 SCOPE AND OBJECTIVES

This Corrective Measures Study (CMS) Report was prepared for the Naval Surface Warfare Center (NSWC) facility located in Crane, Indiana, for the United States Navy Southern Division Naval Facilities Engineering Command (NAVFAC) under Contract Task Order (CTO) 0010, for the Comprehensive Long-Term Environmental Action Navy (CLEAN) 3, Contract N62467-94-D-0888. This CMS report addresses one solid waste management unit (SWMU) identified as SWMU 2 -Dye Burial Grounds (DBG).

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

The objectives of this CMS are as follows.

- Identify Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) criteria.
- Identify risk-based action levels that are protective of human health and the environment.
- Develop Corrective Action Objectives (CAO), which identify chemicals of concern (COCs), receptors, pathways, and preliminary remediation goals (PRGs). The PRGs are based on chemical-specific ARARs, TBCs, and risk-based action levels.
- Develop Corrective Measure Objectives for media affected at SWMU 2.

- Identify and screen corrective measures technologies.
- Develop Corrective Measures Alternatives (CMAs).
- Conduct detailed analysis of CMA.

1.2 ORGANIZATION OF CORRECTIVE MEASURES STUDY

This CMS consists of six sections. Section 1.0 is the introduction. Section 2.0 provides a description of current conditions at SWMU 2. Section 3.0 identifies the ARARs, TBCs, and corrective measure objectives. Section 4.0 provides the identification and screening of corrective measure technologies for soil. Sections 5.0 and 6.0 present the development and evaluation/comparative analysis of CMAs, respectively. Section 6.0 also presents the recommended corrective measure alternative.

1.3 ACTIVITY BACKGROUND INFORMATION

1.3.1 Facility Location

NSWC Crane is located in the southern portion of Indiana, immediately east of Crane Village and Burns City. The facility is approximately 75 miles southwest of Indianapolis and 71 miles northwest of Louisville, Kentucky. NSWC Crane encompasses approximately 100 square miles (62,463 acres). The majority of the facility is located in the northern portion of Martin County. Smaller portions of the facility are located in Greene, Davies, and Lawrence Counties.

NSWC Crane is located in a rural, sparsely populated area. Most of the facility is forested, and the surrounding area is wooded or farmed land. NSWC Crane provides naval support for equipment, shipboard weapons systems, and ordnance. In addition, NSWC Crane supports the Crane Army Ammunition Activity (CAAA) with production and renovation of conventional ammunition and storage, shipment, demilitarization, and disposal of conventional ammunition (Murphy, 1995). More detailed descriptions of NSWC Crane and SWMU 2 are provided in Section 1.0 of the RFI Report (TtNUS, 2003). The location of SWMU 2 is shown on Figure 1-1.

1.3.2 Facility History

1.3.2.1 History of Ownership and Operation

In 1940, Congress authorized construction of a Naval Ammunition Depot (NAD) in southern Indiana, and the NAD Burns City was commissioned in late 1941. In 1943, NAD Burns City was renamed NAD Crane, and the town of Crane was built to house the rapidly growing number of civil service employees. NAD Crane's overall mission was to load, prepare, renovate, receive, store, and issue ammunition to the fleet.

During World War II, NAD Crane's mission expanded to include pyrotechnics production, mine filling, rocket assembly, field storage, torpedo storage, and ordnance spare parts and mobile equipment storage. During the 1950s, several new departments were created, the Ammunition Loading and Production Engineering Center (ALPEC) was transferred to Crane, and the Central Ammunition Supply Control Office (CASCO) was established. NAD Crane supplied ammunition to the fleet during the Korean and Vietnam conflicts. During the Southeast Asia crisis, the number of full-time employees at NAD Crane grew to 6,800.

In 1975, NAD Crane was designated Naval Weapons Support Center Crane (NWSCC). Its new mission was to provide support for ships, aircraft, equipment, shipboard weapons systems, and assigned ordnance items and to perform additional functions as directed.

In 1977, the Single Manager Concept was implemented. The CAAA was created, and the Army assumed ordnance production, storage, and related responsibilities as a tenant organization. In 1992, the facility was designated as NSWC Crane. Other functions at NSWC Crane remained the responsibility of the Navy, and currently the Navy retains ownership of all real estate and facilities at NSWC Crane. Responsibility for overall station safety, security, and environmental protection remains with the Commanding Officer, NSWC Crane. Presently, approximately 4,000 people are employed at NSWC Crane.

1.3.2.2 History of Regulatory Action

Following promulgation of the U.S. EPA RCRA hazardous waste regulatory program, NSWC Crane filed notification and application in October 1980 to operate as a RCRA hazardous waste treatment, storage, or disposal (TSD) facility. Interim status was granted subject to operating requirements and applicable technical standards found in 40 Code of Federal Regulations (CFR) Part 265. Corrective action programs, established as part of the 1984 RCRA Hazardous and Solid Waste Amendments (HSWA), required NSWC Crane to address past releases of hazardous waste or hazardous constituents at all

SWMUs. Accordingly, NSWC Crane submitted a Hazardous Waste Management Report to the U.S. EPA in January 1985. Following the Hazardous Waste Management Report, an RFA Assessment (A.T. Kearney, Inc., 1987) was conducted to characterize the potential for releases of hazardous waste or constituents from 100 SWMUs identified during the assessment.

On December 23, 1989, U.S. EPA issued the federal portion of the Final RCRA Part B permit for NSWC Crane to the Navy. U.S. EPA renewed the RCRA Part B permit in 1995. IDEM now has responsibility for the Federal Corrective Action Program. In October 2001, IDEM renewed the Corrective Action Permit. However, ongoing corrective actions will continue under the U.S. EPA IDEM Work Sharing Agreement for Corrective Action Activities at the Naval Surface Warfare Center.

1.4 PHYSICAL CHARACTERISTICS OF SWMU 2 STUDY AREA

1.4.1 Climate and Meteorology

NSWC Crane is located in a warm, temperate climatic zone. In general, the 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 fairly evenly distributed throughout the calendar year; the maximum precipitation is during the spring and early summer. The average annual precipitation at the facility is 44 inches (liquid equivalent), consisting of 42 inches of rain and 15 inches of snow. Relative humidity for the local area is generally highest in the early morning hours of the monthly period June through September and generally ranges between 80 to 88 percent on average. The lowest values of relative humidity, historically, have occurred during the period March through October, when values average between 54 and 58 percent. 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.

1.4.2 Topography

NSWC Crane is located in the unglaciated area of the Crawford Uplands physiographic division. This division is described as a rugged, dissected plateau that is bounded by the Mitchell Plain Physiographic Province to the east and the Wabash Lowland Physiographic Province to the west. The terrain is predominantly rolling, with moderately incised stream valleys throughout and occasional flat areas in the central and northern portions of NSWC Crane. Deciduous trees and shrubs cover most of the region. The elevations across the facility range from about 500 feet above mean sea level AMSL to about 850 feet AMSL. Lake Greenwood extends west to east across the northern part of the Facility.

Topographic relief in the Crawford Upland ranges from 100 to 350 feet (see Figure 1-1). Greater relief exists in the eastern part of NSWC Crane.

The topography of the Dye Burial Grounds is relatively rugged, consisting of a series of steep-sided, narrow ridges and valleys. SWMU 2 lies approximately 500 feet southwest of the crest of a north-northwest trending ridge separating Sulphur Creek from Little Sulphur Creek. The elevation of SWMU 2 is approximately 740 feet AMSL and rises toward the crest, which is at an elevation of approximately 770 feet AMSL (Figure 1-2).

1.4.3 Geology and Soils

The shallow subsurface materials at the Dye Burial Grounds included fill, natural unconsolidated materials, and bedrock. Fill exists beneath the capped area and was also encountered in borings in the surrounding the capped area. Fill was encountered in all but two of the 20 soil borings drilled at the Dye Burial Ground in July 2001 by Tetra Tech NUS (TtNUS). The fill encountered during the TtNUS investigation consists of reworked natural material composed of silt and clay mixtures. No evidence of buried waste or dye was found in the borings drilled by TtNUS. Fill extends to a maximum depth of approximately 9 feet beneath the ground surface. Thicker sequences of mounded fill exist as cover material overlying bunkers in the immediate SWMU area.

Natural unconsolidated materials (residual soil formed on the Pennsylvanian bedrock) either underlie the fill or exist at the ground surface where the fill is not present. The natural unconsolidated material consists of silt and clay mixtures with a maximum thickness of approximately 10 feet, and extends downward to the Pennsylvanian bedrock surface.

1.4.4 Hydrogeology

In general, ground water at NSWC Crane is contained in joint openings of limestone and sandstone aquifers. Surficial unconsolidated aquifers are thin and have limited potential as water supplies. The upper soil materials on the top and sides of the ridge at SWMU 2 are unsaturated. Four zones of water-bearing bedrock units belonging to three aquifers (Pennsylvania, Golconda/Haney and Beech Creek) have been investigated at the SWMU. The sandstone belonging to the Lower Pennsylvanian Mansfield Formation is the uppermost aquifer. This aquifer exists under the SWMU 2 cap area, extends to the north, south, and west, and terminates on the sides of the ridge where the ground surface intersects the sandstone. In a small area beneath the eastern half of SWMU 2 and to the southeast of SWMU 2, the sandstone aquifer is divided into two parts by a discontinuous lens of shale, that is referred to as the

"Upper Pennsylvanian aquifer" (see RFI Figures 1-6 and 1-7). These names are not formal and only apply to a very small area (see RFI Figure 1-9). Beneath the western portion of SWMU 2 and extending to the south and the west, the sandstone aquifer is not divided by the shale lens. In this area, the upper portion of the aquifer is dry. Ground water in the Pennsylvanian sandstone aquifer flows to the southwest toward Little Sulphur Creek.

The Golconda/Haney aquifer is separated from the Pennsylvanian sandstone aquifer above by the Hardinsburg shale, which is approximately 20 to 30 feet thick at the site. The Hardinsburg serves as an aquitard to vertical migration of ground water. Ground water in the Golconda/Haney aquifer north of the site flows to the east, southeast, and south.

The Beech Creek aquifer (which includes Big Clifty Sandstone) is separated from the shallower aquifers by the Indian Springs Shale, which comprises the upper member of the Big Clifty Formation. The Indian Springs Shale is characterized as an aquiclude at the bottom of the Golconda/Haney aquifer. Ground water in the Beech Creek aquifer flows under confined conditions toward the southwest and Little Sulphur Creek.

1.4.5 Water Supply

Seven primary creeks carry surface water off the installation and eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. The seven creeks that drain NSWC Crane are Furst Creek, Sulphur Creek, Little Sulphur Creek, Boggs Creek, Turkey Creek, Indian Creek, and Seed Tick Creek (Figure 1-1). Also located within the installation are several small ponds and Lake Greenwood, an 800-acre, man-made, spring-fed lake in the northwestern portion of the installation. Lake Greenwood is the main source of drinking water at NSWC Crane and it is also used for recreation. Ground water at SWMU 2 is not currently being used.

1.4.6 Surrounding Land Use

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

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

enough to have an impact on NSWC Crane. None of the areas adjacent to NSWC Crane are zoned, and zoning is not anticipated in the near future. This separation distance of approximately 2,760 feet from the nearest (eastern) NSWC Crane property boundary and the multilayer cap will preclude any off-site impacts from SWMU 2. There are no known land use or community actions under consideration or proposed at this time.

1.4.7 Ecology

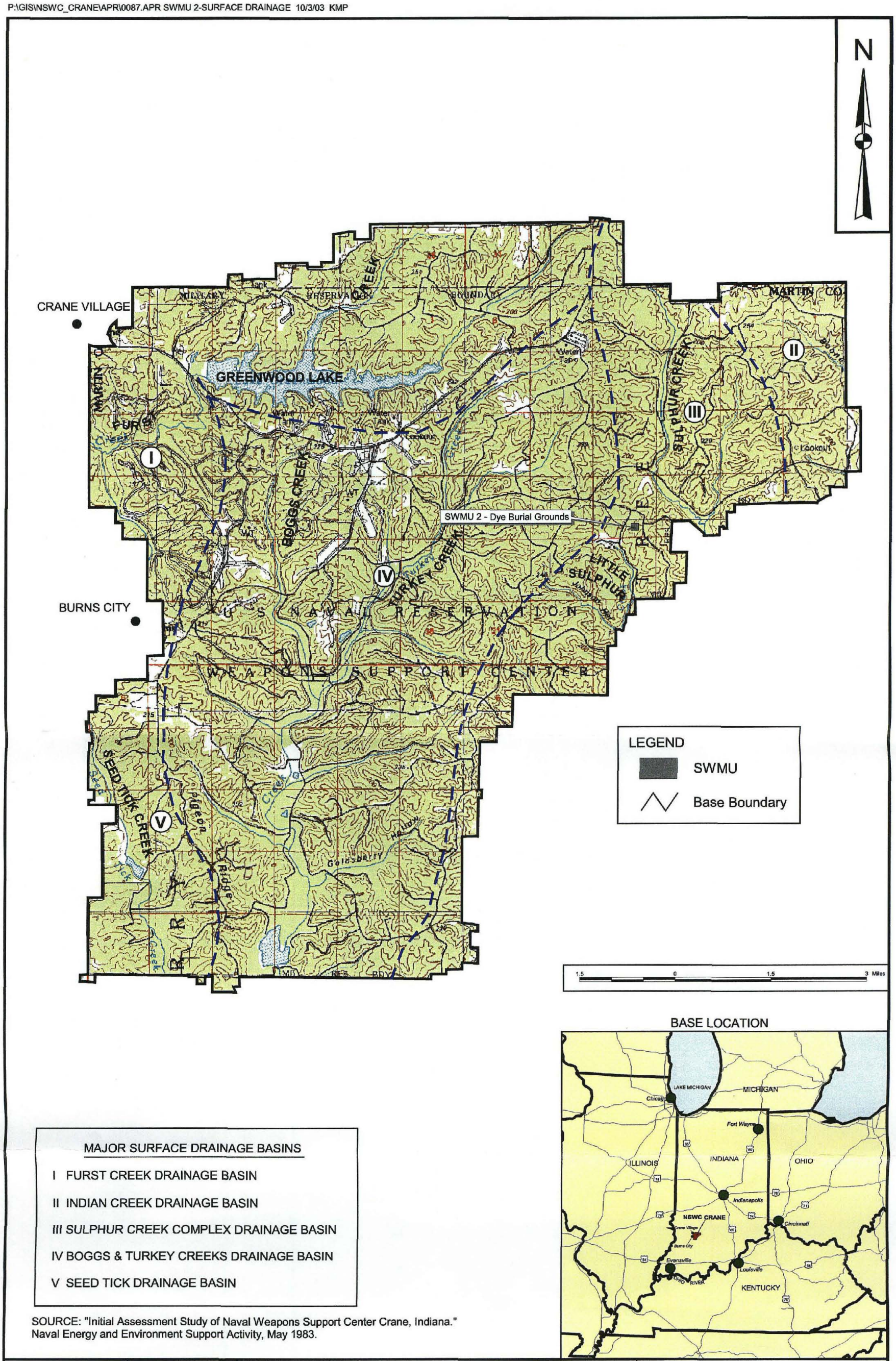
SWMU 2 is approximately 12.4 acres in area and consists of a grass-covered cap (4.2 acres), woods (7.8 acres), and one main gravel road (0.4 acre). The Dye Burial Grounds cap is covered with dense grass; all trees have been cleared from the cap. The tree line is approximately 15 feet from the edge of the cap. Dominant tree species include black oak (*Quercus velutina*), white oak (*Quercus alba*), pignut hickory (*Carya spp.*), and yellow poplar (*Populus spp.*). No scrubs or shrubs are present; leaf litter, limbs, and fallen saplings cover the under story.

Terrestrial habitats (i.e., wooded areas and grasses) near the site may provide shelter and food sources for various species of mammals such as white-tailed deer, coyote, red fox, rabbits, raccoons, and mice and of birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins. The threatened and endangered Indiana Bat may be a potential receptor at SWMU 2.

The bird population includes a number of threatened species, endangered species, or species of special concern that use the site as their home range. These species include the bald eagle, osprey, sharp-skinned hawk, red-shouldered hawk, broad-winged hawk, black and white warbler, hooded warbler, and the worm-eating warbler (B&R Environmental, 1997).

No aquatic habitats were identified at SWMU 2. Drainage swales leading away from the site were identified during a site visit in March 2002; however, these swales were grass lined and covered with moderate leaf litter. The occurrence of aquatic receptors (i.e., fish and macroinvertebrates) would be unlikely because these areas only receive surface water during precipitation events.

P:\GIS\NSWC_CRANE\APR\0087.APR SWMU 2-SURFACE DRAINAGE 10/3/03 KMP



MAJOR SURFACE DRAINAGE BASINS

I FURST CREEK DRAINAGE BASIN

II INDIAN CREEK DRAINAGE BASIN

III SULPHUR CREEK COMPLEX DRAINAGE BASIN

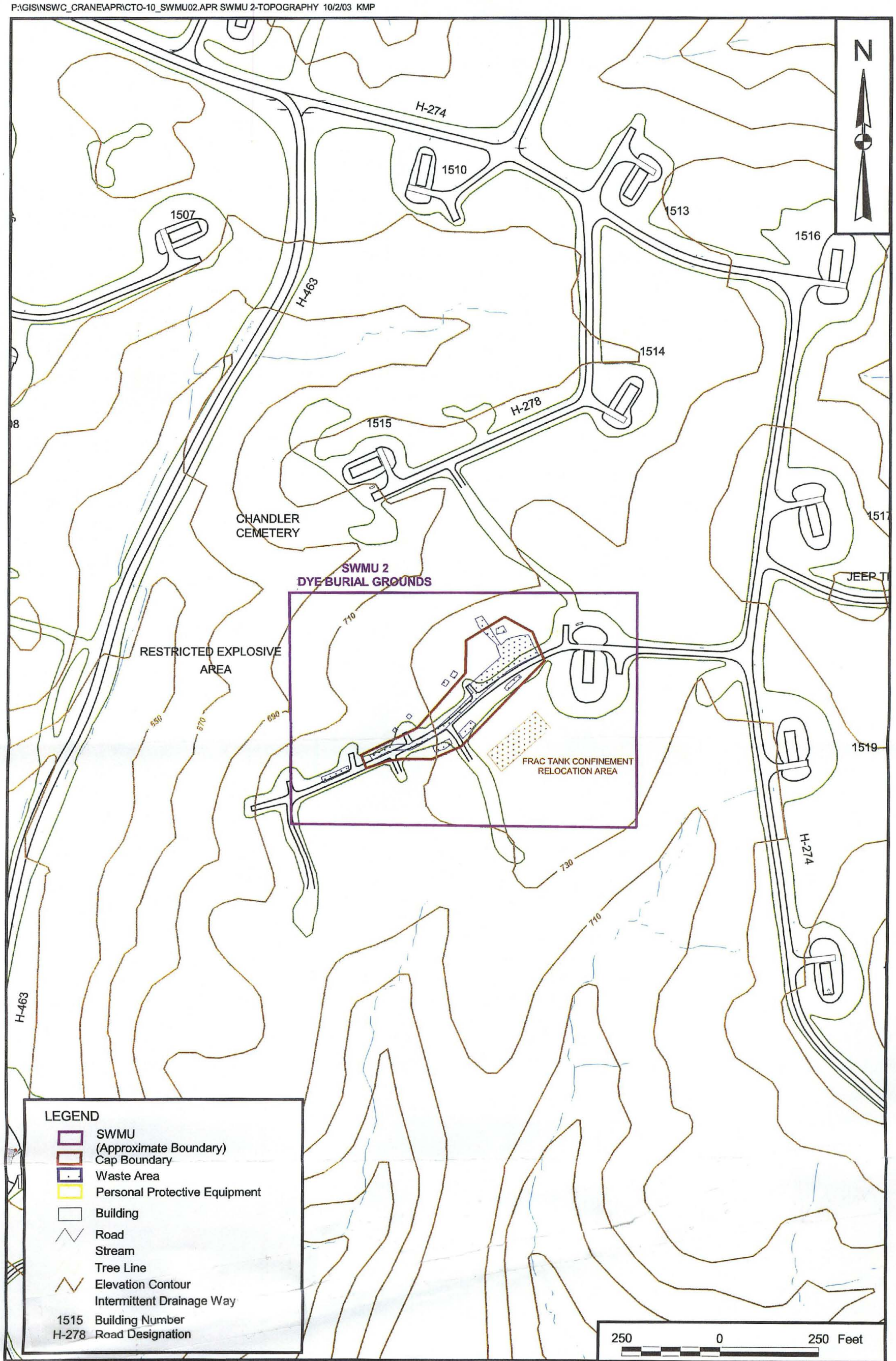
IV BOGGS & TURKEY CREEKS DRAINAGE BASIN

V SEED TICK DRAINAGE BASIN

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

DRAWN BY K. Peila	DATE 10/2/03	SITE LOCATION AND SURFACE DRAINAGE AT THE NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER 3994
CHECKED BY J. Lucas	DATE 10/2/03		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-1 REV 0

P:\GIS\NSWC_CRANE\APR\CTO-10_SWMU02.APR SWMU 2-TOPOGRAPHY 10/2/03 KMP



DRAWN BY K. Peila	DATE 10/2/03	TOPOGRAPHY AT SWMU 2 - DYE BURIAL GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER 3994
CHECKED BY J. Lucas	DATE 10/2/03		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-2 REV 0

2.0 DESCRIPTION OF CURRENT CONDITIONS

2.1 SITE DESCRIPTION

The approximate boundaries of SWMU 2 are provided in Figure 1-2. Although it is known that military smoke dyes and dye-contaminated materials were disposed at the site, no records are available on the specific dyes and quantities. It is estimated that 50,000 pounds of dyes and dye-contaminated materials were deposited in open trenches at the site from 1952 to 1964. Materials reportedly included magnesium, boxes, and rags contaminated with dyes, and about 60 open-topped drums of dye. The sizes of the drums are not known.

SWMU 2 consists of at least four main trenches. Although three trenches were originally thought to be present at the site, additional trenches were located during historical site investigations. The original three trenches are each approximately 10 feet wide, 6 feet deep and 50 feet long. These three trenches are aligned end to end and are situated atop a ridge. All the trenches reportedly were backfilled to the ground surface with soil in 1972, but were not permanently capped. NSWC Crane placed crushed rock along a roadway immediately north of the trench area in 1987 to facilitate access by well drilling vehicles (U.S. ACE, 1998).

Geophysical surveys were conducted at the site in January 1991 to delineate the boundaries of the disposal activities. The results of the survey indicated that there are approximately 17 unidentified anomalies located at the site that may be attributable to site operations and may contain dye-contaminated material. Historically, these disposal activity areas have been referred to as either disposal trenches or waste areas.

Various investigations were performed at SWMU 2 between 1981 to 1986 as part of several multi-site investigations. The first such study was the Initial Assessment Study (IAS), which was initiated in April 1981 in response to the Navy Assessment and Control of Installation Pollutants (NACIP) Program. The IAS was performed by the Naval Energy and Environmental Support Activity (NEESA) and was completed in May 1983 (NEESA, May 1983) with assistance from the Ordnance Environmental Support Agency and the U.S. ACE Water Experiment Station (WES). The intent of the IAS was to identify and assess sites posing a potential threat to human health and the environment from past hazardous materials operations.

During the installation of eight monitoring wells (wells 02-01 through 02-08) along the perimeter of the site, soil samples were collected and tested for various soil characteristics. After the monitoring wells were installed, ground water samples were collected and analyzed for a comprehensive list of chemical constituents and RCRA water-quality parameters. As part of the IAS, both quarterly and semi-annual sampling of the monitoring wells was initiated at the Dye Burial Grounds. Based on the initial conclusions of the IAS, it was determined that disposal activities at the Dye Burial Grounds did not present an immediate human health or environmental threat. However, the site was recommended for further study to evaluate potential long-term impacts.

In response to the recommendation presented in the IAS, an RFI Phase II Ground Water Assessment was performed at the Dye Burial Grounds from 1987 to 1990 (U.S. ACE, 1991). The objective of the study was twofold to further refine the nature and extent of contamination at the site and to further refine the hydrogeology at the site. Twelve monitoring well clusters, consisting of 33 monitoring wells, were installed at the Dye Burial Grounds. In 1988, 26 monitoring wells and one seep were sampled and analyzed for priority pollutant constituents.

The RFI Phase III ground water release characterization commenced in October 1990 with the addition of three monitoring wells (labeled 02C20 through 02C22). In addition to refinement of the nature and extent of contamination, the objective of this effort was to determine regional and site hydrogeology including distribution of aquifers, characteristics of ground water flow, and the influence of stratigraphy and geologic structure on ground water and constituent migration. This study included the collection of four rounds of ground water samples from the 44 monitoring wells. These samples were analyzed for Appendix IX constituents, explosives, and miscellaneous water-quality parameters.

In 1991, a geophysical investigation was conducted at the site to delineate the boundaries of the dye burial trenches and to identify buried anomalies. Several anomalies were observed, in addition to the three known trenches.

In 1995, an interim measures cap design was developed for the site (Glynn, Bennett, and Stark, 1995) to minimize potential threats to human health and the environment through mitigation of the migration of contaminants to ground water. The limits of the cap were identified using the geophysical survey information.

The cap system, from the bottom to the top, consists of the following:

- Foundation fill layer.

- Geotextile 120-mil non-woven cushion layer over the foundation fill layer to protect the liner components against puncture and other damage.

- Geosynthetic clay liner (GCL) over the geotextile layer with hydraulic conductivity (K) less than 1×10^{-6} centimeters/second (cm/sec).

- High-density polyethylene (HDPE) geomembrane layer to prevent migration of moisture into the dye trenches and dye-impacted materials.

- 6-inch sand drainage system layer (K greater than 1×10^{-2} cm/sec) with an overlying geotextile filter fabric to drain infiltration water away from the cap system.

- Perimeter drainage collection system to transport infiltration water away from the cap.

- 6-inch gravel biotic barrier (coarse gravel) layer (greater than 1×10^{-1} cm/sec) with an overlying geotextile filter fabric.

- 27-inch top cover layer to support vegetative growth and provide frost protection for the geomembrane liner. All areas with slopes of 4:1 or greater were stabilized with erosion mats.

An illustration of a typical cap cross section and details are shown in Figure 2-1.

The construction of the multi-layered cap began in 1996. During site preparation (clearing activities), dye-contaminated materials were found outside the planned limits of the cap. An investigation of the extent of contamination outside the cap limits was performed in early July 1996. This investigation consisted of the excavation of 12 potholes (test pits) approximately 24 inches deep. Dyes were visually observed in eight of the potholes.

In 1997, a revised Work Plan for Interim Measures Cleanup at SWMU 2 was prepared by Morrison Knudsen Corporation (MK, 1999) to address the residual contamination found outside the planned cap limits. Excavation of dye-contaminated soils at the disturbed areas began in November 1996. No confirmatory samples were collected to verify that all residual contamination was removed from the disturbed areas.

In late 1997, during the construction of the foundation fill for the cap, seeps of dye-contaminated water were observed primarily in the northeastern and northwestern areas within the cap limits. A seepage collection system was constructed at the northeastern area. During site preparation, eight 500-barrel frac tanks were positioned at various locations within the work area to hold dye-impacted water resulting from storm water runoff. The dye-impacted water was pumped to the tanks; the system was closed after construction of the foundation fill was completed. In September 1998, the cap was completed at the Dye Burial Grounds. The water stored in the frac tanks was analyzed by the Navy according to the SWMU 2 QAPP (MK 1997) and it was determined that the dye-contaminated water was non-toxic. The water was eventually discharged into a sewer manhole located on the east side of the Pyrotechnic Facility Plant #3.

In 2001, RFI field activities were conducted at SWMU 2. The objectives of these activities were as follows:

- To refine estimates of the nature and extent of contamination.
- To evaluate human health risks through a baseline risk assessment.
- To estimate risks to the environment through a screening-level ecological risk assessment.
- To determine whether the interim cap placed over the Dye Burial Ground is preventing chemical contaminant migration.

An RFI report was completed (TtNUS, 2003), describing the nature and extent of contamination and the results of the human health and ecological risk assessments.

2.2 NATURE AND EXTENT OF CONTAMINATION

Soil (surface and subsurface), ground water, surface water, and sediment samples were collected from SWMU 2 and analyzed for the presence of site-related contamination during the investigation phase of the SWMU 2 RFI (TtNUS, 2003). All surface and subsurface soil samples were analyzed for Target Analyte List (TAL) metals (plus tin) and dyes. Ground water samples were analyzed for target analyte list metals (plus tin), dyes, total organic carbon (TOC), chloride, sulfate, and total suspended solids (TSS). One surface water sample was collected and analyzed for total and dissolved TAL metals (plus tin), TOC, hardness, and TSS. All sediment samples were analyzed for TAL metals (plus tin) and dyes.

Figures 2-2, 2-3, and 2-4 display geographical depictions of positive dye detections and positive metals detections in surface/subsurface soils, ground water and surface water/sediment, respectively, at SWMU 2.

The nature and extent of contamination at SWMU 2, as presented in the RFI (TtNUS, 2003), is summarized as follows:

- Military dyes are the primary constituent of concern at SWMU 2. All military dyes disposed at SWMU 2 were organic compounds and did not contain metals. Two organic dyes (Acid Orange 10 and Acid Yellow 23) were detected in 6 of 20 subsurface soil samples collected at depths ranging from 3 feet to 11 feet below ground surface (bgs) outside of the capped area. These samples were collected near the center of SWMU 2 at 50 to 100 feet from the northern SWMU 2 border and at the southwestern end of the SWMU 2 cap boundary.

- All dye concentrations detected in subsurface soil samples were less than 12 mg/kg. The highest dye concentration was 11.5 mg/kg. Dyes were not detected in any of the surface soil, ground water, surface water, or sediment samples. These data indicate that SWMU 2 has had little impact on environmental media. The absence of dye detections in ground water samples demonstrates that dyes are not migrating from soils at SWMU 2 into the ground water. However, dye contamination does exist in soil beyond the capped area.

- Several metals were detected in all sampled media. In general, the majority of the detected metals were present at concentrations comparable to or less than background, except in subsurface soil. In subsurface soil samples collected outside of the capped area, the majority of the detected metals were present at concentrations in excess of background. Most of the background exceedances are attributable to having only a single background concentration value for each of the metals (Soil Group 9). When the results are compared to background data for the other subsurface soil group present at SMWU 2 (Soil Group 8), the SWMU 2 metal concentrations in subsurface soil appear to be similar to background concentrations. There is no pattern with respect to spatial distribution of metals, nor is there a known source of metals at SWMU 2.

- For ground water samples, detected concentrations of metals were greater in downgradient Lower Pennsylvanian bedrock wells than in upgradient wells. These concentrations were associated with wells located on or beyond the capped area boundary. Four of the metals (calcium, magnesium, potassium, and sodium) detected are considered to be essential nutrients. The highest metals concentrations were observed at the same monitoring well that reported the lowest pH measurement. The positive metal results for this monitoring well included aluminum (23,300 µg/L), arsenic (1.6 µg/L), beryllium (4.7 µg/L), cadmium (16.1 µg/L), cobalt (445 µg/L), iron (2,110 µg/L), lead (4.8 µg/L), manganese (3,790 µg/L), nickel (868 µg/L), and zinc (2,280 µg/L). The measured pH (3.7)

at this well was much lower than the pH values in the other Lower Pennsylvanian bedrock wells. This is likely to be the reason metals concentrations were elevated in this well, because the solubilities of most metals increase as pH decreases. The low pH at this well is a result of geochemical conditions and is not related to the dye wastes buried at SWMU 2.

- While some metals were detected in SWMU 2 ground water at concentrations greater than upgradient concentrations, the number of such occurrences, the concentration levels observed, and the lack of spatial patterns with such detections are evidence that ground water is not contaminated with metals as a result of SWMU 2 operations. Therefore, the presence of metals in downgradient wells cannot be attributed to SWMU 2 operations and the need to collect additional ground water samples does not exist. In addition, the cessation of sampling is supported by historical data.

2.3 CONTAMINANT FATE AND TRANSPORT

Evidence for chemical migration at SWMU 2, Dye Burial Grounds, is very limited. No dyes were detected in surface soil, ground water, surface water, or sediment samples. Traces of two azo dyes (Acid Orange 10 and Acid Yellow 23) were detected in subsurface soil, but the presence of a multi-layered cap restricts the opportunity for any substantial quantities of buried dyes to leach via water infiltration or overland runoff. Acidic dyes, which were detected in soil, have high water solubility and would be expected to leach.

The dyes of potential concern at the Dye Burial Ground can generally be classified into acid dyes, basic dyes, or solvent dyes and their chemical/physical characteristics may differ accordingly. For example, the water solubilities of the acid and basic dyes are much greater than the solubilities of the solvent dyes. Likewise, organic carbon partition coefficients (K_{oc}s), octanol/water partition coefficients (K_{ow}s), and bioconcentration factors (BCFs) of acid dyes are typically much less than the values for the solvent dyes. Based on the available BCF values, solvent dyes would be expected to bioaccumulate in animals whereas acidic and basic dyes should not bioaccumulate to a great extent.

The water solubility, K_{oc}, and K_{ow} data may be misleading when predicting fate and transport behavior of the dyes. For example, the published solubility of Acid Orange 10 is 80,000 mg/L and the Kow and Koc values for this dye are very low. Based on these data, Acid Orange 10 would be expected to have high mobility in soil, i.e., it would be readily leached from soil and migrate to ground water. However, other chemical properties may control the leaching. Because of its ionic nature, ion-exchange processes of Acid Orange 10 with clay would probably retard leaching. The same argument can be made for the other acidic and basic dyes. Consequently, it is likely that the dyes (acidic, basic, and solvent) would have very

low mobility in soil and low potential for leaching. This is evidenced by the fact that no dyes were detected in ground water at DBG. The dyes would also be expected to adsorb strongly to inorganic sediment or particulate matter. Leaching of some dyes could occur in extreme conditions such as very low pH but not under normal conditions.

Information on the biodegradation potential of the dyes is limited. Biodegradation does not appear to be an important environmental fate process for the dyes. If biodegradation were to occur, it seems more likely under anaerobic than aerobic conditions.

It should be noted that the some of the published values of the physical/chemical parameters of the dyes were not determined by experiment but were derived from other data and, as such, are only estimates. However, the published values should be sufficient to provide a general picture of a chemical's likely behavior. The physical/chemical characteristics of acid dyes, basic dyes, and solvent dyes are listed in Table 2-1.

Metals were detected at low concentrations in all media sampled. As discussed in the RFI, no source area was identified for metals at SWMU 2. In general, the majority of the detected metals were present at concentrations less than background, except in subsurface soil. The presence of metals in site media cannot be attributed to the composition of dyes disposed at SWMU 2. Metals are naturally present in the environment, and fluctuations in concentrations are not related to disposal activities at SWMU 2.

2.4 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

2.4.1 Human Health Risk Assessment

A baseline human health risk assessment for SWMU 2 was performed to characterize the potential risks to likely human receptors under current and potential future land use. Potential receptors under current land use are construction workers, maintenance workers, and adolescent trespassers. Potential receptors under future land use are recreational users and hypothetical residents (children and adults). Although future land use is likely to be the same as current land use, potential future receptors were evaluated in the baseline human health risk assessment, primarily for decision-making purposes. A land use control (LUC) program is not currently in place at NSWC Crane.

Quantitative estimates of noncarcinogenic and carcinogenic risks [Hazard Indices (HIs) and Incremental Lifetime Cancer Risks (ILCRs)] were developed for potential human receptors. Cumulative HIs for the construction worker, maintenance worker, adult recreational user, and adolescent trespasser under the

reasonable maximum exposure (RME) scenario are less than unity (1), indicating that adverse non-carcinogenic effects are not anticipated for these receptors under the defined exposure conditions. Cumulative HIs for the future adult and child resident exceed unity. Cumulative ILCRs for all receptors were less than or within U.S. EPA's target risk range. Table 2-2 provides a summary of hazard quotients (HQs) for SWMU 2 as presented in the RFI.

The elevated HIs were attributable to exposure to aluminum, cadmium, cobalt, and nickel in ground water, primarily by ingestion. The HIs calculated for residential exposure to ground water are subject to the following sources of uncertainty:

- As discussed previously, the elevated HIs were associated with one ground water sample (02GWC11P301). If this sample was removed from the database, all HIs would be within acceptable levels. This sample exhibited an unusually low pH (3.7) which is likely the reason metals concentrations are elevated, because acidic conditions increase the solubility of metals in water. The acidic conditions at this location are believed to be attributable to the geochemical conditions at the site and not related to the dye wastes buried at SWMU 2.

- The residential land use scenario assumes that ground water at the site is used as a source of domestic drinking water. However, it is unlikely that residences would ever be located at this site. Although enlisted and officer personnel reside at NSWC Crane under current conditions, the residential scenario is not applicable for these receptors because they do not and would not be expected to reside within the boundaries of SWMU 2. Because a cap exists at the site, LUCs will prohibit future development of the site. Other active sources of safe drinking water are available in the local area and it is unlikely the wells would be installed in the vicinity of the SWMU.

In conclusion, no significant potential human health risks are expected for SWMU 2 under current or anticipated future land use. All ILCRs were less than or within U.S. EPA's target risk range of 10^{-4} to 10^{-6} and HIs were less than the acceptable level of 1 for exposures to all media with the exception of future residential exposure to ground water. HIs for future residential exposures to aluminum, cadmium, and nickel in ground water exceeded 1, but the concentrations of these metals are believed to be naturally occurring and not associated with SWMU 2.

2.5 ECOLOGICAL RISK ASSESSMENT

A screening ecological risk assessment (SERA) was performed for the SWMU 2 Dye Burial Grounds. One inorganic chemical, copper, was detected in the surface soil at a maximum concentration that

exceeded conservative screening levels and therefore was selected as a chemical of potential concern (COPC). This COPC was assessed in the Step 3A evaluation, which is the first step of the baseline ecological risk assessment and consists of refining the list of COPCs that were retained following the SERA. Several additional inorganic chemicals were also evaluated in Step 3A because no Region 5 screening levels were available for them.

In the Step 3A evaluation, risks to terrestrial plants and invertebrates from inorganic chemicals in the surface soil were determined to be low to negligible based on their relatively low concentrations compared to the screening levels or alternate benchmarks. The results of the terrestrial food chain modeling also indicated there were no unacceptable risks to receptors from chemicals detected at the Dye Burial Grounds.

TABLE 2-1

PHYSICAL/CHEMICAL CHARACTERISTICS OF ACID DYES, BASIC DYES, AND SOLVENT DYES SWMU 2 - DYE BURIAL GROUNDS NSWC CRANE CRANE, INDIANA

Compound	CAS No.	Molecular Weight	Water Solubility	Specific Gravity	K_{ow}	K_{oc}	H atm/m3/mole	VP mm Hg	BCF	Subject to Biodegradation	Melting Point	Thermal Properties
ACID BLUE 1	129-17-9	566.67	30,000 mg/L	NA	NA	15 (but ionic)	non-volatile	NA	2	NA	NA	NA
ACID BLUE 9	2650-18-2	783.01	5% at 20°C	NA	NA	NA	NA	NA	NA	NA	NA	NA
ACID ORANGE 10	1936-15-8	452.38	80,000 mg/L	NA	0	0 (but ionic, therefore, resists leaching)	low	2.50E-20	low	anaerobic(yes); aerobic (no)	NA	NA
ACID VIOLET 49	1694-09-3	734.9	soluble	NA	NA	NA	NA	NA	NA	NA	NA	NA
ACID YELLOW 23	1934-21-0	534.37	200,000 mg/L	NA	NA	NA	NA	NA	NA	NA	NA	NA
ANTHRACENE	120-12-7	178.23	43 ug/L	1.25	28,184	16,032	4.88E-05	2.67E-06	891	no		Boiling Point = 342°C; heat of vap. = 294 kj/kg; heat of comb. = 40110 kj/kg
BASIC VIOLET 10	81-88-9	479	soluble	NA	NA	NA	NA	NA	NA	NA	NA	NA
BASIC YELLOW 2	2465-27-2	303.66	10,000 mg/L	NA	NA	50000	2.80E-16	1.70E-11	3.8 - 16	no	>250°C	NA
BENZANTHRONE	82-05-3	230.25		NA	NA	>10,000	6.61E-08	2.21E-07	61 - 181	yes	170°C	NA
SOLVENT ORANGE 3	532-82-1	248.71	20 mg/L	NA	NA	840	non-volatile		114	anaerobic(yes)	118°C, decomposes at 235°C	NA
SOLVENT ORANGE 7	3118-97-6	276.32	insoluble	NA	NA	NA	NA	NA	NA	NA	166°C	NA
SOLVENT YELLOW 14	842-07-9	248.3	insoluble	NA	NA	NA	NA	NA	NA	NA	134°C	NA
SOLVENT YELLOW 2	60-11-7	225.28	13.6 mg/L	NA	38,019	7390	7.10E-09	3.30E-07	1780	yes	114-117°C	NA
PIGMENT VIOLET 12	81-64-1	240.2	probably insoluble	NA	NA	NA	NA	NA	NA	NA	NA	NA
SOLVENT RED 1	1229-55-6	278.3	3.3E-4 mg/L	NA	32,000,000	290000	1.10E-10	6.30E-09	290000	NA	183°C	NA
SOLVENT VIOLET 13	81-48-1	329.37		NA						NA	196°C	NA
SOLVENT YELLOW 3	97-56-3	225.28	7.64 mg/L	NA	8,318	1,426 - 3,236	2.91E-08	7.50E-07	196 - 562	NA	101-102°C	NA
VAT BLUE 1	482-89-3	262.26	insoluble	1.35	NA	NA	NA	NA	NA	NA	NA	Sublimes at about 300°C; decomposes at 390°C
VAT YELLOW 2	129-09-9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VAT YELLOW 4	128-66-5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-AMINOANTHROQUINONE	117-79-3	223.24	160 ug/L	NA	1,995	1500	9.20E-11	5.00E-11	18 - 46	no	302°C	Sublimes; Heat of Sublimation = 32.7 kcal/mol

K_{ow} - Octanol/water partition coefficient.

K_{oc} - Organic carbon partition coefficient.

VP - Vapor Pressure.

H - Vapor pressure x molecular weight x water solubility.

BCF - Biocentration factor.

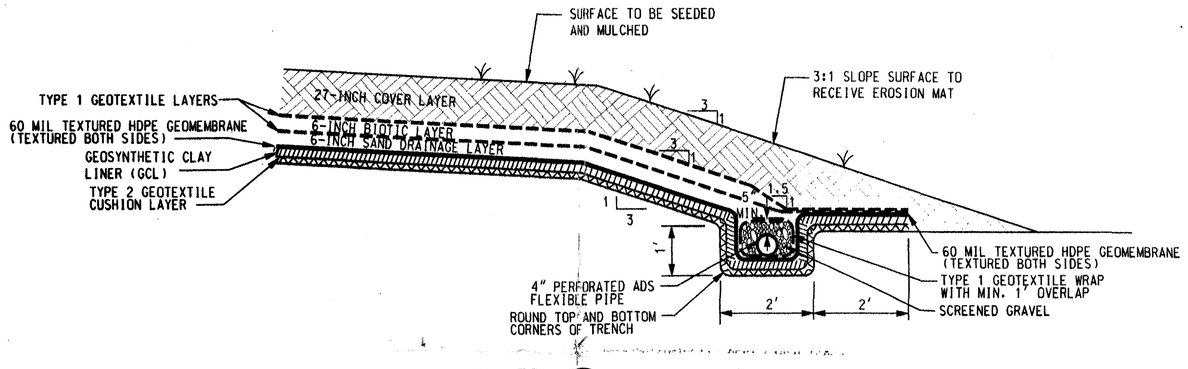
TABLE 2-2

SUMMARY OF RISK DRIVERS
SOIL MIGRATION TO GROUND WATER
SWMU 2 - DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

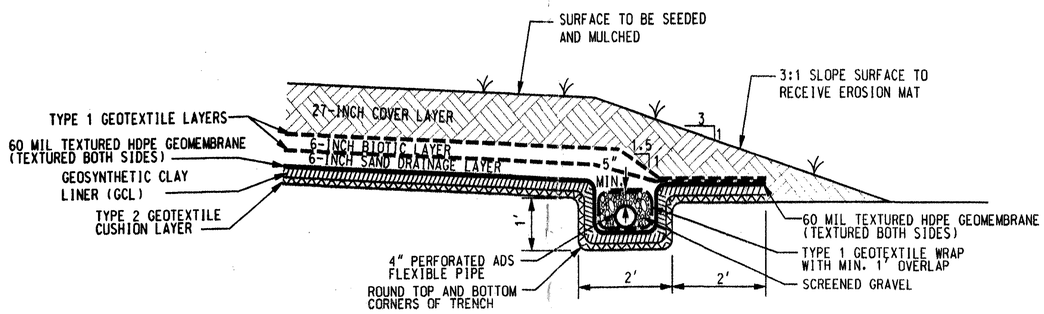
Chemical of Concern[1]	Impact on Human Receptors	Comments
GROUND WATER - LOWER PENNSYLVANIAN AQUIFER		
Aluminum	Future Child resident HQ = 2.2	Risks for aluminum, cadmium, cobalt, and nickel are based on the hypothetical future residential use of ground water. The risk estimates are based on analytical results for four unfiltered ground water samples. The exposure point concentration was influenced by one sample (02GWC11P301) that exhibited an unusually low pH (3.7), which suggests that the metal concentrations may be elevated because of increased solubility of geologic minerals in an acidic environment. In addition, because a cap exists at the site, a land use control will prohibit future development of the site.
Cadmium	Future Child resident HQ = 3.2	
Cobalt	Future Child Resident HQ = 2.1	
Nickel	Future Child resident HQ = 4.2 Future Adult resident HQ = 1.2	

HQ Hazard Quotient.
1 - Chemicals that contribute to a cumulative incremental lifetime cancer risk of greater than 1.0E-4 or a noncarcinogenic chemical contributing to target organ. Hazard Indices (HI) greater than 1.0.

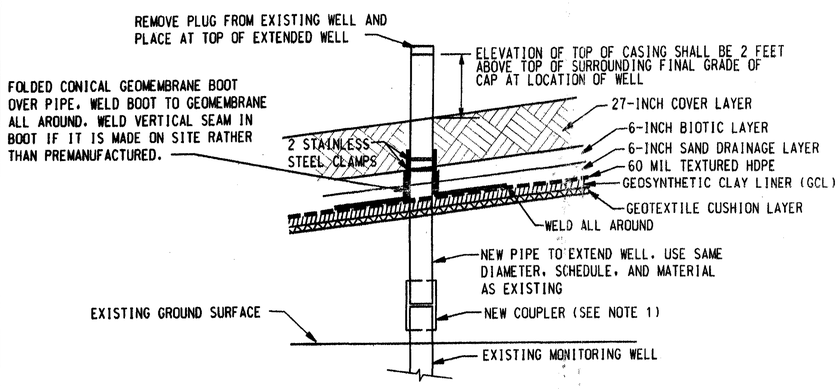
MORRISON KNUDSEN



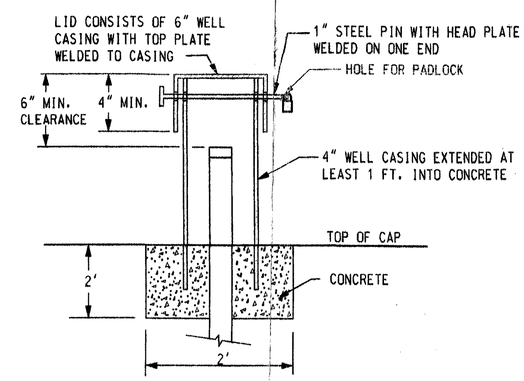
TYPICAL COVER (D/03)
N.T.S.



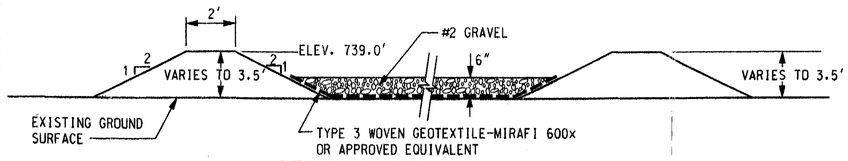
TYPICAL COVER (E/03)
N.T.S.



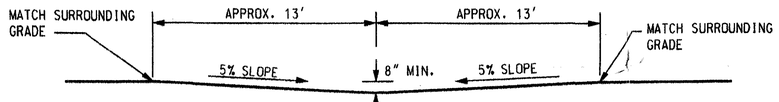
TYPICAL DETAIL OF EXTENSION OF EXISTING MONITORING WELL THROUGH CAP (1/03)
N.T.S.



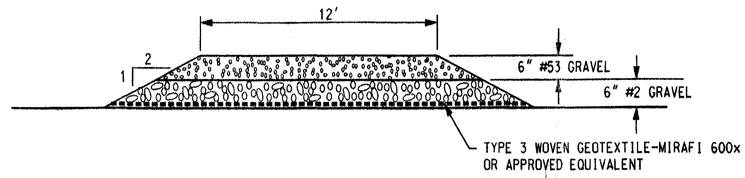
DETAIL-WELL PROTECTIVE CASING
N.T.S.



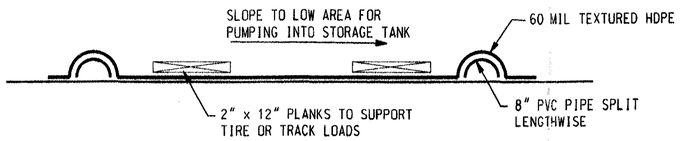
SECTION-FRAC TANK SECONDARY CONTAINMENT AREA BERM (A/03)
N.T.S.



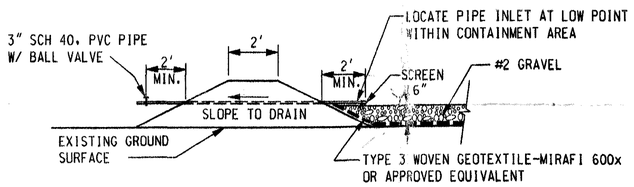
SECTION-SWALE TO RESTORE DRAINAGE ALONG SOUTHEAST SIDE OF CAP (B/03)
N.T.S.



SECTION-RECONSTRUCTED ACCESS ROAD (C/03)
N.T.S.



TEMPORARY DECONTAMINATION STATION DETAIL
N.T.S.



SECTION-FRAC TANK SECONDARY CONTAINMENT AREA (G/03)
N.T.S.

REVISIONS

REV.	DATE	DESCRIPTION	BY	LEAD ENGR	DEPT. MGR.	PROJ. MGR.
A	06/19/97	ISSUE FOR REVIEW AND BID				
0	06/25/97	ISSUE FOR CONSTRUCTION				

NOTES

1. WELL EXTENSION COUPLER SHALL BE INSTALLED USING CONTRACTOR-APPROVED METHOD TO AVOID WELL CONTAMINATION.

SWMU#02/11
DYE BURIAL GROUND INTERIM MEASURES CAP

NSWC, CRANE DIVISION
EASTERN SECTION
TYPICAL CAP CROSS SECTIONS AND DETAILS

MORRISON KNUDSEN CORPORATION
ENVIRONMENTAL SERVICES

DEPT	ARCH	STR/CIV	MECH	ELECT	PIPING	INST	Q/A	ENG. MGR.	PROJ. MGR.
INT									
DATE									

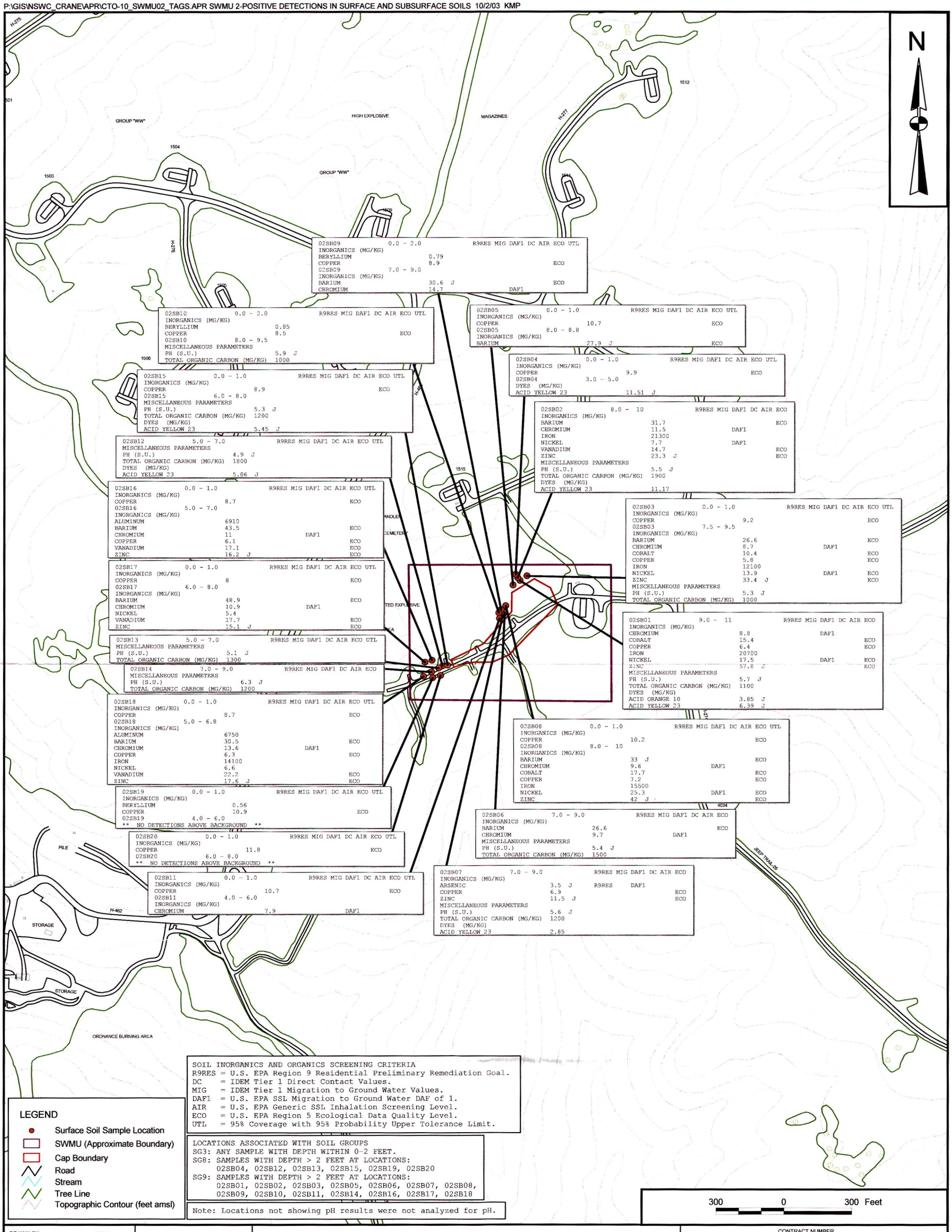
SCALE: AS NOTED		WORK ORDER NUMBER 4324
DRAWN: B. MARKER	06/24/97	
DESIGNED: C. WAITE		
CHECKED:		FIGURE 2-1
VERIFIED:		REV 0
APPROVED:		
FILE: W04324/DYE/DETAILS.DGN		

MORRISON KNUDSEN

MORRISON KNUDSEN

C00921VB04X

P:\GIS\NSWC_CRANE\APR\CTO-10_SWMU02_TAGS.APR SWMU 2-POSITIVE DETECTIONS IN SURFACE AND SUBSURFACE SOILS 10/2/03 KMP



02SB09 0.0 - 2.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
BERYLLIUM 0.79
COPPER 8.9 ECO
02SB09 7.0 - 9.0
INORGANICS (MG/KG)
BARIUM 30.6 J ECO
CHROMIUM 14.7 DAF1

02SB10 0.0 - 2.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
BERYLLIUM 0.85
COPPER 8.5 ECO
02SB10 8.0 - 9.5
MISCELLANEOUS PARAMETERS
PH (S.U.) 5.9 J
TOTAL ORGANIC CARBON (MG/KG) 1000

02SB05 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 10.7 ECO
02SB05 8.0 - 8.8
INORGANICS (MG/KG)
BARIUM 27.9 J ECO

02SB04 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 9.9 ECO
02SB04 3.0 - 5.0
DYES (MG/KG)
ACID YELLOW 23 11.51 J

02SB15 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 8.9 ECO
02SB15 6.0 - 8.0
MISCELLANEOUS PARAMETERS
PH (S.U.) 5.3 J
TOTAL ORGANIC CARBON (MG/KG) 1200
DYES (MG/KG)
ACID YELLOW 23 5.45 J

02SB02 8.0 - 10 R9RES MIG DAF1 DC AIR ECO
INORGANICS (MG/KG)
BARIUM 31.7 ECO
CHROMIUM 11.5 DAF1
IRON 21300
NICKEL 7.7 DAF1
VANADIUM 14.7 ECO
ZINC 23.3 J ECO
MISCELLANEOUS PARAMETERS
PH (S.U.) 5.5 J
TOTAL ORGANIC CARBON (MG/KG) 1900
DYES (MG/KG)
ACID YELLOW 23 11.17

02SB12 5.0 - 7.0 R9RES MIG DAF1 DC AIR ECO UTL
MISCELLANEOUS PARAMETERS
PH (S.U.) 4.9 J
TOTAL ORGANIC CARBON (MG/KG) 1800
DYES (MG/KG)
ACID YELLOW 23 5.06 J

02SB16 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 8.7 ECO
02SB16 5.0 - 7.0
INORGANICS (MG/KG)
ALUMINUM 6910
BARIUM 43.5 ECO
CHROMIUM 11 DAF1
COPPER 6.1 ECO
VANADIUM 17.1 ECO
ZINC 16.2 J ECO

02SB03 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 9.2 ECO
02SB03 7.5 - 9.5
INORGANICS (MG/KG)
BARIUM 26.6 ECO
CHROMIUM 8.7 DAF1
COBALT 10.4 ECO
COPPER 5.8 ECO
IRON 12100
NICKEL 13.9 DAF1 ECO
ZINC 33.4 J ECO
MISCELLANEOUS PARAMETERS
PH (S.U.) 5.3 J
TOTAL ORGANIC CARBON (MG/KG) 1000

02SB17 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 8 ECO
02SB17 6.0 - 8.0
INORGANICS (MG/KG)
BARIUM 48.9 ECO
CHROMIUM 10.9 DAF1
NICKEL 5.4
VANADIUM 17.7 ECO
ZINC 15.1 J ECO

02SB01 9.0 - 11 R9RES MIG DAF1 DC AIR ECO
INORGANICS (MG/KG)
CHROMIUM 8.8 DAF1
COBALT 15.4 ECO
COPPER 6.4 ECO
IRON 20700
NICKEL 17.5 DAF1 ECO
ZINC 57.8 J ECO
MISCELLANEOUS PARAMETERS
PH (S.U.) 5.7 J
TOTAL ORGANIC CARBON (MG/KG) 1100
DYES (MG/KG)
ACID ORANGE 10 3.85 J
ACID YELLOW 23 6.39 J

02SB13 5.0 - 7.0 R9RES MIG DAF1 DC AIR ECO UTL
MISCELLANEOUS PARAMETERS
PH (S.U.) 5.1 J
TOTAL ORGANIC CARBON (MG/KG) 1300

02SB14 7.0 - 9.0 R9RES MIG DAF1 DC AIR ECO
MISCELLANEOUS PARAMETERS
PH (S.U.) 6.3 J
TOTAL ORGANIC CARBON (MG/KG) 1200

02SB18 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 8.7 ECO
02SB18 5.0 - 6.8
INORGANICS (MG/KG)
ALUMINUM 6750
BARIUM 30.5 ECO
CHROMIUM 13.6 DAF1
COPPER 6.3 ECO
IRON 14100
NICKEL 6.6
VANADIUM 22.2 ECO
ZINC 17.6 J ECO

02SB08 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 10.2 ECO
02SB08 8.0 - 10
INORGANICS (MG/KG)
BARIUM 33 J ECO
CHROMIUM 9.6 DAF1
COBALT 17.7 ECO
COPPER 7.2 ECO
IRON 15500
NICKEL 25.3 DAF1 ECO
ZINC 42 J ECO

02SB19 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
BERYLLIUM 0.56
COPPER 10.9 ECO
02SB19 4.0 - 6.0
** NO DETECTIONS ABOVE BACKGROUND **

02SB06 7.0 - 9.0 R9RES MIG DAF1 DC AIR ECO
INORGANICS (MG/KG)
BARIUM 26.6 ECO
CHROMIUM 9.7 DAF1
MISCELLANEOUS PARAMETERS
PH (S.U.) 5.4 J
TOTAL ORGANIC CARBON (MG/KG) 1500

02SB20 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 11.8 ECO
02SB20 6.0 - 8.0
** NO DETECTIONS ABOVE BACKGROUND **

02SB11 0.0 - 1.0 R9RES MIG DAF1 DC AIR ECO UTL
INORGANICS (MG/KG)
COPPER 10.7 ECO
02SB11 4.0 - 6.0
INORGANICS (MG/KG)
CHROMIUM 7.9 DAF1

02SB07 7.0 - 9.0 R9RES MIG DAF1 DC AIR ECO
INORGANICS (MG/KG)
ARSENIC 3.5 J R9RES DAF1
COPPER 6.9 ECO
ZINC 11.5 J ECO
MISCELLANEOUS PARAMETERS
PH (S.U.) 5.6 J
TOTAL ORGANIC CARBON (MG/KG) 1200
DYES (MG/KG)
ACID YELLOW 23 2.85

SOIL INORGANICS AND ORGANICS SCREENING CRITERIA
R9RES = U.S. EPA Region 9 Residential Preliminary Remediation Goal.
DC = IDEM Tier 1 Direct Contact Values.
MIG = IDEM Tier 1 Migration to Ground Water Values.
DAF1 = U.S. EPA SSL Migration to Ground Water DAF of 1.
AIR = U.S. EPA Generic SSL Inhalation Screening Level.
ECO = U.S. EPA Region 5 Ecological Data Quality Level.
UTL = 95% Coverage with 95% Probability Upper Tolerance Limit.

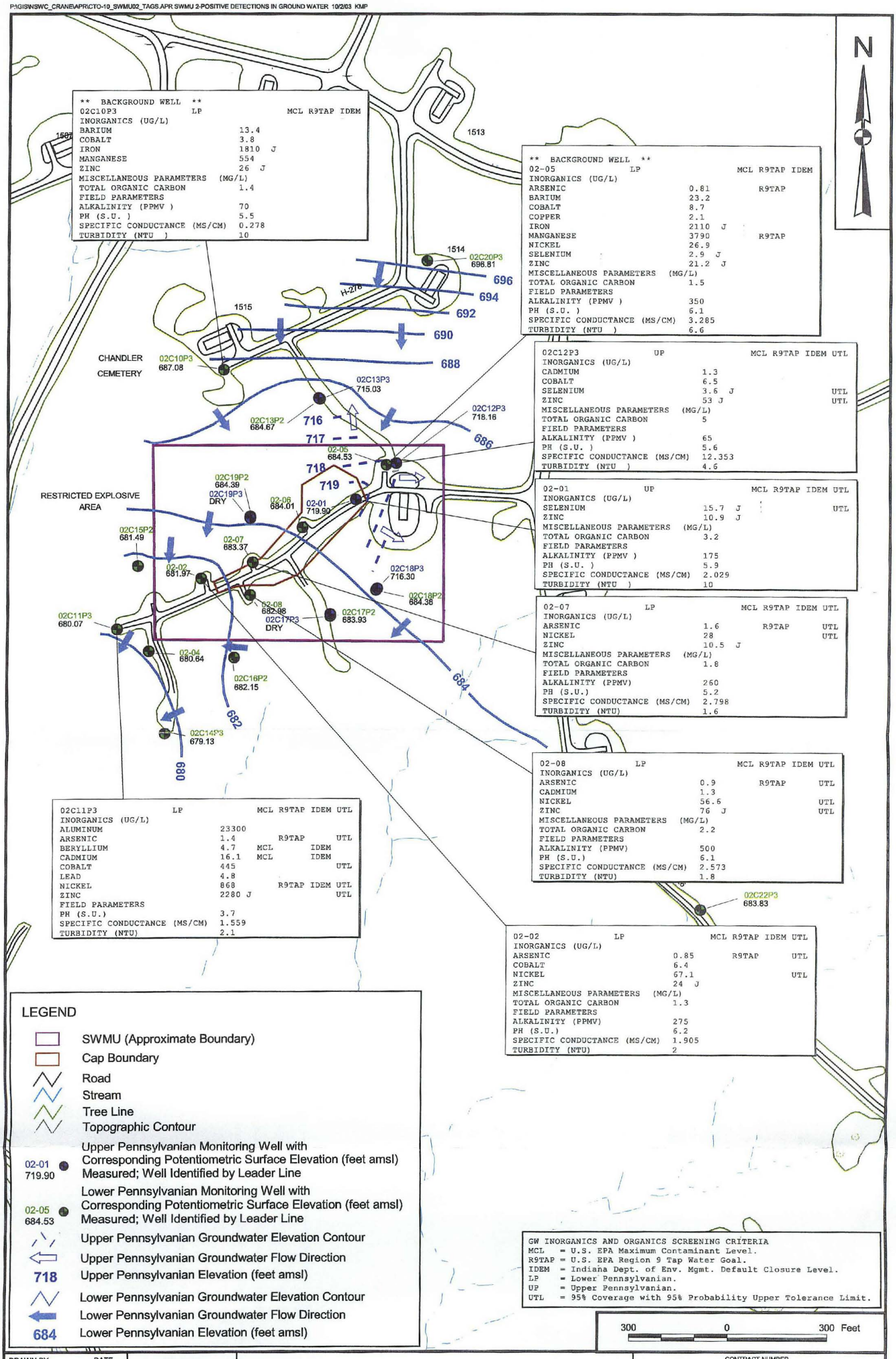
LOCATIONS ASSOCIATED WITH SOIL GROUPS
SG3: ANY SAMPLE WITH DEPTH WITHIN 0-2 FEET.
SG8: SAMPLES WITH DEPTH > 2 FEET AT LOCATIONS:
02SB04, 02SB12, 02SB13, 02SB15, 02SB19, 02SB20
SG9: SAMPLES WITH DEPTH > 2 FEET AT LOCATIONS:
02SB01, 02SB02, 02SB03, 02SB05, 02SB06, 02SB07, 02SB08, 02SB09, 02SB10, 02SB11, 02SB14, 02SB16, 02SB17, 02SB18

Note: Locations not showing pH results were not analyzed for pH.

LEGEND
- Surface Soil Sample Location
- SWMU (Approximate Boundary)
- Cap Boundary
- Road
- Stream
- Tree Line
- Topographic Contour (feet amsl)

DRAWN BY K. Peila	DATE 10/2/03	ORGANICS AND INORGANICS DETECTED IN EXCESS OF BACKGROUND CONCENTRATIONS IN SURFACE AND SUBSURFACE SOILS SWMU 2 - DYE BURIAL GROUNDS NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER 3994
CHECKED BY J. Lucas	DATE 10/2/03		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 2-2 REV 0

P:\GIS\NSWC_CRANE\APR\CTO-10_SWMU02_TAGS.APR SWMU 2-POSITIVE DETECTIONS IN GROUND WATER 10/2/03 KMP



** BACKGROUND WELL **

02C10P3	LP	MCL	R9TAP	IDEM
INORGANICS (UG/L)				
BARIUM	13.4			
COBALT	3.8			
IRON	1810 J			
MANGANESE	554			
ZINC	26 J			
MISCELLANEOUS PARAMETERS (MG/L)				
TOTAL ORGANIC CARBON	1.4			
FIELD PARAMETERS				
ALKALINITY (PPMV)	70			
PH (S.U.)	5.5			
SPECIFIC CONDUCTANCE (MS/CM)	0.278			
TURBIDITY (NTU)	10			

** BACKGROUND WELL **

02-05	LP	MCL	R9TAP	IDEM
INORGANICS (UG/L)				
ARSENIC	0.81		R9TAP	
BARIUM	23.2			
COBALT	8.7			
COPPER	2.1			
IRON	2110 J			
MANGANESE	3790		R9TAP	
NICKEL	26.9			
SELENIUM	2.9 J			
ZINC	21.2 J			
MISCELLANEOUS PARAMETERS (MG/L)				
TOTAL ORGANIC CARBON	1.5			
FIELD PARAMETERS				
ALKALINITY (PPMV)	350			
PH (S.U.)	6.1			
SPECIFIC CONDUCTANCE (MS/CM)	3.285			
TURBIDITY (NTU)	6.6			

02C12P3	UP	MCL	R9TAP	IDEM	UTL
INORGANICS (UG/L)					
CADMIUM	1.3				
COBALT	6.5				
SELENIUM	3.6 J				UTL
ZINC	53 J				UTL
MISCELLANEOUS PARAMETERS (MG/L)					
TOTAL ORGANIC CARBON	5				
FIELD PARAMETERS					
ALKALINITY (PPMV)	65				
PH (S.U.)	5.6				
SPECIFIC CONDUCTANCE (MS/CM)	12.353				
TURBIDITY (NTU)	4.6				

02-01	UP	MCL	R9TAP	IDEM	UTL
INORGANICS (UG/L)					
SELENIUM	15.7 J				UTL
ZINC	10.9 J				
MISCELLANEOUS PARAMETERS (MG/L)					
TOTAL ORGANIC CARBON	3.2				
FIELD PARAMETERS					
ALKALINITY (PPMV)	175				
PH (S.U.)	5.9				
SPECIFIC CONDUCTANCE (MS/CM)	2.029				
TURBIDITY (NTU)	10				

02-07	LP	MCL	R9TAP	IDEM	UTL
INORGANICS (UG/L)					
ARSENIC	1.6		R9TAP		UTL
NICKEL	28				UTL
ZINC	10.5 J				
MISCELLANEOUS PARAMETERS (MG/L)					
TOTAL ORGANIC CARBON	1.8				
FIELD PARAMETERS					
ALKALINITY (PPMV)	260				
PH (S.U.)	5.2				
SPECIFIC CONDUCTANCE (MS/CM)	2.798				
TURBIDITY (NTU)	1.6				

02-08	LP	MCL	R9TAP	IDEM	UTL
INORGANICS (UG/L)					
ARSENIC	0.9		R9TAP		UTL
CADMIUM	1.3				
NICKEL	56.6				UTL
ZINC	76 J				UTL
MISCELLANEOUS PARAMETERS (MG/L)					
TOTAL ORGANIC CARBON	2.2				
FIELD PARAMETERS					
ALKALINITY (PPMV)	500				
PH (S.U.)	6.1				
SPECIFIC CONDUCTANCE (MS/CM)	2.573				
TURBIDITY (NTU)	1.8				

02C11P3	LP	MCL	R9TAP	IDEM	UTL
INORGANICS (UG/L)					
ALUMINUM	23300				
ARSENIC	1.4		R9TAP		UTL
BERYLLIUM	4.7	MCL		IDEM	
CADMIUM	16.1	MCL		IDEM	
COBALT	445				UTL
LEAD	4.8				
NICKEL	868		R9TAP	IDEM	UTL
ZINC	2280 J				UTL
FIELD PARAMETERS					
PH (S.U.)	3.7				
SPECIFIC CONDUCTANCE (MS/CM)	1.559				
TURBIDITY (NTU)	2.1				

02-02	LP	MCL	R9TAP	IDEM	UTL
INORGANICS (UG/L)					
ARSENIC	0.85		R9TAP		UTL
COBALT	6.4				
NICKEL	67.1				UTL
ZINC	24 J				
MISCELLANEOUS PARAMETERS (MG/L)					
TOTAL ORGANIC CARBON	1.3				
FIELD PARAMETERS					
ALKALINITY (PPMV)	275				
PH (S.U.)	6.2				
SPECIFIC CONDUCTANCE (MS/CM)	1.905				
TURBIDITY (NTU)	2				

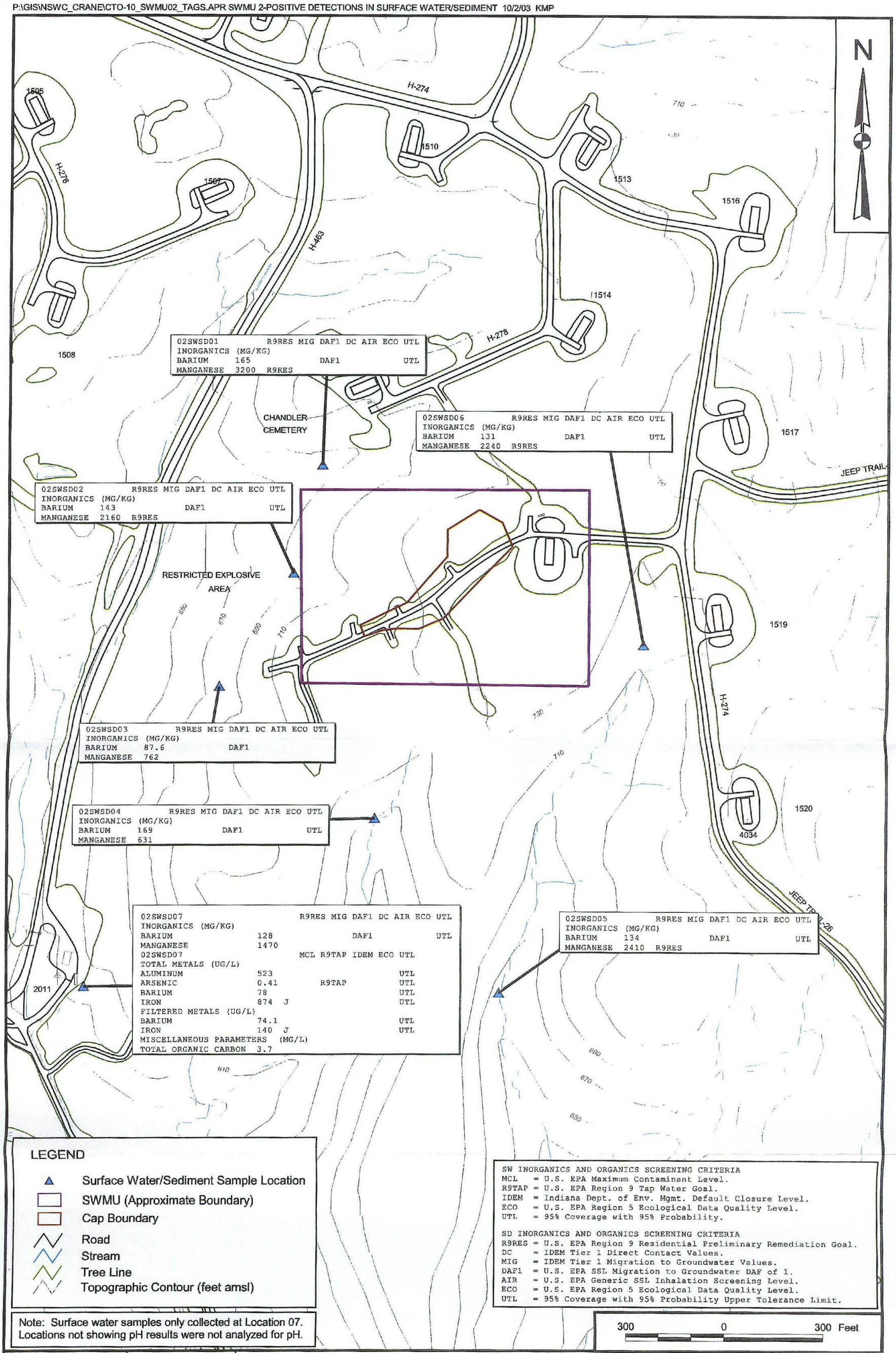
GW INORGANICS AND ORGANICS SCREENING CRITERIA
MCL = U.S. EPA Maximum Contaminant Level.
R9TAP = U.S. EPA Region 9 Tap Water Goal.
IDEM = Indiana Dept. of Env. Mgmt. Default Closure Level.
LP = Lower Pennsylvanian.
UP = Upper Pennsylvanian.
UTL = 95% Coverage with 95% Probability Upper Tolerance Limit.

DRAWN BY	DATE
J. LAMEY	1/29/02
CHECKED BY	DATE
T. JOHNSTON	2/10/03
COST/SCHEDULE-AREA	
SCALE	AS NOTED

ORGANICS, SELECT MISCELLANEOUS PARAMETERS, AND INORGANICS
DETECTED IN EXCESS OF BACKGROUND CONCENTRATIONS IN GROUND WATER
SWMU 2 - DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER 3994
APPROVED BY — DATE —
APPROVED BY — DATE —
DRAWING NO. FIGURE 2-3
REV 0

P:\GIS\NSWC_CRANE\CTO-10_SWMU02_TAGS.APR SWMU 2-POSITIVE DETECTIONS IN SURFACE WATER/SEDIMENT 10/2/03 KMP



DRAWN BY	DATE			CONTRACT NUMBER
J. LAMEY	1/29/02			3994
CHECKED BY	DATE			APPROVED BY / DATE
COST/SCHEDULE-AREA				APPROVED BY / DATE
SCALE				DRAWING NO. / REV
AS NOTED				FIGURE 2-4 / 0

ORGANICS AND INORGANICS IN EXCESS OF BACKGROUND
CONCENTRATIONS IN SURFACE WATER/SEDIMENT
SWMU 2 - DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

3.0 DEVELOPMENT OF CORRECTIVE ACTION OBJECTIVES

3.1 INTRODUCTION

The purpose of this section is to identify ARARs and TBC criteria and to develop corrective action objectives for soil. The corrective action objectives are based on contaminant characterization, risk assessment, and compliance with risk-based and ARAR-based action levels.

3.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ARARs include the requirements, criteria, or limitations promulgated under federal and state law that address a chemical, location, or action at a site. The definition of an ARAR is a follows:

- Any standard, requirement, criterion, or limitation under federal environmental law.
- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-citing law that is more stringent that the associated federal standard, requirement criterion, or limitation.

One of the primary concerns during the development of corrective action objectives is the degree of human health and environmental protection afforded by a given remedy. Consideration should be given to remedies that attain or exceed ARARs.

Definitions of the two types of ARARs, as well as TBC criteria, are given below:

- Applicable Requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a site.

- Relevant and Appropriate Requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" address problems or situations sufficiently similar (relevant) to those encountered at a site such that their use is well suited (appropriate) to the particular site.

- TBC Criteria are nonpromulgated, enforceable guidelines or criteria that may be useful for developing remedial actions or necessary for determining what is protective of human health and/or the

environment. Examples of TBC criteria include U.S. EPA Drinking Water Advisories and Risk-Based Concentrations (RBCs).

ARARs fall into three categories based on the manner in which they are applied:

- Contaminant-Specific – These include health-risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Examples of contaminant-specific ARARs include Maximum Contaminant Levels (MCLs) and Clean Water Act (CWA) ambient water quality criteria.

- Location-Specific – These restrictions are based on the concentrations of specific contaminants or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of a site.

- Action-Specific – These are technology- or activity-based controls or restrictions on activities related to management of contaminants. Action-specific ARARs pertain to implementing a given remedy.

A summary listing of all contaminant-, location-, and action-specific ARARs and TBCs for SWMU 2 are listed in Tables 3-1, 3-2, and 3-3, respectively. Sections 3.3.1, 3.3.2, and 3.3.3 provide a brief description of each contaminant-, location-, and action-specific ARAR and TBC shown in Tables 3-1 through 3-3.

3.3.1 Contaminant-Specific ARARs and TBCs

This section provides a summary description of federal and State of Indiana contaminant-specific ARARs and TBC criteria of potential concern at SWMU 2.

The Safe Drinking Water Act (SDWA) (40 CFR 141-143) promulgated National Primary Drinking Water Standard MCLs (40 CFR Part 141). MCLs are enforceable standards for contaminants in public drinking water supply systems. They consider not only health factors but also the economic and technical feasibility of removing a contaminant from a water supply system. Secondary MCLs (SMCLs) (40 CFR Part 143) are not enforceable but are intended as guidelines for contaminants that may adversely affect the aesthetic quality of drinking water, such as taste, odor, color, and appearance, and may deter public acceptance of drinking water provided by public water systems.

The SDWA also established MCL Goals (MCLGs) for several organic and inorganic compounds in drinking water. MCLGs indicate the level of contaminants in drinking water at which no known or anticipated health

effects would occur, allowing for an adequate margin of safety. MCLGs are non-enforceable public health goals. The National Contingency Plan (NCP) [40 CFR 300.430(e)(2)(i)] states that MCLGs that are set at levels greater than zero shall be attained by remedial actions for ground water or surface waters that are current or potential sources of drinking water where MCLs are relevant and appropriate to the circumstances of the release.

The CWA sets U.S. EPA Ambient Water Quality Criteria (AWQCs) that are non-enforceable guidelines (TBCs) developed for pollutants in surface waters pursuant to Section 304(a)(1) of the CWA. Although AWQCs are not legally enforceable, they are TBC as potential ARARs. AWQCs are available for the protection of human health from exposure to contaminants in surface water as well as from ingestion of aquatic biota and for the protection of freshwater and saltwater aquatic life. AWQCs may be considered for actions that involve ground water treatment and/or discharge to nearby surface waters.

U.S. EPA Health Advisories are non-enforceable guidelines developed by the U.S. EPA Office of Drinking Water for contaminants that may be intermittently encountered in public water supply systems. Health advisories are available for short-term, longer-term, and lifetime exposures for a 10-kg child and a 70-kg adult. Health advisories may be pertinent for remedial action/corrective measures involving ground water, especially for contaminants that are not regulated by the SDWA.

U.S. EPA Generic Soil Screening Levels (SSLs) are guidance that, if exceeded through three possible exposure pathways, may be of potential concern to human receptors. SSLs are risk-based concentrations derived from equations combining exposure information assumptions with U.S. EPA toxicity data. SSLs for protection of ground water use a simple linear equilibrium soil/water partition equation or leach test to estimate contaminant releases in soil leachate. SSLs consider the following exposure pathways: direct ingestion of soil, inhalation of volatile compounds and fugitive dust, and migration of ground water. SSLs are TBC.

Reference Doses (RfDs), as defined in the U.S. EPA Integrated Risk Information System (IRIS), are estimates (with uncertainty spanning perhaps an order of magnitude) of daily exposure to the human population (including sensitive subgroups) that are likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs are developed for chronic and/or subchronic human exposure to hazardous chemicals and are based on the assumption that thresholds exist for certain toxic effects. The RfD is usually expressed as an acceptable dose (mg) per unit body weight (kg) per unit time (day). The RfD is derived by dividing the no- observed-adverse effect level (NOAEL) or the lowest-observed-adverse–effect-level (LOAEL) by an uncertainty factor (UF) times a modifying factor (MF). RfDs are TBC.

U.S. EPA Carcinogenic Slope Factors, as defined in the IRIS, are an upper bound, approximating a 95-percent confidence limit, on the increased cancer risk from a lifetime exposure to a contaminant. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg/day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100. Carcinogenic slope factors are TBC.

Region 9 Primary Remediation Goals are risk-based concentrations derived from standardized equations combining exposure information assumptions with U.S. EPA toxicity data for contaminants in soil, air, and tap water. They are considered to be protective for humans (including sensitive groups) over a lifetime. However, PRGs are not always applicable to a particular site and do not address non-human health endpoints such as ecological impacts. PRGs are not de facto cleanup standards; however, they could be used to establish final cleanup levels for a site after a proper evaluation takes place. Region 9 PRGs are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements. PRGs are TBC.

The Clean Air Act (CAA) (40 CFR 50) consists of two programs or requirements that may be ARARs: National Ambient Air Quality Standards (NAAQS) (40 CFR Parts 50 and 53) and National Emission Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61). NESHAPs, which are emission standards for source types (i.e., industrial categories) that emit hazardous air pollutants, are not likely to be applicable or relevant and appropriate for NSWC Crane because they were developed for specific contaminants and sources. U.S. EPA requires the attainment and maintenance of primary and secondary NAAQS to protect public health and public welfare. These standards are contaminant- and averaging-period- specific national limitations on ambient air quality. States are responsible for assuring compliance with the NAAQS. NAAQS and NESHAPs are relevant and appropriate ARARs.

IDEM has established a non-rule policy called the Risk Integrated System of Closure (RISC) that incorporates environmental risk assessment principles to protect human health and the environment and achieve consistent closure of contaminated soil and ground water. As a non-rule policy document, RISC guidance does not have the effect of law. However, the policy provides a systematic approach for consistently and rationally implementing the laws and rules that govern site investigation and closure. Included in this policy are risk-based closure level constituent concentrations calculated to be protective of human health. The RISC is TBC.

Indiana Ambient Air Quality Standards (AAQS) (325 IAC 1-3) and Air Screening Levels (ASLs) are two State requirements that may be ARARs. The purpose of the AAQS is to establish primary and secondary ambient air quality standards for the state to the extent necessary to protect public health and welfare and

are in accordance with the provisions of the CAA. ASLs are non-rule guidelines that are used to by IDEM to evaluate the ambient impact of hazardous contaminants. When determining a pollutant's maximum allowable concentration, the toxicity of a compound is measured by its permissible exposure limit (PEL). The PEL is the maximum concentration under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effects. The PEL for each chemical is determined by the Occupational Safety and Health Administration (OSHA). IDEM calculates ASLs as generally 0.5 percent of the PEL. If the maximum air concentration is less than the ASL, it indicates that there should not be a significant impact on public health and welfare. Site-specific exceptions may be made. AAQS are relevant and appropriate ARARs. ASLs are TBC.

Indiana Water Quality Standards (IWQS) (IAC 327) establish minimum standards for the protection of surface water quality. IDEM has established two sets of water quality criteria; one for bodies of water that are in the Great Lakes Basin and another for all other state bodies of water. Each set of criteria includes values for the protection of human health, aquatic life and wildlife. There are two categories of human health criteria, drinking and non-drinking. The drinking water criteria apply to the point of intake. Separate human health cancer and non-cancer criteria are derived if the contaminant has the potential to cause cancer. The value of the highest level of protection is used for each contaminant. Water from SWMU 2 does not drain to the Great Lakes Basin. IWQS are relevant and appropriate ARARs.

3.3.2 Location-Specific ARARs and TBCs

This section presents a summary of federal and State of Indiana location-specific ARARs and TBC criteria of potential concern for SWMU 2. The potential ARARs and TBCs are as follows:

The Endangered Species Act of 1973 [16 United States Code (USC) 1531] (50 CFR Part 17) conserves the ecosystems upon which endangered and threatened species depend and to conserve and recover listed species. Corrective measure actions, if required, would need to be conducted in a manner such that the continued existence of any endangered or threatened species is not jeopardized or its critical habitat is not adversely affected. Consultation with the United States Fish and Wildlife Service is also required. SWMU 2 is located in Martin County. The State of Indiana has identified a list of endangered, threatened, and rare species for Martin County. The species include plants, insects, birds, reptiles, and birds. In addition, migrating species may move through the area.

U.S. EPA Ground Water Protection Strategy and Classification Guidelines (U.S. EPA, 1984) is a policy to protect ground water for its highest present or potential beneficial use. The strategy designates three classifications of ground water:

- Class I – Special Ground Water: Water that is highly vulnerable to contamination and is either irreplaceable or ecologically vital as a source of drinking water.

- Class II – Current and Potential Sources of Drinking Water and Waters Having Other Beneficial Uses: Waters that are currently used or that are potentially available.

- Class III – Ground Water Not a Potential Source of Drinking Water and of Limited Beneficial Use. Class III ground water units are further subdivided into the following two subclasses:

  - Subclass IIIA includes ground water units that are highly to intermediately interconnected to adjacent ground water units of a higher class and/or surface waters. They may, as a result, be contributing to the degradation of the adjacent waters. They may be managed at a similar level as class II ground water, depending on the potential for producing adverse effects on the quality of adjacent waters.

  - Subclass IIIB is restricted to ground water characterized by a low degree of interconnection to adjacent surface waters or other ground water units of a higher class within the Classification Review Area. These ground waters are naturally isolated from sources of drinking waters in such a way that little potential exists for producing adverse effects on quality. They have low resource values outside of mining or waste disposal.

At SWMU 2, ground water is likely considered to be Class IIIA. However, a potential future residential land use has been evaluated in the RFI, although unlikely, and therefore the ground water can be considered as Class II.

The Archaeological and Historic Preservation Act (16 USC Section 469) (36 CFR 65) establishes requirements relating to potential loss or destruction of significant scientific, historical, or archaeological data as a result of any proposed remedy. The Secretary of the Interior must be notified if a federal agency finds that its activities, in connection with any federal construction project, might cause loss or destruction of such data. No historic artifacts are expected to be uncovered at SWMU 2; however, artifacts may be discovered during site work.

Historical Preservation and Archeology [Indiana Code (IC) 14-21] establishes requirements for the potential loss or destruction of significant scientific, historical, or archeological data as a result of a proposed remedy. This requirement establishes procedures for notifying the State Division of Historic Preservation and

Archeology when activities result in the discovery of such data. No historic artifacts are expected to be uncovered at SWMU 2; however, artifacts may be discovered during site work.

Indiana Nongame and Endangered Species Conservation (IC 14-22-34) enables the State to develop a list of those species and subspecies of wildlife indigenous to Indiana that are determined to be endangered in Indiana. In addition, this rule governs the taking, possession, removal, capture, destruction, and management of state-listed endangered species. SWMU 2 is located in Martin County. The State of Indiana has identified a list of endangered, threatened, and rare species for Martin County. The species include plants, insects, birds, reptiles, and birds. In addition, migrating species may move through the area.

Indiana Wildlife Regulation (IC 14-22-10) provides protection for wildlife from releases or discharges of contaminants or waste materials into State waters or land that may result in the destruction of wild animals. The State Department of Natural Resources has the authority and responsibility to protect and properly manage the fish and wildlife resources of the State. During the remedy activity, contaminated waste could be released on to soil and possibly result in discharge to State waters.

Indiana Natural Heritage Protection Campaign (IC 14-31-2) promotes the preservation of areas of unusual natural interest for scientific, educational, recreational, cultural, and aesthetic purposes as a link to the Indiana's past and future. The rules also provides for the maintenance and management of those natural areas and the rare native species for which the areas are habitat. Remedy activities at SWMU 2 may result in disturbance of natural areas inhabited by Indiana rare species.

3.3.3 Action-Specific ARARs and TBCs

This section presents a summary of potential federal and State action-specific ARARs and TBCs for SWMU 2.

The CWA (40 CFR 122), as amended, governs point-source discharges through the National Pollutant Discharge Elimination System (NPDES), discharge of dredge or fill material, and oil and hazardous waste spills to United States waters. NPDES requirements (40 CFR Part 122) will be applicable if the direct discharge of pollutants into surface waters is part of the corrective action (i.e., discharge of effluent from a ground water treatment system). These potentially applicable regulations contain discharge limitations, monitoring requirements, and best management practices.

RCRA Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR 264) establish minimum national standards that define the acceptable management of hazardous waste. This regulation is applicable if hazardous waste is sent to a treatment, storage or disposal facility or if hazardous wastes are treated on site.

RCRA Identification and Listing of Hazardous Waste (40 CFR 261) provides for determining if a solid waste is a hazardous waste. This standard defines those solid wastes that are subject to regulation as hazardous waste under 40 CFR Parts 262 to 265 and Parts 124, 270, and 271.

RCRA Standards Applicable to Generators of Hazardous Waste (40 CFR Part 262). A generator that treats, stores, or disposes of hazardous waste on site must comply with these standards that include manifest, pre-transport (i.e., packaging, labeling, and placarding), record keeping, and reporting requirements. The standards are applicable if actions taken at SWMU 2 constitute generation of a hazardous waste (e.g., excavation of contaminated soils that may be hazardous).

Standards Applicable to Transporters of Hazardous Waste (40 CFR Part 263) are applicable to the off-site transportation of hazardous waste. These regulations include requirements for compliance with the manifest and record keeping systems and requirements for immediate action and cleanup of hazardous waste discharges (spills) during transportation. The standards are potentially applicable if corrective actions involve off-site transportation of hazardous waste from SWMU 2.

Standards and Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (40 CFR Parts 264 and 265) are applicable to corrective actions that may be taken at SWMU 2 and to off-site facilities that receive hazardous waste from the site for treatment and/or disposal. Standards for treatment, storage and disposal (TSD) facilities include requirements for preparedness and prevention, corrective action requirements, closure and post-closure care, use and management of containers, and design and operating standards for tank systems, surface impoundments, waste piles, landfills, and incinerators. These standards are potentially applicable if corrective actions involve the on-site treatment or disposal of hazardous waste at SWMU 2.

RCRA Land Disposal Restriction (LDR) Requirements (40 CFR Part 268) restrict certain wastes from being placed or disposed on the land unless they meet specific best demonstrated available technology (BDAT) treatment standards (expressed as concentrations, total or in the toxicity characteristic leaching procedure (TCLP) extract, or as specified technologies). Removal and treatment of a RCRA hazardous waste or movement of the waste outside of a Corrective Action Management Unit (CAMU), thereby constituting "placement" would trigger the LDR requirements.

RCRA Solid Waste Management Regulations (40 CFR 258) establish minimum national design and operating criteria for solid waste (non-hazardous) landfill units. These minimum national criteria ensure the protection of human health and the environment.

Department of Transportation (DOT) Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171 to 179) regulate the transport of hazardous materials, including packaging, shipping equipment, and placarding. These rules are considered applicable to wastes shipped off site for laboratory analysis, treatment, or disposal.

Indiana Environmental Remediation (IC 13-30-10) - This rule requires certain environmental remediation plans to specify remediation objectives based on specified factors. It directs the Indiana Department of Environmental Management to certify completion of plans and to issue covenants not to sue with respect to completed plans.

Indiana Voluntary Remediation Program - The Voluntary Remediation Program (VRP) provides a mechanism for site owners, operators, or potential purchasers to voluntarily enter into an agreement with IDEM to clean up contaminated property. Because the program is voluntary, participants may elect to withdraw from it at any time. However, those who complete a site cleanup under the VRP are issued a Certificate of Completion from IDEM and a Covenant Not to Sue from the Governor's Office. These documents ensure that the owner or operator of the site will be able to proceed with re-use of the site without concern that it may be subject to further enforcement action by IDEM or that they could be subject to further liability at some later date.

Indiana Closure and Corrective Action Policy [Waste-0015-Nonrule Policy Document (NPD)] Different situations have arisen in the past where remedial activities under RCRA have closures that can be more appropriately addressed through the Indiana corrective action authorities. This non-rule policy provides procedures to be followed when this action is implemented.

3.4 MEDIA-SPECIFIC CORRECTIVE ACTION OBJECTIVES

Corrective Action Objectives (CAOs) are developed in this section to address military smoke dyes and dye-contaminated materials that were disposed at SWMU 2. CAOs generally identify COCs, receptors, pathways, and action clean-up levels. The RFI for SWMU 2 concluded that while some metals were detected in SWMU 2 ground water at concentrations greater than upgradient concentrations, the presence of metals in downgradient wells cannot be attributed to SWMU 2 operations and are the result

of localized geochemical conditions at one well. Military dyes have not been detected in ground water. However, dye was detected infrequently in subsurface samples. As a result, soil is the only medium that requires corrective action at SWMU 2.

The medium-specific corrective action objectives for contaminated soils are as follows:

- Prevent human and ecological exposure (ingestion, dermal contact, and dust inhalation) to contaminated soils with concentrations greater than the PRGs.
- Prevent leaching of contaminants to ground water.
- Comply with chemical-specific, location-specific, and action-specific ARARs and TBC guidance.

3.4.1 Chemicals of Concern

Dyes, which are the primary chemicals of concern COCs at SWMU 2, were not detected in surface soil, ground water, surface water, or sediment. Two dyes, Acid Orange 10 and Acid Yellow 23, were detected infrequently in subsurface soil samples at concentrations that were less than levels of concern.

Quantitative estimates of noncarcinogenic and carcinogenic risks (HIs and ILCRs, respectively) have been developed for potential human receptors. Cumulative HIs for the construction worker, maintenance worker, adult recreational user, and adolescent trespasser under the RME scenario were less than unity, indicating adverse non-carcinogenic effects are not anticipated. However, cumulative HIs for the future adult and child resident exceeded unity. Cumulative ILCRs for all receptors were less than or within U.S. EPA's target risk range. The elevated HIs for the future adult and child resident were attributable to exposure to the COCs aluminum, cadmium, cobalt, and nickel in ground water primarily by ingestion.

The elevated HIs for residential exposure to ground water are subject to the following sources of uncertainty:

- The elevated HIs were associated with one ground water sample (02GWC11P301). This sample exhibited an unusually low pH (3.7), which is likely the reason that metals concentrations are elevated, because acidic conditions increase the solubility of metals in water. The acidic conditions at this location are believed to be attributable to the geochemical conditions at the site and not with past dye materials at SMWU 2. The concentrations of these metals are believed to be naturally occurring and not associated with SWMU 2.

- The residential land use scenario assumes that ground water at the site is sued as a source of domestic drinking water. However, it is unlikely that residences would ever be located at this site. Although enlisted and officer personnel reside at NSWC Crane under current conditions, the residential scenario is not applicable for these receptors because they do not and would not be expected to reside within the boundaries of SWMU 2. Because a cap exists at the site, LUCs will prohibit future development of the site. There is one active sources of safe drinking water within the boundary of NSWC Crane. This source is identified as the Crane Division, Naval Surface Warfare Center (NSWC). The source of water for the Crane Division, NSWC source is Lake Greenwood. Therefore, it is unlikely that ground water at the site would be used as a source of potable water in the future. These sources are identified as the Crane Division, Naval Surface Warfare Center (NSWC) and the Crane Water Works. The source of water for the Crane Division, NSWC source is Lake Greenwood. The source of water for the Crane Water Works is ground water, which is purchased from Eastern Heights Utilities located in Bloomfield, Indiana.

Based on the conclusion that the elevated metals concentrations are believed to be naturally occurring due to local conditions and that ground water beneath SWMU 2 would not be used as a source of potable water source in the future, the metals aluminum, cadmium, cobalt, and nickel have been removed from the SWMU 2 COC list in this CMS. As a result, the only remaining COCs for soil at SMWU 2 are the military dyes.

3.4.2 Media Cleanup Standards

Media Cleanup Standards (MCSs) have been developed for the COCs (military dyes) in soil at SWMU 2 and are shown in Table 3-4. The MCSs shown in Table 3-4 for soil were taken from risk-based target levels that are included in the Quality Assurance Project Plan (QAPP) for SWMU 2. The risk-based target levels for dyes were incorporated into the QAPP following U.S. EPA Region 5 review in September 2000 (TtNUS, 2000).

TABLE 3-1

SUMMARY OF CHEMICAL-SPECIFIC ARARs AND TBC CRITERIA
SWMU 2 – DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Requirement	Citation	Status	Synopsis	Comment
FEDERAL				
Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and Secondary MCLs (SMCLs) MCL Goals (MCLGs)	42 USC 300f et seq. 40 CFR 141 to 143	MCLs are relevant and appropriate; SMCLs and MCLGs are TBC	MCLs, SMCLs, and MCLGs established under this act are health-based limits for certain chemical substances in drinking water.	Can be used for determining preliminary remediation goals (PRGs) ground water.
Clean Water Act (CWA) Ambient Water Quality Criteria (AWQC)	33 USC 1251 et seq. Section 304(a)(1)	TBC	Water-quality criteria are non-enforceable guidance and are used in conjunction with the designated use for a stream segment to establish water quality standards under CWA 303.	During remedial activities, groundwater or treatment by-products may be collected. Can be used to determine discharge limits or PRGs for surface water.
U.S. EPA Health Advisories	EPA 822-B-96-002	TBC	U.S. EPA Office of Drinking Water guidelines for chemicals that may be encountered in public water supply systems.	Can be used for determining PRGs for groundwater.
U.S. EPA Generic Soil Screening Levels (SSLs)	EPA 540-R-96-018 Appendix A	TBC	Federal guidance that provides screening levels for protection of human health and ground water from soil contaminants.	Can be used for determining PRGs for soil.
Reference Doses (RfDs) from Integrated Risk Information System (IRIS)	NA	TBC	U.S. EPA Office of Research and Development guidelines used in the public health assessment	Can be used for determining risk-based PRGs.
Carcinogenic Slope Factors from IRIS	NA	TBC	U.S. EPA Environmental Criteria and Assessment Office; U.S. EPA Carcinogen Assessment Group guidelines used in the public health assessment	Can be used for determining risk-based PRGs.
EPA Region 9 PRGs	NA	TBC	U.S. EPA Region 9 has developed PRGs for contaminants in soil, air, and tap water. These risk-based concentrations are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements.	Can be used for determining PRGs

TABLE 3-1

SUMMARY OF CHEMICAL-SPECIFIC ARARs AND TBC CRITERIA
SWMU 2 – DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Requirement	Citation	Status	Synopsis	Comment
Indiana Department of Environmental Management (IDEM) Risk Integrated System of Closure (RISC)	NA	TBC	A non-rule policy that incorporates environmental risk assessment principles to protect human health and the environment and achieve consistent closure of contaminated soil and groundwater.	TBC in risk assessment
Indiana Water Quality Standards	IAC 327	Relevant and appropriate	Establishes minimum standards for surface water quality.	Can be used to determine discharge limits or PRGs for surface water.

TABLE 3-2

SUMMARY OF LOCATION-SPECIFIC ARARs AND TBCs
SWMU 2 –DYE BURIAL GROUNDS
NSWC CRANE
CRANE INDIANA

Requirement	Citation	Status	Synopsis	Comment
FEDERAL				
The Endangered Species Act of 1978	16 USC 1531 50 CFR 17 and 402	Potentially Applicable	Requires federal agencies to ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the future existence or critical habitat of any endangered or threatened species.	The Indiana Bat and several bird species that are either endangered, threatened, or species of special interest may reside in the vicinity of SWMU 2. In addition, migrating species may occasionally move through the area.
U.S. EPA Ground Water Protection Strategy and Classification Guidelines	NA	TBC	Provides guidance in determining the potential beneficial uses of contaminated groundwater.	Groundwater at SWMU 2 is classified as a shallow bedrock aquifer.
The Archaeological and Historic Preservation Act	16 USC 469 36 CFR 65	Potentially Applicable	Establishes requirements relating to potential loss or destruction of significant scientific, historical, or archeological data as a result of a proposed remedy.	No historic artifacts are expected to be uncovered in the vicinity of SWMU 2; however, artifacts may be discovered during site work.
STATE				
Historical Preservation and Archaeology	IC 14-21	Potentially Applicable	Establishes requirements relating to potential loss or destruction of significant scientific, historical, or archeological data as a result of a proposed remedy.	No historic artifacts are expected to be uncovered in the vicinity of SWMU 2; however, artifacts may be discovered during site work.
Nongame and Endangered Species Conservation	IC 14-22-34	Potentially Applicable	Establishes protection and conservation of State nongame and endangered species.	The Indiana Bat and several bird species are either endangered, threatened, or species of special interest may reside in the vicinity of SWMU 2. In addition, migrating species may occasionally move through the area.
Wildlife Regulation	IC 14-22-10	Potentially Applicable	Provides protection of wildlife from releases or discharges of waste material onto or in any water of Indiana that may result in the killing of wildlife.	Release of contaminated waste materials during remedial activities could be discharged into surface water and result in harm to wild animals.
Indiana Natural Heritage Protection Campaign	IC 14-31-2	TBC	Promotes the preservation, maintenance, and management of those natural areas and rare native species for which the areas are habitat.	Applicable to the areas that may be disturbed during remedial activities.

TABLE 3-3

SUMMARY OF ACTION-SPECIFIC ARARs AND TBC CRITERIA
SWMU 2 DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Requirement	Citation	Status	Synopsis	Comment
FEDERAL				
Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES)	40 CFR 122	Potentially applicable	NPDES permits are required for any discharge to surface water.	Any alternative that includes discharges to surface water would have to comply with the permit requirements.
National Environmental Policy Act (NEPA)	42 USC 4321 40 CFR Part 6	Potentially Applicable	Requires federal agencies to evaluate the environmental impacts associated with major actions that they fund, support, permit, or implement.	Alternatives could constitute significant activities, thereby making NEPA requirements ARARs.
Clean Air Act (CAA) National Emission Standards for Hazardous Air Pollutants (NESHAPs)	40 CFR 61	Relevant and appropriate	Establishes emission standards for particular air contaminants from specific sources.	Hazardous air pollutants may be discharged during ground water or soil treatment activities.
CAA National Ambient Air Quality Standards (NAAQS)	40 CFR 50	Relevant and appropriate	Establishes air quality standards for carbon monoxide, lead, nitrogen oxides, particulate matter, ozone, and sulfur oxides emitted from a major source of emissions.	These pollutants may be generated during ground water treatment or soil excavation, handling, or treatment activities.
Resource Conservation and Recovery Act (RCRA) Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264	Potentially Applicable	Establishes minimum national standards for acceptable management of hazardous waste.	These standards would be applicable for on-site treatment, storage, or disposal of hazardous waste.
RCRA Identification and Listing of Hazardous Waste	40 CFR 261	Potentially Applicable	Regulations that govern the procedures for identifying if a solid waste is a hazardous waste.	Specific materials at the site may be classifiable as characteristic or listed hazardous wastes.
RCRA Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Potentially Applicable	Establishes standards for generators of hazardous waste.	Applicable for removed wastes determined to be hazardous.

TABLE 3-3

SUMMARY OF ACTION-SPECIFIC ARARs AND TBC CRITERIA
SWMU 2 DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Requirement	Citation	Status	Synopsis	Comment
RCRA Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Potentially Applicable	Establishes standards for off-site transportation of hazardous waste.	Applicable for removed wastes determined to be hazardous that are transported off site.
RCRA Standards and Interim Standards for Owners and Operators of Hazardous Waste TSD Facilities	40 CFR 264 and 265	Potentially Applicable	Regulations that govern the treatment, storage, and disposal of hazardous waste.	These regulations would be applicable to waste removed from this site including both on-site and off-site management; however, the reuse of treated soils as backfill would not be subject to the disposal facility standard.
RCRA Land Disposal Restrictions (LDRs)	40 CFR 268	Potentially Applicable	Identifies hazardous wastes that are restricted from land disposal and waste analysis requirements.	Treatment or disposal of contaminated soils/ wastes and/or treatment residuals may be considered hazardous waste subject to LDRs.
RCRA Solid Waste Management Regulations	40 CFR 258	Potentially Applicable	Establishes design and operating standards for solid waste (nonhazardous) landfills.	Applicable if nonhazardous soil is stockpiled or disposed on site.
Department of Transportation (DOT) Rules for Hazardous Materials Transport	49 CFR 107 and 171 to 179	Potentially Applicable	Regulations for the transportation of hazardous materials. Requirements cover packaging, marking, labeling, and transportation methods.	Off-site shipments of any contaminated soil that is classified as a hazardous material from this site would have to comply with these regulations. *Dye materials are believed not to be hazardous*
STATE				
Indiana Ambient Air Quality Standards	326 IAC 1-3	Relevant and appropriate	Establishes air quality standards for carbon monoxide, lead, nitrogen oxides, particulate matter, ozone, and sulfur oxides emitted from a major source of emissions.	These pollutants may be generated during ground water treatment or soil excavation, handling, or treatment activities.
Indiana Air Screening Levels	NA	TBC	The Indiana Department of Environmental Management Office of Air Management calculates a maximum acceptable ground-level concentration of toxic air pollutants, which is generally 0.5% of the permissible exposure limit (PEL). Site-specific exceptions may be made.	These pollutants may be generated during ground water treatment or soil excavation, handling, or treatment activities.

TABLE 3-3

SUMMARY OF ACTION-SPECIFIC ARARs AND TBC CRITERIA
SWMU 2 DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Requirement	Citation	Status	Synopsis	Comment
Indiana Environmental Remediation	IC 13-30-10	Potentially Applicable	This rule requires certain environmental remediation plans to specify remediation objectives based on specified factors. It directs IDEM to certify completion of plans and to issue covenants not to sue with respect to completed plans.	Applicable to certain remediation plans.
Indiana Voluntary Remediation Program (VRP)	NA	TBC	The VRP provides a mechanism for site owners, operators or potential purchasers to voluntarily enter into an agreement with IDEM to clean up contaminated property.	Since the program is voluntary, participants may elect to withdraw from it at any time. However, those who complete a site cleanup under the VRP are issued a Certificate of Completion from IDEM and a Covenant Not To Sue from the Governor's Office.
Indiana Closure and Corrective Action Policy	WASTE-0015-NPD	TBC	This non-rule policy document provides procedures to be followed when this action is implemented.	This policy addresses scenarios and procedures in situations where remedial activities under RCRA Subtitle C closures can more appropriately be addressed through Indiana corrective action authorities.

4.0 IDENTIFICATION AND SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

4.1 PRELIMINARY SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

Table 4-1 provides a preliminary screening of corrective measures technologies for soil. This preliminary screening is conducted to eliminate those technologies that are clearly not applicable to conditions at SWMU 2.

The preliminary technology screening is based on overall applicability to the medium of concern, COCs, and conditions present at SWMU 2. For SWMU 2, the environmental medium of concern has been identified as soil, which includes the contaminated soil and non-soil materials (e.g., rags, debris, etc.) that are buried beneath the existing landfill cap. For SWMU 2, the COCs have been identified as military dyes. The purpose of this screening effort is to investigate a reasonable range of available technologies and process options and to eliminate those obviously not applicable to the site. The following table summarizes the technologies retained from the preliminary screening:

General Action	Technology	Process Option
No Action	None	Not Applicable
Limited Action	Institutional Controls	Passive Controls: Land Use Controls (LUCs)
		Active Controls: Fencing, Cap Maintenance, Inspections
	Monitoring	Site and Ground Water Monitoring
Removal	Excavation	Bulk Excavation
Ex-situ Treatment	Physical/Chemical	Chemical Fixation/Stabilization
		Soil Washing/Solvent Extraction
		Size Reduction
	Biological	Bio-Slurry Reactor/Bio-Pile
	Thermal	Low-Temperature Thermal Desorption (LTTD)
Disposal	Off-Site Landfill	Non-Hazardous Waste Landfill

4.2 DETAILED SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES

The technologies retained from the preliminary screening are broadly evaluated in this section. The evaluations are based on criteria of effectiveness, implementability, and relative cost, which are defined as follows:

- Effectiveness - This criterion focuses on the potential effectiveness of process options in protecting human health and the environment and in meeting the CAOs and MCSs. This criterion considers potential impacts to human health and the environment during construction and implementation and how proven and reliable the process is with respect to COCs and site conditions.

- Implementability - Implementability is a measure of both the technical and administrative feasibility of implementing a technology. It provides a means of evaluating the ability of a technology to be adapted to site-specific conditions. Technical feasibility includes consideration of construction and operational issues, demonstrated performance, and adaptability to site conditions. Administrative feasibility considerations include the ability to obtain any necessary permits or easements or adherence to applicable laws and concerns of other regulatory agencies. General availability of necessary equipment and resources is also evaluated.

- Cost - Cost evaluations allow a relative comparison between similar technologies and play a limited role in technology screening. The cost analysis is based on engineering judgment and each technology is evaluated as to whether costs are low, medium, or high relative to the other options in the same technology type. If there is only one process option, costs are compared to other candidate technologies.

The process options presented in the above table for use at SWMU 2 are evaluated in the following sections.

4.2.1 No Action

No Action consists of maintaining status quo at the site. No Action is considered in the CMS process to provide a baseline for comparison with other corrective measures technologies and their effectiveness in mitigating risks posed by site COCs. Because no remedial actions are taken with this technology, there are no costs associated with No Action. There is also no reduction in risk through exposure control or treatment. No action would not be effective in evaluating contaminant mobility and potential migration off site because no monitoring would be performed.

Effectiveness

Although there are currently no unacceptable risks associated with SWMU 2, No Action would not be effective in meeting the CAOs. Because nothing would prevent future disturbance of the existing cap and the cap would no longer be maintained, unacceptable risk could eventually develop because of exposure

to contaminated soil and landfill material. Because no monitoring would be performed, there would be no warning of potential migration of COCs from soil to ground water.

Implementability

There would be no implementability concerns because no action would be implemented.

Cost

There would be no costs associated with No Action.

Conclusion

No Action is retained as a baseline for comparison although it would not be effective.

4.2.2 Limited Action

Two technologies were retained from preliminary screening, institutional controls and monitoring.

4.2.2.1 Institutional Controls

Institutional controls consist of formulating and implementing passive controls such as LUCs to prohibit disturbance of the existing cap, control future site development, and restrict ground water use. Institutional controls also consist of implementing active controls such as fencing to control site access and maintenance of an existing remedial system such as a landfill cap.

Effectiveness

Institutional controls would allow contaminated soil and landfill material to remain on site and would not meet MCSs. However, institutional controls would be effective in meeting the CAOs by maintaining the current status quo under which there are no unacceptable risks.

Implementability

Institutional controls would be readily implementable for SWMU 2. Institutional controls consist of formulating and implementing passive controls such as LUCs to prohibit groundwater use, control future site development that would impact the integrity of the existing cap, and provide notification for construction projects that may contact groundwater.

Cost

Costs of institutional controls would be low.

Conclusion

Institutional controls are retained for the development of corrective measures alternatives.

4.2.2.2 Monitoring

Monitoring includes site monitoring and ground water monitoring. Site monitoring consists of performing regular inspections to check the continued enforcement of institutional controls and to verify the proper operation and/or continued integrity of whatever remedial system or structure might be in place. Ground water monitoring consists of collecting and analyzing ground water samples from monitoring wells located upgradient and downgradient of the existing landfill cap as well as within the cap itself.

Effectiveness

Site monitoring would effectively insure the continued application of necessary institutional controls. In the case of SWMU 2, site monitoring would also be effective to verify the continued integrity of the existing landfill cap.

Ground water monitoring would not of itself prevent potential migration of COCs from soil to ground water, but it would still be effective in meeting the CAOs by providing a warning of the occurrence of such a migration. However, to date no such migration has been detected.

Implementability

Site monitoring would be very simple to implement, especially as long as the Navy retains ownership of the site.

Ground water monitoring has already been performed at SWMU 2, and adequate monitoring wells are already in place. Therefore, a new long-term monitoring program could be readily implemented.

Cost

Capital and operation and maintenance (O&M) costs of monitoring would be low.

Conclusion

Site and ground water monitoring are retained for the development of corrective measures alternatives.

4.2.3 Removal

The only technology considered under this general action is excavation. Excavation can be performed by a variety of equipment such as tractor front-end loaders, backhoes, grade-alls, etc. The type of equipment selected must take into consideration several factors such as the type of material to be removed, the load-bearing capacity of the ground surrounding the removal area, the depth and areal extent of removal, the required rate of removal, and the elevation of the ground water table. At SWMU 2, removal of the existing cap and excavation of the contaminated soil and landfill material could be performed with front-end loaders and backhoes. As part of excavation, perimeter monitoring would be required and suppression of fugitive dust emission would have to be implemented if necessary.

Effectiveness

Excavation is a well-proven and effective method of removing contaminated material from a site. However, this technology merely relocates contaminated materials rather than treating and destroying them. Properly designed excavation could remove soil with concentrations of COCs greater than MCSs to attain the CAOs and allow for unrestricted future use of the site. Contaminated soil, such as that currently present beneath the existing cap at SWMU 2, would be amenable to excavation. However, extreme care would have to be taken in the handling of any dye-contaminated material to prevent spreading.

Sampling is typically required to verify the effectiveness of the removal action. Soil samples would be collected from the sidewalls and, as applicable, from the bottom of the excavation. These samples would be analyzed for COCs to ensure that the remaining soil is not contaminated at unacceptable levels.

Implementability

Excavation of contaminated soil at SWMU 2 would be implementable. Excavation equipment and/or services are readily available from multiple vendors or contractors. This technology is well proven and established in the construction/remediation industry. During excavation, site-specific health and safety procedures and OSHA regulations would have to be complied with to ensure that the exposure of the workers to COCs is minimized. This would include the wearing of appropriate personal protective

equipment (PPE) and the implementation of dust suppression measures. During excavation, extreme care would also have to be taken to prevent the spreading of dyes.

Because the excavation would extend to a depth of approximately 12 feet bgs, shoring of the excavation sidewalls would be required and occasional dewatering might be necessary as well. However, these could be implemented.

Cost

Cost of excavation is typically moderate. However, the estimated volume of contaminated soil at SWMU 2 is large and, thus, the cost of excavating this contaminated soil would be relatively high.

Conclusion

Excavation is retained in combination with other process options for the development of corrective measures alternatives.

4.2.4 Ex-Situ Treatment

4.2.4.1 Chemical Fixation/Stabilization

Ex-situ chemical fixation/stabilization consists of mixing the contaminated soil and landfill material with chemical reagents that bind the COCs within the matrix of the material being treated. The most common fixation/stabilization reagents are pozzolanic-based materials such as Portland Cement, cement kiln dust (CKD), and fly ash. Chemicals such as quick lime or proprietary reagents (e.g., organophilic compounds) are also often added to the fixation/stabilization reagents to increase the effectiveness of the treatment, especially if high concentrations of organic compounds are present that may not readily respond to pozzolanic-based binding. Quick lime is often added to reduce the solubility of metals and neutralize acidity, which would otherwise destroy the cementitious matrix and release the metals into the environment.

The mixing of the material to be treated with the chemical reagents is normally accomplished in the presence of a controlled amount of water with specialized mechanical blending equipment such as a pug mill.

After the material is mixed with the chemical reagents, it is allowed to cure for a specified time period. The duration of curing is dependent on the strength required before handling or disposal. The solidified

material can be formed into monolithic blocks or can be made into a granular material with the consistency of a soil-cement.

Chemical fixation/stabilization typically requires pre-treatment for the removal of oversized materials that would not be adequately blended with the chemical reagents and would interfere with the treatment process.

Effectiveness

The effectiveness of chemical fixation/stabilization is highly dependent on the type of material being treated and the kind of contaminant(s) being immobilized. A thorough physical and chemical characterization of the material to be treated and COCs to be immobilized is needed. Treatability tests would have to be performed to verify effectiveness, determine the most suitable reagents and mixing ratios, and identify pre-treatment requirements.

At SWMU 2, pozzolanic fixation/stabilization would likely be effective for the treatment of soil containing moderate concentrations (probably up to 1 percent by weight) of military dyes. However, this technology would probably not be effective for the treatment of the more concentrated waste that is assumed to be contained in buried drums. Because chemical fixation/stabilization does not destroy COCs or reduce their toxicity, this technology would not of itself meet the CAOs or achieve the MCSs, and the treated material would still require proper disposal to minimize the unacceptable human health risk that could result from direct exposure. However, chemical fixation/stabilization would effectively minimize the potential for migration of COCs from the treated soil to other environmental media such as ground water. Long-term stability and leachability of the treated material would remain as potential concerns because COCs would remain within the treated soil. Most chemical fixation/stabilization processes, including in particular the use of pozzolanic reagents, result in an increase in the volume of the treated material typically ranging from 5 to 15 percent.

Implementability

Ex-situ chemical fixation/stabilization would be readily implementable. The necessary equipment and resources are available at most permitted off-base treatment storage and disposal facilities (TSDFs). Treatability testing would be required to verify effectiveness and determine operating parameters.

Cost

Capital and O&M costs of ex-situ chemical fixation/stabilization would be moderate.

Conclusion

Although ex-situ chemical fixation/stabilization would likely be effective in reducing the potential for COC migration and would be readily implementable, it would not of itself meet the CAOs and disposal of the treated material would still be required. This technology could thus only be retained for pre-treatment purposes. However, it is assumed that the SWMU 2 contaminated soil and landfill material is non-hazardous and that its disposal would not trigger LDRs. Therefore pre-treatment would not be required, and chemical fixation/stabilization is eliminated from further consideration for this CMS.

4.2.4.2 Soil Washing/Solvent Extraction

Soil washing/solvent extraction is based on the use of water or other solvents to extract or desorb contaminants from the soil and dissolve them into the liquid phase. Most often, this technology requires pre-treatment with physical separation processes such as screening, attrition scrubbing, froth flotation, electromagnetic separation, mechanical separation, hydrogravimetric separation (including hydrocyclones, mineral jigs, and spiral classifiers), and multigravity separation. Such physical separation processes achieve waste minimization through a volume reduction process by separating out a size fraction of the soil containing little or no contamination (such as coarse-grained soils and large-sized material) from the more highly contaminated, finer-grained material.

Effectiveness

The effectiveness of soil washing is highly waste- and medium-specific. While the data shown on Table 2-1, seem to indicate that many of the military dyes disposed at SWMU 2 are water soluble and should thus be amenable to soil washing, such soil washing is typically most effective for the removal of compounds from a material onto which these compounds do not adsorb too strongly, such as sand. Because the soil beneath the existing SWMU 2 cap consists primarily of fine silty clay, military dyes are expected to adsorb on it quite well and not be particularly mobile. This assumption is supported by the absence of dye in the ground water beneath the existing SWMU 2 landfill. Therefore, the effectiveness of soil washing/solvent extraction may be limited for this application and this technology might not achieve the CAOs and meet the MCSs. A thorough physical and chemical characterization of the material to be treated and COCs to be removed would be needed. Treatability tests would have to be performed to verify effectiveness, determine the most suitable solvent(s), and identify pre-treatment requirements.

This technology would yield clean soil that would require rinsing with clean water several times to remove the residual solvent. Treatment by-products would consist of spent solvent containing high

concentrations of COCs that would require further treatment and disposal with recovery and reuse of the solvent fluid.

Implementability

Ex-situ soil washing/solvent extraction could be implemented for SWMU 2. However, a full-scale, on-site or off-base, soil washing/chemical extraction system would be very complex, consisting of physical separation operations and chemical extraction processes. The necessary equipment and resources are only available from a relatively limited number of contractors or off-base permitted TSDFs. Treatability testing would be required to verify effectiveness and determine operating parameters. By-products would require further treatment and disposal.

Cost

Capital and O&M costs for soil washing/chemical extraction would be moderate to high. Additional costs for disposal of by-products could also be moderate to high.

Conclusion

Soil washing/chemical extraction is eliminated from further consideration because of significant effectiveness and implementability concerns.

4.2.4.3 Bio-Slurry Reactor/Bio-Pile

Bio-slurry reactor is a technology in which the contaminated material is biologically treated in an enclosed vessel. After removal of foreign materials such as stones and rubble, the contaminated material is mixed with water and a culture of appropriate microorganisms to form a slurry containing 10 to 30 percent solids. This slurry is placed in a tank featuring process controls so that temperature, mixing, and nutrient additions can be manipulated to achieve maximum biological treatment efficiency. Following treatment, the slurry is dried and tested to verify that COCs have been adequately removed, and the treated material is replaced in its original location or used as fill material somewhere else.

Bio-pile is a technology in which the contaminated material is mixed with biologically amended soil and formed into an enclosed compost pile. Oxygen, if needed for aerobic treatment, is provided either by the inducing of an air current through the pile with blowers or vacuum pumps or by the mixing-in of a oxygen-release reagent. Moisture, heat, nutrients, oxygen, and pH are controlled to enhance biodegradation.

Duration of operation may vary from a few weeks to several months, at which time the treated material is either returned to its original location or used as fill material somewhere else.

Effectiveness

Bio-slurry reactors and bio-piles have been proven effective for the treatment of soil contaminated with a wide range of organic compounds. Such a system has been operated at NSWC Crane for the treatment of explosive-contaminated soil but is currently idle. Typically, bio-slurry reactors or bio-piles can achieve close to 100 percent removal of these compounds. However, the effectiveness of these processes for the removal of the military dyes present in the SWMU 2 contaminated soil and landfill material is unproven. Only limited data is available about environmental fate criteria [water/octanol partition coefficient (K_{OW}), organic carbon partition coefficient (K_{OC}), and bioconcentration factor (BCF)] and biodegradability for the military dyes disposed at SWMU 2, but this data as presented in Table 2-1 indicates that these chemicals are very persistent, that biodegradation does not appear to be an important environmental fate process, and that only a few of the dyes might be amenable to anaerobic treatment. Therefore, this technology is not very likely to achieve the CAOs and meet the MCSs.

Implementability

Ex-situ bio-slurry reactor or bio-pile technologies would be implementable for SWMU 2, but each would require a relatively complex sequence of operations, including staging, treatment, and disposal of treated soil. In addition, treated soil from a bio-slurry reactor would also require dewatering and drying prior to disposal or re-use. The necessary equipment and resources are only available from a relatively limited number of contractors or off-base permitted TSDFs. The existing facility previously used for the biological treatment of explosive-contaminated soil could be considered for this application but it would have to be extensively modified because it was designed as an aerobic treatment system, whereas the biodegradation of the SWMU 2 military dyes, if feasible, would almost certainly require anaerobic conditions. Treatability testing would be required to prove effectiveness and determine operating parameters.

Cost

Capital and O&M costs for ex-situ bio-slurry reactors/bio-piles would be moderate to high.

Conclusion

Ex-situ bio-slurry reactors/bio-piles are eliminated from further consideration because of effectiveness and implementability concerns.

4.2.4.4 Low Temperature Thermal Desorption

LTTD technology uses direct or indirect heating to thermally desorb or volatilize organic contaminants. The temperatures used are contaminant- and matrix-specific, with a range of approximately 200 to 1,200°F (95 to 650°C). Typically, wastes are processed through an externally fired pug mill or rotary drum system equipped with heat transfer surfaces that are heated by circulating hot oil. An induced airflow conveys the desorbed organic chemicals through a secondary treatment system such as a granular activated carbon (GAC) adsorption unit, a catalytic oxidation unit, a condenser unit, or an afterburner. However, use of an afterburner for secondary treatment has typically resulted in the LTTD unit being considered an incinerator by regulatory agencies. The off-gas is then discharged through a stack.

LTTD typically requires pre-treatment for the removal of oversized materials that would not be adequately thermally desorbed and could interfere with the treatment process.

Effectiveness

The effectiveness of LTTD is highly contaminant- and matrix-specific. LTTD is typically very effective for the removal of relatively complex and high molecular weight organic compounds such as the military dyes present at SWMU 2. In spite of the relatively limited thermal properties data presented on Table 2- , it seems likely that this technology would achieve the CAOs and meet the MCSs. For military dyes, the operating temperature of an LTTD unit would be expected to be towards the higher end of the range (probably 800 to 1,000° F or 425 to 540° C). A thorough physical and chemical characterization of the material to be treated and COCs to be removed would be needed. Treatability tests would have to be performed to verify effectiveness, determine the optimum operating temperature and detention time, and identify pre-treatment requirements.

To be fully effective, LTTD would require additional treatment of the volatilized contaminants that would be accomplished through treatment of off-gases by such processes as condensation, vapor-phase GAC adsorption, or catalytic oxidation.

Implementability

Ex-situ LTTD would be implementable for SWMU 2. The quantity of contaminated material to be treated (less than 20,000 yd^3) would make it more practical and cost effective for this technology to be implemented at a fixed off-base permitted TSDF rather than on-site with a mobile treatment system. A number of qualified off-base permitted TSDFs are available to provide this service. Pre-treatment for size reduction would most likely be required and could be accomplished on site prior to off-base transportation. Off-gases from the thermal desorption unit would have to be treated. Although the treated material would meet the MCSs, it would probably still have to be disposed by non-hazardous landfill, unless an acceptable and practical application could be readily found for the re-use of this material. Treatability tests would have to be performed to verify effectiveness and determine operating parameters.

Cost

Costs of ex-situ LTTD would be moderate to high.

Conclusion

Although ex-situ LTTD would likely be effective and could be readily implemented at an off-base permitted TSDF, non-hazardous landfilling of the treated material would probably still be required for ultimate disposal. Because it is assumed that the SWMU 2 contaminated soil is non-hazardous and that its disposal would not trigger LDRs, pre-treating this material with LTTD would not significantly improve disposal options and costs. Therefore, LTTD is eliminated from further consideration for this CMS as unnecessary.

4.2.4.5 Size Reduction

Size reduction consists of screening, shredding, crushing, and/or grinding contaminated debris so that they would meet the particle size requirements of subsequent treatment and/or disposal processes. This size reduction is accomplished by processing the oversized contaminated debris in specialized mechanical equipment such as vibrating screens, hammer mills, grinders, and shredders.

Effectiveness

Size reduction would not of itself remove the SWMU 2 COCs and achieve the CAOs or meet the MCSs. However, size reduction is often required as a pre-treatment to optimize the effectiveness of other ex-situ corrective measures technologies such as chemical fixation, soil washing, or LTTD. At SWMU 2, size

reduction technologies might be required and would be effective for the on-site pre-treatment of foreign components other than soil and fill material known to be present within the existing landfill cap (e.g., geotextile liner, drainage pipe) and beneath the cap (e.g., drums).

During operation, risk to site workers operating the size reduction equipment could be adequately minimized through the use of dust suppression controls, the wearing of appropriate PPE, and compliance with OSHA regulations and site-specific health and safety procedures.

Implementability

Size reduction would be readily implementable as a pretreatment step. The necessary equipment and resources are readily available from a wide number of contractors and also at most off-base permitted TSDFs.

Cost

Capital and O&M costs for size reduction would be low.

Conclusion

Size reduction is retained in combination with other technologies and process options for the development of corrective measures alternatives.

4.2.5 Disposal

The only technology considered under this general action is off-base non-hazardous landfilling. This consists of transporting the excavated soil for burial in a permitted off-base RCRA Subtitle D, or solid waste, landfill.

Effectiveness

Off-base non-hazardous landfilling would not permanently or irreversibly remove COCs and meet MCSs. However, this technology would be an effective disposal option for the SWMU 2 contaminated soil and it would archive the CAOs for that site. Off-base landfills are only permitted to operate if they meet certain requirements of design and operation governing foundation, liner, leak detection, leachate collection and treatment, daily cover, post-closure inspections and monitoring, etc., which ensure the effectiveness of these facilities.

Implementability

Off-base non-hazardous landfilling would be implementable for SWMU 2. A number of permitted TSDFs are available for this purpose. Disposal at RCRA Subtitle D solid waste landfills may require certain pre-treatment, mainly the removal of free liquids but, because no excavation would be performed below the ground water table, this requirement should be easy to meet. In addition, a waste profile would have to be prepared including indications of contaminant concentrations and their leachability.

Cost

Costs of off-base non-hazardous landfilling would be moderate to high because of the very large quantities of material involved.

Conclusion

Off-base non-hazardous landfilling is retained in combination with other technologies and process options for the development of corrective measures alternatives.

4.3 SELECTION OF CORRECTIVE MEASURES TECHNOLOGIES AND PROCESS OPTIONS

The following corrective measures technologies and process options are retained to develop corrective measures alternatives:

- No Action
- Institutional Controls
- Monitoring
- Bulk Excavation
- Size Reduction
- Off-Base Non-Hazardous Landfilling

Using these technologies, the following three corrective measures alternatives were developed:

- Alternative 1: No Action
- Alternative 2: Institutional Controls and Monitoring
- Alternative 3: Excavation and Off-Base Disposal

The following sections outline the components of each of the corrective measures alternatives to address the contaminated soil and landfill material at SWMU 2.

4.3.1 Alternative 1: No Action

The No Action alternative maintains the site as is and is retained to provide a baseline for comparison to other alternatives. This alternative would not address the soil contamination other than with the existing landfill cap. However, this cap would not be maintained and no controls would be implemented to prevent its disturbance in the future. Existing monitoring programs and institutional controls would be discontinued, and the site would be available for unrestricted use.

4.3.2 Alternative 2: Institutional Controls and Monitoring

Alternative 2 would consist of two major components: (1) Institutional Controls and (2) Monitoring.

Component 1: Institutional Controls

Institutional controls would consist of formulating and implementing site-specific controls that would prohibit disturbance of the existing cap, control future site development, and restrict ground water use. Institutional controls would also consist of installing and maintaining a fence to control site access and maintaining the existing cap. Over the long term, the integrity and effectiveness of the cap will be evaluated during annual site inspections. The annual inspections are designed to fulfill inspection requirements, identify and take action to correct deficiencies, and promote the long term effectiveness of the cap. During the annual inspection, the follow items will be evaluated:

- Security - Gates and fencing, as well as warning signs, will be checked for damage. Signs will be checked for legibility. Any damage to signs will be repaired.

- Erosion - The soil cover will be checked for erosion damage such as washouts. Any damage to the soil cover will be repaired and revegetated.

- Settlement - The soil cover will be inspected for indications of settlement, subsidence, or displacement. The nature of any repairs will depend on the extent of the settlement, subsidence, or displacement. Any deep-rooted vegetation will be manually removed.

- Monitoring Wells – The wells will be checked for operability of the locks, identification tags, compromised impingement protection, and general condition of the riser.

- Vegetative Cover - The condition of the vegetative cover will be inspected for adequacy.

The various inspection findings and actions will be documented in the facility inspection logbook.

Component 2: Monitoring

Monitoring would consist of regularly collecting and analyzing ground water samples to verify the continued effectiveness of the existing landfill cap and to detect potential migration of COCs from soil to ground water.

Ground water monitoring would consist of regularly collecting and analyzing ground water samples to verify the continued effectiveness of the existing landfill cap and to detect potential migration of COCs (dyes) from soil to ground water. Over the past 50 years, there has been no evidence of dye migration to ground water since the dyes were put in place in the 1950s and a cap was installed in 1997. The frequency of monitoring is based on a study of ground water flow rate and the potential for dye transport. The study estimated the seepage velocity of ground water, the transport velocity of dye materials, and the potential travel time for the dye between the capped area and downgradient wells. Details of the study are provided in Appendix C. In summary, the study estimated that the time of travel for the dyes to migrate from the center of the capped area to a well located 600 feet downgradient (SW) at the boundary of the SWMU to be somewhere between 11 and 70 years. Because fracture flow through the sandstone could allow the travel time to be as low as 11 years, it is recommended that the sampling frequency for five monitoring wells located directly beneath or adjacent to the burial ground should be every 2 years for the next 10 years of monitoring. This sampling frequency should be adequate to detect, in a timely manner, potential changes to the cap's effectiveness and allow time to repair the cap before dye materials would reach downgradient wells.

The study also determined the recommended monitoring wells to include in the monitoring program. Samples would be collected from a total of five existing monitoring wells (02-02, 02-05, 02-06, 02-07, and 02-08). Samples would be analyzed for military dyes.

Reviews would be performed every five years to evaluate site status, assess the continued adequacy of remedial activities, and determine whether further action is required.

4.3.3 Alternative 3: Excavation and Off-Base Disposal

Alternative 3 would consist of two major components: (1) excavation and (2) off-base transportation and disposal.

Component 1: Excavation

Soil contaminated with concentrations of COCs in excess of the MCSs would be excavated, including all of the existing landfill cap and the contaminated soil beneath that cap. An area approximately 1.6 acres in size would be excavated to a depth of 6 to 12 feet bgs. This corresponds to a total volume of approximately 31,000 yd^3 of material to be excavated, including approximately 16,000 yd^3 of cap material and 15,000 yd^3 of contaminated soil and landfill material beneath the cap. Computations of volumes to be excavated are provided in Appendix A.

From the technical point of view, it would be easiest and most efficient to simply remove the entire existing landfill cap, after which the contaminated soil beneath that cap would be excavated as well. This approach would also have the advantage that it would be relatively easy to segregate the non-contaminated cap material from the contaminated soil beneath the cap. This would minimize the volume of material to be disposed and allow for the potential re-use of the non-contaminated material for backfilling of the excavated areas. However, from the environmental point of view, it is important that the integrity of the existing landfill cap be maintained over as large an area as practical during excavation activities to minimize the exposed quantity of contaminated soil. Therefore, it is assumed for the purpose of this CMS that excavation would proceed in a cross-sectional manner and at a pace that would match as closely as possible the rate of off-base transportation and disposal to minimize the need for on-site staging and stockpiling of excavated material. Because the depth of excavation, back-sloping of the excavation walls would be required, leading to the over-excavation of an additional 8,000 yd^3 of non-contaminated soil. For the purpose of this CMS, it is assumed that approximately 20,000 yd^3 of clean landfill cap material and over-excavated soil would be segregated and re-used to backfill the excavated areas. Therefore, the net volume of waste material to be disposed off-base would be 19,000 yd^3

Because foreign components besides soil and fill are known to be present both within the landfill cap (e.g., geotextile liner, drainage pipes) and beneath it (e.g., drums), it is also assumed that on-site segregation and, if necessary, on-site size reduction (e.g., grinding, crushing, shredding) of these foreign components would be required prior to off-base transportation and disposal.

During excavation, extreme care would be taken in the uncovering and handling of any containers suspected to contain military dyes to prevent any leakage from these containers. Stand by containment measures would also be ready for implementation to minimize the impact of any potential leakage. During excavation, engineering controls such as water sprinkling and environmental controls such as perimeter air quality monitoring would be implemented to ensure that fugitive dust emissions are kept to an acceptable minimum.

As excavation proceeds, the soil of the walls and bottom of the excavated area would be sampled and analyzed for military dyes on a quick-turnaround basis to verify that all material with concentrations greater than MCSs has been removed. Immediately following this verification sampling, excavated areas would be backfilled with clean material.

The buffer zone of open excavation between the area of the landfill yet to be excavated and that which has already been backfilled would be kept to a practical minimum and surrounded with surface runoff controls to prevent excess water accumulation. The open face of excavation would be covered with an impervious synthetic liner at the end of each day's work.

As previously mentioned, on-site staging and stockpiling of excavated soil would be kept to a minimum. On-site staging and stockpiling areas would surrounded with surface runoff controls and lined with an impervious synthetic membrane. On-site stockpiles of excavated soil would be covered with an impervious synthetic liner at the end of each day's work.

Any runoff water accumulated in the excavation area or on-site stockpiling areas would be removed, stored, and analyzed to determine if treatment is necessary prior to discharge.

Following completion of excavation and backfilling, the site would be graded and re-vegetated.

Component 2: Off-Base Transportation and Disposal

The excavated material would be transported to an off-base permitted TSDF for disposal. It is assumed that the excavated soil would be non-hazardous and would be disposed in a RCRA Subtitle D type landfill. Samples of the excavated material would be collected and analyzed to ensure that it complies with the TSDF landfill permit.

TABLE 4-1

PRELIMINARY SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES AND PROCESS OPTIONS
SWMU 2 CMS – NSWC CRANE, CRANE, INDIANA

General Action	Technology	Process Options	Description	General Screening	Notes
No Action	No Action	No Action	No activities conducted at site to address contamination.	No action would not be effective but must be considered as a baseline of comparison with other corrective measure technologies.	1
Limited Action	Institutional Controls	Passive Controls	Land use controls (LUCs) to restrict ground water use and future site activities.	LUCs would be effective to control ground water use and future site uses.	1
		Active Controls	Fencing to restrict site access. Maintenance of existing cap. Site inspections	Fencing would effectively control site access. Maintenance of existing cap would ensure its continued effectiveness. Site inspections would effectively control the continued application of LUCs and other institutional controls.	1
	Monitoring	Ground water Monitoring	Ground water sampling and analysis to evaluate potential migration of chemicals of concern (COCs) from soil to ground water.	Ground water monitoring would be an effective mean of assessing the effectiveness of the existing cap and warn of any potential future migration of COCs from soil to ground water.	1
Containment	Capping	Multi-Media Capping	Installation of a multi-media cap on additional areas of the site.	Additional capping is not required because all areas of soil with COCs concentrations greater than Media Cleanup Standards (MCSs) have already been capped.	3
Removal	Excavation	Bulk Excavation	Excavation and removal of existing cap and contaminated soil with backhoes and front-end loaders.	Excavation of contaminated soil with concentrations of COCs greater than MCSs would allow unrestricted future use of the site.	1
In-Situ Treatment	Physical/ Chemical	Chemical Fixation/ Stabilization	Immobilization of COCs within the contaminated soil matrix with in-situ injection and blending of chemicals such as pozzolanic agents.	Waste dyes may be difficult to chemically stabilize. Treatability testing would be required. Effectiveness of process would be very limited by the heterogeneous nature of the treated material.	3
		Soil Washing/ Solvent Extraction	Removal of COCs from contaminated soil through flushing of site with a dissolving fluid.	Waste dyes may be difficult to extract. Treatability testing would be required. Effectiveness of process would be very limited by the heterogeneous nature of the treated material.	3

TABLE 4-1

PRELIMINARY SCREENING OF CORRECTIVE MEASURES TECHNOLOGIES AND PROCESS OPTIONS
SWMU 2 CMS – NSWC CRANE, CRANE, INDIANA

General Action	Technology	Process Options	Description	General Screening	Notes
Ex-Situ Treatment	Physical/ Chemical	Chemical Fixation/ Stabilization	Immobilization of COCs within the contaminated soil matrix through blending with chemicals such as pozzolanic agents.	Waste dyes may be difficult to chemically stabilize. Treatability testing would be required. Pre-treatment with size reduction might be necessary.	1
		Soil Washing/Solvent Extraction	Removal of COCs from contaminated soil through control blending with a dissolving fluid.	Waste dyes may be difficult to extract. Treatability testing would be required. Pre-treatment with size reduction might be necessary.	1
		Size Reduction	Screening, crushing, and/or grinding of oversize materials or debris	Size reduction would most likely be required as a pre-treatment step prior to ex-situ treatment or prior to off-site transportation and disposal.	2
	Biological	Bio-Slurry Reactor/ Bio-Pile	Anaerobic or aerobic biodegradation of COCs under controlled conditions.	Waste dyes may not be readily biodegradable. Treatability testing would be required. Pre-treatment with size reduction might be necessary.	1
	Thermal	Low-Temperature Thermal Desorption (LTTD)	Removal of COCs from soil and waste material through evaporation by controlled heating.	Waste dyes may not be readily evaporated. Treatability testing would be required. Pre-treatment with size reduction might be necessary.	1
Disposal	Off-Site Disposal	Non-Hazardous Waste Landfilling	Contaminated soil with concentrations of COCs greater than MCSs would be disposed in a permitted off-site non-hazardous landfill.	Would be effective. Disposal would have to comply with Land Disposal Restrictions (LDRs). Pre-treatment may be required prior to landfilling.	1

NOTES:
1 Potentially applicable as a primary technology.
2 Potentially applicable as a secondary technology (i.e., as a pre- or post-treatment step for a primary technology).
3 Not applicable as a primary technology. Technology is not be retained for further evaluation

5.0 EVALUATION OF THE CORRECTIVE MEASURES ALTERNATIVES

This section evaluates the corrective measures alternatives presented in Section 4.3. The alternatives are evaluated using criteria set forth in the Office of Solid Waste and Emergency Response (OSWER) Guidance Document 9902.3-2A, RCRA Corrective Action Plan (U.S. EPA, 1995):

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

State acceptance will be evaluated after the State of Indiana has reviewed and commented on the CMS. Public acceptance will be evaluated after comments on the proposed corrective action have been received from the public.

5.1 ALTERNATIVE 1: NO ACTION

5.1.1 Protection of Human Health and the Environment

Alternative 1 is considered primarily for comparison to the other corrective measures. In the short-term, this alternative would be protective of human health and the environment. Although COCs would remain in soil at concentrations greater than MCSs, the existing landfill cap would prevent unacceptable risk from exposure to soil COCs and from migration of these COCs to ground water. However, in the long-term, unacceptable risk could develop from exposure with contaminated soil because site access and development would be unrestricted, the cap would not be maintained, and no controls would be in place to prevent its disturbance. Also, because no controls would be in place to restrict use of ground water and no monitoring would be performed to detect potential migration of COCs from soil to ground water, unacceptable risks could also develop from exposure to ground water.

5.1.2 Attainment of MCSs

Alternative 1 would not attain the MCSs.

5.1.3 Source Control

Alternative 1 would involve no additional source control because no action would be performed at SWMU 2. However, the likely sources of contamination (contaminated soil and landfill material) have already been contained through capping, and no migration of soil COCs to ground water has been detected.

5.1.4 Compliance with Waste Management Standards

There are no actions to be implemented for Alternative 1 and therefore, no waste would be generated.

5.1.5 Other Factors

Long-Term Reliability and Effectiveness

The future potential threat to human health would remain because site access and development would be unrestricted, the existing cap would not be maintained, and no controls would prevent its disturbance. Therefore, exposure to contaminated soil could occur. Because no site or ground water monitoring would be conducted, the reliability and effectiveness of this alternative over the long run would not be known.

This alternative would not achieve CAOs because long-term exposure to contaminated soil would not be prevented and there would be no warning of the potential migration of soil COCs to ground water.

Reduction in Toxicity, Mobility, and Volume

Alternative 1 would involve no reduction in toxicity or volume of COCs. To the extent that the existing cap remains effective, this alternative would provide some control of the mobility of COCs.

Short-Term Effectiveness

Alternative 1 would involve no action and therefore, would not pose any risks to on-site workers during implementation and no environmental impacts would be expected.

Implementability

Because no actions would occur, this alternative would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Alternative 1 would be implemented immediately and would not meet the CAOs and MCSs.

Cost Analysis

There are no costs associated with the No Action alternative.

5.2 ALTERNATIVE 2 - INSTITUTIONAL CONTROLS AND MONITORING

5.2.1 Protection of Human Health and the Environment

Alternative 2 would be protective of human health and the environment in the short and long term. Although COCs would remain in soil at concentrations greater than MCSs, the existing landfill cap would prevent unacceptable risk from exposure to soil COCs and migration of these COCs to ground water. Controls put in place during the corrective measure implementation would be protective by restricting site development and ground water use and preventing disturbance of the cap. Maintenance of the existing cap would be protective by insuring its continued integrity and effectiveness. Fencing would be protective by restricting site access. Site monitoring would be protective by insuring continued application of institutional controls and checking the integrity of the cap. Ground water monitoring would be protective by warning of any potential migration of soil COCs to ground water. Five-year reviews would be protective by evaluating whether additional measures are required to protect human health and the environment due to changing site conditions or failure of the remedy to be protective.

5.2.2 Attainment of MCSs

Alternative 2 would not attain the MCSs.

5.2.3 Source Control

Alternative 2 would not involve additional source control because only institutional controls and monitoring would be implemented. However, the likely sources of contamination (contaminated soil) have already been contained through capping, and no migration of soil COCs to ground water has been detected.

5.2.4 Compliance with Waste Management Standards

Alternative 2 would not involve any removal or treatment of contaminated soil. However, ground water monitoring could generate some residues (e.g., purge water) that would have to be disposed appropriately. The volume of residues generated would be small, and waste management regulations would be easily met.

5.2.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative 2 would be effective and reliable in the long-term and achieve the CAOs. Institutional controls would effectively prevent potential future exposure to contaminated soil and landfill material by maintaining the integrity of the existing landfill cap. Assuming proper maintenance, the expected life of the existing cap would be indefinite. Site monitoring would effectively insure continued application of institutional controls and verify the integrity of the cap. Ground water monitoring would effectively warn of any potential migration of soil COCs to ground water. In the event that the existing cap and institutional controls are shown not to be sufficiently effective, another more active remedy would be evaluated.

Reduction in Toxicity, Mobility, and Volume

Alternative 2 would not reduce toxicity or volume of COCs through active treatment. However, the mobility of the soil COCs would be effectively reduced by the existing landfill cap.

Short-Term Effectiveness

Alternative 2 would involve administration of institutional controls, maintenance of an existing landfill cap, installation and maintenance of a fence, and monitoring. The short-term human health risks associated with these limited remedial activities would be minimal. Monitoring personnel would undergo site-specific health and safety training and wear appropriate PPE. Implementation of this alternative would not result in any threat to the surrounding community or ecological receptors.

Implementability

The technical implementation of Alternative 2 would be very simple. Fencing could readily be installed and maintained around the site, and the landfill cap could continue to be maintained. Site and ground water monitoring would also be easy to perform, and the necessary resources are readily available.

The administrative implementation of Alternative 2 would also be very simple because SWMU 2 is located within a government-operated facility where LUCs can be strictly enforced. Restrictions for future land and ground water use would involve legal assistance and regulatory approval.

Alternative 2 would be implemented within approximately 6 months and would meet CAOs upon implementation. However, Alternative 2 would not meet MCSs and would require on-going institutional controls and monitoring for an indeterminate period of time.

Cost Analysis

The following costs are estimated for Alternative 2:

Capital Cost:	$45,000
Net Present Worth (NPW) of O&M Costs:	$74,000
30-Year NPW:	$119,000

The above costs have been rounded to the nearest $1,000 to reflect the preliminary nature of the estimates. Detailed cost estimates are included in Appendix B.

5.3 ALTERNATIVE 3: EXCAVATION AND OFF-BASE DISPOSAL

5.3.1 Protection of Human Health and the Environment

Alternative 3 would be protective of human health and the environment. Excavation of contaminated soil with concentrations of COCs greater than MCSs would eliminate the potential for unacceptable human health risk and migration of soil COCs to ground water under any future site scenario. However, contaminated soil would be merely relocated rather than treated and destroyed. Off-base disposal of the excavated material at a permitted TSDF would also be protective of human health and the environment.

Some short-term risks could be incurred by workers from exposure to contaminated soil during excavation activities. However, the potential for exposure would be minimized by the implementation of engineering controls (e.g., dust suppression), the wearing of appropriate PPE, and compliance with OSHA regulations and site-specific health and safety procedures. During excavation, there would also be risk of spreading dyes and this would be addressed through special contaminated measures. Potential negative short-term impacts to the surrounding community and environment from fugitive emissions and/or spillage of contaminated soil could be minimized through the implementation of appropriate engineering controls (e.g., perimeter air monitoring, spill prevention procedures, etc.).

5.3.2 Attainment of MCSs

Alternative 3 would meet MCSs within approximately 1 year, at completion of the corrective action.

5.3.3 Source Control

Alternative 3 would eliminate any potential source of contamination at SWMU 2 through the excavation and off-base disposal of contaminated soil with concentrations of COCs greater than MCSs.

5.3.4 Compliance with Waste Management Standards

Alternative 3 would comply with applicable waste management standards.

5.3.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative 3 be effective and reliable in the long-term and achieve the CAOs. Excavation and off-base disposal would effectively and reliably remove from soil with concentration of COCs greater than MCSs, thus eliminating all unacceptable risks under any exposure scenario and preventing potential migration of soil COCs to ground water. However, contaminated soil would merely be relocated rather than treated and destroyed. There would also be a risk associated with the potential for spreading dyes that would have to be addressed through special containment measures.

Reduction in Toxicity, Mobility, and Volume

Alternative 3 would reduce the toxicity, mobility, and volume of COCs although not through active treatment. Approximately 31,000 yd^3 of contaminated soil would be effectively and permanently removed from SWMU 2. However, this contaminated soil would be merely relocated rather than treated and destroyed. A calculation of the amount of contaminated soil is presented in Appendix A.

Short-Term Effectiveness

The short-term impact of Alternative 3 would be minimal. Excavation and off-base disposal could expose construction workers to contaminated soil; however, this potential for exposure would be minimized by the implementation of engineering controls such as dust suppression and by air quality monitoring. The potential for worker exposure would be further reduced by the wearing of appropriate PPE and

compliance with applicable OSHA regulations and proper site-specific health and safety procedures. There would also be a risk associated with the potential for spreading dyes that would have to be addressed through special containment measures.

Excavation and off-base disposal could adversely impact either the surrounding community or the environment. However, measures such as spill prevention and containment, erosion and sedimentation control, perimeter air monitoring, and traffic control would be taken as necessary to insure that the impact remains acceptable.

Implementability

The technical implementation of Alternative 3 would be relatively easy. However, as discussed in Section 4.2.3 excavation activities would be somewhat complicated due to the desirability of cross-sectional excavation and the need to take special care to prevent dye cross-contamination. Excavation could be performed with normal construction equipment, resources, equipment, and materials that would be readily available for this purpose. Because the excavation would extend to 12 ft bgs, there would be a need for backsloping of excavation walls but dewatering requirements would likely be minimal. Special contaminant measures would be required to prevent the spreading of dyes. Off-base disposal would be easily implementable as numerous permitted TSDFs with non-hazardous landfilling capabilities are available for this purpose.

The administrative implementation of Alternative 3 would also be relatively simple. A construction permit might be required for the excavation activities, and the off-base transportation and disposal of the excavated soil would require the completion of numerous administrative procedures which, while constituting a significant effort, could readily be accomplished.

Alternative 3 would be implemented within approximately 1 year and would meet the CAOs and MCSs at completion of the corrective action.

Cost Analysis

The following costs are estimated for Alternative 3:

Capital Costs:	$2,609,000
NPW of O&M Costs:	$0
NPW:	$2,609,000

Detailed cost estimates are provided in Appendix B.

6.0 COMPARATIVE ANALYSIS AND RECOMMENDATION

The following sections provide a comparative analysis of the three corrective measures alternatives, using the same criteria used to evaluate the alternatives in Section 5.0. This comparative analysis is summarized on Table 6-1.

6.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Alternative 1 would not be sufficiently protective of human health and the environment because it would not prevent potential future exposure to contaminated soil or warn of potential migration of soil COCs to ground water. Alternative 2 would be protective of human health and the environment because it would prevent potential future exposure to contaminated soil and warn of potential migration of soil COCs to ground water. Alternative 3 would be more protective than Alternative 2 by completely eliminating rather than merely controlling the potential future exposure to contaminated soil and potential migration of soil COCs to ground water. Alternative 3 would also be most protective because this alternative alone would attain the MCSs. However, Alternative 3 would merely relocate contaminated soil rather than treat and destroy it and there would also be a risk of spreading dyes that would have to be addressed through special containment measures.

6.2 ATTAINMENT OF MCSs

Alternatives 1 and 2 would not attain the MCSs. Alternative 3 would be implemented within approximately 1 year, at the completion of the corrective action.

6.3 SOURCE CONTROL

The likely sources of contamination (landfilled military dyes) have already been controlled by capping, and there is no evidence of soil COCs migration to ground water. Alternative 1 would not provide any additional source control and would not maintain the existing cap or prohibit its potential future disturbance. Alternative 2 would also not provide any additional source control, but it would maintain the existing cap and prohibit its potential future disturbance. Alternative 3 would provide additional source control through excavation and off-base disposal of soil with COC concentrations greater than MCSs.

6.4 COMPLIANCE WITH WASTE MANAGEMENT STANDARDS

Alternative 1 would not generate any waste material. Alternative 2 would not generate any treatment residues and would generate a minimal amount of waste materials associated with ground water monitoring activities (purge water). Alternative 3 would comply with all applicable waste management standards for the excavation, transportation, and disposal of contaminated soil. Permitted off-base TSDFs would be readily available for the disposal of the waste materials generated by Alternatives 2 and 3.

6.5 OTHER FACTORS

6.5.1 Long-Term Reliability and Effectiveness

Alternative 1 would not be long-term effective and reliable or meet the CAOs. Alternative 2 would be long-term effective and reliable and meet the CAOs through maintenance of the existing cap, continued enforcement of institutional controls, and monitoring for potential migration of soil COCs to ground water. Alternative 3 would be more long-term effective and reliable and would better meet the CAOs than Alternative 2 through removal of contaminated soil with concentrations of COCs greater than MCSs, thereby eliminating risk from exposure or from migration of soil COCs to ground water. However, Alternative 3 would merely relocate contaminated soil rather than treat and destroy it and there would also be a risk of spreading dye that would have to be addressed through special containment measures.

6.5.2 Reduction in Toxicity, Mobility, and Volume

Alternative 1 would not reduce the toxicity or volume of COCs, but it would reduce their mobility as long as the existing cap would remain effective. Alternative 2 would not reduce the toxicity or volume of COCs, but it would reduce their mobility. Alternative 3 would reduce the toxicity, mobility, and volume of COCs although not through treatment. This alternative would permanently remove approximately 31,000 yd^3 of contaminated soil from SWMU 2. However, this contaminated soil would merely be relocated rather than treated and destroyed.

6.5.3 Short-Term Effectiveness

Alternative 1 would not result in any short-term risks to human health or the environment. Alternative 2 would result in minimal short-term risks to monitoring personnel. Alternative 3 would also result in short-term risks to remediation workers and there would also be a risk of spreading dye that would have to be addressed through special containment measures. These risks would be addressed and adequately

mitigated through health and safety training and the wearing of appropriate PPE. In addition, Alternative 3 could also result in some risks to the surrounding community from potential spillage of contaminated materials during off-base transportation. However, all of these risks could be effectively mitigated.

6.5.4 Implementability

Alternative 1 would be the easiest to implement because no action would occur.

The monitoring and institutional controls components of Alternative 2 would be very easy to implement. LUCs would be readily implementable because SWMU 2 is located within a government-owned facility where such controls are easier to enforce.

Alternative 3 would more difficult to implement than Alternative 2 because it would require excavation and off-base transportation and disposal of a relatively large volume of contaminated soil. Special containment measures would be required to prevent the spreading of dyes. However, qualified excavation and transportation contractors are readily available, as are permitted off-base TSDFs for the non-hazardous landfilling of the excavated material. A construction permit might be required for the excavation activities, and manifesting of the transported material may also be necessary.

Alternative 1 would be implemented immediately and would not meet CAOs or MCSs. Alternative 2 would be implemented within approximately 6 months and would meet CAOs upon implementation. However, Alternative 2 would not meet MCSs and would require on-going institutional controls and monitoring for an indeterminate period of time. Alternative 3 would be implemented within approximately 1 year and would meet CAOs and MCSs at the completion of corrective action.

6.5.5 Cost

The capital cost of Alternative 2 is $45,000 compared with $2,609,000 for Alternative 3. The 30-year NPW of O&M costs for Alternative 2 is $64,000. There are no O&M costs associated with Alternative 3. The NPW of Alternatives 2 and 3 are $109,000 and $2,609,000, respectively. Detailed costs are provided in Appendix B.

6.5.6 State and Community Acceptance

State acceptance will be evaluated after the State of Indiana has reviewed and commented on the CMS. Public acceptance will be evaluated after comments on the proposed corrective action have been received from the public.

6.6 RECOMMENDED CORRECTIVE MEASURE

Alternative 2 is recommended for use at SWMU 2. If, at any time, it is determined that the existing landfill cap together with institutional controls and monitoring are not sufficient to effectively protect human health and the environment, a more active approach such as that presented and evaluated under Alternative 3 would be considered. Alternative 2 would require long-term controls and monitoring but there would be no immediate threat to human health and the environment and costs would be much lower than those for Alternative 3.

TABLE 6-1

SUMMARY OF COMPARATIVE ANALYSIS OF CORRECTIVE MEASURES ALTERNATIVES
SWMU 2 CORRECTIVE MEASURES STUDY
NSWC CRANE - CRANE, INDIANA

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls and Monitoring	Alternative 3: Excavation and Off-Base Disposal
Protection of Human Health and Environment	Would not be protective in the long term. Existing cap would not be maintained and could be disturbed, allowing to exposure to contaminated material. No monitoring would be performed, and there would be no warning of potential migration of soil COCs to ground water.	Would be protective in the long term. Existing cap would be maintained and not disturbed, preventing exposure to contaminated material. Monitoring would warn of potential migration of soil COCs to ground water.	Would be most protective by removing contaminated soil with concentrations of COCs greater than MCSs. Therefore, the risk from exposure to contaminated material and migration of soil COCs to ground water would be eliminated. However, contaminated soil would be relocated rather than treated and destroyed.
Attainment of MCSs	Would not attain MCSs.	Would not attain MCSs.	Would attain MCSs within 1 year.
Control of Release Sources	Would not add additional source controls and would not maintain or insure future integrity of the existing cap.	Would not add additional source controls but would maintain and insure future integrity of existing cap.	Would remove contaminated soil that could act as a contamination source.
Compliance with Waste Management Standards	Not applicable.	Would comply.	Would comply.
Long-Term Reliability and Effectiveness	Would not be long-term reliable and effective and would not meet CAOs. Existing cap would not be maintained and could be disturbed leading to exposure to contaminated soil. No monitoring would warn of potential migration of soil COCs to ground water.	Would be long-term reliable and effective and meet CAOs. Existing cap would be maintained and not disturbed thereby preventing exposure to contaminated soil. Monitoring would warn of potential migration of soil COCs to ground water.	Would be the most long-term reliable and effective and meet the CAOs. Contaminated soil with COCs concentrations greater than MCSs would be permanently removed from the site, thereby eliminating risk from exposure and potential migration of soil COCs to ground water. However, contaminated soil would be relocated rather than treated and destroyed.

TABLE 6-1

SUMMARY OF COMPARATIVE ANALYSIS OF CORRECTIVE MEASURES ALTERNATIVES
SWMU 2 CORRECTIVE MEASURES STUDY
NSWC CRANE - CRANE, INDIANA

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls and Monitoring	Alternative 3: Excavation and Off-Base Disposal
Reduction of Toxicity, Mobility, or Volume	Would not reduce toxicity or volume. Would only reduce mobility to the extent that the integrity of the existing cap is maintained.	Would not reduce toxicity or volume. Would reduce mobility.	Would reduce toxicity, mobility, and volume although not through treatment. Approximately 19,000 yd^3 of contaminated soil would be permanently removed from the site. However, contaminated soil would be relocated rather than treated and destroyed.
Short-Term Effectiveness	Would not result in short-term risks to site workers or adversely impact the surrounding community.	Would result in slight risk to monitoring workers. This risk would be reduced through compliance with site-specific health and safety procedures.	Would result in a significant risk of exposure of site workers to contaminated soil during the excavation, transportation, and disposal activities. This risk would be reduced through compliance with site-specific health and safety procedures. Could also result in risk to surrounding community from spillage during transportation. This risk would be addressed by appropriate spill prevention measures.
Implementability	Would be simple to implement because no action would occur. Would be implemented immediately and not meet CAOs and MCSs.	Technical implementation would be easy. Resources, materials, and equipment are readily available to install fencing, maintain the cap, and perform monitoring. Administrative implementation of institutional controls would be simple because NSWC Crane is a federal facility. Would be implemented and meet CAOs within 6 months but would not meet MCSs and would require indefinite controls and monitoring.	Technical implementation would be somewhat more difficult than that of Alternative 2 but still relatively simple. Excavation and transportation contractors are readily available as well as permitted TSDFs. Administrative implementation would be very simple because no long-term institutional controls would be required. A construction permit and waste manifesting might be required for excavation and transportation of contaminated soil, but these would be easy to obtain. Would be implemented within 1 year and meet CAOs and MCS at the completion of corrective action..

TABLE 6-1

SUMMARY OF COMPARATIVE ANALYSIS OF CORRECTIVE MEASURES ALTERNATIVES
SWMU 2 CORRECTIVE MEASURES STUDY
NSWC CRANE - CRANE, INDIANA

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Institutional Controls and Monitoring	Alternative 3: Excavation and Off-Base Disposal
Costs:			
Capital	$0	$45,000	$2,609,000
NPW of O&M	$0	$74,000 (30-Year)	$0
NPW	$0	$119,000 (30-Year)	$2,609,000

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APPENDIX A

ESTIMATE OF SOIL VOLUME

TO BE EXCAVATED AT SWMU 2

ALTERNATIVE 3 REV. OCTOBER 2004

ESTIMATE OF DYE CONTAMINATED SOIL
TO BE EXCAVATED DURING REMOVAL AT SWMU 2
NSWC CRANE
CRANE INDIANA

Target Area	Estimated Surface Area (ft^2)	Depth	Estimated Total Soil Volume (ft^3)	Estimated Total Soil Volume (yd^3)
A	4,480	12	53,760	1,991
B	2,604	12	31,248	1,157
C	6,660	12	79,920	2,960
D	5,764	12	69,168	2,562
E	18,750	12	225,000	8,334
F	17,243	12	206,916	7,664
G	10,336	12	124,032	4,594
H	93	12	1,116	41
I	500	12	6,000	222
J	1,250	12	15,000	556
K	1,800	12	21,600	800
L	707	6	4,242	157
		TOTAL	838,002	31,040

EXCAVATED SOIL ASSUMPTIONS

Option 3 assumes removal of the cap and all soil beneath the cap. Soil depth is based on maximum detected depth in RFI. See Figure A-1 for location of target areas.

1. Vertical extent of dye contamination is estimated on the basis of historical information that indicates that trenches were dug to a depth of 6 feet. However, RFI sampling indicates dye has been detected at depths greater than 6 feet. For example, RFI samples measured dyes at depths of 11 feet bgs. A conservative estimate of the depth needing removal would be 12 feet at at all locations (see RFI Figure 4-1).

2. Horizontal extent of contamination is based on historical data and the assumption that all soil under the cap should be removed. Because dye has been detected beyond the cap boundary in the RFI, it is recommended to remove all soil beneath cap. In addition, RFI sampling indicated dye contamination beyond the capped area. As a result, the excavation area has been extended out beyond the defined area of the cap at the northwest corner, an area just north of the central section of DBG beyond the cap boundary, and between trenches in the southwest corner of the DBG.

TETRA TECH NUS, INC. **CALCULATION WORKSHEET**

CLIENT NSWC CRANE	JOB NUMBER CTO 10
SUBJECT Estimated SIZE (AREA) of TARGET AREAS	
BASED ON	DRAWING NUMBER
BY Joe Lucas / CHECKED BY	APPROVED BY / DATE Oct 2004

SWMU 2 (DBG) Target Areas for Soil Excavation
Target areas are identified in markup of Figure 5-8.

AREA

A - 112'L x 40'W = 4,480 ft²

B - ½(44 + 40) x 62 = 2,604 ft²

C - ½(44 + 88) x 100 = 6,660 ft²

D -

D1 - ½(88')(75') = 3,300 ft²

D2 - ½(112')(44') = 2,464 ft²

D TOTAL AREA = 5,764 ft²

E - 150' x 125' = 18,750 ft²

F -

F1 - ½(181' + 125') x 50' = 7,650 ft²

F2 - ½(106' x 181') = 9,593 ft²

F TOTAL AREA 17,243 ft²

G

G1 ½(56)(56) = 1,568 ft²
G2 ½(56)(56) = 1,568 ft²
G3 ½(50)(63) = 1,575 ft³
G4 ½(50)(63) = 1,575 ft³
G5 ½(81)(100) = 4,050 ft³

G TOTAL AREA = 10,336 ft²

TETRA TECH NUS, INC. **CALCULATION WORKSHEET**

CLIENT NSWC CRANE	JOB NUMBER CTO 10
SUBJECT OPTION 1 - Estimated SIZE (AREA) of TARGET AREAS	
BASED ON	DRAWING NUMBER
BY Joe Lucas / CHECKED BY	APPROVED BY / DATE Oct 2004

AREA

H - $\frac{1}{2}(19' + 18') \times 5' = 93\ ft^2$

I - $(25' \times 20') = 500\ ft^2$

J - $(25' \times 50') = 1{,}250\ ft^2$

K - $(60' \times 30') = 1{,}800\ ft^2$

L - $\pi (15')^2 = 707\ ft^2$ (30' circle)

SOIL EXCAVATION VOLUME TO

REMOVE SWMU 2 CAP MATERIAL

TETRA TECH NUS, INC. **CALCULATION WORKSHEET**

CLIENT: NSWC CRANE	JOB NUMBER: N7141
SUBJECT: SOIL EXCAVATION Volume to Remove SWMU2 CAP Material	
BASED ON: MK, April 1999-C04 & 05 Interim Measures Completion Rpt	DRAWING NUMBER:
BY: Joe Lucas / CHECKED BY:	APPROVED BY: / DATE: July 17, 2003

Section	Length	Area 1	Area 2	Ave	Vol.
STA 1+80 to STA 2+00	20'	5x25 = 125	50x5 = 250	200	4,000 ft³
STA 2+00 to STA 2+20	20'	50x5 = 250	50x5 = 250	250	5,000 ft³
STA 2+20 to STA 2+40	20'	50x5 = 250	5x62 = 310	280	5,600 ft³
STA 2+40 to STA 2+60	20'	5x62 = 310	5x75 = 375	343	6,860 ft³
STA 2+60 to STA 2+80	20'	5x75 = 375	5x80 = 400	388	7,760 ft³
STA 2+80 to STA 3+00	20'	5x80 = 400	5x87 = 435	418	8,360 ft³
STA 3+00 to STA 3+20	20'	5x87 = 435	5x110 = 550	493	9,860 ft³
STA 3+20 to STA 3+40	20'	5x110 = 550	5x135 = 675	613	12,260 ft³
STA 3+40 to STA 3+60	20'	5x135 = 675	5x150 = 750	713	14,260 ft³
STA 3+60 to STA 3+80	20'	5x150 = 750	5x150 = 750	750	15,000 ft³
STA 3+80 to STA 4+00	20'	5x150 = 750	5x150 = 750	750	15,000 ft³
STA 4+00 to STA 4+20	20'	5x150 = 750	5x150 = 750	750	15,000 ft³
STA 4+20 to STA 4+40	20'	5x150 = 750	5x150 = 750	750	15,000 ft³
STA 4+40 to STA 4+60	20'	5x150 = 750	5x150 = 750	750	15,000 ft³
STA 4+60 to STA 4+80	20'	5x150 = 750	5x135 = 675	713	14,260 ft³
STA 4+80 to STA 5+00	20'	5x135 = 675	5x135 = 675	675	13,500 ft³

TETRA TECH NUS, INC. **CALCULATION WORKSHEET**

CLIENT: NSWC CRANE	JOB NUMBER: N7141
SUBJECT: Soil Excavation Volume to Remove Swmu2 Cap Material	
BASED ON: Interim Measures Completion Rpt, MK, Apr 1999 (CD4 + CD5)	DRAWING NUMBER:
BY: Joe Lucas; CHECKED BY:	APPROVED BY: ; DATE: July 17, 2003

SECTION	LENGTH	AREA 1	AREA 2	AVE	Volume
STA 5+00 to STA 5+20	20'	5x135=675	5x160=800	738	14,760 ft³
STA 5+20 to STA 5+40	20'	5x160=800	5x160=800	800	16,000 ft³
STA 5+40 to STA 5+60	20'	5x160=800	5x160=800	800	16,000 ft³
STA 5+60 to STA 5+80	20'	5x160=800	5x185=925	863	17,260 ft³
STA 5+80 to STA 6+00	20'	5x185=925	5x200=1,000	963	19,260 ft³
STA 6+00 to STA 6+20	20'	5x200=1,000	5x250=1,250	1,125	22,500 ft³
STA 6+20 to STA 6+40	20'	5x250=1,250	5x250=1,250	1,250	25,000 ft³
STA 6+40 + STA 6+60	20'	5x250=1,250	5x260=1,300	1,275	25,500 ft³
STA 6+60 + STA 6+80	20'	5x260=1,300	5x260=1,300	1,300	26,000 ft³
STA 6+80 + STA 7+00	20'	5x260=1,300	5x240=1,200	1,250	25,000 ft³
STA 7+00 + STA 7+20	20'	5x240=1,200	5x220=1,100	1,150	23,000 ft³
STA 7+20 + STA 7+40	20'	5x220=1,100	5x150=750	925	18,500 ft³
STA 7+40 + STA 7+60	20'	5x150=750	5x45=225	488	9,760 ft³
				TOTAL volume	435,260 ft³ = 16,122 yd³

ALTERNATIVE 3

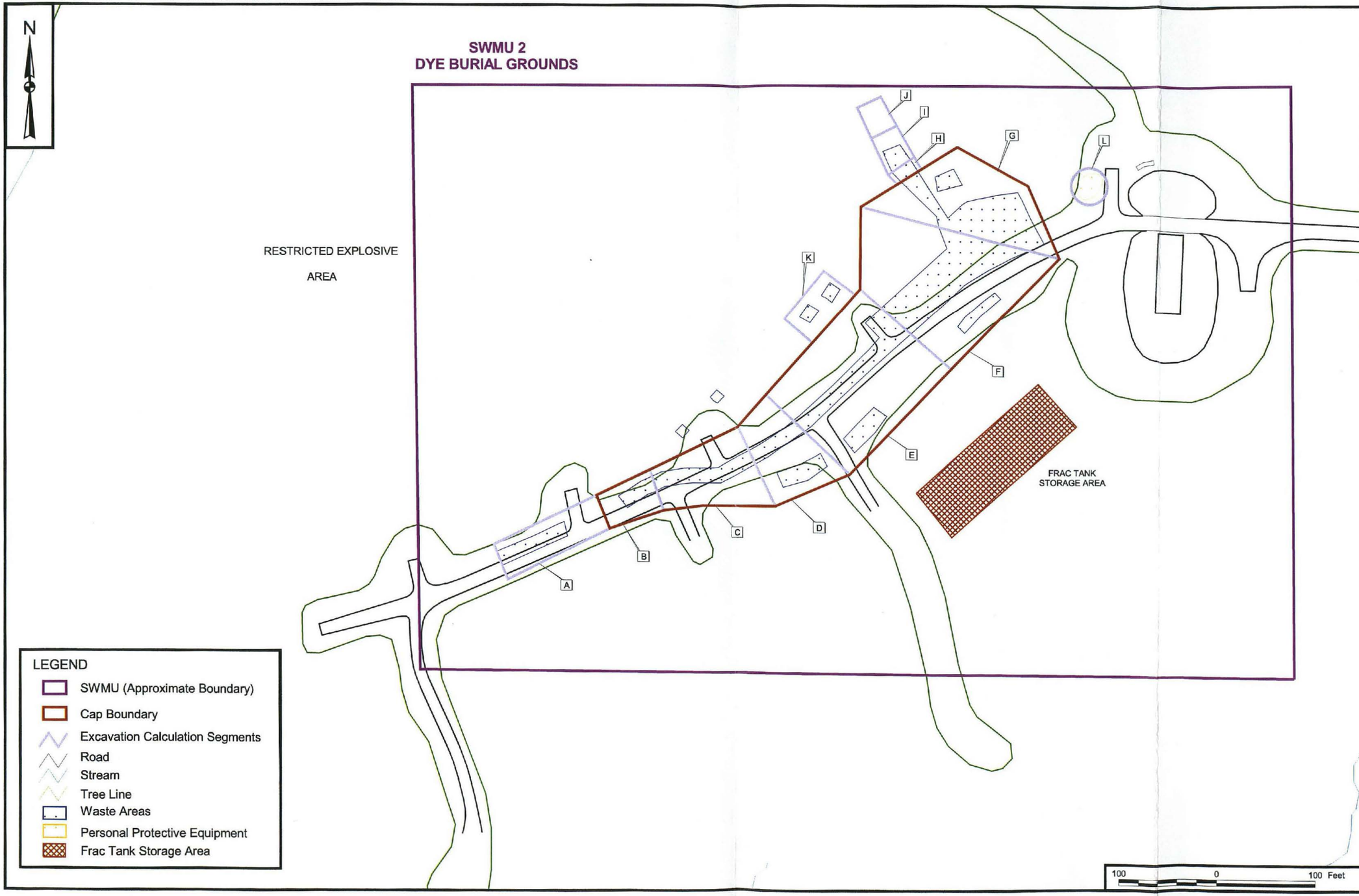
SOIL VOLUME ESTIMATES

APPENDIX A

SOIL VOLUME ESTIMATES FOR ALTERNATIVE 3: EXCAVATION AND OFFBASE DISPOSAL

	Total Soil Excavated (yd^3)	Volume of Clean Soil in Excavated Soil (yd^3)	Contaminated Soil for Offsite Disposal (yd^3)
Cap	16,000	14,700	1,300
Contaminated Soil	15,000	0	15,000
Over Excavated Soil	8,000	5,300	2,700
Total (yd3)	**39,000**	**20,000**	**19,000**

P:\GIS\NSWC_CRANE\APR\CTO-10_SWMU02.APR SWMU 2-EXCAVATION CALCULATION SEGMENTS 10/3/03 KMP



CONTRACT NO.
3994

APPROVED BY ___ DATE ___

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE A-1 REV _

EXCAVATION CALCULATION SEGMENTS
SWMU 2 - DYE BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

DRAWN BY K. Pella DATE 10/2/03

CHECKED BY J. Lucas DATE 10/2/03

COST/SCHED-AREA

SCALE AS NOTED

APPENDIX B

DETAILED COST ESTIMATES

FOR

ALTERNATIVES 2 AND 3

NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA
SWMU 2
ALTERNATIVE 2 INSTITUTIONAL CONTROLS AND MONITORING
CAPITAL COST

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING											
1 1 Prepare Monitoring Plan	100	hr			$35 00		$0	$0	$3,500	$0	$3,500
2 INSTITUTIONAL CONTROLS											
2 1 Prepare Deed Restrictions & Controls	150	hr			$35 00		$0	$0	$5,250	$0	$5,250
2 2 Install Fencing, 6' High	1000	ft	$16 40				$16,400	$0	$0	$0	$16,400
2 3 Install Double Swing Gate, 6' High, 12' Opening	1	ea	$1,125 00				$1,125	$0	$0	$0	$1,125
2 3 Install Warning Signs, 30" x 30", Reflectorized	5	ea	$91 50				$458	$0	$0	$0	$458
Subtotal							$17,525	$0	$8,750	$0	$26,275
Local Area Adjustments							100 0%	78 2%	96 1%	96.1%	
							$17,525	$0	$8,409	$0	$25,934
Overhead on Labor Cost @ 30%									$2,523		$2,523
G & A on Labor Cost @ 10%									$841		$841
G & A on Material Cost @ 10%								$0			$0
G & A on Subcontract Cost @ 10%							$1,753				$1,753
Total Direct Cost							$19,278	$0	$11,772	$0	$31,050
Indirects on Total Direct Cost @ 10%											$3,105
Profit on Total Direct Cost @ 10%											$3,105
Subtotal											$37,260
Health & Safety Monitoring @ 0%											$0
Contingency on Subtotal Cost @ 10%											$3,726
Engineering on Subtotal Cost @ 10%											$3,726
TOTAL COST											**$44,712**

NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA
SWMU 2
ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORING
Annual Cost

Item	Item Cost Years 2, 4, 6, 8, 10, 15, 20, 25, and 30	Item Cost Years 1 - 30	Item Cost Every 5 Years Through 30 Years	Notes
Sampling	$2,540			Labor, Field Supplies.
Site Maintenance		$1,000		Maintain cap, fence (cut grass, reseed, add topsoil)
Analysis/Water	$4,480			Analyze samples from six (6) existing wells plus one (1) QA sample for Military Dyes
Report	$1,000			Document sampling events and results
Site Inspection		$1,000		To verify continued implementation of the controls.
Site Review			$7,000	
TOTALS	$8,020	$2,000	$7,000	

NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA
SWMU 2
ALTERNATIVE 2: INSTITUTIONAL CONTROLS AND MONITORING

Present Worth Analysis

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$44,712		$44,712	1.000	$44,712
1		$2,000	$2,000	0.935	$1,870
2		$10,020	$10,020	0.873	$8,747
3		$2,000	$2,000	0.816	$1,632
4		$10,020	$10,020	0.763	$7,645
5		$9,000	$9,000	0.713	$6,417
6		$10,020	$10,020	0.666	$6,673
7		$2,000	$2,000	0.623	$1,246
8		$10,020	$10,020	0.582	$5,832
9		$2,000	$2,000	0.544	$1,088
10		$17,020	$17,020	0.508	$8,646
11		$2,000	$2,000	0.475	$950
12		$2,000	$2,000	0.444	$888
13		$2,000	$2,000	0.415	$830
14		$2,000	$2,000	0.388	$776
15		$17,020	$17,020	0.362	$6,161
16		$2,000	$2,000	0.339	$678
17		$2,000	$2,000	0.317	$634
18		$2,000	$2,000	0.296	$592
19		$2,000	$2,000	0.277	$554
20		$17,020	$17,020	0.258	$4,391
21		$2,000	$2,000	0.242	$484
22		$2,000	$2,000	0.226	$452
23		$2,000	$2,000	0.211	$422
24		$2,000	$2,000	0.197	$394
25		$17,020	$17,020	0.184	$3,132
26		$2,000	$2,000	0.172	$344
27		$2,000	$2,000	0.161	$322
28		$2,000	$2,000	0.150	$300
29		$2,000	$2,000	0.141	$282
30		$17,020	$17,020	0.131	$2,230
				TOTAL PRESENT WORTH	$119,324

NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA
SWMU 2
ALTERNATIVE 3: EXCAVATION AND OFF-BASE DISPOSAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1 PROJECT PLANNING											
1.1 Prepare Remedial Action Plan	100	hr			$35 00		$0	$0	$3,500	$0	$3,500
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Office Trailer	5	mo	$204.50				$1,023	$0	$0	$0	$1,023
2 2 Storage Trailer (1)	5	mo	$105 00				$525	$0	$0	$0	$525
2.3 Construction Survey	2	ac	$1,097.00				$1,755	$0	$0	$0	$1,755
2 4 Equipment Mobilization/Demobilization	6	ea			$50 00	$176.00	$0	$0	$300	$1,056	$1,356
2.5 Site Utilities	5	mo	$500.00				$2,500	$0	$0	$0	$2,500
3 SITE PREPARATION											
3.1 Dozer to Construct Perimeter Ditch/Swale	1	wk			$1,248.00	$2,322 00	$0	$0	$1,248	$2,322	$3,570
3 2 Geomembrane to Line Ditch/Swale	14,000	sf		$0.26	$0.40		$0	$3,640	$5,600	$0	$9,240
3.3 Stone Check Dams	7.5	cy		$18 00	$5 00	$0.50	$0	$135	$38	$4	$176
3 4 10,000 GallonSediment/Runoff Collection Tank	2	ea		$5,825.00	$1,350 00	$236.04	$0	$11,650	$2,700	$472	$14,822
3.5 20,000 GallonSediment/Runoff Collection Tank	1	ea		$11,572 00	$2,249 00	$393.40	$0	$11,572	$2,249	$393	$14,214
3.6 Trap Contents Disposal	1	ls	$10,000 00				$10,000	$0	$0	$0	$10,000
4 DECONTAMINATION											
4 1 Decontamination Services	5	mo	$3,800.00				$19,000	$0	$0	$0	$19,000
4.2 Equipment Decon Pad	1	ls		$5,800 00	$6,650.00	$700.00	$0	$5,800	$6,650	$700	$13,150
4.3 Decon Water	5,000	gal		$0 20			$0	$1,000	$0	$0	$1,000
4.4 Decon Water Storage Tank, 6,000 gallon	5	mo				$600 00	$0	$0	$0	$3,000	$3,000
4.5 Clean Water Storage Tank, 4,000 gallon	5	mo				$540 00	$0	$0	$0	$2,700	$2,700
4 6 PPE (3 p * 5 days * 22 weeks)	330	day		$31 67			$0	$10,451	$0	$0	$10,451
4.7 Disposal of Decon Waste (liquid & solid)	5	mo	$900 00				$4,500	$0	$0	$0	$4,500
5 EXCAVATE LANDFILL											
5 1 Excavator, 2 CY	5	mo			$10,218 80	$16,271.48	$0	$0	$51,094	$81,357	$132,451
5.2 Front End Loader, 170 HP	5	mo			$7,433.74	$8,234.92	$0	$0	$37,169	$41,175	$78,343
5 3 Laborer	5	mo			$3,464.00		$0	$0	$17,320	$0	$17,320
5.4 Tarp to Protect Excavation Face	100	sy		$1.00	$1 00		$0	$100	$100	$0	$200
5 5 Post-excavation Soil Analysis. Military Dyes	50	ea	$1,000.00				$50,000	$0	$0	$0	$50,000
5.6 Straw Bales	1	ls		$200.00			$0	$200	$0	$0	$200
6 DISPOSAL											
6 1 Drum Transportation and Disposal	60	ea	$85.00				$5,100	$0	$0	$0	$5,100
6.2 Drum Pick-Up Stop Charge	1	ea	$100 00				$100	$0	$0	$0	$100
6.3 Waste Soil Transportation and Off-Site Disposal	19,000	cy	$52.50				$997,500	$0	$0	$0	$997,500
6.4 Waste Characterization Testing (TCLP),1 per 1000 cy	19	ea	$820.00				$15,580	$0	$0	$0	$15,580
7 SITE RESTORATION											
7.1 Import clean backfill	3,000	cy		6.85			$0	$20,550	$0	$0	$20,550
7.2 Dozer, 140 HP, 1/2 Time Operation	5	mo			$2,701.92	$6,314 68	$0	$0	$13,510	$31,573	$45,083
7.3 Dump Truck, 16 Ton, 1/2 Time Operation	5	mo			$2,165 00	$6,155 52	$0	$0	$10,825	$30,778	$41,603
7 4 Fine Grading and seeding, incl. lime, fert, and seed	3,781	sy		$0.26	$1 19	$0.18	$0	$983	$4,500	$681	$6,164
8 MISCELLANEOUS											
8 1 Construction Oversite (3p*5days*22 weeks)	330	days			$320.00		$0	$0	$105,600	$0	$105,600
8.2 Post Construction Documents	200	hr			$40.00		$0	$0	$8,000	$0	$8,000
Subtotal							1107582 7	$66,081	$270,402	$196,211	$1,640,276
Local Area Adjustments							100 0%	78 2%	96.1%	96 1%	
							$1,107,583	$51,676	$259,856	$188,559	$1,607,673
Overhead on Labor Cost @ 30%									$77,957		$77,957
G & A on Labor Cost @ 10%									$25,986		$25,986
G & A on Material Cost @ 10%								$5,168			$5,168
G & A on Subcontract Cost @ 10%							$110,758				$110,758

NAVAL SU[illegible]E WARFARE CENTER CRANE
CRANE, INDIANA
SWMU 2
ALTERNATIVE 3: EXCAVATION AND OFF-BASE DISPOSAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
Total Direct Cost							$1,218,341	$56,843	$363,798	$188,559	$1,827,541
Indirects on Total Direct Cost @ 35%			(not including off-site disposal)								$288,694
Profit on Total Direct Cost @ 10%											$182,754
Subtotal											$2,298,989
Health & Safety Monitoring @ 1%											$22,990
Total Field Cost											$2,321,979
Contingency on Total Field and Subcontractor Costs @ 10%											$232,198
Engineering on Total Field Cost @ 5%			(Total Field Cost minus Subcontractor's Total Direct Cost)								$55,182
TOTAL COST											**$2,609,359**

APPENDIX C

CALCULATION WORKSHEET FOR SEEPAGE VELOCITY OF GROUND WATER, TRANSPORT VELOCITY OF DYE, AND TIME OF TRAVEL FOR DYE BETWEEN CAPPED AREA AND DOWNGRADIENT WELLS

Client: NSWC Crane, Indiana SWMU 02 (Dye Burial Ground) CMS		Job No.: 7141 (CTO 0010)	
Subject: **Calculation Worksheet for Seepage Velocity of Ground Water, Transport Velocity of Dye, and Time of Travel for Dye between Capped Area and Downgradient Wells**			
Based On: Darcys Law and Attached Input Data		Drawing No.: RFI Figure 1-10	
By: Jeff Schubert JPS 10-25-04	Checked By: JPO 10/25/04	Approved By:	Date:

A long-term ground water monitoring plan has been prepared for the Dye Burial Ground (SWMU 02) in order to evaluate whether the constructed cap is performing as planned. This "performance monitoring" will involve the wells that are screened in the Pennsylvanian sandstone aquifer unit that immediately underlies the waste materials at SWMU 02.

Ground water in this aquifer flows to the southwest, as shown on Attachment 1. The sandstone aquifer crops out along the western edge of the hill with the base of the sandstone lying at about 670 feet above mean sea level (msl). Locations of monitoring wells that are screened in the sandstone aquifer are also shown on Attachment 1.

The Pennsylvanian sandstone is well cemented and "tight" in many locations, and is fractured and/or weathered in many other locations. The variability of effective porosity, hydraulic conductivity, recharge, and other hydraulic characteristics is considered to be relatively large, even in a small hillside such as the one that exists beneath the Dye Burial Ground. In order to determine a sound sampling frequency for monitoring wells (i.e., one that could detect the migration of dye before it reaches the second set of downgradient monitoring wells), it is necessary to first evaluate how fast ground water and dissolved dyes might migrate. These calculations are performed and discussed herein. The "worst-case" calculations of ground water flow rates and dye migration rates (Attachment 5) are based on the maximum measured hydraulic conductivity value and a low effective porosity value. The fractures in the sandstone consist of discrete vertical fractures and bedding plane separations. There are no solution openings or other type dissolution or karst features in the sandstone. There also are no known karst features in the limestone units which lie directly beneath the SWMU 02 area.

Based on ground water elevations measured in wells 02-06 and 02-04, the lateral hydraulic gradient between the burial ground and well 02-04 was about 0.0061 foot/foot. Slug tests have been performed on many of the monitoring wells screened in the Pennsylvanian sandstone at SWMU 02 (Fisher, 1996, see Attachment 2). The median and maximum values of horizontal hydraulic conductivity (Kh) determined for the sandstone are identified in Attachment 2. The Pennsylvanian sandstone has clay in much of the interstitial space and is fairly well cemented (Fisher, 1996). Therefore, a relatively low value for effective porosity (0.01) was used in calculations, because it was assumed that most of the effective porosity is due to joints and fractures present in the sandstone.

If the dyes were to enter the shallow ground water aquifer and travel exclusively through a network of fractures, the amount of organic carbon on the fracture surfaces may be very limited and, as a result, the effective value of f_{oc} is likely to be be relatively low. For the dye compounds, values of 0.00002 (unitless) and 840 L/kg were assumed for f_{oc} and K_{oc}, respectively (see Attachment 3 for Koc values estimated for a variety of dyes).

Two different sets of ground water velocities and dye migration velocities have been calculated for the SWMU 02 shallow ground water flow system. Calculations presented in Attachment 4 were based on an effective porosity of 0.01 and a median Kh value of 54.4 feet per year. Under these conditions, the following estimates of ground water flow and transport velocities and potential travel times for dye contaminants were calculated:

- The lateral seepage velocity of ground water to the southwest is about 33 feet per year.
- The time of travel for ground water to migrate between well 02-06 (located near the center of the capped area) to monitoring well 02-04 (monitoring well located about 600 feet downgradient) should be about 18 years.
- The migration velocity of dye contaminants is about 9 feet per year, using the assumed f_{oc} and K_{oc} values.
- The time of travel for dye to migrate between well 02-06 (located near the center of the capped area) to monitoring well 02-04 (monitoring well located about 600 feet downgradient) should be about 70 years.

The second set of calculations are presented in Attachment 5. These were based on an effective porosity of 0.01 and the maximum measured Kh value of 344 feet per year. Under these conservative conditions, the following estimates of ground water flow and transport velocities and potential travel times for dye contaminants were calculated:

- The lateral seepage velocity of ground water to the southwest is about 210 feet per year, or approximately 6.5 times faster than the previously discussed estimate.
- The time of travel for ground water to migrate between well 02-06 (located near the center of the capped area) to monitoring well 02-04 (monitoring well located about 600 feet downgradient) should be about 3 years.
- The migration velocity of dye contaminants is about 55 feet per year, using the assumed f_{oc} and K_{oc} values.
- The time of travel for dye to migrate between well 02-06 (located near the center of the capped area) to monitoring well 02-04 (monitoring well located about 600 feet downgradient) should be about 11 years.

If most of the ground water and dyes are traveling through discrete fractures, then the dyes could potentially migrate to the monitoring wells and the sandstone crop line in about 10 years. However, no dyes have been detected to date in any monitoring well at the site. Even if dyes should leach from the landfill and flow exclusively through fractures in the shallow bedrock aquifer, the lateral travel distance to the nearest location where the dye could discharge to the ground surface is relatively large (about 1000 feet).

Based on the calculated flow velocities and the potential for dyes to travel to downgradient monitoring wells or the side of the ridge in 10 years or less, the initial frequency of sampling for monitoring wells is proposed to be every two years for the first 10 years of monitoring. After 10 years have elapsed, the frequency of sampling should be reduced to five year intervals between sampling.

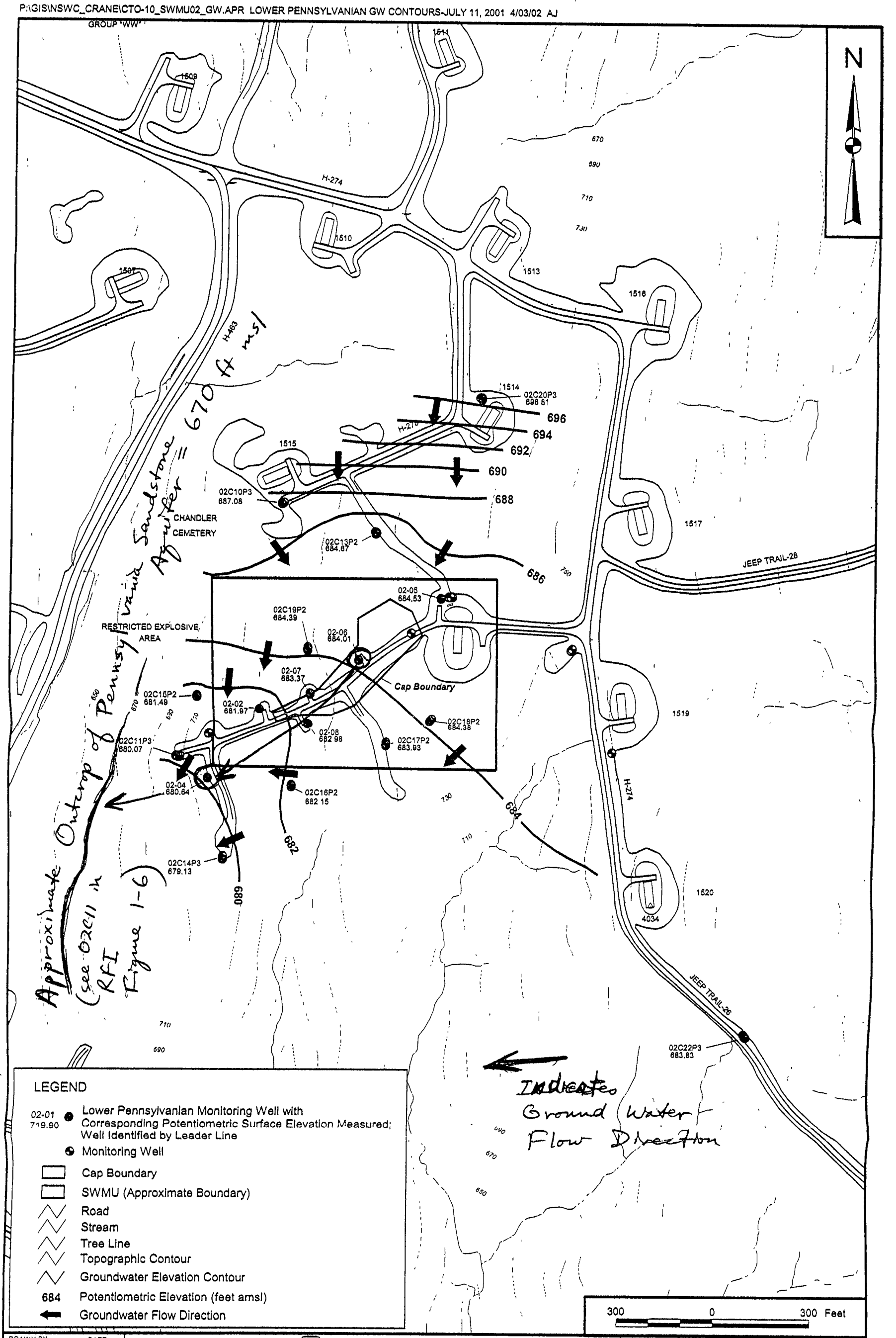
The monitoring wells that should be included in the monitoring program are the ones screened in the Pennsylvanian sandstone (i.e., uppermost aquifer) and located:

- beneath the capped area (02-06), and
- directly adjacent to the capped area (02-02, 02-05, 02-07, and 02-08).

If dyes are detected in any of the five wells listed above, then additional samples should be collected from monitoring wells 02-04, 02C11P3, 02C15P2, and 02C16P2, which are screened in the Pennsylvanian sandstone immediately downgradient of the capped area. The locations of these wells are shown on Attachment 1.

Attachment 1

P:\GIS\NSWC_CRANE\CTO-10_SWMU02_GW.APR LOWER PENNSYLVANIAN GW CONTOURS-JULY 11, 2001 4/03/02 AJ



DRAWN BY J LAMEY — DATE 7/25/01	Tetra Tech NUS, Inc.	CONTRACT NUMBER 7141	OWNER NUMBER CTO 0010
CHECKED BY M COCHRAN — DATE 2/27/02	LOWER PENNSYLVANIAN SANDSTONE AQUIFER GROUND WATER CONTOURS JULY 11, 2001 SWMU 2 - DYE BURIAL GROUNDS NSWC CRANE CRANE, INDIANA	APPROVED BY —	DATE —
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 1 - 10	REV 0

Attachment 1

Well ID	Test ID	Test date	TOS-TOW (m)	Thickness of screened interval (m)	H_0 (m)	S	T (m^2/s)	K_b (m/s)	Curve fit quality	Comments
	2	4/25/95	6.379	3.048	0.31	1.53E-08	3.19E-05	1.04E-05	excellent	
10C53	1	4/11/95	5.861	3.048	0.30	3.98E-03	2.30E-07	7.54E-08	good	
10C53P2	1	4/11/95	3.581	3.048	0.31	6.90E-04	4.44E-05	1.46E-05	excellent	
	2	4/11/95	3.581	3.048	0.37	4.17E-03	4.36E-05	1.43E-05	excellent	
10C54	1	4/11/95	3.545	3.048	0.34	1.82E-03	2.10E-06	6.87E-07	good	
	2	4/11/95	3.545	3.048	0.34	2.15E-02	1.48E-06	4.86E-07	good	
10C55	1	3/23/95	2.649	3.048	0.48	2.97E-03	6.98E-06	2.29E-06	good	
	2	3/23/95	2.649	3.048	0.48	2.49E-03	7.14E-06	2.34E-06	good	
10C56	1	3/21/95	2.724	3.048	0.51	2.92E-02	1.10E-06	3.62E-07	excellent	
	2	3/21/95	2.724	3.048	0.50	4.82E-02	1.03E-06	3.37E-07	good	
10C57	1	3/21/95	0.186	3.048	0.51	5.00E-03	6.78E-09	2.23E-09	fair	20% recovery
	2	7/25/95	0.283	3.048	0.51	2.50E-05	3.46E-08	1.13E-08	fair	40% recovery
Dye Burial Grounds										
2/03	1	4/27/95	3.021	2.777	0.45	1.88E-01	9.19E-10	~~3.31E-10~~	poor	20% recovery
	2	7/27/95	2.844	2.777	0.42	7.28E-03	2.33E-09	~~8.38E-10~~	poor	10% recovery
2/04	1	4/27/95	0.192	2.804	0.33	2.55E-02	3.22E-06	~~1.15E-06~~	fair	partially unconfined?
2/08	1	4/27/95	0.067	2.713	0.24	1.45E-02	6.56E-07	~~2.42E-07~~	good	partially unconfined?
2C10P3	1	5/23/95	1.643	1.524	0.50	6.92E-02	2.98E-06	~~1.96E-06~~	good	partially unconfined?
2C11P3	1	4/27/95	1.042	1.524	0.35	3.01E-01	8.01E-07	5.25E-07	poor	unconfined?
2C12P3	1	4/27/95	2.667	1.524	0.29	8.27E-02	8.16E-07	~~5.35E-07~~	good	unconfined?
2C13P3	1	4/27/95	2.143	1.524						
	2	5/23/95	2.207	1.524	0.28	na	na	na	poor	boundary effects
2C14P3	1	5/23/95	0.911	3.048	0.34	4.96E-01	1.52E-06	4.98E-07	poor	unconfined
2C16P2	1	4/27/95	1.027	3.048	0.15	na	na	na	poor	boundary effects
	2	7/25/95	1.030	3.048	0.25	na	na	na	poor	boundary effects
2C17P2	1	4/27/95	1.134	3.048	0.28	1.67E-02	2.18E-06	~~7.15E-07~~	good	unconfined?
2C18P2	1	4/27/95	0.732	3.048						
	2	5/23/95	0.705	3.048	0.14	5.00E-01	1.18E-06	~~3.88E-07~~	poor	boundary effects
2C20P3	1	5/23/95	4.102	3.048	0.36	3.11E-04	1.01E-05	~~3.32E-06~~	excellent	
Old Burn Pit										
5/6	1	8/1/95	1.628	2.801	0.31	2.57E-04	3.49E-06	1.25E-06	excellent	
5/7	1	8/1/95	3.048	2.841	0.48	5.02E-10	2.62E-06	9.23E-07	excellent	

Median Value of K_h

maximum value of K_h

from Fisher, 1996

Attachment 2

Attachment 2

THE HYDROGEOLOGIC PROPERTIES AND SEDIMENTARY FACIES RELATIONS OF SHALLOW PENNSYLVANIAN BEDROCK AQUIFERS: WELL TESTS, LITHOLOGIC DESCRIPTIONS, AND GAMMA-RAY LOGS

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Compound	CAS No	Molecular Weight	Water Solubility	Specific Gravity	Kow	Koc	H atm/m³/mole	VP mm Hg	BCF	Subject to Biodegradation	Melting Point	Thermal Properties
ACID BLUE 1	129-17-9	566 67	30,000 mg/L			15 (but ionic)	non-volatile		2			
ACID BLUE 9	2650-18-2	783 01	5% at 20°C									
ACID ORANGE 10	1936-15-8	452 38	80,000 mg/L		0	0 (but ionic, therefore, resists leaching)	low	2 50E-20	low	anaerobic(yes), aerobic (no)		
ACID VIOLET 49	1694-09-3	734 9	soluble									
ACID YELLOW 23	1934-21-0	534 37	200,000 mg/L									
ANTHRACENE	120-12-7	178 23	43 ug/L	1 25	28,184	16,032	4 88E-05	2 67E-06	891	no		Boiling Point = 342°C, heat of vap = 294 kj/kg, heat of comb = 40110 kj/kg
BASIC VIOLET 10	81-88-9	479	soluble									
BASIC YELLOW 2	2465-27-2	303 66	10,000 mg/L			50000	2 80E-16	1 70E-11	3 8 - 16	no	>250°C	
BENZANTHRONE	82-05-3	230 25				>10,000	6 61E-08	2 21E-07	61 - 181	yes	170°C	
SOLVENT ORANGE 3	532-82-1	248 71	20 mg/L			840	non-volatile		114	anaerobic(yes)	118°C, decomposes at 235°C	
SOLVENT ORANGE 7	3118-97-6	276 32	insoluble								166°C	
SOLVENT YELLOW 14	842-07-9	248 3	insoluble								134°C	
SOLVENT YELLOW 2	60-11-7	225 28	13 6 mg/L		38,019	7390	7 10E-09	3 30E-07	1780	yes	114-117°C	
PIGMENT VIOLET 12	81-64-1	240 2	probably insoluble									
SOLVENT RED 1	1229-55-6	278 3	3 3E-4 mg/L		31,622,777	290000	1 10E-10	6 30E-09	290000		183°C	
SOLVENT VIOLET 13	81-48-1	329 37									196°C	
SOLVENT YELLOW 3	97-56-3	225 28	7 64 mg/L		8,318	1,426 - 3,236	2 91E-08	7 50E-07	196 - 562		101-102°C	
VAT BLUE 1	482-89-3	262 26	insoluble	1 35								Sublimes at about 300°C, decomposes at 390°C
VAT YELLOW 2	129-09-9											
VAT YELLOW 4	128-66-5											
2-AMINOANTHROQUINONE	117-79-3	223 24	160 ug/L		1,995	1500	9 20E-11	5 00E-11	18 - 46	no	302°C	Sublimes, Heat of Sublimation = 32 7 kcal/mol

Koc for Solvent Orange 3 (relatively low compared to other dye Koc's)

No Koc could be found for Acid Yellow 23 or Acid Orange 10

Attachment 3

ATTACHMENT 4

CALCULATIONS OF GROUND WATER VELOCITY AND TIME-OF-TRAVEL UNDER PROBABLE HYDRAULIC CONDITIONS

Parameter	Value obtained from:	Value	Units
Hydraulic Conductivity (K)	median value from Fischer (1996) (see attachment 1)	5.25E-07	m/s
		5.25E-05	cm/s
		1.49E-01	ft/day
		5.44E+01	ft/year
Hydraulic Gradient (i)	Measured between wells 02-06 and 02-04 (see Attachment 2)	0.0061	unitless
Effective Porosity (n)	assumed value [1]	0.01	unitless
Linear Ground Water Seepage Velocity (V_{gw})	$V_{gw} = (K \cdot i) / n$	33	ft/year
Distance between wells 02-06 and 02-04 (d)	Measured from Figure 1-10 (see Attachment 2)	600	ft
Time of travel for ground water between 02-06 and 02-04 (T_{gw})	$T_{gw} = d / V_{gw}$	18	years
Dry Bulk Density of Aquifer (p_g)	assumed value	1.7	kg/L
Representative Soil-Water Partition Coefficient (K_d) for Dyes	Based on K_{oc} estimate of solvent orange 3 (840 L/kg, see Attachment 3) and assumed f_{oc} value of 0.00002 ($K_d = K_{oc} \cdot f_{oc}$)	0.017	L/kg
Representative Retardation Factor for Dyes (R_f)	$R_f = 1 + (p_g \cdot K_d/n)$	3.9	unitless
Approximate Lateral Migration Velocity of Dye (V_c) in Aquifer	$V_c = V_{gw} / R_f$	9	ft/year
Time of travel for Dyes between 02-06 and 02-04 (T_c)	$T_c = d / V_c$	70	years

Fisher, A.T., 1996. The Hydrogeologic Properties and Sedimentary Facies Relations of Shallow Pennsylvanian Bedrock Aquifers: Well Tests, Lithologic Descriptions, and Gamma-Ray Logs. Indiana Geological Survey, Bloomington, Indiana, Open-File Report 96-3, prepared for Southern Division, Naval Facilities Engineering Command.

[1] Value is relatively low for a sandstone, but assumes that the sandstone is well cemented and fractured.

ATTACHMENT 5

CALCULATIONS OF GROUND WATER VELOCITY AND TIME-OF-TRAVEL UNDER CONSERVATIVE HYDRAULIC CONDITIONS

Parameter	Value obtained from:	Value	Units
Hydraulic Conductivity (K)	median value from Fischer (1996) (see attachment 1)	3.32E-06	m/s
		3.32E-04	cm/s
		9.41E-01	ft/day
		3.44E+02	ft/year
Hydraulic Gradient (i)	Measured between wells 02-06 and 02-04 (see Attachment 2)	0.0061	unitless
Effective Porosity (n)	assumed value [1]	0.01	unitless
Linear Ground Water Seepage Velocity (V_{gw})	$V_{gw} = (K \cdot i) / n$	210	ft/year
Distance between wells 02-06 and 02-04 (d)	Measured from Figure 1-10 (see Attachment 2)	600	ft
Time of travel for ground water between 02-06 and 02-04 (T_{gw})	$T_{gw} = d / V_{gw}$	3	years
Dry Bulk Density of Aquifer (p_g)	assumed value	1.7	kg/L
Representative Soil-Water Partition Coefficient (K_d) for Dyes	Based on K_{oc} estimate of solvent orange 3 (840 L/kg, see Attachment 3) and assumed f_{oc} value of 0.00002 ($K_d = K_{oc} \cdot f_{oc}$)	0.017	L/kg
Representative Retardation Factor for Dyes (R_f)	$R_f = 1 + (p_g \cdot K_d/n)$	3.9	unitless
Approximate Lateral Migration Velocity of Dye (V_c) in Aquifer	$V_c = V_{gw} / R_f$	55	ft/year
Time of travel for Dyes between 02-06 and 02-04 (T_c)	$T_c = d / V_c$	11	years

Fisher, A.T., 1996. The Hydrogeologic Properties and Sedimentary Facies Relations of Shallow Pennsylvanian Bedrock Aquifers: Well Tests, Lithologic Descriptions, and Gamma-Ray Logs. Indiana Geological Survey, Bloomington, Indiana, Open-File Report 96-3, prepared for Southern Division, Naval Facilities Engineering Command.

[1] Value is relatively low for a sandstone, but assumes that the sandstone is well cemented and fractured.