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Resource Conservation and Recovery Act Corrective Measures Proposal Report for SWMU 7 - Old Rifle Range/Old Pistol Range

Naval Surface Warfare Center Crane, Indiana

Contract Task Order 0256

July 2006

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

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REVISION 0
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RESOURCE CONSERVATION AND RECOVERY ACT CORRECTIVE MEASURES PROPOSAL REPORT FOR SWMU 7 - OLD RIFLE RANGE/OLD PISTOL RANGE

NAVAL SURFACE WARFARE CENTER CRANE, INDIANA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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ACRONYMS

°F	degrees Fahrenheit
2,6-DNT	2,6-dinitrotoluene
2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
ALPEC	Ammunition Loading and Production Engineering Center
ARAR	Applicable or Relevant and Appropriate Requirement
B&RE	Brown and Root Environmental
BC/BC	Big Clifty/Beech Creek
bgs	below ground surface
BRAC	Base Realignment and Closure
CAAA	Crane Army Ammunition Activity
CAO	corrective action objective
CASCO	Central Ammunition Supply Control Office
CCCRA	Current Contamination Conditions Risk Assessment
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CM	Corrective Measure
CMA	Corrective Measures Alternative
CMP	Corrective Measures Proposal
CMS	Corrective Measures Study
COC	chemical of concern
COPC	chemical of potential concern
CTO	Contract Task Order
CY	calendar year
DNT	dinitrotoluene
DR	Demolition Range
EPT	Ephemeroptera, Plecoptera, and Trichoptera
HHRSE	Human Health Risk Screening Evaluation
HMX	cyclotetramethylene tetranitramine
HSWA	Hazardous and Solid Waste Amendments
IA	Installation Assessment
IAS	Initial Assessment Study
IDEM	Indiana Department of Environmental Management

in/yr	inches per year
IR	Installation Restoration
LTM	long term monitoring
LUC	land use control
MCL	Maximum Contaminant Level
MCS	Media Cleanup Standard
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mph	miles per hour
msl	mean sea level
NAD	Naval Ammunition Depot
NAVFAC EFD SOUTH	United States Navy Naval Facilities Engineering Field Division South
NEESA	Naval Energy and Environmental Support Agency
NFA	no further action
NOAA	National Oceanic and Atmospheric Administration
NPW	net present worth
NSWC	Naval Surface Warfare Center
NWSCC	Naval Weapons Support Center Crane
O&M	operating and maintenance
OB	open burning
OD	open detonation
OPR	Old Pistol Range
ORR	Old Rifle Range
OSWER	Office of Solid Waste and Emergency Response
PAH	polynuclear aromatic hydrocarbon
PCBs	polychlorinated biphenyls
PPE	personal protective equipment
PRG	Preliminary Remediation Goal
RBTL	risk-based target level
RCRA	Resource Conservation and Recovery Act
RDX	cyclo-trimethyl-trinitramine
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SAIC	Science Applications International Corporation
SB	Statement of Basis
SVOC	semivolatile organic compound

SWMU	Solid Waste Management Unit
TBC	To Be Considered
TNT	2,4,6-trinitrotoluene
TOC	total organic carbon
TOX	total organic halogens
TSD	treatment, storage, or disposal
TtNUS	Tetra Tech NUS, Inc.
U.S.	United States
U.S. EPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VIM	voluntary interim measure
VOCs	volatile organic compounds
yd^3	cubic yards
WES	Waterways Experiment Station

1.0 INTRODUCTION

1.1 SCOPE AND OBJECTIVES

This Corrective Measures Proposal (CMP) Report was prepared for the solid waste management unit (SWMU), 7 [Old Rifle Range (ORR)] at the Naval Surface Warfare Center (NSWC) facility located in Crane, Indiana for the United States Navy, Naval Facilities Engineering Command, Engineering Field Division South (NAVFAC EFD SOUTH) under Contract Task Order (CTO) 0256, of the Comprehensive Long-Term Environmental Action Navy (CLEAN) 3 Contract Number N62467-94-D-0888. For the purposes of this report, SWMU 7 will include both the ORR and Old Pistol Range (OPR).

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. There are typically four distinct phases of work conducted for IR sites. Phase 1 is the Preliminary Assessment [formerly known as the Initial Assessment Study (IAS)]. Phase 2 is a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA), which augments the information collected in the Preliminary Assessment. Phase 3 is the RCRA Facility Investigation (RFI)/CMP, which characterizes the contamination at a facility and develops options for remediation of the site. Phase 4 is the Corrective Measures Implementation, which results in the control or cleanup of contamination at the site. This report has been prepared under Phase 3. The Indiana Department of Environmental Management (IDEM) is the lead oversight agency. However, under a work-sharing agreement, United States Environmental Protection Agency (U.S. EPA) Region 5 is responsible for all phases of the RFI/CMP at SWMU 7.

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

The objectives of the CMP for SWMU 7 are as follows:

- Identify risk-based action levels for chemicals of potential concern (COPCs) or chemicals of concern (COCs) that are protective of current human health receptors and the environment.
- Develop Corrective Measures (CMs) for current receptors.

1.2 PURPOSE OF THE CORRECTIVE MEASURES PROPOSAL

The purpose of the CMP is to present supporting documentation for the proposed CMs that remediate releases for the environmental concerns at SWMU 7. Supporting documentation includes data and information that has been gathered during the RFA, RFI, the 2003 SWMU 7 voluntary interim measure (VIM), and the planned 2006 SWMU 7 remedial action (i.e., source removal).

The submittal of a CMP is appropriate for SWMU 7 based upon the following:

- NSWC Crane is a fenced military installation controlled by the Navy.
- NSWC Crane was not included in the 2005 Base Realignment and Closure (BRAC) process and will remain a military installation for the indefinite future.
- Foreseeable land uses are military (i.e., industrial).
- Residential land uses occur only in very limited areas, none of which are located within or adjacent to SWMU 7.
- Unique topography generally prevents future groundwater contaminant plume migration.

1.3 ORGANIZATION OF CORRECTIVE MEASURES PROPOSAL

The CMP consists of four sections. Section 1.0 is this introduction. Section 2.0 provides a description of the current situation and presents the media cleanup standards (MCSs) for SWMU 7. Section 3.0 describes the CMs recommendations. Section 4.0 provides the details of the CMs recommendations.

1.4 BACKGROUND INFORMATION

1.4.1 Facility Location

NSWC Crane is located in the southern portion of Indiana, approximately 75 miles southwest of Indianapolis and 71 miles northwest of Louisville, Kentucky, immediately east of Crane Village and Burns City (Figure 1-1).

NSWC Crane encompasses 62,463 acres (approximately 98 square miles), most of which are located in the northern portion of Martin County. Smaller portions are located in Greene, Daviess, and Lawrence

Counties. NSWC Crane is located in a rural, sparsely populated area. Most of NSWC Crane 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, renovation, and storage, shipment, demilitarization, and disposal of conventional ammunition.

1.4.2 Facility History

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

1.4.2.1 History of Ownership and Operation

In 1940, Congress authorized construction of a Naval Ammunition Depot (NAD) in southern Indiana; 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 NSWC 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 Vietnam Conflict, the number of full-time employees at NAD Crane increased to 6,800.

In 1975, NAD Crane was redesignated 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. Other functions remained under Navy control, 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. In 1992, the Facility was designated as NSWC Crane. Currently, approximately 4,000 people are employed at NSWC Crane.

1.4.2.2 History of Regulatory Actions

Following promulgation of the U.S. EPA RCRA hazardous waste regulatory program, NSWC Crane filed notification and application to operate as a RCRA hazardous waste treatment, storage, or disposal (TSD) facility in October 1980. Interim status was granted subject to operating requirements and applicable technical standards found in Title 40 of the 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 SWMUs. Accordingly, NSWC Crane submitted a Hazardous Waste Management Report, and an RFA was conducted to characterize the potential for releases of hazardous waste or constituents from approximately 100 SWMUs identified during the RFI 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 permit in 1995. IDEM now has responsibility for the Federal Corrective Action Program. IDEM renewed the Corrective Action Permit in October 18, 2001. However, certain ongoing corrective actions including corrective actions at SWMU 7 will continue under the U.S. EPA/IDEM Work Sharing Agreement for Corrective Action Activities at the Naval Surface Warfare Center - Crane Division.

1.4.3 Project Site

1.4.3.1 Site Description

Historically, SWMU 7 has been referred to as the ORR. However, for the purposes of this report, the area referred to as the ORR consists of these two separate areas; the maintained part of SWMU 7, which is referred to as the ORR, and an adjacent abandoned shooting range referred to as the OPR. The following is a description of each area.

Old Rifle Range

The ORR occupies approximately 20 acres immediately northeast and downslope of the Demolition Range (DR) (Figure 1-2). The site is immediately west of NSWC Crane Highway 8 in the flat-lying floodplain of Turkey Creek. Currently the ORR consists of a flat, grass-covered area bisected from north to south by a maintained gravel road. This road provides access to various groundwater monitoring wells located within the ORR and to a powder burning area that is a RCRA permitted open burning (OB) facility.

The OB area is approximately 1 acre in size and is located in the northern part of the ORR. It is used for burning yellow D (ammonium picrate) in containment pans. West of the gravel road and south of the yellow D burning area are four man-made earthen berms. The first berm is located approximately 100 feet away from the targets with each of the following berm approximately 100 foot apart. The berms were used as firing positions during target shooting. Additionally, there is a chain-link fenced pad used in conjunction with burning operations.

The ORR is roughly rectangular in shape and is located in Sections 26 and 35 of T5N, R4W on the Indian Springs, Indiana Topographic Quadrangle Map (USGS, 1978).

Old Pistol Range

The OPR is approximately 10 acres in size and is located immediately adjacent to the northern end of the ORR (Figure 1-2). Because of similar past operational activities (small-arms firing ranges) at these two locations, they have been collectively referred to as the ORR. Figure 1-3 shows the outlines of the ORR and the OPR on a 2003 aerial photograph.

The OPR contains remnants of a wooden structure that may have been used as a shelter for target shooting. One earthen berm is present at the OPR. The OPR is not maintained and, as a result, small trees and brush cover the entire area.

1.4.3.2 Land Usage

The SWMU 7 OB/open detonation (OD) area, which is a RCRA-permitted hazardous waste treatment facility, is an active facility. The other areas within SWMU 7, which were used for rifle and pistol target practice are inactive.

1.4.3.3 Corrective Action Stages

The Phase III soils RFI Report has been completed (TtNUS, 2005a). An Addendum to the Phase III soils RFI Report (Addendum 1) was developed to evaluate lead contamination at the OPR Hillside Range 1 Berm and Range 2 Berm (TtNUS, 2005b).

Groundwater at one well (06C15) at the ORR has been shown to be contaminated with one explosive compound [2,4,6-trinitrotoluene (TNT)]. The ORR is subject to RCRA groundwater monitoring requirements for hazardous waste treatment facilities, including corrective action. A RCRA groundwater compliance monitoring program is currently being conducted at the ORR. The results of the groundwater

monitoring show that metal concentrations (principally arsenic, barium, manganese) are in excess of upgradient concentrations and risk-based target levels (RBTLs) that are established in the RCRA permit in several wells.

1.4.3.4 Preliminary Remedial Actions

In the summer of 2003, the Navy conducted a VIM to excavate localized high concentrations of TNT previously investigated as part of the RCRA Phase III Soils RFI (TtNUS, 2005a) (Figure 1-4). This removal addressed approximately 95 percent of the calculated TNT risk at SWMU 7. Completion of the VIM resulted in significantly lower TNT concentrations and associated reductions in risk for the SWMU.

1.5 PHYSICAL CHARACTERISTICS OF STUDY AREA

1.5.1 Climate and Meteorology

The climate in the region of NSWC Crane can be described as temperate (NOAA, 1988). Precipitation is distributed evenly throughout the year, and there is no pronounced wet or dry season for this region. Rainfall in the spring and summer is produced mostly from showers and thunderstorms. A peak rainfall of approximately 2.5 inches in a 24-hour period can be expected about once a year. Snowfalls of 3 inches or more occur on an average of two or three times per winter season.

Mean monthly temperatures for the region are shown in Table 1-1. Temperatures range from a minimum of 27.9 degrees Fahrenheit (°F) in January to a maximum of 75.7°F in July. The mean annual temperature for the area is 52.6°F. The annual mean monthly distribution of rain and snow for the area is shown in Table 1-2. The annual rainfall total is about 40 inches per year with the highest mean monthly totals occurring in the late spring and in the early summer period of May through July. Snowfall averages about 23 inches a year, with most occurring in the winter months from December through February.

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

1.5.2 Topography

1.5.2.1 NSWC Crane

NSWC Crane is in the unglaciated area of the Crawford Uplands Physiographic Province. This province is a rugged, highly vegetated, dissected plateau bounded by the Mitchell Plain Physiographic Province to the east and the Wabash Lowland Physiographic Province to the west (USACE WES, 1998). The Mitchell Plain is a low, dissected, limestone plateau characterized by sinkholes and karst topographic features. The boundary between the Crawford Upland and the Mitchell Plain is marked by the highly irregular, eastern-facing Chester Escarpment. Springs, caverns, caves, and other solution weathering features can be found along this escarpment and on the eastern edge of the NSWC Crane facility. The boundary between the Crawford Upland and the Mitchell Plain near the western boundary of NSWC Crane is gradual (USACE WES, 1998).

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

1.5.2.2 SWMU 7

The ORR occupies a roughly rectangular area that is sloping gently to the east. Maximum ground surface elevations within the ORR are about 530 feet above msl, and the minimum elevation is about 500 feet above msl near the road (NSWC Crane Highway 8), for a total relief of about 30 feet within the ORR (Figure 1-5). The area east of the ORR continues to slope toward Turkey Creek, where the minimum elevation is approximately 485 feet above msl (Figure 1-5). The mean slope from the western side of the ORR to Turkey Creek is about 2 percent.

To the west and southwest of the ORR, the ground surface rises steeply to a ridgetop, which has a maximum elevation of about 710 feet above msl (Figure 1-5). Thus, the total relief from the top of the ridge to Turkey Creek is about 225 feet above msl. The DR occupies the sideslopes and top of the ridge to the west and southwest of the ORR (Figure 1-5).

1.5.3 Geology and Soils

1.5.3.1 NSWC Crane

NSWC Crane is located in the eastern flank of the Illinois Basin. The surface and near-surface bedrock at NSWC Crane consists of Lower Pennsylvanian- and Upper Mississippian-age sandstones, limestones, and shales. These Paleozoic-age sedimentary rocks form the core of each ridge and underlie all of the streams and creeks at NSWC Crane. The rock formations have been deformed to yield a gentle dip of 50 feet per mile towards the west-southwest, toward the center of the Illinois structural basin.

In general, Mississippian-age Chester Series sandstones, shales, and limestones are exposed in the valley walls of eastern portions of NSWC Crane and in the lower elevations of deep valleys in western portions. Pennsylvanian-age Mansfield Formation sandstone, siltstones, claystones, and shales are found at the crests of hills and ridges in eastern portions of NSWC Crane and as the surficial bedrock unit further west (see Figure 1-6). The contact between the Mississippian units and overlaying Pennsylvanian units is an unconformity formed by past erosion of the Mississippian surface (Murphy and Ciocco, 1990).

Unconsolidated colluvium and residual soils blanket the tops and sides of the ridges. These soils range from 1 to about 30 feet thick, although the thickness is generally less than 10 feet. Up to 50 feet of alluvial deposits and colluvium have been found in the valley bottoms of the larger streams. Four soil units have been mapped at NSWC Crane, including Wellston-Gilpin, Wellston-Berks-Gilpin, Wellston-Berks-Ebal, and Wakeland-Wilbur-Haymond Soils (McElrath 1988). These soils are primarily silt loams with permeabilities ranging from 0.6 to 2.0 inches per hour (Murphy, 1994).

1.5.3.2 SWMU 7

Locations of geologic cross sections prepared by the United States Army Corps of Engineers (USACE) Waterways Experiment Station (WES) (1998) are shown on Figure 1-7. Three of these cross sections (G-G, H-H, and J-J) trend in a northwest-southeast direction and pass through SWMU 7. Two of these cross sections (G-G and H-H) are reproduced in Figure 1-8. Cross section G-G passes through the northern end of SWMU 7, and cross section H-H passes through the center of SWMU 7. In each case, the left side of the cross section originates on the western side of SWMU 7 where the ground surface starts rising rapidly and the right sides of the cross sections lie close to NSWC Crane Highway 8.

As shown in cross section H-H, the upper portions of the hillsides and the ridgetops are composed of Pennsylvanian-age Mansfield Formation. The Pennsylvanian-age sandstones, siltstones, shales, and coal beds are separated from the Mississippian-age rocks by the pre-Pennsylvanian erosional

unconformity at an elevation of about 535 to 540 feet above msl, as shown in cross section H-H on Figure 1-8.

Directly beneath the Pennsylvanian rocks lie the Golconda-Haney Limestone and the Indian Springs Shale (Upper Mississippian age). These rock units only exist in the ridge to the west of the ORR at elevations ranging from approximately 500 to 535 feet above msl. These two rock units are only present in a very limited area exist within the SWMU 7 boundary (i.e., the area around monitoring well 06C16; see cross section G-G on Figure 1-8 and sampling locations on Figure 1-5). The Golconda-Haney Limestone is considered to be a minor aquifer at NSWC Crane. It is hydraulically separated from the underlying Big Clifty/Beech Creek aquifer by the Indian Springs Shale. Because this limestone aquifer and the shale aquitard are located upgradient of SWMU 7 and at a higher elevation, groundwater in these units is not expected to be affected by any activities that have occurred at SWMU 7. As a result, the Mansfield Formation, Golconda-Haney Limestone, and Indian Springs shale will not be discussed or evaluated further in this report.

In nearly all of the SWMU 7 area, the Big Clifty Sandstone is the uppermost rock unit encountered near the ground surface. This sandstone is uniformly about 40 feet thick, except where the thickness has been reduced by post-Pennsylvanian erosion. As shown in cross section G-G (Figure 1-8), post-Pennsylvanian erosion has significantly reduced the thickness of the Big Clifty Sandstone on the eastern side of SWMU 7. The Big Clifty Sandstone is characterized as a tan to green-gray, massive to thick-bedded, fine-to very fine-grained, well-sorted, friable sandstone with occasional shaly partings (USACE WES, 1998). Boring log information indicated that joints in the sandstone ranged from frequently encountered to sparse in occurrence.

Silty gravel and clay overlie the Big Clifty Sandstone everywhere at SWMU 7. In some cases, only a thin layer (less than 8 feet) of clay and silt residual soil overlies the Big Clifty Sandstone (cross section G-G, Figure 1-8). In other cases, the thickness of alluvium, colluvium, and residual soil was found to be as much as 30 feet (see wells 06C17 and 06C13 in Figure 1-8, cross section H-H). A map showing spatial variations in soil thicknesses is presented as Figure 1-9. The areas of thinnest soil (less than 10 feet) exist on the northeast and the southwestern sides of SWMU 7.

The Beech Creek Limestone lies beneath the Big Clifty Sandstone. This limestone was typically about 17 feet thick in the SWMU 7 area, but ranged from about 15 to 22 feet thick. This formation consists of hard, dense, fossiliferous limestone. The upper 5 to 10 feet were gray to gray-brown, crystalline limestone with occasional styolites. The lower portion was dark gray, crystalline limestone, with occasional to numerous shale partings.

Together, the Big Clifty Sandstone and the Beech Creek Limestone form the Big Clifty/Beech Creek (BC/BC) aquifer. Because both units are permeable and the Big Clifty lies directly above the Beech Creek in direct hydraulic connection, they are considered one aquifer. The combined thickness ranges from about 50 to 60 feet on the western side of the SWMU to about 30 feet thick on the eastern side of the SWMU where part of the aquifer has been removed by post-Pennsylvanian erosion in the Turkey Creek valley.

1.5.4 Surface Water Hydrology

1.5.4.1 NSWC Crane

The surface drainage at NSWC Crane has formed a dense, dendritic pattern throughout the installation which flows generally to the south and southwest. Seven primary creeks in five drainage basins carry surface water off the installation, where it eventually drains into the East Fork of the White River and then to the Wabash River to the southwest. The seven creeks that drain NSWC Crane include Furst Creek, Sulphur Creek, Little Sulphur Creek, Boggs Creek, Turkey Creek, Indian Creek, and Seed Tick Creek. Figure 1-3 shows the surface drainage features and the individual drainage basins at NSWC Crane.

Drainage Basin IV includes Boggs and Turkey Creeks, which are the primary drainageways for the installation and drain the majority of the area. The northern and northwestern sections (Basin I) are drained by Furst Creek, the eastern portion (Basin III) is drained by the Sulphur Creek complex, the extreme eastern portion (Basin II) is drained by Indian Creek, and the southwestern section (Basin V) is drained by Seed Tick Creek.

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 potable water at NSWC Crane and is also used for recreation (NEESA, 1983).

1.5.4.2 SWMU 7

SWMU 7 generally slopes toward Turkey Creek, where the minimum elevation is approximately 485 feet above msl. Thus, a large portion of the SWMU drains directly into Turkey Creek. An unnamed perennial stream flows from northwest to southeast through the northern end of the ORR and drains into Turkey Creek (Figure 1-5). Thus, the northern portion of SWMU 7, including all of the OPR area, drains into the unnamed tributary prior to entering Turkey Creek. Another unnamed tributary creek flows from west to east through the southern end of SWMU 7, and enters Turkey Creek (Figure 1-2). This tributary receives

some surface water runoff from the southern end of the SWMU. It also drains some of the ridgetop area occupied by the DR (SWMU 6). A small man-made sediment retention basin (Pond 3) has been constructed on this unnamed tributary in the vicinity of monitoring well 06C12 (see USACE WES, 1998, Plates 2 and 5). To further aid in the settling of solid from Pond 3, an additional impoundment (Pond 3A) was constructed in the southeastern corner of SWMU 7 near 06C11.

All water and sediment discharging from the SWMU eventually enters Turkey Creek.

1.5.5 Groundwater Hydrology

1.5.5.1 NSWC Crane

Groundwater is present beneath NSWC Crane in both the natural unconsolidated materials and the bedrock. The depth to groundwater ranges from less than 5 feet below ground surface (bgs) in topographic low areas near surface water bodies to almost 25 feet bgs at the higher elevations. The majority of the monitoring wells at the site were completed within the first groundwater-yielding unit encountered during drilling, which was typically either the natural unconsolidated material or the shallow bedrock.

The majority of the NSWC Crane is a dissected plateau, with hills and ridges separated by deeply incised gullies and creeks. In general, each hill and ridge is a "hydrogeologic island" in that precipitation infiltrates the tops and slopes of the islands, moves downward a short distance, and then starts migrating toward the outer edges of the individual hills and ridges. Thus, groundwater flow patterns mimic topography; i.e., groundwater generally flows from the center of the hills and ridges outward toward the deeper gullies and creek valleys.

Because the sandstones, siltstones, and shales of the Mansfield Formation generally have low permeabilities, flow through Pennsylvanian rock is generally through minor fractures and joints, or through the porous sandstones when they are shallow (e.g., less than 50 feet bgs) and highly weathered. The Mississippian limestone formations are well cemented and have little to no intergranular porosity and permeability. However, fractures, joints, and bedding planes can be enlarged due to solutioning of the limestone, particularly along stream valleys where a limestone formation may be closer to the ground surface.

At the Ammunition Burning Grounds (SWMU 3), a portion of the Beech Creek Limestone has been documented as being very permeable, with solution cavities and rapid conduit. Large solution openings

and caves have also formed in other Mississippian limestone aquifers (i.e., Golconda-Haney and Beaver Bend Limestones).

Groundwater flow patterns in the Mississippian aquifers are less well documented than flow patterns in the shallower Pennsylvanian rocks. However, it appears that flow in the deeper limestones, in general, also moves from beneath the hills and ridges radially outward toward the nearest stream valleys. There is no documented case at NSWC Crane where groundwater flow in the Mississippian aquifers is intervalley (i.e., where groundwater migrates from one large watershed into a different watershed).

1.5.5.2 SWMU 7

The Big Clifty Sandstone and Beech Creek Limestone were monitored as one aquifer at SWMU 7, as they were for the DR. The Beech Creek Limestone was the deepest formation monitored at the SWMU. Well screens were placed at two levels within the BC/BC aquifer. Ten- or 20-feet screens were installed near the base of the aquifer and 10 foot screens were installed near the top. The upper screens monitor the uppermost or water-table aquifer at SWMU 7. Many of the upper screens partially screen the deep soil zone that exists at SWMU 7. The maximum thickness of BC/BC aquifer penetrated was 58 feet in boring 06C16 (Figure 1-8). The least penetrated was 26 feet in 06C13 (Figure 1-8). The deeper wells end in the Elwren shale aquiclude, which is persistent beneath the entire SWMU.

Two wells were installed in the Golconda/Haney Limestone. Confirmation well 06-21 was installed in 1983 and RFI well 06C16P3 in 1990 (two other wells in the DR study area also screened the Golconda/Haney). The Golconda/Haney aquifer is absent beneath most of SWMU 7; therefore, groundwater conditions and hydraulic characteristics of this aquifer are not presented or discussed in this report.

The thick alluvial soils that occur over much of SWMU 7 constitute part of the uppermost aquifer. The similarity in water levels in wells installed solely in the soil column and wells installed in the upper Big Clifty Sandstone indicate that the soils are hydraulically connected with the BC/BC aquifer.

As stated previously, joints were sparse to numerous in rock cores recovered from the Beech Creek Limestone. Water loss during drilling through the Beech Creek limestone was most significant in borings at SWMU 7, where the Beech Creek is shallow. Borings 06C12, 06C14, 06C15, and 06C17 (Figure 1-8) each had an open joint, up to 0.2 feet wide, within 3 feet of the top of the Beech Creek aquifer, near the contact with the overlying Big Clifty sandstone. Considerable water loss occurred through the open joints.

These borings also exhibited numerous other joints in the Beech Creek. The only solution feature noted was in the open joints in two of the four borings listed above (USACE WES, 1998).

Flow within the Big Clifty Sandstone is believed to be through joints and through intergranular porosity. The effective intergranular porosity measured on two core samples was 18 percent (USACE WES, 1998).

As part of the RFI, water levels have been measured for the two different aquifer zones (i.e., Upper Big Clifty/overburden and Beech Creek) several times in the early 1990s (USACE WES, 1998) and quarterly in 2000 through 2002 (SAIC, 2002a, 2002b, and 2003a). The groundwater flow direction in the overburden/upper Big Clifty zone (i.e., upper monitoring zone) is generally from northwest to southeast (Figure 1-10). Groundwater levels measured in the Beech Creek Limestone and the base of the Big Clifty Sandstone (i.e., deep monitoring zone) indicate a general groundwater flow to the east and southeast (Figure 1-11). According to the conceptual hydrologic model for SWMU 7, groundwater flows from high topographic elevations (west of SWMU 7) towards the Turkey Creek valley, located on the eastern side of SWMU 7 (see Figure 1-5). Most of the groundwater flow discharges to Turkey Creek.

1.5.6 Water Supply

Lake Greenwood, an 800-acre man-made, spring-fed lake in the northwestern portion of the installation (Figure 1-1) is the main source of drinking water at NSWC Crane and it is also used for recreation. Groundwater at SWMU 7 is not currently and will not be used in the future based on the use of NSWC Crane as a military facility for the indefinite future.

1.5.7 Surrounding Land Use

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

There is no state or local planning within the vicinity of NSWC Crane. The only zoning and land use regulations are found in the municipalities within the region. None of these municipalities are close enough to have an impact on NSWC Crane. None of the areas adjacent to NSWC Crane are zoned, and zoning is not anticipated in the near future.

SWMU 7 is approximately 3 miles east of the nearest NSWC Crane property boundary and is bounded on the east by Highway 48. There is no known current or likely future land use or community actions under consideration or proposed at this time for the SWMU. SWMU 7 is contained completely within NSWC Crane, and likely future land use at areas surrounding the SWMU is expected to be limited to industrial uses. Specifically, the ORR portion of the SWMU is expected to be used for the indefinite future as a RCRA-permitted hazardous waste treatment facility.

1.5.8 Ecological Setting

1.5.8.1 Facility

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

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

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

The bird population includes a number of State or federal threatened, endangered, or species of special concern that use the site as their home range. These species include the bald eagle, osprey, sharp-shinned hawk, red-shouldered hawk, broad-winged hawk, black and white warbler, hooded warbler, and the worm-eating warbler (B&RE, 1997). Also, the Indiana bat, a federal endangered species, is known to

forage at NSWC Crane. During a mist net and radiotelemetry survey conducted for NSWC Crane, a male Indiana bat was captured along Furst Creek, which is approximately 1.5 miles west of SWMU 7. No Indiana bats were captured near SWMU 7. Because of the bat and its potential habitat, the cutting of trees is restricted to certain times during the year, and the cutting of shagbark hickory trees (potential Indiana bat habitat) is prohibited.

1.5.8.2 SWMU 7

RE&I, as a subcontractor to Tetra Tech NUS, Inc. (TtNUS), conducted an ecological risk assessment as part of the RCRA permitting process for the OB/OD treatment units. The information presented in this section was obtained from the site survey described in the Current Contamination Conditions Risk Assessment (CCCRA) Report (B&RE, 1997).

The vegetation at SWMU 7 includes mowed grasslands, wooded slopes, and riparian wooded vegetation in the vicinity of the Turkey Creek drainage. SWMU 7 supports a diverse bird population; a total of 35 species were recorded at SWMU 7 during a survey. Bird habitat diversity (open fields, woodlands, and riparian woods) at SWMU 7 is believed to be responsible for the high bird diversity. SWMU 7 was surveyed during the fall of 1995 which were low-flow conditions for Turkey Creek, and the only species occurrences included five separate captures of opossum. SWMU 7 site activities and related disturbances and predetation pressures were believed responsible for the lack of other species. SWMU 7 macroinvertebrate community was surveyed from three creek pool locations. The upstream pool location had a total of seven species, three of which were Ephemeroptera, Plecoptera, and Trichoptera (EPT) species. The next location, across from SWMU 7, had five species present, and two EPT species were recorded. Further downstream, five species were recorded with only a single EPT species present. To some extent, fish species diversity in Turkey Creek in the vicinity of SWMU 7 reflected the low-flow conditions encountered during the macroinvetebrate sample collection. At the upstream location in Turkey Creek, a total of 12 species were observed. At the location across from SWMU 7, in Turkey Creek, four species were observed. At the downstream location, it was not possible to collect a valid sample by the electric shock method used at the upstream location because the stream was too deep for this method. Therefore, it was necessary to use an alternate method (trotline) which does not capture the smaller fish species.

The CCCRA states, "Population studies within and outside of the impacted area of the ORR do not indicate on the basis of abundance and diversity any adverse effect to the indicator species investigated resulting from operation of the ORR. As a result, the combination of the low trace levels of metals and organics detected in the media and tissues associated with the ORR and the population studies

conducted at the site, the effects of the current activities at this SWMU are not considered to be adversely impacting the ecological population at this site."

Following the CCCRA studies, a Phase III Soils RFI (TtNUS, 2005a) was conducted for the ORR. As part of the Phase III Soils RFI a screening ecological risk evaluation was conducted for the Hillside Range 1 and Range 2 berms and their firing lanes. The Phase III Soils RFI concluded that metals in the Hillside Range 1 and Range 2 firing lanes did not present a risk to ecological receptors and that the metals in the berm areas (primarily lead) had the potential to adversely impact ecological receptors.

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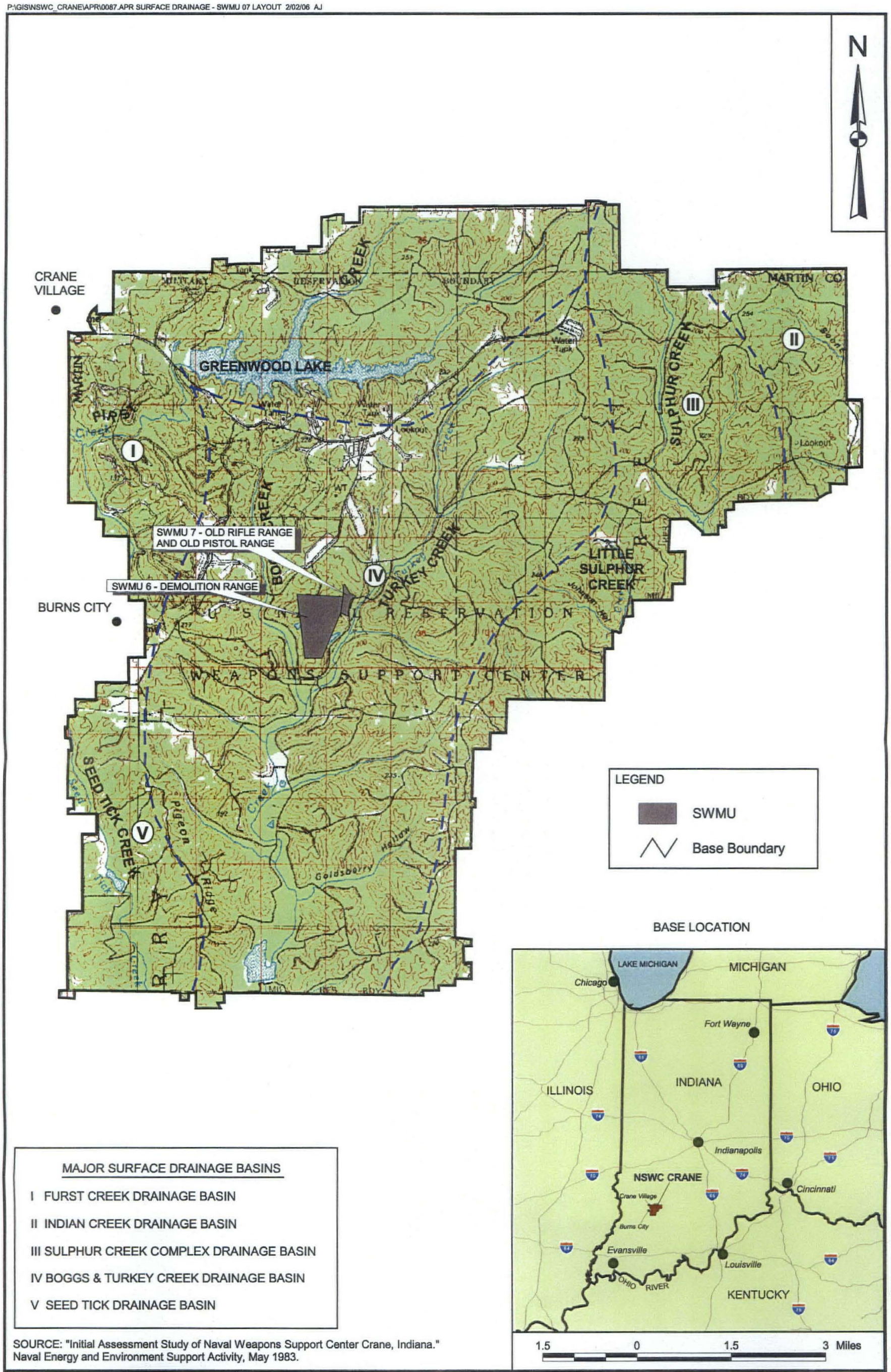

MAJOR SURFACE DRAINAGE BASINS

I FURST CREEK DRAINAGE BASIN

II INDIAN CREEK DRAINAGE BASIN

III SULPHUR CREEK COMPLEX DRAINAGE BASIN

IV BOGGS & TURKEY CREEK 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 J. LAMEY	DATE 4/19/99	SITE LOCATION AND SURFACE DRAINAGE CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0256
CHECKED BY V. PLACHY	DATE 2/02/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 1 - 1 REV 0

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CONTRACT NO. CTO 0256

APPROVED BY ___ DATE ___

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DRAWING NO. FIGURE 1 - 2

REV 0

OLD RIFLE RANGE, OLD PISTOL RANGE, AND DEMOLITION RANGE TOPOGRAPHY
CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

NAVFAC

DRAWN BY C. SPEHAR DATE 12/20/05

CHECKED BY V. PLACHY DATE 2/02/06

COST/SCHED-AREA

SCALE AS NOTED

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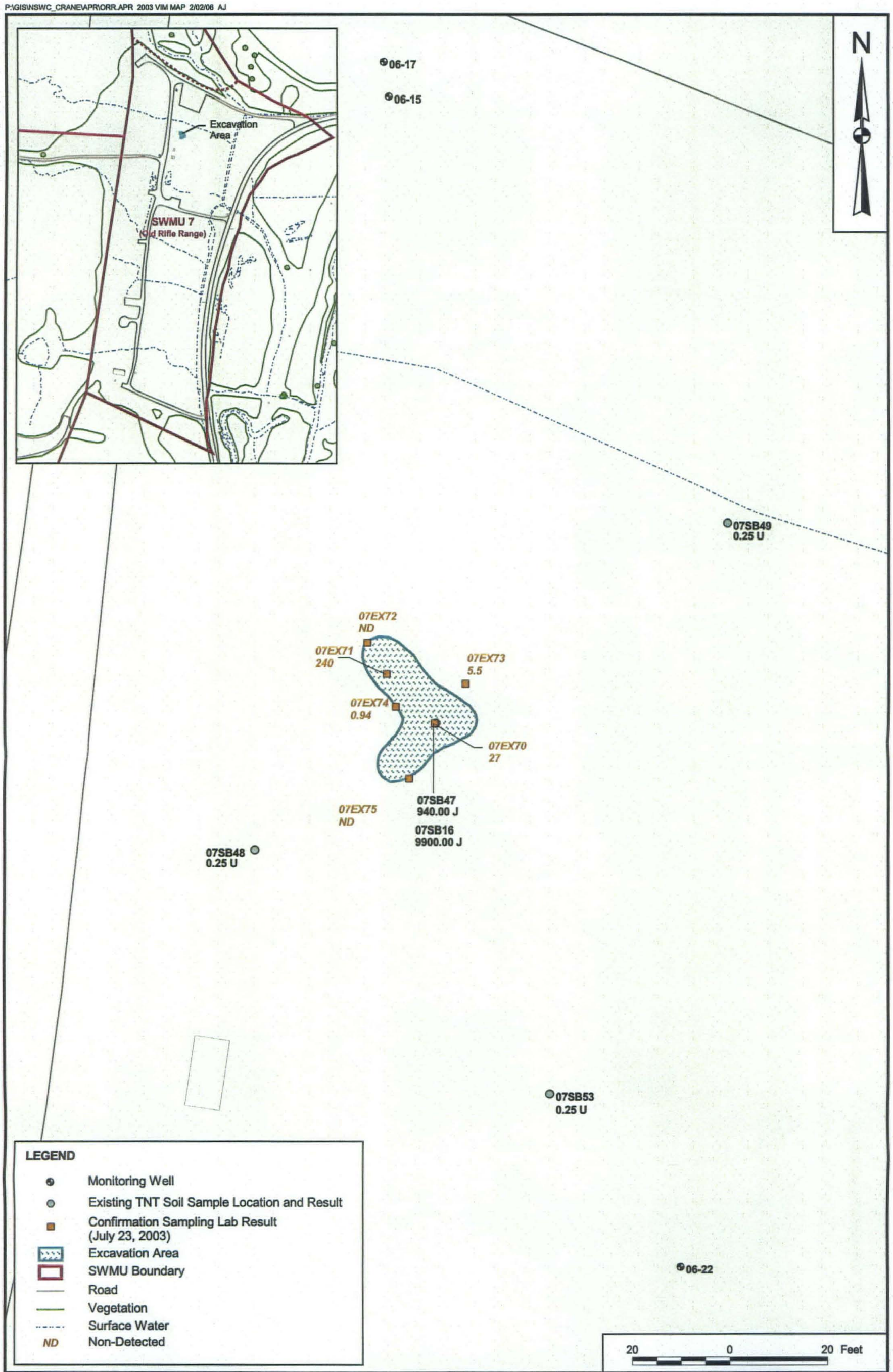
DRAWN BY C. SPEHAR	DATE 12/20/05	OLD RIFLE RANGE / OLD PISTOL RANGE 2003 AERIAL PHOTOGRAPH CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0256
CHECKED BY V. PLACHY	DATE 2/02/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 1 - 3 REV 0

P:\GIS\NSWC_CRANE\APR\ORR.APR 2003 VIM MAP 2/02/06 AJ



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C. SPEHAR	12/20/05	CTO 0256
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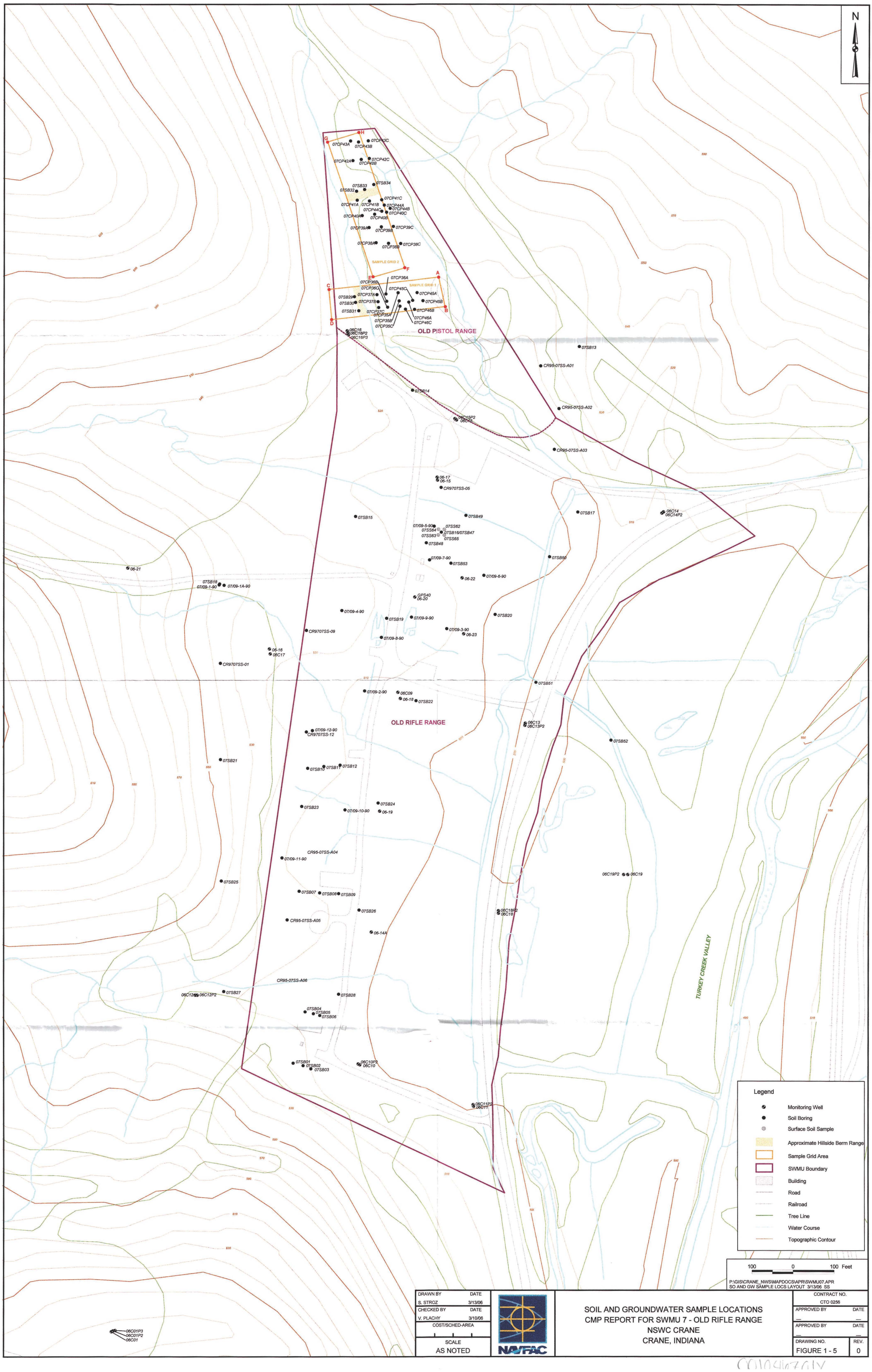
V. PLACHY	2/02/06	— / —
COST/SCHEDULE-AREA		APPROVED BY / DATE
		— / —
SCALE		DRAWING NO. / REV
AS NOTED		FIGURE 1 - 4 / 0

NAVFAC

2003 VOLUNTARY INTERIM MEASURE
CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA



DRAWN BY	DATE
S. STROZ	3/13/06
CHECKED BY	DATE
V. PLACHY	3/10/06
COST/SCHED-AREA	
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SOIL AND GROUNDWATER SAMPLE LOCATIONS
CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

CONTRACT NO.	
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FIGURE 1 - 5	0

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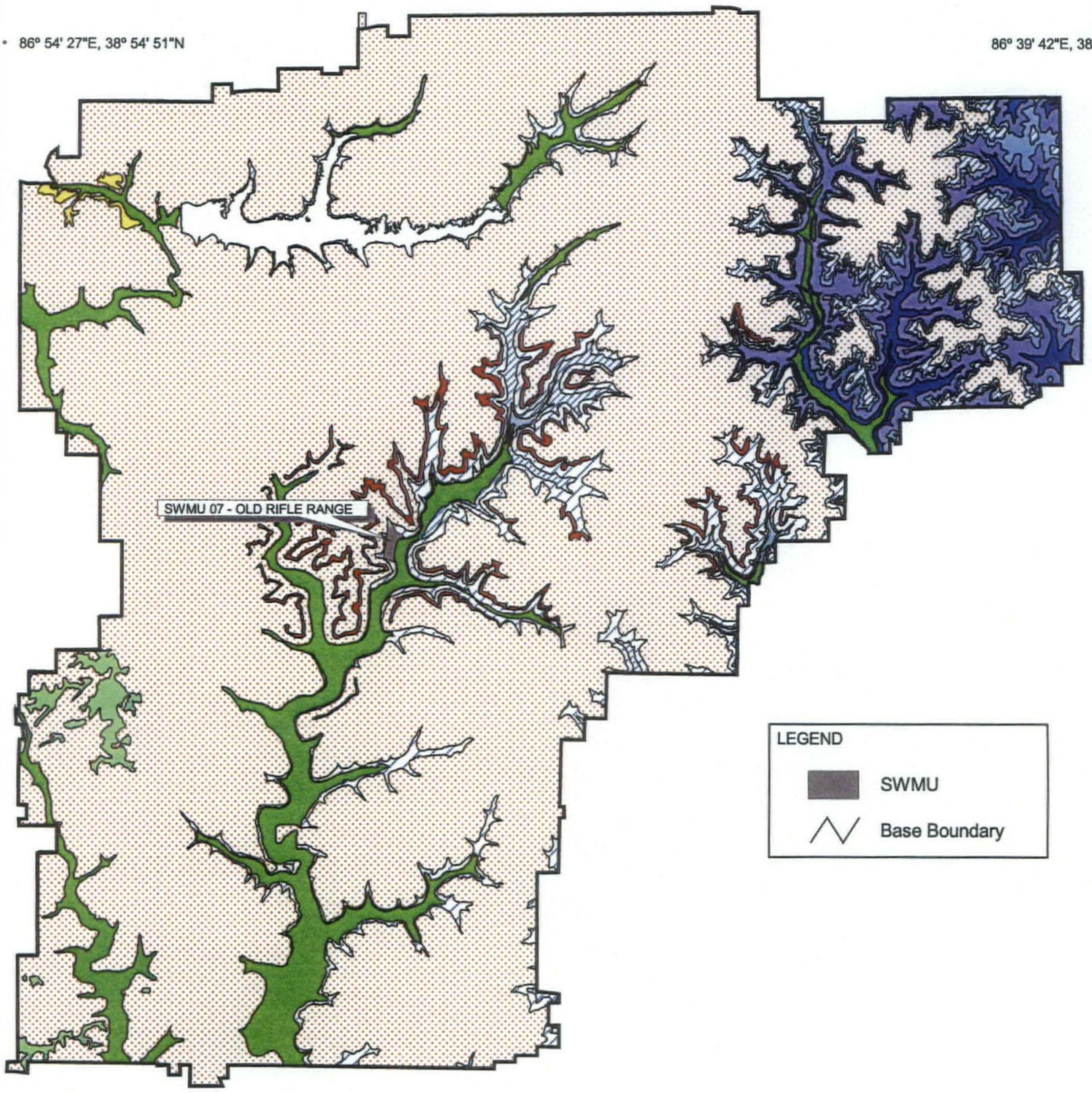

Inferred Depositional Environment		Explanation of Geology
Alluvium	Qal	*Alluvium*
Loess/Glacial Outwash	Ql	*Loess*
	Qo	*Glacial Outwash*
Residual soil derived from Pennsylvanian bedrock/colluvium	P	*Raccoon Creek Group and undifferentiated*
	Ps	*Sandstone-dominated horizon of Lower Pennsylvanian*
Residual soil derived from Mississippian bedrock/colluvium	M6	*Glenn Dean Ls, Hardinsburg Fm, Haney Ls, Indian Springs Shale Mbr, and undifferentiated*
	M5	*Sandstone member of the Big Clifty Fm*
	M4	*Beech Creek Ls*
	M3	*Elwren Fm, Reelsville Ls, upper Sample Fm, and undifferentiated*
	M2	*Lower part of Sample Fm, Beaver Bend Ls, Bethel Fm, and undifferentiated*
	M1	*Paoli Ls, Ste Genevieve Ls, and undifferentiated*

Source: Background Soils Report. TtNUS 2001. (Modified from Blunck, 1995).

1.5 0 1.5 3 Miles

DRAWN BY	DATE
D. PERRY	3/15/99
CHECKED BY	DATE
V. PLACHY	2/02/06
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

NAVFAC

SURFICIAL GEOLOGY AND DEPOSITIONAL ENVIRONMENTS
CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

CONTRACT NUMBER	
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APPROVED BY	DATE
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FIGURE 1 - 6	0

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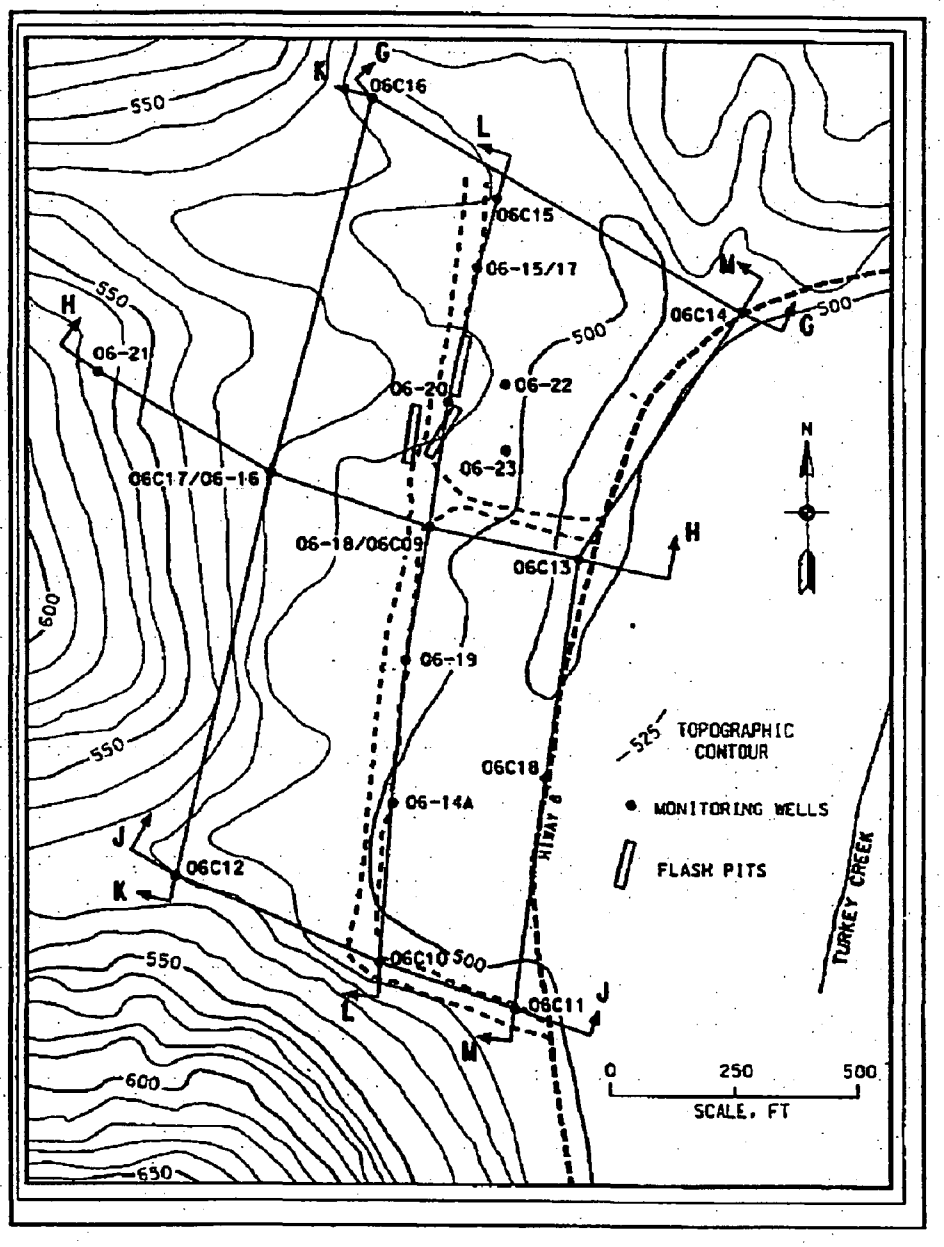

Figure 16. Locations of geologic cross sections GG through MM, Old Rifle Range

SOURCE: USACE WES, 1998

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C. SPEHAR	12/19/05	NAVFAC	LOCATIONS OF GEOLOGIC CROSS-SECTIONS CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE NSWC CRANE CRANE, INDIANA	CTO 0256
CHECKED BY	DATE			APPROVED BY / DATE
V. PLACHY	2/02/06			APPROVED BY / DATE
COST/SCHED-AREA				FIGURE NO. / REV
SCALE				FIGURE 1 - 7 / 0
AS NOTED				

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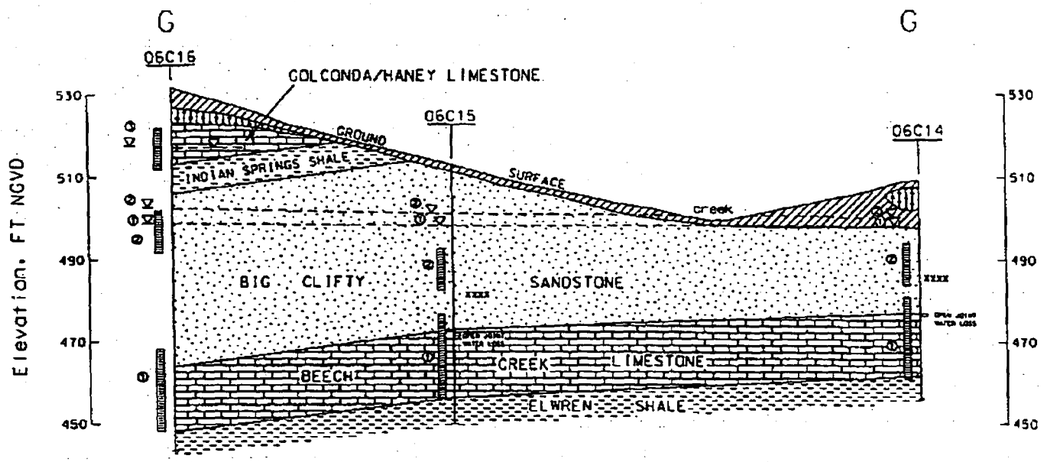

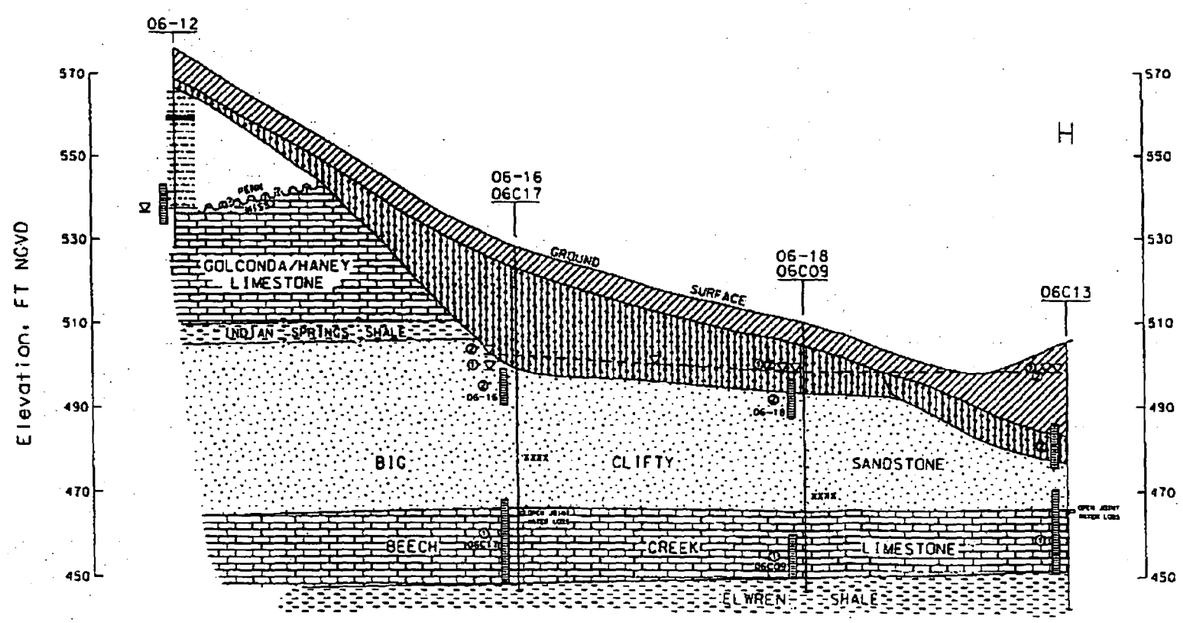

LEGEND

- CL (LEAN CLAY)
- GM (SILTY GRAVEL)
- SHALE
- SANDSTONE
- LIMESTONE
- COAL
- WATER LEVEL FOR CORRESPONDING WELL SCREEN
- WELL SCREEN NUMBER/POSITION
- 06C14 WELL CLUSTER NUMBER
- WATER TABLE/ PIEZO. SURFACE
- ZONE OF OXIDATION
- MISS-PENN CONTACT

DEPARTMENT OF THE NAVY — NAVAL FACILITIES ENGINEERING COMMAND

NAVAL SURFACE WARFARE CENTER
CRANE DIVISION - CRANE, INDIANA

PREPARED BY
U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION
VICKSBURG, MISSISSIPPI

Old Rifle Range
Geologic Cross-Sections
G-G and H-H

0 100
HORIZ. SCALE, FT

Plate 10

SOURCE: USACE WES, 1998

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G-G AND H-H CROSS SECTIONS
CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

NAVFAC

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CHECKED BY V. PLACHY — DATE 2/02/06

COST/SCHED-AREA

SCALE AS NOTED

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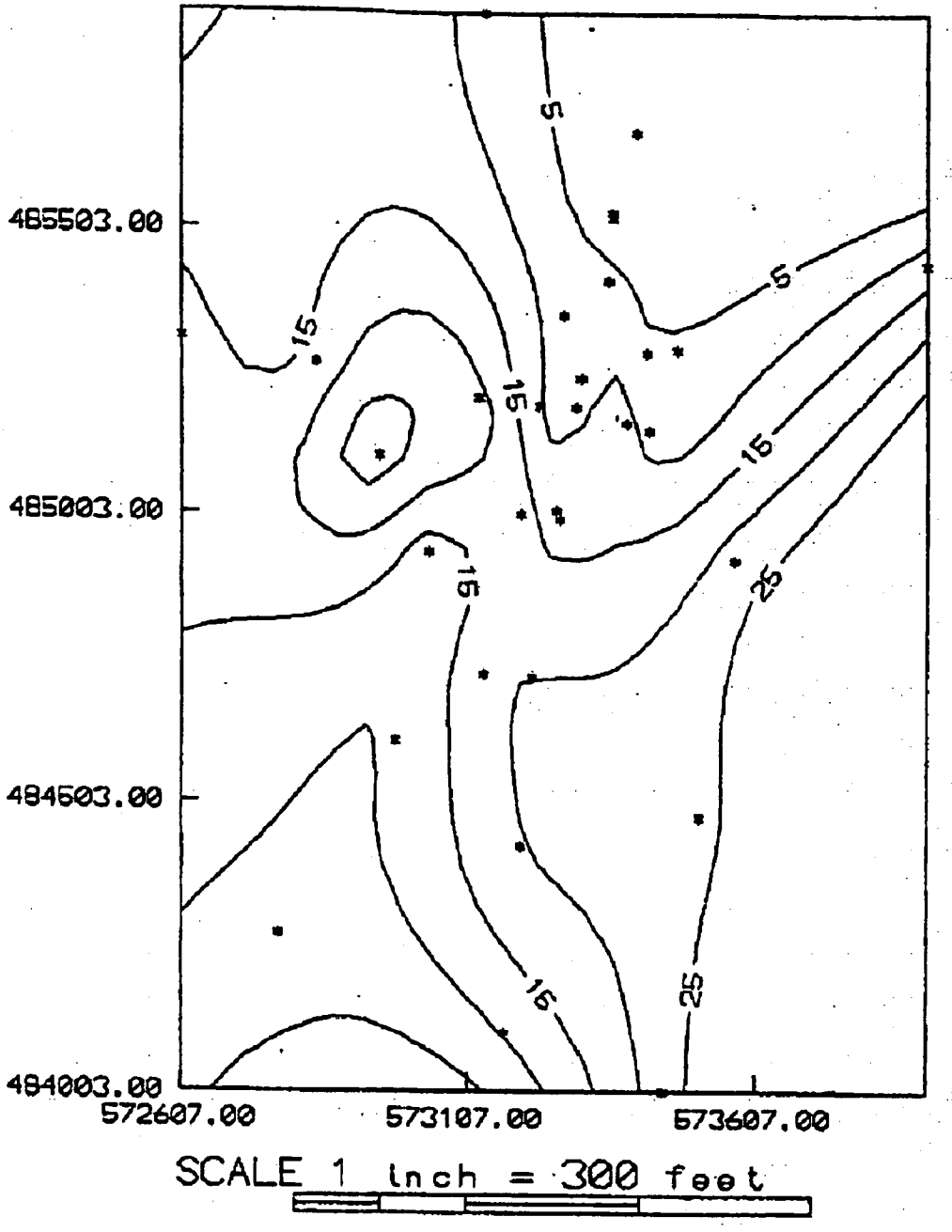

SOURCE: USACE WES, 1998

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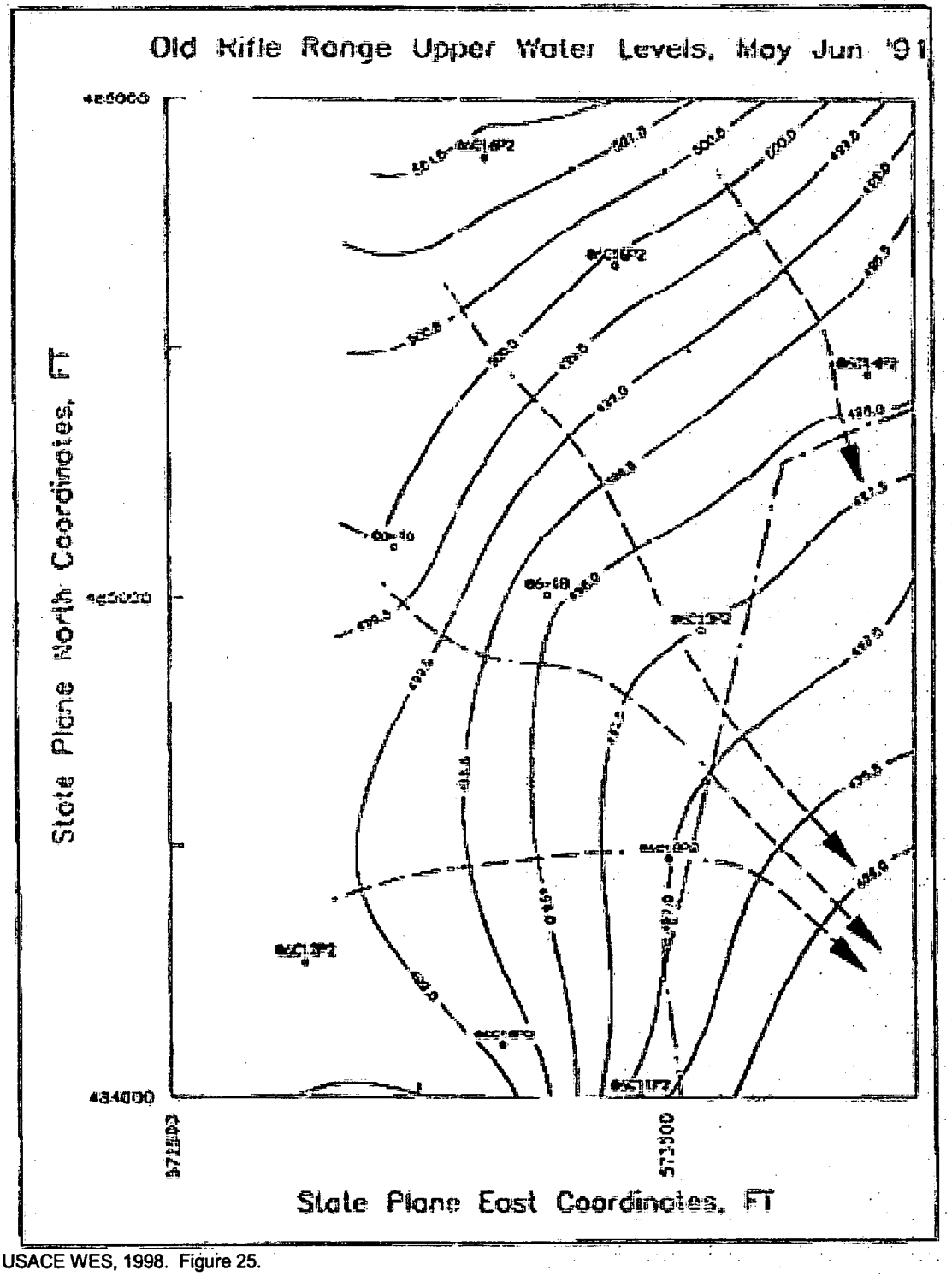
C. SPEHAR	12/19/05		SOIL THICKNESS	CTO 0256
CHECKED BY	DATE		CMP REPORT FOR SWMU 7 - OLD RIFLE RANGE	APPROVED BY / DATE
V. PLACHY	2/02/06		NSWC CRANE	APPROVED BY / DATE
COST/SCHED-AREA		NAVFAC	CRANE, INDIANA	FIGURE NO. / REV
SCALE				FIGURE 1 - 9 / 0
AS NOTED				



Source: USACE WES, 1998. Figure 25.

DRAWN BY S. STROZ — DATE 03/07/06		PIEZOMETRIC SURFACE UPPER BIG CLIFTY CMP REPORT FOR SWMU 7 NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0256
CHECKED BY V. PLACHY — DATE 03/07/06			APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED	NAVFAC		DRAWING NO. FIGURE 1-10 — REV 0

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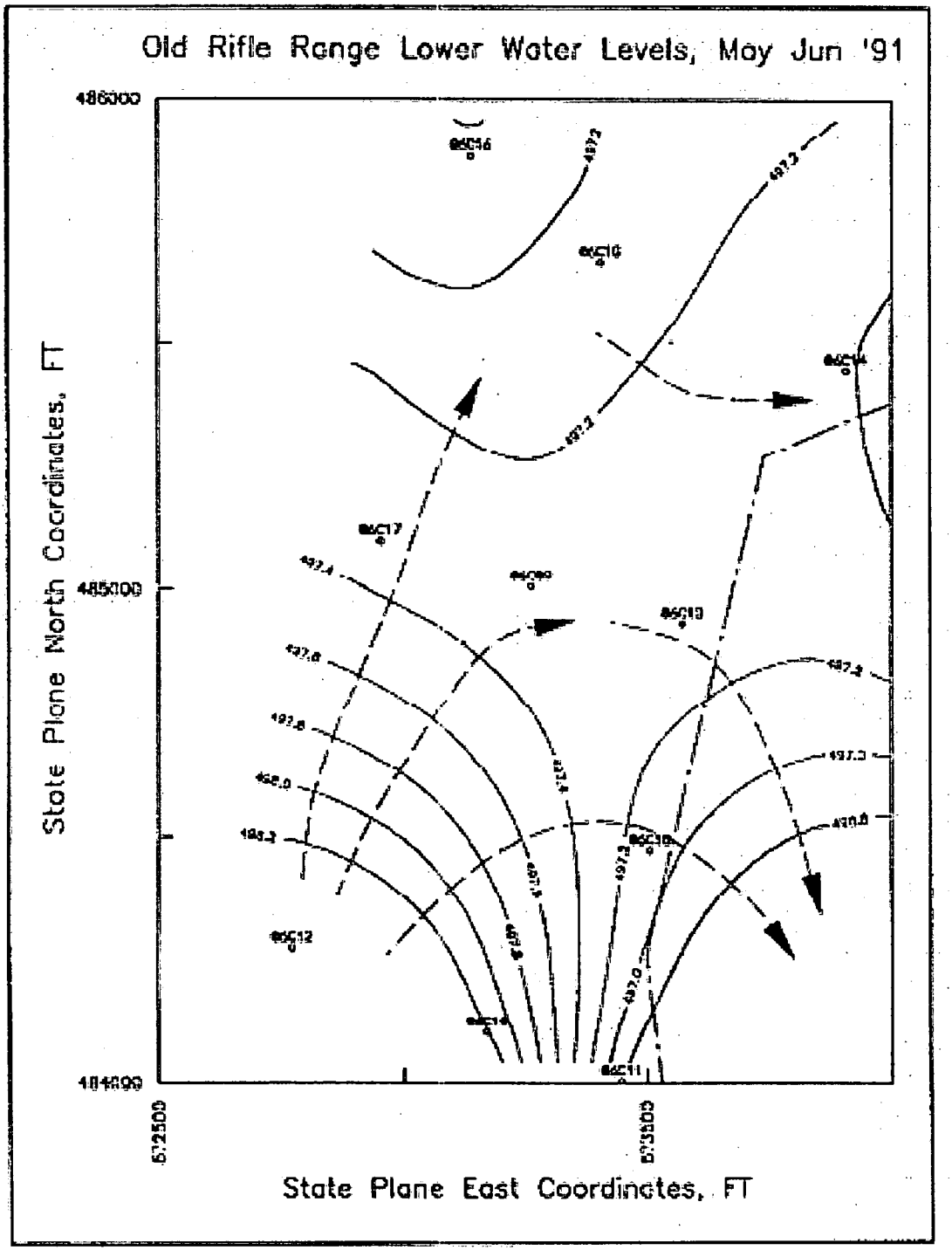

Source: USACE WES, 1998. Figure 27.

DRAWN BY S. STROZ	DATE 3/07/06	PIEZOMETRIC SURFACE BIG CLIFTY/ BEECH CREEK AQUIFER CMP REPORT FOR SWMU 7 NSWC CRANE CRANE, INDIANA	CONTRACT NUMBER CTO 0256
CHECKED BY V. Plachy	DATE 3/07/06		APPROVED BY — DATE —
COST/SCHEDULE-AREA			APPROVED BY — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-11 REV 0

NAVFAC

P:\GIS\CRANE_NSWC\MAPDOCS\SWMU07.APR LOWER WATER LEVELS LAYOUT_3/07/06 SS

2.0 DESCRIPTION OF CURRENT CONDITIONS AT SWMU 7 AND MEDIA CLEANUP STANDARDS

Various historical investigations and risk assessments have been conducted at SWMU 7. Section 2.1 describes the historical investigations that have resulted in identification of the chemicals of potential concern (COPCs). Section 2.2 summarizes the results of the human health risk screening evaluation (HHRSE) for groundwater to determine whether risk exists for current human SWMU 7 receptors. Section 2.3 presents the MCSs. Section 2.4 describes the conceptual site model for SWMU 7.

Based on the various historical investigations, no unacceptable ecological risks have been identified.

The following chemicals have been identified as COPCs for human health risk:

ORR AREA OF SWMU 7

Soils:

- Explosives (TNT)
- Polynuclear aromatic hydrocarbons (PAHs) [benzo(a)anthracene [B(a)A], benzo(a)pyrene [B(a)P], benzo(b)fluoranthene [B(a)F], dibenzo(a,h)anthracene (DBA), indeno(1,2,3-cd)pyrene (IP), and heptachlor epoxide]
- Metals (lead)

Groundwater:

- Explosives [dinitrotoluene (DNT), TNT, cyclo-trimethyl-trinitramine (RDX), and degradation products]
- Pesticides (heptachlor epoxide)
- Metals (lead)

OPR AREA OF SWMU 7

Soils:

- Metals (arsenic, lead, and manganese)

2.1 HISTORICAL INVESTIGATIONS

This section presents a summary of the current contamination conditions at SWMU 7 based upon the following:

- USACE WES 1991 Draft RFI Phase II Release Assessment for Soils at the ORR (USACE WES, 1991).
- CCCRA (B&RE, 1997).
- Phase II Groundwater RFI (TtNUS, 2002).
- Phase III Soils RFI (TtNUS, 2005a).
- Phase III Soils RFI Addendum 1 (TtNUS, 2005b).
- Routine Groundwater Monitoring Reports for Reporting Years 2000, 2001, 2002, 2003, and 2004 (SAIC, 2002a, 2002b, 2003a, 2003b, and 2005).

2.1.1 Soil Contamination

PAHs

The draft 1990 USACE WES RFI report concluded that contamination of the soil by organic compounds could not be confirmed. The report recommended no further action (NFA) for soils (i.e., no Phase III study) be taken at SWMU 7.

The CCCRA identified four PAHs [B(a)P, B(b)F, DBA, and IP] as chemicals of concern (COCs) in one sample (07SS-A05) (B&RE, 1997). The Phase III RFI included the collection of 41 grab and composite soil samples that were all analyzed for PAHs. The Phase III RFI for the ORR concluded that no further evaluation was warranted for PAHs (TtNUS, 2005a). Therefore, PAHs in soil will not be carried forward in this CMP Report.

Explosives

The draft 1990 USACE WES RFI report concluded that the contamination of soil was limited to explosive compounds in surface soils in the immediate vicinity of the flashing pits. The report recommended NFA for soils (i.e., no Phase III study) at SWMU 7.

The CCCRA did not identify any explosives in soil as COCs (B&RE, 1997). The Phase III Soils RFI at the ORR identified excess risk associated with one explosive (TNT) for one sample (07SS16) (TtNUS, 2005a). In the summer of 2003, the Navy conducted a VIM to excavate this localized high concentration of TNT. The two VIM pre-excavation TNT soil samples had concentrations as high as 9,900 milligrams per kilograms (mg/kg). The six VIM post-excavation samples collected from the sidewalls and bottom of the excavated areas averaged 47.7 mg/kg with individual concentrations ranging from non-detection (0.5 mg/kg) to 250 mg/kg. Thus the post-excavation VIM sampling indicated that the removal was effective in eliminating the excess risk associated with TNT at the ORR (TtNUS, 2003). Therefore, explosives in soil will not be discussed further in this CMP Report.

Metals

The draft 1990 USACE WES RFI report concluded that the presence of metals and other inorganics in the soil at the ORR could not confidently be attributed to disposal operations at the site. The report recommended NFA for soils (i.e., no Phase III study) be taken at SWMU 7.

The CCCRA did not identify any metals in soil as COCs (B&RE, 1997). The Round 1 Fieldwork for the Phase III Soils RFI at the ORR indicated that there is no excess risk associated with metals (arsenic, beryllium, and manganese) (TtNUS, 2005a).

X-Ray Flourescence analyses conducted as part of the Phase III Soil RFI Addendum indicated that the concentration of lead at six locations at the OPR Hillside Range 1 Berm (07XSS02, 07XSS03, 07XSS04, 07XSS05, 07XSS07, and 07XSS08) presented significant human health risk to the construction worker (TtNUS, 2005). Additionally, X-Ray Flourescence analyses conducted as part of the Phase III Soil RFI Addendum indicated that the concentration of lead at three locations at OPR Range 2 Berm (07XSS12, 07XSS16, and 07XSS17) presented significant human health risk to the construction worker (TtNUS, 2005). Therefore, lead is considered a contaminant of concern and an MCS was developed (Section 2.3).

The X-Ray fluorescence analysis indicated that lead concentrations in the berms may also present potential significant risk to ecological receptors. However, as discussed in U.S. EPA (1999) Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites, remedial actions generally should not be designed to protect organisms on an individual basis (with the exception of certain protected species) but to protect local populations and communities of biota.

The contaminated areas at the Hillside Range 1 and Range 2 berms total approximately 3,000 square feet. The adverse risk to ecological receptors would only occur in this very small area which is much less than 0.1 percent of the surrounding contiguous forested area. Based on observations during site visits, it does not appear that populations of plants/invertebrates and/or plant invertebrate community are being significantly impacted by the metals in these berms. Even if impacts would occur, these impacts would be limited to the areas of the berms where the metals concentrations are elevated. Furthermore, because these berms comprise only a small portion of the overall habitat for ecological receptors in this area, any localized impacts to individual ecological receptors will not impact the overall ecology in this area. Therefore, with regard to the protection of SWMU 7 ecological receptors, metals in these berms will not be discussed further in this CMP Report.

2.1.2 Groundwater Contamination

Explosives (TNT)

The routine groundwater monitoring reports for 2000, 2001, 2002, 2003, and 2004 (SAIC, 2002a, 2002b, 2003a, 2003b, and 2005) (Appendix A) at the ORR identified one explosive (TNT) that exceeded its RBTL at a single monitoring well (06C15). Monitoring well 06C15 is located in the vicinity of the 2003 VIM soil excavation (see Figure 1-4).

For reporting years 2000 through 2004, TNT was detected during all four quarters in one well, 06C15, at concentrations greater than the RBTL. TNT degradation products were also consistently detected in this well, specifically 2-ADNT and 4-ADNT. The presence of these daughter products indicates that some natural attenuation of TNT is occurring.

Based on information from these routine monitoring reports and trend plots (Appendix B), the concentrations of explosives (including TNT) and degradation products 2-ADNT and 4-ADNT in groundwater are decreasing.

Heptachlor Epoxide

The CCCRA identified one pesticide (heptachlor epoxide) as a COC (B&RE, 1997). Analysis for heptachlor epoxide occurs as part of the RCRA Part B Operating Permit routine groundwater monitoring requirements. Concentrations of heptachlor epoxide ranged from 0.062 µg/L at monitoring well 06C13 to 2.0 µg/L at monitoring well 06C15. Heptachlor epoxide was not detected during the 2000, 2001, 2002, 2003, and 2004 routine groundwater monitoring for Appendix IX constituents (SAIC, 2002a, 2002b, 2003a, 2003b, and 2005). Therefore, heptachlor epoxide will not be discussed further in this CMP report.

Metals

The CCCRA identified three metals (arsenic, beryllium, and manganese) as COCs (B&RE, 1997). Analysis for these metals occurs as part of the RCRA Part B Operating Permit routine groundwater monitoring requirements.

The routine groundwater monitoring reports indicated RBTL and statistical background exceedances as follows by reporting year:

- 2000 - Six metals (arsenic, barium, cadmium, iron, manganese, and zinc) (SAIC, 2002a)
- 2001 - Four metals (arsenic, barium, manganese, and zinc) (SAIC, 2002b)
- 2002 - Six metals (arsenic, barium, manganese, selenium, silver, and zinc) (SAIC, 2003a)
- 2003 - Six metals (arsenic, barium, chromium, lead, manganese, and zinc) (SAIC, 2003b)
- 2004 - Four metals (arsenic, barium, manganese, and lead) (SAIC, 2005).

Appendix A contains summary information from the routine groundwater monitoring reports.

2.1.4 Surface Water Contamination

The CCCRA did not identify any COCs associated with surface water contamination (B&RE, 1997). Therefore, there is no human or ecological risk associated with surface water contamination at the ORR.

2.1.5 Sediment Contamination

The CCCRA did not identify any COCs associated with sediment contamination (B&RE, 1997). Therefore, there is no human or ecological risk associated with sediment contamination at the ORR.

2.2 HHRSE FOR GROUNDWATER

The ORR is an active operating RCRA-permitted hazardous waste treatment facility. As a treatment facility, ORR is required to perform groundwater monitoring. As part of the monitoring program, contaminant concentrations in downgradient monitoring wells are compared to concentrations in upgradient monitoring wells. If the downgradient concentrations are statistically significantly higher than upgradient concentration and exceed the RBTL specified in the permit, it is necessary to determine whether corrective measures are required. As a part of this process, an HHRSE was conducted for the metals and explosive that exceeded these criteria. Appendix C contains the detailed HHRSE.

The HHRSE concluded that arsenic is the only COPC recommended for further evaluation as a potential groundwater COC in the CMP. Therefore, an MCS for arsenic in groundwater was developed (Section 2.3).

The ORR is an operating RCRA-permitted hazardous waste treatment facility and no residential activities are expected to occur at the ORR. However, to ensure no residential land use occurs, land use controls (LUCs) are recommended.

2.3 MCSs

As stated above, arsenic in groundwater and lead in soil are considered potential COCs; therefore, MCSs were developed for these constituents.

An arsenic MCS of 10 µg/L is based on the National Primary Drinking Water Regulations' Maximum Contaminant Level (MCL).

A lead MCS of 400 mg/kg is required for soils to protect the current on-site construction worker. This is based on the U.S. EPA Region 9 Preliminary Remediation Goal (PRG) for lead (Appendix D).

2.4 CONCEPTUAL SITE MODEL

Contaminants were released into surface/subsurface soils and migrated toward downgradient locations from those releases to deeper soils and groundwater. The following is a summary of the conceptual site model for the ORR and OPR:

- There is localized explosives contamination of groundwater in one monitoring well (06C15). The presence of the TNT degradation products 2-ADNT and 4-ADNT indicate that natural attenuation is occurring.

- Soil contaminated with explosives in the vicinity of monitoring well 06C15 has been removed. There is no known remaining source of explosives in soil.

- Current operating practices at the ORR have eliminated releases of contaminants to soils and groundwater. Therefore, the existing source of the TNT contaminant is being depleted.

- The existing use for SWMU 7 is military/industrial. Receptors associated with the existing use include the site worker, construction worker, and trespasser.

- Contaminated groundwater underlying SWMU 7 is not used and therefore does not present a risk under the industrial use scenario.

- Excess risk from soil is present only for the construction worker from exposure to lead in localized areas at Hillside Range 1 Berm and Range 2 Berm.

- Excess risk is present for future residents ingesting groundwater. Reasonable future uses for SWMU 7 do not include residential housing.

- There is no unacceptable risk to ecological receptors at SWMU 7.

3.0 REMEDIAL ACTION EVALUATION AT SWMU 7

This Section summarizes the CMs for groundwater and soils remedial action at SWMU 7.

As previously discussed, SWMU 7 is an active RCRA-permitted hazardous waste treatment facility, and human receptors and pathways of exposure are limited to the existing land use scenario (military/industrial). Per RCRA requirements, future land use scenarios will be addressed at the time of closure in the RCRA closure plan.

3.1 CORRECTIVE MEASURES

3.1.1 Groundwater

Two CMs will be considered for explosives in groundwater:

- No Action, designated as Alternative GW-1-Exp
- Limited Action, consisting of LUCs and long-term monitoring (LTM) is designated as Alternative GW-2-Exp. The purpose of this alternative is to:
  - prevent the use of GW
  - determine whether TNT is naturally degrading

Two CMs will be considered for metals in groundwater.

- No Action, designated as Alternative GW-1-Metal
- Limited Action, consisting of LUCs, designated as Alternative GW-2-Metal. This purpose of this alternative is to:
  - prevent the use of groundwater

It should be noted that although Alternative GW-2-Metal does not include LTM for metals, the existing Groundwater Monitoring Program at SWMU 7 which is required by the RCRA Operating Permit for the Open Burning Unit includes monitoring for metals.

NFA is required for pesticides in groundwater.

3.1.2 Soils

Two CMs will be considered for metals in soils:

- No Action, designated as Alternative S-1
- Limited Action, consisting of removal of lead contaminated soil, off-site disposal, and LUCs, designated as Alternative S-2
  - Conduct localized lead removal at the OPR limited to the Hillside Range 1 Berm and Range 2 Berm.
- NFA is required for explosives in soil.
- NFA is required for PAHs in soil.

4.0 CORRECTIVE MEASURES COMPARISON

This section evaluates the CMs presented in Section 3.0 and summarized in Table 4-1. The alternatives are evaluated using the following 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

Two additional criteria will also be evaluated when the required information is available prior to the selection and implementation of a corrective action measure. These are regulatory and community acceptance of the proposed alternative, as follows:

- Regulatory Acceptance: The Navy will respond to comments and resolve issues with the IDEM and U.S. EPA throughout the finalization of the CMP and other reports pertaining to the corrective measures selection and implementation process.

- Community Acceptance: The Navy has established a Restoration Advisory Board to provide updates on the environmental activities at NSWC Crane. The Crane RAB members are notified prior to RAB meetings, which is currently on an as-needed basis. A website has been established for the purposes of providing information on the current status of projects and remedial decisions (http://www.crane.navy.mil/newscommunity/Envir_RAB-default.asp?bhcp-1). Reports on environmental activities are also maintained as part of the Administrative Record and access to the reports is available upon request to the NSWC Crane Environmental Department. This mechanism provides access to reports will be used to obtain input from the local community on this CMP and other reports pertaining to the corrective measures selection and implementation process. The Statement of Basis (SB), which will be generated following approval of this CMP report, will be the

official document of record in which the proposed corrective action is first made available to the public. The public will have opportunity to comment on the SB, and the comments will be considered when selecting the final remedial alternative.

4.1 GROUNDWATER ALTERNATIVES

4.1.1 Alternative GW-1-EXP: No Action

4.1.1.1 Protection of Human Health and the Environment

Alternative GW-1-Exp is considered primarily as a baseline for comparison to the other corrective measures alternatives (CMAs). This alternative would not be protective of human health because of lack of monitoring and institutional controls. Although there are no current users of groundwater at SWMU 7 and thus no unacceptable risks to human receptors, Alternative GW-1-Exp would not prevent future use of the aquifer as a drinking water source, which could result in unacceptable human health risks.

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

4.1.1.2 Attainment of Media Cleanup Standards

Alternative GW-1-Exp would eventually attain the explosive MCS through natural attenuation but, in the absence of LTM, this occurrence would not be verified.

4.1.1.3 Source Control

Contaminated soils that could have acted as sources of explosives contamination in groundwater have been excavated and disposed off site as part of the proposed VIM (TtNUS, 2003). Alternative GW-1-Exp would not involve any additional source control because no action would be performed as part of this alternative and no other source has been identified.

4.1.1.4 Compliance with Waste Management Standards

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

4.1.1.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative GW-1-Exp would not be reliable and effective in the long term because no action would occur. Although explosives concentrations in groundwater would decrease as a result of natural attenuation, the effectiveness of this process would not be verified through monitoring. The potential threat to human health and the environment would remain because there would be no controls to prevent future groundwater use or monitoring to warn of potential contaminant migration.

Reduction in Toxicity, Mobility, and Volume

Alternative GW-1-Exp would not reduce contaminant mobility. Alternative GW-1-Exp would reduce the toxicity and volume of explosives through natural attenuation, but this would not be verified through monitoring.

Short-Term Effectiveness

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

Implementability

Because no action would occur, Alternative GW-1-Exp would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost

There are no costs associated with the No Action, Alternative GW-1-Exp.

4.1.2 Alternative GW-2-Exp: Land Use Controls and Long-Term Monitoring

4.1.2.1 Protection of Human Health and the Environment

Alternative GW-2-Exp would be protective of human health and the environment. Natural attenuation would protect human health by reducing explosives concentrations in groundwater. LUCs would protect human health by preventing exposure to contaminated groundwater as long as concentrations of

explosives remain above MCSs. Monitoring would protect human health and the environment by verifying the progress of groundwater remediation and warning of potential contaminant migration.

4.1.2.2 Attainment of MCSs

Alternative GW-2-Exp would eventually attain the explosives MCSs through natural attenuation. Current site information does not allow the accurate prediction of the timeframe required for natural attenuation to attain MCSs.

4.1.2.3 Source Control

Contaminated soil that could have acted as a source of explosives contamination in groundwater was excavated and disposed during the 2003 VIM (TtNUS, 2003). The RFI did not identify any other source of explosives contamination in soil. Alternative GW-2-Exp would not involve any additional source control measures.

4.1.2.4 Compliance with Waste Management Standards

Alternative GW-2-Exp would not involve any removal or ex-situ treatment of contaminated groundwater. However, periodic sampling activities would generate some residues (e.g., purge water) that would have to be properly disposed. The volume of residues generated would be very small and waste management regulations would be easily met.

4.1.2.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative GW-2-Exp would be reliable and effective in the long-term. Natural attenuation would eventually reduce groundwater explosives concentrations. LUCs would reliably and effectively prevent potential future exposure to contaminated groundwater. Monitoring would reliably and effectively verify the progress of remediation and warn of potential contaminant migration. Five-year site reviews would verify the long-term reliability and effectiveness of Alternative GW-2-Exp and trigger consideration of another more active alternative in case this alternative does not perform as expected.

Reduction in Toxicity, Mobility, and Volume

Alternative GW-2-Exp would not reduce contaminant mobility. However, Alternative GW-2-Exp would reduce toxicity and volume of explosives through natural attenuation.

Short-Term Effectiveness

Alternative GW-2-Exp would involve administration of LUCs and implementation of LTM. The short-term human health risks associated with these limited remedial activities would be minimal. Sampling personnel would undergo site-specific health and safety training and wear appropriate personal protection equipment (PPE). Implementation of this alternative would not result in any short-term threat to the surrounding community or to ecological receptors.

Implementability

Alternative GW-2-Exp would be readily implementable. LUCs would be readily implementable because SWMU 7 is completely contained within NSWC Crane and would be similar to other LUCs that are ongoing at other environmental sites within NSWC Crane. Monitoring would also be readily implementable and would be similar to other monitoring that is ongoing at several other environmental sites within NSWC Crane.

Alternative GW-2-Exp could be implemented within approximately 6 months. Current site information does not allow the accurate prediction of the timeframe required for natural attenuation to attain MCSs.

Cost

The following costs are estimated for Alternative GW-2-Exp: Limited Action (LUCs and LTM):

Capital Cost:	$ 3,000
30-Year Net Present Worth (NPW) of Operating and Maintenance (O&M) Costs:	$142,000
30-Year NPW:	$144,000

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

4.1.3 Alternative GW-1-METALS: No Action

4.1.3.1 Protection of Human Health and the Environment

Alternative GW-1-Metals is considered primarily as a baseline for comparison to the other CMAs. This alternative would not be protective of human health because of lack of monitoring and institutional controls. Although there are no current users of groundwater at SWMU 7 and thus no unacceptable risks to human receptors, Alternative GW-1-Metals would not prevent future use of the aquifer as a drinking water source, which could result in unacceptable human health risks.

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

4.1.3.2 Attainment of MCSs

Alternative GW-1-Metals would eventually attain the metals MCSs through natural attenuation (e.g., dispersion, dilution) but, in the absence of LTM, this occurrence would not be verified.

4.1.3.3 Source Control

Lead-contaminated soils that could be acting as sources of metals contamination in groundwater were identified for excavation and off-site disposal as part of a proposed remediation action at the OPR (TtNUS, 2005b). Alternative GW-1-Metals would not involve any additional source control because no action would be performed as part of this alternative and no other source has been identified.

4.1.3.4 Compliance with Waste Management Standards

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

4.1.3.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative GW-1-Metals would not be reliable and effective in the long term because no action would occur. Although metal concentrations in groundwater would decrease as a result of natural attenuation

(e.g., dispersion and dilution) the effectiveness of this process would not be verified through monitoring. The potential threat to human health and the environment would remain because there would be no controls to prevent future groundwater use or monitoring to warn of potential contaminant migration.

Reduction in Toxicity, Mobility, and Volume

Alternative GW-1-Metals would not reduce contaminant mobility. Alternative GW-1-Metals would reduce the toxicity and volume of metals through natural attenuation (e.g., dispersion, dilution) but this would not be verified through monitoring.

Short-Term Effectiveness

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

Implementability

Because no action would occur, Alternative GW-1-Metals would be readily implementable. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

Cost

There are no costs associated with the No Action Alternative GW-1-Metals.

4.1.4 Alternative GW-2 Metals: Limited Action (LUCs)

4.1.4.1 Protection of Human Health and the Environment

Alternative GW-2-Metals would be protective of human health and the environment. LUCs would protect human health by preventing exposure to contaminated groundwater as long as concentrations of explosives remain above MCSs.

4.1.4.2 Attainment of MCSs

Alternative GW-2-Metals would not attain the metals MCSs.

4.1.4.3 Source Control

Metal-contaminated soils that could be acting as sources of metals contamination in groundwater were identified for excavation and off-site disposal as part of a proposed remediation action at the OPR (TtNUS, 200b). Alternative GW-2-Metals would not involve any additional source control because no action would be performed as part of this alternative and no other source has been identified.

4.1.4.4 Compliance with Waste Management Standards

There are no actions to be implemented for Alternative GW-2-Metals and therefore no waste would be generated.

4.1.4.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative GW-2-Metals would be reliable and effective in the long-term. LUCs would reliably and effectively prevent potential future exposure to contaminated groundwater.

Reduction in Toxicity, Mobility, and Volume

Alternative GW-2-Metals would not reduce contaminant mobility.

Short-Term Effectiveness

Alternative GW-2-Metals would involve administration of LUCs. The short-term human health risks associated with this limited remedial activity would be minimal. Implementation of this alternative would not result in any short-term threat to the surrounding community or to ecological receptors.

Implementability

Alternative GW-2-Metals would be readily implementable. LUCs would be readily implementable because SWMU 7 is completely contained within NSWC Crane and would be similar to other LUCs that are ongoing at other environmental sites within NSWC Crane.

Alternative GW-2-Metals could be implanted within approximately 6 months.

Cost

The following costs are estimated for Alternative GW-2-Metals: Limited Action (LUCs):

Capital Cost:	$ 3,000
30-Year NPW of O&M Costs:	$36,000
30-Year NPW:	$40,000

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

4.2 SOIL ALTERNATIVES

4.2.1 Alternative S-1: No Action

4.2.1.1 Protection of Human Health and the Environment

Alternative S-1 is considered primarily as a baseline for comparison to the other CMs. This alternative would not be protective of human health because of lack of institutional controls. Alternative S-1 would not prevent exposure to localized lead-contaminated soils, which could result in unacceptable human health risks.

4.2.1.2 Attainment of Media Cleanup Standards

Alternative S-1 would not attain the lead MCS.

4.2.1.3 Source Control

Localized lead-contaminated soil has been identified (TtNUS, 2005b). Alternative S-1 would not involve any source control measures.

4.2.1.4 Compliance with Waste Management Standards

Because Alternative S-1 would not involve removal of lead-contaminated soil, no waste would be generated.

4.2.1.5 Other Factors

Long-Term Reliability and Effectiveness

Alternative S-1 would not be reliable and effective in the long term because no action would occur.

Reduction in Toxicity, Mobility, and Volume

Alternative S-1 would not reduce contaminant mobility.

Short-Term Effectiveness

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

Implementability

Alternative S-1 would be readily implementable because no action would occur. The technical feasibility criteria, including constructability, operability, and reliability, are not applicable.

4.2.2 Alternative S-2: Soil Removal and Off-site Disposal

4.2.2.1 Protection of Human Health and the Environment

Alternative S-2 would be protective of human health and the environment. Localized lead contamination at Hillside Range 1 Berm and Range 2 Berm would be removed and disposed off site.

4.2.2.2 Attainment of Media Cleanup Standards

Alternative S-2 would attain the lead MCS through removal and off-site disposal.

4.2.2.3 Source Control

Localized lead-contaminated soil has been identified (TtNUS, 2005b). Removal and off-site disposal of the localized lead-contamination would provide for lead source control.

4.2.2.4 Compliance with Waste Management Standards

Alternative S-2 would involve removal but no treatment of lead-contaminated soil. The volume of waste generated in the removal would be disposed in an approved hazardous waste land disposal.

4.2.2.5 Other Factors

Long-Term Reliability and Effectiveness

Removal is a well-proven and effective method of removing contaminated material from a site. Off-base hazardous landfilling would not treat or destroy lead-contaminated soil; however, it would permanently and irreversibly remove it from SWMU 7. Properly designed excavation could remove soil with concentrations of lead greater than the MCS to attain the CAOs and to allow for unrestricted future use of the site. Excavation would be limited to surface soil (2 feet bgs) to address unacceptable human health risks.

Sampling is typically required to verify the effectiveness of a 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 lead to ensure that the remaining soil is not contaminated at unacceptable levels.

This technology would be an effective disposal option for the SWMU 7 lead-contaminated soil. 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, etc., which ensure the effectiveness of these facilities.

Reduction in Toxicity, Mobility, and Volume

Alternative S-2 would reduce contaminant mobility and volume of lead-contaminated soil at SWMU 7. Alternative S-2 would not reduce the toxicity of the lead-contaminated soil but would transfer it to an off site landfill.

Short-Term Effectiveness

The short-term human health risks associated with these limited remedial activities as well as removal and off-site disposal would be minimal. Soil removal would be conducted by third-party consultants with personnel trained in the removal of hazardous wastes. Sampling personnel would undergo site-specific

health and safety training and wear appropriate PPE. Implementation of this alternative would not result in any short-term threat to the surrounding community or ecological receptors.

Implementability

Alternative S-2 removal and off-site disposal would be readily implementable.

Alternative S-2 could be implemented within approximately 6 months.

Cost

Alternative S-2 would require the removal of approximately 33 and 17 cubic yards (yd^3) of contaminated soil for the Hillside Range 1 Berm and Range 2 Berm, respectively, with off-site disposal as hazardous waste (See Appendix E-3 for remediation volume estimate).

There are six and three areas of localized lead-contamination which are approximately 15 by 10 feet by 1 foot deep for Hillside Range 1 Berm and Range 2 Berm, respectively (Appendix E-3). Difficulties in precision excavation of such small areas are anticipated. Therefore, it is assumed that the areas immediately adjacent to the lead-contaminated areas would also be excavated as well as the excavation depth would slightly exceed 1 foot resulting in approximately 100 yd^3 of excavated soils (Appendix E-4). The estimated removal and disposal costs for 100 yd^3 of lead-contaminated soil at Hillside Range 1 Berm and Range 2 Berm are $126,500 and $101,500 when disposed as hazardous waste (Appendix E-5) and non-hazardous waste (Appendix E-6), respectively. Both the hazardous and non-hazardous waste costs exclude the cost associated with bid document preparation, field oversight, confirmation sampling, and remediation documentation report.

The following costs are estimated for Alternative S2-Metals:

Excavation and Non-Hazardous Waste Off-Site Disposal:

Capital Cost:	$101,000
30-Year NPW of Annual Costs:	$ 22,000
30-Year NPW:	$124,000

Hazardous Waste

Capital Cost:	$127,000
30-Year NPW of Annual Costs:	$ 22,000
30-Year NPW:	$149,000

The above cost figures have been rounded to the nearest $1,000 to reflect the preliminary nature of these estimates.

4.3 SWMU 7 CMP CONCLUSIONS

The following sections summarize conclusions of the CMP for SWMU 7. These recommendations are based on the conceptual site model which has been presented in Section 2.4 and focuses on existing and planned future uses for the ORR and the OPR (military/industrial).

4.3.1 Groundwater

The following recommendations are made for the site groundwater:

- Screening and detailed evaluations of alternatives to address excess risk from ingestion of groundwater to the site workers, construction workers, and trespassers at SWMU 7 are not necessary because none of these receptors are exposed to groundwater and all exposure to groundwater can be prevented by LUCs.

- For explosives contamination in groundwater, Alternative GW-2-Exp (LUCs and LTM) is the recommended alternative. LUCs should be designed to prevent the use of groundwater. LTM should be designed to provide information as to whether explosives (TNT) contamination is degrading naturally.

- For metals contamination in groundwater, Alternative GW-2-Metals (LUCs) is the recommended alternative. LUCs should be designed to prevent the use of groundwater.

4.3.2 Soils

The following recommendations are made for the site soils:

- Screening and detailed evaluations of alternatives to address excess risk from exposure to explosives in soils are not necessary because of the 2003 VIM.

- Screening and detailed evaluations of alternatives to address excess risk from exposure to lead-contaminated soils for site workers, construction workers, and trespassers at SWMU 7 are not necessary. The existing risk can be mitigated by the removal of a small quantity of soil (approximately 50 to 100 yd^3). This small quantity does not warrant a detailed alternative evaluation.

- Alternative S-2 (lead-contaminated soil removal and LUCs) is the recommended alternative for lead in soils. A remediation of localized lead-contamination at Hillside Range 1 Berm and Range 2 Berm should be conducted. LUCs should be evaluated to assure that no changes occur in current military/industrial use of SWMU 7.

TABLE 4-1

REMEDY EVALUATION PROCESS SUMMARY
SWMU 7 (OLD RIFLE RANGE)
NSWC CRANE
CRANE, INDIANA

	INVESTIGATION STAGE			REMEDIAL ACTION EVALUATION PHASE		
	Document	Findings/Evaluations	Conclusions	Considerations	Evaluation/Conclusions	Remedy
Human Health (Groundwater):						
Explosives (DNT, TNT, and RDX)	CCCRA	Excess risk from DNT, TNT, and RDX	Conduct further evaluations	• Groundwater not used • TNT present only in one well (MW06C15) • TNT degradation is occurring • MW06C15 located near location where VIM was conducted • Data indicates that plume is stable (limited to one well)	• No risk to current receptors was identified. • NA and LUC / LTM only remedial actions evaluated.	• LUC/LTM to prevent use of groundwater and to determine whether TNT is naturally degrading
	Routine Groundwater Monitoring Program	Statistical comparison to background and RBTLs	TNT and daughter products in well 06C15 are only explosives detected			
Pesticides (heptachlor epoxide)	CCCRA	Excess risk for future park visitor (Beech Creek Aquifer)	Conduct further evaluations	• Heptachlor epoxide not present in groundwater	• None required	• NFA
	Routine Groundwater Monitoring Program	Not detected	Not detected			
Metals (Ag, As, Ba, Cd, Mn, Pb, Se, and Zn)	CCCRA	excess risk from As and Be	Conduct further evaluations	• Groundwater not used • Risk screening showed As to be only metal exceeding risk thresholds or MCLs	• No risk to current receptors was identified. • NA and LUC only remedial actions evaluated.	• LUC to prevent use of groundwater
	Routine Groundwater Monitoring Program	Statistical comparison to background and RBTLs	Ag, As, Ba, Cd, Mn, Pb, Se, and Zn exceeds RBTL			
Human Health (Soils):						
Explosives (TNT)	CCCRA	HHRA and ERA conducted for TNT	NFA	• No evaluation necessary	• None required	• NFA
	Phase III Soils RFI	1 AOC for TNT identified	Proceed to VIM for 2 highest TNT areas (07SB16/07SB47)	• VIM conducted at ORR	• Following the VIM, No risk for explosives	• NFA
Metals (As and Pb)	Phase III Soils RFI	Excess risk (As) for industrial worker and future resident at ORR	Defer until closure of unit	• Limited area of Pb contamination at OPR	• Risk presented to industrial worker and future residents • Residential use will not occur • Industrial use does occur	• Conduct limited removal action • LUCs to prevent residential use
	Phase III Soils RFI - Addendum 1	Excess risk for three metals Cu, Pb, and Sb. Pb was the risk driver.	Conduct further evaluation			
PAHs [B(a)A, B(a)F, B(a)P, DBA, and IP]	CCCRA	Excess risk from ingestion of B(a)P, B(a)F, DBA, and IP	Conduct further evaluations	• None required	NA	NFA
	Phase III Soils RFI	41 grab/composite samples collected for PAH analysis	NFA			

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Ag	silver
As	arsenic
B(a)A	benzo(a)anthracene
B(a)F	benzo(a)fluoranthene
B(a)P	benzo(a)pyrene
Ba	barium
Be	beryllium
Cd	cadmium
Cu	copper
CY	calendar year
DBA	dibenzo(a,h)anthracene
DNT	dinitrotoluene
IP	indeno(1,2,3-cd)pyrene
LTM	long term monitoring
LUC	land use control
MCL	maximum contaminant levels
Mn	manganese
NA	not applicable
NFA	no further action
ORR	Old Rifle Range
OPR	Old Pistol Range
PAHs	polynuclear aromatic hydrocarbons
Pb	lead
RBTL	risk-based target level
RDX	cyclo-trimethyl-trinitramine
Sb	antimony
Se	selenium
TNT	2,4,6-trinitrotoluene
VIM	Voluntary Interim Measure
Zn	zinc

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USGS Quad Map, 1978.

APPENDIX A

2000 THROUGH 2004 SUMMARY
OF
ANNUAL ROUTINE GROUNDWATER MONITORING REPORTS

NAVSEA

CRANE

Surface Warfare Center Division

ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2000

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: December 16, 2002

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8.2 Old Rifle Range

The well network at the ORR monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections, by quarter, for the upper Big Clifty monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Detections in the upper Big Clifty were mainly metals and other inorganics. Samples were analyzed for organic compounds in only the second quarter. Detections of organics were limited to Bis(2-ethylhexyl)phthalate in two wells. Bis(2-ethylhexyl)phthalate is a common lab contaminant. The lab QC blank associated with the sample for well 06C11P2 indicates that the detection is likely a lab artifact (Table 6.2.3). No explosives were detected in any of the four quarters. Barium and manganese were the most frequently detected metals (100% of samples), often at levels above the RBTL (100% and 75%, respectively). Other metals detected include arsenic, cadmium, selenium, and antimony.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Like the upper wells, barium and manganese were frequently detected (100% and 78% of samples, respectively), often above the RBTL (100% and 61% of samples, respectively). Arsenic was also detected with some frequency (53% of samples), however, above the RBTL less frequently (19% of samples). Other metals detected more than twice include antimony, zinc, cadmium, copper, and selenium. Detections of organics were limited to Bis(2-ethylhexyl)phthalate in well 06C18 in only the second quarter. Detections of explosives at the ORR were limited mostly to well 06C15. Three compounds were detected in well 06C15 in both the third and fourth quarters: TNT, 2-Amino-4,6-dinitrotoluene, and 4-Amino-2,6-dinitrotoluene. Of the detections of explosives, only TNT exceeded the RBTL.

ORR results were evaluated to determine which constituents were statistically higher than background (Section 7.0). Table 8.2 shows the ORR results that were significantly high and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives

as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Constituents that exceeded both thresholds in ORR wells were limited to the metals arsenic, barium, cadmium, zinc, iron, and manganese.

RDX and HMX were not detected in any ORR well in the quarterly sampling of 2000. TNT was detected all four quarters in one well, 06C15, at concentrations greater than the RBTL. However, the TNT concentrations were not significantly higher than background. Nitro-toluene daughter compounds were also consistently detected in well 06C15, specifically 2-Amino-4, 6-dinitrotoluene and 4-Amino-2, 6-dinitrotoluene. The presence of the nitro-toluene daughter products indicates that some natural attenuation is occurring in the system. The concentrations of 2-Amino-4, 6-dinitrotoluene and 4-Amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 μg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.1 for well references). Barium concentrations in the upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.5 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2). Four of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C13, 06C16, 06C18) and the downgradient well 06C19 had barium concentrations greater than the RBTL and significantly higher than background. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, we did not have soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 μg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19) In addition to exceeding the RBTL, concentrations in each of these five wells were significantly higher than background (Table 8.2). Manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (03C11P2, 03C13P2, 03C18P2, 03C19P2) (Figure 8.2.12 and Table 8.2).

Arsenic was found above the RBTL of 2 μg/L in two of the Big Clifty/Beech Creek POC well, 06C13 and 06C11, and the downgradient well 06C19 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C13P2 and 06C18P2 had concentrations greater than the RBTL. Of the arsenic exceedances, results from POC wells 06C13P2, 06C13, 06C18P2 and downgradient well 06C19P2 were significantly higher than background (Table 8.2).

Table 8.2 Old Rifle Range Monitoring Points with results exceeding RBTL and statistically higher than background. [C, Compliance; DG, Downgradient]

Parameter	Well	MP Objective	RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium	06C18P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
Cadmium	06C18P2	C		X		
Zinc (filtered)	06C13P2	C		X		
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Old Rifle Range – Big Clifty/Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Zinc	06C14	C				X
	06C15	C				X
Iron	06C18	C		X		
Manganese	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese (filtered)	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X

NAVSEA

CRANE

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ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2001

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Binder 2 of 2

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8.2 Old Rifle Range

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Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections, by quarter, for the upper Big Clifty monitoring wells at the ORR. For associated lab qualifiers, please see Tables 6.2.1 – 6.2.5. Values that exceeded the Risked-Based Target Level are flagged. Detections in the upper Big Clifty were predominantly metals and other inorganics. Samples were analyzed for organic compounds in only the second quarter. Detections of organics were limited to Total Organic Carbon (TOC) and Total Organic Halogens (TOX). No explosives were detected in any of the four quarters. Barium and manganese were the most frequently detected metals (100% and 85% of samples), usually at levels above the RBTL (100% and 80% of samples, respectively). Other metals detected in at least 25% of the samples include arsenic, cadmium, selenium, and antimony.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the Risked-Based Target Level are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Similar to results in the upper Big Clifty wells, barium and manganese were frequently detected (100% and 74% of samples, respectively), often above the RBTL (100% and 58% of samples, respectively). Arsenic was also detected with some frequency (49% of samples), however, above the RBTL less frequently (19% of samples) than barium and manganese. Other metals detected in at least 25% of samples include antimony, chromium, copper, nickel, and zinc. With the exception of TOC and TOX, detections of organics were limited to Bis(2-ethylhexyl)phthalate in one sample from well 06C12. Bis(2-ethylhexyl)phthalate is a common lab contaminant. However, quality control samples associated with the analysis do not indicate lab contamination. Detections of explosives at the ORR were limited to well 06C15. Two compounds were detected in three quarters (and a field duplicate) in well 06C15: 2-Amino-4,6-dinitrotoluene, and 4-Amino-2,6-dinitrotoluene. Two other compounds were detected in well 06C15: TNT (three of four quarters) and 1,3,5-Trinitrobenzene (two of four quarters). Only the three detections of TNT exceeded a RBTL.

ORR results were evaluated to determine which constituents were statistically higher than background (Section 7.0). Table 8.2 shows the ORR results that were significantly high and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Inorganics that exceeded both thresholds in ORR wells were limited to the metals arsenic, barium, zinc, and manganese.

As mentioned above, detection of explosives at the ORR in 2001 was predominantly nitrotoluene daughter compounds in one well, 06C15. Well 06C15 is located in the northern portion of the ORR. RDX and HMX were not detected in any ORR well in the quarterly sampling of 2001. TNT was detected above the RBTL in three samples from well 06C15, and all three results were significantly higher than background. No explosives were found in the upgradient well, 03C08. Nitro-toluene daughter compounds were consistently detected in well 06C15, specifically 2-Amino-4, 6-dinitrotoluene and 4-Amino-2, 6-dinitrotoluene. The presence of the nitrotoluene daughter products indicates that some natural attenuation is occurring in the system. The concentrations of 2-Amino-4, 6-dinitrotoluene and 4-Amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 μg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.1 for well references). Barium concentrations in the upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.5 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2). Four of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C13, 06C16, 06C18) and the downgradient well 06C19 had barium concentrations greater than the RBTL and significantly higher than background. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples from the base were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, we did not have soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 μg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19). In addition to exceeding the RBTL in every quarter, concentrations in each of these five wells were significantly higher than background (Table 8.2). Manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (03C11P2, 03C13P2, 03C18P2, 03C19P2) (Figure 8.2.12 and Table 8.2).

Arsenic was found above the RBTL of 2 μg/L in two of the Big Clifty/Beech Creek POC wells, 06C13 and 06C18 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C13P2 and 06C18P2 and downgradient well 06C19P2 had concentrations greater than the RBTL. Of the arsenic exceedances, results were significantly higher than background from POC wells 06C13P2, 06C13, 06C18P2, 06C18, and downgradient well 06C19P2 (Table 8.2).

Table 8.2 Old Rifle Range Monitoring Points with results exceeding RBTL and statistically higher than background. [C = Compliance; DG = Downgradient; MP Objective = type of well]

Parameter	Well	MP Objective	RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	
Barium	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Zinc (filtered)	06C18P2	C				X
Old Rifle Range – Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
	06C18	C			X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese (filtered)	06C11	C	X			
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Zinc (filtered)	06C13	C		X		
Old Rifle Range – Beech Creek Aquifer						
EXPLOSIVES						
2,4,6-Trinitrotoluene	06C15	C		X		X

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Surface Warfare Center Division

ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2002

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: 31 October 2003
Binder 2 of 2

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8.2 Old Rifle Range

The well network at the Old Rifle Range monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections, by quarter, for the upper Big Clifty monitoring wells at the ORR. For associated lab qualifiers, please see Tables 6.2.1–6.2.5. Values that exceeded the RBTL are flagged. Detections in the upper Big Clifty were predominantly metals and other inorganics. Samples were analyzed for organic compounds in only the second quarter. Detections of organics were limited to total organic carbon (TOC) and total organic halogens (TOX). No explosives were detected in any of the four quarters. Barium and manganese were the most frequently detected metals (100% and 85% of samples), usually at levels above the RBTL (100% and 80% of samples, respectively). Other metals detected in at least 25% of the samples include arsenic and antimony.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Barium and manganese were frequently detected (100% and 69% of samples, respectively), often above the RBTL (100% and 58% of samples, respectively). Arsenic was also detected with some frequency (47% of samples), however, above the RBTL less frequently (25% of samples) than barium and manganese. Other metals detected in at least 25% of samples include antimony and zinc. With the exception of TOC and TOX, detections of organics were limited to one detection of 2,4-D. Detections of explosives at the ORR were limited to well 06C15. Explosives detected in well 06C15 include 2,4,6-trinitrotoluene and 1,3,5-trinitrobenzene and degradation products 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene.

The 2002 ORR results were incorporated with the 2000-2001 data and evaluated to determine which constituents were statistically higher than background (Section 7.0). The statistical analysis was done both with and without the outlying data points. Table 8.2.1 shows the ORR results that were significantly high and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Inorganics that exceeded both thresholds in ORR wells were limited to the metals arsenic, barium, zinc, and manganese.

As mentioned above, detection of explosives at the ORR in 2001 was predominantly TNT and nitro-toluene degradation products in one well, 06C15. Similar results were observed in results from quarterly sampling in 2000 and 2001. Well 06C15 is located in the northern portion of the ORR. RDX and HMX were not detected in any ORR well in the quarterly sampling of 2002. TNT was detected above the RBTL in all four samples from well 06C15. Statistical analysis found the TNT results to be significantly higher than background. No explosives were found in the upgradient, background well, 03C08. Nitro-toluene daughter compounds were also consistently detected in well 06C15, specifically 2-amino-4, 6-dinitrotoluene, 4-amino-2, 6-dinitrotoluene, and 1,3,5-Trinitrotoluene. The presence of nitrotoluene daughter products in the wells indicates that some natural attenuation is occurring in the system. The concentrations of 2-amino-4, 6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 µg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.5 for well references). Barium concentrations in the upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.1 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2). Six of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C12, 06C13, 06C16, 06C18, 06C19) had filtered barium concentrations greater than the RBTL and significantly higher than background when the data outliers were removed. Three of the POC wells in the Big Clifty/Beech Creek network (06C13, 06C16, 06C18) had filtered barium concentrations greater than the RBTL and significantly higher than background when the data outliers were not removed. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples from the base were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, we did not have soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 µg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19). In addition to exceeding the RBTL in every quarter, concentrations in each of these five wells were significantly higher than background (Table 8.2). Well 06C11 also exhibited concentrations that exceeded both thresholds. Manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (03C11P2, 03C13P2, 03C18P2, 03C19P2) (Figure 8.2.12 and Table 8.2).

Arsenic was consistently found above the RBTL of 2 µg/L in two of the Big Clifty/Beech Creek POC wells, 06C13 and 06C18 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C11P2, 06C13P2, 06C18P2 and downgradient well 06C19P2 exhibited concentrations greater than the RBTL. Of the arsenic exceedances, results were significantly higher than background in POC wells 06C13P2, 06C13, 06C18P2, and downgradient well 06C19P2

(Table 8.2.1) Old Rifle Range Monitoring Points with results exceeding RBTL and statistically higher than background. [C = Compliance; DG = Downgradient; MP Objective = type of well]

Parameter	Well	MP Objective	2002 RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
Barium (filtered) Outliers Removed	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Selenium (filtered)	06C18P2	C	X			
Old Rifle Range – Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered) Outliers Removed	06C11	C	X	X	X	X
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Silver	06C15	C		X		
Lead	06C11	C				X
Manganese	06C11	C		X		X
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese (filtered)	06C11	C		X		
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X

	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Zinc (filtered)	06C13	C	X	X		
Old Rifle Range – Beech Creek Aquifer						
EXPLOSIVES						
2,4,6-Trinitrotoluene	06C15	C	X	X	X	X

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CY2003

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: 12 August 2004
Binder 2 of 2

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2003

8.2 Old Rifle Range

The well network at the Old Rifle Range monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections, by quarter, for the upper Big Clifty monitoring wells at the ORR. For associated lab qualifiers, please see Tables 6.2.1–6.2.5. Values that exceeded the RBTL are flagged. Detections in the upper Big Clifty were predominantly metals and other inorganics. Detections of organics were limited to total organic carbon (TOC) and total organic halogens (TOX), with volatile organic compounds sampled only during the second quarter. The only explosive detected was nitrocellulose in two separate wells, one during the first quarter (06C18P2) and one in the second quarter(06C13P2). Barium and manganese were the most frequently detected metals (100% and 80% of samples), usually at levels above the RBTL (100% of samples for both parameters). Other metals detected include arsenic (80% of samples) and dissolved antimony (70% of samples). Ammonia was persistent in all downgradient wells.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Barium and manganese were frequently detected (100% and 64% of samples, respectively), often above the RBTL (100% and 55% of samples, respectively). Arsenic was also detected with some frequency (50% of samples), however, above the RBTL less frequently (22% of samples) than barium and manganese. Dissolved antimony was detected in 64% of samples collected, but none of the results were above the RBTL. Zinc occurred in 28% of samples, 10% of those (1 sample) being above the RBTL. The only detection of organics was the persistent detection of total organic carbon (TOC) in well C13. Detections of explosives at the ORR were limited to 2,4,6-trinitrotoluene and 1,3,5-trinitrobenzene and degradation products 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene. In addition, nitrocellulose was detected in two wells in the second quarter (06C16 and 06C11).

The 2003 ORR results were incorporated with the 2000-2002 data and evaluated to determine which constituents were statistically higher than background (Section 7.0). The statistical analysis was done both with and without the outlying data points. Table

8.2.1 shows the ORR results that were significantly higher than the background well and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Inorganics that exceeded both thresholds in ORR Upper Big Clifty wells were limited to the metals arsenic, barium, and manganese. Wells bottoming in the Beech Creek aquifer exceeded thresholds for arsenic, barium, lead, manganese and zinc, with a single well exceeding the threshold for chromium in the first quarter (06C14). Also, 2,4,6-trinitrotoluene exceeded both thresholds for all four quarters in well C15.

As mentioned above, detection of explosives at the ORR in 2003 was predominantly TNT and nitro-toluene degradation products in one well, 06C15. Similar results were observed in results from quarterly sampling in 2000, 2001 and 2002. Well 06C15 is located in the northern portion of the ORR. RDX and HMX were not detected in any ORR well in the quarterly sampling of 2003. TNT was detected above the RBTL in all four samples from well 06C15. Statistical analysis found the TNT results to be significantly higher than background. No explosives were found in the upgradient, background well, 06C08. Nitro-toluene daughter compounds were also consistently detected in well 06C15, specifically 2-amino-4, 6-dinitrotoluene, 4-amino-2, 6-dinitrotoluene, and 1,3,5-Trinitrotoluene. The presence of nitrotoluene daughter products in the wells indicates that some natural attenuation is occurring in the system. The concentrations of 2-amino-4, 6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 μg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.5 for well references). Barium concentrations in the Upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.1 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2.1). Six of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C12, 06C13, 06C16, 06C18, 06C19) had filtered barium concentrations greater than the RBTL and significantly higher than background when the data outliers were removed. Three of the POC wells in the Big Clifty/Beech Creek network (06C13, 06C16, 06C18) had filtered barium concentrations greater than the RBTL and significantly higher than background when the data outliers were not removed. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples from the base were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, there is no soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 μg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19). In addition to exceeding the RBTL in every quarter, concentrations in each of these five wells were significantly higher than background (Table 8.2.1). Filtered manganese was detected above the RBTL of 50 μg/L consistently in the same five wells.

Manganese (Figure 8.2.12) and filtered manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (06C11P2, 06C13P2, 06C18P2, 06C19P2) (Table 8.2.1).

Arsenic was consistently found above the RBTL of 2 μg/L in Big Clifty/Beech Creek POC well 06C13 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C13P2, 06C18P2 and downgradient well 06C19P2 exhibited concentrations greater than the RBTL. Of the arsenic exceedances, results were significantly higher than background in POC wells 06C13P2, 06C13, 06C18P2, and downgradient well 06C19P2.

(Table 8.2.1) Old Rifle Range Monitoring Points with results exceeding RBTL and statistically higher than background. [C = Compliance; DG = Downgradient; MP Objective = type of well]

Parameter	Well	MP Objective	2002 RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty Aquifer						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Barium	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
Barium (filtered) Outliers Removed	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Old Rifle Range – Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Arsenic (filtered) Outliers Removed	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered) Outliers Removed	06C11	C	X	X	X	X
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Chromium	06C14	C	X			
Lead	06C11	C	X	X	X	X
	06C14	C	X	X		
Manganese	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X

	06C19	DG	X	X	X	X
Manganese (filtered)	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Zinc (filtered)	06C13	C		X		
Old Rifle Range – Beech Creek Aquifer						
EXPLOSIVES						
2,4,6-Trinitrotoluene	06C15	C	X	X	X	X

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ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2004

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
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Report date: 29 September 2005

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From Science to Solutions™

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8.2 Old Rifle Range

The well network at the Old Rifle Range monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections by quarter for the Upper Big Clifty monitoring wells at the ORR. For associated lab qualifiers, please see Tables 6.2.1–6.2.5. Values that exceeded the RBTL are flagged. Detections in the Upper Big Clifty were predominantly metals and other inorganics. Detections of organics were limited to total organic carbon (TOC) and total organic halogens (TOX), with volatile organic compounds sampled only during the fourth quarter. No explosives were detected in any wells in any of the four sampling programs. Barium and manganese were the most frequently detected metals (100% and 95% of samples), usually at levels above the RBTL (100% of samples for both parameters). Other metals detected include total and dissolved arsenic (75% and 70% of samples) and dissolved antimony (22% of samples), which is down from 70% last year. Ammonia was persistent in nearly all downgradient wells.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Barium and total and dissolved manganese were frequently detected (100%, 64% and 53% of samples, respectively), often above the RBTL (100%, 83% and 84% of samples, respectively). Total and dissolved arsenic was also detected with some frequency (55% and 44% of samples), however, above the RBTL less frequently (45% and 55% of samples) than barium and manganese. Dissolved antimony was detected in 50% of samples collected, but none of the results were above the RBTL. Zinc occurred in 25% of samples, 11% of those (1 sample) being above the RBTL. The only detection of organics was the persistent detection of total organic carbon (TOC) in well C13 and a single positive in well 06C16 in the second quarter. Detections of explosives at the ORR were limited to 2,4,6-trinitrotoluene and 1,3,5-trinitrobenzene and degradation products 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene in well 06C15 in every quarter. 2,4,6-trinitrotoluene was consistently above the RBTL. In addition, nitroglycerin was detected in the second quarter.

The 2004 Old Rifle Range results were evaluated to determine which constituents were

statistically higher than background (Section 7.0). In addition, the newer data was combined with data from 2000-2003 to establish the long term moving average for each constituent. Table 8.2.1 shows the ORR results that were significantly higher than the background well and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Inorganics that exceeded both thresholds in ORR Upper Big Clifty wells were limited to the metals arsenic, barium, and manganese. Wells bottoming in the Beech Creek aquifer exceeded thresholds for arsenic, barium, lead and manganese. Also, 2,4,6-trinitrotoluene exceeded both thresholds for all four quarters in well C15.

As mentioned above, detection of explosives at the ORR in 2004 was predominantly TNT and nitro-toluene degradation products in one well, 06C15, located in the northern portion of the sampling area. Similar results were observed in results from quarterly sampling in 2000 - 2003. RDX and HMX were not detected in any ORR well in the quarterly sampling for 2004. TNT was detected above the RBTL in all four samples from well 06C15. Statistical analysis found the TNT results to be significantly higher than background. No explosives were found in the upgradient, background well, 06C08. Nitro-toluene daughter compounds were also consistently detected in well 06C15, specifically 2-amino-4, 6-dinitrotoluene, 4-amino-2, 6-dinitrotoluene, and 1,3,5-trinitrotoluene. The presence of nitrotoluene daughter products in the well indicates that some natural attenuation is occurring in the system. The concentrations of 2-amino-4, 6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 μg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.5 for well references). Barium concentrations in the Upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.1 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2.1). Four of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C13, 06C16, 06C18) had filtered barium concentrations greater than the RBTL and were significantly higher than background. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples from the base were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, there is no soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 μg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19). In addition to exceeding the RBTL in every quarter, concentrations in each of these five wells were significantly higher than background (Table 8.2.1). Filtered manganese was detected above the RBTL of 50 μg/L consistently in the same five wells. Manganese (Figure 8.2.12) and filtered manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (06C11P2,

06C13P2, 06C18P2, 06C19P2) (Table 8.2.1).

Total and dissolved arsenic was consistently found above the RBTL of 2 μg/L in Big Clifty/Beech Creek POC well 06C13 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C13P2, 06C18P2 and downgradient well 06C19P2 exhibited concentrations greater than the RBTL. Of the arsenic exceedances, results were significantly higher than background in POC wells 06C13P2, 06C13, 06C18P2, and downgradient well 06C19P2.

(Table 8.2.1) Old Rifle Range monitoring points with results exceeding RBTL and statistically higher than background. [C = Compliance; DG = Downgradient; MP Objective = type of well]

Parameter	Well	MP Objective	2004 RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty Aquifer						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Barium	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X		X	X
	06C18P2	C	X		X	X
	06C19P2	DG	X	X	X	X
Old Rifle Range – Big Clifty/Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Lead	06C11	C			X	X
	06C14	C	X	X		
Manganese	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese (filtered)	06C12	C	X		X	X
	06C13	C	X		X	X
	06C14	C	X		X	X
	06C18	C	X		X	X
	06C19	DG	X	X	X	X
EXPLOSIVES						
2,4,6-Trinitrotoluene	06C15	C	X	X	X	X

9.0 Conclusions

Results from the 2004 quarterly monitoring at the Ammunition Burning Grounds generally agree with previous findings. Metals, explosives, and organic compounds were detected in the Beech Creek Aquifer, often at concentrations above the respective RBTL. Risk-Based Target Limits were commonly exceeded in points of compliance wells. Barium, TCE, and RDX were the most frequently detected compounds at the site. Barium, TCE, and RDX were all found at concentrations above the RBTL in multiple wells on the site. Explosives are migrating offsite by way of the springs. RDX was commonly detected above the RBTL in both springs. HMX was detected frequently in onsite wells and in the springs, but at concentrations well below the RBTL. In addition to RDX and HMX, TNT, and nitro-toluene daughter products of the explosives were also found exiting Spring A in three of the four quarters. The presence of the degradation products indicates that some natural attenuation of explosives is occurring in the system.

Exceedance of an RBTL alone does not trigger action by 40 CFR 264 Subpart F. 40 CFR 264.91(a)(2) requires corrective action under 264.100 whenever an RBTL is exceeded at a POC *and* the concentration is statistically significant compared to background. Points of compliance define the edge of the monitoring zone as outlined in the GWMP. Statistical analysis revealed detections that were significantly higher than background concentrations in ABG POC wells. Constituents that exceeded an RBTL and were statistically significant in one or more POC wells include 1,3,5-trinitrobenzene, RDX, arsenic, barium, lead, zinc, 1,2-dichloroethane, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, and TCE.

Barium, Trichloroethene, and RDX were the constituents with the highest number of significant exceedances in ABG POC wells. All the other constituents listed above exceeded the RBTL and met the statistical threshold in no more than two POC sites. RDX and TCE may pose the most serious threat of offsite migration at the ABG. RDX exceeded the concentration and statistical thresholds in four ABG POC wells as well as Spring A. However, the number of sites exceeding both thresholds for RDX has decreased each year from 2000 to 2002, but remained the same for 2003 and 2004.

The number of ABG wells exceeding both thresholds for TCE decreased sharply from 2001 when ten wells were found to have concentrations that exceeded both the concentration and statistical threshold. In 2002, only two wells exceeded both thresholds. 2003 saw an increase to seven wells, but in 2004 the results were down to three wells. The decrease in the number of wells exceeding both thresholds for RDX and TCE evident in the 2004 data may be due to natural attenuation.

Barium exceeded both thresholds in nine POC wells and both springs. Historic activities at the ABG could have contributed to the elevated presence of barium in groundwater underlying the site. Items have been burned at the unit that contained barium sulfate, an inert filler for projectiles and flares, known as "Salt-Load". The barium results may be due to natural or background conditions at the site. Results from the Basewide Background Soils Investigation (TtNUS, 2001) indicated that background samples were all greater than the SRBTL. However, comparisons of soil barium concentrations measured at the site with the Background Soils Investigation results shows that surface and subsurface soil concentrations at the site are generally greater than found basewide.

Detected constituents at the Old Rifle Range were predominantly metals. Elevated barium concentrations were ubiquitous in both well networks at the ORR. Similar to the ABG, the results may be due to natural or background conditions at the site. Other metals detected with some frequency at the ORR included manganese and arsenic. Previous work at the ORR showed the persistence of TNT, RDX, and HMX. Detections of these parent compounds in 2004 were limited to TNT in Well 06C15, as was the case in 2002 and 2003. In addition, nitro-toluene daughter products were also detected in Well 06C15.

Constituents that exceeded an RBTL and were statistically significant in one or more ORR POC wells include arsenic, barium, manganese, and lead. Manganese and barium were the constituents with the highest number of significant exceedances in ORR POC wells. Manganese exceeded the RBTL and statistical threshold in POC Wells 06C11P2, 06C13P2, 06C18P2, 06C12, 06C13, 06C14, and 06C18 as well as the downgradient Wells 06C19 and 06C19P2. Barium exceeded the RBTL and statistical threshold in POC wells 06C13P2, 06C18P2, 06C11, 06C13, 06C16, and 06C18.

Previous work at the Demolition Range showed the persistence of metals. Results at the DR generally agree with the historic data. Detections in DR monitoring wells were predominately metals. Similar to the ABG and ORR, elevated barium concentrations were ubiquitous in both well networks at the DR. As is the case with the other sites, the results may be due to natural or background conditions.

Constituents that exceeded an RBTL and were statistically significant in one or more DR POC wells include arsenic, barium, and manganese. Historically, as noted in the Groundwater Monitoring Plan, Wells 06C06 and 06C07 were found to have the highest number of statistical exceedances. Results from 2004 indicate that POC Well 06C03 exhibited the most exceedances of both the concentration and statistical thresholds. Barium was the constituent with the highest number of significant exceedances in DR POC wells. Point of compliance wells with total barium concentrations that exceeded both thresholds includes 06C03P2, 06C04P2, 06C04 and 06C07. POC wells with dissolved barium concentrations that exceeded both thresholds include 06C02, 06C03, 06C04, 06C05, 06C07, 06C03P2 and 06C04P2. Total and dissolved manganese exceeded the RBTL and statistical threshold in three POC wells, including 06C02, 06C03, and 06C04.

APPENDIX B

TEMPORAL PLOTS FOR 2,4-TRINITROTOLUENE
AND
DEGRADATION PRODUCT
4-AMINO-2,6-DINITROTOLUENE AND 2-AMINO-4,6-DINTIROTOLUENE

FIGURE B-1.1
Monitoring Well 06C15 Temporal Plot
(No Duplicate Sample Data)

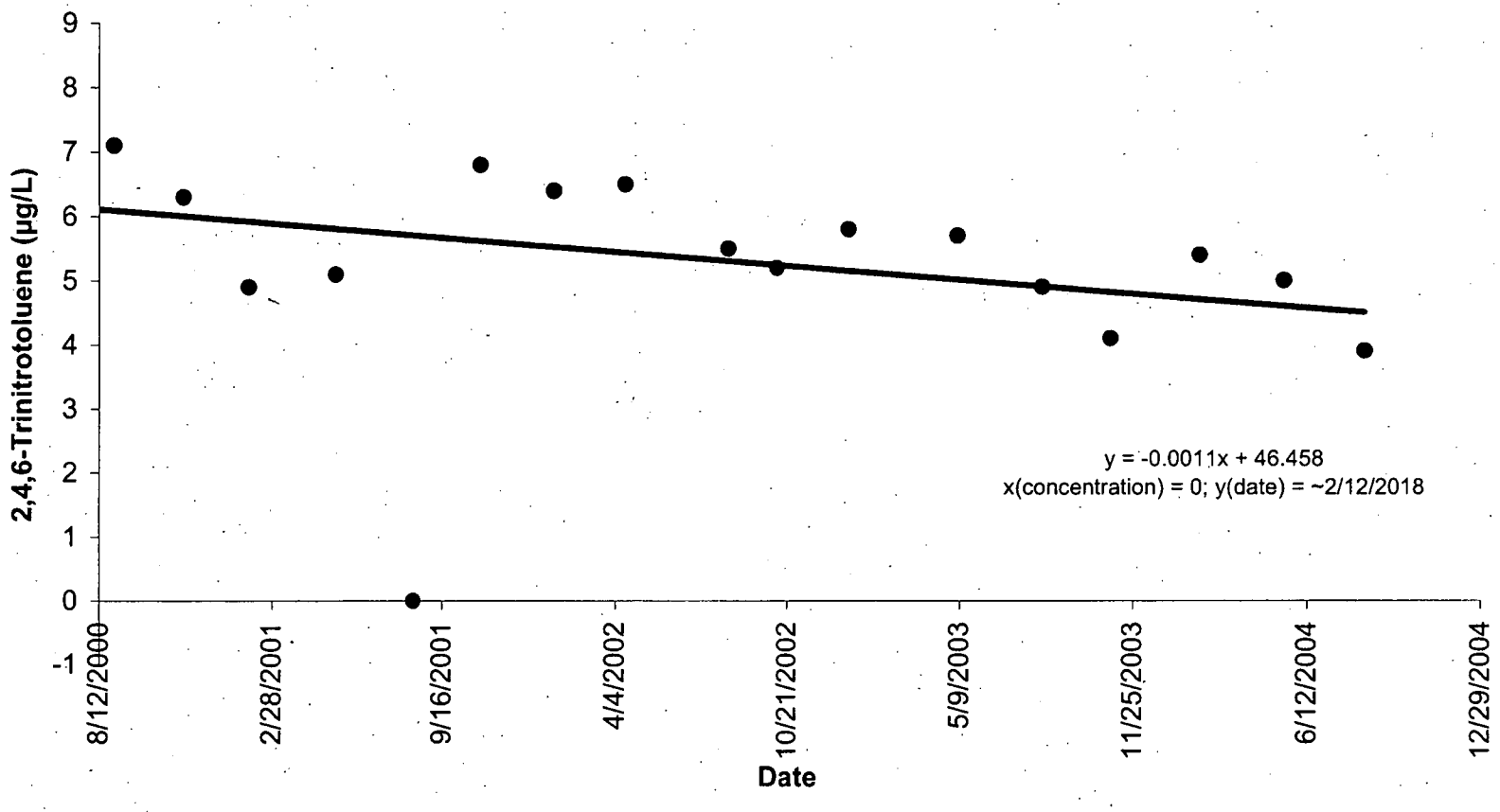


TABLE B-1.1

MONITORING WELL 06C15
TEMPORAL CONCENTRATION DATA
2,4,6-TRINITROTOLUENE
(NO DUPLICATE SAMPLE DATA)
NSWC CRANE
CRANE, INDIANA

Sample Date	Sample Results (µg/L)
3/13/2000	7.8 J
4/26/2000	6.5
8/29/2000	7.1
11/17/2000	6.3
2/1/2001	4.9
5/14/2001	5.1
8/13/2001	0 U
10/31/2001	6.8
1/24/2002	6.4
4/16/2002	6.5
8/13/2002	5.5
10/9/2002	5.2
1/1/2003	5.8
5/7/2003	5.7
8/12/2003	4.9 J
10/30/2003	4.1
2/10/2004	5.4
5/17/2004	5
8/17/2004	3.9
11/16/2004	6.2
2/24/2005	4.3
4/20/2005	3.8
8/12/2005	4.2
10/24/2005	4.4

FIGURE B-1.2
Monitoring Well 06C15 Temporal Plot
(No Duplicate Nor Non-Dectections Sample Data)

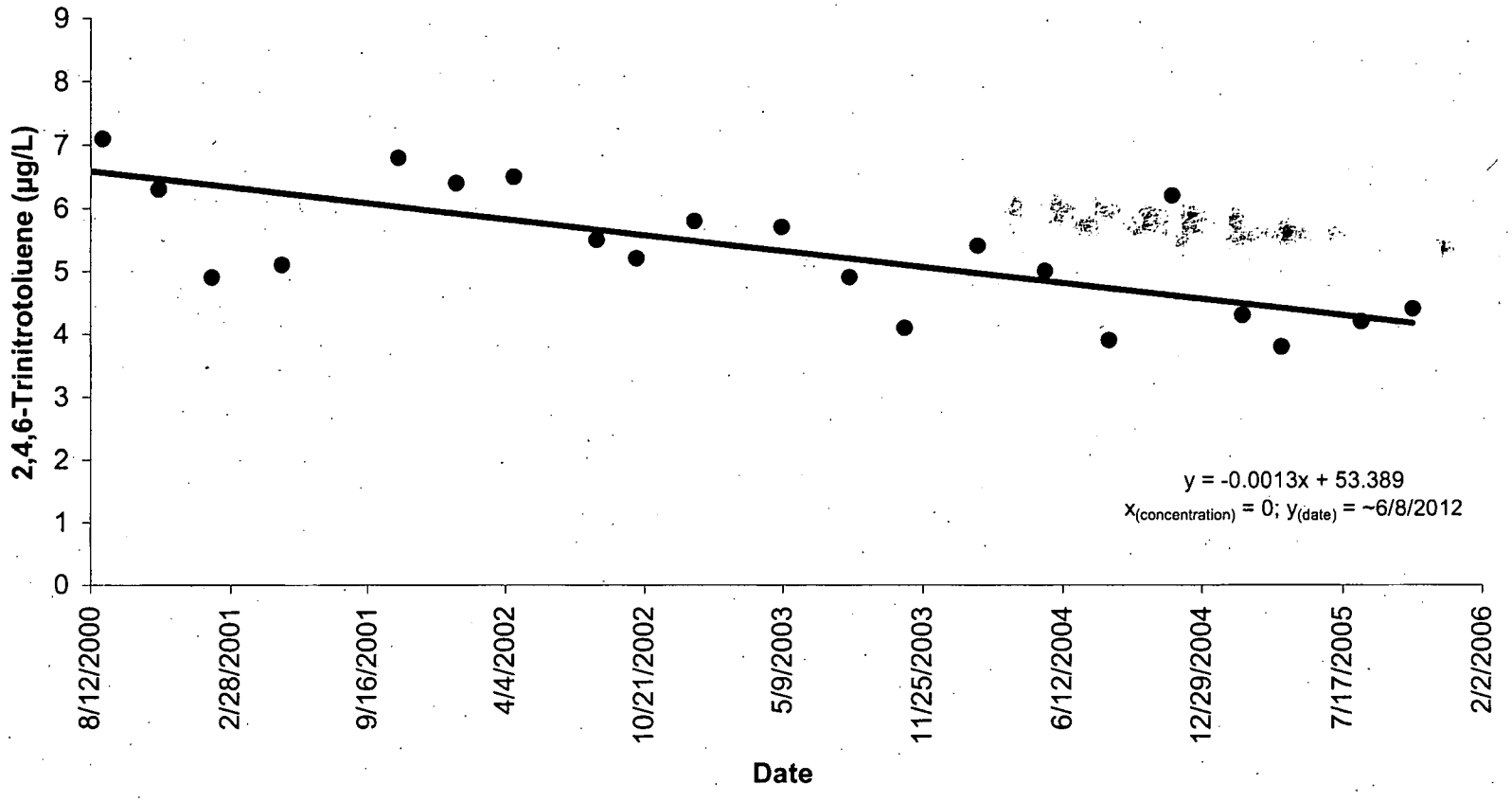


TABLE B-1.2

MONITORING WELL 06C15
TEMPORAL CONCENTRATION DATA
2,4,6-TRINITROTOLUENE
(NO DUPLICATE AND NO NON-DETECTIONS SAMPLE DATA)
NSWC CRANE
CRANE, INDIANA

Sample Date	Sample Results (µg/L)
3/13/2000	7.8 J
4/26/2000	6.5
8/29/2000	7.1
11/17/2000	6.3
2/1/2001	4.9
5/14/2001	5.1
10/31/2001	6.8
1/24/2002	6.4
4/16/2002	6.5
8/13/2002	5.5
10/9/2002	5.2
1/1/2003	5.8
5/7/2003	5.7
8/12/2003	4.9 J
10/30/2003	4.1
2/10/2004	5.4
5/17/2004	5
8/17/2004	3.9
11/16/2004	6.2
2/24/2005	4.3
4/20/2005	3.8
8/12/2005	4.2
10/24/2005	4.4

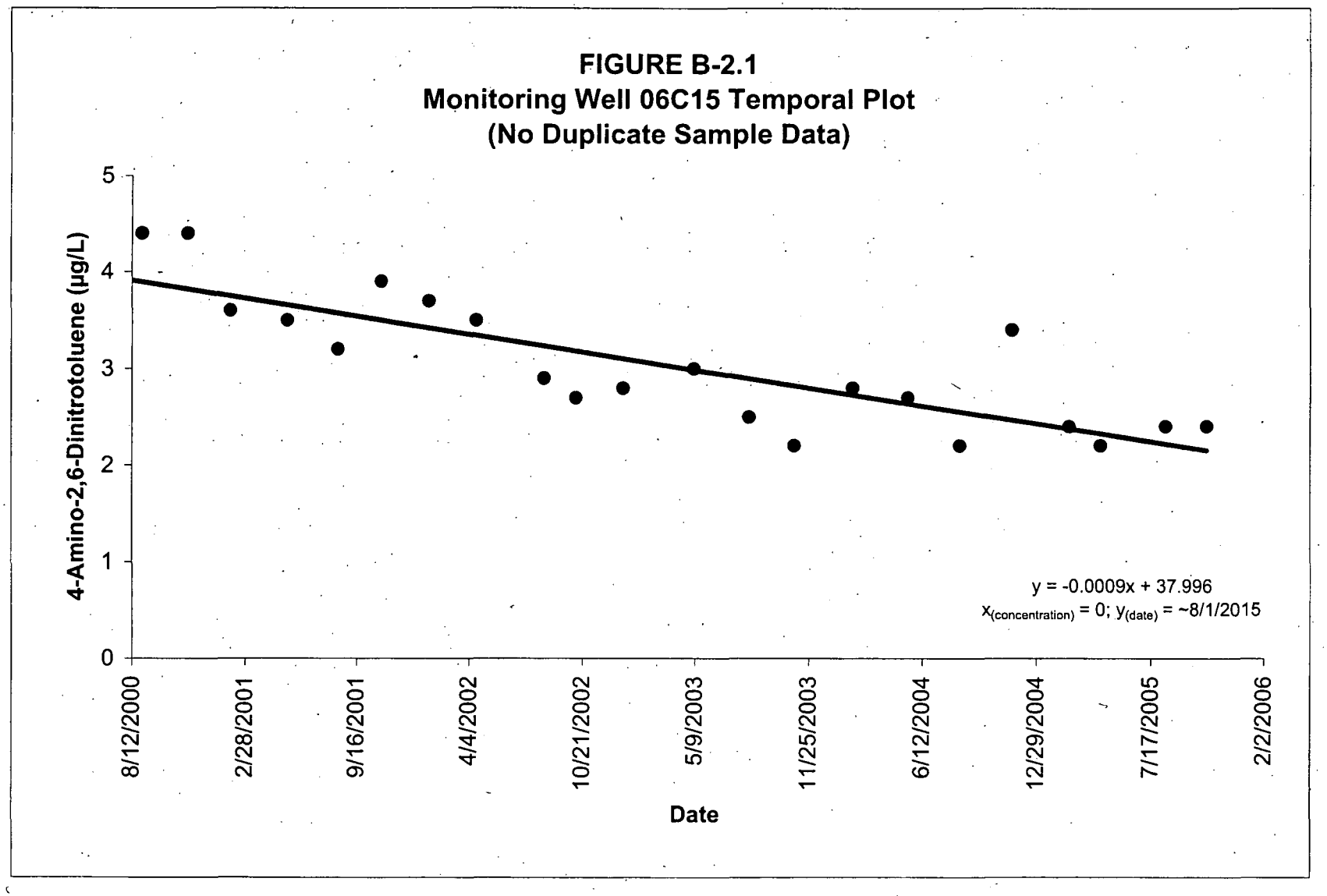


FIGURE B-2.1
Monitoring Well 06C15 Temporal Plot
(No Duplicate Sample Data)
4-Amino-2,6-Dinitrotoluene (µg/L)
5
4
3
2
1
0
8/12/2000
2/28/2001
9/16/2001
4/4/2002
10/21/2002
5/9/2003
11/25/2003
6/12/2004
12/29/2004
7/17/2005
2/2/2006
Date
y = -0.0009x + 37.996
x(concentration) = 0; y(date) = ~8/1/2015

TABLE B-2.1

MONITORING WELL 06C15
TEMPORAL CONCENTRATION DATA
4-AMINO-2,6-DINITROTOLUENE
(NO DUPLICATE SAMPLE DATA)
NSWC CRANE
CRANE, INDIANA

Sample Date	Sample Results (µg/L)
3/13/2000	4.3 J
4/26/2000	3.6
8/29/2000	4.4
11/17/2000	4.4
2/1/2001	3.6
5/14/2001	3.5
8/13/2001	3.2
10/31/2001	3.9
1/24/2002	3.7
4/16/2002	3.5
8/13/2002	2.9
10/9/2002	2.7
1/1/2003	2.8 J
5/7/2003	3 J
8/12/2003	2.5 J
10/30/2003	2.2
2/10/2004	2.8
5/17/2004	2.7
8/17/2004	2.2
11/16/2004	3.4
2/24/2005	2.4
4/20/2005	2.2
8/12/2005	2.4
10/24/2005	2.4

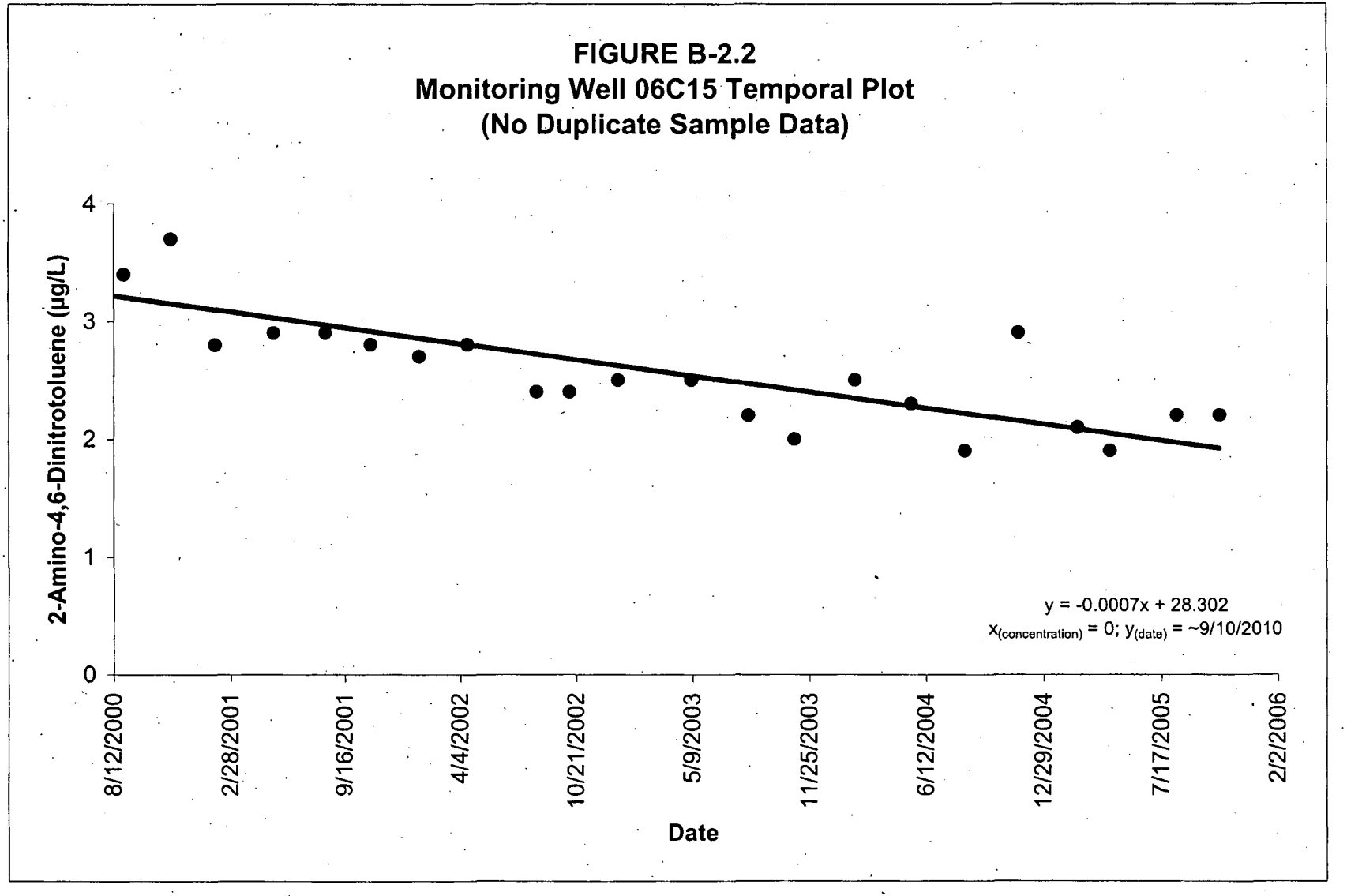


FIGURE B-2.2
Monitoring Well 06C15 Temporal Plot
(No Duplicate Sample Data)
2-Amino-4,6-Dinitrotoluene (µg/L)
4
3
2
1
0
y = -0.0007x + 28.302
x(concentration) = 0; y(date) = ~9/10/2010
8/12/2000
2/28/2001
9/16/2001
4/4/2002
10/21/2002
5/9/2003
11/25/2003
6/12/2004
12/29/2004
7/17/2005
2/2/2006
Date

TABLE B-2.2

MONITORING WELL 06C15
TEMPORAL CONCENTRATION DATA
2-AMINO-4,6-DINITROTOLUENE
(NO DUPLICATE SAMPLE DATA)
NSWC CRANE
CRANE, INDIANA

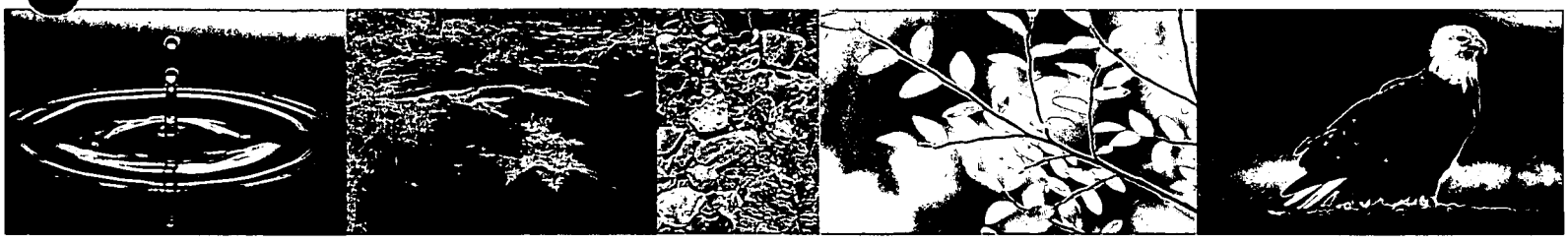
Sample Date	Sample Results (µg/L)
3/13/2000	3.7 J
4/26/2000	3.4
8/29/2000	3.4
11/17/2000	3.7
2/1/2001	2.8
5/14/2001	2.9
8/13/2001	2.9
10/31/2001	2.8
1/24/2002	2.7
4/16/2002	2.8
8/13/2002	2.4
10/9/2002	2.4
1/1/2003	2.5 J
5/7/2003	2.5 J
8/12/2003	2.2 J
10/30/2003	2 J
2/10/2004	2.5
5/17/2004	2.3
8/17/2004	1.9
11/16/2004	2.9
2/24/2005	2.1
4/20/2005	1.9
8/12/2005	2.2
10/24/2005	2.2

APPENDIX C

HUMAN HEALTH RISK SCREENING EVALUATION FOR THE OLD RIFLE RANGE (ORR) PORTION OF SWMU 7

Comprehensive Long-term Environmental Action Navy

CONTRACT NUMBER N62467-94-D-0888



Rev. 0
07/06

Human Health Risk Screening Evaluation
for
SWMU 7 - Old Rifle Range/Old Pistol Range

Naval Surface Warfare Center
Crane, Indiana

Contract Task Order 0256

July 2006

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

TETRA TECH NUS, Inc.

REVISION 0
JULY 2006

HUMAN HEALTH RISK SCREENING EVALUATION FOR SWMU 7 - OLD RIFLE RANGE/OLD PISTOL RANGE

NAVAL SURFACE WARFARE CENTER CRANE, INDIANA

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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Submitted by:
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CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0256

JULY 2006

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- **B USERS' GUIDE AND BACKGROUND TECHNICAL DOCUMENT FOR U.S. EPA REGION 9's PRELIMINARY REMEDIATION GOALS (PRGs) TABLE**
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1-12 Human Health Risk Evaluation of Domestic Use of Groundwater (Filtered Samples) Well Group No. 5 (06C11, 06C12, 06C14, 06C16, 06C18, 06C19), Big Clifty/Beech Creek

ACRONYMS

µg/L	micrograms per liter
CASRN	Chemical Abstract Service Registry Number
CFR	Code of Federal Regulations
Cmax	maximum concentration
CMP	Corrective Measures Proposal
COPCs	Chemicals of Potential Concern
EPC	exposure point concentration
HHRSE	Human Health Risk Screening Evaluation
HI	Hazard Index
HQ	Hazard Quotient
IDEM	Indiana Department of Environmental Management
IRIS	Integrated Risk Information System
LOAEL	lowest-observed-adverse-effect-level
MCL	Maximum Contaminant Level
mg/kg	milligrams per kilogram
NCEA	National Center for Environmental Assessment
NOAEL	no-observed-adverse-effects-level
OB	open burning
OPR	Old Pistol Range
ORR	Old Rifle Range
POC	point-of-compliance
PRGs	Preliminary Remediation Goals
RBTLs	risk-based target levels
SDWA	Safe Drinking Water Act
SWMU	Solid Waste Management Unit
TNT	2,4,6-Trinitrotoluene
U.S. EPA	United States Environmental Protection Agency

1.0 HUMAN HEALTH RISK SCREENING EVALUATION

1.1 BACKGROUND AND OBJECTIVES

The Old Rifle Range (ORR) portion of Solid Waste Management Unit (SWMU) 7 contains a hazardous waste treatment facility for the open burning (OB) of reactive wastes. United States Environmental Protection Agency (U.S. EPA) Region 5 has issued a hazardous waste treatment permit for the operation of the OB Unit. The permit contains requirements for groundwater monitoring in compliance with 40 Code of Federal Regulations (CFR) 264, Subpart F. Compliance monitoring is being conducted because hazardous constituents were detected in groundwater during interim status monitoring. The permit also requires an evaluation of the need for corrective actions. Groundwater monitoring requirements included in the permit include designation of the point-of-compliance (POC) identification of upgradient monitoring wells, and downgradient wells at the POC, aquifers monitored, constituents to be monitored, risk-based target levels (RBTLs), and statistical procedures for determining whether downgradient concentrations exceed upgradient concentrations. The permit also requires the development of an annual groundwater monitoring report. This report includes identification of constituents that are found in statistically significant concentrations in downgradient wells and that are detected at concentrations greater than RBTLs listed in the Permit.

Information from the annual monitoring reports for the calendar years 2000 (SAIC, 2002a), 2001 (SAIC, 2002b), and 2002 (SAIC, 2003) was used to identify which chemicals were found in statistically significant concentrations and greater than RBTLs in one or more wells. A Human Health Risk Screening Evaluation (HHRSE) was conducted to determine whether corrective measures were necessary for these chemicals.

The following wells are included in the groundwater monitoring program for the Big Clifty Upper and Big Clifty/Beech Creek aquifers:

Big Clifty Upper	Big Clifty/Beech Creek	
06C11P2	06C11	06C16
06C13P2	06C12	06C18
06C18P2	06C13	06C19
06C19P2	06C14	06C08 (Background)
06C14P2 (Background)	06C15	

The following chemicals were evaluated in this HHRSE:

- Arsenic
- Barium
- Cadmium
- Chromium
- Lead
- Iron
- Manganese
- Silver
- Selenium
- Zinc
- 2,4,6-Trinitrotoluene (TNT)

A summary of the analytical results for monitoring wells sampled as part of the compliance monitoring program are presented in Appendix A. Basic descriptive statistics (e.g., concentration ranges detected, frequencies of detection, arithmetic mean concentrations, etc) for results for groundwater samples collected from the Big Clifty Upper and Big Clifty/Beech Creek groundwater units are presented in Tables 2-1 and 2-2, respectively.

Information on the selection of chemicals of potential concern, exposure assessment, characterization of estimated potential human health risks, uncertainty analysis, and summary and conclusions for the risk screening are contained in Sections 1.2, 1.3 , 1.4, 1.5, and 1.6, respectively.

1.2 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

Chemicals of Potential Concern (COPCs) are the target analytes detected in an environmental medium that are selected for evaluation in a risk assessment. A chemical was selected as a COPC for this HHRSE if the maximum detected concentration in the groundwater exceeded the primary (health-based) Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL), the Indiana Department of Environmental Management (IDEM) default closure level for groundwater, or a screening level based on the U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) for tap water. The PRGs are chemical concentrations corresponding to fixed levels of risk [i.e., a Hazard Quotient (HQ) of 1 for non-carcinogenic chemicals or a lifetime cancer risk of 1E-06 for carcinogenic chemicals]. Although the Region 9 PRG established for cancer risk is typically used as a COPC screening level for a carcinogen, one-tenth the

PRG is typically recommended by U.S. EPA Region 5 as a COPC screening criterion for non-carcinogenic compounds to account for the potential cumulative effects of multiple compounds affecting the same target organ. The Region 9 PRGs for tap water assume daily, domestic use of a water supply.

Lead, silver, and selenium did not exceed an SDWA MCL, IDEM default closure level for groundwater, or a screening level U.S. EPA Region 9 PRG for tap water. Therefore, lead, silver, and selenium were not selected as COPCs.

The following chemicals were selected as COPCs for monitoring wells screened in the Big Clifty Upper groundwater unit:

- Unfiltered groundwater samples: arsenic, iron, and manganese.
- Filtered groundwater samples: arsenic, barium, chromium, manganese, and zinc.

Arsenic was the only target analyte detected at concentrations exceeding a primary (health-based) SDWA MCL. However, iron and manganese were detected at concentrations exceeding secondary (aesthetic-based) MCLs. The maximum concentrations of four non-carcinogens (barium, chromium, manganese, and zinc) exceeded one-tenth the Region 9 PRG established for non-carcinogenic effects but did not exceed the actual PRG established at an HQ of 1. Maximum concentrations of arsenic and iron exceed Region 9 PRGs established for tap water.

The following chemicals were selected as COPCs for monitoring wells screened in the Big Clifty/Beech Creek groundwater unit:

- Unfiltered groundwater samples: TNT, arsenic, cadmium, chromium, iron, and manganese.
- Filtered groundwater samples: arsenic, barium, chromium, and manganese.

Arsenic and cadmium were the only target analytes detected at concentrations exceeding primary (health-based) SDWA MCLs. However, iron and manganese were detected at concentrations exceeding secondary (aesthetic-based) MCLs. The maximum concentrations of five non-carcinogens (barium, cadmium, chromium, iron, and manganese) exceeded one-tenth the Region 9 PRG established for non-carcinogenic effects but did not exceed the actual PRG established at an HQ of 1. Maximum concentrations of arsenic and TNT exceed Region 9 PRGs established for tap water.

1.3 EXPOSURE ASSESSMENT

This section presents the exposure assessment for the evaluation of groundwater at SWMU 7. Receptors evaluated in the risk assessment are identified, and the methodology used to determine the exposure point concentration (EPC) (i.e., the concentration to which a receptor is exposed) is presented.

The ORR is an area approximately 20 acres in size and is located immediately adjacent to and south of the Old Pistol Range (OPR) (another component of SWMU 7). The site is currently well vegetated. Surface water drainage from the area flows to the east. The geologic/hydrogeologic characteristics of the Big Clifty Upper and Big Clifty/Beech groundwater units are discussed in detail in Section 1.5.4 of the Corrective Measures Proposal (TtNUS, 2006).

Groundwater underlying SWMU 7 is not currently used for any purpose. Additionally, the facility does not have any plans to develop the groundwater resource in the future. However, for purposes of the HHRSE, this exposure assessment will assume that a hypothetical future resident may be exposed to COPCs in groundwater. The exposure assessment assumptions (e.g., water ingestion rates, etc) are those specified in the calculation of the Region 9 PRGs for the hypothetical residential use of a groundwater or surface water resource as a tap-water supply. The Region 9 PRGs for tap water assume that a resident is exposed via the ingestion and inhalation of volatiles exposure pathways. The exposure assessment methodology for the U.S. EPA Region 9 PRGs is presented in Appendix B.

The EPC is the COPC concentration to which the receptor is exposed. Per U.S. EPA guidance, the 95 percent upper confidence limit (95%UCL) on the arithmetic mean is typically recommended as the EPC. However, risk assessment guidance published by U.S. EPA Regions 1 and 4 recommends that the groundwater EPC should be the arithmetic average concentration of the wells in the highly concentrated area of the plume. In either case, the determination of the EPC initially requires a review of the COPCs selected to determine the predominant risk drivers, an evaluation of the spatial distribution of the COPCs, and finally, a grouping of the wells such that the EPC calculated represents the mean concentration to which a receptor is exposed [i.e., the EPC is not lowered (diluted) by an inappropriate grouping of wells (data)]. A review of the descriptive statistics and the Region 9 PRGs presented in Tables 1-1 and 1-2 indicates that arsenic, manganese, and TNT are the primary risk drivers in the HHSRE. Specifically, arsenic and TNT are the only carcinogens selected as COPCs and, based on a review of frequencies of detection and the relative magnitudes of the arithmetic mean concentrations to the Region 9 PRGs, manganese is the predominant non-carcinogenic COPC. Consequently, the spatial distributions of arsenic, manganese, and TNT were used to define the following monitoring well groupings evaluated in the HHRSE:

- ***Monitoring Well Group 1 (06C13P2 and 06C18P2)***: Big Clifty Upper wells consistently demonstrating elevated arsenic and manganese concentrations.

- ***Monitoring Well Group 2 (0611P2 and 06C19P2):*** Big Clifty Upper wells consistently demonstrating low arsenic and manganese concentrations.

- ***Monitoring Well Group 3 (06C13):*** Big Clifty/Beech Creek well consistently demonstrating elevated arsenic concentrations.

- ***Monitoring Well Group 4 (06C15):*** Only Big Clifty/Beech Creek well demonstrating TNT contamination. TNT was also not detected in the Big Clifty Upper monitoring wells.

- ***Monitoring Well Group 5 (06C11, 06C12, 06C14, 06C16, 06C18, and 06C19):*** Big Clifty/Beech Creek not included in Group 3 or Group 4. No obvious consistent patterns noted for arsenic or manganese. TNT was not detected in these wells.

The EPCs evaluated in this HHSRE will be the 95%UCL concentrations for the groundwater data available for each well grouping. However, the uncertainty section includes a discussion of risk estimates/conclusions resulting if arithmetic mean concentrations were used as EPCs. The 95%UCL values are calculated following U.S EPA's Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites (U.S. EPA, 2002) and using the U.S. EPA Pro-UCL software. (Appendix C)

1.4 RISK CHARACTERIZATION

The risk characterization for the COPCs detected in groundwater is conducted using the simple risk-ratio technique presented below, the EPCs developed for each monitoring well group, and the EPA Region 9 PRGs for tap water:

$$\frac{\text{U.S. EPA Region 9 PRG}}{\textit{EPC}\text{ for COPC}} = \frac{\text{Hazard Index (HI) of 1 or Cancer Risk Estimate of 1E - 06}}{\text{?? Hazard Index or Cancer Risk Estimate}}$$

Risk estimates (HIs and cancer risks) for the hypothetical future resident using the groundwater at the ORR as a domestic water source are summarized below and detailed in Tables 1-3 through 1-12.

Well Grouping	Hazard Index (Risk Drivers)	Cancer Risk (Risk Drivers)
No. 1 (06C13P2, 06C18P2)	*Total Metals = 9* *Dissolved Metals = 3.5* *Risk Drivers: arsenic, iron*	*Total Metals = 6E-04* *Dissolved Metals = 6.8E-04* *Risk Drivers: arsenic*
No. 2 (0611P2, 06C19P2)	Total Metals = 0.85 Dissolved Metals = 0.44 No Risk Drivers	Total Metals = 6.1E-05 Dissolved Metals = 4.4E-05 Risk Drivers: arsenic
No. 3 (06C13)	*Total Metals = 5.2* *Dissolved Metals = 3.5* *Risk Drivers: arsenic*	*Total Metals = 1.1E-03* *Dissolved Metals = 7E-04* *Risk Drivers: arsenic*
No. 4 (06C15)	Total Metals = 0.49 Dissolved Metals = 0.44 No Risk Drivers	Total Metals = 3.2E-06 Dissolved Metals = 3.2E-06 Risk Drivers: TNT
No. 5 (06C11, 06C12, 06C14, 06C16, 06C18, 06C19)	Total Metals = 0.73 Dissolved Metals = 0.53 No Risk Drivers	Total Metals = 3.3E-05 Dissolved Metals = 2.9E-05 Risk Drivers: arsenic

Risk Characterization Results for Monitoring Well Group No. 1: Arsenic [maximum concentration (C_{max}) = 37.1 micrograms per liter (µg/L)] is the only metal detected in the Group No. 1 groundwater samples at concentrations exceeding a primary (i.e., health-based) SDWA MCL. However, manganese (C_{max} = 653 µg/L) and iron (C_{max} = 64,500 µg/L) concentrations exceed secondary (aesthetic-based) standards. The cancer risk estimates for arsenic (6E-04, total arsenic; 6.8E-04, dissolved arsenic) exceeds the U.S. EPA target risk range typically used to determine the need for environmental remediation (i.e., the 1E-04 to 1E-06 cancer risk range). HIs calculated for arsenic (total arsenic = 2.4; dissolved arsenic = 2.8) exceed 1, indicating a potential for adverse non-carcinogenic health effects if the groundwater is used as a domestic water supply. The HI calculated for both total and dissolved manganese is 0.6; the HI for total iron is 5.9. However, the HI for iron is based on the analytical result reported for ***one*** unfiltered groundwater sample collected from monitoring well 06C18P2 in May 2000 and a U.S. EPA recommended reference dose that actually represents a typical, daily intake for adults. Consequently, adverse health effects cannot be predicted based on a simple exceedance of this reference dose. Iron, an essential nutrient, is further discussed in the Uncertainty Section, Section 1.5. ***Arsenic is the only COPC recommended for further evaluation as a potential chemical of concern (COC) in the Corrective Measures Proposal (CMP).*** However, the following information (drawn primarily from the Phase III RFI report for ORR soils) should be considered when selecting the final COCs for Well Group No. 1.

Arsenic reported in the Phase III Soils RFI report for the ORR (TtNUS, 2005), arsenic concentrations in surface soil samples at the ORR ranged from 3.7 to 13.8 milligrams per kilogram (mg/kg). The arithmetic

mean was 8.16 mg/kg (Table 3-8 of the RFI report). The maximum and arithmetic mean arsenic concentrations in background surface soil samples were 10.2 mg/kg and 6.11 mg/kg, respectively. Although the statistical analysis detailed in the Phase III Soils RFI indicates that arsenic concentrations in ORR surface soils exceed background arsenic concentrations, the preceding comparison of background and site descriptive statistics for the surface soils indicates the exceedance of background is marginal and that the arsenic concentrations at most soil sampling locations do not exceed background.

- Arsenic concentrations in ORR subsurface soils ranged from 3.3 to 15.4 mg/kg; the arithmetic mean concentration was 7.72 mg/kg (Table 3-8; TtNUS, 2005). The maximum and arithmetic mean arsenic concentrations in background subsurface soil samples were 9 mg/kg and 7.72 mg/kg, respectively. The statistical analysis detailed in the Phase III Soils RFI indicates that arsenic concentrations in ORR subsurface soils ***do not exceed*** background arsenic concentrations. The lack of a demonstrated subsurface source of arsenic contamination at the ORR suggests that the arsenic concentrations in the compliance monitoring wells may not be site related.

- The arsenic concentrations reported in the Phase III Soils RFI for the ORR are consistent with those reported for ORR soils in the Current Contamination Conditions Risk Assessment for the Ammunition Burning Ground, the Old Rifle Range, and the Demolition Range (B&RE, 1997). The arsenic concentrations in soils reported in this report ranged from 3.2 mg/kg to 9.1 mg/kg. The arithmetic mean concentration for ORR soils was 6.3 mg/kg, suggesting at most a marginal exceedance of background conditions.

- The spatial distribution of arsenic concentrations in surface soils at the ORR is presented in Figures 3-1 through 3-4 of the Phase III Soils RFI and suggests limited contaminant "hot spots"/source areas only.

Risk Characterization Results for Monitoring Well Group No. 2: None of the target analytes evaluated for Group No. 2 was detected at concentrations exceeding available SDWA primary MCLs. The secondary MCLs for iron and manganese were exceeded, but target-specific HIs for these metals were not greater than 1 and would not be greater than 1 even if the maximum detected concentrations were evaluated. HIs summed for all COPCs do not exceed 1 and would not exceed 1 even if the maximum detected concentrations were evaluated. The cancer risk estimate for arsenic, the only carcinogenic COPC evaluated, did not exceed 1E-04. Consequently, ***none of the COPCs evaluated for Group No. 2 are recommended for further evaluation in the CMP*** because the aforementioned U.S. EPA risk benchmarks are not exceeded and the target analytes were not detected at concentrations exceeding SDWA primary MCLs.

Risk Characterization Results for Monitoring Well Group No. 3: Arsenic (C_{max} = 114 µg/L) was the only COPC detected in the Group No. 3 monitoring wells at concentrations exceeding SDWA primary MCLs. It is also the only target analyte identified as a risk driver. Cancer risk estimates developed for both total and dissolved arsenic exceeded 1E-04. HIs developed for both total and dissolved arsenic concentrations exceeded 1 indicating a potential for adverse non-carcinogenic health effects. The secondary MCL for manganese was exceeded but the target specific HI for manganese (i.e., the central nervous system) is not greater than 1 and would not be greater than 1 even if the maximum detected concentration was evaluated. ***Consequently, arsenic is the only COPC recommended for further evaluation as a potential COC in the CMP.*** However, the factors considered in the discussion presented for Well Group No. 1 should also be considered when selecting the final COCs for Well Group No. 3.

Risk Characterization Results for Monitoring Well Group No. 4: None of the target analytes evaluated for Group No. 4 was detected at concentrations exceeding available SDWA primary MCLs. HIs summed for all COPCs do not exceed 1 and would not exceed 1 even if the maximum detected concentrations were evaluated. The cancer risk estimate for TNT, the only carcinogenic COPC evaluated, did not exceed 1E-05. The single iron concentration (462 µg/L) reported for the unfiltered Group No. 4 monitoring well samples marginally exceeded the secondary (aesthetic-based) MCL for iron (300 µg/L). Consequently, ***none of the COPCs evaluated for Group No. 4 are recommended for further evaluation in the CMP*** because the aforementioned U.S. EPA risk benchmarks are not exceeded and the target analytes were not detected at concentrations exceeding SDWA primary MCLs.

Risk Characterization Results for Monitoring Well Group No. 5: One reported detection of cadmium (C_{max} = 5.8 µg/L) exceeded its primary SDWA MCL (5 µg/L). However, the HQ calculated cadmium and the HI calculated for all COPCs evaluated for Group No. 5 do not exceed 1. The cancer risk estimates developed for total and dissolved arsenic, the only carcinogenic COPC, do not exceed 1E-04, and arsenic concentrations do not exceed the current primary SDWA MCL of 10 µg/L. The secondary MCLs for iron and manganese were exceeded, but target-specific HIs for these metals are not greater than 1 and would not be greater than 1 even if the maximum detected concentrations were evaluated. ***None of the COPCs evaluated for Group No. 5 are recommended for further evaluation in the CMP*** because the aforementioned U.S. EPA risk benchmarks are not exceeded and only the maximum detection of one metal (cadmium) marginally exceeded a SDWA primary MCL.

1.5 UNCERTAINTY ANALYSIS

The following significant sources of uncertainty should be considered when interpreting the results of this HHRSE of the 2000 through 2004 analytical results for groundwater samples collected from the compliance monitoring wells at SWMU 7:

- The Region 9 PRG for iron in tap water (11,000 µg/L) used in this HHRSE was calculated using a reference dose that is based on the recommended/typical dietary intake for adults (0.3 mg/kg/day). The value is a no-observed-adverse-effects-level (NOAEL). Unfortunately, as documented in the Risk Assessment Issue Paper for: Derivation of a Provisional RfD for iron [Chemical Abstract Service Registry Number (CASRN) 7439-89-6] prepared by National Center for Environmental Assessment (NCEA) in 1996, a precise lowest-observed-adverse-effect-level (LOAEL) for normal adult individuals consuming a typical western diet is compromised by the available toxicity studies, which contain confounding factors, inadequate endpoint assessments, and too short an exposure duration or too few test subjects. Much higher dietary intakes (average 6.7 mg/kg/day) of the less soluble forms of iron than the current recommended reference dose (0.3 mg/kg/day) are tolerated in nonwestern diets. Precise LOAEL information is needed to determine a more definitive reference dose for quantitative human health risk assessment (i.e., specifically, the prediction of the potential for adverse non-cancer effects). Non-cancer risk estimates based on the current reference dose are highly uncertain because of the lack of a precise LOAEL data.

1.6 SUMMARY AND CONCLUSIONS

This HHRSE was conducted based on analytical results for groundwater samples collected from the following ORR compliance monitoring wells in 2000 through 2004:

Big Clifty Upper	Big Clifty/Beech Creek
06C11P2	06C11
06C13P2	06C12
06C18P2	06C13
06C19P2	06C14
06C14P2 (Background)	06C15
	06C16
	06C18
	06C19
	06C08 (Background)

All of these monitoring wells are screened in the Big Clifty Upper or Big Clifty/Beech Creek units. Based on previous evaluations presented in the Annual Groundwater Monitoring Reports for the ORR, analytical results reported for the following chemicals exceed background concentrations and RBTLs originally established for the compliance monitoring program: arsenic, barium, cadmium, chromium, lead, iron, manganese, silver, selenium, zinc, and TNT. With the exception of lead, silver, and selenium, all of these chemicals were selected as COPCs for human health risk assessment because maximum detected concentrations exceeded federal SDWA MCLs and/or screening levels based on Region 9 PRGs for tap water. EPCs were developed for COPCs detected in each of following five monitoring well groups:

- ***Monitoring Well Group 1 (06C13P2, 06C18P2)***: Big Clifty Upper wells consistently demonstrating elevated arsenic and manganese concentrations.

- ***Monitoring Well Group 2 (0611P2 and 06C19P2):*** Big Clifty Upper wells consistently demonstrating low arsenic and manganese concentrations.

- ***Monitoring Well Group 3 (06C13):*** Big Clifty/Beech Creek well consistently demonstrating elevated arsenic concentrations.

- ***Monitoring Well Group 4 (06C15):*** Only Big Clifty/Beech Creek well demonstrating TNT contamination.

- ***Monitoring Well Group 5 (06C11, 06C12, 06C14, 06C16, 06C18, and 06C19):*** Big Clifty/Beech Creek wells not included in Group 3 or Group 4. No obvious consistent patterns noted for arsenic or manganese.

- ***However, arsenic is the only COPC recommended for further evaluation as a potential COC in the CMP.*** The arsenic concentrations in Monitoring Well Group 1 (06C13P2 and 06C18) and Monitoring Well Group 3 (06C13) exceed the current federal SDWA MCL. The cancer and non-cancer risk estimates developed for arsenic concentrations in these monitoring well groups also exceed the 1E-04 cancer risk level and an HI of 1, respectively. With one other exception (the HI for iron in Monitoring Well Group 1), cancer and non-cancer risk estimates developed for all other COPCs and all other monitoring well groups do not exceed these risk benchmarks. It should be noted that arsenic is a naturally occurring inorganic. An evaluation of arsenic concentrations in ORR soils (i.e, the potential source areas) suggests that most of the arsenic concentrations in the compliance monitoring wells may be naturally occurring. Iron is also a naturally occurring inorganic

and an essential nutrient. Based on the uncertainties associated with the current reference dose for iron, the non-cancer risk results presented in this HHRSE for iron are likely overestimated.

TABLE 1-1

SUMMARY OF DESCRIPTIVE STATISTICS
BIG CLIFTY UPPER
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection	Federal MCL (1)	Region 9 PRG Tap Water (2)	Basis(3)
Total Metals (µg/L)										
ARSENIC	73/80	1.1	37.1	1.10	13.3	14.5	06C13P21A02	10	0.045	C
BARIUM	80/80	29	183	---	68.6	68.6	06C18P21A02	2000	2600	N
CADMIUM	2/80	1.1	1.5	0.78 - 1.1	0.561	1.30	06C18P22A00	5	18	N
CHROMIUM	5/80	0.640	7.9	2.2 - 5.6	2.68	2.26	06C18P21A00	100	110	N
IRON	3/3	572	64500	---	23254	23254	06C18P22A00	---	11000	N
LEAD	2/80	0.160	1.7	0.11 - 1.1	0.541	0.930	06C18P22A04	15	---	
MANGANESE	80/80	85.7	653	---	322	322	06C13P22A04	---	880	N
SELENIUM	22/80	0.56	6.1 J	0.44 - 1.1	0.982	2.13	06C18P21A02	50	180	N
ZINC	9/80	2.4	69.1	11.1 - 237	8.96	23.3	06C18P23A01	---	11000	N
Dissolved Metals (µg/L)										
ARSENIC, FILTERED	63/80	0.650	42.3	1 - 1.1	14.0	17.6	06C13P24A04-F	10	0.045	C
BARIUM, FILTERED	80/80	26.9	625	---	71.7	71.7	06C18P24A01-F	2000	2600	N
CADMIUM, FILTERED	4/80	1.1	1.7	0.7 - 1.1	0.541	1.40	06C18P21A00-F	5	18	N
CHROMIUM, FILTERED	12/80	3.5	16	1 - 5.6	3.13	7.18	06C18P21A02-F	100	110	N
LEAD, FILTERED	4/80	0.190	0.240	1 - 1.1	0.490	0.215	06C18P24A01-F	15	---	
MANGANESE, FILTERED	78/80	76.2	681 J	1500	322	311	06C13P23A04-F	---	880	N
SELENIUM, FILTERED	10/80	0.470	2.4	0.4 - 1.1	0.627	1.56	06C18P22A00-F	50	180	N
ZINC, FILTERED	14/80	2.8	2590	10 - 11.1	53.4	281	06C19P23A04-F	---	11000	N

1) Value presented is the federal SDWA MCL (U.S. EPA, 2004).
2) Value presented is the U.S. EPA Region 9 PRG for tap water. (U.S. EPA Region 9, 2004).
3) "N" indicates that the PRG value presented is based on the potential for non-carcinogenic effects. "C" indicates that the value presented is based on the potential for carcinogenic effects.

Chemicals that are bolded have been selected as COPCs for human health risk assessment.
The protocol for the selection of COPCs is presented in Section 1.

µg/L - micrograms per liter
COPCS - chemicals of potential concern
MCL - Maximum Contaminant Level
PRG - Preliminary Remediation Goal
SDWA - Safe Drinking Water Act
U.S. EPA - United States Environmental Protection Agency

TABLE 1-2

SUMMARY OF DESCRIPTIVE STATISTICS
BIG CLIFTY BEECH CREEK
SWMU 7 -OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter	Frequency of Detection	Minimum Concentration	Maximum Concentration	Range of Nondetects	Mean Concentration	Average of Positive Detects	Sample with Maximum Detection	Federal MCL (1)	Region 9 PRG Tap Water (2)	Basis (3)
Energetics (µg/L)										
2,4,6-TRINITROTOLUENE	19/160	3.9	7.8 J	0.14 - 1.7	0.995	5.74	06C151A00	---	2.2	C
2-AMINO-4,6-DINITROTOLUENE	20/160	1.9	3.7	0.14 - 1.7	0.654	2.74	06C151A00, 06C154A00	---	---	
4-AMINO-2,6-DINITROTOLUENE	20/160	2.2	4.4	0.14 - 1.7	0.720	3.27	06C153A00, 06C154A00	---	---	
Total Metals (µg/L)										
ARSENIC	83/160	0.940	114	0.22 - 1.1	6.43	11.9	06C134A02	10	0.045	C
BARIUM	160/160	20.9	127	---	58.9	58.9	06C163A00	2000	2600	N
CADMIUM	1/160	5.8	5.8	0.78 - 1.1	0.575	5.80	06C141A01	5	18	N
CHROMIUM	12/160	0.710	14.9	2.2 - 5.6	2.80	3.92	06C141A03	100	110	N
IRON	5/7	462	3520	111	1002	1381	06C182A00	---	11000	N
LEAD	30/160	0.130	8.4	0.11 - 1.1	0.894	2.43	06C114A02	15	---	
MANGANESE	127/160	3	550	5.6 - 16.7	195	244	06C131A03	---	880	N
SELENIUM	28/160	0.5	3	0.44 - 1.1	0.708	1.50	06C132A04	50	180	N
SILVER	3/160	0.190	5	0.11 - 222	7.02	3.00	06C152A02	---	180	N
ZINC	57/160	2	292	11.1	19.0	43.4	06C152A02	---	11000	N
Dissolved Metals (µg/L)										
ARSENIC, FILTERED	76/160	0.31	55.3	0.2 - 1.1	4.39	8.70	06C131A04-F	10	0.045	C
BARIUM, FILTERED	160/160	9.6	326	---	54.5	54.5	06C163A02-F	2000	2600	N
CADMIUM, FILTERED	2/160	1.1	1.2	0.7 - 1.1	0.505	1.15	06C121A00-F	5	18	N
CHROMIUM, FILTERED	20/160	2	13.4	1 - 5.6	2.98	6.93	06C161A02-F	100	110	N
LEAD, FILTERED	10/160	0.120	5.1 J	0.1 - 1.1	0.530	0.961	06C142A02-F	15	---	
MANGANESE, FILTERED	109/160	3.8	534 J	5 - 1500	198	265	06C133A04-F	---	880	N
SELENIUM, FILTERED	4/160	0.510	2.1	0.4 - 1.1	0.512	1.26	06C132A00-F	50	180	N
ZINC, FILTERED	33/160	2	385	10 - 100	19.5	73.6	06C142A02-F	---	11000	N

1) Value presented is the federak SDWA MCL (U.S. EPA, 2004).
2) Value presented is the U.S. EPA Region 9 PRG for tap water. (U.S. EPA Region 9, 2004).
3) "N" indicates that the PRG value presented is based on the potential for non-carcinogenic effects. "C" indicates that the value presented is based on the potential for carcinogenic effects.

Chemicals that are bolded have been selected as chemicals of potential concern (COPCs) for human health risk assessment.
The protocol for the selection of COPCs is presented in Section 1.

µg/L - micrograms per liter
COPCS - chemicals of potential concern
MCL - Maximum Contaminant Level
PRG - Preliminary Remediation Goal
SDWA - Safe Drinking Water Act
U.S. EPA - United States Environmental Protection Agency

TABLE 1-3

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (UNFILTERED SAMPLES)
WELL GROUP NO. 1 (06C13P2, 06C18P2)
BIG CLIFTY UPPER
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3]	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5]	Estimated HQ
	(µg/L)	(µg/L)			(µg/L)	
Arsenic	26.8 [6]	4.50E-02	5.96E-04	Skin, CVS	1.10E+01	2.4E+00
Barium	113 [6]	NA	NA	Kidney	2.60E+03	4.3E-02
Chromium	3.01 [6]	NA	NA	NA	1.10E+02	2.7E-02
Iron	64500 [7]	NA	NA	GI[8]	1.10E+04	5.9E+00
Manganese	541 [9]	NA	NA	CNS	8.80E+02	6.1E-01
Zinc	25.8 [10]	NA	NA	Blood	1.1E+04	2.3E-03
		Total Carcinogenic Risk	5.96E-04		Total HI	9.0E+00

Target Organ HIs

Skin =	2.4E+00
CVS =	2.4E+00
Kidney =	4.3E-02
GI =	5.9E+00
CNS =	6.1E-01
Blood =	2.3E-03

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS, unless otherwise noted.
5 - PRG is shaded if EPC exceeds one-tenth the PRG.
6 - Student-t or Modified-t UCL
7 - Maximum Concentration.
8 - Groundwater and Surface Water Cleanup Target Levels for Chapter 62-777, F.A.C., FDEP, April 17, 2005.
9 - Student-t.
10 - 95% Chebyshev UCL.

Abbreviations:

µg/L = micrograms per liter.
EPC = Exposure Point Concentration.
CNS = Central nervous system.
CVS = Cardiovascular system.
F.A.C. = Florida Administrative Code.
FDEP = Florida Department of Environmental Protection
GI = Gastrointestinal.
HI = Hazard Index.
HQ = Hazard quotient.
ILCR = Incremental Lifetime Cancer Risk.
IRIS = Integrated Risk Information System .
NA = Not applicable.
PRG = Preliminary Remediation Goal.
UCL = Upper confidence level.

TABLE 1-4

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (FILTERED SAMPLES)
GROUP NO. 1 (06C13P2, 06C18P2)
BIG CLIFTY UPPER
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
Arsenic, Filtered	30.6 [6]	4.50E-02	6.80E-04	Skin, CVS	1.10E+01	2.8E+00
Barium, Filtered	173 [7]	NA	NA	Kidney	2.60E+03	6.7E-02
Chromium, Filtered	4.73 [7]	NA	NA	NA	1.10E+02	4.3E-02
Manganese, Filtered	554 [8]	NA	NA	CNS	8.80E+02	6.3E-01
Zinc, Filtered	185 [9]	NA	NA	Blood	1.1E+04	1.7E-02
		Total Carcinogenic Risk	6.80E-04		Total HI	3.5E+00

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS.
5 - PRG is shaded if EPC exceeds one-tenth the PRG.
6 - Approximate Gamma 95% UCL.
7 - 95% Chebyshev UCL.
8 - Student-t.
9 - 99% Chebyshev UCL.

Target Organ HIs

Skin =	2.8E+00
CVS =	2.8E+00
Kidney =	6.7E-02
CNS =	6.3E-01
Blood =	1.7E-02

Abbreviations:

µg/L = micrograms per liter
EPC = Exposure Point Concentration.
CNS = Central nervous system.
CVS = Cardiovascular system.
HI = Hazard Index.
HQ = Hazard Quotient.
ILCR = Incremental Lifetime Cancer Risk.
IRIS = ntegrated Risk Information System.
NA = Not applicable.
PRG = Preliminary Remediation Goal.
UCL = Upper confidence level.

TABLE 1-5

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER - (UNFILTERED SAMPLES)
WELL GROUP NO. 2 (06C11P2, 06C19P2)
BIG CLIFTY UPPER
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
Arsenic	2.76 [6]	4.50E-02	6.13E-05	Skin, CVS	1.10E+01	2.5E-01
Barium	36.6 [7]	NA	NA	Kidney	2.60E+03	1.4E-02
Chromium	0.92 [8]	NA	NA	NA	1.10E+02	8.4E-03
Iron	4690 [8]	NA	NA	GI[9]	1.10E+04	4.3E-01
Manganese	131 [10]	NA	NA	CNS	8.80E+02	1.5E-01
Zinc	8.45 [11]	NA	NA	Blood	1.1E+04	7.7E-04
		Total Carcinogenic Risk	6.13E-05		Total HI	8.5E-01

Target Organ HIs

Skin =	2.5E-01
CVS =	2.5E-01
Kidney =	1.4E-02
GI =	4.3E-01
CNS =	1.5E-01
Blood =	7.7E-04

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS, unless otherwise noted.
5 - PRG is shaded if the EPC exceeds one-tenth the PRG.
6 - 95% Chebyshev UCL.
7 - Approximate Gamma 95% UCL.
8 - Maximum concentration.
9 - Groundwater and Surface Water Cleanup Target Levels for Chapter 62-777, F.A.C., FDEP, April 17, 2005..
10 - Student-t.
11 - Student-t or Modified-t UCL.

Abbreviations:

µg/L = micrograms per liter
EPC = Exposure Point Concentration
CNS = Central Nervous System
CVS = Cardiovascular System
GI = Gastrointestinal
F.A.C. = Florida Administrative Code.
FDEP = Florida Department of Environmental Protection
HI = Hazard Index
HQ = Hazard Quotient
ILCR = Incremental Lifetime Cancer Risk
IRIS = ntegrated Risk Information System.
NA = Not Applicable
PRG = Preliminary Remediation Goal
UCL = Upper Confidence Level

TABLE 1-6

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (FILTERED SAMPLES)
WELL GROUP NO. 2 (06C11P2, 06C19P2)
BIG CLIFTY UPPER
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
Arsenic, Filtered	1.98 [6]	4.50E-02	4.40E-05	Skin, CVS	1.10E+01	1.8E-01
Barium, Filtered	35.6 [7]	NA	NA	Kidney	2.60E+03	1.4E-02
Chromium, Filtered	4.56 [6]	NA	NA	NA	1.10E+02	4.1E-02
Manganese, Filtered	120 [7]	NA	NA	CNS	8.80E+02	1.4E-01
Zinc, Filtered	715 [6]	NA	NA	Blood	1.1E+04	6.5E-02
		Total Carcinogenic Risk	4.40E-05		Total HI	4.4E-01

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS.
5 - PRG is shaded if EPC exceeds one-tenth the PRG.
6 - 95% Chebyshev UCL.
7 - Student-t.

Target Organ HIs

Skin =	1.8E-01
CVS =	1.8E-01
Kidney =	1.4E-02
CNS =	1.4E-01
Blood =	6.5E-02

Abbreviations:

µg/L = micrograms per liter
EPC = Exposure Point Concentration.
CNS = Central nervous system.
CVS = Cardiovascular system.
HI = Hazard Index.
HQ = Hazard Quotient.
ILCR = Incremental Lifetime Cancer Risk.
IRIS = ntegrated Risk Information System.
NA = Not applicable.
PRG = Preliminary Remediation Goal.
UCL = Upper confidence level.

TABLE 1-7

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (UNFILTERED SAMPLES)
WELL GROUP NO. 3 (06C13)
BIG CLIFTY/BEECH CREEK
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
Arsenic	51.2 [6]	4.50E-02	1.14E-03	Skin, CVS	1.10E+01	4.7E+00
Barium	76 [6]	NA	NA	Kidney	2.60E+03	2.9E-02
Chromium	0.83 [7]	NA	NA	NA	1.10E+02	7.5E-03
Manganese	486 [8]	NA	NA	CNS	8.80E+02	5.5E-01
Zinc	32.8 [9]	NA	NA	Blood	1.1E+04	3.0E-03
		Total Carcinogenic Risk	1.14E-03		Total HI	5.2E+00

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS.
5 - PRG is shaded if EPC exceeds one-tenth the PRG.
6 - Student-t or Modified-t UCL.
7 - Maximum Concentration.
8 - Student-t.
9 - 95% Chebyshev UCL.

Target Organ HIs

Skin =	4.7E+00
CVS =	4.7E+00
Kidney =	2.9E-02
CNS =	5.5E-01
Blood =	3.0E-03

Abbreviations:

µg/L = micrograms per liter
EPC = Exposure Point Concentration
CNS = Central Nervous System
CVS = Cardiovascular System
GI = Gastrointestinal
F.A.C. = Florida Administrative Code.
FDEP = Florida Department of Environmental Protection
HI = Hazard Index
HQ = Hazard Quotient
ILCR = Incremental Lifetime Cancer Risk
IRIS = ntegrated Risk Information System.
NA = Not Applicable
PRG = Preliminary Remediation Goal
UCL = Upper Confidence Level

TABLE 1-8

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (FILTERED SAMPLES)
WELL GROUP NO. 3 (06C13)
BIG CLIFTY/BEECH CREEK
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
Arsenic, Filtered	31.4 [6]	4.50E-02	6.98E-04	Skin, CVS	1.10E+01	2.9E+00
Barium, Filtered	59.6 [7]	NA	NA	Kidney	2.60E+03	2.3E-02
Cadmium, Filtered	0.579 [6]	NA	NA	Kidney	1.80E+01	3.2E-02
Chromium, Filtered	2 [8]	NA	NA	NA	1.10E+02	1.8E-02
Manganese, Filtered	504 [7]	NA	NA	CNS	8.80E+02	5.7E-01
Zinc, Filtered	265 [9]	NA	NA	Blood	1.1E+04	2.4E-02
		Total Carcinogenic Risk	6.98E-04		Total HI	3.5E+00

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS.
5 - PRG is shaded if EPC exceeds one-tenth the PRG.
6 - Student-t or Modified-t UCL.
7 - Approximate Gamma 95% UCL.
8 - Maximum Concentration.
9 - 99% Chebyshev UCL.

Target Organ HIs

Skin =	2.9E+00
CVS =	2.9E+00
Kidney =	5.5E-02
CNS =	5.7E-01
Blood =	2.4E-02

Abbreviations:

µg/L = micrograms per liter
EPC = Exposure Point Concentration.
CNS = Central nervous system.
CVS = Cardiovascular system.
HI = Hazard Index.
HQ = Hazard Quotient.
ILCR = Incremental Lifetime Cancer Risk.
IRIS = ntegrated Risk Information System.
NA = Not applicable.
PRG = Preliminary Remediation Goal.
UCL = Upper confidence level.

TABLE 1-9

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (UNFILTERED SAMPLES)
WELL GROUP NO. 4 (06C15)
BIG CLIFTY/BEECH CREEK
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
2,4,6-Trinitrotoluene	7 [6]	2.20E+00	3.18E-06	Liver	1.80E+01	3.9E-01
Barium	29.3 [7]	NA	NA	Kidney	2.60E+03	1.1E-02
Chromium	0.71 [8]	NA	NA	NA	1.10E+02	6.5E-03
Iron	462 [8]	NA	NA	GI[9]	1.10E+04	4.2E-02
Manganese	18.1 [10]	NA	NA	CNS	8.80E+02	2.1E-02
Zinc	179 [11]	NA	NA	Blood	1.1E+04	1.6E-02
		Total Carcinogenic Risk	3.18E-06		Total HI	4.9E-01

Target Organ HIs

Liver =	3.9E-01
Kidney =	1.1E-02
GI =	4.2E-02
CNS =	2.1E-02
Blood =	1.6E-02

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS, unless otherwise noted.
5 - PRG is shaded if EPC exceeds one-tenth the PRG.
6 - 95% Chebyshev UCL.
7 - Student-t.
8 - Maximum Concentration.
9 - Groundwater and Surface Water Cleanup Target Levels for Chapter 62-777, F.A.C., FDEP, April 17, 2005.
10 - Student-t or Modified-t UCL.
11 - 99% Chebyshev UCL.

Abbreviations:

µg/L = micrograms per liter
EPC = Exposure Point Concentration
CNS = Central Nervous System
CVS = Cardiovascular System
GI = Gastrointestinal
F.A.C. = Florida Administrative Code.
FDEP = Florida Department of Environmental Protection
HI = Hazard Index
HQ = Hazard Quotient
ILCR = Incremental Lifetime Cancer Risk
IRIS = ntegrated Risk Information System.
NA = Not Applicable
PRG = Preliminary Remediation Goal
UCL = Upper Confidence Level

TABLE 1-10

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (FILTERED SAMPLES)
06C15
BIG CLIFTY/BEECH CREEK
SWMU 7(OLD RIFLE RANGE)
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
2,4,6-Trinitrotoluene	7 [6]	2.20E+00	3.18E-06	Liver	1.80E+01	3.9E-01
Barium, Filtered	28.9 [7]	NA	NA	Kidney	2.60E+03	1.1E-02
Chromium, Filtered	3.21 [8]	NA	NA	NA	1.10E+02	2.9E-02
Manganese, Filtered	7.82 [8]	NA	NA	CNS	8.80E+02	8.9E-03
Zinc, Filtered	19.8 [6]	NA	NA	Blood	1.1E+04	1.8E-03
		Total Carcinogenic Risk	3.18E-06		Total HI	4.4E-01

Footnotes:
2 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - Integrated Risk Information System (IRIS).
5 - PRG is shaded if EPC exceeds 1/10th the PRG.
1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or 1/10th the noncarcinogenic PRG.
6 - 95% Chebyshev UCL.
7 - Student-t.
8 - Student-t or Modified-t UCL.

Target Organ HIs

Liver =	3.9E-01
Kidney =	1.1E-02
CNS =	8.9E-03
Blood =	1.8E-03

Abbreviations:
µg/L = micrograms per liter
EPC = Exposure Point Concentration.
CNS = Central nervous system.
CVS = Cardiovascular system.
HI = Hazard Index.
HQ = Hazard Quotient.
ILCR = Incremental Lifetime Cancer Risk.
IRIS = ntegrated Risk Information System.
NA = Not applicable.
PRG = Preliminary Remediation Goal.
UCL = Upper confidence level.

TABLE 1-11

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (UNFILTERED SAMPLES)
WELL GROUP NO. 5 (06C11, 06C12, 06C14, 06C16, 06C18, 06C19)
BIG CLIFTY/BEECH CREEK
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,2] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
Arsenic	1.5 [6]	4.50E-02	3.33E-05	Skin, CVS	1.10E+01	1.4E-01
Barium	74.8 [6]	NA	NA	Kidney	2.60E+03	2.9E-02
Cadmium	0.659 [7]	NA	NA	Kidney	1.80E+01	3.7E-02
Chromium	3.08 [7]	NA	NA	NA	1.10E+02	2.8E-02
Iron	2159 [8]	NA	NA	GI[9]	1.10E+04	2.0E-01
Manganese	261 [10]	NA	NA	CNS	8.80E+02	3.0E-01
Zinc	31.7 [6]	NA	NA	Blood	1.1E+04	2.9E-03
		Total Carcinogenic Risk	3.33E-05		Total HI	7.3E-01

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS, unless otherwise noted.
5 - PRG is shaded if EPC exceeds one-tenth the PRG.
6 - 95% Chebyshev UCL.
7 - Student-t or Modified-t UCL.
8 - Student-t.
9 - Groundwater and Surface Water Cleanup Target Levels for Chapter 62-777, F.A.C., Florida Department of Environmental Protection (FDEP), April 17, 2005.
10 - 97.5% Chebyshev UCL.

Target Organ HIs

Skin =	1.4E-01
CVS =	1.4E-01
Kidney =	6.5E-02
GI =	2.0E-01
CNS =	3.0E-01
Blood =	2.9E-03

Abbreviations:

µg/L = micrograms per liter
EPC = Exposure Point Concentration
CNS = Central Nervous System
CVS = Cardiovascular System
GI = Gastrointestinal
F.A.C. = Florida Administrative Code.
FDEP = Florida Department of Environmental Protection
HI = Hazard Index
HQ = Hazard Quotient
ILCR = Incremental Lifetime Cancer Risk
IRIS = ntegrated Risk Information System.
NA = Not Applicable
PRG = Preliminary Remediation Goal
UCL = Upper Confidence Level

TABLE 1-12

HUMAN HEALTH RISK EVALUATION OF DOMESTIC USE OF GROUNDWATER (FILTERED SAMPLES)
WELL GROUP NO. 5 (06C11, 06C12, 06C14, 06C16, 06C18, 06C19)
BIG CLIFTY/BEECH CREEK
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Parameter[1]	Exposure Point Concentration (µg/L)	Incremental Lifetime Carcinogenic Risk (ILCR)		Estimated Non-Carcinogenic Hazard Quotient (HQ)		
		PRG - Tap Water[2,3] (µg/L)	Estimated ILCR	Primary Target Organs[4]	PRG - Tap Water[2,5] (µg/L)	Estimated HQ
Arsenic, Filtered	1.32 [6]	4.50E-02	2.93E-05	Skin, CVS	1.10E+01	1.2E-01
Barium, Filtered	74.5 [6]	NA	NA	Kidney	2.60E+03	2.9E-02
Cadmium, Filtered	0.514 [7]	NA	NA	Kidney	1.80E+01	2.9E-02
Chromium, Filtered	3.97 [6]	NA	NA	NA	1.10E+02	3.6E-02
Manganese, Filtered	275 [8]	NA	NA	CNS	8.80E+02	3.1E-01
Zinc, Filtered	35.9 [6]	NA	NA	Blood	1.1E+04	3.3E-03
		Total Carcinogenic Risk	2.93E-05		Total HI	5.3E-01

Footnotes:

1 - Analyte name is shaded if EPC is greater than the carcinogenic and/or one-tenth the non-carcinogenic PRG.
2 - Region IX - PRGs Tables, October 2004.
3 - PRG is shaded if the EPC exceeds the PRG.
4 - Primary Target Organs - IRIS.
5 - PRG is shaded if EPC exceeds one-tenth the PRG.
6 - 95% Chebyshev UCL.
7 - Student-t or Modified-t UCL.
8 - 97.5 Chebyshev UCL.

Target Organ HIs

Skin =	1.2E-01
CVS =	1.2E-01
Kidney =	5.7E-02
CNS =	3.1E-01
Blood =	3.3E-03

Abbreviations:

µg/L = micrograms per liter
EPC = Exposure Point Concentration.
CNS = Central nervous system.
CVS = Cardiovascular system.
HI = Hazard Index.
HQ = Hazard Quotient.
ILCR = Incremental Lifetime Cancer Risk.
IRIS = ntegrated Risk Information System.
NA = Not applicable.
PRG = Preliminary Remediation Goal.
UCL = Upper confidence level.

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APPENDIX A

2000 THROUGH 2004 SUMMARY
OF
ANNUAL GROUNDWATER MONITORING REPORT

NAVSEA

CRANE

Surface Warfare Center Division

ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2000

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: December 16, 2002

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8.2 Old Rifle Range

The well network at the ORR monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections, by quarter, for the upper Big Clifty monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Detections in the upper Big Clifty were mainly metals and other inorganics. Samples were analyzed for organic compounds in only the second quarter. Detections of organics were limited to Bis(2-ethylhexyl)phthalate in two wells. Bis(2-ethylhexyl)phthalate is a common lab contaminant. The lab QC blank associated with the sample for well 06C11P2 indicates that the detection is likely a lab artifact (Table 6.2.3). No explosives were detected in any of the four quarters. Barium and manganese were the most frequently detected metals (100% of samples), often at levels above the RBTL (100% and 75%, respectively). Other metals detected include arsenic, cadmium, selenium, and antimony.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Like the upper wells, barium and manganese were frequently detected (100% and 78% of samples, respectively), often above the RBTL (100% and 61% of samples, respectively). Arsenic was also detected with some frequency (53% of samples), however, above the RBTL less frequently (19% of samples). Other metals detected more than twice include antimony, zinc, cadmium, copper, and selenium. Detections of organics were limited to Bis(2-ethylhexyl)phthalate in well 06C18 in only the second quarter. Detections of explosives at the ORR were limited mostly to well 06C15. Three compounds were detected in well 06C15 in both the third and fourth quarters: TNT, 2-Amino-4,6-dinitrotoluene, and 4-Amino-2,6-dinitrotoluene. Of the detections of explosives, only TNT exceeded the RBTL.

ORR results were evaluated to determine which constituents were statistically higher than background (Section 7.0). Table 8.2 shows the ORR results that were significantly high and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives

as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Constituents that exceeded both thresholds in ORR wells were limited to the metals arsenic, barium, cadmium, zinc, iron, and manganese.

RDX and HMX were not detected in any ORR well in the quarterly sampling of 2000. TNT was detected all four quarters in one well, 06C15, at concentrations greater than the RBTL. However, the TNT concentrations were not significantly higher than background. Nitro-toluene daughter compounds were also consistently detected in well 06C15, specifically 2-Amino-4, 6-dinitrotoluene and 4-Amino-2, 6-dinitrotoluene. The presence of the nitro-toluene daughter products indicates that some natural attenuation is occurring in the system. The concentrations of 2-Amino-4, 6-dinitrotoluene and 4-Amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 μg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.1 for well references). Barium concentrations in the upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.5 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2). Four of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C13, 06C16, 06C18) and the downgradient well 06C19 had barium concentrations greater than the RBTL and significantly higher than background. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, we did not have soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 μg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19) In addition to exceeding the RBTL, concentrations in each of these five wells were significantly higher than background (Table 8.2). Manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (03C11P2, 03C13P2, 03C18P2, 03C19P2) (Figure 8.2.12 and Table 8.2).

Arsenic was found above the RBTL of 2 μg/L in two of the Big Clifty/Beech Creek POC well, 06C13 and 06C11, and the downgradient well 06C19 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C13P2 and 06C18P2 had concentrations greater than the RBTL. Of the arsenic exceedances, results from POC wells 06C13P2, 06C13, 06C18P2 and downgradient well 06C19P2 were significantly higher than background (Table 8.2).

Table 8.2 Old Rifle Range Monitoring Points with results exceeding RBTL and statistically higher than background. [C, Compliance; DG, Downgradient]

Parameter	Well	MP Objective	RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium	06C18P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
Cadmium	06C18P2	C		X		
Zinc (filtered)	06C13P2	C		X		
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Old Rifle Range – Big Clifty/Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Zinc	06C14	C				X
	06C15	C				X
Iron	06C18	C		X		
Manganese	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese (filtered)	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X

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ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2001

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
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Report date: December 16, 2002
Binder 2 of 2

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8.2 Old Rifle Range

The well network at the ORR monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections, by quarter, for the upper Big Clifty monitoring wells at the ORR. For associated lab qualifiers, please see Tables 6.2.1 – 6.2.5. Values that exceeded the Risked-Based Target Level are flagged. Detections in the upper Big Clifty were predominantly metals and other inorganics. Samples were analyzed for organic compounds in only the second quarter. Detections of organics were limited to Total Organic Carbon (TOC) and Total Organic Halogens (TOX). No explosives were detected in any of the four quarters. Barium and manganese were the most frequently detected metals (100% and 85% of samples), usually at levels above the RBTL (100% and 80% of samples, respectively). Other metals detected in at least 25% of the samples include arsenic, cadmium, selenium, and antimony.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the Risked-Based Target Level are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Similar to results in the upper Big Clifty wells, barium and manganese were frequently detected (100% and 74% of samples, respectively), often above the RBTL (100% and 58% of samples, respectively). Arsenic was also detected with some frequency (49% of samples), however, above the RBTL less frequently (19% of samples) than barium and manganese. Other metals detected in at least 25% of samples include antimony, chromium, copper, nickel, and zinc. With the exception of TOC and TOX, detections of organics were limited to Bis(2-ethylhexyl)phthalate in one sample from well 06C12. Bis(2-ethylhexyl)phthalate is a common lab contaminant. However, quality control samples associated with the analysis do not indicate lab contamination. Detections of explosives at the ORR were limited to well 06C15. Two compounds were detected in three quarters (and a field duplicate) in well 06C15: 2-Amino-4,6-dinitrotoluene, and 4-Amino-2,6-dinitrotoluene. Two other compounds were detected in well 06C15: TNT (three of four quarters) and 1,3,5-Trinitrobenzene (two of four quarters). Only the three detections of TNT exceeded a RBTL.

ORR results were evaluated to determine which constituents were statistically higher than background (Section 7.0). Table 8.2 shows the ORR results that were significantly high and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Inorganics that exceeded both thresholds in ORR wells were limited to the metals arsenic, barium, zinc, and manganese.

As mentioned above, detection of explosives at the ORR in 2001 was predominantly nitrotoluene daughter compounds in one well, 06C15. Well 06C15 is located in the northern portion of the ORR. RDX and HMX were not detected in any ORR well in the quarterly sampling of 2001. TNT was detected above the RBTL in three samples from well 06C15, and all three results were significantly higher than background. No explosives were found in the upgradient well, 03C08. Nitro-toluene daughter compounds were consistently detected in well 06C15, specifically 2-Amino-4, 6-dinitrotoluene and 4-Amino-2, 6-dinitrotoluene. The presence of the nitrotoluene daughter products indicates that some natural attenuation is occurring in the system. The concentrations of 2-Amino-4, 6-dinitrotoluene and 4-Amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 μg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.1 for well references). Barium concentrations in the upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.5 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2). Four of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C13, 06C16, 06C18) and the downgradient well 06C19 had barium concentrations greater than the RBTL and significantly higher than background. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples from the base were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, we did not have soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 μg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19). In addition to exceeding the RBTL in every quarter, concentrations in each of these five wells were significantly higher than background (Table 8.2). Manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (03C11P2, 03C13P2, 03C18P2, 03C19P2) (Figure 8.2.12 and Table 8.2).

Arsenic was found above the RBTL of 2 μg/L in two of the Big Clifty/Beech Creek POC wells, 06C13 and 06C18 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C13P2 and 06C18P2 and downgradient well 06C19P2 had concentrations greater than the RBTL. Of the arsenic exceedances, results were significantly higher than background from POC wells 06C13P2, 06C13, 06C18P2, 06C18, and downgradient well 06C19P2 (Table 8.2).

Table 8.2 Old Rifle Range Monitoring Points with results exceeding RBTL and statistically higher than background. [C = Compliance; DG = Downgradient; MP Objective = type of well]

Parameter	Well	MP Objective	RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	
Barium	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Zinc (filtered)	06C18P2	C				X
Old Rifle Range – Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
	06C18	C			X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese (filtered)	06C11	C	X			
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Zinc (filtered)	06C13	C		X		
Old Rifle Range – Beech Creek Aquifer						
EXPLOSIVES						
2,4,6-Trinitrotoluene	06C15	C		X		X

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ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

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NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
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8.2 Old Rifle Range

The well network at the Old Rifle Range monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections, by quarter, for the upper Big Clifty monitoring wells at the ORR. For associated lab qualifiers, please see Tables 6.2.1–6.2.5. Values that exceeded the RBTL are flagged. Detections in the upper Big Clifty were predominantly metals and other inorganics. Samples were analyzed for organic compounds in only the second quarter. Detections of organics were limited to total organic carbon (TOC) and total organic halogens (TOX). No explosives were detected in any of the four quarters. Barium and manganese were the most frequently detected metals (100% and 85% of samples), usually at levels above the RBTL (100% and 80% of samples, respectively). Other metals detected in at least 25% of the samples include arsenic and antimony.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Barium and manganese were frequently detected (100% and 69% of samples, respectively), often above the RBTL (100% and 58% of samples, respectively). Arsenic was also detected with some frequency (47% of samples), however, above the RBTL less frequently (25% of samples) than barium and manganese. Other metals detected in at least 25% of samples include antimony and zinc. With the exception of TOC and TOX, detections of organics were limited to one detection of 2,4-D. Detections of explosives at the ORR were limited to well 06C15. Explosives detected in well 06C15 include 2,4,6-trinitrotoluene and 1,3,5-trinitrobenzene and degradation products 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene.

The 2002 ORR results were incorporated with the 2000-2001 data and evaluated to determine which constituents were statistically higher than background (Section 7.0). The statistical analysis was done both with and without the outlying data points. Table 8.2.1 shows the ORR results that were significantly high and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Inorganics that exceeded both thresholds in ORR wells were limited to the metals arsenic, barium, zinc, and manganese.

As mentioned above, detection of explosives at the ORR in 2001 was predominantly TNT and nitro-toluene degradation products in one well, 06C15. Similar results were observed in results from quarterly sampling in 2000 and 2001. Well 06C15 is located in the northern portion of the ORR. RDX and HMX were not detected in any ORR well in the quarterly sampling of 2002. TNT was detected above the RBTL in all four samples from well 06C15. Statistical analysis found the TNT results to be significantly higher than background. No explosives were found in the upgradient, background well, 03C08. Nitro-toluene daughter compounds were also consistently detected in well 06C15, specifically 2-amino-4, 6-dinitrotoluene, 4-amino-2, 6-dinitrotoluene, and 1,3,5-Trinitrotoluene. The presence of nitrotoluene daughter products in the wells indicates that some natural attenuation is occurring in the system. The concentrations of 2-amino-4, 6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 μg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.5 for well references). Barium concentrations in the upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.1 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2). Six of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C12, 06C13, 06C16, 06C18, 06C19) had filtered barium concentrations greater than the RBTL and significantly higher than background when the data outliers were removed. Three of the POC wells in the Big Clifty/Beech Creek network (06C13, 06C16, 06C18) had filtered barium concentrations greater than the RBTL and significantly higher than background when the data outliers were not removed. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples from the base were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, we did not have soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 μg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19). In addition to exceeding the RBTL in every quarter, concentrations in each of these five wells were significantly higher than background (Table 8.2). Well 06C11 also exhibited concentrations that exceeded both thresholds. Manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (03C11P2, 03C13P2, 03C18P2, 03C19P2) (Figure 8.2.12 and Table 8.2).

Arsenic was consistently found above the RBTL of 2 μg/L in two of the Big Clifty/Beech Creek POC wells, 06C13 and 06C18 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C11P2, 06C13P2, 06C18P2 and downgradient well 06C19P2 exhibited concentrations greater than the RBTL. Of the arsenic exceedances, results were significantly higher than background in POC wells 06C13P2, 06C13, 06C18P2, and downgradient well 06C19P2

(Table 8.2.1) Old Rifle Range Monitoring Points with results exceeding RBTL and statistically higher than background. [C = Compliance; DG = Downgradient; MP Objective = type of well]

Parameter	Well	MP Objective	2002 RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
Barium (filtered) Outliers Removed	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Selenium (filtered)	06C18P2	C	X			
Old Rifle Range – Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered) Outliers Removed	06C11	C	X	X	X	X
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Silver	06C15	C		X		
Lead	06C11	C				X
Manganese	06C11	C		X		X
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese (filtered)	06C11	C		X		
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X

	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Zinc (filtered)	06C13	C	X	X		
Old Rifle Range – Beech Creek Aquifer						
EXPLOSIVES						
2,4,6-Trinitrotoluene	06C15	C	X	X	X	X

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ANNUAL GROUNDWATER MONITORING REPORT FOR AMMUNITION BURNING GROUNDS, OLD RIFLE RANGE, and DEMO RANGE

CY2003

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: 12 August 2004
Binder 2 of 2

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2003

8.2 Old Rifle Range

The well network at the Old Rifle Range monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections, by quarter, for the upper Big Clifty monitoring wells at the ORR. For associated lab qualifiers, please see Tables 6.2.1–6.2.5. Values that exceeded the RBTL are flagged. Detections in the upper Big Clifty were predominantly metals and other inorganics. Detections of organics were limited to total organic carbon (TOC) and total organic halogens (TOX), with volatile organic compounds sampled only during the second quarter. The only explosive detected was nitrocellulose in two separate wells, one during the first quarter (06C18P2) and one in the second quarter(06C13P2). Barium and manganese were the most frequently detected metals (100% and 80% of samples), usually at levels above the RBTL (100% of samples for both parameters). Other metals detected include arsenic (80% of samples) and dissolved antimony (70% of samples). Ammonia was persistent in all downgradient wells.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Barium and manganese were frequently detected (100% and 64% of samples, respectively), often above the RBTL (100% and 55% of samples, respectively). Arsenic was also detected with some frequency (50% of samples), however, above the RBTL less frequently (22% of samples) than barium and manganese. Dissolved antimony was detected in 64% of samples collected, but none of the results were above the RBTL. Zinc occurred in 28% of samples, 10% of those (1 sample) being above the RBTL. The only detection of organics was the persistent detection of total organic carbon (TOC) in well C13. Detections of explosives at the ORR were limited to 2,4,6-trinitrotoluene and 1,3,5-trinitrobenzene and degradation products 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene. In addition, nitrocellulose was detected in two wells in the second quarter (06C16 and 06C11).

The 2003 ORR results were incorporated with the 2000-2002 data and evaluated to determine which constituents were statistically higher than background (Section 7.0). The statistical analysis was done both with and without the outlying data points. Table

8.2.1 shows the ORR results that were significantly higher than the background well and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Inorganics that exceeded both thresholds in ORR Upper Big Clifty wells were limited to the metals arsenic, barium, and manganese. Wells bottoming in the Beech Creek aquifer exceeded thresholds for arsenic, barium, lead, manganese and zinc, with a single well exceeding the threshold for chromium in the first quarter (06C14). Also, 2,4,6-trinitrotoluene exceeded both thresholds for all four quarters in well C15.

As mentioned above, detection of explosives at the ORR in 2003 was predominantly TNT and nitro-toluene degradation products in one well, 06C15. Similar results were observed in results from quarterly sampling in 2000, 2001 and 2002. Well 06C15 is located in the northern portion of the ORR. RDX and HMX were not detected in any ORR well in the quarterly sampling of 2003. TNT was detected above the RBTL in all four samples from well 06C15. Statistical analysis found the TNT results to be significantly higher than background. No explosives were found in the upgradient, background well, 06C08. Nitro-toluene daughter compounds were also consistently detected in well 06C15, specifically 2-amino-4, 6-dinitrotoluene, 4-amino-2, 6-dinitrotoluene, and 1,3,5-Trinitrotoluene. The presence of nitrotoluene daughter products in the wells indicates that some natural attenuation is occurring in the system. The concentrations of 2-amino-4, 6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 µg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.5 for well references). Barium concentrations in the Upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.1 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2.1). Six of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C12, 06C13, 06C16, 06C18, 06C19) had filtered barium concentrations greater than the RBTL and significantly higher than background when the data outliers were removed. Three of the POC wells in the Big Clifty/Beech Creek network (06C13, 06C16, 06C18) had filtered barium concentrations greater than the RBTL and significantly higher than background when the data outliers were not removed. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples from the base were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, there is no soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 µg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19). In addition to exceeding the RBTL in every quarter, concentrations in each of these five wells were significantly higher than background (Table 8.2.1). Filtered manganese was detected above the RBTL of 50 µg/L consistently in the same five wells.

Manganese (Figure 8.2.12) and filtered manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (06C11P2, 06C13P2, 06C18P2, 06C19P2) (Table 8.2.1).

Arsenic was consistently found above the RBTL of 2 μg/L in Big Clifty/Beech Creek POC well 06C13 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C13P2, 06C18P2 and downgradient well 06C19P2 exhibited concentrations greater than the RBTL. Of the arsenic exceedances, results were significantly higher than background in POC wells 06C13P2, 06C13, 06C18P2, and downgradient well 06C19P2.

(Table 8.2.1) Old Rifle Range Monitoring Points with results exceeding RBTL and statistically higher than background. [C = Compliance; DG = Downgradient; MP Objective = type of well]

Parameter	Well	MP Objective	2002 RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty Aquifer						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Barium	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
Barium (filtered) Outliers Removed	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Old Rifle Range – Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Arsenic (filtered) Outliers Removed	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered) Outliers Removed	06C11	C	X	X	X	X
	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Chromium	06C14	C	X			
Lead	06C11	C	X	X	X	X
	06C14	C	X	X		
Manganese	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X

	06C19	DG	X	X	X	X
Manganese (filtered)	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Zinc (filtered)	06C13	C		X		
Old Rifle Range – Beech Creek Aquifer						
EXPLOSIVES						
2,4,6-Trinitrotoluene	06C15	C	X	X	X	X

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CY2004

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
CRANE, INDIANA

Report date: 29 September 2005

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From Science to Solutions™

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8.2 Old Rifle Range

The well network at the Old Rifle Range monitors the Big Clifty sandstone and the Beech Creek limestone. The two formations are underlain by the Elwren shale aquiclude and are considered one aquifer. One monitoring well network, consisting of five wells, is screened in the upper part of the Big Clifty, including a portion of the thick soil zone that covers the site. The deeper monitoring well network, consisting of nine wells, is screened near the base of the Beech Creek. Comparisons of water levels between paired wells indicate little difference between the upper and lower wells. Groundwater flow through the limestone is primarily through a system of connected joints. The Big Clifty and Beech Creek formations beneath the ORR contain more open discontinuities than the same formations at other sites in the study area (Tetra Tech, 1999).

Metals and explosives were identified as contaminants at the ORR by the USACE sampling in the early 1990's (Murphy, 1995). The USACE identified arsenic, nickel, and manganese as statistically significant contaminants. Barium, copper, and antimony persisted in four rounds of sampling, but were considered naturally occurring or artifacts of sampling. TNT, RDX, and HMX were found "persistently" in five wells on the northern half of the ORR by the USACE.

Figures 8.2.1-8.2.4 show all detections by quarter for the Upper Big Clifty monitoring wells at the ORR. For associated lab qualifiers, please see Tables 6.2.1–6.2.5. Values that exceeded the RBTL are flagged. Detections in the Upper Big Clifty were predominantly metals and other inorganics. Detections of organics were limited to total organic carbon (TOC) and total organic halogens (TOX), with volatile organic compounds sampled only during the fourth quarter. No explosives were detected in any wells in any of the four sampling programs. Barium and manganese were the most frequently detected metals (100% and 95% of samples), usually at levels above the RBTL (100% of samples for both parameters). Other metals detected include total and dissolved arsenic (75% and 70% of samples) and dissolved antimony (22% of samples), which is down from 70% last year. Ammonia was persistent in nearly all downgradient wells.

Figures 8.2.5-8.2.8 show all detections, by quarter, for the Big Clifty/Beech Creek monitoring wells at the ORR. Values that exceeded the RBTL are flagged. Similar to results in the upper wells, detections in the lower wells were mainly metals and other inorganics. Barium and total and dissolved manganese were frequently detected (100%, 64% and 53% of samples, respectively), often above the RBTL (100%, 83% and 84% of samples, respectively). Total and dissolved arsenic was also detected with some frequency (55% and 44% of samples), however, above the RBTL less frequently (45% and 55% of samples) than barium and manganese. Dissolved antimony was detected in 50% of samples collected, but none of the results were above the RBTL. Zinc occurred in 25% of samples, 11% of those (1 sample) being above the RBTL. The only detection of organics was the persistent detection of total organic carbon (TOC) in well C13 and a single positive in well 06C16 in the second quarter. Detections of explosives at the ORR were limited to 2,4,6-trinitrotoluene and 1,3,5-trinitrobenzene and degradation products 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene in well 06C15 in every quarter. 2,4,6-trinitrotoluene was consistently above the RBTL. In addition, nitroglycerin was detected in the second quarter.

The 2004 Old Rifle Range results were evaluated to determine which constituents were

statistically higher than background (Section 7.0). In addition, the newer data was combined with data from 2000-2003 to establish the long term moving average for each constituent. Table 8.2.1 shows the ORR results that were significantly higher than the background well and exceeded an RBTL in at least one of the four quarters. Monitoring point objectives as per the GWMP (Tetra Tech NUS, 1999) are noted in the table. Inorganics that exceeded both thresholds in ORR Upper Big Clifty wells were limited to the metals arsenic, barium, and manganese. Wells bottoming in the Beech Creek aquifer exceeded thresholds for arsenic, barium, lead and manganese. Also, 2,4,6-trinitrotoluene exceeded both thresholds for all four quarters in well C15.

As mentioned above, detection of explosives at the ORR in 2004 was predominantly TNT and nitro-toluene degradation products in one well, 06C15, located in the northern portion of the sampling area. Similar results were observed in results from quarterly sampling in 2000 - 2003. RDX and HMX were not detected in any ORR well in the quarterly sampling for 2004. TNT was detected above the RBTL in all four samples from well 06C15. Statistical analysis found the TNT results to be significantly higher than background. No explosives were found in the upgradient, background well, 06C08. Nitro-toluene daughter compounds were also consistently detected in well 06C15, specifically 2-amino-4, 6-dinitrotoluene, 4-amino-2, 6-dinitrotoluene, and 1,3,5-trinitrotoluene. The presence of nitrotoluene daughter products in the well indicates that some natural attenuation is occurring in the system. The concentrations of 2-amino-4, 6-dinitrotoluene and 4-amino-2, 6-dinitrotoluene were determined to be significantly higher than background. However, these two compounds were not evaluated for inclusion in Table 8.2 because an RBTL has not been established for them due to a lack of risk-based criteria (Tetra Tech NUS, 1999).

Similar to results at the ABG, total and dissolved barium were detected above the RBTL of 3.9 μg/L in all wells in all sampling rounds. Figure 8.2.9 shows the quarterly total barium concentrations in the Big Clifty/Beech Creek aquifer (see Figure 8.2.5 for well references). Barium concentrations in the Upper Big Clifty wells are similar to the concentrations found in the deeper wells (Figure 8.2.10) (see Figure 8.2.1 for well references). However, more of the wells in the deeper network were determined to be significantly higher than background (Table 8.2.1). Four of the POC wells in the Big Clifty/Beech Creek network (06C11, 06C13, 06C16, 06C18) had filtered barium concentrations greater than the RBTL and were significantly higher than background. The wells in the Upper Big Clifty that exceeded both thresholds include two POC wells on the eastern perimeter, 06C13P2 and 06C18P2. Similar to the ABG, elevated barium concentrations at the ORR may be due to natural or background conditions at the site. As discussed previously, results from the Basewide Background Soils Investigation indicated that all of the barium samples from the base were greater than the SRBTL of 1.04 mg/kg. Unlike the ABG, however, there is no soil data specific to the ORR to compare to the background levels.

Manganese was detected above the RBTL of 50 μg/L consistently in five wells screened in the Big Clifty/Beech Creek aquifer (Figure 8.2.11) (06C12, 06C13, 06C14, 06C18, and 06C19). In addition to exceeding the RBTL in every quarter, concentrations in each of these five wells were significantly higher than background (Table 8.2.1). Filtered manganese was detected above the RBTL of 50 μg/L consistently in the same five wells. Manganese (Figure 8.2.12) and filtered manganese concentrations in the upper aquifer exceeded both thresholds in four wells at the eastern edge of the site (06C11P2,

06C13P2, 06C18P2, 06C19P2) (Table 8.2.1).

Total and dissolved arsenic was consistently found above the RBTL of 2 µg/L in Big Clifty/Beech Creek POC well 06C13 (Figure 8.2.13). Similar results were found in the corresponding shallow wells in the Upper Big Clifty network; point of compliance wells 06C13P2, 06C18P2 and downgradient well 06C19P2 exhibited concentrations greater than the RBTL. Of the arsenic exceedances, results were significantly higher than background in POC wells 06C13P2, 06C13, 06C18P2, and downgradient well 06C19P2.

(Table 8.2.1) Old Rifle Range monitoring points with results exceeding RBTL and statistically higher than background. [C = Compliance; DG = Downgradient; MP Objective = type of well]

Parameter	Well	MP Objective	2004 RBTL Exceedances by Quarter			
			1st	2nd	3rd	4th
Old Rifle Range – Upper Big Clifty Aquifer						
METALS						
Arsenic	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Arsenic (filtered)	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Barium	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
Barium (filtered)	06C18P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
Manganese	06C11P2	C	X	X	X	X
	06C13P2	C	X	X	X	X
	06C18P2	C	X	X	X	X
	06C19P2	DG	X	X	X	X
Manganese (filtered)	06C11P2	C	X	X	X	X
	06C13P2	C	X		X	X
	06C18P2	C	X		X	X
	06C19P2	DG	X	X	X	X
Old Rifle Range – Big Clifty/Beech Creek Aquifer						
METALS						
Arsenic	06C13	C	X	X	X	X
Arsenic (filtered)	06C13	C	X	X	X	X
Barium	06C11	C	X	X	X	X
	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Barium (filtered)	06C13	C	X	X	X	X
	06C16	C	X	X	X	X
	06C18	C	X	X	X	X
Lead	06C11	C			X	X
	06C14	C	X	X		
Manganese	06C12	C	X	X	X	X
	06C13	C	X	X	X	X
	06C14	C	X	X	X	X
	06C18	C	X	X	X	X
	06C19	DG	X	X	X	X
Manganese (filtered)	06C12	C	X		X	X
	06C13	C	X		X	X
	06C14	C	X		X	X
	06C18	C	X		X	X
	06C19	DG	X	X	X	X
EXPLOSIVES						
2,4,6-Trinitrotoluene	06C15	C	X	X	X	X

9.0 Conclusions

Results from the 2004 quarterly monitoring at the Ammunition Burning Grounds generally agree with previous findings. Metals, explosives, and organic compounds were detected in the Beech Creek Aquifer, often at concentrations above the respective RBTL. Risk-Based Target Limits were commonly exceeded in points of compliance wells. Barium, TCE, and RDX were the most frequently detected compounds at the site. Barium, TCE, and RDX were all found at concentrations above the RBTL in multiple wells on the site. Explosives are migrating offsite by way of the springs. RDX was commonly detected above the RBTL in both springs. HMX was detected frequently in onsite wells and in the springs, but at concentrations well below the RBTL. In addition to RDX and HMX, TNT, and nitro-toluene daughter products of the explosives were also found exiting Spring A in three of the four quarters. The presence of the degradation products indicates that some natural attenuation of explosives is occurring in the system.

Exceedance of an RBTL alone does not trigger action by 40 CFR 264 Subpart F. 40 CFR 264.91(a)(2) requires corrective action under 264.100 whenever an RBTL is exceeded at a POC *and* the concentration is statistically significant compared to background. Points of compliance define the edge of the monitoring zone as outlined in the GWMP. Statistical analysis revealed detections that were significantly higher than background concentrations in ABG POC wells. Constituents that exceeded an RBTL and were statistically significant in one or more POC wells include 1,3,5-trinitrobenzene, RDX, arsenic, barium, lead, zinc, 1,2-dichloroethane, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, and TCE.

Barium, Trichloroethene, and RDX were the constituents with the highest number of significant exceedances in ABG POC wells. All the other constituents listed above exceeded the RBTL and met the statistical threshold in no more than two POC sites. RDX and TCE may pose the most serious threat of offsite migration at the ABG. RDX exceeded the concentration and statistical thresholds in four ABG POC wells as well as Spring A. However, the number of sites exceeding both thresholds for RDX has decreased each year from 2000 to 2002, but remained the same for 2003 and 2004.

The number of ABG wells exceeding both thresholds for TCE decreased sharply from 2001 when ten wells were found to have concentrations that exceeded both the concentration and statistical threshold. In 2002, only two wells exceeded both thresholds. 2003 saw an increase to seven wells, but in 2004 the results were down to three wells. The decrease in the number of wells exceeding both thresholds for RDX and TCE evident in the 2004 data may be due to natural attenuation.

Barium exceeded both thresholds in nine POC wells and both springs. Historic activities at the ABG could have contributed to the elevated presence of barium in groundwater underlying the site. Items have been burned at the unit that contained barium sulfate, an inert filler for projectiles and flares, known as "Salt-Load". The barium results may be due to natural or background conditions at the site. Results from the Basewide Background Soils Investigation (TtNUS, 2001) indicated that background samples were all greater than the SRBTL. However, comparisons of soil barium concentrations measured at the site with the Background Soils Investigation results shows that surface and subsurface soil concentrations at the site are generally greater than found basewide.

Detected constituents at the Old Rifle Range were predominantly metals. Elevated barium concentrations were ubiquitous in both well networks at the ORR. Similar to the ABG, the results may be due to natural or background conditions at the site. Other metals detected with some frequency at the ORR included manganese and arsenic. Previous work at the ORR showed the persistence of TNT, RDX, and HMX. Detections of these parent compounds in 2004 were limited to TNT in Well 06C15, as was the case in 2002 and 2003. In addition, nitro-toluene daughter products were also detected in Well 06C15.

Constituents that exceeded an RBTL and were statistically significant in one or more ORR POC wells include arsenic, barium, manganese, and lead. Manganese and barium were the constituents with the highest number of significant exceedances in ORR POC wells. Manganese exceeded the RBTL and statistical threshold in POC Wells 06C11P2, 06C13P2, 06C18P2, 06C12, 06C13, 06C14, and 06C18 as well as the downgradient Wells 06C19 and 06C19P2. Barium exceeded the RBTL and statistical threshold in POC wells 06C13P2, 06C18P2, 06C11, 06C13, 06C16, and 06C18.

Previous work at the Demolition Range showed the persistence of metals. Results at the DR generally agree with the historic data. Detections in DR monitoring wells were predominately metals. Similar to the ABG and ORR, elevated barium concentrations were ubiquitous in both well networks at the DR. As is the case with the other sites, the results may be due to natural or background conditions.

Constituents that exceeded an RBTL and were statistically significant in one or more DR POC wells include arsenic, barium, and manganese. Historically, as noted in the Groundwater Monitoring Plan, Wells 06C06 and 06C07 were found to have the highest number of statistical exceedances. Results from 2004 indicate that POC Well 06C03 exhibited the most exceedances of both the concentration and statistical thresholds. Barium was the constituent with the highest number of significant exceedances in DR POC wells. Point of compliance wells with total barium concentrations that exceeded both thresholds includes 06C03P2, 06C04P2, 06C04 and 06C07. POC wells with dissolved barium concentrations that exceeded both thresholds include 06C02, 06C03, 06C04, 06C05, 06C07, 06C03P2 and 06C04P2. Total and dissolved manganese exceeded the RBTL and statistical threshold in three POC wells, including 06C02, 06C03, and 06C04.

APPENDIX B

USERS' GUIDE AND BACKGROUND TECHNICAL DOCUMENT FOR U.S. EPA REGION 9'S PRELIMINARY REMEDIATION GOALS (PRGS) TABLE

USERS' GUIDE AND BACKGROUND TECHNICAL DOCUMENT FOR USEPA REGION 9'S PRELIMINARY REMEDIATION GOALS (PRG) TABLE

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DISCLAIMER

Preliminary remediation goals (PRGs) focus on common exposure pathways and may not consider all exposure pathways encountered at CERCLA / RCRA sites (Exhibit 1-1). PRGs do not consider impact to groundwater or address ecological concerns. The PRG Table is specifically not intended as a (1) stand-alone decision-making tool, (2) as a substitute for EPA guidance for preparing baseline risk assessments, (3) a rule to determine if a waste is hazardous under RCRA, or (4) set of final cleanup or action levels to be applied at contaminated sites.

The guidance set out in this document is not final Agency action. It is not intended, nor can it be relied upon to create any rights enforceable by any party in litigation with the United States. EPA officials may decide to follow the guidance provided herein, or act at variance with the guidance, based on an analysis of specific circumstances. The Agency also reserves the right to change this guidance at any time without public notice.

1.0 INTRODUCTION

Region 9 Preliminary Remediation Goals (PRGs) are risk-based tools for evaluating and cleaning up contaminated sites. They are being used to streamline and standardize all stages of the risk decision-making process.

The Region 9 PRG Table combines current human health toxicity values with standard exposure factors to estimate contaminant concentrations in environmental media (soil, air, and water) that are considered by the Agency to be health protective of human exposures (including sensitive groups), over a lifetime. Chemical concentrations above these levels would not automatically designate a site as "dirty" or trigger a response action. However, exceeding a PRG suggests that further evaluation of the potential risks that may be posed by site contaminants is appropriate. Further evaluation may include additional sampling, consideration of ambient levels in the environment, or a reassessment of the assumptions contained in these screening-level estimates (e.g. appropriateness of route-to-route extrapolations, appropriateness of using chronic toxicity values to evaluate childhood exposures, appropriateness of generic exposure factors for a specific site etc.).

The risk-based concentrations presented in the Table may be used as screening goals or initial cleanup goals if applicable. Generally a screening goal is intended to provide health protection without knowledge of the specific exposure conditions at a site. PRGs may also be used as initial cleanup goals when the exposure assumptions based on site-specific data match up with the default exposure assumptions in the PRG Table. When considering PRGs as cleanup goals, it is EPA's preference to assume maximum beneficial use of a property (that is, residential use) unless a non-residential number (for example, industrial soil PRG) can be justified.

Before applying PRGs at a particular site, the Table user should consider whether the exposure pathways and exposure scenarios at the site are fully accounted for in the PRG calculations. Region 9 PRG concentrations are based on direct contact pathways for which generally accepted methods, models, and assumptions have been developed (i.e. ingestion, dermal contact, and inhalation) for specific land-use conditions and do not consider impact to groundwater or ecological receptors (see Developing a Conceptual Site Model below).

EXHIBIT 1-1
TYPICAL EXPOSURE PATHWAYS BY MEDIUM
FOR RESIDENTIAL AND INDUSTRIAL LAND USES[a]

EXPOSURE PATHWAYS, ASSUMING:		
MEDIUM	RESIDENTIAL LAND USE	INDUSTRIAL LAND USE
Ground Water	***Ingestion from drinking***	Ingestion from drinking
	Inhalation of volatiles	Inhalation of volatiles
	Dermal absorption from bathing	Dermal absorption
Surface Water	***Ingestion from drinking***	Ingestion from drinking
	Inhalation of volatiles	Inhalation of volatiles
	Dermal absorption from bathing	Dermal absorption
	Ingestion during swimming	
	Ingestion of contaminated fish	
Soil	***Ingestion***	***Ingestion***
	Inhalation of particulates	***Inhalation of particulates***
	Inhalation of volatiles	***Inhalation of volatiles***
	Exposure to indoor air from soil gas	Exposure to indoor air from soil gas
	Exposure to ground water contaminated by soil leachate	Exposure to ground water contaminated by soil leachate
	Ingestion via plant, meat, or dairy products	Inhalation of particulates from trucks and heavy equipment
	Dermal absorption	***Dermal absorption***

Footnote:
[a]Exposure pathways considered in the PRG calculations are indicated in boldface italics.

2.0 READING THE PRG TABLE

2.1 General Considerations

With the exceptions described below, PRGs are chemical concentrations that correspond to fixed levels of risk (i.e. either a one-in-one million [10^{-6}] cancer risk or a noncarcinogenic hazard quotient of 1) in soil, air, and water. In most cases, where a substance causes both cancer and noncancer (systemic) effects, the 10^{-6} cancer risk will result in a more stringent criteria and consequently this value is presented in the printed copy of the Table. PRG concentrations that equate to a 10^{-6} cancer risk are indicated by "ca". PRG concentrations that equate to a hazard quotient of 1 for noncarcinogenic concerns are indicated by "nc".

If the risk-based concentrations are to be used for site screening, it is recommended that both cancer and noncancer-based PRGs be used. Both carcinogenic and noncarcinogenic values may be obtained at the Region 9 PRG homepage at:

http://www.epa.gov/region09/waste/sfund/prg/

It has come to my attention that some users have been multiplying the cancer PRG concentrations by 10 or 100 to set "action levels" for triggering remediation or to set less stringent cleanup levels for a specific site after considering non-risk-based factors such as ambient levels, detection limits, or technological feasibility. This risk management practice recognizes that there may be a range of values that may be "acceptable" for carcinogenic risk (EPA's risk management range is one-in-a-million [10^{-6}] to one-in-ten thousand [10^{-4}]). However, this practice could lead one to overlook serious noncancer health threats and it is strongly recommended that the user consult with a toxicologist or regional risk assessor before doing this. For carcinogens, I have indicated by asterisk ("ca*") in the PRG Table where the noncancer PRGs would be exceeded if the cancer value that is displayed is multiplied by 100. Two stars ("ca**") indicate that the noncancer values would be exceeded if the cancer PRG were multiplied by 10. There is no range of "acceptable" noncarcinogenic "risk" so that under no circumstances should noncancer PRGs be multiplied by 10 or 100, when setting final cleanup criteria. In the rare case where noncancer PRGs are more stringent than cancer PRGs set at one-in-one-million risk, a similar approach has been applied (e.g. "nc**").

In general, PRG concentrations in the printed Table are risk-based but for soil there are two important exceptions: (1) for several volatile chemicals, PRGs are based on the soil saturation equation ("sat") and (2) for relatively less toxic inorganic and semivolatile contaminants, a non-risk based "ceiling limit" concentration is given as 10^{+5} mg/kg ("max"). At the Region 9 PRG website, the risk-based calculations for these same chemicals are also available in the "InterCalc Tables" if the user wants to view the risk-based concentrations prior to the application of "sat" or "max". For more information on why the "sat" value and not a risk-based value is presented for several volatile chemicals in the PRG Table, please see the discussion in Section 4.6.

With respect to applying a "ceiling limit" for chemicals other than volatiles, it is recognized that

this is not a universally accepted approach. Some within the agency argue that all values should be risk-based to allow for scaling (for example, if the risk-based PRG is set at a hazard quotient = 1.0, and the user would like to set the hazard quotient to 0.1 to take into account multiple chemicals, then this is as simple as multiplying the risk-based PRG by 1/10th). If scaling is necessary, PRG users can do this simply by referring to the "InterCalc Tables" at our website where risk-based soil concentrations are presented for all chemicals (see soil calculations, "combined" pathways column).

In spite of the fact that applying a ceiling limit is not a universally accepted approach, we have opted to continue applying a "max"soil concentration to the PRG Table for the following reasons:

- Risk-based PRGs for some chemicals in soil exceed unity (>1,000,000 mg/kg) which is not possible.

- The ceiling limit of 10^{+5} mg/kg is equivalent to a chemical representing 10% by weight of the soil sample. At this contaminant concentration (and higher), the assumptions for soil contact may be violated (for example, soil adherence and windborne dispersion assumptions) due to the presence of the foreign substance itself.
- PRGs currently do not address short-term exposures (e.g. pica children and construction workers). Although extremely high soil PRGs are likely to represent relatively non-toxic chemicals, such high values may not be justified if in fact more toxicological data were available for evaluating short-term and/or acute exposures.

In addition to Region 9 PRG values, the PRG Table also includes California EPA PRGs ("CAL-Modified PRGs") for specific chemicals where CAL-EPA screening values may deviate significantly from the federal values (see Section 2.4) and EPA OSWER soil screening levels (SSLs) for protection of groundwater (see Section 2.5).

2.2 Toxicity Values

Hierarchy of Toxicity Values

There is a new hierarchy of human health toxicity values that replaces earlier guidance. This is important because human toxicity values known as cancer slope factors (SF) or non-cancer reference doses (RfDs) form the basis of the PRG values listed in the table. As noted in OSWER Directive 9285.7-53 (dated December 5, 2003), the updated EPA hierarchy is as follows: Tier 1 - EPA's Integrated IRIS, Tier 2 - EPA's Provisional Peer Reviewed Toxicity Values (PPRTVs), and Tier 3 - Other Toxicity Values. Tier 3 includes additional EPA sources (e.g. historic HEAST and NCEA provisional values) and non-EPA sources of toxicity information (e.g. California EPA toxicity values).

The PRG Table lists Tier 1 toxicity values from IRIS as "i" and Tier 2 toxicity values known as PPRTVs as "p". Tier 3 toxicity values were obtained from various sources including California EPA databases "c", historic HEAST tables "h" and NCEA provisional values "n".

Inhalation Conversion Factors

As of January 1991, IRIS and NCEA databases no longer present RfDs or SFs for the inhalation route. These criteria have been replaced with reference concentrations (RfC) for noncarcinogenic effects and unit risk factors (URF) for carcinogenic effects. However, for purposes of estimating risk and calculating risk-based concentrations, inhalation reference doses (RfDi) and inhalation slope factors (SFi) are preferred. This is not a problem for most chemicals because the inhalation toxicity criteria are easily converted. To calculate an RfDi from an RfC, the following equation and assumptions may be used for most chemicals:

$$\text{RfDi}\ \frac{\text{mg}}{(\text{kg-day})} = \text{RfC}(\text{mg}/\text{m}^3) \times \frac{20\text{m}^3}{\text{day}} \times \frac{1}{70\text{kg}}$$

Likewise, to calculate an SFi from an inhalation URF, the following equation and assumptions may be used:

$$\text{SFi}\ \frac{(\text{kg-day})}{(\text{mg})} = \text{URF}(\text{m}^3/\text{ug}) \times \frac{\text{day}}{20\text{m}^3} \times 70\text{kg} \times \frac{10^3\ \text{ug}}{\text{mg}}$$

Route-to-Route Methods

Route-to-route extrapolations ("r") were frequently used when there were no toxicity values available for a given route of exposure. Oral cancer slope factors ("SFo") and reference doses ("RfDo") were used for both oral and inhaled exposures for organic compounds lacking inhalation values. Inhalation slope factors ("SFi") and inhalation reference doses ("RfDi") were used for both inhaled and oral exposures for organic compounds lacking oral values. Route extrapolations were not performed for inorganics due to portal of entry effects and known differences in absorption efficiency for the two routes of exposure.

An additional route extrapolation is the use of oral toxicity values for evaluating dermal exposures. In general, dermal toxicity values are not listed in EPA databases and consequently must be estimated from oral toxicity information. However, a scientifically defensible data base often does not exist for making an adjustment to the oral slope factor/RfD so that the oral toxicity value is often applied without adjustment to estimate a dermal toxicity value. For more information please refer to recent Agency guidance (USEPA 2004) entitled *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* available on the web at: http://www.epa.gov/superfund/programs/risk/ragse/index.htm

Please note that whenever route-extrapolated values are used to calculate risk-based PRGs, additional uncertainties are introduced in the calculation.

2.3 PRGs Derived with Special Considerations

Most of the Region 9 PRGs are readily derived by referring to Equations 4-1 thru 4-8 contained in this "User's Guide/Technical Background Document" to the Region 9 PRGs. However, there are some chemicals for which the standard equations do no apply and/or adjustments to the toxicity values are recommended. These special case chemicals are discussed below.

Cadmium The PRGs for Cadmium are based on the oral RfD for water which is slightly more conservative (by a factor of 2) than the RfD for food. Because the PRGs are considered screening values, we elected to use the more conservative RfD for cadmium. However, reasonable arguments could be made for applying an RfD for food (instead of the oral RfD for water) for some media such as soils.

The water RfD for cadmium assumes a 5% oral absorption factor. The assumption of an oral absorption efficiency of 5% for Cadmium leads to an estimated dermal RfD of 2.5E-05. The PRG calculations incorporate these adjustments per recent guidance (USEPA 2004).

Chromium 6 For Chromium 6 (Cr6), IRIS shows an air unit risk of 1.2E-2 per (ug/cu.m) or expressed as an inhalation cancer slope factor (adjusting for inhalation/body weight) of 42 $(mg/kg\text{-}day)^{-1}$. However, the supporting documentation in the IRIS file states that these toxicity values are based on an assumed 1:6 ratio of Cr6:Cr3. Because of this assumption, we in Region 9 prefer to present PRGs based on these cancer toxicity values as "total chromium" numbers.

In the PRG Table, we also include a Cr6 specific value (assuming 100% Cr6) that is derived by multiplying the "total chromium" value by 7, yielding a cancer potency factor of 290 $(mg/kg\text{-}day)^{-1}$. This is considered to be an overly conservative assumption by some within the Agency. However, this calculation is also consistent with the State of California's interpretation of the Mancuso study that forms the basis of Cr6's toxicity values.

If you are working on a project outside of California (and outside of Region 9), you may want to contact the appropriate regulatory officials to determine what their position is on this issue. As mentioned, Region 9 also includes PRGs for "total chromium" which is based on the same ratio (1:6 ratio Cr6:Cr3) that forms the basis of the cancer slope factor of 42 $(mg/kg\text{-}day)^{-1}$ presented in IRIS.

Dioxin Dioxins, furans, and some polychlorinated biphenyls are members of the same family and exhibit similar toxicological properties. Before using the dioxin PRG at an individual site, these dioxin-related compounds must be summed together. However, they differ in the degree of toxicity so that a toxicity equivalence factor (TEF) must first be applied to adjust the measured concentrations to a toxicity equivalent concentration. EPA Region 9 has adopted the 1997 World Health Organization (WHO) TEFs. For more on this, please refer to the following article (in Environmental Health Perspectives, Vol. 6, No. 12, Dec. 1998) online at: http://ehp.niehs.nih.gov/members/1998/106p775-792vandenberg/vandenberg-full.html

Lead Residential PRGs for Lead (Region 9 EPA and California EPA) are derived based on pharmacokinetic models. Both EPA's Integrated Exposure Uptake Biokinetic (IEUBK) Model and California's LeadSpread model are designed to predict the probable blood lead concentrations for children between six months and seven years of age who have been exposed to lead through various sources (air, water, soil, dust, diet and *in utero* contributions from the mother). Run in the reverse, these models also allow the user to calculate lead PRGs that are considered "acceptable" by EPA or the State of California.

EPA uses a second Adult Lead Model to estimate PRGs for an industrial setting. This PRG is intended to protect a fetus that may be carried by a pregnant female worker. It is assumed that a cleanup goal that is protective of a fetus will also afford protection for male or female adult workers. The model equations were developed to calculate cleanup goals such that there would be no more than a 5% probability that fetuses exposed to lead would exceed a blood lead (PbB) of 10 g/dL. An updated screening level for soil lead at commercial/industrial (i.e., non-residential) sites of 800 ppm is based on a recent analysis of the combined phases of NHANES III that chooses a cleanup goal protective of all subpopulations.

For more information on EPA's lead models and other lead-related topics, please go to:
http://www.epa.gov/oerrpage/superfund/programs/lead/

For more information on California's LeadSpread Model and Cal-Modified PRGs for lead, please go to:
http://www.dtsc.ca.gov/ScienceTechnology/ledspred.html

Manganese The IRIS RfD (0.14 mg/kg-day) includes manganese from all sources, including diet. The author of the IRIS assessment for manganese recommends that the dietary contribution from the normal U.S. diet (an upper limit of 5 mg/day) be subtracted when evaluating non-food (e.g. drinking water or soil) exposures to manganese, leading to a RfD of 0.071 mg/kg-day for non-food items. The explanatory text in IRIS further recommends using a modifying factor of 3 when calculating risks associated with non-food sources due to a number of uncertainties that are discussed in the IRIS file for manganese, leading to a RfD of 0.024 mg/kg-day. This modified RfD is applied in the derivation of the Region 9 PRGs for soil and water. For more information regarding the Manganese RfD, you may want to contact Dr. Bob Benson at (303) 312-7070.

Nitrates/Nitrates Tap water PRGs for Nitrates/Nitrites are based on the MCL as there is no available RfD for these compounds. For more information, please see IRIS at:
http://www.epa.gov/iriswebp/iris/index.html

Thallium IRIS has many values for the different salts of thallium. However, our analytical data packages typically report "thallium". Therefore, as a practical matter it makes more sense to report a PRG for plain thallium. We have done this by making the adjustment contained in the IRIS file for thallium sulfate based on the molecular weight of the thallium in the thallium salt. The adjusted oral RfD for plain thallium is 6.6 E-05 mg/kg-day which we use to calculate a thallium PRG.

Vinyl Chloride In EPA's recent reassessment of vinyl chloride toxicity, IRIS presents two cancer slope factors for vinyl chloride (VC): one that is intended to be applied towards evaluating adult risks and a second more protective slope factor that takes into account the unique susceptibility of developing infants and young children. For residential PRGs, the Region 9 PRG Table applies the more conservative cancer potency factor that addresses exposures to both children and adults whereas for the industrial soils PRG, the adult only cancer slope factor is applied.

Because of the age-dependent vulnerability associated with vinyl chloride exposures, and due to the method that is applied in deriving the cancer slope factor for VC, an assumption of a 70 year exposure over the lifetime is assumed, consistent with the way that the toxicity value for VC was derived. Therefore, instead of the usual exposure assumption of 6 years as a child and 24 years as an adult that is assumed for carcinogenic substances, we have revised the exposure assumption for VC to 6 years as a child and 64 years as adult. Since most of the cancer risk is associated with the first 30 years of exposure to VC, there is actually little difference between a 30 year exposure assumption (typically assumed for Superfund risk assessments) and the 70 year exposure assumption that is assumed in calculating the PRG for VC.

2.4 Cal-Modified PRGs

When EPA Region 9 first came out with a Draft of the PRG Table in 1992, there was concern expressed by California EPA's Department of Toxic Substances and Control (DTSC) that for some chemicals, the risk-based concentrations that are calculated using Cal-EPA toxicity values are "significantly" more protective than the risk-based concentrations that are calculated using EPA toxicity values. Because the risk-based PRGs are order-of-magnitude estimates at best, it was agreed by both Agencies that a difference of approximately 4 or greater would be regarded as a significant difference. For chemicals with California and EPA values that differ by a factor of 4 or more, both the EPA PRGs and the "Cal-Modified PRGs" are listed in the Table.

Please note that in the State of California, Cal-Modified PRGs should be used as screening levels for contaminated sites if they are more stringent than the Federal numbers.

2.5 Soil Screening Levels

Generic, soil screening levels (SSLs) for the protection of groundwater have been included in the PRG Table for 100 of the most common contaminants at Superfund sites. Generic SSLs are derived using default values in standardized equations presented in EPA OSWER's *Soil Screening Guidance* series, available on the web at http://www.epa.gov/superfund/resources/soil/index.htm .

The SSLs were developed using a default dilution-attenuation factor (DAF) of 20 to account for natural processes that reduce contaminant concentrations in the subsurface. Also included are generic SSLs that assume no dilution or attenuation between the source and the receptor well (i.e., a DAF of 1). These values can be used at sites where little or no dilution or attenuation of soil leachate concentrations is expected at a site (e.g., sites with shallow water tables, fractured media, karst topography, or source size greater than 30 acres).

In general, if an SSL is not exceeded for the migration to groundwater pathway, the user may eliminate this pathway from further investigation.

It should be noted that in the State of California, the California Regional Water Quality Control Board has derived "California SSLs" for a number of pathways including migration to groundwater. These are not included in the Region 9 PRG Table, but may be accessed at the following website:

http://www.swrcb.ca.gov/rwqcb2/rbsl.htm

Or, for more information on the "California SSLs", please contact Dr Roger Brewer at: (510) 622-2374.

2.6 Miscellaneous

Volatile organic compounds (VOCs) are indicated by "y" in the VOC column of the Table and in general, are defined as those chemicals having a Henry's Law constant greater than 10^{-5} (atm-m^3/mol) and a molecular weight less than 200 g/mole). Three borderline chemicals (dibromochloromethane, 1,2-dibromochloropropane, and pyrene) which do not strictly meet these criteria of volatility have also been included based upon discussions with other state and federal agencies and after a consideration of vapor pressure characteristics etc. Volatile organic chemicals are evaluated for potential volatilization from soil/water to air using volatilization factors (see Section 4.4).

Chemical-specific dermal absorption values for contaminants in soil and dust are presented for arsenic, cadmium, chlordane, 2,4-D, DDT, lindane, TCDD, PAHs, PCBs, and pentachlorophenols as recommended in the *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance* (USEPA 2004). Otherwise, default skin absorption fractions are assumed to be 0.10 for nonvolatile organics. Please note that previous defaults of 0.01 and 0.10 for inorganics and VOCs respectively, have been withdrawn per new guidance.

3.0 USE OF PRGS AT SITES

The decision to use PRGs at a site will be driven by the potential benefits of having generic risk-based concentrations in the absence of site-specific risk assessments. The original intended use of PRGs was to provide initial cleanup goals for individual chemicals given specific medium and land-use combinations (see RAGS Part B, 1991), however risk-based concentrations have several applications. They can also be used for:

- Setting health-based detection limits for chemicals of potential concern
- Screening sites to determine whether further evaluation is appropriate
- Calculating cumulative risks associated with multiple contaminants

A few basic procedures are recommended for using PRGs properly. These are briefly described below. Potential problems with the use of PRGs are also identified.

3.1 Conceptual Site Model

The primary condition for use of PRGs is that exposure pathways of concern and conditions at the site match those taken into account by the PRG framework. Thus, it is always necessary to develop a conceptual site model (CSM) to identify likely contaminant source areas, exposure pathways, and potential receptors. This information can be used to determine the applicability of PRGs at the site and the need for additional information. For those pathways not covered by PRGs, a risk assessment specific to these additional pathways may be necessary. Nonetheless, the PRG lookup values will still be useful in such situations for focusing further investigative efforts on the exposure pathways not addressed.

To develop a site-specific CSM, perform an extensive records search and compile existing data (e.g. available site sampling data, historical records, aerial photographs, and hydrogeologic information). Once this information is obtained, CSM worksheets such as those provided in ASTM's *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (1995) can be used to tailor the generic worksheet model to a site-specific CSM. The final CSM diagram represents linkages among contaminant sources, release mechanisms, exposure pathways and routes and receptors. It summarizes our understanding of the contamination problem.

As a final check, the CSM should answer the following questions:

- Are there potential ecological concerns?
- Is there potential for land use other than those covered by the PRGs (that is, residential and industrial)?
- Are there other likely human exposure pathways that were not considered in development of the PRGs (e.g. impact to groundwater, local fish consumption, raising beef, dairy, or other livestock)?
- Are there unusual site conditions (e.g. large areas of contamination, high fugitive dust levels, potential for indoor air contamination)?

If any of these four conditions exist, the PRG may need to be adjusted to reflect this new information. Suggested websites for the evaluation of pathways not currently addressed by Region 9 PRG's are presented in Exhibit 3-1.

EXHIBIT 3-1
SUGGESTED WEBSITES FOR EVALUATING EXPOSURE PATHWAYS NOT CURRENTLY ADDRESSED BY REGION 9 PRGs

EXPOSURE PATHWAY	WEBSITE
Migration of contaminants to an underlying potable aquifer	EPA Soil Screening Guidance: http://www.epa.gov/superfund/resources/soil/index.htm California Water Board Guidance: http://www.swrcb.ca.gov/rwqcb2/rbsl.htm
Ingestion via plant uptake	EPA Soil Screening Guidance: http://www.epa.gov/superfund/resources/soil/index.htm EPA Fertilizer Risk Assessment: http://www.epa.gov/epaoswer/hazwaste/recycle/fertiliz/risk/
Ingestion via meat, dairy products, human milk	EPA Protocol for Combustion Facilities: http://www.epa.gov/epaoswer/hazwaste/combust/riskvol.htm#volume1 California "Hot Spots" Risk Guidelines: http://www.oehha.ca.gov/air/hot_spots/HRSguide.html
Inhalation of volatiles that have migrated into basements or other enclosed spaces.	EPA's draft Subsurface Vapor Intrusion Guidance: http://www.epa.gov/correctiveaction/eis/vapor.htm EPA's Version of Johnson & Ettinger Model: http://www.epa.gov/oerrpage/superfund/programs/risk/airmodel/johnson_ettinger.htm
Ecological pathways	EPA Ecological Soil Screening Guidance: http://www.epa.gov/superfund/programs/risk/ecorisk/ecossl.htm NOAA Sediment Screening Table: http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html

3.2 Background Levels Evaluation

A necessary step in determining the applicability of Region 9 risk-based PRGs is the consideration of background contaminant concentrations. There is new EPA guidance on determining background at sites. *Guidance for Characterizing Background Chemicals in Soil at Superfund Sites* (USEPA 2001b) is available on the web at: http://www.epa.gov/superfund/programs/risk/background.pdf .

EPA may be concerned with two types of background at sites: naturally occurring and

anthropogenic. Natural background is usually limited to metals whereas anthropogenic (i.e. human-made) "background" includes both organic and inorganic contaminants. Before embarking on an extensive sampling and analysis program to determine local background concentrations in the area, one should first compile existing data on the subject. Far too often there is pertinent information in the literature that gets ignored, resulting in needless expenditures of time and money.

Generally EPA does not clean up below natural background. In some cases, the predictive risk-based models generate PRG concentrations that lie within or even below typical background concentrations for the same element or compound. If natural background concentrations are higher than the risk-based PRG concentrations, then background concentrations should also be considered in determining whether further evaluation and/or remediation is necessary at a particular site. Exhibit 3-2 presents summary statistics for selected elements in soils that have background levels that may exceed risk-based PRGs.

Where anthropogenic "background" levels exceed PRGs and EPA has determined that a response action is necessary and feasible, EPA's goal will be to develop a comprehensive response to the widespread contamination. This will often require coordination with different authorities that have jurisdiction over the sources of contamination in the area.

EXHIBIT 3-2
BACKGROUND CONCENTRATIONS OF SELECTED ELEMENTS IN SOILS

TRACE	U.S. STUDY DATA[1]			CALIFORNIA DATA[2]		
ELEMENT	Range	GeoMean	ArMean	Range	GeoMean	ArMean
Arsenic	<.1-97	5.2 mg/kg	7.2 mg/kg	0.59-11	2.75 mg/kg	3.54 mg/kg
Beryllium	<1-15	0.63 "	0.92 "	0.10-2.7	1.14 "	1.28 "
Cadmium	<1-10	--	<1	0.05-1.7	0.26	0.36
Chromium	1-2000	37	54	23-1579	76.25	122.08
Nickel	<5-700	13	19	9.0-509	35.75	56.60

[1]Shacklette and Hansford, "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States",USGS Professional Paper 1270, 1984.

[2]Bradford et. al, "Background Concentrations of Trace and Major Elements in California Soils", Kearney Foundation Special Report, UC-Riverside and CAL-EPA DTSC, March 1996.

3.3 Screening Sites with Multiple Pollutants

A suggested stepwise approach for PRG-screening of sites with multiple pollutants is as follows:

- Perform an extensive records search and compile existing data.

- Identify site contaminants in the PRG Table. Record the PRG concentrations for various media and note whether PRG is based on cancer risk (indicated by "ca") or noncancer hazard (indicated by "nc"). Segregate cancer PRGs from non-cancer PRGs and exclude (but don't eliminate) non-risk based PRGs ("sat" or "max").

- For cancer risk estimates, take the site-specific concentration (maximum or 95 UCL) and divide by the PRG concentrations that are designated for cancer evaluation ("ca"). Multiply this ratio by 10^{-6} to estimate chemical-specific risk for a reasonable maximum exposure (RME). For multiple pollutants, simply add the risk for each chemical:

$$Risk \quad [(\frac{conc_x}{PRG_x}) \quad (\frac{conc_y}{PRG_y}) \quad (\frac{conc_z}{PRG_z})] \times 10^{6}$$

- For non-cancer hazard estimates. Divide the concentration term by its respective non-cancer PRG designated as "nc" and sum the ratios for multiple contaminants. The cumulative ratio represents a non-carcinogenic hazard index (HI). A hazard index of 1 or less is generally considered "safe". A ratio greater than 1 suggests further evaluation. **[Note that carcinogens may also have an associated non-cancer PRG that is not listed in the PRG Table. To obtain these values, the user should view or download the InterCalc Tables at the PRG website and display the appropriate sections.]**

$$Hazard\ Index \quad [(\frac{conc_x}{PRG_x}) \quad (\frac{conc_y}{PRG_y}) \quad (\frac{conc_z}{PRG_z})]$$

For more information on screening site risks, the reader should contact EPA Region 9's Technical Support Section.

3.4 Potential Problems

As with any risk-based tool, the potential exists for misapplication. In most cases the root cause will be a lack of understanding of the intended use of Region 9 PRGs. In order to prevent misuse of PRGs, the following should be avoided:

- Applying PRGs to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios,

- Not considering background concentrations when choosing PRGs as cleanup goals,

- Use of PRGs as cleanup levels without the nine-criteria analysis specified in the National Contingency Plan (or, comparable analysis for programs outside of Superfund),

- Use of PRGs as cleanup levels without verifying numbers with a toxicologist or regional risk assessor,

- Use of antiquated PRG Tables that have been superseded by more recent publications;
- Not considering the effects of additivity when screening multiple chemicals, and
- Adjusting PRGs upward by factors of 10 or 100 without consulting a toxicologist or regional risk assessor.

4.0 TECHNICAL SUPPORT DOCUMENTATION

Region 9 PRGs consider human exposure hazards to chemicals from contact with contaminated soils, air, and water. The emphasis of the PRG equations and technical discussion are aimed at developing screening criteria for soils, since this is an area where few standards exist. For air and water, additional reference concentrations or standards are available for many chemicals (e.g. MCLs, non-zero MCLGs, AWQC, and NAAQS) and consequently the discussion of these media are brief.

4.1 Ambient Air and the Vapor Intrusion Pathway

The ambient air PRG is applicable to both indoor and outdoors and is based on a residential exposure scenario using standard Superfund exposure factors (see Exhibit 4-1 below).

The air PRG may also be used as a health-protective indoor air target for determining soil gas and groundwater screening levels for the evaluation of the subsurface vapor intrusion pathway. The "vapor intrusion pathway" refers to the migration of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals in buried wastes and/or contaminated groundwater can emit vapors that may migrate through subsurface soils and into indoor air spaces of overlying buildings in ways similar to that of radon gas seeping into homes.

To derive a soil gas and/or groundwater screening level that targets the air PRG, it is necessary to divide the air PRG by an appropriate attenuation factor. The attenuation factor represents the factor by which subsurface vapor concentrations migrating into indoor air spaces are reduced due to diffusive, advective, and/or other attenuating mechanisms. The attenuation factor can be empirically determined and/or calculated using an appropriate vapor intrusion model such as the Johnson and Ettinger model available at: http://www.epa.gov/oerrpage/superfund/programs/risk/airmodel/johnson_ettinger.htm . Once the appropriate attenuation factor is determined, the following equation can be used to derive a screening level that would be protective of indoor air assuming residential land use.

For Soil Gas, the relationship is as follows:

$C_{soil\text{-}gas}[ug/m^3]$ = Air PRG $[ug/m^3]/AF$

where

$C_{soil\text{-}gas}$ = soil gas screening level
AF = attenuation factor (ratio of indoor air concentration to soil gas concentration)

For Groundwater, the relationship is as follows:

C_{gw}[ug/L] = Air PRG [ug/m^3] x 10^{-3} m^3/L x 1/H x 1/AF

where

C_{gw} = groundwater screening level
H = dimensionless Henry's Law Constant at 25C [(mg/L - vapor)/(mg/L - water)]
AF = attenuation factor (ratio of indoor air concentration to soil gas concentration)

For more information on EPA's current understanding of this emerging exposure pathway, please refer to EPA's recent draft guidance *Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* (USEPA 2002) available on the web at:
http://www.epa.gov/correctiveaction/eis/vapor.htm

4.2 Soils - Direct Ingestion

Calculation of risk-based PRGs for direct ingestion of soil is based on methods presented in RAGS HHEM, Part B (USEPA 1991a) and *Soil Screening Guidance* (USEPA 1996a,b, USEPA 2001a). Briefly, these methods backcalculate a soil concentration level from a target risk (for carcinogens) or hazard quotient (for noncarcinogens).

Residential Soil PRGs

A number of studies have shown that inadvertent ingestion of soil is common among children 6 years old and younger (Calabrese et al. 1989, Davis et al. 1990, Van Wijnen et al. 1990). To take into account the higher soil intake rate for children, two different approaches are used to estimate PRGs, depending on whether the adverse health effect is cancer or some effect other than cancer.

For carcinogens, the method for calculating PRGs uses an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weights, and exposure duration for children from 1 to 6 years old and others from 7 to 31 years old. This health-protective approach is chosen to take into account the higher daily rates of soil ingestion in children as well as the longer duration of exposure that is anticipated for a long-term resident. For more on this method, see USEPA RAGs Part B (1991a).

For noncarcinogenic concerns, the more protective method of calculating a soil PRG is to evaluate childhood exposures separately from adult exposures. In other words, an age-adjustment factor is not applied as was done for carcinogens. This approach is considered conservative because it combines the higher 6-year exposure for children with chronic toxicity criteria. In their analysis of the method, the Science Advisory Board (SAB) indicated that, for most chemicals, the approach may be overly protective. However, they noted that there are specific instances when the chronic RfD may be based on endpoints of toxicity that are specific to children (e.g. fluoride and nitrates) or when the dose-response is steep (i.e., the dosage difference between the no-observed-adverse-effects level [NOAEL] and an adverse effects level is small). Thus, for the purposes of screening, EPA Region 9 has adopted this approach for calculating soil PRGs for noncarcinogenic health concerns.

Industrial Soil PRGs

In the *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (Supplemental SSL Guidance, EPA 2001a), two different soil ingestion rates are assumed for non-construction workers: 100 mg/day is assumed for outdoor workers whereas 50 mg/day is assumed for indoor workers. The default value of 100 mg/day for outdoor workers is also recommended by EPA's Technical Review Workgroup for Lead (TRW), and it reflects increased exposures to soils for outdoor workers relative to their indoor counterparts. For more on this, please see the Supplemental SSL Guidance available at the following website:

http://www.epa.gov/superfund/resources/soil/index.htm

Because the Region 9 PRGs are generic and intended for screening sites early in the investigation process (often before site-specific information is available), we have chosen to use the 100 mg/day soil ingestion (i.e. outdoor worker) assumption to calculate industrial soil PRGs. The appropriateness of this assumption for a particular site may be evaluated when additional information becomes available regarding site conditions or site development.

4.3 Soils - Dermal Contact

Dermal Contact Assumptions

Exposure factors for dermal contact with soil are based on recommendations in *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance* (USEPA 2004). Recommended RME (reasonable maximum exposure) defaults for adult workers' skin surface areas (3300 cm^2/day) and soil adherence factors (0.2 mg/cm^2) now differ from the defaults recommended for adult residents (5700 cm^2/day, 0.07 mg/cm^2) as noted in Exhibit 4-1. This is due to differences in the range of activities experienced by workers versus residents.

Dermal Absorption

Chemical-specific skin absorption values recommended by the Superfund Dermal Workgroup were applied when available. Chemical-specific values are included for the following chemicals: arsenic, cadmium, chlordane, 2,4-D, DDT, lindane, TCDD, PAHs, PCBs, and pentachlorophenols.

The *Supplemental Guidance for Dermal Risk Assessment* (USEPA 2004) recommends a default dermal absorption factor for semivolatile organic compounds of 10% as a screening method for the majority of SVOCs without dermal absorption factors. Default dermal absorption values for other chemicals (VOCs and inorganics) are not recommended in this new guidance. Therefore, the assumption of 1% for inorganics and 10% for volatiles is no longer included in the PRG Table. This change has minimal impact on the final risk-based calculations because human exposure to VOCs and inorganics in soils is generally driven by other pathways of exposure.

4.4 Soils - Vapor and Particulate Inhalation

Agency toxicity criteria indicate that risks from exposure to some chemicals via inhalation far outweigh the risk via ingestion; therefore soil PRGs have been designed to address this pathway

as well. The models used to calculate PRGs for inhalation of volatiles/particulates are based on updates to risk assessment methods presented in RAGS Part B (USEPA 1991a) and are identical to the *Soil Screening Guidance: User's Guide and Technical Background Document* (USEPA 1996a,b).

It should be noted that the soil-to-air pathway that is evaluated in the PRGs calculations is based on inhalation exposures that result from the volatilization or particulate emissions of chemicals from soil to outdoor air. **The soil PRG calculations do not evaluate potential for volatile contaminants in soil to migrate indoors. For more on the subsurface vapor intrusion pathway please see Section 4.1.**

To address the soil-to-outdoor air pathways, the PRG calculations incorporate volatilization factors (VF_s) for volatile contaminants and particulate emission factors (PEF) for nonvolatile contaminants. These factors relate soil contaminant concentrations to air contaminant concentrations that may be inhaled on-site. The VF_s and PEF equations can be broken into two separate models: an emission model to estimate emissions of the contaminant from the soil and a dispersion model to simulate the dispersion of the contaminant in the atmosphere.

The box model in RAGS Part B has been replaced with a dispersion term (Q/C) derived from a modeling exercise using meteorological data from 29 locations across the United States because the box model may not be applicable to a broad range of site types and meteorology and does not utilize state-of-the-art techniques developed for regulatory dispersion modeling. The dispersion model for both volatiles and particulates is the AREA-ST, an updated version of the Office of Air Quality Planning and Standards, Industrial Source Complex Model, ISC2. However, different Q/C terms are used in the VF and PEF equations. Los Angeles was selected as the 90th percentile data set for volatiles and Minneapolis was selected as the 90th percentile data set for fugitive dusts (USEPA 1996 a,b). A default source size of 0.5 acres was chosen for the PRG calculations. This is consistent with the default exposure area over which Region 9 typically averages contaminant concentrations in soils. If unusual site conditions exist such that the area source is substantially larger than the default source size assumed here, an alternative Q/C could be applied (see USEPA 1996a,b).

Volatilization Factor for Soils

Volatile chemicals, defined as those chemicals having a Henry's Law constant greater than 10^{-5} (atm-m^3/mol) and a molecular weight less than 200 g/mole, were screened for inhalation exposures using a volatilization factor for soils (VF_s). Please note that VF_s's and other physical-chemical data for VOCs are contained in the InterCalc Tables at the EPA Region 9 PRG website.

The emission terms used in the VF_s are chemical-specific and were calculated from physical-chemical information obtained from several sources. The priority of these sources were as follows: *Soil Screening Guidance* (USEPA 1996a,b), *Superfund Chemical Data Matrix* (USEPA 1996c), *Fate and Exposure Data* (Howard 1991), *Subsurface Contamination Reference Guide* (EPA 1990a), and *Superfund Exposure Assessment Manual* (SEAM, EPA 1988). When there was a choice between a measured or a modeled value (e.g. Koc), our default was to use modeled values. In those cases where Diffusivity Coefficients (Di) were not provided in existing literature, Di's were calculated using Fuller's Method described in SEAM. A surrogate term was required for some chemicals that lacked physico-chemical information. In these cases, a proxy chemical of similar structure was used that may over- or under-estimate the PRG for soils.

Equation 4-9 forms the basis for deriving generic soil PRGs for the inhalation pathway. The following parameters in the standardized equation can be replaced with specific site data to develop a simple site-specific PRG

- Source area
- Average soil moisture content
- Average fraction organic carbon content
- Dry soil bulk density

The basic principle of the VF_s model (Henry's law) is applicable only if the soil contaminant concentration is at or below soil saturation "sat". Above the soil saturation limit, the model cannot predict an accurate VF-based PRG. How these particular cases are handled, depends on whether the contaminant is liquid or solid at ambient soil temperatures (see Section 4.6).

Particulate Emission Factor for Soils

Inhalation of chemicals adsorbed to respirable particles (PM_{10}) were assessed using a default PEF equal to 1. 316 x 10^9 m^3/kg that relates the contaminant concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. The generic PEF was derived using default values in Equation 4-11, which corresponds to a receptor point concentration of approximately 0.76 ug/m^3. The relationship is derived by Cowherd (1985) for a rapid assessment procedure applicable to a typical hazardous waste site where the surface contamination provides a relatively continuous and constant potential for emission over an extended period of time (e.g. years). This represents an annual average emission rate based on wind erosion that should be compared with chronic health criteria; it is not appropriate for evaluating the potential for more acute exposures.

The impact of the PEF on the resultant PRG concentration (that combines soil exposure pathways for ingestion, skin contact, and inhalation) can be assessed by accessing the Region 9 PRG website and viewing the pathway-specific soil concentrations listed in the InterCalc Tables. Equation 4-11 forms the basis for deriving a generic PEF for the inhalation pathway. For more details regarding specific parameters used in the PEF model, the reader is referred to *Soil Screening Guidance: Technical Background Document* (USEPA 1996a).

Note: the generic PEF evaluates windborne emissions and does not consider dust emissions from traffic or other forms of mechanical disturbance that could lead to greater emissions than assumed here.

4.5 Soils - Migration to Groundwater

The methodology for calculating SSLs for the migration to groundwater was developed to identify chemical concentrations in soil that have the potential to contaminate groundwater. Migration of contaminants from soil to groundwater can be envisioned as a two-stage process: (1) release of contaminant in soil leachate and (2) transport of the contaminant through the underlying soil and aquifer to a receptor well. The SSL methodology considers both of these fate and transport mechanisms.

SSLs are backcalculated from acceptable ground water concentrations (i.e. nonzero MCLGs, MCLs, or risk-based PRGs). First, the acceptable groundwater concentration is multiplied by a

dilution factor to obtain a target leachate concentration. For example, if the dilution factor is 10 and the acceptable ground water concentration is 0.05 mg/L, the target soil leachate concentration would be 0.5 mg/L. The partition equation (presented in the *Soil Screening Guidance* document) is then used to calculate the total soil concentration (i.e. SSL) corresponding to this soil leachate concentration.

The SSL methodology was designed for use during the early stages of a site evaluation when information about subsurface conditions may be limited. Because of this constraint, the methodology is based on conservative, simplifying assumptions about the release and transport of contaminants in the subsurface. For more on SSLs, and how to calculate site-specific SSLs versus generic SSLs presented in the PRG Table, the reader is referred to the *Soil Screening Guidance* document (USEPA 1996a,b).

4.6 Soil Saturation Limit

The soil saturation concentration "sat" corresponds to the contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. Above this concentration, the soil contaminant may be present in free phase, i.e., nonaqueous phase liquids (NAPLs) for contaminants that are liquid at ambient soil temperatures and pure solid phases for compounds that are solid at ambient soil temperatures.

Equation 4-10 is used to calculate "sat" for each volatile contaminant. As an update to RAGS HHEM, Part B (USEPA 1991a), this equation takes into account the amount of contaminant that is in the vapor phase in soil in addition to the amount dissolved in the soil's pore water and sorbed to soil particles.

Chemical-specific "sat" concentrations must be compared with each VF-based PRG because a basic principle of the PRG volatilization model is not applicable when free-phase contaminants are present. How these cases are handled depends on whether the contaminant is liquid or solid at ambient temperatures. Liquid contaminant that have a VF-based PRG that exceeds the "sat" concentration are set equal to "sat" whereas for solids (e.g., PAHs), soil screening decisions are based on the appropriate PRGs for other pathways of concern at the site (e.g., ingestion).

4.7 Tap Water - Ingestion and Inhalation

Calculation of PRGs for ingestion and inhalation of contaminants in domestic water is based on the methodology presented in RAGS HHEM, Part B (USEPA 1991a). Ingestion of drinking water is an appropriate pathway for all chemicals. For the purposes of this guidance, however, inhalation of volatile chemicals from water is considered routinely only for chemicals with a Henry's Law constant of 1×10^{-5} atm-m^3/mole or greater <u>and</u> with a molecular weight of less than 200 g/mole.

For volatile chemicals, an upperbound volatilization constant (VF_w) is used that is based on all uses of household water (e.g showering, laundering, and dish washing). Certain assumptions were made. For example, it is assumed that the volume of water used in a residence for a family of four is 720 L/day, the volume of the dwelling is 150,000 L and the air exchange rate is 0.25 air changes/hour (Andelman in RAGS Part B). Furthermore, it is assumed that the average transfer efficiency weighted by water use is 50 percent (i.e. half of the concentration of each

chemical in water will be transferred into air by all water uses). Note: the range of transfer efficiencies extends from 30% for toilets to 90% for dishwashers.

4.8 Default Exposure Factors

Default exposure factors were obtained primarily from RAGS Supplemental Guidance Standard Default *Exposure Factors* (OSWER Directive, 9285.6-03) dated March 25, 1991 and more recent information from U.S. EPA's Office of Solid Waste and Emergency Response, U.S. EPA's Office of Research and Development, and California EPA's Department of Toxic Substances Control (see Exhibit 4-1).

Because contact rates may be different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors ("adj"). Use of age-adjusted factors are especially important for soil ingestion exposures, which are higher during childhood and decrease with age. However, for purposes of combining exposures across pathways, additional age-adjusted factors are used for inhalation and dermal exposures. These factors approximate the integrated exposure from birth until age 30 combining contact rates, body weights, and exposure durations for two age groups - small children and adults. Age-adjusted factors were obtained from RAGS PART B or developed by analogy (see derivations next page).

For soils only, noncarcinogenic contaminants are evaluated in children separately from adults. No age-adjustment factor is used in this case. The focus on children is considered protective of the higher daily intake rates of soil by children and their lower body weight. For maintaining consistency when evaluating soils, dermal and inhalation exposures are also based on childhood contact rates.

(1) ingestion([mg-yr]/[kg-d]):

$$IFS_{adj} \quad \frac{ED_c \times IRS_c}{BW_c} \quad \frac{(ED_r \quad ED_c) \times IRS_a}{BW_a}$$

(2) skin contact([mg-yr]/[kg-d]):

$$SFS_{adj} \quad \frac{ED_c \times AF \times SA_c}{BW_c} \quad \frac{(ED_r \quad ED_c) \times AF \times SA_a}{BW_a}$$

(3) inhalation ([m^3-yr]/[kg-d]):

$$InhF_{adj} \quad \frac{ED_c \times IRA_c}{BW_c} \quad \frac{(ED_r \quad ED_c) \times IRA_a}{BW_a}$$

EXHIBIT 4-1
STANDARD DEFAULT FACTORS

Symbol	Definition (units)	Default	Reference
CSFo	Cancer slope factor oral (mg/kg-d)-1	--	IRIS, PPRTV, HEAST, NCEA, or California
CSFi	Cancer slope factor inhaled (mg/kg-d)-1	--	IRIS, PPRTV, HEAST, NCEA, or California
RfDo	Reference dose oral (mg/kg-d)	--	IRIS, PPRTV, HEAST, NCEA, or California
RfDi	Reference dose inhaled (mg/kg-d)	--	IRIS, PPRTV, HEAST, NCEA, or California
TR	Target cancer risk	10^{-6}	--
THQ	Target hazard quotient	1	--
BWa	Body weight, adult (kg)	70	RAGS (Part A), EPA 1989 (EPA/540/1-89/002)
BWc	Body weight, child (kg)	15	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
ATc	Averaging time - carcinogens (days)	25550	RAGS(Part A), EPA 1989 (EPA/540/1-89/002)
ATn	Averaging time - noncarcinogens (days)	ED*365	
SAa	Exposed surface area for soil/dust (cm^2/day)		Dermal Assessment, EPA 2004 (EPA/540/R-99/005)
	– adult resident	5700	
	– adult worker	3300	
SAc	Exposed surface area, child in soil (cm^2/day)	2800	Dermal Assessment, EPA 2004 (EPA/540/R-99/005)
AFa	Adherence factor, soils (mg/cm^2)		Dermal Assessment, EPA 2004 (EPA/540/R-99/005)
	– adult resident	0.07	
	– adult worker	0.2	
AFc	Adherence factor, child (mg/cm^2)	0.2	Dermal Assessment, EPA 2004 (EPA/540/R-99/005)
ABS	Skin absorption defaults (unitless):		
	– semi-volatile organics	0.1	Dermal Assessment, EPA 2004 (EPA/540/R-99/005)
	– volatile organics	--	Dermal Assessment, EPA 2004 (EPA/540/R-99/005)
	– inorganics	--	Dermal Assessment, EPA 2004 (EPA/540/R-99/005)
IRAa	Inhalation rate - adult (m^3/day)	20	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
IRAc	Inhalation rate - child (m^3/day)	10	Exposure Factors, EPA 1997 (EPA/600/P-95/002Fa)
IRWa	Drinking water ingestion - adult (L/day	2	RAGS(Part A), EPA 1989 (EPA/540/1-89/002)
IRWc	Drinking water ingestion - child (L/day)	1	PEA, Cal-EPA (DTSC, 1994)
IRSa	Soil ingestion - adult (mg/day)	100	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
IRSc	Soil ingestion - child (mg/day),	200	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
IRSo	Soil ingestion - occupational (mg/day)	100	Soil Screening Guidance (EPA 2001a)
EFr	Exposure frequency - residential (d/y)	350	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EFo	Exposure frequency - occupational (d/y)	250	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EDr	Exposure duration - residential (years)	30[a]	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EDc	Exposure duration - child (years)	6	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EDo	Exposure duration - occupational (years)	25	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
	Age-adjusted factors for carcinogens:		
IFSadj	Ingestion factor, soils ([mg-yr]/[kg-d])	114	RAGS(Part B), EPA 1991 (OSWER No. 9285.7-01B)
SFSadj	Dermal factor, soils ([mg-yr]/[kg-d])	361	By analogy to RAGS (Part B)
InhFadj	Inhalation factor, air ([m^3-yr]/[kg-d])	11	By analogy to RAGS (Part B)
IFWadj	Ingestion factor, water ([L-yr]/[kg-d])	1.1	By analogy to RAGS (Part B)
VFw	Volatilization factor for water (L/m^3)	0.5	RAGS(Part B), EPA 1991 (OSWER No. 9285.7-01B)
PEF	Particulate emission factor (m^3/kg)	See below	Soil Screening Guidance (EPA 1996a,b)
VFs	Volatilization factor for soil (m^3/kg)	See below	Soil Screening Guidance (EPA 1996a,b)
sat	Soil saturation concentration (mg/kg)	See below	Soil Screening Guidance (EPA 1996a,b)

Footnote:
[a]Exposure duration for lifetime residents is assumed to be 30 years total. For carcinogens, exposures are combined for children (6 years) and adults (24 years).

4.9 Standardized Equations

The equations used to calculate the PRGs for carcinogenic and noncarcinogenic contaminants are presented in Equations 4-1 through 4-8. The PRG equations update RAGS Part B equations. The methodology backcalculates a soil, air, or water concentration level from a target risk (for carcinogens) or hazard quotient (for noncarcinogens). For completeness, the soil equations combine risks from ingestion, skin contact, and inhalation simultaneously. **Note: the InterCalc Tables available at the EPA Region 9 PRG website also includes pathway-specific concentrations, should the user decide against combining specific exposure pathways; or, the user wants to identify the relative contribution of each pathway to exposure.**

To calculate PRGs for volatile chemicals in soil, a chemical-specific volatilization factor is calculated per Equation 4-9. Because of its reliance on Henry's law, the VF_s model is applicable only when the contaminant concentration in soil is at or below saturation (i.e. there is no free-phase contaminant present). Soil saturation ("sat") corresponds to the contaminant concentration in soil at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above this point, pure liquid-phase contaminant is expected in the soil. If the PRG calculated using VF_s was greater than the calculated sat, the PRG was set equal to sat, in accordance with *Soil Screening Guidance* (USEPA 1996 a,b). The equation for deriving sat is presented in Equation 4-10.

PRG EQUATIONS

Soil Equations: For soils, equations were based on three exposure routes (ingestion, skin contact, and inhalation).

Equation 4-1: Combined Exposures to Carcinogenic Contaminants in Residential Soil

$$C(mg/kg) \quad \frac{TR \times AT_c}{EF_r \left[\left(\frac{IFS_{adj} \times CSF_o}{10^6 mg/kg} \right) \left(\frac{SFS_{adj} \times ABS \times CSF_o}{10^6 mg/kg} \right) \left(\frac{InhF_{adj} \times CSF_i}{VF_s^a} \right) \right]}$$

Equation 4-2: Combined Exposures to Noncarcinogenic Contaminants in Residential Soil

$$C(mg/kg) \quad \frac{THQ \times BW_c \times AT_n}{EF_r \times ED_c \left[\left(\frac{1}{RfD_o} \times \frac{IRS_c}{10^6 mg/kg} \right) \left(\frac{1}{RfD_o} \times \frac{SA_c \times AF \times ABS}{10^6 mg/kg} \right) \left(\frac{1}{RfD_i} \times \frac{IRA_c}{VF_s^a} \right) \right]}$$

Equation 4-3: Combined Exposures to Carcinogenic Contaminants in Industrial Soil

$$C(mg/kg) \quad \frac{TR \times BW_a \times AT_c}{EF_o \times ED_o \left[\left(\frac{IRS_o \times CSF_o}{10^6 mg/kg} \right) \left(\frac{SA_a \times AF \times ABS \times CSF_o}{10^6 mg/kg} \right) \left(\frac{IRA_a \times CSF_i}{VF_s^a} \right) \right]}$$

Footnote:
[a]Use VF_s for volatile chemicals (defined as having a Henry's Law Constant [atm-m^3/mol] greater than 10^{-5} and a molecular weight less than 200 grams/mol) or PEF for non-volatile chemicals.

Equation 4-4: Combined Exposures to Noncarcinogenic Contaminants in Industrial Soil

$$C(mg/kg) \quad \frac{THQ \times BW_a \times AT_n}{EF_o \times ED_o [(\frac{1}{RfD_o} \times \frac{IRS_o}{10^6 mg/kg}) \quad (\frac{1}{RfD_o} \times \frac{SA_a \times AF \times ABS}{10^6 mg/kg}) \quad (\frac{1}{RfD_i} \times \frac{IRA_a}{VF_s^a})]}$$

Tap Water Equations:

Equation 4-5: Ingestion and Inhalation Exposures to Carcinogenic Contaminants in Water

$$C(ug/L) \quad \frac{TR \times AT_c \times 1000 ug/mg}{EF_r [(IFW_{adj} \times CSF_o) \quad (VF_w \times InhF_{adj} \times CSF_i)]}$$

Equation 4-6: Ingestion and Inhalation Exposures to Noncarcinogenic Contaminants in Water

$$C(ug/L) \quad \frac{THQ \times BW_a \times AT_n \times 1000 ug/mg}{EF_r \times ED_r [(\frac{IRW_a}{RfD_o}) \quad (\frac{VF_w \times IRA_a}{RfD_i})]}$$

Air Equations:

Equation 4-7: Inhalation Exposures to Carcinogenic Contaminants in Air

$$C(ug/m^3) \quad \frac{TR \times AT_c \times 1000 ug/mg}{EF_r \times InhF_{adj} \times CSF_i}$$

Equation 4-8: Inhalation Exposures to Noncarcinogenic Contaminants in Air

$$C(ug/m^3) \quad \frac{THQ \times RfD_i \times BW_a \times AT_n \times 1000 ug/mg}{EF_r \times ED_r \times IRA_a}$$

Footnote:
[a]Use VF_s for volatile chemicals (defined as having a Henry's Law Constant [atm-m^3/mol] greater than 10^{-5} and a molecular weight less than 200 grams/mol) or PEF for non-volatile chemicals.

SOIL-TO-AIR VOLATILIZATION FACTOR (VF_s)

Equation 4-9: Derivation of the Volatilization Factor

$$VF_s\,(m^3/kg) \quad (Q/C) \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{4}\,(m^2/cm^2)$$

where:

$$D_A \quad \frac{[\,(\Theta_a^{10/3} D_i H \quad \Theta_w^{10/3} D_w)\,/\,n^2\,]}{\rho_B K_d \quad \Theta_w \quad \Theta_a H}$$

Parameter	Definition (units)	Default
VF_s	Volatilization factor (m^3/kg)	--
D_A	Apparent diffusivity (cm^2/s)	--
Q/C	Inverse of the mean conc. at the center of a 0.5-acre square source ($g/^{M2}$-s per kg/m^3)	68.81
T	Exposure interval (s)	9.5×10^8
ρ_b	Dry soil bulk density (g/cm^3)	1.5
Θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.28 or n-Θ_w
n	Total soil porosity (L_{pore}/L_{soil})	0.43 or 1 - (ρ_b/ρ_s)
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
ρ_s	Soil particle density (g/cm^3)	2.65
Di	Diffusivity in air (cm^2/s)	Chemical-specific
H	Henry's Law constant (atm-m^3/mol)	Chemical-specific
H'	Dimensionless Henry's Law constant	Calculated from H by multiplying by 41 (USEPA 1991a)
D_w	Diffusivity in water (cm^2/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g) = $K_{oc}f_{oc}$	Chemical-specific
K_{oc}	Soil organic carbon-water partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.006 (0.6%)

Equation 4-10: Derivation of the Soil Saturation Limit

$$sat \quad \frac{S}{\rho_b} \; (K_d \rho_b \quad \Theta_w \quad H\,\Theta_a)$$

Parameter	Definition (units)	Default
sat	Soil saturation concentration (mg/kg)	--
S	Solubility in water (mg/L-water)	Chemical-specific
ρ_b	Dry soil bulk density (kg/L)	1.5
n	Total soil porosity (L_{pore}/L_{soil})	0.43 or 1 - (ρ_b/ρ_s)
ρ_s	Soil particle density (kg/L)	2.65
K_d	Soil-water partition coefficient (L/kg)	K_{oc} x f_{oc} (chemical-specific)
k_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical-specific
f_{oc}	Fraction organic carbon content of soil (g/g)	0.006 or site-specific
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
Θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.28 or n-Θ_w
w	Average soil moisture content (kg_{water}/kg_{soil} or L_{water}/kg_{soil})	0.1
H	Henry's Law constant (atm-m^3/mol)	Chemical-specific
H'	Dimensionless Henry's Law constant	H x 41, where 41 is a units conversion factor

Equation 4-11: Derivation of the Particulate Emission Factor

$$PEF(m^3/kg) \quad Q/C \times \frac{3600s/h}{0.036 \times (1 \quad V) \times (U_m/U_t)^3 \times F(x)}$$

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m^3/kg)	1.316×10^9
Q/C	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/^{M2}-s per kg/m^3)	90.80
V	Fraction of vegetative cover (unitless)	0.5
U_m	Mean annual windspeed (m/s)	4.69
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32
F(x)	Function dependent on U_m/U_t derived using Cowherd (1985) (unitless)	0.194

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APPENDIX C

EXPOSURE POINT SUMMARY TABLES

TABLE C-1
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
06C13P2 06C18P2
BIG CLIFTY UPPER
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Chemical	Raw Statistics												Data Distribution	EPA's ProUCL Recommended UCL to Use Adjusted		Reason for Adjustment	Comments
	Frequency of Detection		Mininum Detected	Maximum Detected	Sample of Maximum Detected	Mean of All Samples	Mean of Positive Detects	Median	Standard Deviation	Coefficient of Variation	Skewness	Outlier?					
	Number	Percent															
Total Metals (µg/L)																	
ARSENIC	40/40	100%	12.5	37.1	OC13P21A02	24.6	24.6	23.8	8.34	0.339	0.013	- -	Non-parametric	26.8	Student-t or Modified-t UCL		- -
BARIUM	40/40	100%	54.7 J	183	OC18P21A02	101	101	91.6	44.8	0.442	0.313	- -	Non-parametric	113	Student-t or Modified-t UCL		- -
CHROMIUM	**3/40**	**8%**	**0.73 B**	**7.9**	**OC18P21A00**	**2.75**	**3.24**	**2.80**	**0.998**	**0.363**	**3.12**	**Yes**	**Non-parametric**	**3.01**	**Student-t or Modified-t UCL**		**- -**
IRON	1/1	100%	64500	64500	OC18P22A00	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	64500	Maximum Concentration	N < 10	- -
MANGANESE	40/40	100%	349	653	OC13P22A04	520	520	520	76.4	0.147	-0.138	- -	Normal	541	Student-t		- -
ZINC	**4/40**	**10%**	**2.4 B**	**69.1**	**OC18P23A01**	**11.0**	**32.1**	**5.55**	**21.4**	**1.94**	**4.14**	**ND(1)**	**Non-parametric**	**25.8**	**95% Chebyshev(Mean, Std) UCL**		**Max ND > Max & UCL**
Dissolved Metals (µg/L)																	
ARSENIC, FILTERED	40/40	100%	0.650 B	42.3	OC13P24A04-F	26.5	26.5	26.5	10.4	0.391	-0.224	- -	Gamma	30.6	Approximate Gamma 95% UCL		- -
BARIUM, FILTERED	40/40	100%	53.4	625	OC18P24A01-F	109	109	86.4	93.1	0.856	4.54	Yes	Non-parametric	173	95% Chebyshev(Mean, Std) UCL		- -
CHROMIUM, FILTERED	**5/40**	**13%**	**3.5**	**16**	**OC18P21A02-F**	**3.08**	**7.70**	**2.50**	**2.40**	**0.779**	**4.38**	**Yes**	**Non-parametric**	**4.73**	**95% Chebyshev(Mean, Std) UCL**		**- -**
MANGANESE, FILTERED	38/40	95%	361	681 J	OC13P23A04-F	529	517	513	93.2	0.176	0.510	ND(1)	Normal	554	Student-t		Min ND & Max ND > Max & UCL
ZINC, FILTERED	**10/40**	**25%**	**6 B**	**505**	**OC18P24A01-F**	**34.8**	**124**	**5.00**	**95.7**	**2.75**	**4.14**	**Yes**	**Non-parametric**	**185**	**99% Chebyshev(Mean, Std) UCL**		**- -**

Bolded shaded values indicate that frequency of detection is less than 50 percent.
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
The Discordance Outlier test assumes normality after the maximum concentration is removed.
Only one outlier is tested for, the Discordance test does not test for multiple outliers.
µg/L - microgram per liter.
B qualified data were evaluated as positive detections.
NA(1) - Not applicable, there are an insufficient number of samples to calculate statistics.
ND(1) - The highest concentration is a non-detect value, therefore, the Discordance Test could not be performed.

TABLE C-2
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
06C11P2 06C19P2
BIG CLIFTY UPPER
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Chemical	Raw Statistics												Data Distribution	EPA's ProUCL Recommended UCL to Use Adjusted		Reason for Adjustment
	Frequency of Detection		Mininum Detected	Maximum Detected	Sample of Maximum Detected	Mean of All Samples	Mean of Positive Detects	Median	Standard Deviation	Coefficient of Variation	Skewness	Outlier?				
	Number	Percent														
Total Metals (µg/L)																
ARSENIC	33/40	83%	1.1	4.2	OC19P23A01	2.07	2.39	2.25	0.999	0.483	-0.085	- -	Non-parametric	2.76	95% Chebyshev(Mean, Std) UCL	
BARIUM	40/40	100%	29	41.1	OC11P24A02	35.7	35.7	36.2	3.16	0.088	-0.658	- -	Gamma	36.6	Approximate Gamma 95% UCL	
CHROMIUM	**2/40**	**5%**	**0.640 B**	**0.92 B**	**OC11P24A01**	**2.61**	**0.780**	**2.80**	**0.568**	**0.217**	**-2.83**	**ND(1)**	**Non-parametric**	**0.92**	**Maximum Concentration**	FOD
IRON	2/2	100%	572	4690	OC19P22A00	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	4690	Maximum Concentration	N < 10
MANGANESE	40/40	100%	85.7	193 J	OC11P23A02	125	125	121	23.8	0.191	0.823	Yes	Normal	131	Student-t	
ZINC	**5/40**	**13%**	**3.2 B**	**34**	**OC11P22A03**	**6.90**	**16.4**	**5.55**	**5.83**	**0.845**	**4.07**	**Yes**	**Non-parametric**	**8.45**	**Student-t or Modified-t UCL**	
Dissolved Metals (µg/L)																
ARSENIC, FILTERED	23/40	58%	0.81 B	2.7	OC19P24A04-F	1.39	2.05	1.45	0.847	0.608	0.057	- -	Non-parametric	1.98	95% Chebyshev(Mean, Std) UCL	
BARIUM, FILTERED	40/40	100%	26.9	45.5	OC19P22A00-F	34.6	34.6	34.7	3.48	0.100	0.532	Yes	Normal	35.6	Student-t	
CHROMIUM, FILTERED	**7/40**	**18%**	**3.6**	**10.3**	**OC11P21A02-F**	**3.18**	**6.80**	**2.50**	**2.01**	**0.633**	**2.33**	**Yes**	**Non-parametric**	**4.56**	**95% Chebyshev(Mean, Std) UCL**	
MANGANESE, FILTERED	40/40	100%	76.2	160	OC11P24A02-F	114	114	115	19.8	0.174	0.222	- -	Normal	120	Student-t	
ZINC, FILTERED	**4/40**	**10%**	**2.8 B**	**2590**	**OC19P23A04-F**	**72.1**	**675**	**5.00**	**409**	**5.67**	**6.31**	**Yes**	**Non-parametric**	**715**	**99% Chebyshev(Mean, Std) UCL**	

Bolded shaded values indicate that frequency of detection is less than 50 percent.
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
The Discordance Outlier test assumes normality after the maximum concentration is removed.
Only one outlier is tested for, the Discordance test does not test for multiple outliers.
µg/L - microgram per liter.
B qualified data were evaluated as positive detections.
NA(1) - Not applicable, there are an insufficient number of samples to calculate statistics.
ND(1) - The highest concentration is a non-detect value, therefore, the Discordance Test could not be performed.

TABLE C-3
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
06C11, 06C12, 06C14, 06C16, 06C18, 06C19
BIG CLIFTY BEECH CREEK
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Chemical	Raw Statistics												Data Distribution	EPA's ProUCL Recommended UCL to Use		Comments
	Frequency of Detection		Mininum Detected	Maximum Detected	Sample of Maximum Detected	Mean of All Samples	Mean of Positive Detects	Median	Standard Deviation	Coefficient of Variation	Skewness	Outlier?				
	Number	Percent														
Total Metals (µg/L)																
ARSENIC	63/120	53%	0.940 B	4.1	OC144A02	1.20	1.79	1.10	0.767	0.642	1.02	NA(1)	Non-parametric	1.50	95% Chebyshev(Mean, Std) UCL	- -
BARIUM	120/120	100%	20.9	127	OC163A00	62.0	62.0	46.5	32.3	0.521	0.581	NA(1)	Non-parametric	74.8	95% Chebyshev(Mean, Std) UCL	- -
CADMIUM	**1/120**	**1%**	**5.8**	**5.8**	**OC141A01**	**0.586**	**5.80**	**0.550**	**0.481**	**0.822**	**10.9**	**NA(1)**	**Non-parametric**	**0.659**	**Student-t or Modified-t UCL**	- -
CHROMIUM	**10/120**	**8%**	**0.71 B**	**14.9**	**OC141A03**	**2.86**	**4.56**	**2.80**	**1.47**	**0.513**	**5.62**	**NA(1)**	**Non-parametric**	**3.08**	**Student-t or Modified-t UCL**	- -
IRON	4/6	67%	609	3520	OC182A00	1092	1611	757	1297	1.19	1.65	Yes	Normal	2159	Student-t	N < 10
MANGANESE	95/120	79%	3 J	486	OC141A00	180	225	167	143	0.793	0.289	NA(1)	Non-parametric	261	97.5% Chebyshev(Mean, Std) UCL	- -
ZINC	**44/120**	**37%**	**2 B**	**249 NJ**	**OC142A04**	**18.1**	**39.9**	**5.55**	**34.2**	**1.89**	**4.64**	**NA(1)**	**Non-parametric**	**31.7**	**95% Chebyshev(Mean, Std) UCL**	- -
Dissolved Metals (µg/L)																
ARSENIC, FILTERED	**56/120**	**47%**	**0.31 B**	**2.6**	**OC181A02-F, OC182A01-F, OC184A04-F**	**1.04**	**1.66**	**0.550**	**0.695**	**0.670**	**0.879**	**NA(1)**	**Non-parametric**	**1.32**	**95% Chebyshev(Mean, Std) UCL**	- -
BARIUM, FILTERED	120/120	100%	9.6	326	OC163A02-F	58.3	58.3	42.0	40.6	0.696	2.64	NA(1)	Non-parametric	74.5	95% Chebyshev(Mean, Std) UCL	- -
CADMIUM, FILTERED	**1/120**	**1%**	**1.2**	**1.2**	**OC121A00-F**	**0.502**	**1.20**	**0.500**	**0.074**	**0.147**	**6.77**	**NA(1)**	**Non-parametric**	**0.514**	**Student-t or Modified-t UCL**	- -
CHROMIUM, FILTERED	**17/120**	**14%**	**2.5**	**13.4**	**OC161A02-F**	**3.12**	**7.36**	**2.50**	**2.14**	**0.688**	**3.00**	**NA(1)**	**Non-parametric**	**3.97**	**95% Chebyshev(Mean, Std) UCL**	- -
MANGANESE, FILTERED	88/120	73%	3.8	466	OC121A03-F	185	230	153	158	0.855	0.822	NA(1)	Non-parametric	275	97.5% Chebyshev(Mean, Std) UCL	Max ND > Max & UCL
ZINC, FILTERED	**22/120**	**18%**	**2 B**	**385**	**OC142A02-F**	**15.7**	**63.1**	**5.00**	**50.9**	**3.25**	**6.41**	**NA(1)**	**Non-parametric**	**35.9**	**95% Chebyshev(Mean, Std) UCL**	- -

Bolded shaded values indicate that frequency of detection is less than 50 percent.
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
The Discordance Outlier test assumes normality after the maximum concentration is removed.
Only one outlier is tested for, the Discordance test does not test for multiple outliers.
µg/L - microgram per liter.
B qualified data were evaluated as positive detections.
NA(1) - There are more than 50 samples, therefore, the Discordance Test could not be performed.

TABLE C-4
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
06C15
BIG CLIFTY BEECH CREEK
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Chemical	Raw Statistics												Data Distribution	EPA's ProUCL Recommended UCL to Use		Reason for Adjustment	Comments
	Frequency of Detection		Mininum Detected	Maximum Detected	Sample of Maximum Detected	Mean of All Samples	Mean of Positive Detects	Median	Standard Deviation	Coefficient of Variation	Skewness	Outlier?		Adjusted			
	Number	Percent															
Energetics (µg/L)																	
2,4,6-TRINITROTOLUENE	19/20	95%	3.9 J	7.8 J	OC151A00	5.47	5.74	5.60	1.57	0.286	-1.88	- -	Non-parametric	7	95% Chebyshev(Mean, Std) UCL		- -
Total Metals (ug/L)																	
BARIUM	20/20	100%	26.7	31.4	OC153A00	28.9	28.9	28.8	1.18	0.041	0.185	- -	Normal	29.3	Student-t		- -
CHROMIUM	**1/20**	**5%**	**0.71 B**	**0.71 B**	**OC154A01**	**2.61**	**0.710**	**2.80**	**0.587**	**0.225**	**-2.95**	**ND(1)**	**Non-parametric**	**0.71**	**Maximum Concentration**	FOD	**UCL > Max, Min ND & Max ND > Max, Max ND > UCL**
IRON	1/1	100%	462	462	OC151A00	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	NA(1)	462	Maximum Concentration	N < 10	
MANGANESE	12/20	60%	12.9 J	32.1	OC151A00	15.4	20.1	16.9	6.94	0.451	0.595	- -	Non-parametric	18.1	Student-t or Modified-t UCL		- -
ZINC	**9/20**	**45%**	**8.6 B**	**292**	**OC152A02**	**32.0**	**64.4**	**5.55**	**65.9**	**2.06**	**3.63**	**Yes**	**Non-parametric**	**179**	**99% Chebyshev(Mean, Std) UCL**		
Dissolved Metals (µg/L)																	
BARIUM, FILTERED	20/20	100%	25.4	32.9	OC153A00-F	28.3	28.3	28.2	1.68	0.059	0.876	Yes	Normal	28.9	Student-t		- -
CHROMIUM, FILTERED	**2/20**	**10%**	**4.3**	**7.1**	**OC152A02-F**	**2.75**	**5.70**	**2.50**	**1.20**	**0.436**	**2.52**	**Yes**	**Non-parametric**	**3.21**	**Student-t or Modified-t UCL**		
MANGANESE, FILTERED	**2/20**	**10%**	**8.4**	**8.5**	**OC154A01-F**	**7.68**	**8.45**	**7.50**	**0.370**	**0.048**	**1.65**	**- -**	**Non-parametric**	**7.82**	**Student-t or Modified-t UCL**		**Min ND & Max ND > Max & UCL**
ZINC, FILTERED	**4/20**	**20%**	**4.8 B**	**38.6**	**OC152A02-F**	**9.36**	**26.7**	**5.00**	**10.7**	**1.14**	**2.22**	**Yes**	**Non-parametric**	**19.8**	**95% Chebyshev(Mean, Std) UCL**		

Bolded shaded values indicate that frequency of detection is less than 50 percent.
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
The Discordance Outlier test assumes normality after the maximum concentration is removed.
Only one outlier is tested for, the Discordance test does not test for multiple outliers.
µg/L - micrograms per liter.
B qualified data were evaluated as positive detections.
NA(1) - Not applicable, there are an insufficient number of samples to calculate statistics.
ND(1) - The highest concentration is a non-detect value, therefore, the Discordance Test could not be performed.

TABLE C-5
SUMMARY OF EXPOSURE POINT CONCENTRATIONS
06C13
BIG CLIFTY BEECH CREEK
SWMU 7 - OLD RIFLE RANGE
NSWC CRANE
CRANE, INDIANA

Chemical	Raw Statistics												Data Distribution	EPA's ProUCL Recommended UCL to Use Adjusted		Reason for Adjustment	Comments
	Frequency of Detection		Mininum Detected	Maximum Detected	Sample of Maximum Detected	Mean of All Samples	Mean of Positive Detects	Median	Standard Deviation	Coefficient of Variation	Skewness	Outlier?					
	Number	Percent															
Total Metals (µg/L)																	
ARSENIC	20/20	100%	29.6	114	OC134A02	43.8	43.8	36.8	19.3	0.440	2.82	Yes	Non-parametric	51.2	Student-t or Modified-t UCL		- -
BARIUM	20/20	100%	61.3	123	OC134A02	70.7	70.7	65.5	14.0	0.197	3.08	Yes	Non-parametric	76	Student-t or Modified-t UCL		- -
CHROMIUM	**1/20**	**5%**	**0.83 B**	**0.83 B**	**OC134A01**	**2.62**	**0.830**	**2.80**	**0.566**	**0.217**	**-2.92**	**ND(1)**	**Non-parametric**	**0.83**	**Maximum Concentration**	FOD	**UCL > Max, Min ND & Max ND > Max, Max ND > UCL**
MANGANESE	20/20	100%	398 J	550	OC131A03	467	467	455	49.5	0.106	0.457	- -	Normal	486	Student-t		- -
ZINC	**4/20**	**20%**	**3.9 B**	**104**	**OC133A01**	**11.4**	**34.7**	**5.55**	**22.0**	**1.93**	**4.33**	**Yes**	**Non-parametric**	**32.8**	**95% Chebyshev(Mean, Std) UCL**		
Dissolved Metals (µg/L)																	
ARSENIC, FILTERED	20/20	100%	17.7	55.3	OC131A04-F	28.4	28.4	28.3	7.66	0.270	2.23	Yes	Non-parametric	31.4	Student-t or Modified-t UCL		- -
BARIUM, FILTERED	20/20	100%	52.3	68.1	OC133A00-F	58.0	58.0	57.0	4.09	0.070	1.27	- -	Gamma	59.6	Approximate Gamma 95% UCL		- -
CADMIUM, FILTERED	**1/20**	**5%**	**1.1**	**1.1**	**OC131A00-F**	**0.525**	**1.10**	**0.500**	**0.140**	**0.267**	**3.93**	**Yes**	**Non-parametric**	**0.579**	**Student-t or Modified-t UCL**		
CHROMIUM, FILTERED	**1/20**	**5%**	**2**	**2**	**OC134A01-F**	**2.41**	**2.00**	**2.50**	**0.473**	**0.197**	**-3.78**	**ND(1)**	**Non-parametric**	**2**	**Maximum Concentration**	FOD	**UCL > Max, Max ND > Max & UCL**
MANGANESE, FILTERED	19/20	95%	328 J	534 J	OC133A04-F	469	454	454	89.8	0.191	1.41	ND(1)	Gamma	504	Approximate Gamma 95% UCL		Min ND & Max ND > Max & UCL
ZINC, FILTERED	**7/20**	**35%**	**3.3 B**	**313**	**OC132A03-F**	**52.3**	**134**	**5.00**	**95.4**	**1.83**	**1.99**	**Yes**	**Non-parametric**	**265**	**99% Chebyshev(Mean, Std) UCL**		

Bolded shaded values indicate that frequency of detection is less than 50 percent.
For non-detects, 1/2 sample quantitation limit was used as a proxy concentration.
The Discordance Outlier test assumes normality after the maximum concentration is removed.
Only one outlier is tested for, the Discordance test does not test for multiple outliers.
µg/L - micrograms per liter.
B qualified data were evaluated as positive detections.
ND(1) - The highest concentration is a non-detect value, therefore, the Discordance Test could not be performed.

APPENDIX D

LEAD MEDIA CLEANUP STANDARD CALCULATIONS

SITE NAME: OLD RIFLE RANGE
LOCATION: NSWC CRANE, CRANE, INDIANA
RECEPTOR: CONSTRUCTION WORKER
MEDIA: SURFACE/SUBSURFACE SOIL
DATE: AUGUST 17, 2005

Calculations of Preliminary Remediation Goals (PRGs)

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 05/19/03

Exposure Variable	PRG Equation[1] 1*	2**	Description of Exposure Variable	Units	Values for Non-Residential Exposure Scenario: Using Equation 1 219 Days/yr	Using Equation 1 150 Days/yr	Using Equation 2 219 Days/yr	Using Equation 2 150 Days/yr
$PbB_{fetal,\,0.95}$	X	X	95th percentile PbB in fetus	ug/dL	10	10	10	10
$R_{fetal/maternal}$	X	X	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	X	X	Biokinetic Slope Factor	ug/dL per ug/day	0.4	0.4	0.4	0.4
GSD_i	X	X	Geometric standard deviation PbB	--	2.18	2.18	2.18	2.18
PbB_0	X	X	Baseline PbB	ug/dL	1.53	1.53	1.53	1.53
IR_S	X		Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	0.100	--	--
IR_{S+D}		X	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	0.100	0.100
W_S		X	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	1.0	1.0
K_{SD}		X	Mass fraction of soil in dust	--	--	--	0.7	0.7
$AF_{S,D}$	X	X	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,D}$	X	X	Exposure frequency (same for soil and dust)	days/yr	219	150	219	150
$AT_{S,D}$	X	X	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PRG			Preliminary Remediation Goal	ppm	539	787	539	787

[1] Equation 1 does not apportion exposure between soil and dust ingestion (excludes W_S, K_{SD}).
When $IR_S = IR_{S+D}$ and $W_S = 1.0$, the equations yield the same PRG.

***Equation 1, based on Eq. 4 in USEPA (1996).**

$$PRG = \frac{([PbB_{95}fetal/(R*(GSD_i^{1.645})])-PbB_0)*AT_{S,D}}{BKSF*(IR_{S+D}*AF_{S,D}*EF_{S,D})}$$

****Equation 2, alternate approach based on Eq. 4 and Eq. A-19 in USEPA (1996).**

$$PRG = \frac{([PbB_{fetal,0.95}/(R*(GSD_i^{1.645})])-PbB_0)*AT_{S,D}}{BKSF*([(IR_{S+D})*AF_S*EF_S*W_S]+[K_{SD}*(IR_{S+D})*(1-W_S)*AF_D*EF_D])}$$

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

APPENDIX E

HILLSIDE RANGE 1 BERM AND RANGE 2 BERM COST ESTIMATE AND REMEDIATION VOLUME

E-1 COST ESTIMATE
ALTERNATIVE GW-2-EXP

NAVAL [illegible]FACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative GW-2-Exp: Limited Action (Land Use Controls and Long-Term Monitoring)
Capital Cost

Item	Quantity	Unit	Subcontract	Unit Cost Material	Labor	Equipment	Labor	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS								
1.1 Prepare Site - Specific LUC	40	hr			$35.00		$1,400	$1,400
Subtotal							$1,400	$1,400
Local Area Adjustments							82.9%	
							$1,161	$1,161
Overhead on Labor Cost @ 30%							$348	$348
G & A on Labor Cost @ 10%							$116	$116
G & A on Material Cost @ 10%								$0
G & A on Subcontract Cost @ 10%								$0
Total Direct Cost							$1,625	$1,625
Indirects on Total Direct Cost @ 35%								$569
Profit on Total Direct Cost @ 10%								$162
Subtotal								$2,356
Health & Safety Monitoring @ 1%								$24
Total Field Cost								$2,380
Contingency on Total Field Costs @ 0%								$0
Engineering on Total Field Cost @ 10%								$238
TOTAL CAPITAL COST								**$2,618**

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative GW-2-Exp: Limited Action (Land Use Controls and Long-Term Monitoring)
Operation and Maintenance Cost

	Item	Quantity	Unit	Unit Cost	Subtotal	Notes
1	System Maintenance		ls	$0	$131	5% of Installation Cost; replacement signs, etc.
3	Sampling labor, travel & living, supplies	2	ea	$670	$1,340	1 person/2day per week
4	Analysis of groundwater	8	ea	$146	$1,168	TNT and degradation
2	Annual Report	1	ea	$1,000	$1,000	
				O & M per year	**$3,639**	

NAVAL S[illegible]ACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative GW-2-Exp: Limited Action (Land Use Controls and Long-Term Monitoring)
Annual Cost

Item	Item Cost Year 1	Item Cost Years 2 - 3	Item Cost Years 4 - 30	Item Cost Every 5 Years Through 30 Years	Notes
Sampling	$4,660	$2,330	$1,165		Assume 1 people for 2 days at $65/hr each, field supplies $125, Annual for all years.
Analysis/Water	$1,577	$3,154	$1,134		Analyze samples from two aquifier at four (8) existing wells plus one (1) QA sample for metals for each sampling event. Annual sampling
Report	$1,000	$2,000	$1,000		Document sampling events and results, $1,000 per report.
Site Inspection	$1,000	$1,000	$1,000		To verify continued implementation of the LUC
Site Review				$15,000	Site review every 5 years for 30 years.
TOTALS	**$8,237**	**$8,484**	**$4,299**	**$15,000**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative GW-2-Exp: Limited Action (Land Use Controls and Long-Term Monitoring)
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$2,618			$2,618	1.000	$2,618
1		$3,639	$8,237	$11,876	0.935	$11,104
2		$3,639	$8,484	$12,122	0.873	$10,583
3		$3,639	$8,484	$12,122	0.816	$9,892
4		$3,639	$4,299	$7,938	0.763	$6,057
5		$3,639	$19,299	$22,938	0.713	$16,355
6		$3,639	$4,299	$7,938	0.666	$5,287
7		$3,639	$4,299	$7,938	0.623	$4,945
8		$3,639	$4,299	$7,938	0.582	$4,620
9		$3,639	$4,299	$7,938	0.544	$4,318
10		$3,639	$19,299	$22,938	0.508	$11,652
11		$3,639	$4,299	$7,938	0.475	$3,770
12		$3,639	$4,299	$7,938	0.444	$3,524
13		$3,639	$4,299	$7,938	0.415	$3,294
14		$3,639	$4,299	$7,938	0.388	$3,080
15		$3,639	$19,299	$22,938	0.362	$8,304
16		$3,639	$4,299	$7,938	0.339	$2,691
17		$3,639	$4,299	$7,938	0.317	$2,516
18		$3,639	$4,299	$7,938	0.296	$2,350
19		$3,639	$4,299	$7,938	0.277	$2,199
20		$3,639	$19,299	$22,938	0.258	$5,918
21		$3,639	$4,299	$7,938	0.242	$1,921
22		$3,639	$4,299	$7,938	0.226	$1,794
23		$3,639	$4,299	$7,938	0.211	$1,675
24		$3,639	$4,299	$7,938	0.197	$1,564
25		$3,639	$19,299	$22,938	0.184	$4,221
26		$3,639	$4,299	$7,938	0.172	$1,365
27		$3,639	$4,299	$7,938	0.161	$1,278
28		$3,639	$4,299	$7,938	0.150	$1,191
29		$3,639	$4,299	$7,938	0.141	$1,119
30		$3,639	$19,299	$22,938	0.131	$3,005
					TOTAL PRESENT WORTH	**$144,208**

E-2 COST ESTIMATE
ALTERNATIVE GW-2-METALS

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative GW-2-Metals: Limited Action (Land Use Controls)
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Material	Labor	Equipment	Labor	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS								
1.1 Prepare Site - Specific LUC	40	hr			$35.00		$1,400	$1,400
Subtotal							$1,400	$1,400
Local Area Adjustments							82.9%	
							$1,161	$1,161
Overhead on Labor Cost @ 30%							$348	$348
G & A on Labor Cost @ 10%							$116	$116
G & A on Material Cost @ 10%								$0
G & A on Subcontract Cost @ 10%								$0
Total Direct Cost							$1,625	$1,625
Indirects on Total Direct Cost @ 35%								$569
Profit on Total Direct Cost @ 10%								$162
Subtotal								$2,356
Health & Safety Monitoring @ 1%								$24
Total Field Cost								$2,380
Contingency on Total Field Costs @ 0%								$0
Engineering on Total Field Cost @ 10%								$238
TOTAL CAPITAL COST								**$2,618**

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative GW-2-Metals: Limited Action (Land Use Controls)
Operation and Maintenance Cost

	Item	Quantity	Unit	Unit Cost	Subtotal	Notes
1	System Maintenance		ls	$0	$131	5% of Installation Cost; replacement signs, etc.
2	Annual Report	1	ea	$1,000	$1,000	
				O & M per year	**$1,131**	

NAVAL S[illegible]ACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative GW-2-Metals: Limited Action (Land Use Controls)
Annual Cost

Item	Item Cost Year 1	Item Cost Years 2 - 3	Item Cost Years 4 - 30	Item Cost Every 5 Years Through 30 Years	Notes
Annual Report	$1,000	$2,000	$1,000		Document sampling events and results, $1,000 per report.
Site Inspection	$500	$500	$500		To verify continued implementation of the LUC
Site Review				$1,000	Site review every 5 years for 30 years.
TOTALS	**$1,500**	**$2,500**	**$1,500**	**$1,000**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative GW-2-Metals: Limited Action (Land Use Controls)
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$2,618			$2,618	1.000	$2,618
1		$1,131	$1,500	$2,631	0.935	$2,460
2		$1,131	$2,500	$3,631	0.873	$3,170
3		$1,131	$2,500	$3,631	0.816	$2,963
4		$1,131	$1,500	$2,631	0.763	$2,007
5		$1,131	$2,500	$3,631	0.713	$2,589
6		$1,131	$1,500	$2,631	0.666	$1,752
7		$1,131	$1,500	$2,631	0.623	$1,639
8		$1,131	$1,500	$2,631	0.582	$1,531
9		$1,131	$1,500	$2,631	0.544	$1,431
10		$1,131	$2,500	$3,631	0.508	$1,844
11		$1,131	$1,500	$2,631	0.475	$1,250
12		$1,131	$1,500	$2,631	0.444	$1,168
13		$1,131	$1,500	$2,631	0.415	$1,092
14		$1,131	$1,500	$2,631	0.388	$1,021
15		$1,131	$2,500	$3,631	0.362	$1,314
16		$1,131	$1,500	$2,631	0.339	$ 892
17		$1,131	$1,500	$2,631	0.317	$ 834
18		$1,131	$1,500	$2,631	0.296	$ 779
19		$1,131	$1,500	$2,631	0.277	$ 729
20		$1,131	$2,500	$3,631	0.258	$ 937
21		$1,131	$1,500	$2,631	0.242	$ 637
22		$1,131	$1,500	$2,631	0.226	$ 595
23		$1,131	$1,500	$2,631	0.211	$ 555
24		$1,131	$1,500	$2,631	0.197	$ 518
25		$1,131	$2,500	$3,631	0.184	$ 668
26		$1,131	$1,500	$2,631	0.172	$ 453
27		$1,131	$1,500	$2,631	0.161	$ 424
28		$1,131	$1,500	$2,631	0.150	$ 395
29		$1,131	$1,500	$2,631	0.141	$ 371
30		$1,131	$2,500	$3,631	0.131	$ 476
					TOTAL PRESENT WORTH	**$39,109**

E-3 LEAD-CONTAMINATED SOIL IN-PLACE VOLUME ESTIMATE

CALCULATION WORKSHEET

CLIENT NSWC Crane		JOB NUMBER 112GN4267 0000.NG0110120	
SUBJECT SWMU 7 Volume Estimate for Lead Removal at the Old Pistol Range.			
BASED ON Information From Roger Clark		DRAWING NUMBER Figures E-1 and E-2	
BY VJPlachy	CHECKED BY JDGoerdt	APPROVED BY	DATE 12/1/2005

Objective: Estimate for volume of lead (Pb) contaminated soils at the Old Pistol Range (OPR) portion of SWMU 7 for Hillside Range 1 Berm and Range 2 Berm.

Inputs and Assumptions:

1. Hillside Range 1 Berm

	L 15'	L 15'	L 15'	L 15'	L 15'
W 10'	07XSS10	07XSS09	**07XSS08**	**07XSS07**	07XSS06
W 10'	**07XSS05**	**07XSS04**	**07XSS03**	**07XSS02**	07XSS01

Range 2 Berm

	L 15'	L 15'	L 15'	L 15'	L 15'
W 10'	07XSS20	07XSS19	07XSS18	**07XSS17**	**07XSS16**
W 10'	07XSS15	07XSS14	**07XSS13**	07XSS12	07XSS11

2. There is only contamination within the sampled areas.

3. Range 2 Berm Hotspot: 07XSS13, 07XSS16, and 07XSS17
   Therefore, the number of contaminated areas (Nc_{R-2}) = 3

4. Hillside Range 1 Berm Hotspots: 07XSS02, 07XSS03, 07XSS04, 07XSS05, 07XSS07, and 07XSS08
   Therefore, (Nc_{R-1}) = 6

5. Maximum excavation depth (D_A) = 1 ft

6. Conversion factor: 1 yd^3 = 27 ft^3

7. Acronyms
   - D = depth
   - ft = feet
   - L = length
   - max = maximum
   - Nc_{R-X} = number of contaminated areas in Range X
   - OPR = Old Pistol Range
   - Pb = lead
   - V = volume
   - W = width
   - yd^3 = cubic yards

Calculations:

1. Volume of each Pb (V_{Pb}) contaminated area in Hillside Range 1 Berm (ft^3 and yd^3):

$$V_{Pb\text{-}Range1} = \left| L\ (ft) \right| \left| W\ (ft) \right| \left| D_A\ (ft) \right| \left| Nc_{R-1} \right|$$

$$= \left| 15'\ ft \right| \left| 10'\ ft \right| \left| 1.00\ ft \right| \left| 6 \right|$$

$$= \boxed{900\ ft^3} = \left| 900\ ft^3 \right| \left| \frac{1\ yd^3}{27\ ft^3} \right| = \boxed{33\ yd^3}$$

2. Volume of each Pb (V_{Pb}) contaminated area in Range 2 Berm (ft^3 and yd^3):

CLIENT NSWC Crane	JOB NUMBER 112GN4267 0000.NG0110120
SUBJECT SWMU 7 Volume Estimate for Lead Removal at the Old Pistol Range.	
BASED ON Information From Roger Clark	DRAWING NUMBER Figures E-1 and E-2

BY	CHECKED BY	APPROVED BY	DATE
VJPlachy	JDGoerdt		12/1/2005

$$V_{Pb\text{-}Range2} = \left| L\ (ft) \right| \left| W\ (ft) \right| \left| D_A\ (ft) \right| \left| Nc_{R\text{-}2} \right|$$

$$= \left| 15'\ ft \right| \left| 10'\ ft \right| \left| 1.00\ ft \right| \left| 3 \right|$$

$$= \boxed{450\ ft^3} = \left| 450\ ft^3 \right| \left| \frac{1\ yd^3}{27\ ft^3} \right| = \boxed{17\ yd^3}$$

1. Volume of each Pb (V_{Pb}) contaminated area in Hillside Range 1 Berm and Range 2 Berm (ft^3 and yd^3):

$$V_{Pb\text{-}total} = \left| V_{Pb\text{-}Range1} \right| + \left| V_{Pb\text{-}Range2} \right| = \left| 900 \right| + \left| 450 \right| = 1{,}350\ ft^3 \left| \frac{1\ yd^3}{27\ ft^3} \right| = \boxed{50\ yd^3}$$

E-4 LEAD-CONTAMINATED SOIL REMEDIATION VOLUME ESTIMATE

CALCULATION WORKSHEET

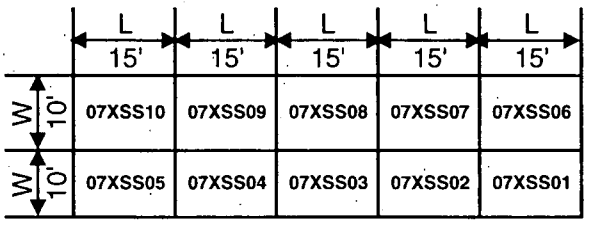
CLIENT NSWC Crane		JOB NUMBER 112GN4267 0000.NG0110120	
SUBJECT SWMU 7 Volume Estimate for Lead Removal at the Old Pistol Range.			
BASED ON Information From Roger Clark		DRAWING NUMBER Figures E-1 and E-2	
BY VJPlachy	CHECKED BY JDGoerdt	APPROVED BY	DATE 2/6/2006

Objective: Estimate for volume of lead (Pb) contaminated soils at the Old Pistol Range (OPR) portion of SWMU 7 for Hillside Range 1 Berm and Range 2 Berm that will be disposed.

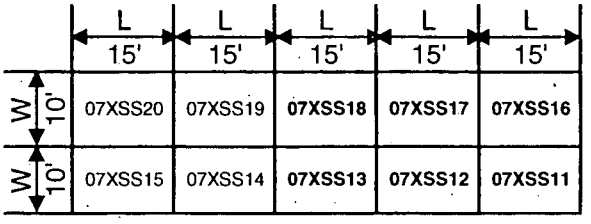
Inputs and Assumptions:

1. Hillside Range 1 Berm

8.



Range 2 Berm



2. There is only contamination within the sampled areas.

3. Range 2 Berm Hotspot: 07XSS13, 07XSS16, and 07XSS17
   Range 2 Berm excavation areas: 07XSS18, 07XSS17, 07XSS16, 07XSS13, 07XSS12, and 07XSS11
   Therefore, the number of contaminated areas (Nc_{R-2}) = 6

4. Hillside Range 1 Berm Hotspots: 07XSS02, 07XSS03, 07XSS04, 07XSS05, 07XSS07, and 07XSS08
   Range 1 Hilside Berm excavation areas: 07XSS10, 07XSS09, 07XSS08, 07XSS07, 07XSS06, 07XSS05, 07XSS04, 07XSS03, 07XSS02, and 07XSS01
   Therefore, (Nc_{R-1}) = 10

5. Maximum excavation depth (D_A) = 1.1 ft

6. Conversion factor: 1 yd^3 = 27 ft^3

7. Acronyms
   - D = depth
   - ft = feet
   - L = length
   - max = maximum
   - Nc_{R-X} = number of contaminated areas in Range X
   - OPR = Old Pistol Range
   - Pb = lead
   - V = volume
   - W = width
   - yd^3 = cubic yards

CALCULATION WORKSHEET

CLIENT NSWC Crane		JOB NUMBER 112GN4267 0000.NG0110120	
SUBJECT SWMU 7 Volume Estimate for Lead Removal at the Old Pistol Range.			
BASED ON Information From Roger Clark		DRAWING NUMBER Figures E-1 and E-2	
BY VJPlachy	CHECKED BY JDGoerdt	APPROVED BY	DATE 2/6/2006

Calculations:

1. Volume of each Pb (V_{Pb}) contaminated area in Hillside Range 1 Berm (ft^3 and yd^3):

$$V_{Pb\text{-}Range1} = \left| L\ (ft) \right| \left| W\ (ft) \right| \left| D_A\ (ft) \right| \left| Nc_{R\text{-}1} \right|$$

$$= \left| 15'\ ft \right| \left| 10'\ ft \right| \left| 1.10\ ft \right| \left| 10 \right|$$

$$= \boxed{1{,}650\ ft^3} = \left| 1{,}650\ ft^3 \right| \left| \frac{1\ yd^3}{27\ ft^3} \right| = \boxed{61\ yd^3}$$

2. Volume of each Pb (V_{Pb}) contaminated area in Range 2 Berm (ft^3 and yd^3):

$$V_{Pb\text{-}Range2} = \left| L\ (ft) \right| \left| W\ (ft) \right| \left| D_A\ (ft) \right| \left| Nc_{R\text{-}2} \right|$$

$$= \left| 15'\ ft \right| \left| 10'\ ft \right| \left| 1.10\ ft \right| \left| 6 \right|$$

$$= \boxed{990\ ft^3} = \left| 990\ ft^3 \right| \left| \frac{1\ yd^3}{27\ ft^3} \right| = \boxed{37\ yd^3}$$

1. Volume of each Pb (V_{Pb}) contaminated area in Hillside Range 1 Berm and Range 2 Berm (ft^3 and yd^3):

$$V_{Pb\text{-}total} = \left| V_{Pb\text{-}Range1} \right| + \left| V_{Pb\text{-}Range2} \right| = \left| 1{,}650 \right| + \left| 990 \right| = 2{,}640\ ft^3 \left| \frac{1\ yd^3}{27\ ft^3} \right| = \boxed{98\ yd^3}$$

E-5 HAZARDOUS WASTE COST ESTIMATE
ALTERNATIVE S-2

NSWC CR
CRANE, INDIANA
SWMU 7 - OLD RIFLE RANGE AND OLD PISTOL RANGE
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as Hazardous Waste,)
Capital Cost -- Disposal Hazardous Waste

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 Construction Plan	200	hours			$35.00		$0	$0	$7,000	$0	$7,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Storage Trailer	1	mo		$105.00			$0	$105	$0	$0	$105
2.2 Construction Survey, Limits of Excavation	1	ea	$1,450.00				$1,450	$0	$0	$0	$1,450
2.3 Equipment Mobilization/Demobilization	2	ea			$147.00	$350.00	$0	$0	$294	$700	$994
3 DECONTAMINATION											
3.1 Temporary Equipment Decon Pad	1	ls		$3,886.00	$4,455.50	$469.00	$0	$3,886	$4,456	$469	$8,811
3.2 Decontamination Services	0.5	mo		$210.00	$1,800.00	$315.00	$0	$105	$900	$158	$1,163
3.3 Decon Water	500	gal		$0.20			$0	$100	$0	$0	$100
3.4 Disposal of Decon Waste (liquid & solid)	1	mo	$900.00				$900	$0	$0	$0	$900
4 EXCAVATE SOIL											
4.1 Excavator, backhoe/loader	5	day			$287.20	$256.40	$0	$0	$1,436	$1,282	$2,718
4.2 Laborer, 3	5	day			$640.00		$0	$0	$3,200	$0	$3,200
4.3 XRF Sampling	0	wk				$1,500.00	$0	$0	$0	$0	$0
4.4 Confirming Laboratory Samples	0	ea	$30.00				$0	$0	$0	$0	$0
5 DISPOSAL											
5.1 Waste Characterization Testing (TCLP)	1	ea	$825.00	$10.00	$30.00	$10.00	$825	$10	$30	$10	$875
5.2 Transportation	150	ton	$20.00				$3,000	$0	$0	$0	$3,000
5.3 Hazardous Landfill Disposal	150	ton	$142.50				$21,375	$0	$0	$0	$21,375
6 SITE RESTORATION											
6.1 Import Topsoil	75	cy		$22.00			$0	$1,650	$0	$0	$1,650
6.2 Excavator, backhoe/loader	5	day			$287.20	$256.40	$0	$0	$1,436	$1,282	$2,718
6.3 Laborer, 3	5	day			$640.00		$0	$0	$3,200	$0	$3,200
6.4 Seed & Fertilizer	24	msf		$11.20	$5.10	$3.33	$0	$269	$122	$80	$471
7 MISCELLANEOUS											
7.1 Construction Oversite (2p for 10 days)	0	days			$600.00		$0	$0	$0	$0	$0
7.2 Post Construction Documents	0	hr			$35.00		$0	$0	$0	$0	$0
Subtotal							$27,550	$6,125	$22,074	$3,980	$59,729
Local Area Adjustments							100.0%	77.1%	95.6%	95.6%	
							$27,550	$4,722	$21,103	$3,805	$57,180
Overhead on Labor Cost @ 30%									$6,331		$6,331
G & A on Labor Cost @ 10%									$2,110		$2,110
G & A on Material Cost @ 10%								$472			$472
G & A on Subcontract Cost @ 10%							$2,755				$2,755
G & A on Equipment Cost @ 10%										$381	$381
Total Direct Cost							$30,305	$5,194	$29,544	$4,186	$69,229

NSWC CRANE
CRANE, INDIANA
SWMU 7 - OLD RIFLE RANGE AND OLD PISTOL RANGE
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as Hazardous Waste,)
Capital Cost -- Disposal Hazardous Waste

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
Indirects on Total Direct Cost @ 35%			(Total Direct Cost minus Transportation and Disposal Costs)								$15,699
Profit on Total Direct Cost @ 10%											$6,923
Subtotal											$91,851
Health & Safety Monitoring @ 2%											$1,837
Total Field Cost											$93,688
Contingency on Total Field Costs @ 25%											$23,422
Engineering on Total Field Cost @ 10%											$9,369
TOTAL COST											**$126,478**

NSWC C[illegible]E
CRANE, INDIANA
SWMU 7 - OLD RIFLE RANGE AND OLD PISTOL RANGE
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as Hazardous Waste,)
Annual Cost -- Disposal Hazardous Waste

Item	Item Cost Year 1	Item Cost Years 2 - 3	Item Cost Years 4 - 30	Item Cost Every 5 Years Through 30 Years	Notes
Annual Report	$1,000	$2,000	$1,000		Document sampling events and results, $1,000 per report.
Site Inspection	$500	$500	$500		To verify continued implementation of the LUC
Site Review				$1,000	Site review every 5 years for 30 years.
TOTALS	**$1,500**	**$2,500**	**$1,500**	**$1,000**	

NSWC CRANE
CRANE, INDIANA
SWMU 7 - OLD RIFLE RANGE AND OLD PISTOL RANGE
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as Hazardous Waste,)
Present Worth Analysis -- Disposal Hazardous Waste

Year	Capital Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$126,478		$ 126,478	1.000	$ 126,478
1		$1,500	$ 1,500	0.935	$ 1,403
2		$2,500	$ 2,500	0.873	$ 2,183
3		$2,500	$ 2,500	0.816	$ 2,040
4		$1,500	$ 1,500	0.763	$ 1,145
5		$2,500	$ 2,500	0.713	$ 1,783
6		$1,500	$ 1,500	0.666	$ 999
7		$1,500	$ 1,500	0.623	$ 935
8		$1,500	$ 1,500	0.582	$ 873
9		$1,500	$ 1,500	0.544	$ 816
10		$2,500	$ 2,500	0.508	$ 1,270
11		$1,500	$ 1,500	0.475	$ 713
12		$1,500	$ 1,500	0.444	$ 666
13		$1,500	$ 1,500	0.415	$ 623
14		$1,500	$ 1,500	0.388	$ 582
15		$2,500	$ 2,500	0.362	$ 905
16		$1,500	$ 1,500	0.339	$ 509
17		$1,500	$ 1,500	0.317	$ 476
18		$1,500	$ 1,500	0.296	$ 444
19		$1,500	$ 1,500	0.277	$ 416
20		$2,500	$ 2,500	0.258	$ 645
21		$1,500	$ 1,500	0.242	$ 363
22		$1,500	$ 1,500	0.226	$ 339
23		$1,500	$ 1,500	0.211	$ 317
24		$1,500	$ 1,500	0.197	$ 296
25		$2,500	$ 2,500	0.184	$ 460
26		$1,500	$ 1,500	0.172	$ 258
27		$1,500	$ 1,500	0.161	$ 242
28		$1,500	$ 1,500	0.150	$ 225
29		$1,500	$ 1,500	0.141	$ 212
30		$2,500	$ 2,500	0.131	$ 328
				TOTAL PRESENT WORTH	**$148,937**

NSWC CRANE
CRANE, INDIANA
SWMU 7 - OLD RIFLE RANGE AND OLD PISTOL RANGE
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as Hazardous Waste,)
Capital Costs -- Disposal Hazardous Waste

ASSUMPTIONS

1. Excavation to depth of 1 foot with no groundwater
2. No utilities (underground or overhead)
3. No wetlands or stream restoration
4. All materials are to be disposed off-site as non-hazardous or hazardous
5. Assume no site support equipment or utilities are needed
6. Due to the geography of the areas being excavated (on a sloped surface and interspaced with contaminate and non-contaminated areas, it was assume that the actual excavation will include the entire footprint area of 20' x 75' x 1' at each location (the ORR and OPR).

CALCULATIONS

Volume to be excavated is 100 cubic yards
Assume 1.5 tons per cy for 150 tons

Construction Time Line

Mob	1	day
Excavation/Disposal	4	days
Backfill	2	days
Restoration	2	days
Demob	1	day
	10	days

Total backfill = topsoil only (assume 50% of removed or 50 cubic yards)

		ft		ft		
Seed & Fertilizer:	roadway	20		450	9,000	sq ft
	berm 1	20		75	1,500	sq ft
	berm 2	20		75	1,500	sq ft
					12,000	sq ft
			times		2	
					24,000	sq ft
			or		24	msf

E-6 NON-HAZARDOUS WASTE COST ESTIMATE
ALTERNATIVE S-2

NAVAL [illegible]FACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as NonHazardous Waste)
Capital Cost -- LUC

Item	Quantity	Unit	Unit Cost Subcontract	Material	Labor	Equipment	Labor	Subtotal
1 PROJECT PLANNING & INSTITUTION CONTROLS								
1.1 Prepare Site - Specific LUC	40	hr			$35.00		$1,400	$1,400
Subtotal							$1,400	$1,400
Local Area Adjustments							82.9%	
							$1,161	$1,161
Overhead on Labor Cost @ 30%							$348	$348
G & A on Labor Cost @ 10%							$116	$116
G & A on Material Cost @ 10%								$0
G & A on Subcontract Cost @ 10%								$0
Total Direct Cost							$1,625	$1,625
Indirects on Total Direct Cost @ 35%								$569
Profit on Total Direct Cost @ 10%								$162
Subtotal								$2,356
Health & Safety Monitoring @ 1%								$24
Total Field Cost								$2,380
Contingency on Total Field Costs @ 0%								$0
Engineering on Total Field Cost @ 10%								$238
TOTAL CAPITAL COST								**$2,618**

NSWC CRANE
Crane, Indiana
SWMU 7, Old Pistol Range
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as NonHazardous Waste)
Capital Cost -- Disposal Hazardous Waste

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 Construction Plan	200	hours			$35.00		$0	$0	$7,000	$0	$7,000
2 MOBILIZATION/DEMOBILIZATION AND FIELD SUPPORT											
2.1 Storage Trailer	1	mo		$105.00			$0	$105	$0	$0	$105
2.2 Construction Survey, Limits of Excavation	1	ea	$1,450.00				$1,450	$0	$0	$0	$1,450
2.3 Equipment Mobilization/Demobilization	2	ea			$147.00	$350.00	$0	$0	$294	$700	$994
3 DECONTAMINATION											
3.1 Temporary Equipment Decon Pad	1	ls		$3,886.00	$4,455.50	$469.00	$0	$3,886	$4,456	$469	$8,811
3.2 Decontamination Services	0.5	mo		$210.00	$1,800.00	$315.00	$0	$105	$900	$158	$1,163
3.3 Decon Water	500	gal		$0.20			$0	$100	$0	$0	$100
3.4 Disposal of Decon Waste (liquid & solid)	1	mo	$900.00				$900	$0	$0	$0	$900
4 EXCAVATE SOIL											
4.1 Excavator, backhoe/loader	5	day			$287.20	$256.40	$0	$0	$1,436	$1,282	$2,718
4.2 Laborer, 3	5	day			$640.00		$0	$0	$3,200	$0	$3,200
4.3 XRF Sampling	0	wk				$1,500.00	$0	$0	$0	$0	$0
4.4 Confirming Laboratory Samples	0	ea	$30.00				$0	$0	$0	$0	$0
5 DISPOSAL											
5.1 Waste Characterization Testing (TCLP)	1	ea	$825.00	$10.00	$30.00	$10.00	$825	$10	$30	$10	$875
5.2 Transportation	150	ton	$20.00				$3,000	$0	$0	$0	$3,000
5.3 Non-Hazardous Landfill Disposal	150	ton	$45.00				$6,750	$0	$0	$0	$6,750
6 SITE RESTORATION											
6.1 Import Topsoil	75	cy		$22.00			$0	$1,650	$0	$0	$1,650
6.2 Excavator, backhoe/loader	5	day			$287.20	$256.40	$0	$0	$1,436	$1,282	$2,718
6.3 Laborer, 3	5	day			$640.00		$0	$0	$3,200	$0	$3,200
6.4 Seed & Fertilizer	24	msf		$11.20	$5.10	$3.33	$0	$269	$122	$80	$471
7 MISCELLANEOUS											
7.1 Construction Oversite (2p for 10 days)	0	days			$600.00		$0	$0	$0	$0	$0
7.2 Post Construction Documents	0	hr			$35.00		$0	$0	$0	$0	$0
Subtotal							$12,925	$6,125	$22,074	$3,980	$45,104
Local Area Adjustments							100.0%	77.1%	95.6%	95.6%	
							$12,925	$4,722	$21,103	$3,805	$42,555
Overhead on Labor Cost @ 30%									$6,331		$6,331
G & A on Labor Cost @ 10%									$2,110		$2,110
G & A on Material Cost @ 10%								$472			$472
G & A on Subcontract Cost @ 10%							$1,293				$1,293
G & A on Equipment Cost @ 10%										$381	$381
Total Direct Cost							$14,218	$5,194	$29,544	$4,186	$53,141

NSWC CR
Crane, Ind
SWMU 7, Old Pistol Range
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as NonHazardous Waste)
Capital Cost -- Disposal Hazardous Waste

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
Indirects on Total Direct Cost @	35%		(Total Direct Cost minus Transportation and Disposal Costs)								$15,187
Profit on Total Direct Cost @	10%										$5,314
Subtotal											$73,643
Health & Safety Monitoring @	2%										$1,473
Total Field Cost											$75,115
Contingency on Total Field Costs @	25%										$18,779
Engineering on Total Field Cost @	10%										$7,512
TOTAL COST											**$101,406**

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as NonHazardous Waste)
Operation and Maintenance Cost

	Item	Quantity	Unit	Unit Cost	Subtotal	Notes
1	System Maintenance		ls	$0	$131	5% of LUC_CapCost; replacement signs, etc.
2	Annual Report	1	ea	$1,000	$1,000	
				O & M per year	**$1,131**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as NonHazardous Waste)
Annual Cost

Item	Item Cost Year 1	Item Cost Years 2 - 3	Item Cost Years 4 - 30	Item Cost Every 5 Years Through 30 Years	Notes
Annual Report	$1,000	$2,000	$1,000		Document sampling events and results, $1,000 per report.
Site Inspection	$500	$500	$500		To verify continued implementation of the LUC
Site Review				$1,000	Site review every 5 years for 30 years.
TOTALS	**$1,500**	**$2,500**	**$1,500**	**$1,000**	

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as NonHazardous Waste)
Present Worth Analysis

Year	Capital Cost	Operation & Maintenance Cost	Annual Cost	Total Year Cost	Annual Discount Rate at 7%	Present Worth
0	$104,023			$104,023	1.000	$104,023
1		$1,131	$1,500	$2,631	0.935	$2,460
2		$1,131	$2,500	$3,631	0.873	$3,170
3		$1,131	$2,500	$3,631	0.816	$2,963
4		$1,131	$1,500	$2,631	0.763	$2,007
5		$1,131	$2,500	$3,631	0.713	$2,589
6		$1,131	$1,500	$2,631	0.666	$1,752
7		$1,131	$1,500	$2,631	0.623	$1,639
8		$1,131	$1,500	$2,631	0.582	$1,531
9		$1,131	$1,500	$2,631	0.544	$1,431
10		$1,131	$2,500	$3,631	0.508	$1,844
11		$1,131	$1,500	$2,631	0.475	$1,250
12		$1,131	$1,500	$2,631	0.444	$1,168
13		$1,131	$1,500	$2,631	0.415	$1,092
14		$1,131	$1,500	$2,631	0.388	$1,021
15		$1,131	$2,500	$3,631	0.362	$1,314
16		$1,131	$1,500	$2,631	0.339	$ 892
17		$1,131	$1,500	$2,631	0.317	$ 834
18		$1,131	$1,500	$2,631	0.296	$ 779
19		$1,131	$1,500	$2,631	0.277	$ 729
20		$1,131	$2,500	$3,631	0.258	$ 937
21		$1,131	$1,500	$2,631	0.242	$ 637
22		$1,131	$1,500	$2,631	0.226	$ 595
23		$1,131	$1,500	$2,631	0.211	$ 555
24		$1,131	$1,500	$2,631	0.197	$ 518
25		$1,131	$2,500	$3,631	0.184	$ 668
26		$1,131	$1,500	$2,631	0.172	$ 453
27		$1,131	$1,500	$2,631	0.161	$ 424
28		$1,131	$1,500	$2,631	0.150	$ 395
29		$1,131	$1,500	$2,631	0.141	$ 371
30		$1,131	$2,500	$3,631	0.131	$ 476
					TOTAL PRESENT WORTH	**$140,515**

NAVAL SURFACE WARFARE CENTER CRANE
Crane, Indiana
SWMU 7
Alternative S-2: Limited Action (Excavation and Off-Site Disposal as NonHazardous Waste)
Capital Costs

ASSUMPTIONS

1. Excavation to depth of 1 foot with no groundwater
2. No utilities (underground or overhead)
3. No wetlands or stream restoration
4. All materials are to be disposed off-site as non-hazardous or hazardous
5. Assume no site support equipment or utilities are needed
6. Due to the geography of the areas being excavated (on a sloped surface and interspaced with contaminated and non-contaminated areas, it was assume that the actual excavation will include the entire footprint area of 20' x 75' x 1' at each location (the ORR and OPR).

CALCULATIONS

Volume to be excavated is 100 cubic yards
Assume 1.5 tons per cy for 150 tons

Construction Time Line

Mob	1	day
Excavation/Disposal	4	days
Backfill	2	days
Restoration	2	days
Demob	1	day
	10	days

Total backfill = topsoil only (assume 50% of removed or 50 cubic yards)

		ft		ft		
Seed & Fertilizer:	roadway	20		450	9,000	sq ft
	berm 1	20		75	1,500	sq ft
	berm 2	20		75	1,500	sq ft
					12,000	sq ft
			times		2	
					24,000	sq ft
			or		24	msf