FINAL

Water Area Munitions Study

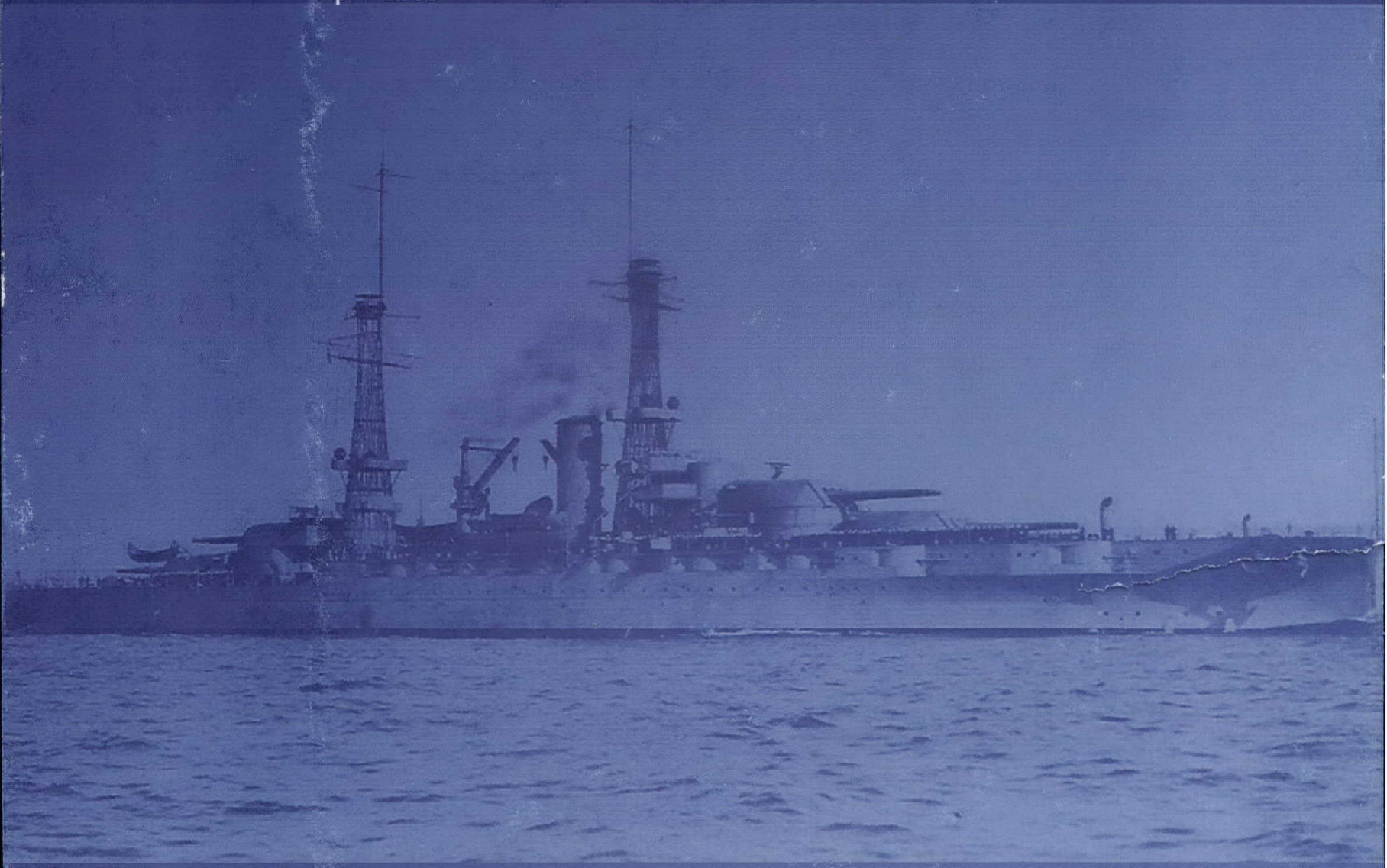
Dugger Lake Facility

Naval Surface Warfare Center Crane Division, Indiana

April 2005

N00164.AR.000938
NSWC CRANE
5090.3a

MALCOLM PIRNIE



FINAL
WATER AREA MUNITIONS STUDY
DUGGER LAKE FACILITY
NAVAL SURFACE WARFARE CENTER
CRANE DIVISION, INDIANA

April 2005

Prepared for:

Naval Surface Warfare Center
Crane Division
Naval Facilities Engineering Command
300 Highway 361
Building 3260
Code 095
Crane, Indiana 47522-5001

Prepared by:

MALCOLM PIRNIE, INC.
300 East Lombard Street, Suite 610
Baltimore, Maryland 21202

FINAL
WATER AREA MUNITIONS STUDY
DUGGER LAKE FACILITY
NAVAL SURFACE WARFARE CENTER
CRANE DIVISION, INDIANA

DoD Contract Number: N62472-02-D-1300

Reviewed and Approved by:

Jeffrey R. Bennett, P.E., DEE
Program Officer
Malcolm Pirnie, Inc.

Hien Dinh
Team Leader
Malcolm Pirnie, Inc.

Malcolm Pirnie, Inc. prepared this report at the direction of Engineering Field Activity Northeast. This document should be used only with the approval of the Engineering Field Activity Northeast. This report is based, in part, on information provided in other documents and is subject to the limitations and qualifications presented in the referenced documents.

April 2005

Table of Contents

ACRONYMS I
GLOSSARY OF TERMS III
EXECUTIVE SUMMARY ES-1
1. INTRODUCTION 1-1
1.1. PURPOSE 1-2
1.2. PROJECT MANAGEMENT 1-2
1.3. WATER AREA MUNITIONS STUDY APPROACH 1-2
2. INSTALLATION BACKGROUND 2-1
2.1. LOCATION AND SETTING 2-1
2.2. INSTALLATION HISTORY 2-3
2.3. MUNITIONS RELATED TRAINING / STORAGE / USAGE 2-4
3. PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS 3-1
3.1. CLIMATE 3-1
3.2. TOPOGRAPHY 3-1
3.3. GEOLOGY 3-1
3.4. SOIL AND VEGETATION TYPES 3-2
3.5. HYDROLOGY 3-3
3.6. HYDROGEOLOGY 3-3
3.7. CULTURAL AND NATURAL RESOURCES 3-3
3.8. ENDANGERED AND SPECIAL STATUS SPECIES 3-4
4. SUMMARY OF DATA COLLECTION EFFORT 4-1
4.1. HISTORICAL ARCHIVE REPOSITORIES (OFF-SITE) 4-1
4.2. PERSONAL INTERVIEWS 4-4
4.3. ON-SITE DATA REPOSITORIES 4-6
4.4. VISUAL SURVEY 4-7
4.5. OFF-SITE DATA SOURCES 4-7
5. SITE CHARACTERISTICS 5-1
5.1. HISTORY AND SITE DESCRIPTION 5-1
5.1.1. Topography 5-2
5.1.2. Geology 5-2
5.1.3. Soil and Vegetation Types 5-2
5.1.4. Hydrology 5-3
5.1.5. Hydrogeology 5-3
5.1.6. Cultural and Natural Resources 5-3
5.1.7. Endangered and Special Status Species 5-3
5.2. VISUAL SURVEY OBSERVATIONS AND RESULTS 5-4
5.3. MUNITIONS AND MUNITIONS RELATED MATERIALS ASSOCIATED WITH THE SITE 5-5
5.4. MEC PRESENCE 5-7
5.4.1. Known MEC Areas 5-8

5.4.2. Suspected MEC Areas *5-8*
5.4.3. Areas Not Suspected to Contain MEC *5-8*
5.5. ORDNANCE PENETRATION ESTIMATES 5-8
5.6. MUNITIONS CONSTITUENTS 5-9
5.7. CONTAMINANT MIGRATION ROUTES 5-9
5.8. RECEPTORS 5-10
5.8.1. Nearby Populations *5-10*
5.8.2. Buildings Near/Within Site *5-11*
5.8.3. Utilities On/Near Site *5-11*
5.9. LAND USE 5-11
5.10. ACCESS CONTROLS / RESTRICTIONS 5-12
5.11. CONCEPTUAL SITE MODEL 5-12
5.12. SUMMARY 5-21

APPENDICES

Appendix A: References

Appendix B: Project Source Data – General

Appendix C: Project Source Data – Site Specific

Appendix D: Ordnance Technical Data Sheets

MAPS

MAP 2-1: AREA LOCATION MEC SITE: DUGGER LAKE FACILITY 2-2
MAP 5-1: VISUAL SURVEY: DUGGER LAKE FACILITY 5-22
MAP 5-2: RANGE/SITE DETAILS: DUGGER LAKE FACILITY 5-23
MAP 5-3: MUNITIONS CHARACTERIZATION: DUGGER LAKE FACILITY 5-24

FIGURES

FIGURE 5.1-1: TEST BARGE (PHOTO FROM OESO FILES) 5-2
FIGURE 5.2-1: CURRENT VIEW OF DUGGER LAKE 5-4
FIGURE 5.2-2: CURRENT VIEW OF NEARBY MINING COMPANY PUMPING WATER FROM DUGGER LAKE 5-5
FIGURE 5.8-1: VIEW OF PRIVATE RESIDENCE AT DUGGER LAKE 5-11
FIGURE 5.11-1: MEC EXPOSURE PATHWAY ANALYSIS 5-18
FIGURE 5.11-2: MC EXPOSURE PATHWAY ANALYSIS 5-19
FIGURE 5.11-3: DUGGER LAKE FACILITY GRAPHICAL ILLUSTRATION 5-20

TABLES

TABLE 2.2-1: HISTORY OF NSWC CRANE 2-3
TABLE 5.3-1: PYROTECHNICS AND ASSOCIATED HAZARDS 5-7
TABLE 5.11-1: CONCEPTUAL SITE MODEL INFORMATION PROFILES – DUGGER LAKE FACILITY 5-13

ACRONYMS

°F	degrees Fahrenheit
bgs	below ground surface
BRAC	Base Realignment and Closure
CAAA	Crane Army Ammunition Activity
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CSM	Conceptual Site Model
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
ECD	Explosive Capsulated Device
EFANE	Engineering Field Activity Northeast
EOD	Explosive Ordnance Disposal
FUDS	Formerly Used Defense Site
GIS	Geographical Information System
KY	Kentucky
LANTDIV	Atlantic Division
MEC	Munitions and Explosives of Concern
MC	Munitions Constituents
MK	Mark
MRP	Military Munitions Response Program
NAVFAC	Naval Facilities Engineering Command
NSWC	Naval Surface Warfare Center
NWSC	Naval Weapons Support Center
OE	Ordnance and Explosives
OESP	Ordnance Environmental Support Office
PAO	Public Affairs Office
POC	Point of Contact
RG	Record Groups
RPM	Remedial Project Manager
SEC	Synchronous Equipment Clock
SI	Site Investigation

U.S.	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WAMS	Water Area Munitions Study

GLOSSARY OF TERMS

Base Realignment and Closure (BRAC) – A Department of Defense (DoD) program that focuses on compliance and cleanup efforts at military installations undergoing closure or re-alignment, as authorized by Congress in four rounds of base closures for 1988, 1991, 1993, and 1995. (DERP Management Guidance, September, 2001)

Closed Range – A range that has been taken out of service as a range and that either has been put to new uses that are incompatible with range activities or is not considered by the military to be a potential range area. A closed range is still under the control of a DoD component. (DERP Management Guidance, September, 2001)

Defense Site – All locations that are or were owned by, leased to, or otherwise possessed or used by the DoD. The term does not include any operational range, operating storage or manufacturing facility, or facility that is used or was permitted for the treatment or disposal of military munitions. (10 U.S.C. 2710(e)(1))

Discarded Military Munitions – Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include unexploded ordnance, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (10 U.S.C. 2710(e)(2))

Explosive Ordnance Disposal (EOD) – The detection, identification, field evaluation, rendering-safe, recovery, and final disposal of unexploded explosive ordnance (UXO). It may also include the rendering-safe and/or disposal of EO (explosive ordnance) which has become hazardous by damage or deterioration, when disposal of such EO requires techniques, procedures, or equipment which exceed the normal requirements for routine disposal. (OPNAVINST 8027.1G, 14 Feb 92)

Explosives Safety – A condition where operational capability and readiness, personnel, property, and the environment are protected from the unacceptable effects of an ammunition or explosives mishap. (DoD Directive 6055.9 July 1996)

Formerly Used Defense Site (FUDS) – Real property that was formerly owned by, leased by, possessed by, or otherwise under the jurisdiction of the Secretary of Defense or the Components (including governmental entities that are the legal predecessors of DoD or the Components) and those real properties where accountability rested with DoD but where activities at the property were conducted by contractors (i.e., government-owned, contractor-operated (GOCO) properties) that were transferred from DoD control prior to October 17, 1986. The status of a site as a FUDS is irrespective of current ownership or current responsibility within the federal government. (DERP Management Guidance, September, 2001)

Munitions Constituents (MC) – Any materials originating from unexploded ordnance, discarded military munitions or other military munitions, including explosive and non-explosive materials, and emission, degradation, or breakdown elements of such ordnance or munitions. (10 U.S.C. 2710 (e)(4))

Munitions and Explosives of Concern (MEC) – This term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks, means: unexploded ordnance, discarded military munitions or munitions constituents (e.g., TNT, RDX) present in high enough concentrations to pose an explosive hazard. (OUSD(AT&L) 18 December 2003)

Operational Range – A range that is under the jurisdiction, custody, or control of the Secretary of Defense and that is used for range activities, or although not currently being used for range activities, that is still considered by the Secretary to be a range and has not been put to a new use that is incompatible with range activities. (10 U.S.C. 101 (e)(3))

Other than Operational Range – Encompasses closed, transferred and transferring ranges.

Range – A designated land or water area set aside, managed, and used for range activities of the DoD. Ranges include firing lines and positions, maneuver areas, firing lanes, test pads, detonation pads, impact areas, electronic scoring sites, buffer zones with restricted access and exclusionary areas, and airspace areas designated for military use in accordance with regulations and procedures prescribed by the Administrator of the Federal Aviation Administration. (10 U.S.C. 101 (e)(3))

Transferred Range – A property formerly used as a military range that is no longer under military control and had been leased by the DoD, transferred, or returned from the DoD to another entity, including federal entities. This includes a range that is no longer under military control but was used under the terms of a withdrawal, executive order, special-use permit or authorization, right-of-way, public land order, or other instrument issued by the federal land manager. (DERP Management Guidance, September, 2001)

Transferring Range – A range that is proposed to be transferred or returned from the DoD to another entity, including federal entities. This includes a range that is used under the terms of a withdrawal, executive order, act of Congress, special-use permit or authorization, right-of-way, public land order, or other instrument issued by the federal land manager or property owner. An operational or closed range will not be considered a "transferring range" until the transfer is imminent. (DERP Management Guidance, September, 2001)

Unexploded Ordnance – Military munitions that have been primed, fused, armed, or otherwise prepared for action; have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and remain unexploded either by malfunction, design, or any other cause. (10 U.S.C. 101(e)(5))

EXECUTIVE SUMMARY

The Department of Defense (DoD) has established the Military Munitions Response Program under the Defense Environmental Restoration Program (DERP) to address munitions and explosives of concern (MEC) (including unexploded ordnance (UXO) and discarded military munitions (DMM)) and munitions constituents (MC) at other than operational military ranges and other sites. Closed, transferred, and transferring military ranges and sites not located on an operational range are considered other than operational. This report addresses other than operational ranges and sites at an active installation. It may include transferring and/or transferred ranges and munitions disposal sites associated with an active installation if they are not included in the Base Realignment and Closure (BRAC) or Formerly Used Defense Site (FUDS) Programs.

However, by definition munitions related sites located in water are not addressed under the Navy Military Munitions Response Program (MRP). For example, deep-sea sites including former munitions disposal areas and ranges are not addressed under the MRP. In order to document the history of these areas in a standard format, a Water Area Munitions Study (WAMS) report is complied. This report represents the WAMS for the Dugger Lake Facility associated with the Naval Surface Warfare Center, Crane Division (NSWC Crane), Indiana.

NSWC Crane is located in Martin County in south-central Indiana. NSWC Crane is the third largest naval installation in the world encompassing 100 square miles and employing approximately 3,400 Naval employees and 550 Army employees. The installation was originally built to prepare, load, renovate, receive, store, and issue all ammunition, including pyrotechnics and illuminating projectiles, and to act as a principal source of supply at a most critical time - the early days of World War II; however, due to its expertise in engineering and electronics, NSWC Crane today is a multi-mission, multi-service product center with both fleet support and industrial base missions.

According to site personnel, the Dugger Lake Facility was used for hydro acoustic testing and the testing of marine markers, cable cutters, swimmer recall devices, synchronous equipment clock (SEC) and explosive capsulated device (ECD) from 1975 through 1994. No evidence of MEC was observed around the rim of the lake, and site personnel indicated that numerous underwater

dives throughout the period of time testing was conducted at the lake have not identified any MEC or related debris. There is a potential for MC to exist in the lake sediments at the site due to the amount of MC associated with the tested munitions. Because water is pumped from the lake on a continual basis by a local mining company, it is unlikely that MC still remain within the water column.

1. INTRODUCTION

The Department of Defense (DoD) has established the Military Munitions Response Program under the Defense Environmental Restoration Program (DERP) to address munitions and explosives of concern (MEC) (including unexploded ordnance and discarded military munitions) and munitions constituents (MC) at other than operational ranges. The term "other than operational ranges" includes closed, transferred and transferring military ranges, as well as any other past-use site known or suspected to contain MEC or MC that is not located on an operational range. This report addresses other than operational ranges and sites at an active installation. It may include transferred and/or transferring ranges and munitions disposal sites associated with an active installation if they are not included in the Formerly Used Defense Sites (FUDS) and Base Realignment and Closure (BRAC) Programs.

However, by definition, munitions related sites located in water are not addressed under the Navy Military Munitions Response Program (MRP). For example, deep-sea sites including former munitions disposal areas and ranges are not addressed under the MRP. In order to document the history of these areas in a standard format, a Water Area Munitions Study (WAMS) report is complied. This report represents the WAMS for the Dugger Lake Facility associated with the Naval Surface Warfare Center, Crane Division (NSWC Crane), Indiana.

This WAMS is organized into the following sections:

- Section 1 – Introduction
- Section 2 – Installation Background
- Section 3 – Physical and Environmental Characteristics
- Section 4 – Summary of Data Collection Effort
- Section 5 – Site Characteristics

The following supporting information is appended to this WAMS:

- References (Appendix A)
- Project Source Data – General (Appendix B)
- Project Source Data – Site Specific (Appendix C)
- Ordnance Technical Data Sheets (Appendix D)

1.1. Purpose

This WAMS summarizes the history of munitions use at the Dugger Lake Facility at NSWC Crane and provides an assessment of the current conditions with respect to MEC and MC. The WAMS provides the necessary information for Navy and regulatory decision-makers to develop a Conceptual Site Model (CSM) for the site. The CSM presents information regarding: 1) MEC and/or MC known or suspected to be at the site; 2) current and future reasonably anticipated or proposed uses of the real property; and 3) actual, potentially complete, or incomplete exposure pathways that link them. The CSM is the basis for the risk evaluation, prioritization, and remediation cost estimate.

1.2. Project Management

This WAMS is being coordinated and managed by the Navy Engineering Field Activity Northeast (EFANE), a component of the Atlantic Division (LANTDIV) of the Naval Facilities Engineering Command (NAVFAC). The EFANE performs engineering functions for Navy installations throughout the northeast United States (U.S.) and is the Program Manager for this WAMS. Malcolm Pirnie, Inc. has been contracted to prepare this WAMS. The Navy Remedial Project Manager (RPM) for Southern Division and the installation points of contact (POC) for NSWC Crane provided valuable information and assistance throughout the WAMS data collection process. The Navy RPM is the responsible party for this WAMS.

1.3. Water Area Munitions Study Approach

The WAMS process for the Dugger Lake Facility involved collecting and reviewing existing and available information about the site; data collection activities included off-site and on-site research and interviews. The Malcolm Pirnie data collection team conducted the on-site portion of the data collection and visual survey on March 18-20, 2003. A summary of the data collection process for the Dugger Lake Facility is presented in Section 4.

This WAMS is inclusive and makes use of all available data relating to munitions use at the Dugger Lake Facility, including historical records, field data, anecdotal evidence, interviews with site personnel, and professional knowledge and experience. It is based, in part, on information provided in documents referenced in Appendix A and is subject to the limitations and qualifications presented in the referenced documents.

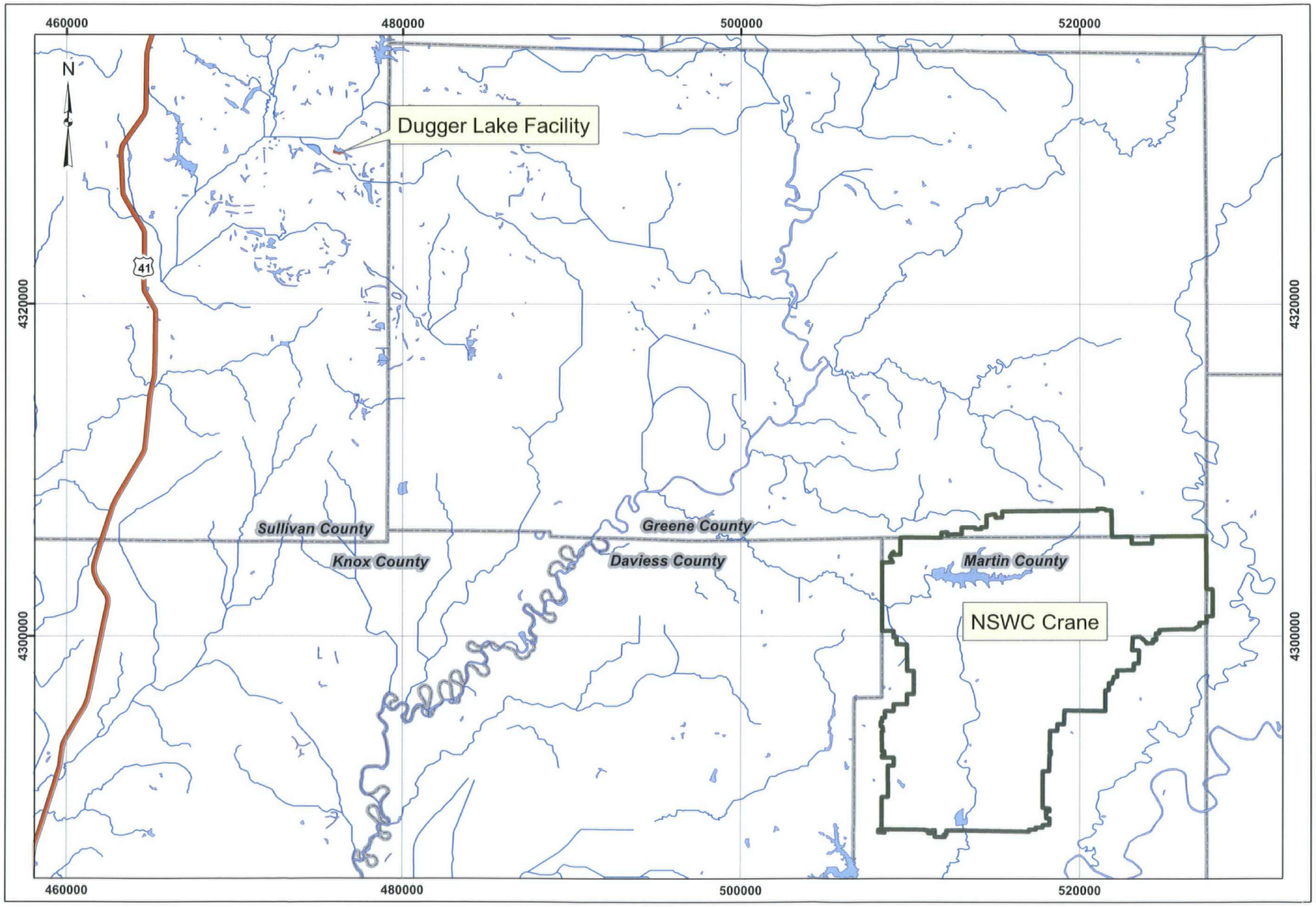
2. INSTALLATION BACKGROUND

The following sections provide general information about NSWC Crane including its location and setting; a brief history of the installation; its missions over time; and a history of munitions related training, storage, and usage.

2.1. Location and Setting

NSWC Crane covers roughly the northern third of Martin County with a small overlap into Greene County to the north and an even smaller overlap into Lawrence County on the east. The approximately 63,000-acre base is approximately 37 miles southwest of Bloomington, Indiana, and approximately 70 miles southwest of Indianapolis, Indiana, as shown in Map 2-1. NSWC Crane is situated in a rural setting in southwest Indiana. Surrounding towns include Crane Village to the northwest, Burns City to the west and Bedford to the east. An 800-acre lake, Lake Greenwood, is located along the north-central portion of the base and serves as the primary water supply for NSWC Crane. Map 2-1 depicts the location of the Dugger Lake Facility.

The Dugger Lake Facility is private property located approximately 30 miles northwest of NSWC Crane. The Dugger Lake facility is the only other than operational range identified that is located off the installation.



Water Area Munitions Study
NSWC Crane, Indiana

MALCOLM PIRNIE

Map 2-1
Area Location Map
Dugger Lake Facility

Legend

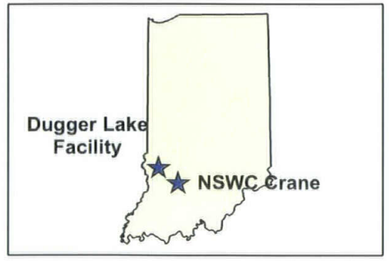
- Installation Boundary
- Counties
- Interstate
- Steams
- Waterbodies
- Dugger Lake Facility

2 0 2 4 6 Miles

Data Source: NSWC Crane, Orthophoto, 1998
NSWC Crane, GIS Data, 2003
ESRI, GIS Data, 2002

Coordinate System: UTM Zone 16N
Datum: NAD83
Units: Meters

Contract: N62472-02-D-1300
Edition: Final Water Area Munitions Study
Date: April 2005



2.2. Installation History

NSWC Crane began in 1941 as the Naval Ammunition Depot. Since its inception, NSWC Crane has been under four different commands. The Ammunition Quality Evaluation Unit was added in 1947, which led NSWC Crane into expanded activities, capabilities, and expertise. In 1975, the installation name changed to Naval Weapons Support Center, Crane (NWSC Crane) to reflect its true function of weapons support. The Crane Army Ammunition Activity (CAAA) was established in 1977 to assume the loading, assembly and storage of ammunition at the installation. After merging with the Naval Ordnance Station at Louisville, Kentucky (KY), in 1992, the installation received its current name: Crane Division, Naval Surface Warfare Center, and continues to be a recognized leader in highly technical product lines servicing the Navy. Table 2.2-1 contains a summary of NSWC Crane's history.

Table 2.2-1: History of NSWC Crane

Time Period	Significant Events
Prior to 1795	Indian Territory
1795 – 1940	Greenville Treaty signed and settlers arrived. The White River Project was dedicated in 1939, which provided a state park and restored forest productivity.
1941	Established in 1941 as the *Naval Ammunition Depot* for the production, testing, and storage of ordnance, including pyrotechnics and illuminating projectiles, under the command of the Bureau of Ordnance.
1947	Ammunition Quality Evaluation Unit was added by the Bureau of Ordnance to expand the quality control system and establish a laboratory at Crane.
1950s	Crane came under command of the Bureau of Weapons and expanded activities, capabilities, and expertise to include small arms, sonobouy surveillance, microwave tubes, POLARIS missiles, and other engineering support.
1960s	Crane came under command of the Naval Ordnance Systems Command and began providing technical support for weapons systems.
1974	Crane came under the Naval Sea Systems Command and Naval Ship Systems Command.
1975	The installation name changed to *NWSC, Crane* to reflect its true function.
1977	Establishment of the tenant command CAAA. The CAAA assumed the loading, assembly and storage of ammunition at the installation.
1992	Crane was merged with the Naval Ordnance Station at Louisville, KY to form the *Crane Division, NSWC.*
Present	NSWC Crane serves a modern and sophisticated Navy as a recognized leader in highly technical product lines.

2.3. Munitions Related Training / Storage / Usage

During World War II, the Korean Conflict, and the Vietnam Conflict, NSWC Crane developed, tested, stored, trained with and used all types of Naval munitions including small arms, detonators, cartridge actuated devices, propellant actuated devices and various pyrotechnics.

3. PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS

The following sections provide general information for the Dugger Lake Facility, including its climate; topography; geology; soil and vegetation types; hydrology; hydrogeology; cultural and natural resources; and endangered species.

3.1. Climate

The Dugger Lake Facility is located in Sullivan County. The climate of Sullivan County is mid-continent and is characterized by wide ranges in temperature from summer to winter. The average minimum temperature in January is 22 degrees Fahrenheit (°F), and the average maximum temperature is 39°F. The average minimum temperature in July is 65°F, and the average maximum temperature is 88°F. Rainfall, on the average, is 38 inches annually. Monthly precipitation averages between two and five inches. Snowfall averages a little more than 14 inches per winter season but is extremely variable. The wind is from the southwest most of the time, but in some winters the prevailing wind is from the west or northwest. Relative humidity ranges from 40 to 50 percent in the summer and 10 to 20 percent in the winter. The frost line in southern Indiana is approximately 2.5 feet below ground surface (bgs).

3.2. Topography

The Dugger Lake Facility is a water testing facility; however, the topography of the nearby area is generally level or gently undulating dissected by numerous well-defined waterways. The surface configuration of Sullivan County presents a succession of mounds and low ridges, often erroneously attributed to human activity (coal mining). The elevation of the area surrounding the Dugger Lake Facility ranges from approximately 440 feet to 480 feet.

3.3. Geology

Pennsylvania rocks are the bedrock surface throughout the Lower Wabash River basin, in which the Dugger Lake Facility is located, and are more than 1,000 feet thick. A lithologic sequence of sandstone, shaly sandstone, shale, thin limestone, coal, and underclay comprise the Raccoon Creek, Carbondale, and McLeansboro Groups of Pennsylvanian age. Pennsylvanian bedrock exposed at the land surface or bedrock surface in the basin belong to the Linton, Petersburg, and Dugger Formations. These deeper rock formations contain water sources for a number of the

areas surrounding the Dugger Lake Facility. The region physiography is characterized by nearly level to steep uplands.

The areas surrounding the Dugger Lake Facility are coalmines. Coal measures are the only rock formations which occur in Sullivan County. The beds comprise a series of shales, compact and argillaceous sandstones, clays, and fossiliferous limestones, with four seams of coal. Deep borings have proven the existence of at least two other seams, without reaching the lower coals usually found in connection with the conglomerate.

The glacial drift rests immediately upon the rocks of the coal measures and consists of three layers: first, blue and gray clays, irregularly mixed with coarse and fine gravel; second, the same clays with coarse gravel and boulders of granite, gneiss, quartz rock, and porphyry, with a very small quantity of gold, copper, lead and magnetic iron ore, and red garnets; and third, and last at the base, blue and white plastic clay, from two to five feet thick. All of these materials have been transported during the great ice flow from the stratified rocks of the Azoic and Metamorphic regions at the northwest portion of the state. Layers along the ground surface include stratified clays and some silty sand loams.

3.4. Soil and Vegetation Types

According to the Soil Survey of Sullivan County, Indiana, conducted by the United States Department of Agriculture (USDA), Forest Service, in cooperation with the Purdue University Agricultural Experiment Station, the primary soil types located at the area of the Dugger Lake Facility, Sullivan County, are a variety of silt loams.

Three different types of Ava silt loam can be found in the area of the Dugger Lake Facility. They are zero to two percent slopes, two to six percent slopes-eroded, and two to six percent slopes-severely eroded. This soil is on narrow ridge tops and at the head of drainage ways. Perching of water above the fragipan often results in some delay in spring farming operations. Erosion resulting from medium surface runoff is a hazard. This soil's permeability ranges from 0.05 to 2.5 inches per hour, and it has a moderate frost heave potential.

The Cincinnati silt loam consists of deep, well-drained soils that have a medium textured surface layer and a medium textured to moderately fine textured subsoil. A firm brittle fragipan occurs at

a depth of 26 to 32 inches. These soils are on uplands. The native vegetation was hardwood forest. Permeability is slow, surface runoff is slow to rapid, and the available moisture capacity is medium. This soil's permeability ranges from 0.05 to 2.5 inches per hour, and it has a moderate frost heave potential.

The Stendal silt loam soil is on the bottomlands of small streams. Flooding is likely during winter and during early spring. The slope range is zero to two percent. The soil's permeability ranges from 0.8 to 2.5 inches per hour, and it has a moderate to high frost heave potential.

The Vigo silt loam consists of deep, somewhat poorly drained soils that have a medium-textured surface layer and mainly moderately fine textured subsoil. The two types are the zero to two percent slopes and the two to four percent slopes-eroded. This soil type is on broad flats and small ridge tops. Its permeability ranges from less than 0.05 to 2.5 inches per hour, and it has a moderate frost heave potential.

3.5. Hydrology

Sullivan County is located in the Lower Wabash watershed. The Lower Wabash River basin includes about 10 percent of the drainage area of the Wabash River basin in Indiana. The major tributary to the Wabash River with a drainage area greater than 50 square miles near the site is the Busseron Creek. The Wabash River and its many tributaries drain almost all of Sullivan County. The Wabash River is the western boundary of the county.

3.6. Hydrogeology

The town of Dugger, located to the south of the Dugger Lake Facility, obtains its water supply from glaciofluvial sand and gravel deposits that are an important source of groundwater. These deposits are 45 to 75 feet deep, but are commonly about 55 feet deep.

3.7. Cultural and Natural Resources

Sullivan County was surveyed for archeological and cultural resources in 2001; five were identified. None of the five identified sites are located at the Dugger Lake Facility or in the immediate area. Although the potential for cultural resources exists for the area in which the site is located, there have not been any archeological or cultural sites identified at or near the site.

According to the Environmental Assessment Report for Glendora Lake, which is located less than five miles from Dugger Lake, the AMAX Coal Company performed a cultural resource reconnaissance, consisting of a review of existing literature of known cultural resources within the mining areas and an examination of the files maintained by the Indiana State Historic Preservation Office. No historic or prehistoric archaeological sites were found during mining activities.

The Glendora Lake Environmental Assessment Report also listed several aquatic invertebrates, insects, and fish in area rivers and streams; however, the report did not specify aquatic animals potentially occurring in man-made lakes.

The Environmental Assessment Report also reported the following vegetation types located within the area of the Dugger Lake Facility:

Asters	Goldenrods (Solidago)
Medicks (Medicago)	Yarrows (Achillea)
Bonesets (Eupatorium)	Selfheals (Prunella)
Rose (Rosa mutiflora)	Grapes (Vitis)
Trumpet Creeper (Campsis radicans)	Poison Ivy (Toxicodendron radicans)
Sassafras (Sassafras albidum)	Boxelder (Acer negundo)
Sumacs (Rhus)	Hazels (Corylus)
Black Walnut (Juglans nigra)	Elms (Ulmus)

3.8. Endangered and Special Status Species

Sullivan County the following species listed on the federal and state endangered species lists: federally endangered Indiana Bat (*Myotis sodalis*) and fanshall pearly mussel (*Cyprogenia stegaria*) and the federally threatened bald eagle (*Haliaeetus leucocephalus*).

4. SUMMARY OF DATA COLLECTION EFFORT

Five primary sources of information were researched as part of the data collection effort for the WAMS. The sources of data included:

1) Historical archives;
2) Personal interviews;
3) Installation data repositories;
4) Visual survey; and
5) Off-site data sources and repositories, such as local libraries and museums.

These five sources of data are discussed below, along with their relative application to this WAMS.

4.1. Historical Archive Repositories (off-site)

The data collection team reviewed archival records located at the National Archives in College Park, Maryland, and in Washington, D.C., as well as the regional branches located in Philadelphia and New York City. The data collection team researched the following records and record groups (RG) for documents relating to munitions usage at NSWC Crane. Records marked with "*" indicate boxes were pertinent information was identified and photocopied for use in the WAMS.

Textual Records:

RG 71, Bureau of Yards and Docks

Entry 12, General Correspondence, 1917-1925

Entry 13, General Correspondence re: Shore Establishments, 1916-1925

Entry 17, Index to General Correspondence, 1917-1925

Entry 21, Index to General Correspondence, 1925-1942

Entry 74, Blueprints of Naval Bases, 1940-1942

Entry 75, Drawings, 1898-1939, Vol.1, Vol.2, Box 1*

RG 72, Bureau of Aeronautics

Entry 62, General Correspondence, 1925-1942, Boxes 2797, 3842, 3843, 3844, 3845, 3920, 4014, 4019, 4020, 4036

Confidential Correspondence, 1922-1944, Box 1209

Entry 62-B, General Correspondence

1943-45, Boxes 2933, 2978, 2996, 3000, 3010, 3050, 3066*, 3078, 3385*, 3475

1946, Boxes 333, 416, 417, 418*, 419-426, 427*, 433, 436*, 437-438, 488*, 495, 503, 506, 509, 512, 513,

1947, Boxes 318, 363, 364, 365, 366*, 379*, 380, 405, 421, 426*, 430, 431, 434,

1948-1949, Boxes 371, 377*, 378*, 379, 430

1950, Box 199

1951, Boxes 163-164

1953, Boxes 242-243

1955, Boxes 193-194

1956, Boxes 184-185

1957, Boxes 192-193

1958, Box 147

RG 74, Bureau of Ordnance

Entry 25, General Correspondence, 1912-1926, Box 277*, 2317, 2318, 3087, 3093, 3112*, 3113*, 3142

Entry 25, General Correspondence, 1926-1944, Boxes 751, 754, 758*, 771, 777, 786, 787, 788*, 789*, 1060, 1078*, 1652

Entry 25-C, General Correspondence, Confidential, 1926-1939, Boxes 76, 638, 103

Entry 25-E, General Correspondence, Confidential, 1940-1942, Boxes 183, 192*

Entry 33, Index to General Correspondence, 1914-1926, Boxes 24, 33

General Correspondence, 1912-1926, Box 277*, 3112*, 3113*

Entry 33, Index to General Correspondence, 1926-1943, Boxes 21, 27

Entry1001, General Correspondence, 1907-1949, Boxes 8, 10, 11, 13, 14, 25, 26, 35-37, 51, 61, 62, 70*, 88, 101, 105, 106

Entry 1003 A-B, General Correspondence, 1948-1959, Boxes 584, 587

Construction and Procurement Files

1945, Boxes 1077*, 1190*, 1209*, 1220*, 1222, 1256*, 1257*, 1264, 1265, 1284*, 1285, 1390-1393, 1443*, 1444*, 1445*, 1446*, 1488*, 1489*, 1519-1539, 1600, 1643-1645, 1695-1696

1946, Boxes 193, 253*, 258, 265, 266, 280, 282, 289, 349*, 350*, 366*, 379*, 380*, 381*, 382*, 383*, 384*, 385*, 386*, 434*, 435

1947, Boxes 129, 188*, 199, 210*, 211, 263-265, 279*, 280, 288, 289*, 290*, 291*, 292, 330-331

RG 80, Secretary of the Navy

Entry 13, Spindle File, Letters Sent, 1918-1942, Boxes 115-118, 309, 352-353, 371-372

Entry 19, General Correspondence, 1897-1915, Boxes 1239-1241

Entry 19, General File, 1897-1926, #26395, 27280, 27812, 28332

Entry 22, General Correspondence, 1916-1926, Boxes 379, 680*, 681*, 682*, 1605, 1800, 1808, 1878*, 1879-1882, 2022, 2159, 2255*

Entry 22, General Correspondence, 1926-1940, Boxes 90,

Entry 22, General Correspondence, 1926-1944, Boxes 3071-3072, 3260

General Correspondence, 1940-1942, Box 833

Entry 130, Alphabetical File of the Assistant Secretary, 1921-1940, Box 4

Microfilm 1067, Index to General Correspondence of Secretary of Navy, 1930-1942, Rolls 29, 38, 63, 66, 90, 157

Microfilm 1052, General and Special Indexes to General Correspondence of Secretary of Navy, 1897-1926, Rolls 12, 13, 15, 24, 35, 36, 49, 62, 83, 100, 116, 119

RG 71, Bureau of Yards and Docks

Naval Property Case Files, Boxes 442, 443*, 444-450, 451*, 452

Unprocessed Naval Property Case Files, Boxes 31, 40

RG 72, Bureau of Aeronautics: [NT1-18]

Entry 62-B, General Correspondence, 1943-45, Boxes 2933, 2978, 2996, 3010, 3050, 3078, 3475

Entry 67, Confidential General Correspondence, 1922-1944, Box 1209

RG 74, Bureau of Ordnance

Entry 1001, General Correspondence, 1907-1949, Boxes 8, 10, 11, 13, 14, 25, 26, 35-37, 51, 61, 62, 70*, 88, 101, 105, 106

Entry 1003 A-B, General Correspondence, 1948-1959, boxes 584, 587

Entry 1529, Construction and Procurement Subject Files, 1945, Boxes 1519-1524, 1525*, 1526-1528, 1529*, 1530-1532, 1533*, 1534-1539

Entry 4444, Construction and Procurement Subject Files, 1946, Box 379*, 380*, 381*, 382*

Entry 1529, Construction and Procurement Subject Files, 1947, Boxes 289-291

Cartographic Records:

RG 71, Bureau of Yards and Docks

Maps for facility 903, codes 1, 2, 3, 15, 16, 32, 34, 42, 44-48

Series I microfilm, Roll 649.4*

RG 385, Naval Facilities Engineering Command, 1917-1989

Architectural and Engineering Plans, Boxes 223*, 224, 225*, 226*, 227, 228, 229, 230*

4.2. Personal Interviews

The data collection team visited the following offices located at NSWC Crane to interview representatives and research records related to the munitions/ordnance usage at the installation:

- Environmental Department
- Public Works Department
- Geographic Information Systems (GIS) Department
- Explosive Ordnance Disposal (EOD)
- Ordnance Test Group
- Explosive Safety Office
- Base Historian Office
- Public Affairs Office (PAO)
- Glendora Test Facility

According to the personnel located at the installation, most people having specific knowledge regarding munitions activities at the sites identified within this report are either deceased or retired and un-locatable. The data collection team attempted to locate these individuals; however, none were found. A summary of the personnel interviewed and general information obtained from each office is presented below.

Environmental Department – The data collection team interviewed the Environmental Protection Specialist, Mr. Phil Keith. Mr. Keith has been employed at NSWC Crane for 19 years. He provided the team access to current installation maps along with various other environmental information pertaining to areas within the installation. Mr. Keith did not have any information pertaining directly to the Dugger Lake Facility. Mr. Keith was the POC for the Navy range inventory and the data collection portion of the WAMS.

Public Works and GIS Department – The data collection team interviewed the Environmental Protection Specialist, Mr. Thomas Brent. Mr. Brent has been employed at NSWC Crane for approximately 15 years. He provided the team access to various environmental documents and studies conducted throughout various areas of the installation; however, no specific documentation regarding the Dugger Lake Facility was available. Mr. Brent provided the team with electronic map files for the installation.

EOD – The data collection team interviewed Lieutenant Ron Zitzman. Lt. Zitzman, EOD Officer-in-Charge, has been stationed at NSWC Crane for 18 months. He provided the investigating team with several binders of EOD response records from fiscal years 2000 to 2003. However, these EOD response records did not provide any specific information related to the Dugger Lake Facility or any records of munitions/ordnance usage at the site.

Ordnance Test Group – The data collection team interviewed Mr. Steve Schantz and Mr. Bart Barthold. Each had some knowledge of munitions/ordnance usage at the sites. Mr. Schantz is the Range Safety Officer at NSWC Crane and has been employed for numerous years. He indicated that the testing that occurred at the Dugger Lake Facility was conducted off a barge that is currently located at Glendora Lake. Mr. Barthold is familiar with testing that occurred at the site and he performed numerous dives during the period of time that the facility conducted testing. Exact dates of his dives were not provided. He gave the data collection team a list of test dates and items tested at the Dugger Lake Facility. In addition, Mr. Barthold was able to give specific information regarding the condition of the lake and details of tests that occurred there.

Explosive Safety Office – The data collection team interviewed the Explosive Safety Officer, Ms. Linda Stoll. She did not have any specific information related to the Dugger Lake Facility or any records of munitions/ordnance usage at the site.

Base Historian Office – The data collection team interviewed the Base Historian, Mr. John Allen. Mr. Allen was born and raised in the area surrounding NSWC Crane and has been employed in a variety of positions at NSWC Crane for approximately the past 60 years. He provided the team with historical summaries and other useful information regarding the history of NSWC Crane; however, he did not have any specific information regarding the types of munitions activities conducted at the Dugger Lake Facility except to note that a barge, which is currently located at Glendora Lake, was used at the site.

PAO - The data collection team spoke with Ms. Sue Webster who oversees the PAO at NSWC Crane. She did not have any specific information related to the Dugger Lake Facility or any records of munitions/ordnance usage at the site.

Glendora Test Facility – The data collection team spoke with Mr. Mel Jackoway who is employed at the Glendora Test Facility and was involved with testing at the Dugger Lake Facility. Mr. Jackoway indicated that testing occurred at the Dugger Lake Facility from 1975 through 1994. Mr. Jackoway stated that Dugger Lake is 100 feet deep and that the barge used for testing is approximately 54 feet by 32 feet. He indicated that all retrievable debris associated with testing was recovered when testing operations were moved to Glendora Lake. Glendora Lake is a naval operational range located off the installation. Successful tests consume 98% of the explosive filler and resulted in very small debris. Some of this very small debris may still be located at the bottom of the lake. Mr. Jackoway stated that the Dugger Lake Facility was primarily used for hydro acoustic testing. In addition, SEC, ECD, Mark (MK) 58, cable cutters, and swimmer recall devices were tested at the site.

4.3. On-Site Data Repositories

There is no central data repository, such as a library or museum, located at the NSWC Crane except for continuing EOD response records; however, these records did not contain any information on explosive/munitions usage occurring at the site.

The base historian provided the data collection team with a copy of the book written by Mr. Robert L. Reid and Mr. Thomas E. Rodgers, entitled A Good Neighbor: The First Fifty Years at Crane 1941-1991. This book provided historical information pertaining to the installation.

A copy of the 1987 Preliminary Review/Visual Site Inspection Report was received from the Environmental Department to provide information pertaining to the environmental setting at the installation.

Various email correspondence relating to information regarding the installation was also received from the Environmental Department.

4.4. Visual Survey

The data collection team conducted a visual survey of each site/range as part of the data collection effort for the WAMS. The purpose of the visual survey was to identify any MEC ordnance related materials (e.g., expended rounds, fragmentation, range debris, old targets), any evidence of MC (such as ground scarring, stressed vegetation, or chemical residue) and/or surface features that could provide additional information to aid in the characterization of the site. The visual survey was also used to enhance, augment, or confirm the archival data and, in some cases, provide new data to the team. A description of the area surveyed and the results of the survey are provided in Section 5.

4.5. Off-Site Data Sources

The data collection team contacted the following libraries and historical societies to obtain additional historical information regarding the site; however, no information was obtained pertaining to the identified site.

- Indiana Historical Society
- Indiana State Library
- Bedford Public Library
- Bloomfield Library
- Shoals Public Library
- Martin County Historical Society

In addition, the data collection team reviewed archival records located at the Ordnance Explosives Support Office (OESO) Library at Indian Head Division-NSWC (IHDIV-NSWC), Indian Head, Maryland. OESO provides Navy-wide environmental program support for ordnance and munitions. The data collection team researched the files available for NSWC Crane, and the following sources were of value to this WAMS:

Textual Records:

Proposed Development Plan for Station, December 21, 1940

Chief of Bureau of Yards & Docks, July 14, 1941 indicating revisions of boundary lines.

Installation Assessment of NWSC Crane, Indiana, March 1978.

Cultural Resources Survey, Crane Division NSWC, Crane, Indiana, June 1992.

Environmental Assessment, Hydroacoustic Test Facility, Glendora Lake, Sullivan County, Indiana, December 1991

Environmental Impact Assessment, for Open Burning/Detonation of Waste Munitions/Propellant, August 1975.

Records Research On-Site Survey by OESO and the Army Records Research, Pollution Control Program, 1971.

Geology and Hydrology Study for the Ammunition Burning Grounds, October 1987.

Preliminary Review/Visual Site Inspection Report of Naval Weapons Support Center, Crane, Indiana, March 1987.

Test Barge Photograph from Glendora Lake Report.

Maps:

NWSC Crane, Indiana, General Development Map, updated April 1974.

U.S. Naval Ammunition Depot Crane, Indiana, Production Areas Map.

The data collection team researched environmental information such as soil and endangered species information pertaining to the installation from the U.S. Department of Fish & Wildlife and the USDA. Historical and other environmental information was researched using the Internet. A complete list of Internet sources can be found in Appendix A.

5. SITE CHARACTERISTICS

The following sections provide site-specific information about the Dugger Lake Facility associated with NSWC Crane, including history and site description; visual survey observation and results; munitions characterization; contaminant migration routes; receptors; land use; access controls and restrictions; and the CSM.

5.1. History and Site Description

The Dugger Lake Facility is located at the northwest quarter of section 26, township 8 north, range 8 west, in Sullivan County, Indiana. The Dugger Lake Facility is approximately 30 miles northwest of NSWC Crane. Dugger Lake totals approximately 48 acres. According to the Range Inventory, the Dugger Lake Facility was estimated to be 5.9 acres. A map identified by the data collection team outlined the area of Dugger Lake leased by NSWC Crane for testing, indicating the site was approximately 8.5 acres, which included a portion of the shoreline. Dugger Lake is a man-made lake that was originally constructed for coal mining and is 100 feet deep. The lake is still currently used as a water source for a nearby mining company and is spring fed. According to NSWC Crane personnel, the Dugger Lake Facility was leased by NSWC Crane from Dr. and Mrs. Mark O. Lynch for use between 1975 and 1994 for testing sonobouys, marine markers, cable cutters, swimmer recall devices, and hydro acoustic testing. According to site personnel and a photograph identified in the OESO files (Figure 5.1-1), testing was conducted at the site off a barge that was floated out into the middle of the lake. The barge is two-story and measures approximately 54 feet by 32 feet. The barge was moved from the Dugger Lake Facility to the Glendora Test Facility in 1994. Testing that was previously conducted at the Dugger Lake Facility continues at the Glendora Test Facility at Glendora Lake.

Figure 5.1-1: Test Barge (photo from OESO files)

5.1.1. Topography

The Dugger Lake Facility is entirely water; however, the topography of the nearby area is generally level or gently undulating dissected by numerous well-defined waterways. The Dugger Lake Facility is located at an elevation of approximately 470 feet on a relatively flat parcel of land that gently slopes to the southwest. The depth of the lake is 100 feet.

5.1.2. Geology

There are no wells located near the Dugger Lake Facility; therefore, the site-specific geology is unknown. Dugger Lake is a former coalmine area. The surrounding area is still mined for coal.

5.1.3. Soil and Vegetation Types

According to the Soil Survey of Sullivan County, Indiana, conducted by the USDA, Forest Service in 1970, in cooperation with the Purdue University Agricultural Experiment Station, the primary soil types located in the area of the Dugger Lake Facility are a variety of silt loams

including Ava silt loam, Cincinnati silt loam, Stendal silt loam, and Vigo silt loam. It appears that the identified soils were detailed in the Soil Survey prior to the construction of Dugger Lake. Since Dugger Lake is a man-made lake, it is anticipated that the some combination of the soils listed above, as well as surface runoff from other nearby silt loam types, would be the composition of sediments of Dugger Lake.

Since the Dugger Lake Facility is entirely water and is well oxygenated during water removal by the mining company, no vegetation types exist at the site.

5.1.4. Hydrology

Dugger Lake is spring fed. Water leaves Dugger Lake via leaching, run-off, evaporation or pumping by the mining company.

5.1.5. Hydrogeology

No groundwater drinking water wells are located at the Dugger Lake Facility.

5.1.6. Cultural and Natural Resources

Although the potential for cultural resources exists for the area in which the site is located, there have not been any archeological or cultural sites identified at or near the Dugger Lake Facility.

5.1.7. Endangered and Special Status Species

There are no known listed endangered species at the Dugger Lake Facility; however, due to the surrounding environment there is a potential for the state and federally listed (threatened) bald eagle (Haliaeetus leucocephalus) and state and federally listed (endangered) Indiana bat (Myotis Sodalis) to occupy the area around the Dugger Lake Facility. No records were available specifying types of aquatic life that may reside in Dugger Lake.

5.2. Visual Survey Observations and Results

The data collection team conducted a visual survey of the Dugger Lake Facility and the surrounding areas as part of the data collection effort for the water study on March 20, 2003. The Malcolm Pirnie survey team included Ms. Molly Howard, Mr. Hien Dinh, Mr. Svend Egholm, Mr. Bill Walenius, and Mr. Terry Stark. Mr. Phil Keith and Mr. Steve Schantz of NSWC Crane accompanied the survey team. The survey team was not able to walk the area around the lake due to access restrictions; however, the team was able to visually observe the area around the lake from the available access points: the adjacent roadway and access gate.

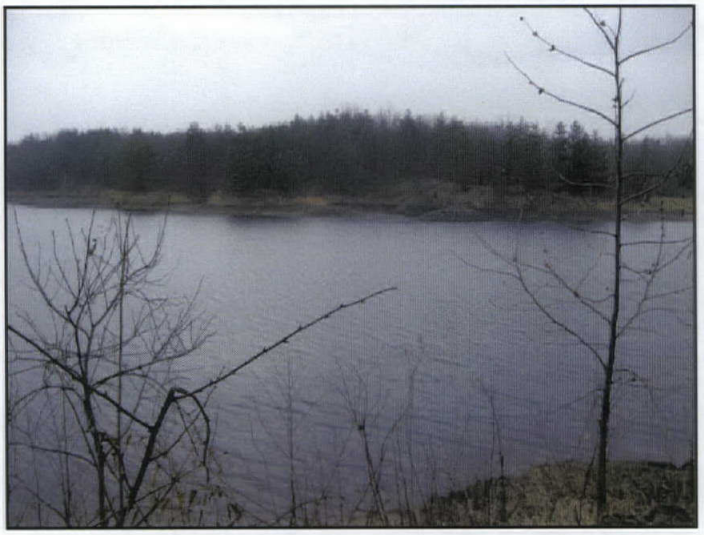


Figure 5.2-1: Current View of Dugger Lake

Figure 5.2-1 shows a view of Dugger Lake. Dugger Lake is approximately 48 acres; however, only about 8.5 acres of the lake and shoreline were leased by NSWC Crane for testing. Figure 5.2-2 shows the area of the lake used for pumping water by a local mining company. A private residence is located near the south-central portion of the lake. An access road leads to the private residence. The leased area of the lake is shown on Map 5-1 located at the end of Section 5.

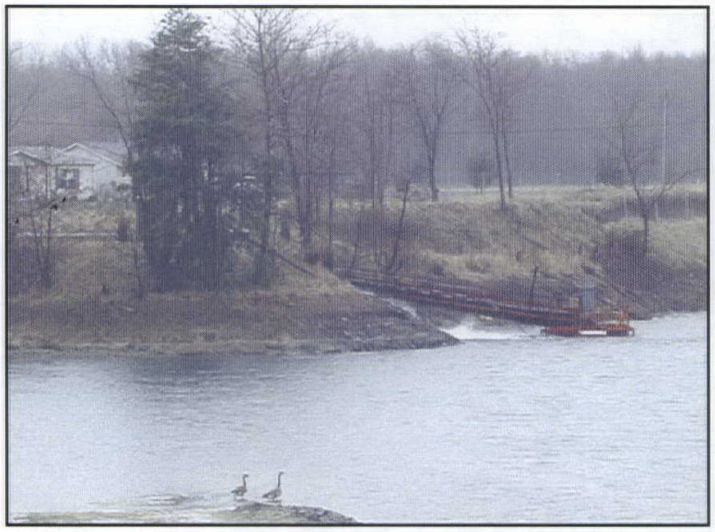


Figure 5.2-2: Current view of nearby mining company pumping water from Dugger Lake

Additional range/site details are illustrated on Map 5-2, also located at the end of Section 5. The Dugger Lake Facility is surrounded by a locked fence and woodlands. During the site visit, no evidence of munitions testing was identified at the site, and no evidence of MEC remaining at the site was observed.

5.3. Munitions and Munitions Related Materials Associated with the Site

This section describes the munitions or munitions related materials known or suspected to be at the site, including the types and estimated maximum penetration depths. This includes both MEC and non-hazardous munitions related scrap (e.g., fragmentation, base plates, inert mortar fins).

The data collection team was given documentation along with personnel interviews that indicated the following types of munitions were tested at the Dugger Lake Facility:

- MK 58 Mod 2 Marine Marker
- MK 3 Mod 1 Cable Cutters
- Swimmer Recall Devices
- SEC
- ECD

The data collection team was unable to locate specific records of the quantities of each of the munitions listed above that were tested at the Dugger Lake Facility.

The MK 58 Mod 2 is a marine marker designed for air/sea rescues, such as a target marker. The MK 58 Marine Marker is a pyrotechnic composed of a red phosphorous composition and fuzed with a saltwater activated battery. The MK 3 Mod 1 Cable Cutter is a demolition material used principally to cut cable from underwater obstructions, although it can be used on land. It has a cutting capacity at water depths up to 150 feet. The Cable Cutter contains explosive composition B at 0.25 pounds and an M550 impact fuzing system. Swimmer recall devices are classified as miscellaneous explosive devices containing black powder. The swimmer recall devices tested at the Dugger Lake Facility were M60 igniter pull-ring devices attached to an M80. Swimmer recall devices are used to notify divers to return to the surface. The recall device is thrown into the water after the fuze is ignited. The item detonates within the water, notifying divers they need to return to the surface. A SEC was a device to arm/disarm underwater mines. These devices contained approximately eight pounds of detasheet. An ECD was a 6-foot by 12-foot nylon sheet with about 40 non-electric detonators attached to it. The ECDs were used as torpedo decoys.

According to Mr. Jackoway and Mr. Barthold, numerous testing at the Dugger Lake Facility was conducted off a test barge between 1975 and 1994. No testing records or logs were maintained. The munitions were attached to 0.5-inch cable and lowered into the lake from the barge. Testing conducted at Dugger Lake Facility was mainly to test functionality and sequence of the identified munitions. It was Navy policy at the time to remove all retrievable munitions debris by EOD divers after testing. If the test was successful, the tested munitions would not leave any significant debris, and if unsuccessful, the munitions were retrieved intact from an attached cable by testing personnel on the barge or divers.

Pyrotechnic materials testing at the Dugger Lake Facility contain combustible chemicals which, when ignited, rapidly generate a flame of intense heat, flash, infrared radiation, smoke or sound display (or combinations of these effects) for a variety of purposes. Compared to other explosive substances, pyrotechnics are more adversely affected by moisture, temperature, and rough handling. Some compositions may become more sensitive, and even ignite, when exposed to moisture or air. Mixtures which contain chlorates and sulfur are susceptible to spontaneous combustion. Most pyrotechnics produce a very hot fire that is difficult to extinguish and most burn without serious explosions. Many chemicals used in pyrotechnics produce toxic effects when ignited. Other pyrotechnics, which contain propelling charges, create an extremely hazardous missile hazard if accidentally ignited. The following are some of the different types of devices that contain pyrotechnic material that may be found at the Dugger Lake Facility. The

table at the end of the bulleted items is a summary of the hazards associated to each type of pyrotechnic device.

- SIMULATORS AND DECOYS. This class of pyrotechnics is intended to produce smoke, flame and sounds which approximate that produced by actual weapons used in military operations in a ground or surface environment. These items can simulate explosives, booby traps, artillery flash, artillery impact, hand grenades, artillery air burst and other similar events.

- DYE MARKER DEVICES. Items previously in this class of devices, used to produce a color mark on water, are now obsolete or unserviceable.

Table 5.3-1: Pyrotechnics and Associated Hazards

Class of Pyrotechnic	Type of Potential Hazard/Safety Precautions
Simulators and Decoys	• High concentration of energy • Minimum safety devices
Dye Marker Devices	• Declared obsolete or unserviceable • Contain explosive burster charge

Additional technical information about these ordnance types used at the Dugger Lake Facility is included in Appendix D.

Based on the information obtained during the data collection process, no special consideration munitions (chemical warfare materiel filled munitions, electrically fuzed munitions, depleted uranium associated munitions) are known or suspected to have been used at the site; therefore, the Dugger Lake Facility is not suspected to contain special consideration MEC.

5.4. MEC Presence

The entire site has been subdivided and categorized into one of three levels of MEC presence including: Known MEC Areas, Suspect MEC Areas, and Areas Not Suspected to Contain MEC. The MEC presence is discussed below.

Map 5-3 illustrates the munitions characterization of the Dugger lake Facility and is provided at the end of Section 5.

5.4.1. Known MEC Areas

There are no known MEC areas associated with the site.

5.4.2. Suspected MEC Areas

The entire Dugger Lake is a Suspect MEC area. There is no reasonable way to contain MEC within the 8.5-acre area leased by NSWC Crane since there is wave action created by the water pumping from the nearby mining company. It was Navy policy at the time to remove all retrievable munitions debris by EOD divers after testing. If the test was successful, the tested munitions would not leave any significant debris, and if unsuccessful, the munitions were retrieved intact from an attached cable by testing personnel on the barge or divers. MEC may be contained in various areas throughout the lake; however, according to testing conducted at the site and personnel interviews, minimal MEC related debris are expected to remain at the site. Map 5-3 at the end of Section 5 illustrates the munitions characterization of the Dugger Lake Facility.

5.4.3. Areas Not Suspected to Contain MEC

Based on the site history, the areas surrounding the Dugger Lake Facility are not suspected to contain MEC.

5.5. Ordnance Penetration Estimates

The depth to which munitions penetrate below the ground surface depends on many factors, including the type of soil, the angle of impact, the size of the munition, the velocity at impact, and site-specific environmental conditions. Over the years, the DoD has studied and modeled munitions penetration depths and has issued various guidance and technical documents on the subject. For the purposes of the WAMS, maximum probable penetration depths are estimated following guidance listed in the latest draft (July 2002) of the DoD Directive on Explosives Safety issued by the DoD Explosives Safety Board [*DoD Directive 6055.9* (*DoD Ammunition and Explosives Safety Standards*)]. The Directive refers to *TM 5.855.1* and *NAVFAC P-1080.*

All identified MEC tested at the Dugger Lake Facility are only anticipated to have been present in the lake waters or resting on the lake bottom. Since the MEC tested at the Dugger Lake Facility

consisted of pyrotechnics, cable cutters, and instruments to recall divers and disarm underwater mines, it is not anticipated the MEC would have penetrated the sediments or subsurface soils of the lake.

5.6. Munitions Constituents

There is potential for MC to be associated with the types of munitions suspected to have been used at the Dugger Lake Facility. Potential MC associated with munitions tested at the Dugger Lake Facility include the following: a red phosphorous composition (within the MK 58 Marine Marker) that may contain 9-diethylamino-phenl-5-benzo (a) phenazinone, 1-methylaminoanthraquinone, 1-(2-methoxyphenylazo)-2-naphthol, 2-quinolyl-2-indandione, 1-3 (Rhodamine B) plus 1-(4-phenylazo)-2-naphthol, 2-amionanthraquinone plus 1-methylaminoanthraquinone, 0-tolylazo-o-tolylazo-B-naphthol (Sudan IV); plus 2-quinolyl-2 indandione-1,3 (Rhodamine B); plus auramine hydrochloride, and 1-(tolylazoxylylazo)-2-naphthol or 1-(2-methoxyphenylazo)-2-naphthol and 1-methlaminoanthraquinone (Celanthrene Red), explosive composition B, black powder, and an assortment of metals.

A potential exists for MC to be present within the lake sediments at the site due to amounts of MC associated with the munitions. MC is unlikely to have been retained in the water at the site due to the mining operations removal of water on a routine basis.

According to NSWC Crane personnel, in addition to the MC associated with the testing performed at the Dugger Lake Facility, sulfur contamination exists within the lake as a result of the previous coal mining operations conducted at the site.

5.7. Contaminant Migration Routes

Studies have shown that ordnance can migrate due to environmental factors such as wave action. If MEC were present at the site, it would be located only within the water or resting directly on the bottom of the lakebed. Since MEC would be contained within the water of the lake, it is possible that the MEC could potentially migrate throughout the lake via wave action caused by the pumping from the mining company.

It is possible for MC to migrate in the environment via the groundwater, soil, and surface water. MC are not anticipated to be present at the Dugger Lake Facility, except for already present

sulfur; however, if MC are present at the site, they may migrate via the surface water and sediments during the local mining company's pumping of water from the lake. MC remaining at the site would be present in the water and lakebed sediments.

5.8. Receptors

The potential contaminant receptors at the Dugger Lake Facility are receptors of MEC/MC in surface water and sediment. Only surface water and sediment are expected to have the potential for receptor interaction since the lake was the impact area of the testing. Users of surface water at Dugger Lake include several species of vegetation and indigenous animals, as well as humans. AMAX Coal Company uses Dugger Lake for pumping water for its operations. The property owner and trespassers may use the lake for recreational activities. Fish from Dugger Lake may be consumed by humans and used as a food source by other animals. Potential receptors of surface water include current and future mining personnel, property owner, trespassers, fauna and flora. Potential receptors of the sediment include aquatic fauna and floral that may burrow, forage, or grow in the sediment.

5.8.1. Nearby Populations

Sullivan County has a population of 21,825, which comprises 0.35 percent of the state's population. The population per square mile within the county is 48.6. Cass Township, in which the Dugger Lake Facility is located, has a population of 1,490. The nearby town of Dugger has a population is approximately 1,050. Several private residences are located near Dugger Lake including the one shown in Figure 5.8-1.

Figure 5.8-1: View of private residence at Dugger Lake

5.8.2. Buildings Near/Within Site

Several private residences are located adjacent and within the immediate vicinity of the Dugger Lake Facility. In addition to the residences, the pumping mechanism used by the local mining company is also located at the site.

5.8.3. Utilities On/Near Site

The nearby private residences have utilities. Since the facility is a lake, it is unlikely that any underground utilities exist under the lake; however, the local mining company must have power in order to operate the water pump located at the site. Several overhead utilities were observed along the road indicating utilities exist in the vicinity of the site.

5.9. Land Use

The Dugger Lake Facility is no longer used for testing and is considered transferred. NSWC Crane no longer has a lease on the property. The area is to remain transferred as private property with no further use as a testing facility by the Navy. Dugger Lake will continue to be used as a recreational area and as process water for AMAX Coal Company for mining operations. The land use is not anticipated to change during the foreseeable future; therefore the reasonably

anticipated future land use for the area is recreation and as process water. NSWC Crane personnel did not have any knowledge regarding whether the lake has ever been dredged or whether there are any future plans for dredging.

5.10. Access Controls / Restrictions

A locked fence controls access to the Dugger Lake Facility from the adjacent roadways. Heavy forested areas surround the lake on all other sides. The property owner and the mining company have keys for entrance into the locked gate. A locked gate to a private driveway is also located off the roadway. Once inside the fence-line and/or gate, there appear to be no other barriers to the site other than natural barriers such as forested areas.

5.11. Conceptual Site Model

This CSM was developed following guidance documents issued by the United States Environmental Protection Agency (USEPA) for hazardous waste sites and the U.S. Army Corps of Engineers (USACE) for ordnance and explosives (OE) sites. Guidance documents included the USEPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA/540/G-89/004) and the USACE CSM Guidance Development of Integrated Conceptual Site Models for Environmental Ordnance and Explosives (OE) Sites, which was final as of February 2003.

The CSM describes the site and its environmental setting. The CSM presents information regarding: 1) MEC and/or MC known or suspected to be at the site; 2) current and future reasonably anticipated or proposed uses of the real property; and 3) actual, potentially complete, or incomplete exposure pathways that link them. The CSM is the basis for the risk evaluation, prioritization, and remediation cost estimate.

The CSM is presented in a series of information profiles that presents information about the site. The information profiles are included in Table 5.11-1.

Table 5.11-1: Conceptual Site Model Information Profiles – Dugger Lake Facility		
Profile Type	**Information Needs**	**Preliminary Assessment Findings**
Range/Site Profile	Installation Name	NSWC Crane Division
	Installation Location	Crane, Martin County, Indiana
	Range/Site Name	Dugger Lake Facility
	Range/Site Location	30 miles northwest of NSWC Crane in Sullivan County, Indiana
	Range/Site History	Hydro acoustic testing and testing of sonobouys, marine markers, cable cutters, swimmer recall devices, SECs and ECDs from 1975 to 1994. Site is privately owned by Dr. Lynch and was leased to the Navy for testing purposes. The Navy no longer leases the site.
	Range/Site Area and Layout	Approximately 8.5 acres
	Range/Site Structures	Fence surrounds the lake
	Range/Site Boundaries	N: 225 North Road S: Undeveloped land E: Undeveloped land W: 700 East Road
	Range/Site Security	The site is located on non-military private property, which is surrounded by a fence. The fence is locked.
Munitions/ Release Profile	Munitions Types	MK 58 Marine Markers, cable cutters, swimmer recall devices, SEDs, ECDs
	Maximum Probability Penetration Depth	All munitions were deployed in the water off of a test barge and are not expected to have penetrated the soil of the lakebed.
	MEC Density	Suspect- Minimal range related debris is expected to be at the site based upon the Navy operating procedures to collect and remove related debris immediately after testing from the water. In addition, NSWC Crane divers indicated no debris was identified on the bottom of the lake.
	MEC Scrap/Fragments	None found along the rim of the lake. The PA team did not enter the water to investigate.
	Associated Munitions Constituents	Composition of chemicals such as 9-diethylamino-phenl-5-benzo (a) phenazinone, 1-methylaminoanthraquinone, 1-(2-methoxyphenylazo)-2-naphthol, explosive composition B, and black powder.

Table 5.11-1: Conceptual Site Model Information Profiles – Dugger Lake Facility		
Profile Type	**Information Needs**	**Preliminary Assessment Findings**
	Migration Routes/Release Mechanisms	Wave action
Physical Profile	Climate	Temperate climate zone, which has a wide temperature range between summer and winter.
	Topography	Water. The lake is located at approximately 470 feet above mean sea level on a relatively flat parcel of land that gently slopes to the southwest.
	Geology	The area is located on the eastern flank of the Illinois Basin consisting of shale, sandstone, limestone, and numerous coal beds.
	Soil	Various silt loams
	Hydrogeology	The town of Dugger, located to the south of the Dugger Lake Facility, obtains its water supply from glaciofluvial sand and gravel deposits that are an important source of groundwater. These deposits are 45 to 75 feet deep, but are commonly about 55 feet deep.
	Hydrology	Dugger Lake is spring fed. Water leaves the lake via leaching, run-off, evaporation, or pumping by the mining company. The area in which the site is located is in the Lower Wabash watershed.
	Vegetation	None
Land Use and Exposure Profile	Current Land Use	Dugger Lake is privately owned and water from the lake is pumped and used by a local mining company. The surrounding area is used for mining, farmland, and residences. The lake could be used occasionally by the landowner and visitors for recreation (e.g., fishing, swimming)
	Current Human Receptors	Mining company personnel, property owner, and trespassers
	Current Activities (frequency, nature of activity)	Recreational activities and water pumping
	Potential Future Land Use	The land use is expected to remain the same as current land use.
	Potential Future Human Receptors	Mining company personnel, property owner, and trespassers
	Potential Future Land Use-Related Activities:	The land use related activities are expected to remain the same as current activities.

Table 5.11-1: Conceptual Site Model Information Profiles – Dugger Lake Facility		
Profile Type	**Information Needs**	**Preliminary Assessment Findings**
	Zoning/Land Use Restrictions	The surrounding land use is zoned for residential and mining operations.
	Demographics/Zoning	Sullivan County has a population of 21,818, which comprises 0.35 percent of the state's population. The population per square mile in Sullivan County is 48.6.
	Beneficial Resources	Dugger Lake is used as a source of water for a local mining company.
Ecological Profile	Habitat Type	Water with surrounding lacustrine
	Degree of Disturbance	Mining company removes water from the lake on a routine basis.
	Ecological Receptors	
	Federal Endangered Species:	Indiana Bat
	Federal Threatened Species:	Bald Eagle (*Haliaeetus leucocephalus*)
	State Endangered Species:	Bald Eagle (*Haliaeetus leucocephalus*)
	State Threatened Species:	Upland sandpiper (*Bartramia langicauda*)
	Other Ecological Receptors:	Aquatic life
	Relationship of MEC/MC Sources to Habitat and Potential Receptors	Ecological receptors may come into direct contact with MEC/MC (in the water of the lake).

A key element of the CSM is the exposure pathway analysis. For MEC, a complete or potentially complete exposure pathway must include the following components: 1) a source (e.g., locations where MEC are expected to be found); 2) access (e.g., controlled or uncontrolled access, items on the surface or within the subsurface); 3) an activity (e.g., non-intrusive grounds maintenance or intrusive construction); and 4) receptors (e.g., Navy personnel, construction workers, recreational users or authorized visitors). It is important to recognize that environmental mechanisms (e.g., erosion) and/or human intervention may result in the repositioning of MEC.

For MC, a complete or potentially complete exposure pathway must include the following components: 1) a source (e.g., locations where MC are expected to be found); 2) an exposure medium (e.g., surface soil); 3) an exposure route (e.g., dermal contact); and 4) receptors (e.g., Navy personnel, construction workers, recreational users or authorized visitors). If the point of exposure is not at the same location as the source, the pathway may also include a release mechanism (e.g., volatilization) and a transport medium (e.g., air).

The potential interactions between the source and receptors are assessed differently between MEC and MC. For MC, interaction between the source and receptors involves a release mechanism for the MC, an exposure medium that contains the MC, and an exposure route that places the receptor into contact with the contaminated medium. For MEC, interaction between the potential receptors and an MEC source has two components. The receptor must have access to the source and must engage in some activity that results in contact with individual MEC items within the source area.

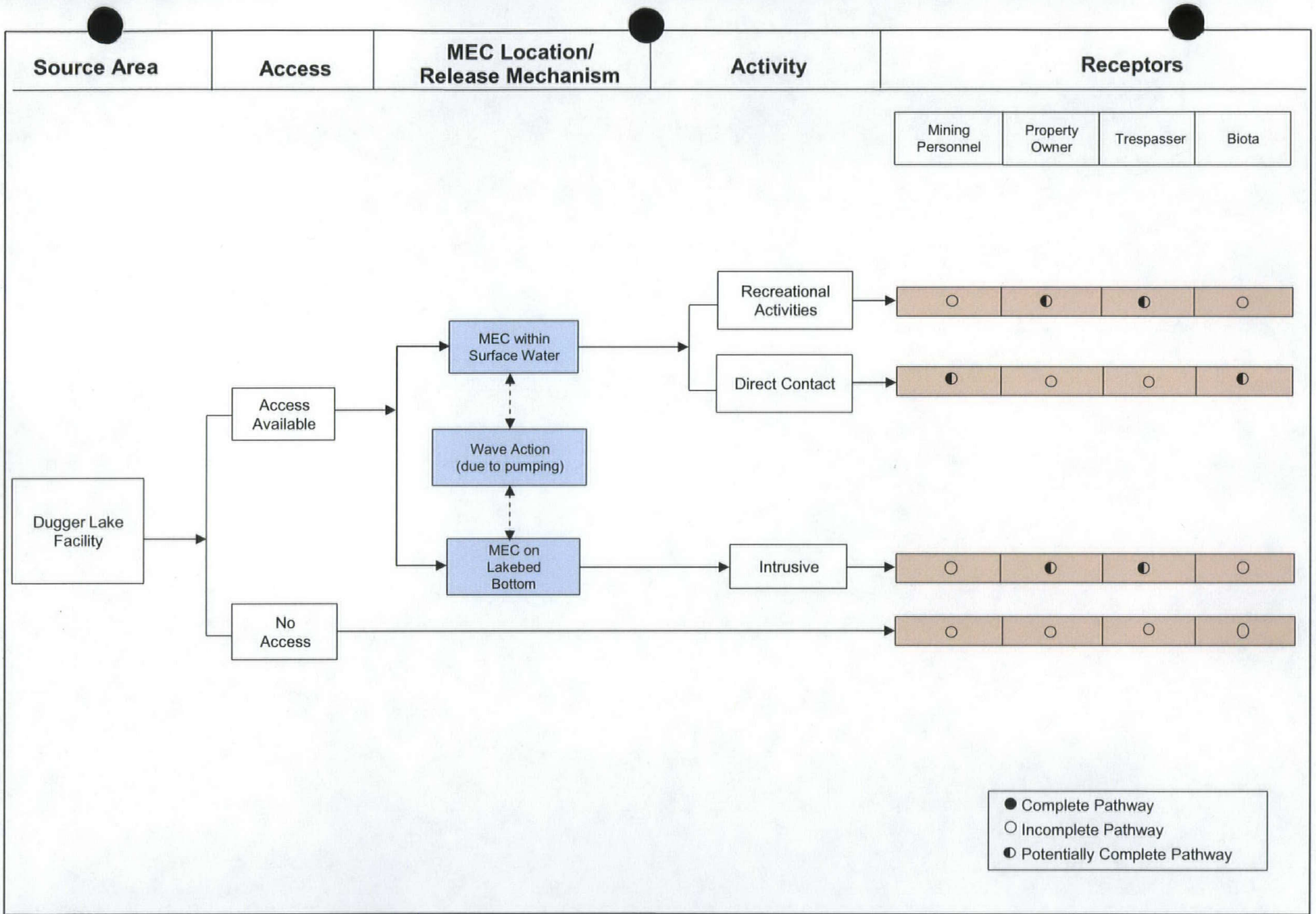
Figure 5.11-1, the MEC Exposure Pathway Analysis located at the end of Section 5.11, depicts a potential for MEC to be present at the site; however, based on discussions with site personnel, this is unlikely. MEC could be accessed by site receptors through the surface water. Human receptors (mining personnel, property owner and trespassers) may contact MEC in the water during recreational activities and/or during pumping operations at the site. Ecological receptors (biota) at the site may come in direct contact with MEC in the water.

Figure 5.11-2, the MC Exposure Pathway Analysis located at the end of 5.11, shows a potential for MC to exist at the site. Given this potential, the figure identifies the exposure pathways through which site receptors may come in contact with or be impacted by MC. A potentially complete pathway exists for both human receptors (mining personnel, property owner and trespassers) and ecological receptors (biota) through ingestion, dermal contact, and through the food chain. Human receptors may come into contact with contaminated water during recreational activities and/or during pumping operations. Biota at the site may contact and/or consume contamination in the water during natural activities. Potential bioaccumulation in game animals can pose a threat to human receptors if fishing is conducted at the site.

A graphical illustration of the details of the CSM is included in Figure 5.11-3 at the end of Section 5, which visually demonstrates the site characteristics as observed and determined by the data collection team during the site reconnaissance. The graphical illustration shows the total area of Dugger Lake is approximately 48 acres; however, the area of the lake leased by NSWC Crane was approximately 8.5 acres. The leased area is highlighted on the graphical illustration. Dugger Lake is 100 feet deep. A fence surrounds the western portion of the lake that has two gates allowing access to the lake for those who are permitted. The local mining company pumps water from the lake along the western side of the lake where a pump is located. Pumping causes

wave action within the lake. The lake is surrounded by heavily forested area and 225 North Road to the north and 700 East Road to the west. A house is located near the south-central portion of the lake. An access road leads to the house.

Groundwater at Dugger Lake is expected to be located at 45-75 feet bgs. The lake is spring fed. Precipitation at the site may cause runoff into the lake from the surrounding areas. The lake may be subject to evaporation during higher temperatures.



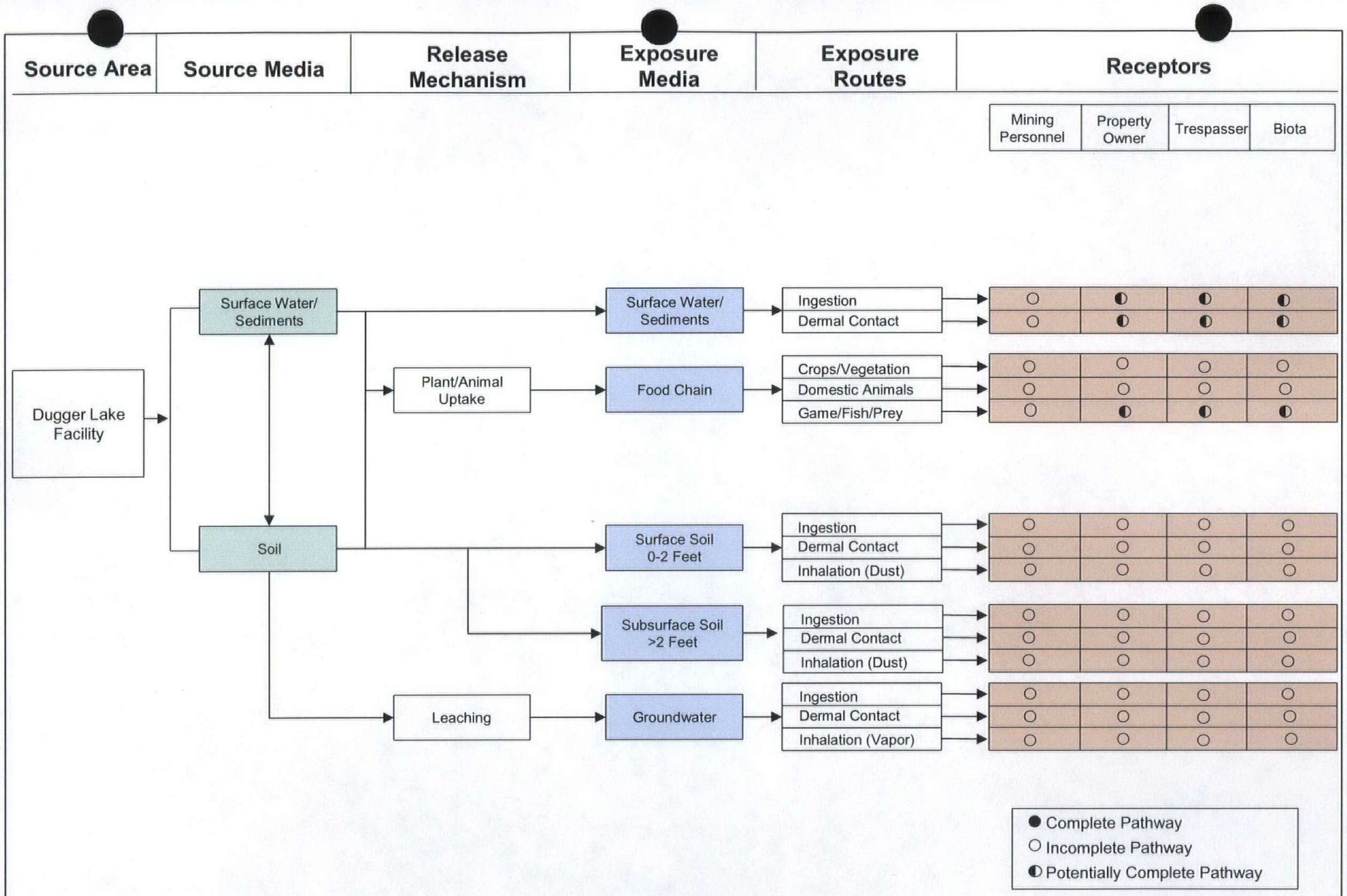
MALCOLM PIRNIE

Prepared for:

WATER AREA MUNITIONS STUDY – FINAL REPORT
DUGGER LAKE FACILITY – MEC EXPOSURE PATHWAY ANALYSIS
NSWC CRANE, INDIANA

MALCOLM PIRNIE, INC.

FIGURE 5.11-1
April 2005



MALCOLM PIRNIE

Prepared for:

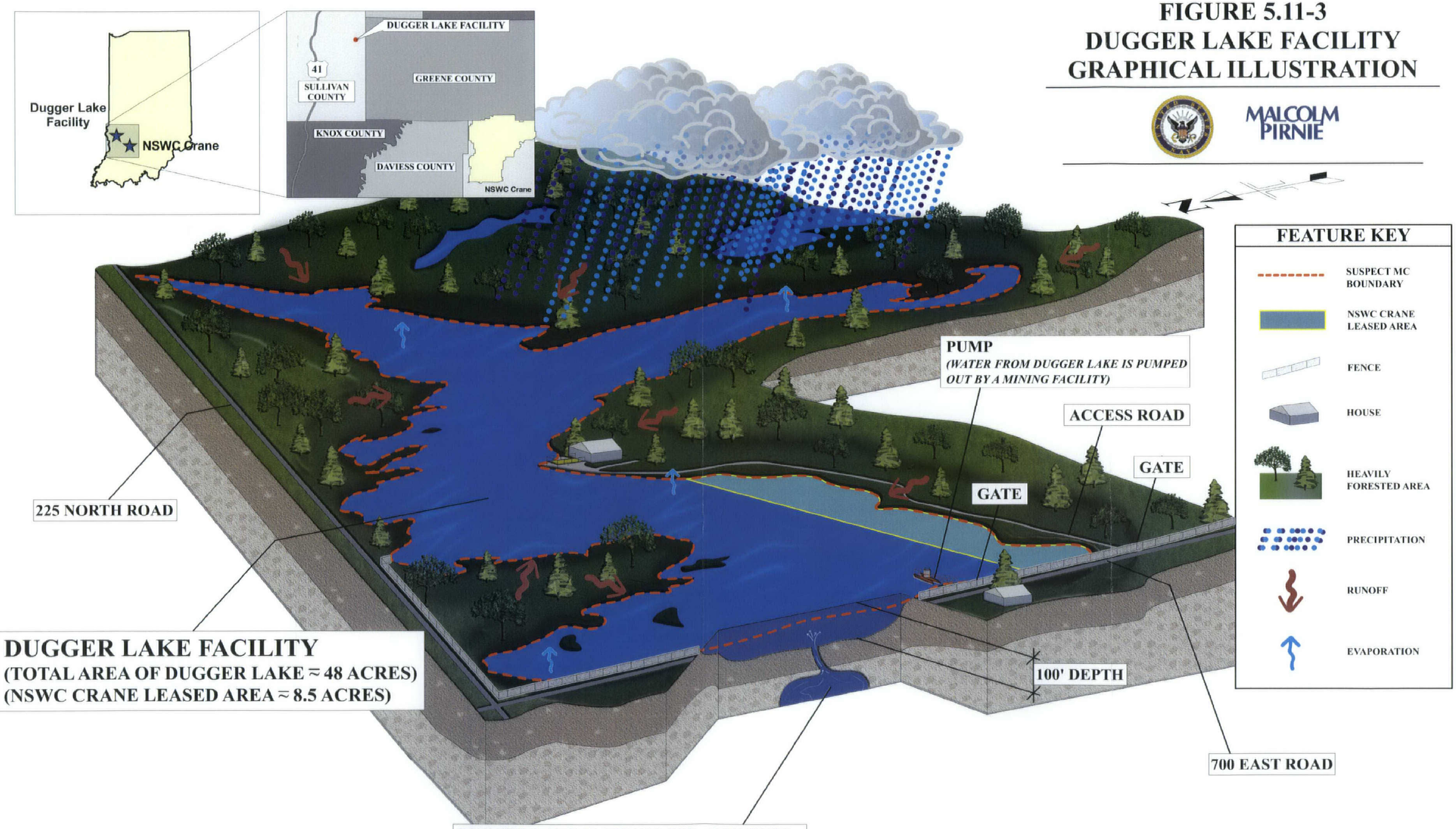
WATER AREA MUNITIONS STUDY – FINAL REPORT
DUGGER LAKE FACILITY – MC EXPOSURE PATHWAY ANALYSIS
NSWC CRANE, INDIANA

MALCOLM PIRNIE, INC.

FIGURE 5.11-2
April 2005

FIGURE 5.11-3
DUGGER LAKE FACILITY
GRAPHICAL ILLUSTRATION

MALCOLM PIRNIE



DUGGER LAKE FACILITY
(TOTAL AREA OF DUGGER LAKE ≈ 48 ACRES)
(NSWC CRANE LEASED AREA ≈ 8.5 ACRES)

DUGGER LAKE IS SPRING FED; HOWEVER, THE ACTUAL LOCATION OF THE SPRING(S) IS UNKNOWN.

NOTE:

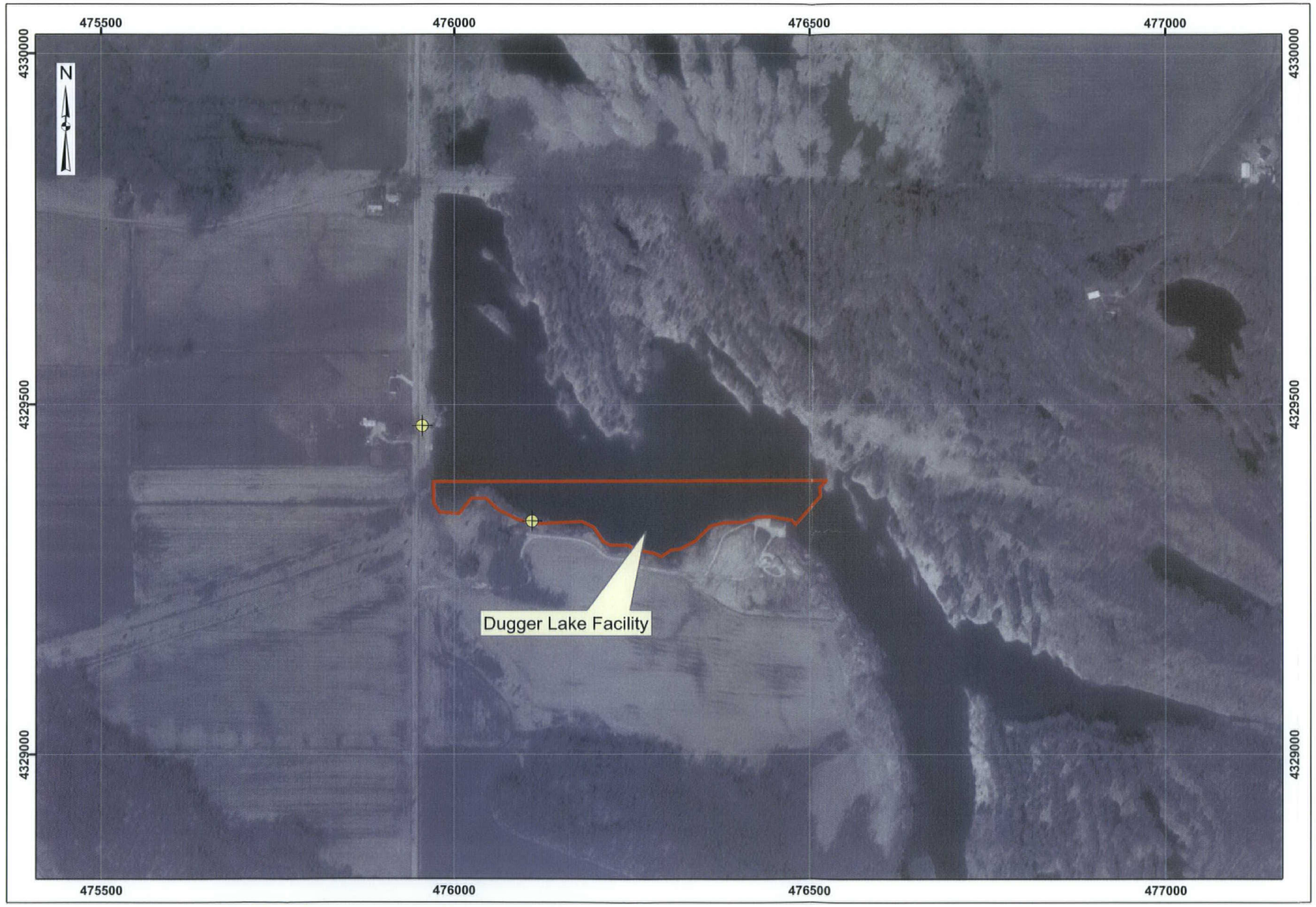
1. **GROUNDWATER IS SUSPECTED TO BE LOCATED AT 45-75 FEET BELOW GROUND SURFACE.**

DISCLAIMER

THIS ILLUSTRATION IS INTENDED FOR USE IN CONJUNCTION WITH THE REPORT IN WHICH IT WAS SUBMITTED AND IS NOT INTENDED TO BE USED AS A STAND ALONE DOCUMENT.

5.12. Summary

The history of the Dugger Lake Facility indicates its use for hydro acoustic testing and testing of marine markers, cable cutters, swimmer recall devices, SEC and ECD from 1975 through 1994. No evidence of MEC was observed around the rim of the lake, and site personnel indicate that numerous underwater dives at the lake have not identified any MEC. Documentation and site interviews described testing activities at the site. It was Navy policy at the time to remove ordnance after testing. If successful, the munitions tested would not leave any significant debris, and if unsuccessful, the munitions were retrieved intact from an attached cable. It is not expected that MEC remain in the lake. Potential MC expected to be associated with the munitions tested at the site include explosive composition B, black powder, and an assortment of metals. There is a potential for MC to exist in the lake sediments at the site due to the amount of MC associated with the tested munitions. Because water is pumped from the lake on a continual basis by a local mining company, it is unlikely that MC still remain within the water column.



Water Area Munitions Study
NSWC Crane, Indiana

MALCOLM PIRNIE

Map 5-1
Visual Survey
Dugger Lake Facility

Legend

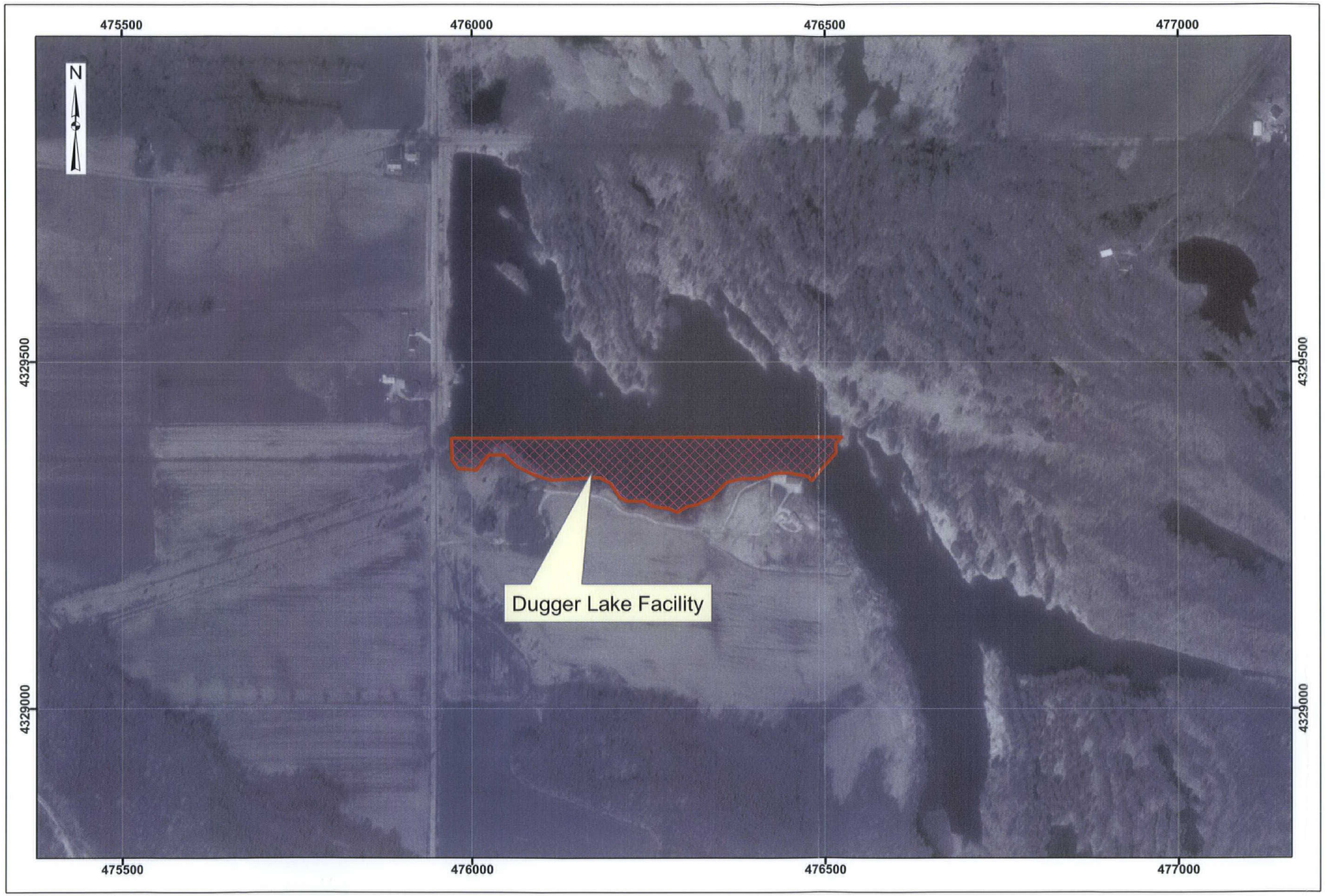
- Installation Boundary
- Site Reconnaissance
- Dugger Lake Facility *(leased area)*

100 0 100 200 300 Meters

Data Source: NSWC Crane, GIS Data, 2003
DDS, Orthophoto, 1999

Coordinate System: UTM Zone 16N
Datum: NAD83
Units: Meters

Contract: N62472-02-D-1300
Edition: Final Water Area Munitions Study
Date: April 2005



Water Area Munitions Study
NSWC Crane, Indiana

MALCOLM PIRNIE

Map 5-2
Range/Site Details
Dugger Lake Facility

Legend

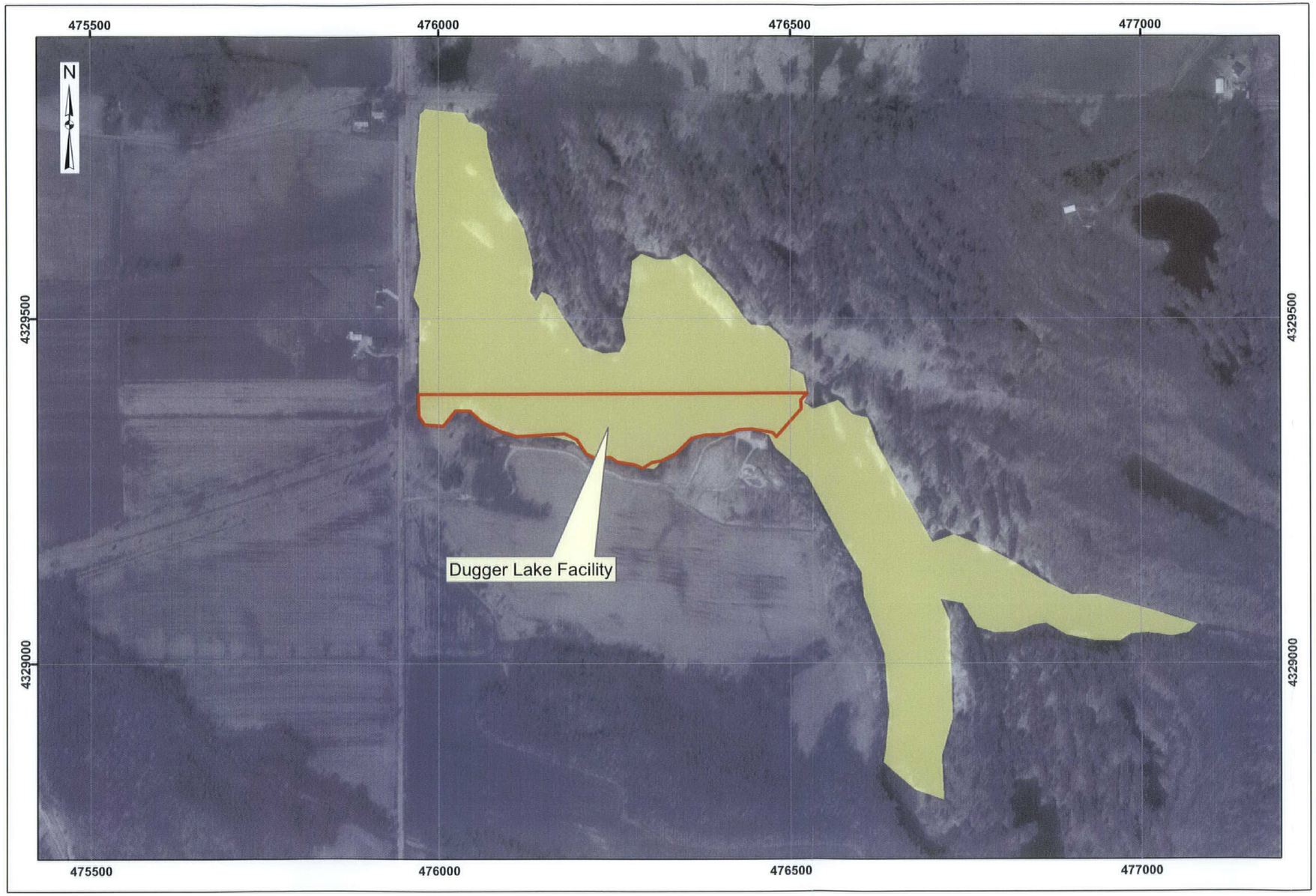
- Installation Boundary
- Target Area
- Dugger Lake Facility (leased area)

100 0 100 200 300 Meters

Data Source: NSWC Crane, GIS Data, 2003
DDS, Orthophoto, 1999

Coordinate System: UTM Zone 16N
Datum: NAD83
Units: Meters

Contract: N62472-02-D-1300
Edition: Final Water Area Munitions Study
Date: April 2005



Water Area Munitions Study
NSWC Crane, Indiana

MALCOLM PIRNIE

Map 5-3
Munitions Characterization
Dugger Lake Facility

Legend

Installation Boundary

Dugger Lake Facility *(leased area)*

MEC Presence*

Known

Suspect

* MEC Presence was determined through review of historical documentation, interviews, and visual survey.

100 0 100 200 300 Meters

Data Source: NSWC Crane, GIS Data, 2003
DDS, Orthophoto, 1999

Coordinate System: UTM Zone 16N
Datum: NAD83
Units: Meters

Contract: N62472-02-D-1300
Edition: Final Water Area Munitions Study
Date: April 2005

Appendix A: References

REFERENCES

Text Sources:

A.T. Kearney, Inc. Preliminary Review/Visual Site Inspection Report of Naval Weapons Support Center, Crane, IN. March 1987.

Department of the Army Office of the Project Manager for Chemical Demilitarization and Installation Restoration, Aberdeen Proving Ground, Maryland. Installation Assessment of Naval Weapons Support Center, Crane, Indiana, Record Evaluation Report No. 117. March 1978.

Environmental Assessment, Hydroacoustic Test Facility, Glendora Lake, Sullivan County, Indiana December 1991

Naval Energy and Environmental Support Activity Code 112N, Port Hueneme, CA 93043. Navy Assessment and Control of Installation Pollutants: Initial Assessment Study of Naval Weapons Support Center, Crane, IN. May 1983.

Reid, Robert L. and Rodgers, Thomas E. A Good Neighbor: The First Fifty Years at Crane 1941-1991. Historic Indiana Project, 1991.

U.S. Department of Agriculture, Soil Conservation Service. Soil Survey Sullivan County, Indiana. Issued January 1971.

Interviews:

Allen, John. Personal interview by Julie Grim. March 20, 2003.

Barthold, Bart. Personal interview by Julie Grim. August 4, 2003.

Jackoway, Mel. Personal interview by Julie Grim. February 18, 2004.

Keith, Philip. Personal interview by Julie Grim. March 19, 2003.

Laughlin, Tom. Personal interview by Julie Grim. February 25, 2004.

Zitzman, Ron. Personal interview by Julie Grim. March 19, 2003.

Internet Sources:

Geology of Sullivan County, Indiana
www.indiana.edu/~libgeol/cox1870/1870sull.html

Indiana Data and Statistics
www.state.in.us/isdh/dataandstats/fish/fish_99/lakes.htm

Indiana Department of Environmental Management Publications and Forms
www.state.in.us/idem/water/publications/reports.html

Indiana Department of Environmental Management US Fish and Wildlife
www.midwest.fws.gov/Endangered/lists/indiana-cty.html

Lower Wabash River Basin, by Keith Bobay
http://in.water.usgs.gov/atlasweb/lwab.pdf

NSWC Crane Natural Resources Guide
www.crane.navy.mil/nat_res/na02001.htm

NSWC Crane History
www.crane.navy.mil/General/About/history.htm

Maps:

Electronic base map data dated 1998 was received from Tom Brent, Environmental Protection Specialist at NSWC Crane Division. No munitions related ranges or information is depicted on the maps but they establish base map references for the installation. The data layers included:

- Installation boundaries
- Installation landmarks (buildings, pads, roads)
- Topography
- Hydrology
- Environmental features (wetlands, habitat)
- Imagery (aerial photography from current and earlier time periods)

No munitions related ranges or information is depicted on the maps but they establish base map references for the installation.

Appendix B: Project Source Data – General

Interview Record

Installation/Range or Site: NSWC Crane, Indiana

Date/Time: March 19, 2003

Person Conducting the Interview/Title/Organization: Molly Howard, Malcolm Pirnie

Person Being Interviewed/Title/Organization: Mr. Phil Keith

Reason for Selecting Person to Interview (i.e., Years at Installation, Position, Previous History, etc.): Point of Contact

---

Interview Notes (i.e., Range History, Ordnance Types, Land Use, Historical Records/Maps Available):

Lake Greenwood Pyro Test Area Near Dam

- Mr. Keith accompanied the survey team to the dam, and showed the team the length of the dam and locations where testing was said to have occurred
- Noted that items were fired from the dam into the lake, several hundred yards offshore
- Boats were also used at this location and were floated into the lake from the dam

Lake Oberlin

-Mr. Keith accompanied the team to the location of the lake and noted its use by the boy scouts

-Identified the physical features at the lake, including the dock and the areas in the lake where the testing may have occurred

Interview Notes Continued:

Dugger Lake

-Mr. Keith accompanied the team to Dugger Lake and was able to identify areas on the lake where testing may have occurred

-He also stated that the water pumped from the lake was used for local mining purposes.

Interview Record

Installation/Range or Site: NSWC Crane, Indiana

Date/Time: March 19, 2003

Person Conducting the Interview/Title/Organization: Julie Grim, Malcolm Pirnie

Person Being Interviewed/Title/Organization: Ron Zitzman

Reason for Selecting Person to Interview (i.e., Years at Installation, Position, Previous History, etc.): EOD detachment at Crane

---

Interview Notes (i.e., Range History, Ordnance Types, Land Use, Historical Records/Maps Available):

-July, 2001 has been part of EOD

-EOD response at golf course, location at the tee

-test at OTA, 8027 reports, EOD owns none

IV. ENVIRONMENTAL SETTING

A. Meteorology

The NWSC is located in a temperate climate zone with an average of 44 inches of precipitation annually (Ref. 3, p.5-6). Temperatures vary widely throughout the year with a mean winter low temperature of 26 degrees farenheit and a mean summer high temperature of 89 degrees farenheit. The humidity is generally high, ranging from 40 to 90 percent (Ref. 3, p. 5-6). Winds in southwestern Indiana are generally from the south southwest at an average speed of 8.2 mph (Ref. 21, p.354).

B. Floodplain and Surface Water

The facility is characterized by well developed dendritic surface drainage (Ref. 3, p. 5-19). There are five drainage basins, consisting of seven streams, that carry surface water off site (Ref. 4, p.14). Flow within the drainage basins is generally toward the southwest. The following is a list of drainage basins and the general area that each encompasses within the site (Ref. 4, p.14).

Drainage Basin	Streams Within Basin	Site Drainage Area
Basin I	Furst Creek	Northwest Section
Basin II	Indiana Creek	Extreme Eastern Section
Basin III	Sulphur Creek Little Sulphur Creek	Eastern Section
Basin IV	Boggs Creek Turkey Creek	Central, Southcentral Sections
Basin V	Seed Tick Creek	Southwestern Section

Boggs Creek and Turkey Creek provide the primary surface drainage pathways for the facility. The facility's water supply is from Lake Greenwood in the northwest corner of the site. Lake Greenwood is an 800 acre spring fed lake that discharges to Furst Creek (Ref. 3, p.5-19). Figure 2 provides the location of the surface drainage basins at NWSC.

Sections of facility property bordering the surface drainage routes at NWSC are within the 100 year floodplain. According to NWSC's Part B Permit Application, there are no hazardous waste units located within the 100 year floodplain (Ref. 6, p.B-7).

C. Geology and Soils

The NWSC is underlain by sedimentary rocks of lower Pennsylvanian and upper Mississippian Ages. With the exception of minor outwash and lacustral deposits in the northwest corner of the facility, there are no Pleistocene glacial deposits covering the site (Ref. 19). Surface deposits at NWSC consist of recent (Holocene) and Pleistocene unconsolidated alluvial silt, sand, and gravel and residual soils developed from the underlying rock (Ref. 4, p.10).

The soils covering the NWSC belong to the Zanesville and Muskingum Soil Series (Ref. 4, p. 10). These soils are characterized as dark organic silt loams with underlying mottled tan to gray clay with varying percentages of silt and sand. Soil thickness is variable with values ranging from less than one foot to over 40 feet (Ref. 4, p. 10).

The sedimentary bedrock beneath the facility dips gently to the west southwest. The inclination of the strata reflects NWSC's location on the eastern flank of the Illinois Basin. This section of the basin is comprised of Pennsylvanian and Mississippian strata consisting of shale, sandstone, limestone, and coal (Pennsylvanian) beds. The Pennsylvanian Mansfield Formation (Racoon Creek Group) unconformably overlies the Mississippian Stephensport and West Baden Groups (Ref. 18, Plate No. 1 and p. 151) at the site.

The Mansfield Formation has two distinct vertical divisions (Ref. 18, p.86). The lower division is comprised primarily of sandstone while the upper division consists of predominantly shale and mudstone (Ref. 18, p.86). Thin bituminous coal beds are prevalent throughout the formation.

The Stephensport Group conformably overlies the older West Baden Group. The Stephensport Group has five formations of which three are limestones and two are interbedded shale/sandstone formations (Ref. 18, Plate No. 2, p.13, 52, 56, and 87). Similarly the West Baden Group consists of the alternating carbonate/clastic lithology characteristic of the Stephensport Group with one exception. There is a noticeable lack of limestone tracer beds within a southwest trending linear area of the West Baden Group. This area, that outcrops northeast of the site, is referred to as the West Baden Clastic Belt (Ref. 18, p.43). The Belt consists of sandstone with adjoining bands of silty to sandy shale within the Elivren Formation (Ref. 18, p.43).

D. Groundwater

Groundwater resources at NWSC have not been studied extensively because the facility utilizes surface waters from Lake Greenwood for human consumption, process operations, and recreation. However, the existing lithologies, occurrences of springs and seeps, and the well developed surface drainage indicate the existence of groundwater that is hydraulically connected to the surface environment.

According to a Naval Assessment and Control of Installation Pollutants (NACIP) study, the groundwater at NWSC is divided into two regimes: one associated with soil/alluvial cover and the other associated with the bedrock (Ref. 3, p.5-22). This study reports that shallow groundwater is generally transient occurring during high precipitation periods. Free water within alluvial deposits is likely to percolate into bedrock or be discharged into intermittent streams along alluvial - bedrock contacts (Ref. 3, p.5-22). Table 1 is adapted from the NACIP study, it exhibits the general water bearing properties of the alluvial deposits and bedrock at NWSC.

7-79

INSTALLATION ASSESSMENT
OF
NAVAL WEAPONS SUPPORT CENTER,
CRANE, INDIANA
RECORD EVALUATION REPORT NO 117

March 1978

DEPARTMENT OF THE ARMY
OFFICE OF THE PROJECT MANAGER
FOR
CHEMICAL DEMILITARIZATION AND INSTALLATION RESTORATION
ABERDEEN PROVING GROUND, MARYLAND 21010

DISTRIBUTION LIMITED TO US GOVERNMENT AGENCIES ONLY
FOR PROTECTION OF PRIVILEGED INFORMATION EVALUATING
ANOTHER COMMAND MARCH 1978. OTHER REQUESTS FOR
THIS DOCUMENT MUST BE REFERRED TO COMMANDER
NAVAL WEAPONS SUPPORT CENTER CRANE IN 47522

STATEMENT

"The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation."

EXECUTIVE SUMMARY

I. GENERAL

A. A records search was conducted on the Naval Weapons Support Center (NWSC) at Crane, Indiana to uncover indications of contamination at the installation by chemical, biological, and radiological materials resulting from past manufacturing, testing, storage, and disposal operations, and to assess the possibility of contaminant migration beyond the installation boundaries.

B. The on-site phase of the search was performed from 19 to 23 September 1977; however, data were collected from other agency sources through 15 October 1977. In addition to the on-site search, Team members also contacted personnel at the Naval Ordnance Station, Indian Head, Maryland, and the Naval Weapons Laboratory, Dahlgren, Virginia, who were familiar with operations at NWSC.

C. The procedure followed by the Records Research Team included:

1. Acquiring all pertinent documents on NWSC from other government agencies, including:

a. Department of Defense Explosive Safety Board (DDESB).

b. US Army Environmental Hygiene Agency (USAEHA).

c. US Geological Survey (USGS).

d. Defense Documentation Center (DDC).

e. US Department of Interior Ecological Survey, Carson City, Nevada.

f. US Army Engineer Waterways Experiment Station (WES).

g. National Technical Information Service (NTIS).

h. Naval Ordnance Environmental Health Center (NOEHC).

i. Naval Sea Systems Command (NSSC).

INSTALLATION ASSESSMENT

OF

CRANE ARMY AMMUNITION ACTIVITY

NWSC CRANE, INDIANA

RECORDS EVALUATION REPORT NO. 117

APPROVED:

FRANK A. JONES, JR.
Colonel, CmlC
Project Manager for
Cml Demil and
Instl Restoration

2. Obtaining copies of all pertinent installation regulations, standing operating procedures, and other available documentation.

3. Interviewing former and present key employees.

4. Analyzing the above information.

D. This report reflects the status of NWSC as of 15 October 1977.

II. FINDINGS

A. Crane Army Ammunition Activity (CAAA) License

A license, NF(R)-36943, was granted by NWSC to the Army, effective 1 October 1977 which authorizes the use by CAAA of a significant portion of the facilities at NWSC, Crane. The license was required for the establishment of the CAAA as Single Manager of conventional ammunition with assigned responsibilites as set forth in DOD Directive 5160.65 of 26 November 1975. Facilities are to be utilized for the accomplishment of Army functions required in the procurement, production, storage, supply, demilitarization and maintenance/renovation of conventional ammunition. A copy of the subject license is included as Appendix E of this report.

B. Industrial and Production Operations

1. Production areas of the installation potentially contaminated with waste from explosive and pyrotechnic operations include the 3-inch (Rockeye) and 40mm explosive loading complexes, the booster area, mine filling areas A and B, and the old 16-inch loading and demilitarization facility, see Chapter IIA of report. Contaminants identified include TNT, RDX, tetryl, lead styphnate, Composition A and B, Explosive D, HMX, aluminum, alkaline nitrates, lead chromate, and other explosive/pyrotechnic waste products.

2. Potentially contaminated wastewaters from manufacturing and demilitarization operations are dumped initially into sumps with the overflow going directly into open ditches. Prior to the recent installation of efficient dust collectors, considerable quantities of explosive powders were vented directly into the atmosphere. The soil in the vicinity of these sites is heavily contaminated and vegetation in the area of the plant is either missing or in a state of stress (i.e., dying, stunted, discolored).

C. Testing and Firing Ranges

1. Extensive testing of explosive and pyrotechnic munitions has been conducted and is being conducted at several locations on the installation. The principal ranges include three pyrotechnic ranges, a rocket

range, a rifle range, an explosive demolition area, a small arms testing area, and an ordnance burning area. Types of munitions tested include small arms, 40mm grenades, pyrotechnic flares and smoke signaling devices, mortar, bomb and projectile ammunition, and experimental devices.

2. Unexploded ordnance (UXO) were reported at several of the ranges and the demolition pits. UXO munitions include small pyrotechnic devices, aerial dispensed devices, mortar rounds, and other naval artillery shells. At the demolition area, explosive munitions are scattered as a result of demilitarization operations. During the Team's ground tour, UXO with parachutes were observed hanging from trees.

3. Lake Greenwood, which is the source of drinking and production water at NWSC, was used from the early 1940's to the late 1960's for the testing of floating pyrotechnic devices including signaling smokes and flares. Four locations were identified at Lake Greenwood where testing was conducted.

D. Disposal Operations

1. Two landfills are presently active at the installation; they are the sanitary landfill and the McComish Gorge landfill. The sanitary landfill began operations in 1971, replacing the old open burning pit as a means of disposing of daily refuse. This landfill has a leaching problem and the installation is attempting to rectify the problem by constructing a pond to hold the leachate. The McComish Gorge landfill is utilized for timbers and other large items not suitable for the main sanitary landfill. Personnel interviewed by the Team indicated that a potential exists for both landfills to be contaminated by waste materials.

2. Contaminated waste from installation activities is disposed of by burial or burning at various locations on the installation. Disposal areas include a chemical agent burial ground (1947), an ordnance burning area used since 1965, an old pyrotechnic burning pit used from the early 1940's to 1970, and a pit where approximately 50,000 pounds of smoke dyes were buried in 1969. Some of these dyes (auramine hydrochloride, yellow dye) are reported to be carcinogenic in the lastest Register of Toxic Chemical Substance published by National Institute for Occupational Safety and Health.

3. The chemical agent burial ground is located in the southeast quarter of the NWSC. Several hundred pounds of mustard agent and several pounds of radioactive thorium were buried here in 1947. One of the mustard pits was excavated in 1974 and several bombs were found to contain live mustard agent. The bombs were sealed by an Army Technical Escort Team and stored. Total number of pits is not known and a

project is being conducted by the installation to determine if migration of mustard agent is occurring. The thorium was removed from the site in 1974 and shipped to an AEC (DOE) site for storage. The site was then surveyed and certified free of radioactive contamination by the Material and Safety Department of NWSC, Crane.

E. Storage Operations

1. There are approximately 2300 storage magazines at NWSC. Materials stored within these structures include explosive and pyrotechnic powders, explosive and pyrotechnic munitions ranging from small arms to large bombs and naval projectiles, anti-riot munitions, initiators, fuzes, munition components, and subassemblies.

2. Approximately 2808 chemical agent identification kits, which contain small quantities of various chemical agents in ampules, are stored in magazines. These kits are scheduled to be moved to another site for demilitarization.

F. Biological Agent Operations

Biological Warfare agents and weapons were never developed, manufactured, tested or stored at the installation.

G. Radiological Operations

Radiological materials and weapons were never developed, manufactured, or tested on the installation. The installation is licensed to use small quantities of radiological materials for biological tracers (carbon 14), lead detection (krypton 85), radiography (cobalt 60), iridium 192, and nickel 63. Weapons equipped with Promethium-147 sights are stored at NWSC.

H. Water and Water Quality

1. The installation is drained by several surface water drainageways. The central portion of the installation is drained by Boggs and Turkey Creeks; the eastern portion by Sulphur Creek; and the northern and western portions by Furst and Culpepper Creeks.

2. A water quality monitoring program is conducted by the installation at six locations within the Boggs, Turkey, Furst, and Culpepper Creeks drainage areas. However, no water quality monitoring is conducted on the waterways that exit the installation's eastern boundary. The six monitoring locations are in the northern and central areas of the installation. No

B. Current Manufacturing Operations

A potential exists for contamination from current manufacturing operations to exit the installation via unmonitored surface and subsurface waters. Of particular concern is explosive waste (Red Water) from the Rockeye operation which is dumped into Sulphur Creek. This creek is one of several creeks in the eastern and southern areas of the installation not monitored under the installation's water quality program. In addition, NWSC is exceeding discharge limits imposed by NPDES permits.

C. Lake Greenwood

Since Lake Greenwood is not monitored by the installation for the presence of explosive or pyrotechnic waste materials, a potential exists for the lake to be contaminated by those waste materials.

D. Chemical Agent Burial Ground

An unknown quantity of mustard munitions is still buried at the Chemical Agent Burial Ground. The area is fenced, however, the exact location and number of burial pits is not known. Based on location of the burial ground, contaminant migration beyond installation boundaries is considered remote.

E. Burial of Pyrotechnic Dyes

An estimated 50,000 pounds of pyrotechnic smoke is buried at the Ordnance Burning Ground. During periods of heavy rain, colored materials seep from the filled pits. Since the dyes included carcinogenic materials, a potential exists for them to migrate via surface and subsurface waters.

F. Water Monitoring Program

The installation's present water monitoring program does not include analysis for explosive waste materials nor does it monitor all streams exiting the installation.

monitoring is done on Boggs Creek in the southern portion of the installation; neither are the waters impounded by Boggs Dam monitored. At the time of the Team's visit (September 1977), available water quality data for the six monitoring locations indicated that the installation is having difficulty in complying with EPA discharge permits. (See Chapter IE1a of report).

3. Lake Greenwood is monitored intermittently by the installation. The water quality data provided by the installation, and collected in 1970, indicate that the lake water was potable. No current analysis was available to the team for explosive manufacturing wastes such as TNT and RDX. Due to the lake's location in the northern section of the installation, only limited amounts of wastewaters from the manufacturing areas reach the lake via drainageways and creeks. The State Health Department conducts a water quality program that includes Lake Greenwood; however, analyses are not conducted for potential pyrotechnic and explosive contaminants.

4. Big Sulphur Creek, which drains the Rockeye manufacturing area, exits the installation to the east and receives wastewaters that are heavily contaminated by explosive manufacturing wastes including red water (TNT). The Records Search Team, during its ground tour, tracked the wastewaters for over a mile and the red color was visually detectable over the whole distance. Little Sulphur Creek drains the ordnance burning area where an estimated 25 tons of pyrotechnic dyes are buried. No water monitoring is conducted in this area.

5. Data on subsurface waters (groundwater) is limited. The installation has data from five wells which indicate groundwater depths of between 141 to 313 feet. Only limited water quality data are available on four of these wells and consist of a 1970 report that addresses alkalinity, pH, and hardness. General regional dip of the bedrock is approximately 20 feet per mile to the west-southwest.

III. CONCLUSIONS

A. Past Explosive Operations

Several areas of the installation (including the explosive and pyrotechnic areas, burial and burning sites, landfills, and test ranges) are suspected of being contaminated with toxic and hazardous materials. No firm conclusions can be drawn regarding migration of contaminants from past manufacturing, demilitarization, and disposal operations because of limited surface and subsurface water data.

TABLE OF CONTENTS

	Page
I. GENERAL	I-1
A. Purpose of the Assessment	I-1
B. Authority	I-1
C. Introduction	I-1
D. Summary Description of Installation	I-3
1. Location and Size	I-3
2. Area Description	I-3
3. Organization and Mission	I-6
4. History	I-8
E. Environmental	I-9
1. Water Quality	I-9
a. Surface	I-9
b. Subsurface	I-12
c. Analysis	I-12
2. Biota	I-17
a. General	I-17
b. Flora	I-18
c. Fauna	I-20
3. Geology	I-22
a. Physiography and Topography	I-22
b. Subsurface Geology	I-22
c. Soils	I-24
II. CONTAMINATION ASSESSMENT	II-1
A. Industrial Operations	II-1
1. Rockeye/3-Inch Explosive Loading Area	II-1
2. 40-Millimeter Loading Complex	II-5
3. Booster Area	II-7
4. Mine Filling Area A	II-7
5. Mine Filling Area B	II-7
6. Loading and Filling Area	II-9
7. Pyrotechnic Area	II-12
8. Old 16-Inch Loading and Demilitarization Area	II-13
9. Building 181, Clothing Change House Area	II-13
10. Transfer Depot - Building 600	II-13
11. Laundry (Building 180)	II-13
12. Small Arms Area	II-14
B. Laboratories	II-14
1. Quality Evaluation Laboratory Complex	II-14
2. Applied Science Department Complex (ASD)	II-14
3. Naval Ammunition Production Engineering Center (NAPEC)	II-15
C. Field Test Ranges	II-15
1. Pyrotechnic Test Range	II-15
2. Range 2167/Pyro Control Test Range	II-15
3. Rocket Range	II-15

	PAGE
4. Conservation Dam (Facility No. 2845)	II-17
5. Old Pyrotechnic Test Area	II-17
6. Lake Greenwood	II-17
7. Lake Oberlin	II-17
8. Rifle Range and Old Ordnance Ground	II-17
D. Burial Sites of Hazardous Materials	II-18
1. Burial Sites of Chemical and Radiological Materials	II-18
a. Chemical Burial Ground	II-18
b. Burial of Pyrotechnic Dyes	II-20
2. Burial Sites of Explosive Material	II-20
a. McComish Gorge	II-20
b. Ordnance Demolition Area	II-20
E. Storage of Toxic/Hazardous Material	II-23
F. Support Activities	II-23
1. Water Supply	II-23
2. Waste Disposal	II-23
G. Land Use Factors	II-23
1. Pesticide/Herbicide Usage	II-23
2. Sanitary Landfills	II-24
H. Geological Migration Potential	II-25
I. Environmental Indicators	II-25
1. Land Indicators	II-25
2. Waterways Indicators	II-26
III. FINDINGS	III-1
IV. CONCLUSIONS	IV-1

LIST OF FIGURES

Figure No.	Title	Page No.
I-1	Site Map, Naval Weapons Support Center, Crane, ID	I-4
I-2	Population and Distance of Towns near NWSC, Crane, ID	I-5
I-3	Naval Weapons Support Center Organization Chart	I-7
I-4	Water Supply	I-10
I-5	Surface Drainage	I-11
I-6	Water Wells	I-13
I-7	Discharge of Green Water from Naval Weapons Support Center	I-16
I-8	Geology	I-23
I-9	Boring Location	I-25
II-1	Rockeye Manufacturing Area	II-2
II-2	Red Water Discharge Point	II-2
II-3	Red Water 50 Yards Downstream	II-3
II-4	Red Water 200 Yards Downstream	II-3
II-5	Red Water 400 Yards Downstream	II-4
II-6	Red Water Approximately One-half Mile Downstream	II-4
II-7	General Development Map	II-6
II-8	Mine Filling Area "A"	II-8
II-9	Mine Filling Area "B"	II-10
II-10	Loading and Filling Area (High Explosive)	II-11
II-11	Pyrotechnic Test Range	II-16
II-12	Mustard Gas Burial Plot	II-19
II-13	Demolition Area	II-21
II-14	Demolition Area and Lake 330	II-22

LIST OF TABLES

Table No.	Title	
I-1	Water Treatment Plant Data for July 1977	I-12
II-1	Pesticide and Herbicide Usage	II-24

LIST OF APPENDIXES

Appendix	Title
A	Photographs of Naval Weapons Support Center, Crane, IN
B	Biota of Naval Weapons Support Center, Crane, IN
C	Indiana Water Quality Standards
D	Boring Logs of Naval Weapons Support Center, Crane, IN
E	License NF(R)-36943 to Crane Army Ammunition Activity
F	Green Water Report
G	Munitions Operations (1964-1977)

BIBLIOGRAPHY

1. Allen (Editor), Indiana Pittman-Robertson wildlife restoration, 1939-1955. Indiana Dept. Cons., Div. Fish and Game Bull. 3.240 pp.

2. Barbour, R. W. and W. H. Davis. 1969. Bats of America. Univ. Press, Lexington, Ky. 286 pp.

3. Bloom, E., and Lucas, P. E., "Redesign and Reconstruction of Lake Greenwood," Soil Conservation Service, Indianapolis, IN 1973.

4. Cainright, James E., 1959, Fossil Plants of Indiana. 45 pp + 5plates. Report of Progress # 14 (includes map). Indiana Geological Survey, Bloomington, Indiana.

5. Coulter, Stanley. A catalogue of the flowering plants and of the ferns and their allies indigenous to Indiana. Indiana Geol. Rept. 24:625-649. 1900

6. Daily, Fay Menoyer, 1971, Checklist of Indiana Algae, 1929-1971. Obtain from author, Botany Dept., Bulter Univ., Box 169, Indianapolis, IN.

7. Danos, F. J., "Sanitary/Environmental Survey," for Naval Weapons Support Center, Crane, Indiana, Naval Facilities Engineering Command, Philadelphia, PA, 1975.

8. Dawson, T. A., "Deep Test Well in Lawrence County, Indiana: Drilling Techniques and Stratigraphic Interpretations," Progress Report No. 22, Indiana Department of Conservation, Geological Survey, Bloomington, IN, 1960.

9. Deam, Chas. C. Plants new or rare in Indiana. XII. Proc. Indiana Acad. Sci. 1923:221. 1924

10. Deam, Chas. C. Flora of Indiana: on the distribution of the ferns, fern allies and flowering plants. Proc. Indiana Acad. Sci. 34: 39-53 1925.

11. Deam Chas. C. Plants new or rare in Indiana. XIII. Proc. Indiana Acad. Sci. 35:197. 1926.

12. Deam, Chas. C. 1929 Grasses of Indiana. PP. 1-356. Division of Forestry, Dept of Conservation, State of Indiana, Publication No. 82. Indianapolis.

13. Deam, Chas. C. 1932. Shrubs of Indiana. Indiana Dept. of Conservation, Indianapolis.

14. Deam Chas. C. 1940 Flora of Indiana. Pp. 1-1236. Div of Forestry, Published by the Dept. of Conservation, Indianapolis. Wm. B. Burford Printing Co. Contractor for State Printing of Binding.

15. Esarey, R. E. , Et. al., "Stratigraphy along the Mississippian-Pennsylvanian Unconformity of Western Indiana," Fourth Annual Indiana Geological Field Conference, May 12, 13, and 14, 1950, Indiana Department of Conservation, Bloomington, IN, 1950.

16. Fenneman, M. M., "Physiography of Eastern United States," 1st ed., 7th Impression, McGraw-Hill, New York, 1938.

17. Gravens, J. H. (ed.) 1976. Distributional studies of the Indiana bat (Myotis sodalis) on three national forests of the Eastern region. U.S. Forest Service, Eastern Region.

18. Hahn, W. L. 1908. The Mammals of Indiana. 33rd Ann. Rept. Ind. Dept. Geol. and Nat. Res., pp. 419-654.

19. Hall, J. S. 1960. A life history and taxonomic study of the Indiana bat, Myotis sodalis. Ph.D. Thesis, Univ. ILL. 129 pp.

20. Hart, J. W. 1969 A checklist of the mosquitoes of Indiana with a record of the occurence of Aëdes in firmatus D & K. Proc. Indiana Acad. Sci. 78: 257-259. (1968) 1969.

21. Hay, O. P. 1984. The Lampreys and Fishes of Indiana. 19th Ann. Rept. Ind. Dept. Geol. and Nat. Res., pp. 147-246.

22. Herring, W. C., "Technical Atlas of the Ground-Water Resources of Marion County, Indiana, "Department of Natural Resources, State Division of Water, Indianapolis, IN, 1976.

23. Hessler. Robert, The adventitious plants of Fayette County, Indiana. Proc. Indiana Acad. Sci. 1893:260. 1984

24. Indiana Department of Natural Resources, "Regional Geologic Map No. 3," Vincennes Sheet Indiana Geological Gurvey, Bloomington, IN 1970.

25. Indiana Department of Natural Resources, Division of Fish and Wildlife. 1975. Non-gam and Endangered Species Conservation - A Preliminary Report. Indianapolis, Indiana.

26. Jones, C. 1971. The status of populations of bats in the United States. Second Ann. Symp. Bat Res., Albuquerque, New Mexico (unpublished).

27. Keith, James H., "Biotic and Abiotic Studies of a Terresterial Cave Ecosystem in Indiana", Nov 1975, PhD Thesis, XVI = 198 pp., Indiana University

28. Lindsey, A. A. (Ed.) 1966. Natural features of Indiana. Indiana Acedemy of Sciences. Chapters include Cave Fauna (C.K. Krekeler and E. C. Williams Jr.) Fishes (J.R. Gammon and S. D. Gerking), Amphibians and Reptiles (S.A. Minton, Jr.), Birds (J.D. Webster) and Mammals (R. E. Mumford).

29. Maegerleim. S. D. "Caves of the Naval Weapons Support Center, Crnae, Indiana," unpublished, no date.

30. Marshall, Philip T. et al, 1976, A biological evaluation of the Forest Test Caterpiller in South-Central Indiana, Feb 19, 1976. 12 pp. report, Div of Forestry, Indiana Dept of Natural Resources and US Forest Service.

31. McDonald, E. S., sister. The life-forms of the flowering plants of Indiana. Amer. Midl. Nat 18: 687-773 (incl. 7 pl). 1937.

32. McPherson, Alan & Sue, 1977, Wild food plants of Indiana & adjacent states. $4.95 paper. vit 216 pp. Indiana Univ. Press, Bloomington.

33. Midlands Area Guide (The), Hoosier Forest Rlan, Hoosier Natural Forest, U.S. Forest Service, Bedford, Indiana. Pp. 1-123, 1977.

34. Minton, Sherman A., Jr. Amphibians and Reptiles of Indiana. Indiana Academy of Science Monograph No. 3, Indianapolis, IN 1972.

35. Morris, Palph L. 1943 Annotated list of the ants of Indiana. Proc. Indian Acad. Sci 52: 203-224. (1942) 1943.

36. Mumford, R. E. 1969. Distribution of the Mammals of Indiana. Monogr. No. 1 Indiana Acad. Sci. Indianapolis, IN.

37. Mumford, R. E. 1795. Checklist of Birds of Indiana. Indiana Audubon Quarterly May 1977.

38. Murdock, S. H., "A Story of Indiana Geology," Zerox, No Date.

39. Natural Features of Indiana. 1966 Edited by Alton A. Kindsey (Indiana Acad. Science) and "Natural Areas of Indiana & Their Preservation", 1969. Edited by Alton Lindsey. (American Midland Naturalist, Notre Dame, IN)

$0. Natural Resources Conservation Program 1975-74-73. 80 pp. (stapled) report. Naval Weapons Support Center, Crane, IN.

41. Nelson, J. S. and S. D. Ferking. 1968. Annotated Key to the Fishes of Indiana. Dept of Zoology, Indiana University.

42. Palmer, C. M. 1929, Algae of Indiana. A classified checklist of those published between 1875-1928. Proc. Indiana Acad. Sci. 38: 109-121.

43. Parker, T. A. (Pardree University) 1969, An annotated list of the spiders of Indiana. Proc. Indiana Acad. Sci 78" 266-314. (1968) 1969.

44. Peattie, Donald Culross 1936, Flora of the Indiana Dures, Feld Museum of Natural History, Chicago.

45. Richardson, David H.S. 1974, The vanishing lichers, their history, biology, and importance. 231 pp. $12.00 Hafner Press, NY

46. Ritter, Carroll "Cave Inventory", A biology teacher & spelunker. Consists of a general inventory of Caves within Hoosier National Forest, (Contact H. E. McReynolds, U.S. D. A., Forest Service, Bedford, Indiana(47421)).

47. Rudd, R. L. 1964 Pesticides and the living landscape XIV + 320 pp. Univ. of Wisconsin Press, Madison.

48. Schneider, A. F. and Gray, H. H., "Geology of the Upper East Fork Drainage Basin, Indiana, "Special Report No. 3, Department of Natural Resources, Indiana Geological Survey, Bloomington, IN, 1966.

49. Smith, Chas. Piper. Report upon a botanical survey of the Indiana State Forest Reservation. Indiana Forestry Report. 3:111-113. 1904.

50. Stoneburner, Daniel L. et al. 1976 A comparrison of two diversity indexes used in wastewater impact assessments. J. Water Pollution Control Federat 48(4): 736-741. April 1976

51. Stormer, Fred A. 1972. Population ecology and managemnt of white-tailed deer of Crane Naval Ammunition Depot.

52. Stormer, Fred A. et al. 1974 Assessment of population levels of White-tailed deer on NAD Crane. Search Bulletin No.910. Pp. 1-11 July 1974

53. U. S. Geological Survey, "The Role of Ground Water in the National Water Situation," Geological Survey Water Supply Paper 1800, Washington, DC 1963

54. Watkins, F. A., Jr., and Jordan, D. G., "Groundwater Resources of West-Central Indiana, " Preliminary Report Green County, Bulletin No. 11, Indiana Department of Conservation and U. S. Geological Survey, 1961.

55. Wayne, W. J., "Pleistocene Formations in Indiana, "Bulletin No. 25, Indiana Department of Conservation, Geological Survey, Bloomington, IN. 1963.

56. Welch, W. Mosses of Indiana, 1957. Pp. 1-478. Div of Forestry, Dept of Conservation, State of Indiana, Indianapolis, IN.

I. GENERAL

A. Purpose of the Assessment

1. To search for, identify, and assess actual or potential chemical, biological, or radiological contaminant migration at Naval Weapons Support Center (NWSC)*, Crane, Indiana from available records and by interview with present and former employees.

2. To identify any immediate on-post safety hazards associated with CBR contamination and unexploded ordnance (UXO).

B. Authority

Department of the Army (DA) charter for the Project Manager for Chemical Demilitarization and Installation Restoration (PMDCIR) dated 29 April 1977.

C. Introduction

1. Pursuant to the designation of the US Army as the DOD Single Source Manager for Conventional Ammunition, and the attendant assumption of ownership and control of certain production and storage facilities formerly under the purview of the US Navy, Headquarters, US Army Armament Materiel Readiness Command (ARRCOM) requested PMCDIR to undertake a search of NWSC records.

2. Personnel from NWSC were briefed on the program prior to the start of the on-site records search. The purpose of the briefing was to outline the assessment scope and to provide guidelines to NWSC personnel for the records search.

3. Before the actual on-site review of records began, various Government agencies were contacted for documents pertinent to the records research effort. Agencies contacted included:

a. Department of Defense Explosive Safety Board (DDESB).

b. US Army Environmental Hygiene Agency (USAEHA).

c. US Geological Survey (USGS).

d. Defense Documentation Center (DDC).

e. US Army Engineer Waterways Experiment Station (WES).

*In the past the Naval Weapons Support Center was known as the Naval Ammunition Depot, Crane, Indiana.

f. National Technical Information Service (NTIS).

g. Naval Sea Systems Command (NSSC).

h. Naval Ordnance Environmental Health Center (NOEHC).

i. Naval Ordnance Station, Indian Head, Maryland (NOS).

j. Naval Facilities Engineering Command.

4. The collection of documents occurred during the period of 15 September 1977 through 15 October 1977. The following team members provided input to this report:

a. Mr. William Collins (Team Leader).

b. Mr. Norman Leibel (Ordnance Specialist).

c. Dr. Elmer Worthley (Environmentalist).

d. Mr. Harry Woods (Hydrogeologist).

e. Mr. John Bane (Chemist).

f. Mr. Reed Magness (Chemist).

g. Mr. Daniel Wenz (Chemical Engineer).

h. Mr. James Scott (PM-CDIR Representative/Chemist).

5. In addition to the review of records, interviews were conducted with more than 25 persons, including present and former employees. An aerial and a ground tour of the installation were also made. Photographs taken during the tours are included in Appendix A. Team members also contacted and interviewed personnel at Naval Ordance Station, Indian Head, Maryland and Naval Weapons Laboratory, Dahlgren, Virginia who were either former employees at NWSC or were aware of certain operations conducted there.

6. The findings and conclusions are based on the records made available to the Team at the time of the search, and the corroborated testimony of the past and present employees.

D. Summary Description of Installation

1. Location and Size

The NWSC Crane is located primarily in Martin County, Indiana, with a small area in the north, lying in Greene County and in the east, in Lawrence County (See Figure I-1). Daviess County borders the NWSC on the west. Located in southwestern Indiana, NWSC Crane lies approximately 25 miles southwest of Bloomington, Indiana, and 70 miles southwest of Indianapolis, Indiana. Figure I-2 shows the towns nearest to NWSC Crane, with their approximate populations. The NWSC is bounded on the north by State Road 45/58, on the west by US Route 231, and on the south by US Route 50/150.

The NWSC consists of 1,006 acres of improved grounds, 10,047 acres of semi-improved grounds, and 51,411 acres of unimproved grounds, a total of 62,404 acres. Included in the NWSC acreage is an 800-acre man-made lake, Lake Greenwood, constructed by the Civilian Conservation Corps.

There are approximately 2800 structures at NWSC, including 800 general purpose buildings and 2000 ammunition storage facilities.

2. Area Description

Martin County has an area of 337 square miles (215,680 acres); its county seat is Shoals. The county lies in the hilly part of Indiana, with an average elevation of 660 feet, and a height range of 425 to 860 feet. The local climate is characterized by warm and humid summers and moderately cold winters. Rainfall is fairly well distributed throughout the year, but there is usually an excess during the spring and an inadequate supply during summer.

Information on the counties surrounding or including NWSC Crane includes:

COUNTY	POPULATION	MAJOR CITIES AND TOWNS	RESOURCES	MAJOR MANUFACTURERS	RECREATIONAL FACILITIES
Martin	10,969	Loogootee, Shoals	Argriculture, Timber	Carnahan Mfg. Company; Edison, Inc.; U.S. Gypsum, National Gypsum	W. Boggs Creek Recreational Area; Patoka Reservoir; Martin County State Forest

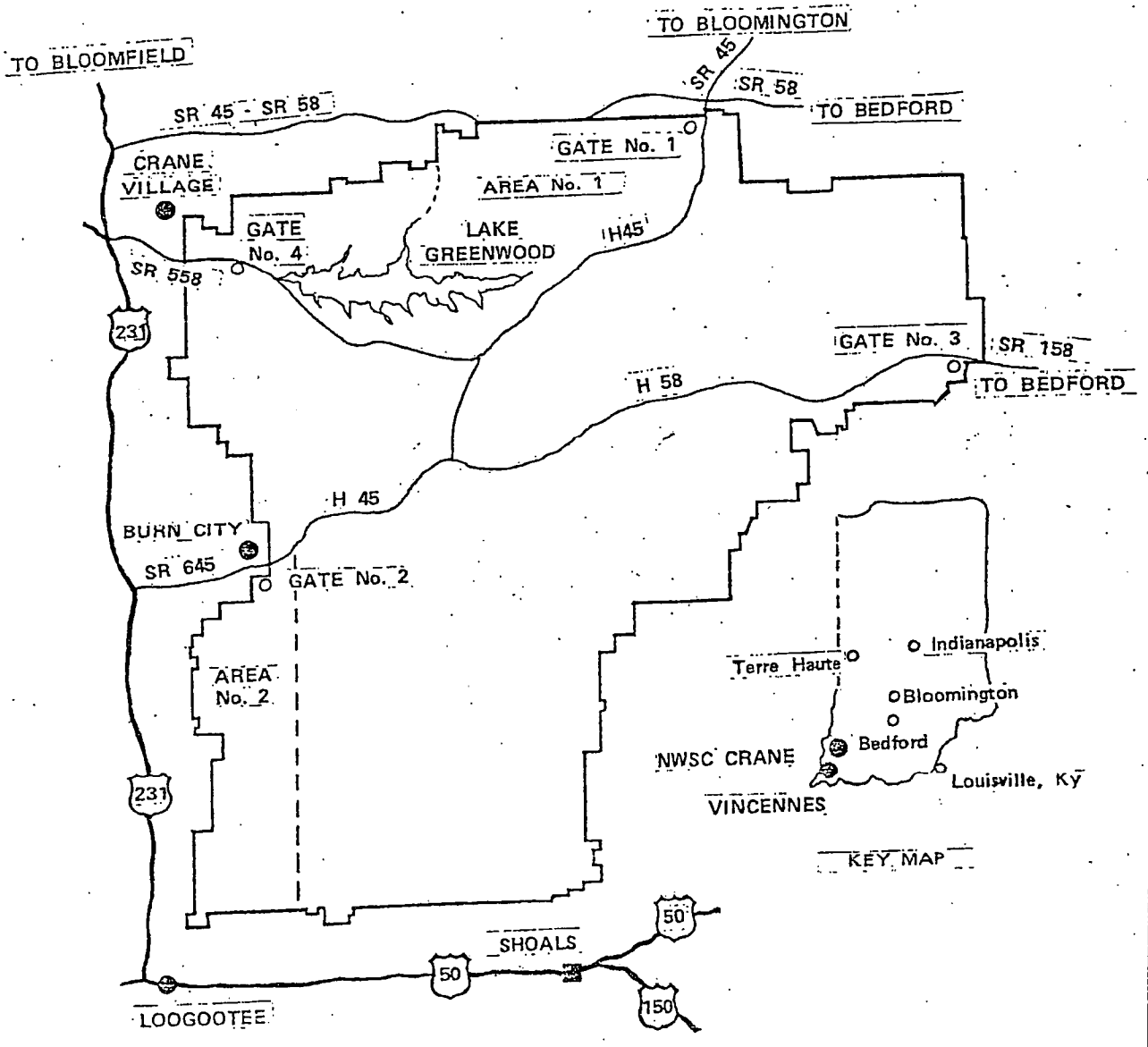


Figure I-1 SITE MAP, NAVAL WEAPONS SUPPORT CENTER, CRANE, INDIANA

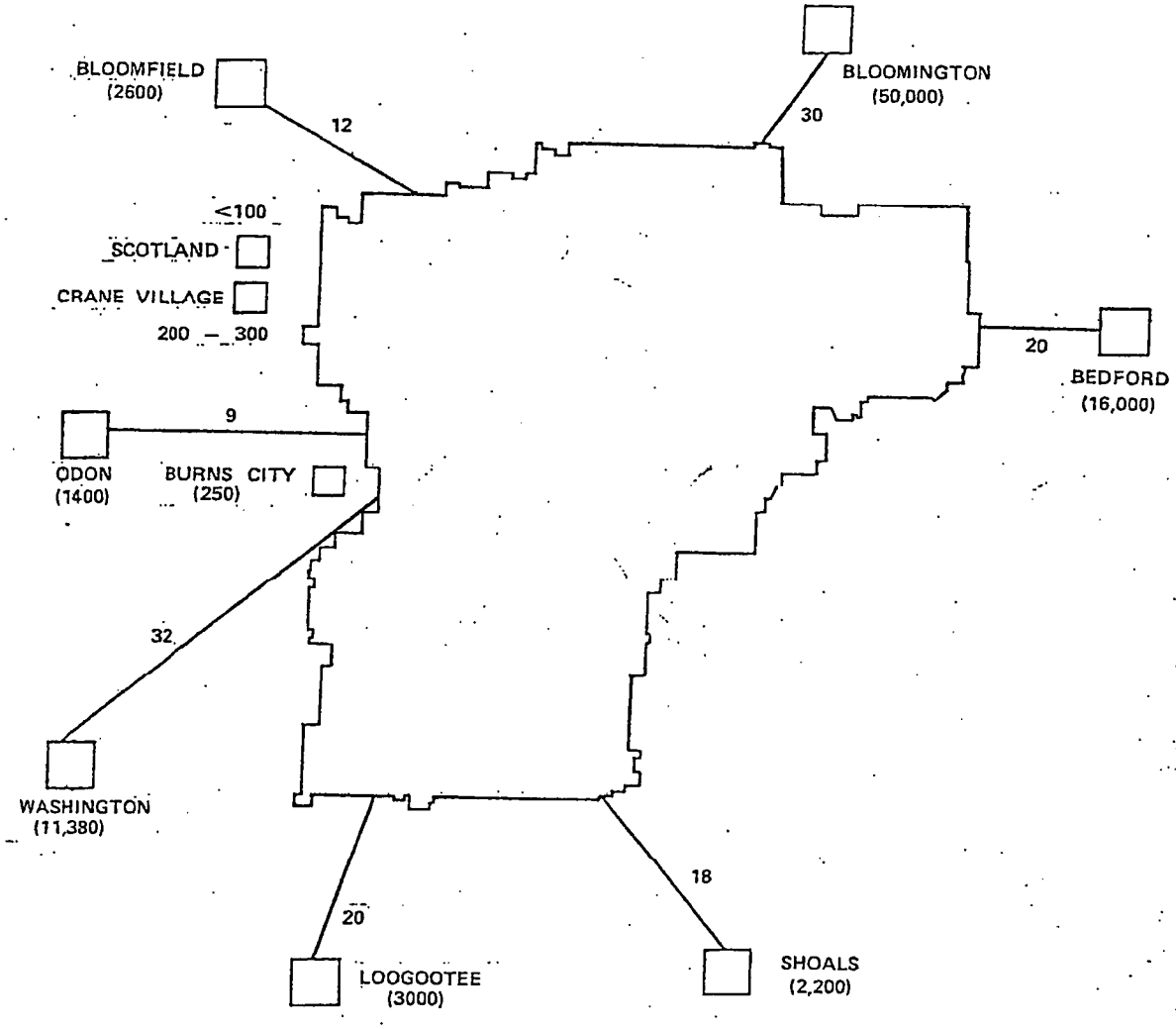


Figure I-2 POPULATION AND DISTANCE OF TOWNS NEAR NWSC, CRANE, INDIANA

COUNTY	POPULATION	MAJOR CITIES AND TOWNS	RESOURCES	MAJOR MANUFACTURERS	RECREATIONAL FACILITIES
Greene	26,894	Linton, Jasonville, Bloomfield	Coal, Agriculture	G.E. Keller Aluminum; Amax Coal Co.; Peabody Coal Co.	Lake Monroe Reservoir; Shakamak State Park; Greene-Sullivan State Forest
Lawrence	42,348	Bedford, Mitchell	Limestone, Timber	Indiana Limestone; Central Foundry Div. of G.M.; Philco-Ford; Lehigh-Portland Cement Co.; Carpenter Body Works	Wayne-Hoosier National Forest; Lake Monroe Reservoir; Springmill State Park
Daviess	26,602	Washington	Agriculture, Timber	Uniroyal Corp.	Patoka Reservoir; Santa Claus, Indiana

3. Organization and Mission

a. Mission. The original mission of NAD Crane (its name before 1975) was loading, preparing, renovating, receiving, storing, and issuing all types of ammunition to the fleet. The mission of Crane has expanded through the years to include applied science, weapons engineering, quality evaluation and engineering, maintenance and repair of military hardware, pyrotechnics, ammunition generation, industrial production equipment, support services, and quality assurance. Crane also stores a number of strategic materials, such as brass, iodine, tantalite, mica, talc, antimony, bismuth, columbite, and lead.

b. Organization. The organization of NWSC Crane, as of May 1977, is in the manual NAVWPNSUPPCENINST 5450.21D with changes dated 14 April 1976 (see Figure I-3). This organization was subject to change as of 1 October 1977, when the conventional ammunition production, renovation, quality assurance, and demilitarization functions were transferred from the Navy to the Army under the Single Manager concept for conventional ammunition procurement, production, supply, and maintenance/renovation in the

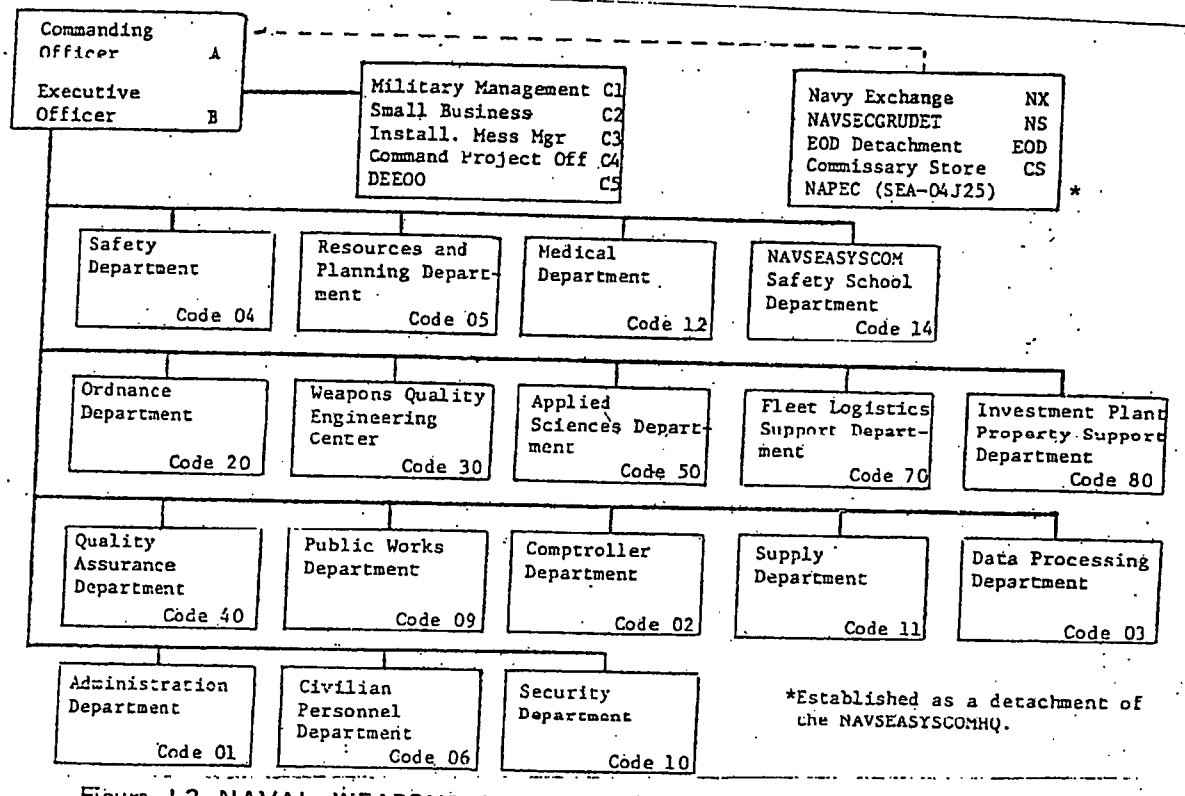


Figure I-3 NAVAL WEAPONS SUPPORT CENTER ORGANIZATIONAL CHART

Continental United States as directed by the Secretary of Defense. Installation strength as of September 1977 was 3,407 full-time personnel, civilian; 180 temporary or part-time, and 51 military. These figures apply to NWSC Crane and the Naval Ammunition Production and Engineering Center (a tenant activity). Other tenant activities account for 835 civilians and 19 military. The number of employees at Crane has varied from a high of approximately 10,000 during WWII, 4,700 during the Korean action, 7,000 during the Vietnam period, to the present level.

4. History.

In 1940, Congress appropriated funds to build new inland ammunition production facilities that would be secure from enemy attack. The Naval Ammunition Depot (NAD), Burns City, Indiana, was constructed using 35,000 acres of land from the White River Land Utilization Project, a public land acquisition project begun in 1934, and 26,830 additional acres from private ownership. The depot was officially commissioned on December 1, 1941. On May 1, 1943, NAD Burns City was renamed NAD Crane.

During WWII, there were more than 112,000,000 pounds of high explosives, and 86,000,000 pounds of smokeless powder stored in the various magazines. At one time, there were also 54,000 500-pound bombs stored at NAD, as well as other types of bombs, and 5000 torpedoes. Guns, rockets, gun mounts and parts, automotive equipment, aviation, and underwater ordnance were also stored there in the mid-forties. A chemical warfare area was established at Crane early in WWII, in the high explosives area, for the purpose of unloading, storing, and servicing chemical warfare material. The first items stored were 155mm mustard shells. In January 1945, Crane became a major storage point in the Navy for chemical warfare munitions.

After WWII, thousands of carloads of equipment and materials arrived at Crane for storage, preservation, sorting, scrapping, or shipment.

Crane successfully met its purpose of providing ammunition to the Fleet during the Korean and Vietnam conflicts, reaching a high level of ordnance production in 1967-68 with approximately one million MK68 and MK82 bombs, one-half million major caliber projectiles, and one-half million MK24 flares being produced.

Over the years, the need for scientific and engineering personnel at Crane has increased, while that for laborers, helpers, and munitions workers has decreased, due to the expanded mission noted in paragraph ID3a above. On 1 July 1975, NAD Crane was renamed the Naval Weapons Support Center (NWSC) Crane, to more accurately reflect the expanded scientific and engineering functions.

E. Environmental

1. Water Quality

a. Surface. Water for the Naval Weapons Support Center (NWSC) Crane is obtained from Lake Greenwood, an 800-acre lake, situated in the northwestern portion of the NWSC (Figure I-4). Lake Greenwood is a multiple purpose reservoir that is used for recreation, flood control, and water supply. The lake has an average water depth of approximately 15 feet and is oriented in an east-west direction with a 55-foot-high compacted dam forming the western end.

Six centrifugal pumps (on the south shore of Lake Greenwood) supply raw water to the 2.1 million-gallon-a-day water treatment plant in Building 4 (Figure I-4). The water treatment consists of aeration, clarification with alum, rapid sand filtration, and chlorination. The water distribution system, consisting of 6- to 10-inch diameter lines equipped with air, electric, and hydraulic control values, is located primarily within the industrial and cantonment areas as identified by the crosshatched area in Figure I-4. Two small communities, Burns City and Crane Village, near the western boundary, purchase potable water on a fee basis from the NWSC.

The surface drainage network has formed a dendritic pattern throughout the installation. Seven creeks in four separate drainage basins carry surface water off the installation (Figure I-5). Drainage from Basin II in the northeast and southeast part of the NWSC consists of several small drainageways. The north and northwest drainage (Basin I) eventually empties into Furst Creek which flows in a westwardly direction and crosses the NWSC boundary. Rainey Hollow, Big Sulphur Creek, and Little Sulphur Creek drain the eastern sector identified as Basin III. Drainage Basin IV occupies the central portion of the installation where Boggs Creek and Turkey Creek receive the drainage from the industrial area and that portion of the cantonment area south of Roads H43 and H5. This drainage crosses the south-central boundary. Seed Tick Creek drains Basin V and exits the NWSC along the southwest boundary. All surface drainage from the NWSC empties into the East Fork of the White River south of the installation.

The NWSC maintains close coordination with the Soil Conservation Service concerning soil erosion and flood control. Ten ponds have been constructed under this program with the structures on Boggs and Seed Tick Creeks being the largest. Several small ponds and catch basins are associated with the manufacturing processes on the installation.

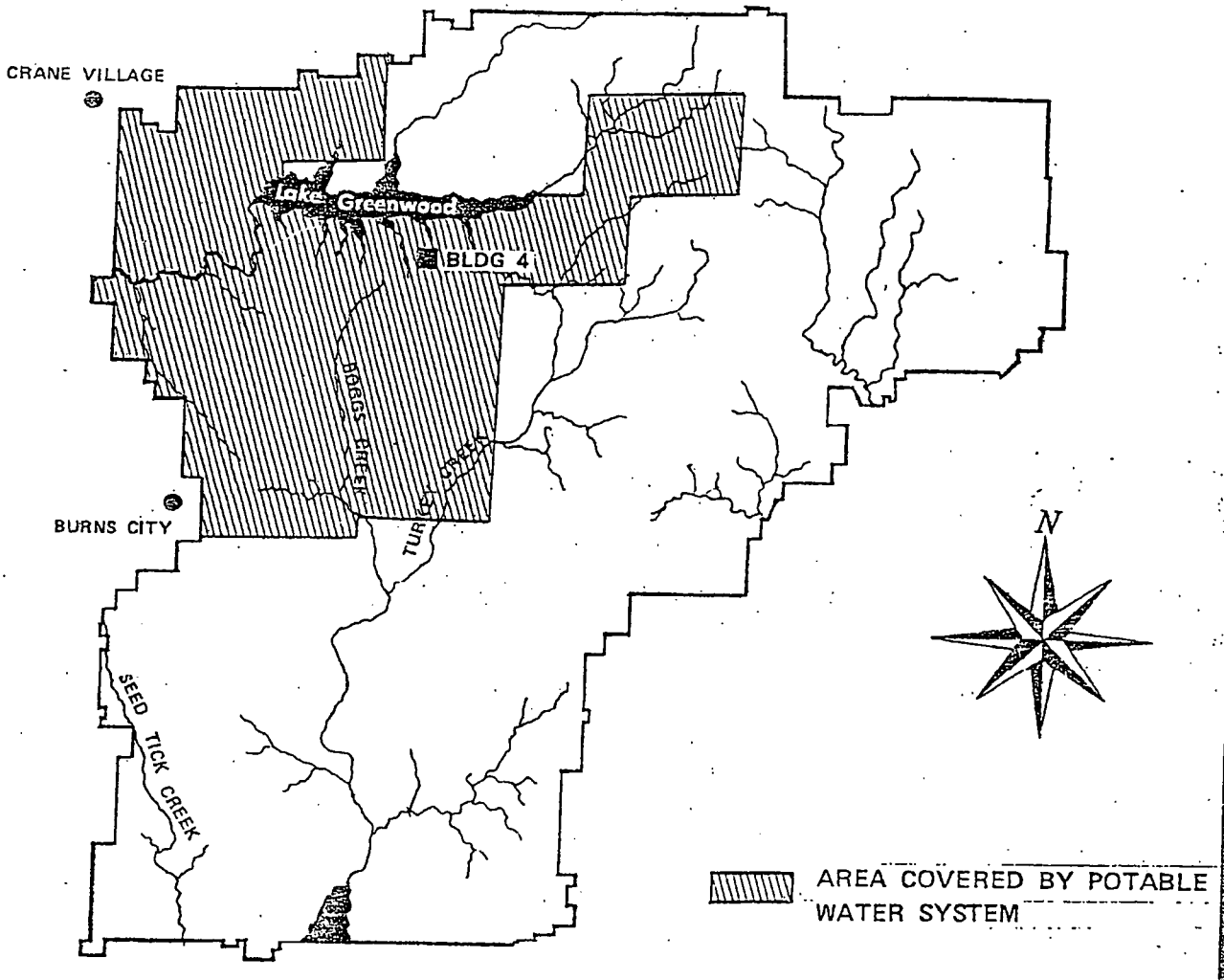


Figure I-4 WATER SUPPLY

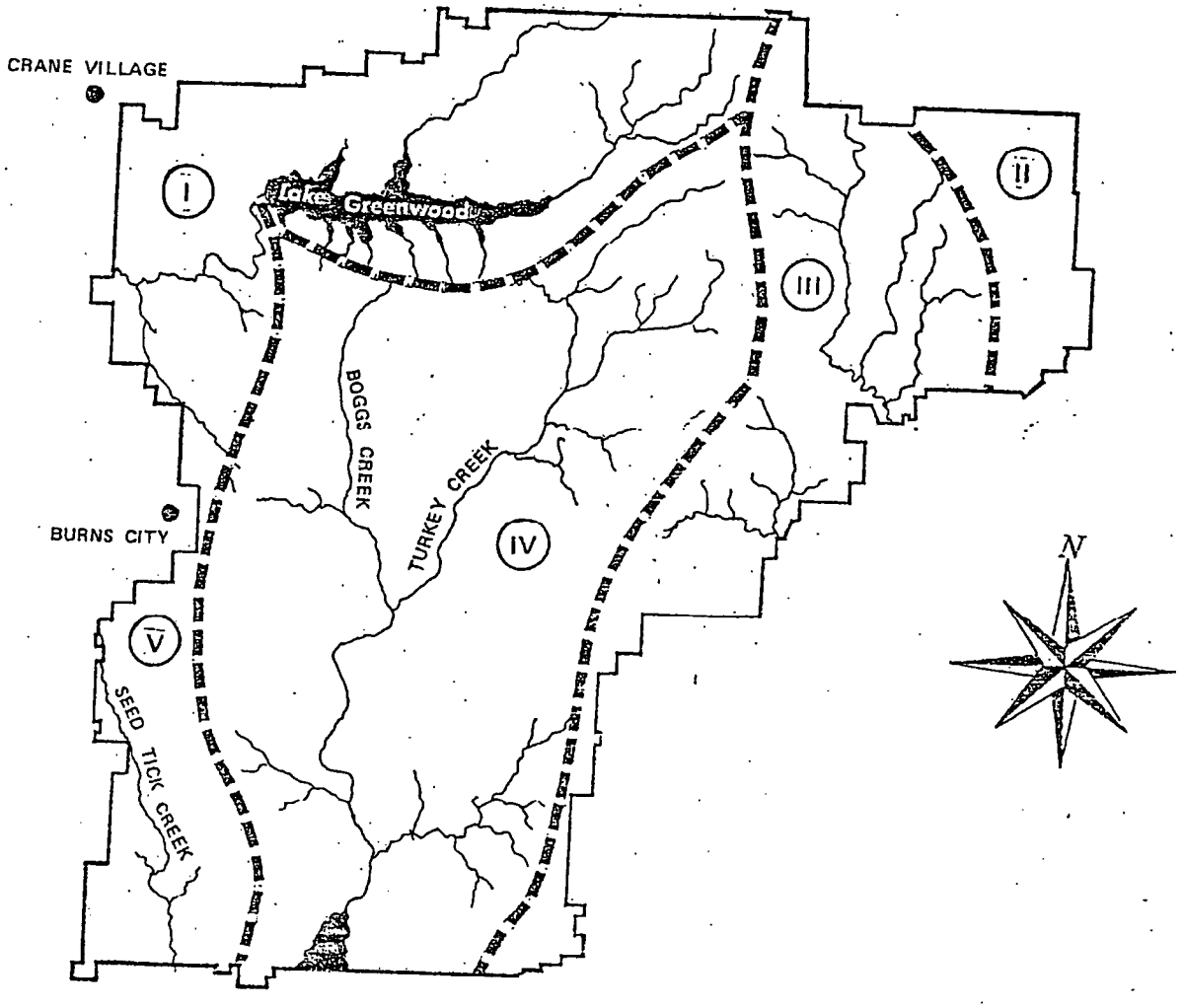


Figure I-5 SURFACE DRAINAGE

b. Subsurface. Data on groundwater conditions within the installation are extremely limited. The utilization of surface water for domestic consumption and manufacturing has precluded groundwater exploration, leaving a gap in groundwater data.

Available groundwater data are from five wells (Figure I-6) drilled in the early 1940's. No water was reported in the overburden which ranged in thickness from 0 to 26 feet. Limited water was obtained from sandstone and limestone at depths between 141 and 313 feet below the surface with the shallowest water level at 85 feet in well No. 5. The well logs are presented in Appendix D.

The regional dip of the bedrock is approximately 20 feet per mile to the west-southwest and the water level shoud conform to this general pattern.

c. Analysis. Lake Greenwood, an 800-acre lake situated in the northwest section of NWSC, supplies both potable and industrial water for the installation. The State Board of Health of Indiana analyzes four samples of water per week from NWSC and its immediate environs for compliance with State potable water standards. (See Appendix C.) Samples taken include: 1) raw water from the intake to the water treatment plant (WTP), 2) treated water from the WTP, and 3) potable water from Crane Village and Burns City which are located adjacent to the western boundary. Water from these sampling points is of good quality and currently meets the State's requirements.

Table I-1 provides a monthly report of the water treatment plant's operational data averaged over a 31-day period.

TABLE I-1. Water Treatment Plant Data for July 1977

PARAMETER	RAW WATER	TREATED WATER	UNITS
Turbidity	2.3	1.0	mg/l*
Alkalinity	12	27	mg/l
pH	6.8	8.3	
Hardness	43	76	mg/l
Chlorine		1.0 (24 tests per day)	mg/l

*milligrams per liter (mg/l)

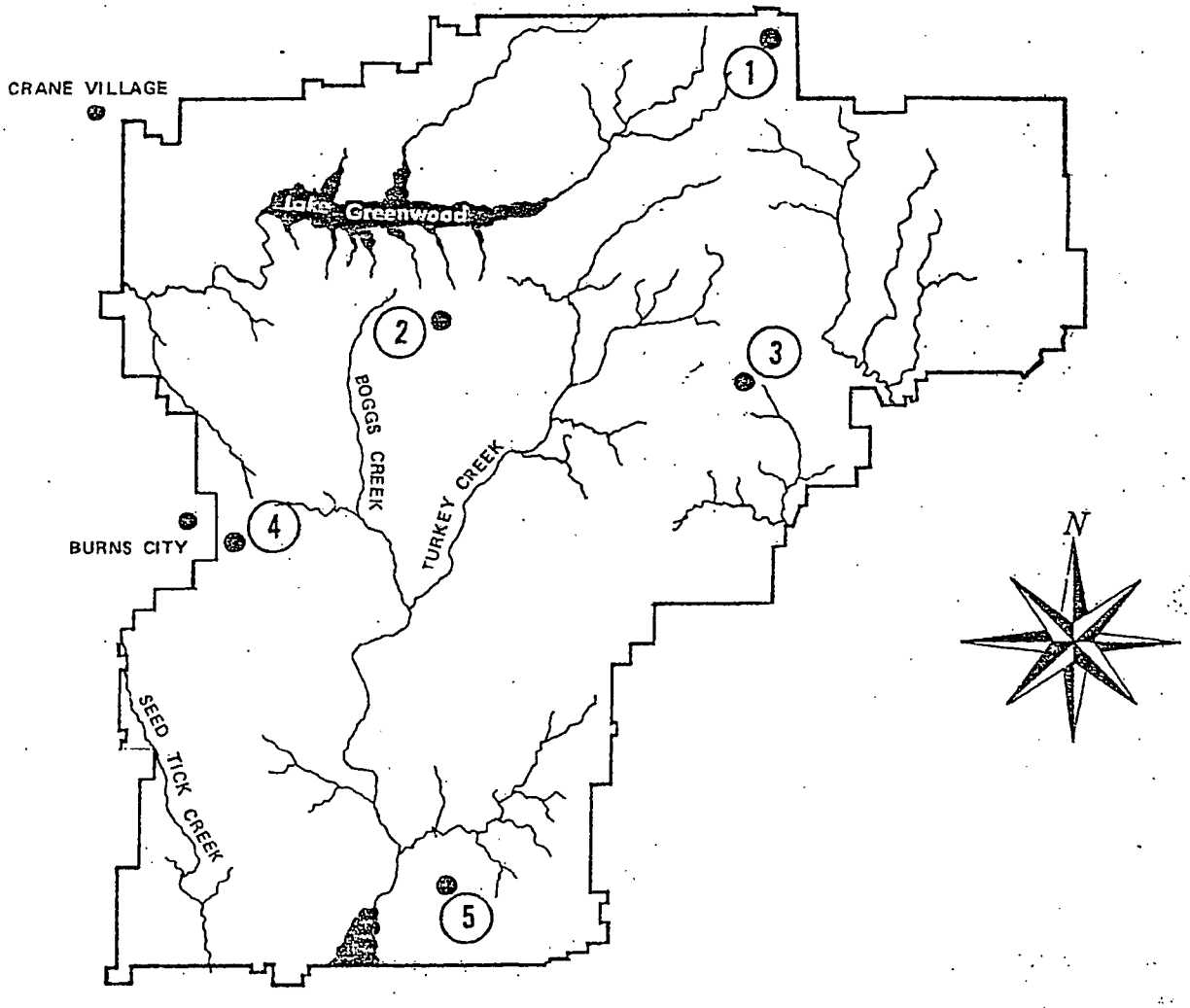


Figure I-6 WATER WELLS

Water quality at NWSC Crane has suffered in the past and continues to suffer to a lesser degree in the present both from spills and from practices of discharging untreated and/or inadequately treated sanitary and industrial wastewaters directly to the watershed. In 1960, several hundred gallons of a cyanide solution was accidently discharged to surface drainage.* The spilled solution was dammed up and chemically treated to destroy the cyanide radical; however, the metal associated with the cyanide radical still presented a potential water contamination problem. In 1970, two of the installation streams were cited as being polluted with effluent from 1) the main sewage treatment plant (STP) 2) the Rockeye bomblet loading area STP (due to inadequacies in sludge digestion and effluent disinfection, 3) the Depot laundry, and 4) the Depot Plating Shop.** The laundry discharged to an open ditch that connected into the sanitary sewage system. Laundry wastewater contaminants included phosphates, detergents, explosives, and pyrotechnics. Effluent from the Plating Shop contained concentrated slugs of metal ions (sodium, cadmium, zinc) and cyanide. Remedial action was proposed under Line Item No. P-108.

In 1971, a project (Project No. P-997) was proposed to abate water pollution associated with operation of the Case Overhaul Facility. The paint and rust stripping operations was discharging untreated wastewater containing caustic, acids, and iron oxides directly to the watershed.

Project No. P-996 (1972) was offered to provide proper disposal of wastes from Buildings 4, 7, 36, 115, 126, 130, 133, 136, 140, 146, 150, 199, 1820, 1885, 1886, 2044, 2084, 2087, 2088, and 2921. Discharges from these areas included acids, used petroleum products, chemicals, and domestic products. These wastes were being discharged to the watershed via overloaded, inadequate, or nonexistent facilities in violation of State and Federal Standards.

In 1973, the Medium Caliber Projectile Loading Facility (Building 104) was cited for the direct discharge of wastewater to the watershed (see Project No. P-130). In addition, ammonium picrate and cyclonite (RDX) dusts passed to the watershed without treatment via settling basins. Other problem sources cited that year included discharge of untreated "Rockeye" Bomblet Facility wastewater containing complexes of trinitrotoluene (TNT) and inadequacies of the septic system for disposal of sanitary wastes.

---

*Memorandum, From 122H to 053D, 8 September 1977, Naval Weapons Support Center, Crane, Indiana.

**Five Year Station Plan for Naval Ammunition Depot, Crane, Indiana (FY 75-79), pg. C-1, Approved July 1974.

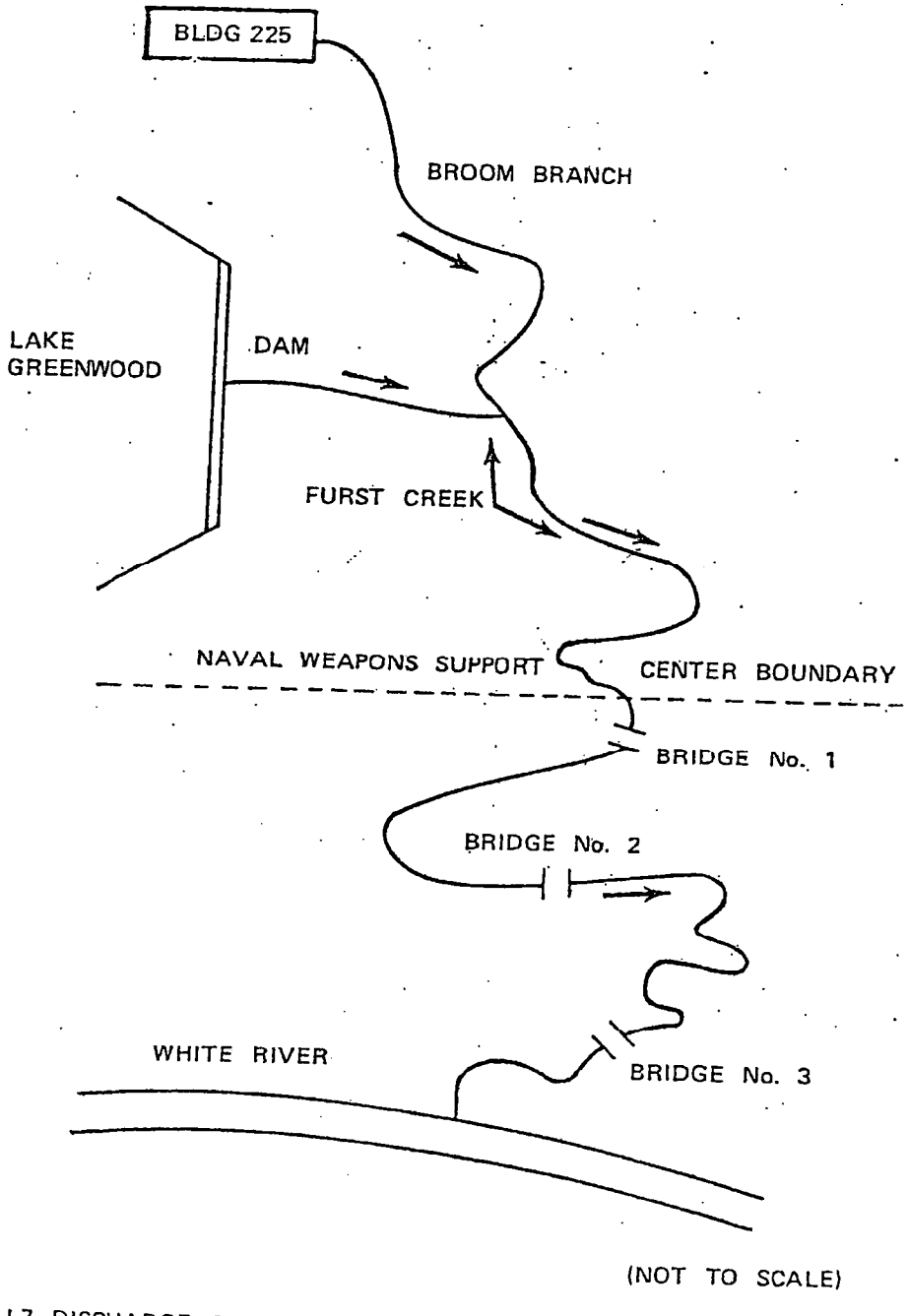


Figure I-7 DISCHARGE OF GREEN WATER FROM NAVAL WEAPONS SUPPORT CENTER

During FY75, a need was recognized (Line Item No. P-132) for the continuous monitoring of five streams flowing off the installation; the need for monitoring was due to contamination of the streams with untreated industrial wastes and with discharges from the sewage treatment system.

In 1974, the need to provide tertiary treatment capability at all four sewage treatment plants was cited. This capability was mandatory by 1977 in order to comply with Indiana Stream Pollution Control requirements.

In 1975, STP No. 1 effluent to Boggs Creek was cited as often being in violation of its NPDES Permit (Permit No. IN-0021539) for fecal coliform, residual chlorine, oil, and grease.* The effluent from STP No. 2 was often in violation of Permit No. IN-022155 for fecal coliform and STP No. 3 (Permit No. IN-0021563) lacked effluent chlorination. The operation of STP No. 4 (Permit No. IN-0021547) was satisfactory. (Project No. P-117 was designed to replace STP's No. 1 through 4 with an advanced waste treatment plant in 1977). Other problem areas included contamination of Furst Creek with heating oil from the NWSC Fuel Farm. The most severe wastewater problem discussed in the Sanitary/Environmental Survey was the industrial waste problem associated with the Metal Plating Shop, Building 1884. Activities in this shop included zinc and cadmium plating and anodizing of metals. Sodium hydroxide; sodium, cadmium and zinc cyanides; and hydrochloric acids were among the materials used. Discharge from this shop was in noncompliance with NPDES Permit No. IN-0035157.

In 1976, the burning of Building 225, a large storage building, resulted in several chemicals including pentachlorophenol and sodium fluorescein (a green dye) entering the surface drainage system. The spillage was initially contained and treated; however, the contained water was eventually allowed to flow off the installation.** (See Figure I-7).

Data obtained at the time of the Research Team's visit (19 - 23 September 1977) indicated that the installation was having difficulties during 1977 in meeting discharge limits imposed by its NPDES Permits. (See Appendix C for analyses sheets showing permit conditions and for figures showing approximate locations of outfalls.) As shown in the analyses of wastewater, all four sewage treatment plants (Outfalls 001 through 004, respectively) were in noncompliance at least once during the month of July.

---

*Sanitary/Environmental Survey for Naval Weapons Support Center, Crane, Indiana.

**Memorandum, From 303 to Distribution List, Subj: "Green Water" Report, 20 September 1976, NWSC, Crane, Indiana.

Sewage treatment plant (STP) No. 1 failed requirements for total suspended solids (TSS), fecal coliform and chlorine residual, STP No. 2 failed requirements for fecal coliform and chlorine residual, and STP's No. 3 and 4 failed requirements for chlorine residual.

Although wastewater from the Metal Plating Shop (Discharge point 005), is currently neutralized and treated to destroy cyanide before discharge to surface waters, the effluent periodically fails to comply fully with its discharge limits. There are continuing problems with pH, TSS, cyanide, copper, iron, lead, and zinc. Discharge point 005 (Boggs Creek below its confluence with Turkey Creek) had difficulties with TSS, chromium, copper, and iron.

The new advanced sewage treatment plant was put on-stream on 16 September 1977; however, since several weeks of debugging were required before it became fully operational, analyses of its output were not available during the survey.

The present water monitoring program does not include analyses of any of the NWSC major streams at the point where each leaves installation property. It is necessary to have this data in order to determine whether contaminants are actually migrating off the installation. In the eastern part of the installation, Big Sulphur Creek drains southeast from the Rockeye manufacturing area and is contaminated with explosives manufacture wastes including complexes of TNT. Further south, Little Sulphur Creek drains southeast from the vicinity of a pyrotechnic burial site and an ordnance burning area. Boggs Creek, just below its confluence with Turkey Creek, contains heavy metals; therefore, the potential exists for these contaminants to migrate off the installation at the southern boundary. Seed Tick Creek enters the installation in the southwest and drains southeast from the general area of a sanitary landfill that currently has a leachate (of unknown composition) problem. In the northwest, Furst Creek receives drainage from the vicinity of the McComish Gorge landfill and an old open burning pit via Culpepper Branch and drains west off the installation.

2. Biota

a. General. The approximately 63,000-acre NWSC Crane occupies the northern third of Martin County, Indiana, with small extensions into adjacent Greene, Daviess, and Lawrence counties. Indiana, with an area of 36,045 square miles, is one of the north central states and lies between latitude 37°40' and 41°50'N and between longitude 84°49' and 88°2'W. The northern three-fifths of Indiana was covered with the Wisconsin ice sheet and the southern two-fifths (including the the NWSC area) was slightly affected by glaciation. This unglaciated region is characterized by steep ridges separated by a dendritic drainage pattern. Initially, valleys are trench-like, but grade into flat alluvial floodplains. Summers are hot and

humid, and winters are mild. Snow cover is light and of short duration. The frostfree period is more than 180 days. Soils are derived primarily from sandstone and are of silt-loam texture. Generally, they are acidic and low in nutrients (Ulrich et al., 1946). The average annual precipitation is about 39 inches. The average temperature is about 52 degrees with extremes as low as 20 degrees below zero and as high as 100 degrees. The average growing season is about 120 days near NWSC.

b. Flora. When the Depot was established in 1941, farming ceased. Currently, the land for the most part is in varying stages of forest succession. About three-fourths of the area has woody cover, a large part of which occupies land that was originally too steep for farming. Old fields, vestiges of past cultivation, occur on broader uplands and stream bottoms. A considerable area is maintained as openings by mowing. The major portion of this acreage consists of roadsides, perimeter firebreaks, power lines, water lines, and earth-covered storage magazines. Openings on dry upland sites contain almost pure stands of grasses (Andropogon spp) with scattered clumps of invading woody plants such as persimmon (Diospyros virginiana), sassafras (Sassafras albidum), and sumac (Rhus copallinum and R. glabra). As soil moisture improves, forbs become more prevalent.

On wetter sites, river birch (Betula nigra), willow (Salix spp), sycamore (Platanus occidentalis), and cottonwood (Populus deltoides) are common woody invaders. The dominant species of the hillside communities are hickory (Carya spp), white and black oak (Quercus spp), red maple (Acer rubrum), sugar maple (A. saccharum), tulip poplar (Liriodendron tulipifera), ash (Fraximus americana), and beech (Fagus grandifolia). About 2 percent of the area is in scattered plantings of pines (Pinus spp).

Approximately 50,395 acres of NWSC Crane are classified in the Central Hardwoods Forest of the United States. Commercial trees include black walnut, red and white oak, sugar maple, yellow poplar, white ash, beech, hickory, and sycamore. When the Navy obtained title to the lands, approximately one-half of the forested area was overcut, burned, pastured, contained undesirable species, or had little growing stock. Since the beginning of the Navy Forest Management Program in 1963, much of the depleted land has been restored and many young healthy stands of timber can be found on the installation (See Appendix B).

An estimate 959,820 board feet of hardwood sawtimber have been harvested during the last three years. The timber was sold by competitive bid and returned nearly $67,000 to the Government. The timber was marked under the direction of professional foresters who prepared environmental impact assessments to allow proper review of possible environmental problems.

Timber stand improvement operations were conducted on 800 acres. Most of these operations were to remove unmerchantable, diseased, cull, or stunted trees left remaining after a timber harvest. Removal of these trees allows growing room for new trees and helps perpetuate a young healthy forest.

Insect and disease problems are minor and the main protection is furnished by the young diversified forest being produced by present silvicultural practices. Careful inspection of timber harvesting operations helps to keep logging damages to the residual stand to a minimum and reduces the common but costly insect and rot damages associated with logging. Crane natural resource personnel keep abreast of potential insect and disease problems by reviewing current reports and literature from Federal, State, and professional sources.

The diversified and extremely interesting biological resources of this area owe their origin and character in part to the variety of habitats produced by present climate, soils, and topography. The diversity of habitats is evident when one considers that with the possible exception of marsh and agricultural habitats, Crane has an excellent interspersion of all other habitat types of the region. Crane's central position on the continent has also resulted in the converging here of floral elements traceable to origins in other direction. For a listing of flora including trees and plants see Appendix B and Bibliography references 12 and 56.

The Biology Survey Committee, Indiana Academy of Sciences, has prepared a list of 485 species of rare plants in Indiana. A county breakdown of these species may be obtained from the Department of Biology, University of Notre Dame.

Although a complete list of rare plant species is not available for NWSC, the following plants in need of conservation have been recorded from the base:

Showy Orchis
Lesser Fringed Orchis
Ginseng (This species is dug for commercial sale).
Nodding Trillium
Large White Trillium
Yellow Trillium
Sessile Trillium
Twinleaf (Suspected as being present on NWSC (found nearby))
Sullivantia Sullvantii (Ohionis)
Asplenium penvatifidum
Asplenium trichomanes
Vittaria lineata "herb-wagneri"

c. Fauna. The mobility of animals generally, except in some of the lower orders and specialized forms, tends to create wider distribution patterns and fewer specialized ecological limitations than is the case with the plant base upon which animal life depends. Thus, there are few really distinctive zoological resources. However, the representation of the aboriginal fauna, with the exception of such major mammals as black bear and mountain lion, is surprisingly complete. There is a great variety and abundance of bird and mammal life, and the prosepct for perpetuating and improving this situation is very good.

White-tailed deer are abundant throughout the area. It is interesting to note that deer were exterminated from Indiana by 1900, due to unrestricted hunting and the clearing of the land for farming. Crane's present herd of 3,000 to 4,000 deer has grown from a stocking of 12 deer in 1942 by the Indiana Department of Natural Resources. A controlled hunt is held annually to help maintain a healthy herd.

Another animal that had to be reintroduced to Indiana is the beaver. While sightings of beaver are rare, the many dams and lodges constructed by beaver are easy to find. Several of the beaver-dams provide water for the only natural resident duck, the wood duck, on the installation.

Small mammals such as opossums, raccons, cottontail rabbits, and red and gray foxes can be seen frequently. Carnivores that are seen less frequently include the long-tailed weasel, striped skunk, mink, and coyote.

Larger rodents which are commonly seen are the muskrat, woodchuck,* gray squirrel, fox squirrel, and eastern chipmunk. Woodchucks are especially abundant and conspicuous along roadsides and on storage magazines. One rodent that is rarely seen, since it is almost entirely nocturnal, is the flying squirrel.

Lying along the Mississippi Valley flyway of waterfowl and shore birds, the installation receives seasonal influxes of numerous species in these categories. In the inlet on Lake Greenwood between the Commissioned Officers Mess and the Housing Area, a resident free-flying flock of Canada geese and mallard ducks is maintained. The nucleus of this flock was released in 1974. During the winter months, a bubbler system maintains open ice-free water and food is provided for the birds. It is not unusual to see over 500 birds in this inlet during extremely cold weather. Other migrating waterfowl which have been seen include the ringnecked ducks, lesser scaups, hooded mergansers, black ducks, redheads, common mergansers, bufflehead, and common loons.

*Often referred to as a groundhog.

Game birds at the installation include wild turkey, ruffed grouse, bobwhite quail, and woodcock. The wild turkey was reintroduced to the installation in 1974 and many sightings of this noble bird have since been made. Restocking efforts have also been successful with the ruffed grouse and several makes are heard each spring when they "drum" the air with rapidly beating wings in an attempt to attract a female.

Raptors that rest on the installation include the red-tailed hawk, redshouldered hawk, broad-winged hawk, sparrow hawk, Cooper's hawk, sharp-shinned hawk, great horned owl, barred owl, screech owl, and turkey vulture. From 50 to 100 turkey vultures live on the installation from late February through November. The hills and valleys provide good physical conditions for thermal updrafts in which the turkey vultures enjoy soaring in lazy circles.

Fall and winter raptorial visitors to the installation include the roughlegged hawk, marsh hawk, short-eared owl, long-eared owl, saw-whet owl, bald eagle, and golden eagle. This is probably the only place in the state where two species of eagles can be seen with any regularity. The primary foods of hawks and owls are the small animals of the woods, fields, and roadsides; and where cover is sufficient, these predators have only a minor impact on populations of game animals. These raptors are all protected by state and federal laws.

Many other species of birds can be found on the installation. The following checklist is by no means complete; however, it does give a good indication of the types of birds present:

American coot	Killdeer	Herring gull
Rock dove	Mourning dove	Belted kingfisher
Common flicker	Hairy woodpecker	Red-bellied woodpecker
Yellow-bellied sapsucker	Downy woodpecker	Horned lark
Blue jay	Common crow	Carolina chickadee
Tufted Titmouse	Brown creeper	White-breasted nuthatch
Red-breasted nuthatch	Winter wren	Carolina wren
Mockingbird	American rober	Eastern bluebird
Golden-crowned kinglet	Ceder waxwing	Starling
House sparrow	Cardinal	American goldfinch
Rufous-sided towhee	Dark-eyed junco	Tree sparrow
Field sparrow	Whip-poor-will	Purple martin
Red-winged blackbird	Swamp sparrow	White-throated sparrow
Song sparrow	Great blue heron	Ruby-throated hummingbird
Yellow-breasted chat	Common grackle	

There is a good variety of land reptile life including the box turtle, several lizards, and a number of species of snakes. Poisonous land snakes are represented by copperheads and rattlesnakes. Nonpoisonous land and water snakes are fairly common.

Quite a few species of frogs and salamanders inhabit the installation. Bullfrogs can be heard nightly during the summer months. Toads are common and several species of water turtles are present.

The aquatic life of the lakes, ponds, and streams is interesting. Many invertebrate forms occur. Crayfish are abundant and freshwater mussels can be found in some locations. Fish life is represented by the following species:

Golden shiner	Yellow perch	Bluegill sunfish
Redear sunfish	Warmouth	Walleye pike
Channel catfish	Largemouth bass	White crappie
Spotted sucker	White bass	Yellow bullhead
Carp	Brown bullhead	Longear sunfish
Black crappie		

3. Geology

a. Physiography and Topography. The NWSC lies in the Mitchell Plain section of the Interior Low Plateau Province. The topography consists of flat to gently undulating surfaces dissected by numerous drainageways, with ranges in elevation from 470 to 860 feet above mean sea level (msl). Bounding inclines along the streams have slopes that approach 20 degrees and rise up to 150 feet above the valley floor. The bounding inclines of the smaller drainageways are V-shaped while the larger drainageways occupy floodplains up to 2000 feet wide.

b. Subsurface Geology. The NWSC is underlain by geologic rock formations of lower Pennsylvanian and upper Mississippian age. Figure I-8 indicates the areal distribution of three units with unit 1 representing the Raccoon Creek group (Pennsylvanian) and units 2 and 3 representing the Stephensport group (Mississippian). The Illinoian glacial drift overlies the rocks in the northwest sector of the installation; however, this unit is not mapped in Figure I-8.

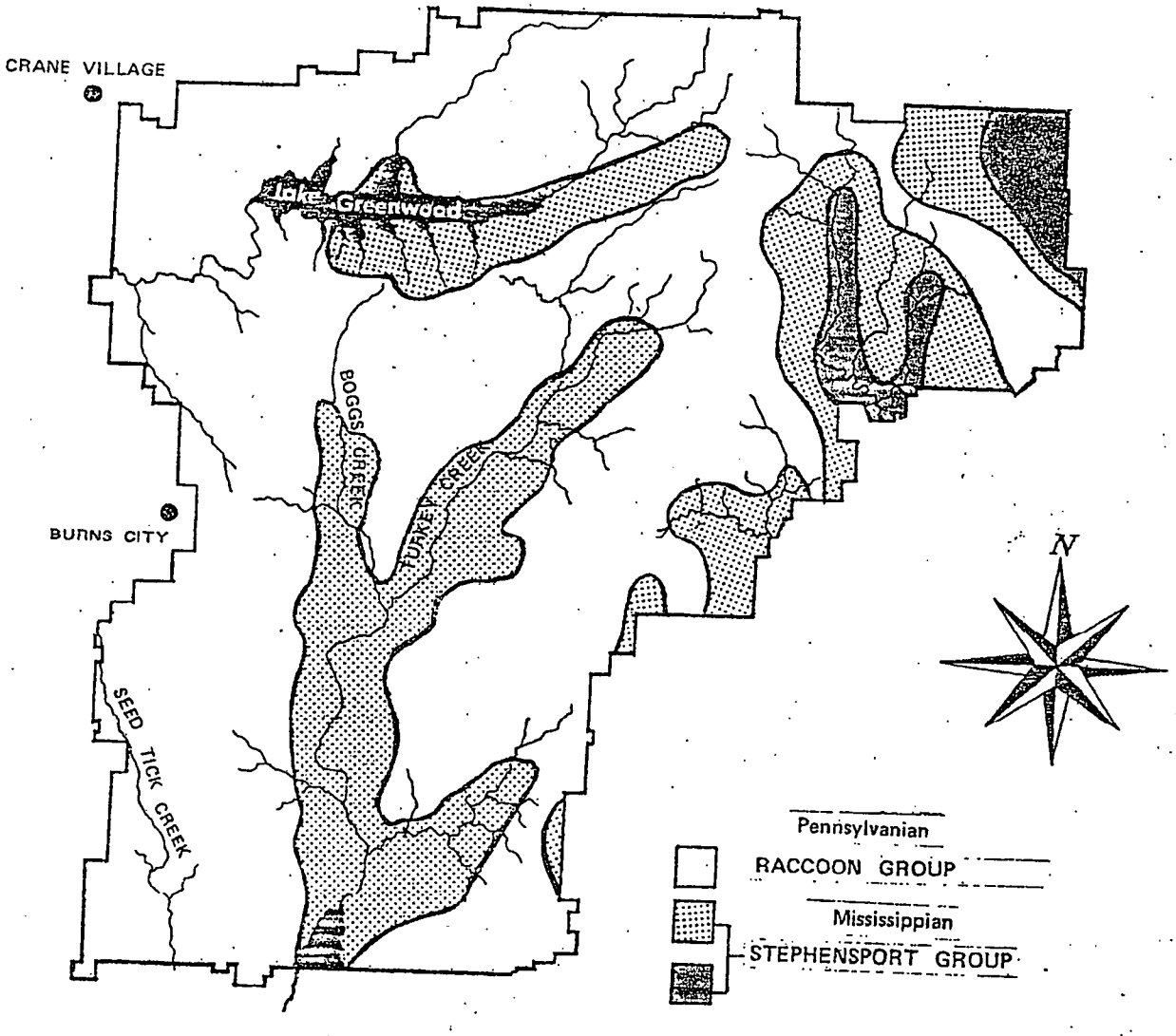


Figure I-8 GEOLOGY

Characteristics of the three mapped units are very similar and consist of gray to tan, fine to coarse-grained sandstone and limestone interbedded with seams of dark gray shale, clay, and light gray siltstone and mudstone. The total thickness fo the three units ranges between 350 and 475 feet.

c. Soils. From the boring logs, the major soil type is a 2- to 3-inch-thick surface layer of brown to tan organic clay loam underlain by clay intermixed with silts and sand. The United States Department of Agriculture identifies three-fourths of Martin County (which includes the NWSC) as the Zanesville and Muskingum soil series. These series are identified as a dark brown organic silt loam at the surface, underlain by 48 inches of mottled tan, gray, and yellow clay with varying percentages of sand and silt. Occasionally, a clay hardpan occurs between 25 and 32 inches below the surface.

Subsurface exploration at the sanitary landfill included observation wells, auger, and splitspoon borings. Data from seven observation wells indicate that clay occurs from the surface to a maximum depth of 19 feet. Sand rock, assumed to be sandstone, is at depths between 5 and 19 feet. Data from 15 auger holes show clay to sandy clay down to a maximum depth of 10.5 feet with the top of sandstone ranging from 4.5 feet to just beyond 10.5 feet. Data from splitspoon borings B50 through B52 provide a more detailed description of the soil above the sandstone that was reached at 16.6 feet. The top 2 feet consist of dark brown soft inorganic silt grading to dark yellow in color and becoming sandy down to approximately 3 to 5 feet. The next 2 feet are dark yellowish brown, dry, hard lean clay. This clay zone is absent in the data from boring B51. The remainder of the overburden is a light brown, mottled gray hard silty sand with scattered sandstone fragments.

Ten borings at the compactor site identified 14 to 18 feet of light brown to yellow silt and sand with an occasional zone of lean clay overlying sandstone. Data from six auger holes show 8.5 to 10.5 feet of red, blue-gray clay over shale.

One boring at Trinity Springs (some two miles east of the southeast boundary in the floodplain of Indian Creek) presented 13 feet of gray clay, 72 feet of gray silty clay, and 5 feet of brown silty, sandy clay. No rock was encountered in this hole.

The location of the above borings are shown in Figure I-9 and the drilling logs are presented in Appendix E.

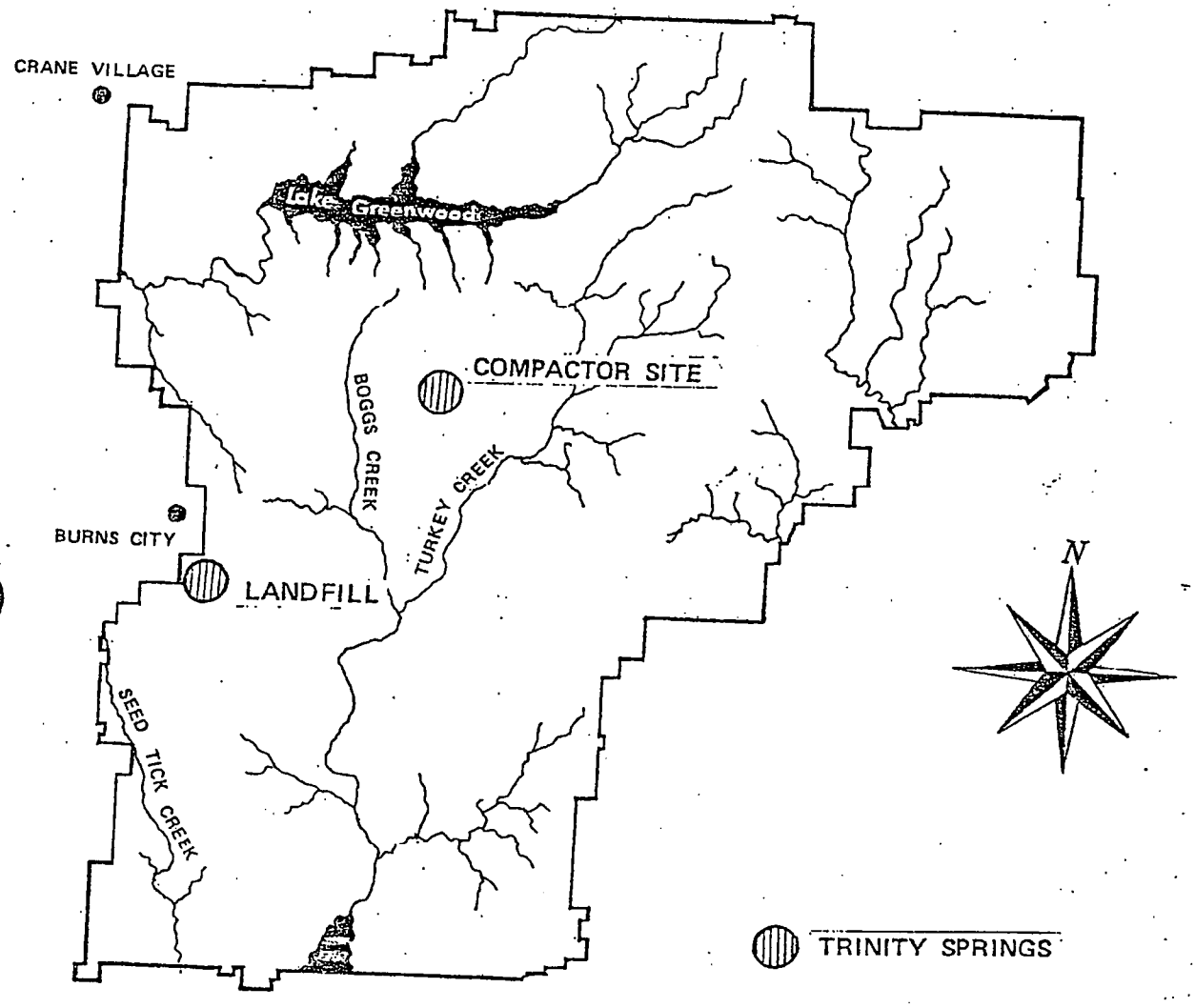


Figure I-9 BORING LOCATION

II. CONTAMINATION ASSESSMENT

A. Industrial Operations

The major source of industrial contamination at NWSC is from contaminated wastewater from the filling and demilitarization operations. Much of the present and practically all past (prior to 1970's) operations discharged contaminated wastewaters directly into the nearby ditches and streams or into sump pits or settling ponds that overflow directly into the streams. Most of the contaminants identified are explosives or explosive related chemicals carried by the wastewater into the nearby ditches and streams. These contaminants included RDX, tetryl, Composition A, B&D, TNT, HMX, aluminum, lead chromate and alkaline nitrates. Each industrial area is discussed below.

Large quantities of ammunition have been loaded and demilitarized at NWSC in the past (see Appendix G). These figures show that large quantities of explosives have been handled at NWSC. Due to the manner in which wastewater has been handled, a high potential exists in the industrial areas for contamination of nearby ground, ditches, and streams with explosives and associated chemicals.

1. Rockeye/3-Inch Explosive Loading Area

This area is located in the northeastern portion of the installation and is presently a cast loading line for the Rockeye Rocket. Figure II-1 is an aerial view of the complex. Records indicate that many thousands of 3-inch munitions were filled in this area during WW II, and the Korean and Vietnam conflicts. At present, TNT is the principal contaminant in the area; however, records indicate that large quantities of RDX, HBX, and Composition B munitions were handled in the area. The primary cause of contamination in this area is a result of wastewater discharge and run-off from the filling operation. Wastewater from the tray and bomblet washing areas runs into sumps. The drills used in this operation are water-cooled with recirculating water and the slush is gathered daily and also placed into the sumps. The sumps are periodically pumped and the residue is sent to the burning ground for disposal. It should be noted that once the sumps are filled, the excess wastewater drains directly into the drainageways and, (depending upon which side of the complex the sump pits are located) eventually to Sulphur or Boggs Creeks water beds.

All explosives spilled on the floor are collected and sent to the burning ground for disposal while the cleaning water from the floors runs directly into the sumps. All of these factors contribute to the contamination of the drainageways leading from this complex. The new milcon project to control this contamination is scheduled for operation in January 1978 and should greatly reduce furture contamination.

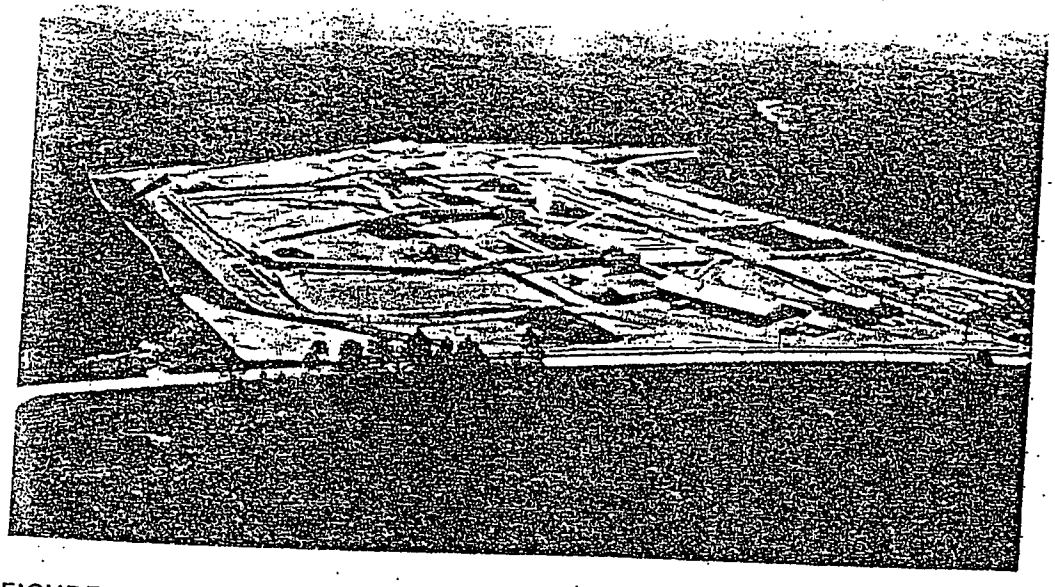


FIGURE II–1 ROCKEYE MANUFACTURING AREA, NWSC, CRANE, INDIANA (ARROW INDICATES POINT OF DISCHARGE OF RED WATER THROUGH FENCE AROUND ROCKEYE AREA)

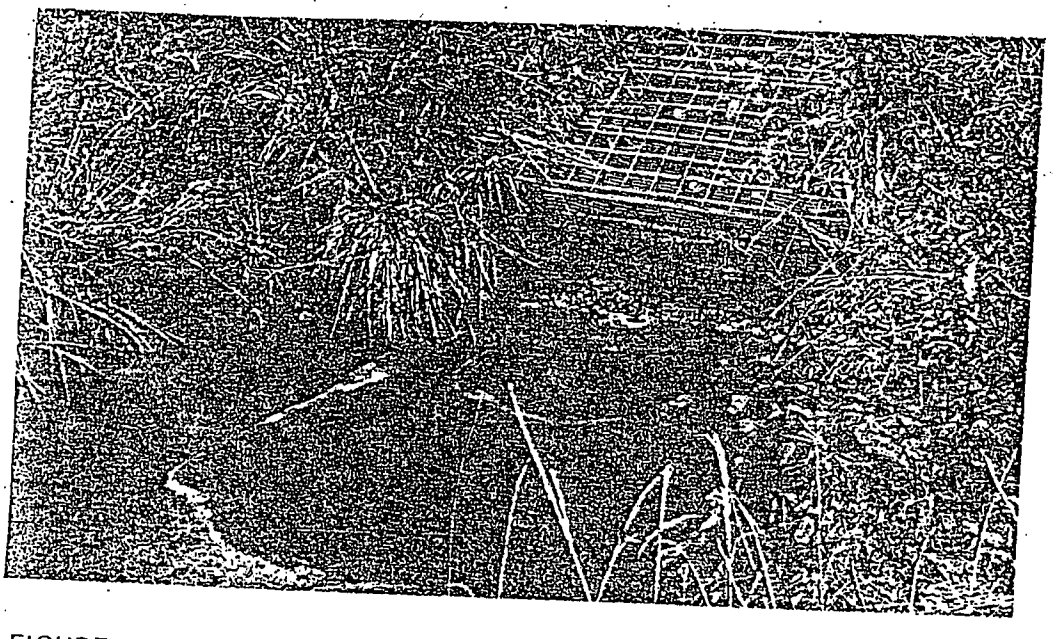


FIGURE II–2 RED WATER DISCHARGE POINT AT FENCE SURROUNDING THE ROCKEYE AREA

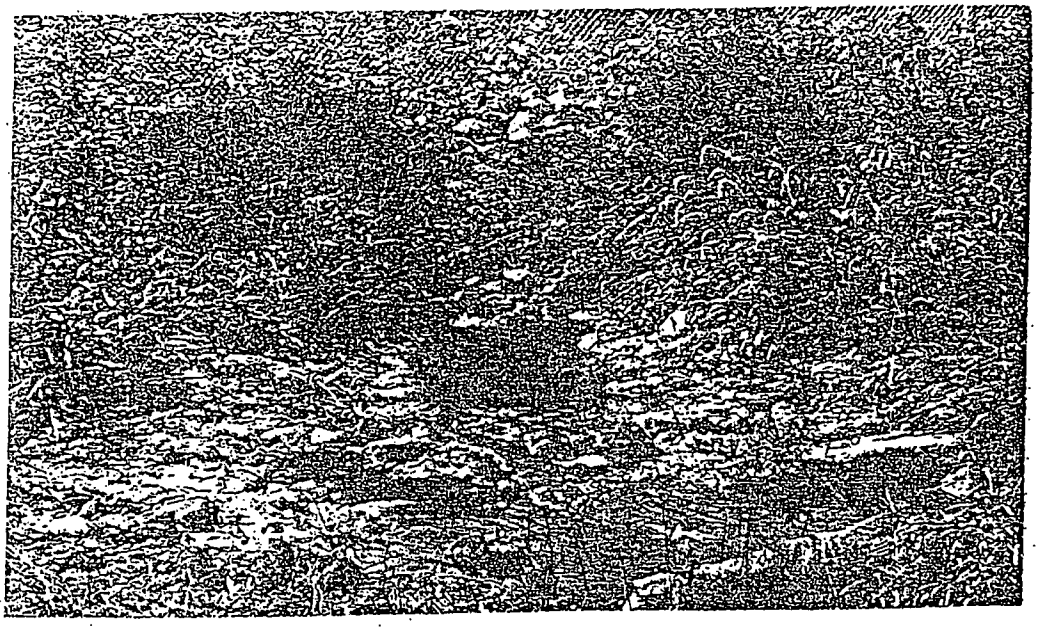


FIGURE II–3 RED WATER 50 YARDS DOWNSTREAM FROM ROCKEYE FENCE

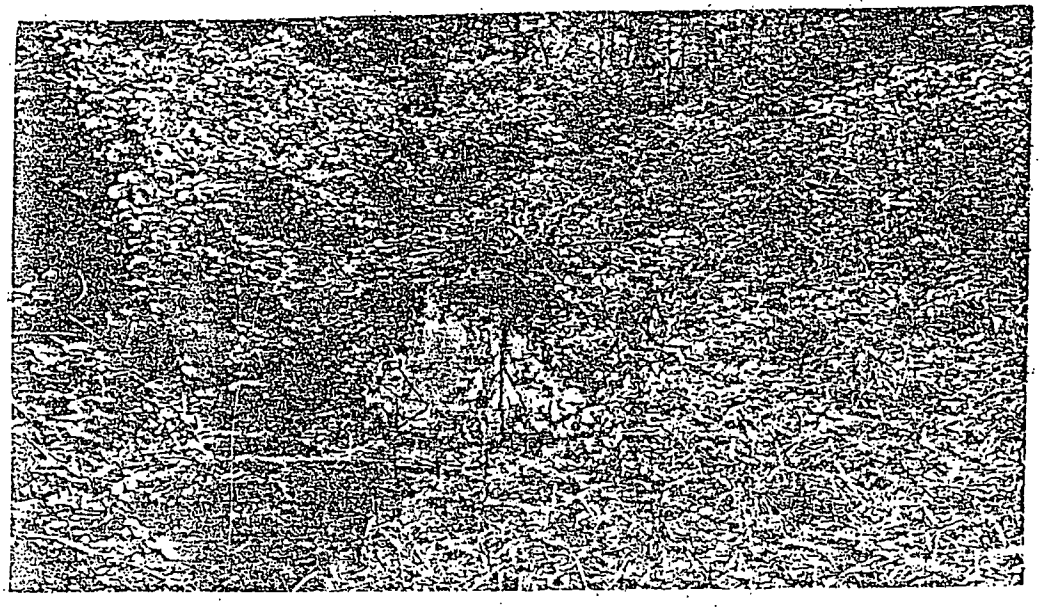


FIGURE II–4 RED WATER 200 YARDS DOWNSTREAM FROM ROCKEYE FENCE

FIGURE II–5 RED WATER 400 YARDS DOWNSTREAM FROM ROCKEYE FENCE

FIGURE II–6 RED WATER APPROXIMATELY ONE-HALF MILE DOWNSTREAM FROM ROCKEYE FENCE

Red water, indicative of TNT contamination, was observed by team members in the surface water drainage ditches on the northeastern side of the complex. This wastewater drainageway was followed by team members and red water was observed where the stream enters Sulphur Creek approximately 2 1/2 to 3 miles from its source. Although no water sampling and analysis of Sulphur Creek could be found in the records, concentrations of 150 to 200 parts per million (ppm) of TNT were reported in water samples taken in the drainageways near the complex. The vivid red color of the water shown in Figures II-2 through II-6 indicates a significantly high concentration of TNT in the stream even at the point of entering Sulphur Creek. It would be expected that this situation would become more critical as the workload increases and additional shifts are added. This complex presently employs a single shift of approximately 100 employees; however, as many as three full shifts have been employed in the past during peak times of national emergencies.

2. 40-Millimeter Loading Complex

The 40-Millimeter (mm) Loading Complex is located at map coordinates Q-31 (Figure II-7)*. All reported loading and demilitarization operations are confined to Building 146. This complex has been used for cast loading munitions with TNT, RDX, and HBX explosives along with the demilitarization of such ammunition as: 20mm, 30 and 50 cal munitions, shotgun shells, fuzes, detonators, boosters, tracers, flares, and various types of smoke munitions.

The major contamination in this area is from the demilitarization of 5-inch munitions filled with Composition A. One interviewee reported that numerous Army ammunition and rockets were demilitarized in this complex during the mid-fifties; this demilitarization was said to be a steamout procedure of TNT and Composition B filled items. The present demilitarization activity is reported to be intermittent in nature with overall total of approximately 300 projectiles being washed out over the last 2 to 3 years. At present, 5-inch munitions loaded with Composition A are being washed out with 9,000 to 10,000 psi water after 5 pounds of material is contour drilled out and sold. The remaining material (3 to 3 1/2 pounds per round) is washed out into a hopper and taken to the burning ground for destruction. The water is filtered and sent to the sumps where it is cooled and recycled. This recycling system has been in use for the last 2 to 3 years; however, prior to this, all water went directly into the sewer that drained into the Boggs Creek watershed. The extensive prior use of this complex has contaminated the area with explosives especially from the steam demilitarization facility and with residual contamination from the demilitarization furnaces.

*All map coordinates will be identified on Figure II-7.

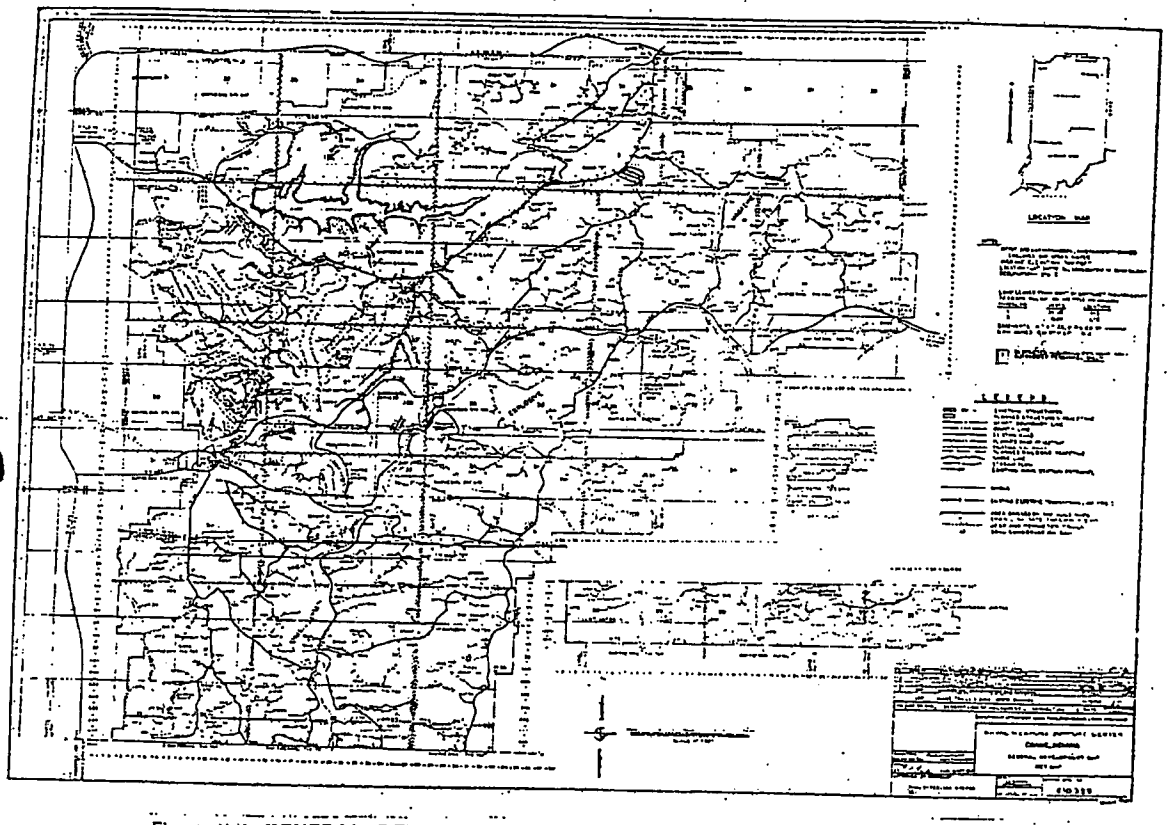


Figure II-7 GENERAL DEVELOPMENT MAP, NAVAL WEAPONS SUPPORT CENTER (KEY MAP) NAVFAC DWG No. 610328

3. Booster Area

The Booster Area is located at map coordinates W-26. This complex is presently used to load initiating devices with tetryl, lead azide, and lead stephnate; however, in the past, large quantities of booster devices were loaded with TNT and tetryl. Each building in the area has a sump and all screening and rinse waters go to the sump. All sumps are treated to neutralize the materials and any overflow of the sumps enters into an earthen dammed holding basin. The operation is well controlled and little contamination is permitted due to the sensitive nature of the explosives. No contaminated material enters the sewer from the assembly rooms, and all collections are sent to the burning ground and destroyed.

4. Mine Filling Area A

Mine Filling Area A is located at map coordinates E-24 and is a cast loading area (Figure II-8). This area has been extensively used in the past, with TNT and RDX as the most significant contaminants from past operations. The major sources of past contamination were from the wastewater disposal and the exhaust ventilation systems. Explosive contamination through the exhaust ventilation system has been measured at approximately 40,000 pounds per year. In discussions of the procedure with employees, it was reported that during peak filling periods, the roof of the building near the exhaust ventilation system had to be hosed down to prevent the buildup of explosive material on the roof. This material was washed off the roof onto the surrounding ground and into the ditches that lead into Turkey Creek and eventually into Boggs Creek which drains off the installation. In addition, the hot water-steam demilitarization facility at Building 160 also contributed to the explosive wastewater contamination. It was reported that 120mm rounds loaded with Composition B were steamed out in Building 160 as recently as 6 months ago. This operation was used on cast loaded explosives such as Composition B, TNT, HBX, tritonal, etc, but not on the highly soluble explosives such as amatol and ammonium picrate. Most of the explosives reclaimed by this operation were reported to have been sold or sent to the burning ground; however, some of the TNT was reported to have been reused. This area has new pollution control equipment installed for both the wastewater and the exhaust ventilation system, but the plant has not been operated since its installation.

5. Mine Filling Area B

This area is similar to Mine Filling Area A except that it has larger kettles. Explosives loaded in this area within the last 10 to 12 years included Composition B, H6, and tritonal. The line was operated at full production during the 1967 through 1973 time frames; however, it has not been in operation since that time. The Fill Line was built during the

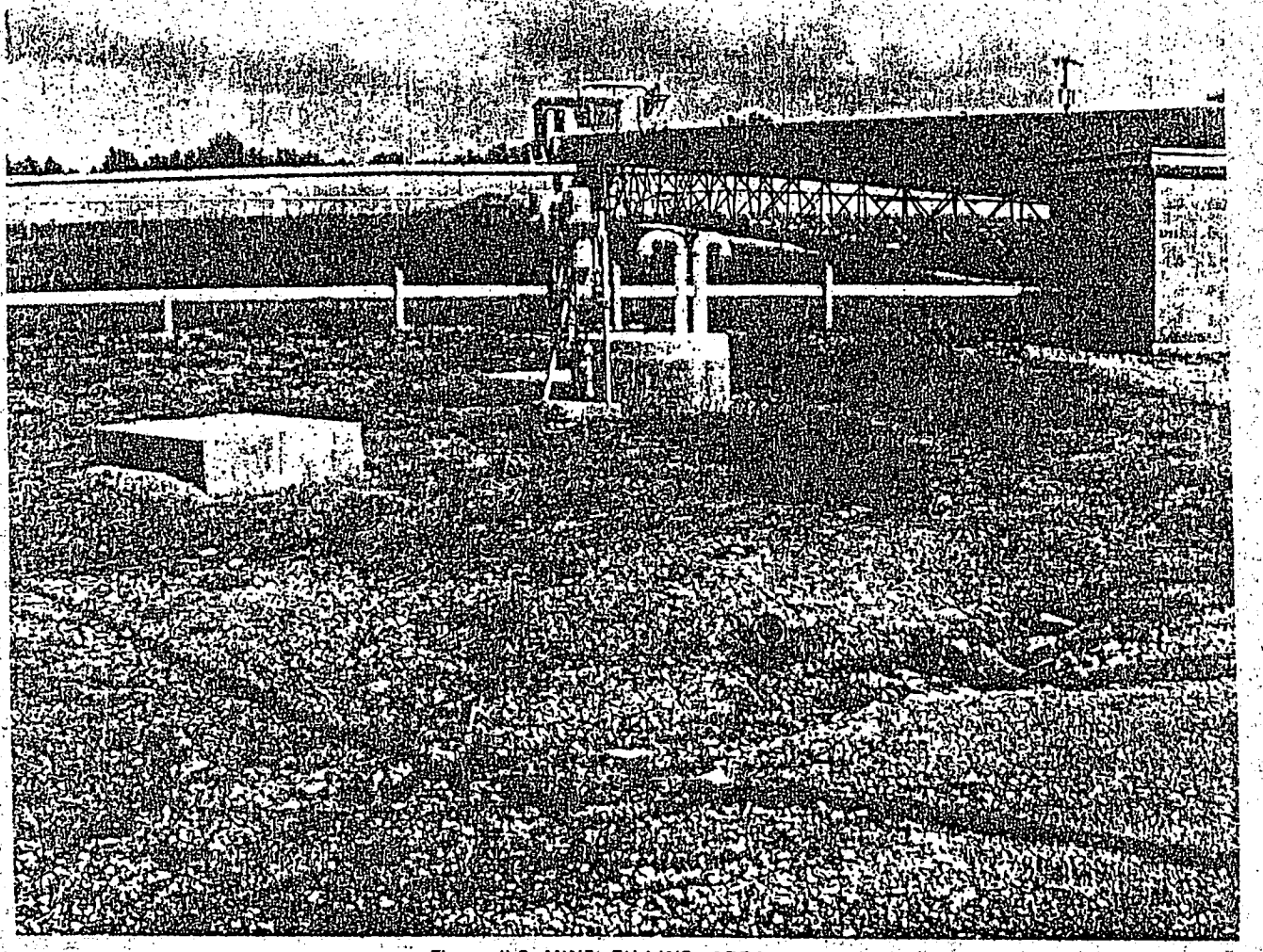


Figure II-8 MINE FILLING AREA "A"

WW II era and large quantities of TNT and possibly some Composition B explosives were reported loaded during that time frame. It was also reported that spin stabilized rocket heads were loaded in this area during the latter part of WW II. During the Korean War, the area was used to load MK53 and MK54 aerial depth bombs with TNT and HBX. Also, it was reported that during the 1950's this area was used to load large quantities of depth charges of the ash can type with TNT and to load MK25 and MK39 mine casings with HBX.

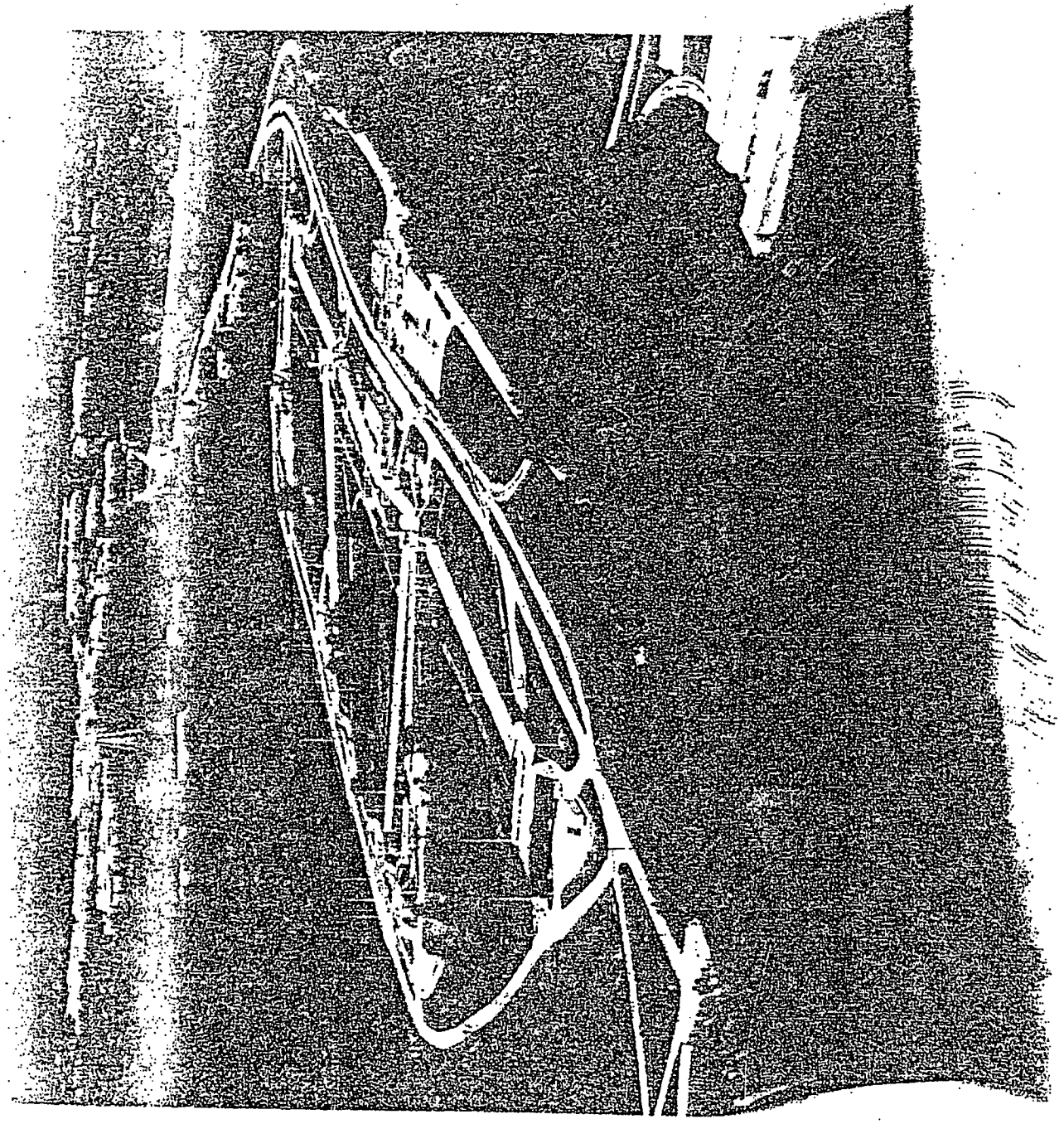
Minol was reported to have been loaded into some rounds during the Vietnam period. It was also reported that H6 was loaded into 250, 500, 1000, and 2000 pound bombs during the 1958-1960 time frame. In addition, Building 160 was reported to have been used for downloading, washout/steam out of bombs and mines from 120mm up to 1000 pounds in size.

There were reports that large quantities of TNT, Composition B, HBX-1. HBX-3, and H6 were treated in the sumps in this area. In addition, explosive contamination through the exhaust ventilation system similar to the Mine Fill Area A was also reported. This was estimated to be 40,000 pounds of explosive per year when in full operation.

Operations over the last 20 to 30 years permitted the excess water from the sumps to flow directly into the ditches that eventually flowed into the Boggs Creek watershed. Thus, the entire ground area and particularly the ditches leading from Mine Fill Area B are considered heavily contaminated with explosives as a result of these extensive past operations (See Figure II-9).

6. Loading and Filling Area

The Loading and Filling Area is located at map coordinates EE-17, Figure II-10. This area was built in 1942 and 1943 and has been in use since that time. Large quantities of ammunition were loaded in this area. Contamination from past operations would probably be from explosives such as Composition A and Explosive D (ammonium picrate), and from various acids and caustic materials used in the area. The most contaminated area would be around Building 104 where most of the past loading and washout was conducted. The Explosive D is highly soluble in water, and over the years large quantities have been discharged into the nearby stream that leads into Boggs Creek. The Explosive D is washed out with hot water until saturated, then sent to holding tanks to cool. The explosive is crystalized out, collected, and sent to the burning ground. The water is then reheated and recycled. This process continues for approximately 1 week; then the water is sent to the sump pits and the system is recharged with a new supply of fresh water. It is estimated that 20,000,000 pounds of Explosive D and 10,000,000 pounds of Composition A have been processed through this area since its start. Practically all the Composition A operation has been a



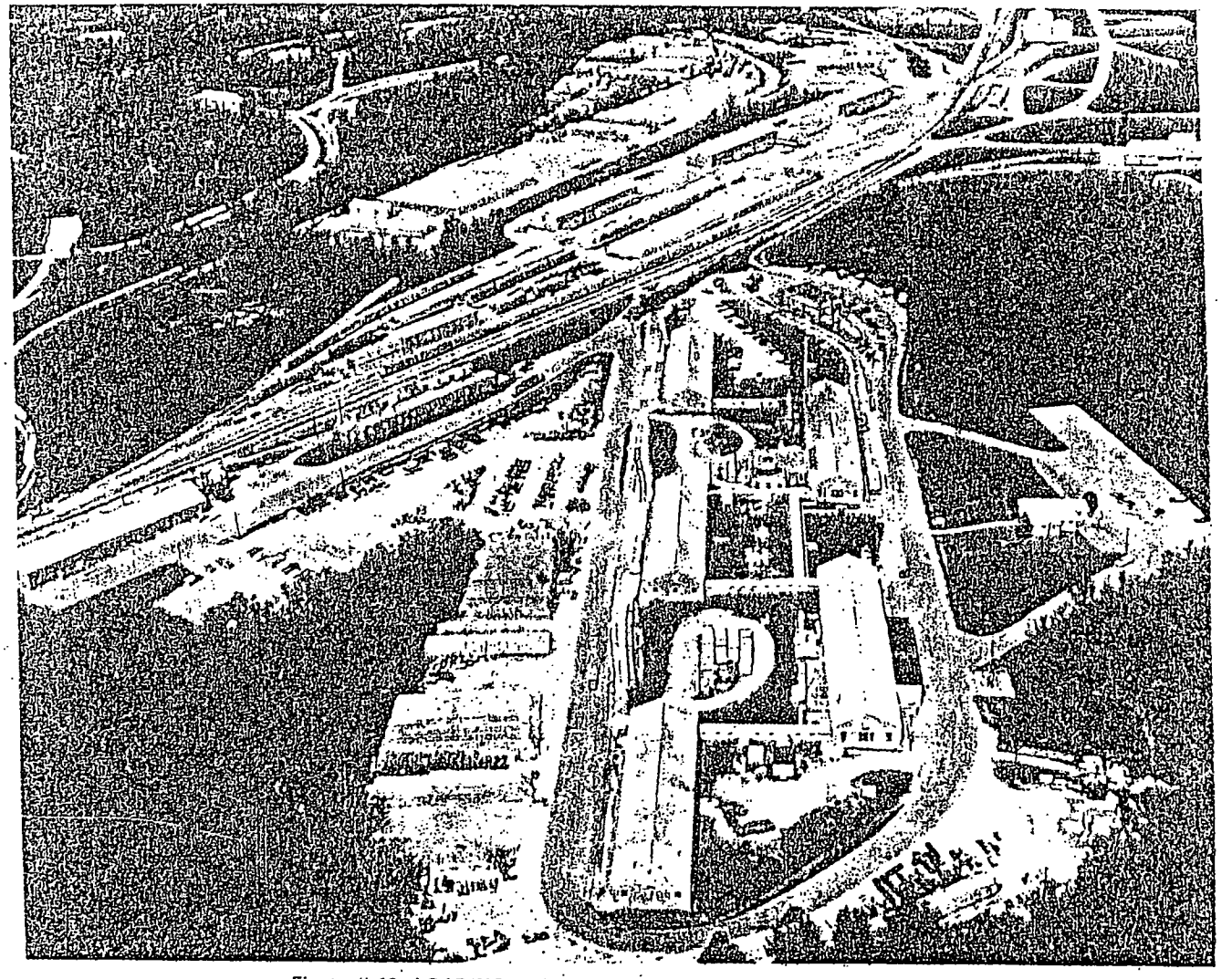


Figure II-10 LOADING AND FILLING AREA (HIGH EXPLOSIVE)

loading process while the Composition D operation is estimated to have been 75 percent loading and the remaining 25 percent demilitarization.

One other contamination spot of concern in the Loading and Filling Area is in the vicinity of old Building 225. A fire destroyed this building and its contents on 13 July 1976. This building was reportedly used for storage of large quantities of paints, solvents, dyes, inks, wood preservatives, etc. Over 600,000 gallons of water were estimated to have been pumped on to the blaze and pollutants were reportedly found in downstream samples of water. Details of this fire and subsequent activities are in the "Green Water" Report dated 20 September 1976 (See Appendix F). Building 225 has since been razed and the area reportedly cleaned; however, as a result of the large quantity of chemicals stored in the building, it would be expected that the general area in and around where Building 225 stood would continue to have residue from the building contents. The surface water in this area drains to the west and into the Furst Creek watershed. Reports have been made of small amounts of dye leaching from the nearby railroad bed during periods of heavy rains, but no toxic results could be identified.

7. Pyrotechnic Area

The Pyrotechnic Area is located at map coordinates U-24. The buildings in this area use sump pits in collecting waste and washdown water. Red phosphorus is considered the most significant contaminant in the area. Other possible contaminants identified are chlorates, dyes, oxidizers, and fuels for flares and smoke munitions. All waste and wash water reportedly drains into the respective building sump pits which are periodically pumped out into tank trucks and taken to the burning ground. All overflow of these sumps pits drains into the Boggs Creek watershed. Also within this area is a plating shop that utilizes heavy metals, caustics, acids, and cyanides. Records of past operations indicate that a cyanide neutralization treatment facility has been utilized at least, the last 12 years. However, it is expected that significant heavy metal contamination (zinc, cadmium) has been experienced from wastewater being discharged into an open ditch that drains into Boggs Creek. The acids and casutic wastes are mixed before sewering and are reported to be neutralized; however, no tests or samples are made to support this.

With the Pyrotechnic Area, there are also two old burning areas that were used many years ago. One is located behind Building 126; the other is located across Highway 5. Wastes from past activities of many years ago could still be leaching into the pits from these areas; however, neither burning area has been used for over 6 years and contamination would not be expected to be significant.

8. Old 16-Inch Loading and Demilitarization Area

This area is located at map coordinates HH-13. These facilities have not been used for 16-inch loading and demilitarization for 12 to 15 years. When this facility was in operation, large quantities of Explosive D (ammonium picrate) were loaded and washed out and heavy explosive contamination would be expected; however, due to the high solubility of Explosive D, there is little likelihood that extensive contamination of this material remains in the area. These facilities have since been converted to a pyrotechnic assembly area and little contamination would be expected from the operation.

9. Building 181, Clothing Change House Area

This area is located at map coordinates JJJ-22. Many years ago, this building was used as a chemical warfare agent decontamination building, but has not been used as such for more than 12 to 15 years. The EOD Team is presently using this area for sawing bombs into sections, etc. There was a report that CW agents (probably mustard) were burned nearby; however, this could not be confirmed by any formal documentation or by anyone interviewed at the installation. Most of the decontamination equipments (tanks, exhaust hoods, charcoal filters, etc.) have been removed from the building and little hazard from past contamination would be expected.

10. Transfer Depot - Building 600

This facility is located at map coordinates FF-27. This is where the trucks used to transport bulk explosives to and from storage were cleaned. The trucks were backed up to a pit and the truck beds were hosed down to remove any explosive contamination. Over the years, significant amounts of explosives have been washed into the pit and allowed to accumulate. No estimate of actual amount could be obtained during the records search; however, due to the large quantities moved in this manner in the past, it would be expected that the amount of waste material would be significant. Portions of the explosives have probably leached out and into Turkey Creek which flows nearby.

11. Laundry (Building 180)

The Laundry is located at map coordinates T-22. This is an industrial laundry and is used primarily to launder clothing worn by explosives and pyrotechnic workers. The primary contaminant identified is phosphates. This contaminant is a result of applying fire retardant to the clothing in the laundering process. Other contaminants identified are

detergents, ammonia, explosives, and solid matter. Prior to 1973, the wastewater from this operation was directly discharged into an open ditch that drains into Boggs Creek. This procedure was in operation from the early WW II era to 1973; since 1973, the wastewater has washed into the sanitary sewage system. Thus, this area is not considered to be a seriously contaminated area.

12. Small Arms Area

The Small Arms Area is located at map cordinates G-18. This facility is mainly a packaging and preservation operation. It has a metal coating facility that uses caustics, phosphates, and acids; however, no significant contamination was identified in the records search.

B. Laboratories

1. Quality Evaluation Laboratory Complex

This complex is located at map coordinates R-29. Building 2044 of this complex is probably the most likely building to have caused contamination in the past. Located within this building is a laboratory (lab) complex that includes a chemistry lab, a physic lab, a microbiological lab, a metallurgy lab, an X-ray facility, a photographic lab, a model machine shop, and a testing area for explosives.

In the past, the building wastes were discharged into septic tanks and absorption fields. These areas were apparently overloaded, as seepage onto the ground surface was reported in documents reviewed by the team, (Pollution Control Program 1971). Pollutants identified were formaldehyde, Elon, hydroquinone, sodium sulfate, sodium sulfite, borax, and bleach. The drainage from this area is into Turkey Creek which drains into Boggs Creek near the center of the installation. The building wastes are presently connected to the sewer line. This action is considered to correct the on-going operation of the building; however, the past pollutants remain in the absorption field.

2. Applied Science Department Complex (ASD)

This complex is located at map coordinates GG-14. This area has been used primarily for research and development of pyrotechnics. Past operations sent chemicals directly into the stream that flows into Boggs Creek. Explosives and magnesium oxide are the heaviest pollutants in this area. In addition, it was reported that dyes, some of which are carcinogenic, and chemical waste in support of the research and development (R&D) laboratory have been discharged into the stream. Since the quantities used

for R&D are much less than the quantities used in the nearby Loading and Filling Area (see paragraph II.A.6 above), it is concluded that this laboratory complex is not a major contributor of pollutants in the area.

3. Naval Ammunition Production Engineering Center (NAPEC)

This complex is located at map coordinates G-18. This is a research and development (R&D) tenant activity responsible for providing engineering support for naval ammunition. This R&D group is an organizational element of the Naval Sea Systems Command. The R&D effort includes producibility studies, design modifications, development of imporved production methods, processes and line layouts, development of Technical Data Packages for porduction, preparation of quality acceptance procedures, production facilities and equipment design, and investigation and correction of malfunctions. Little contamination as a result of this R&D effort could be identified.

C. Field Test Ranges

1. Pyrotechnic Test Range

This test area is located at map coordinates VV-18, and Figure II-11. Tests performed in the area are functional tests on flares, signals, and other marking devices. A drop test tower is also located in the area, but should not be a major contributor to contamination. Most of the contamination would be a result of pyrotechnic testing. Chlorates, dyes, oxidizers, fuels, and other by-products of flares and smokes could be in the area; however, no tests have been made to document contamination even though Boggs Creek flows through the middle of this test range.

2. Range 2167/Pyro Control Test Range

This range is located at map coordinates CC-24. This range is used for quality assurance testing of pyrotechnic devices. Trees in the area are dying; however, the reason in unknown. It is believed to result from the pesticide control program, but no data could be supplied to support this. Lead chromate contamination was also identified on the surface of the ground and was reported to be a result of testing of the Mark 1-3 flare. It was reported that more than 100 of these flares have been tested to date.

3. Rocket Range

This range is located at map coordinates KKK-18. It was reported that 7.2 Rockets were tested at this range during the early to mid 1960's. These rockets were reportedly dummy loaded and little hazard

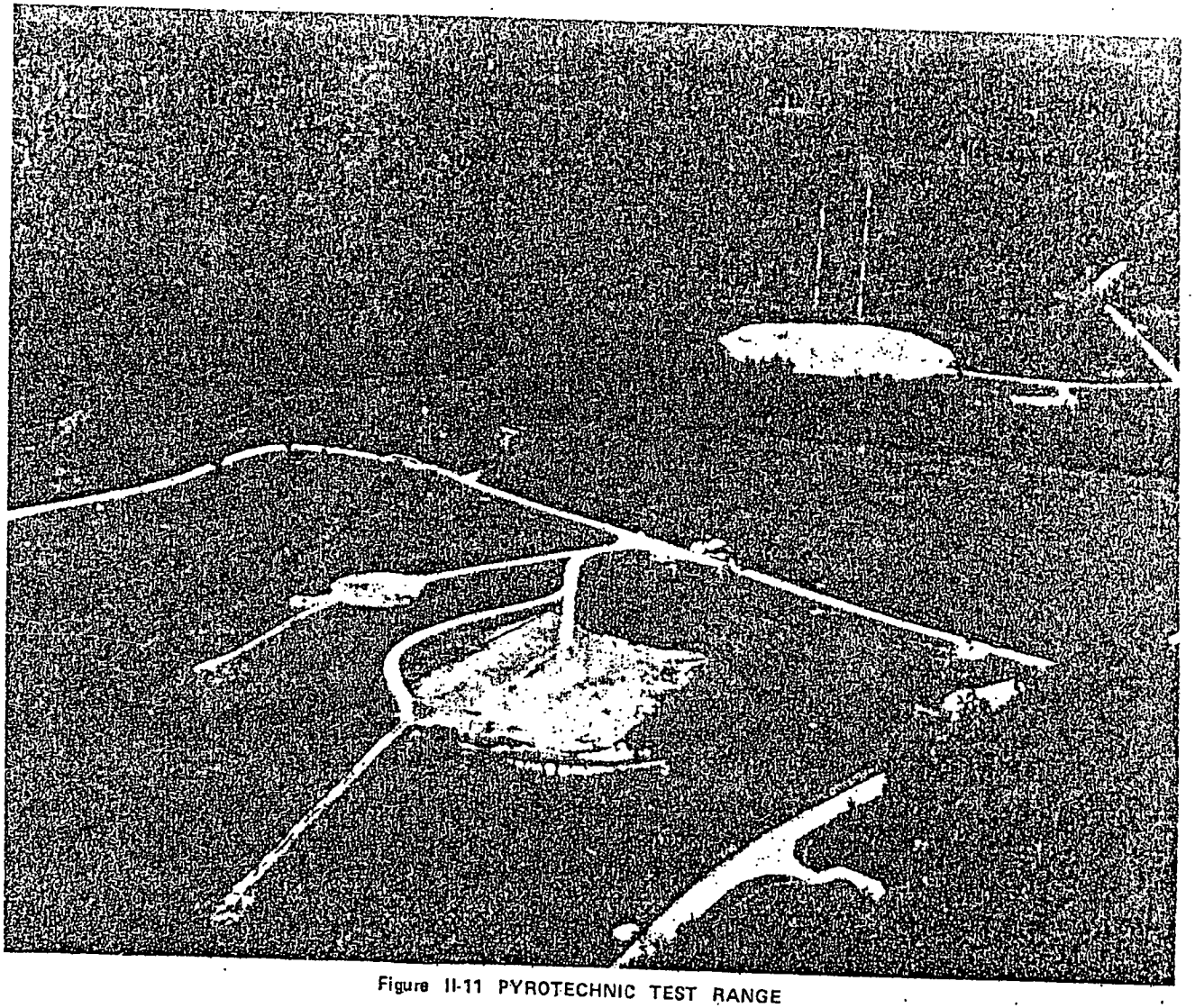


Figure II-11 PYROTECHNIC TEST RANGE

would be associated with them. Very little documentation of this test range was in the records; however, it was reported that a few rounds had been found as a result of excavations at the range. This range has not been heavily used in recent years and contamination is considered to be minimal.

4. Conservation Dam (Facility No. 2845)

This test area is located at map coordinates ZZ-18 near the intersection of Highways 161 and 30. This conservation pond was reportedly used in the past for testing floating type pyrotechnics. No documentation could be found to support this; and as nearly as could be determined, only limited testing was performed. Little contaminaiton could be expected from past operations.

5. Old Pyrotechnic Test Area

This area is located at map coordinates S-26. Until about 6 years ago, this area was heavily used to function test flares, firing devices, and smoke markers. Contamination would be similar to that at the Pyrotechnic Test Ranges. No testing has been conducted at this site for approximately 6 years; however, there is a potential for pyrotechnic by-products remaining in the area. Most likely, contaminants are chlorate dyes, oxidizers, and fuels from the functioning of flares and smoke devices.

6. Lake Greenwood

This is an 800-acre lake located in the northwestern portion of the center. As many as four sites were reported as test sites for floating type makers and flares in the past (see Figure II-7). It was reported by interviews that the MK-25 and MK-72 were tested in this area during the 1950 through 1960 time frame. Also, it was reported that mine location markers were tested on the lake up to the 1968 through 1969 time frame. Little or no contamination is suspected as a result of these tests.

7. Lake Oberlin

This lake is located at map coordinates L-10. It was reported that this lake was used in the mid-to-late 1950's for testing submarine floatation flares. No documentation could be found to confirm this report; however, little contamination would be expected as a result of these tests.

8. Rifle Range and Old Ordnance Ground

This range is located at map coordinates GG-24. Little documentation could be found on testing at this area; however, interviewees

did state that the area had been utilized for bomb cook-off testing. It was reported that black powder had been destroyed in this area over the past 6 to 8 months. In addition, it was reported that a nearby area on the jeep trail was used as a demolition area prior to 1946. contaminants in these areas would be from explosive residues and their by-products. Turkey Creek flows nearby this area; however, no evidence of contamination from this area could be documented, therefore the extent of contamination cannot be determined.

D. Burial Sites of Hazardous Materials

A review of available records and interviews with present and former employees indicate that biological materials have never been buried on NWSC. The records do, however, indicate the burial of chemical, radiological, and explosive materials in the past.

1. Burial Sites of Chemical and Radiological Materials

a. Chemical Burial Ground. The location of the chemical burial ground is at map coordinates FFF-29. Details of the burial plot are in P.W. Sketch 238 dated 2-24-72 (see Figure II-12). It was reported that several hundred pounds of mustard agent and several pounds of pyrotechnic mixtures containing radioactive thorium were disposed of at this burial ground in the mid-1950's.

The radioactive thorium was excavated and removed in May 1974 and the surrounding soil has been certified free of radioactive contamination. The records indicate that the material was disposed of by the AEC at a licensed disposal point. During the excavation, one mustard site was excavated and three rounds containing mustard agent were found; one round was complete while the other two has apparently been emptied and the containers and other material thrown into the hole. The Army Technical Escort Team at Edgewood Arsenal was called in and the rounds were sealed and stored. The records indicate that at least five additional sites are located within the confines of the burial ground (Figure II-12); these sites are suspected of containing unknown amounts of mustard agent. As nearly as could be determined from the records and in interviews with present and former employees involved with the burial, the burial operations were also handled by Technical Escort personnel from Edgewood Arsenal. Rounds were taken to Building 600 where the good rounds were loaded and shipped to Ogden, Utah and the leaking containers were taken to the burial ground, emptied into holes 12 feet deep and covered with a heavy lime slurry. The containers were then thrown into the holes and covered with soil. Since one round was in complete state when found during the excavation in 1974, the possibility exists that other complete rounds could be in the remaining burial sites.

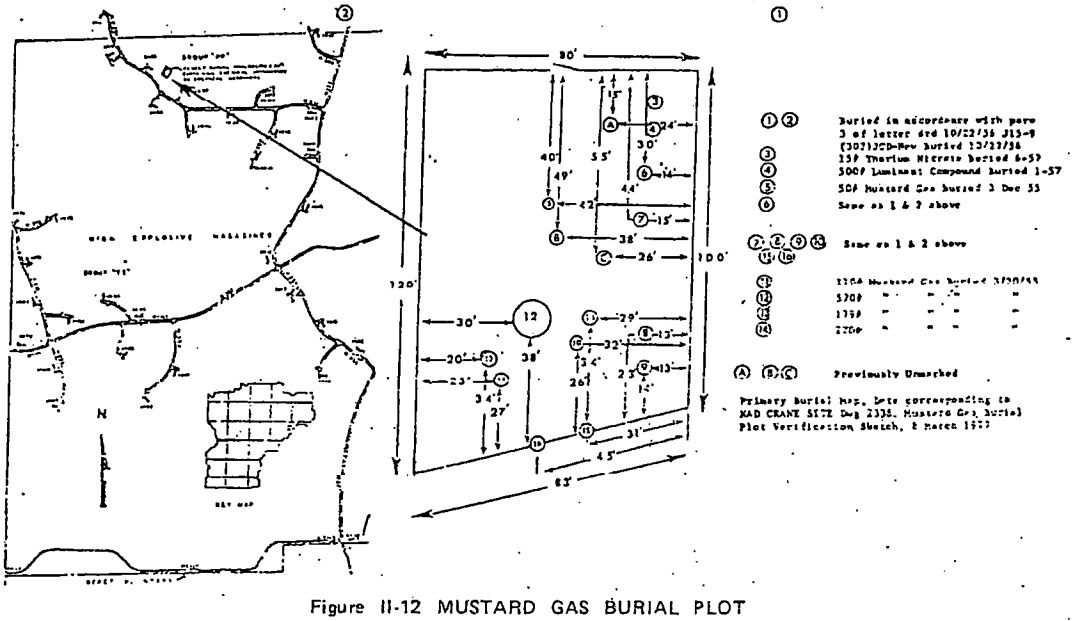


Figure II-12 MUSTARD GAS BURIAL PLOT

No records could be found on any water analysis in this area, either on surface or subsurface. However, because of the manner in which the agent was buried, there is a good possibility that mustard agents or their by-products could be getting into the surrounding waters via surface or subsurface.

b. Burial of Pyrotechnic Dyes. This burial site is located in the Ordnance Burning Area at map coordinates AA-47. This site was reportedly used from the 1940's until 1969 for the disposal of scrap material. This material was dumped into open trenches. During interviews with several employees, there were verbal reports of dyes overflowing from the pits during periods of rain. Some of these dyes are considered carcinogenic but no data could be found to support any contamination as a result of this operation. The pits were filled with soil in 1972; however, colored material seeps from this area at times of heavy rains. There is the possibility of contamination by these dye materials, but since no data is available, the extent of contamination cannot be determined without further tests.

2. Burial Sites of Explosive Material

a. McComish Gorge. This gorge was reportedly used for disposal of construction and odd type materials. Documentation of what was dumped into the gorge could not be found; however, during an interview, one past employee reported that "all-kinds of material including possible live rounds" were dumped into the gorge. The material identified by the past employee included tree stumps, concrete-filled practice 7.2 projectile warheads, and other material not acceptable for landfill or ordnance burning and demolition areas. Contamination from this gorge is not considered to be serious; however, due to the lack of knowledge of exactly what was dumped into the gorge, the gorge should be considered as a possible hazardous area.

b. Ordnance Demolition Area. This area is located at map coordinates GG-21. Although there is little old documentation on quantities and types of munitions detonated, this facility has been used extensively for many years and is presently active approximately 4 months out of the year. During the active period, approximately 20 shots per day are fired and the limit per detonation is 500 pounds. Unexploded ordnance (UXO) was reportedly found within the range area. Also, it was reported that sometime during the 1950's, insulation contaminated with Explosive D was buried in the demolition area. No documentation on just where it was buried could be found. In addition, FS smoke mixture was reportedly disposed of by being included with the explosives. The major contamination in this area would probably be from UXO's. Water samples from Pond 333 which is located nearby and receives the area's surface runoff has shown contamination from explosives. Figures II-13 and II-14 are views of the demolition area.

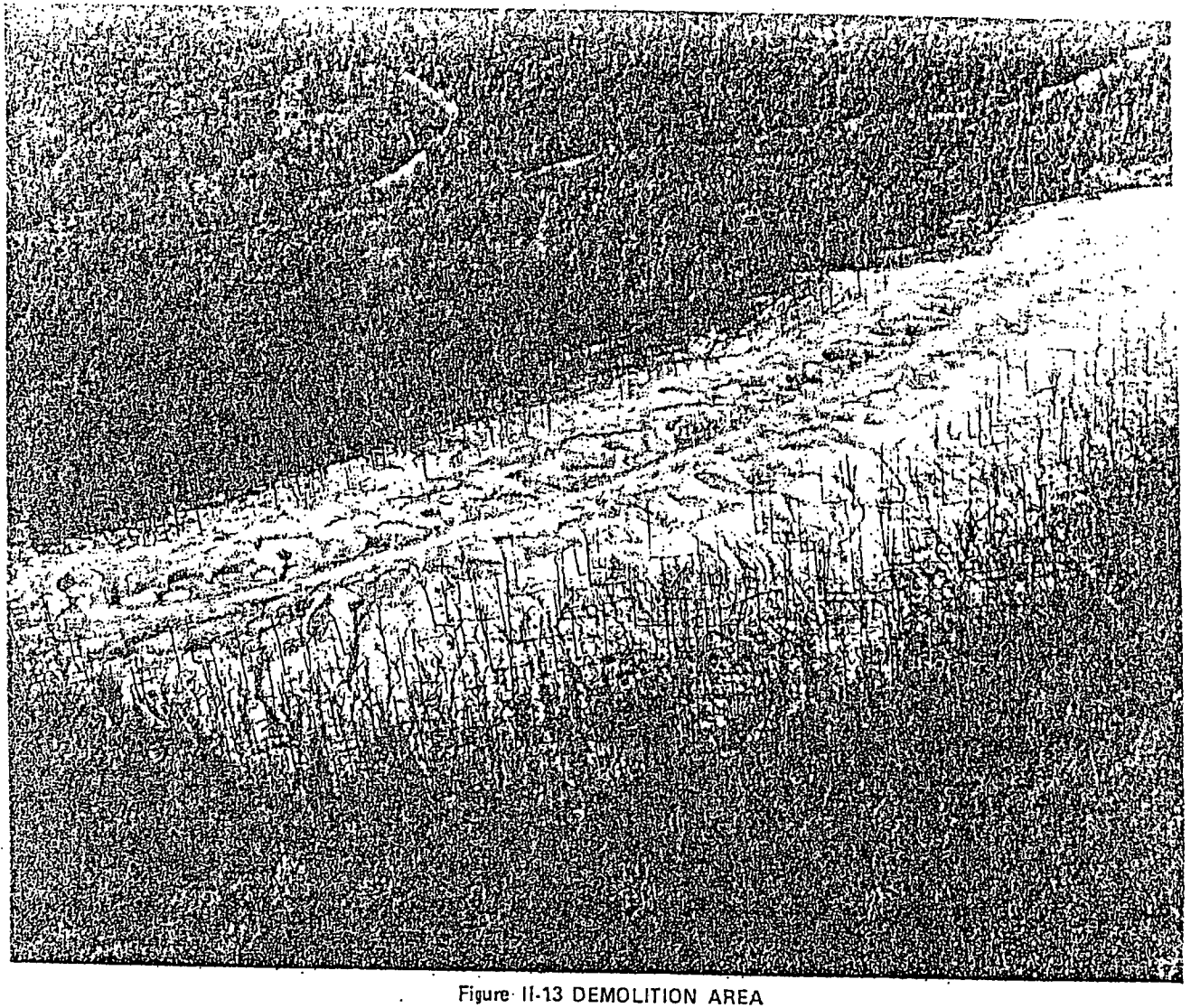


Figure II-13 DEMOLITION AREA

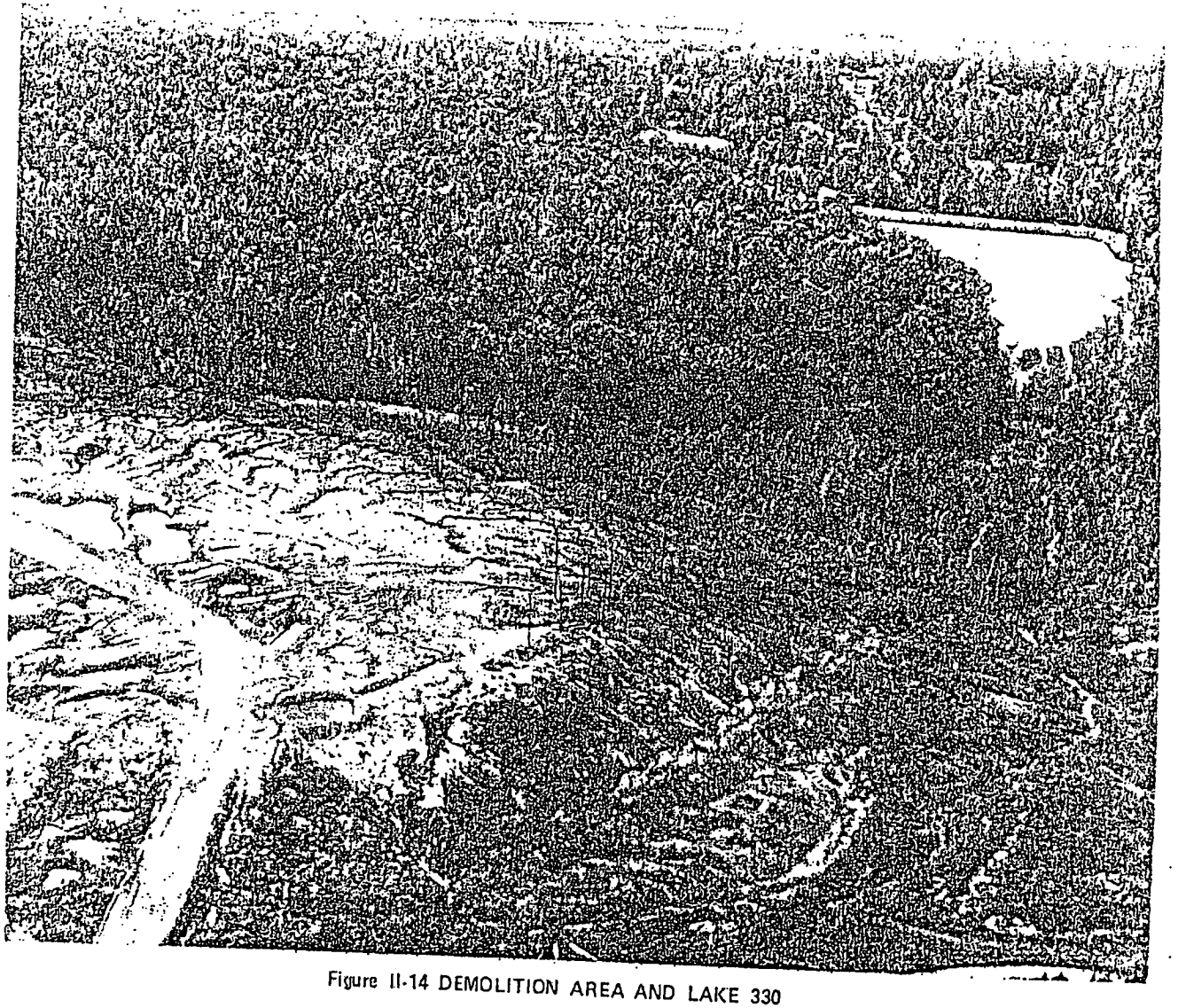


Figure II-14 DEMOLITION AREA AND LAKE 330

E. Storage of Toxic/Hazardous Material

Large quantities of explosives, explosive loaded ordnance items, red phosphorous, pyrotechnic, and riot control agents are stored in more than 2300 storage magazines at NWSC. A listing of these materials is available on computer printout. There is little probability of major contamination from this storage operation. There are no toxic chemical munitions stored at NWSC, however, there are 2808 obsolete War Gas Identification Sets on record being stored in several magazines.

F. Support Activities

1. Water Supply

Sufficient water is provided by Lake Greenwood for all phases of operations and activities of the NWSC. Although surface runoff from industrial areas and storage areas empties into the lake, this runoff is not believed to be transporting contaminants. No groundwater data associated with the lake is available.

2. Waste Disposal

The primary and secondary treatment process of the sanitary sewage adheres to all regulations pertaining to effluent treatment prior to discharging it into Boggs Creek. Previously, three small sanitary sewage plants were in the system but these plants are presently being used primarily as aeration basins and lift stations associated with the main plant near Boggs Creek.

Drainage from industrial operations is carried to the treatment plant or is discharged into open ditches. Red colored water leaving the eastern perimeter of the Rockeye Plant is discharged into a tributary of Sulphur Creek which eventually leaves the installation.

G. Land Use Factors

1. Pesticide/Herbicide Usage

A wide variety of pesticides and herbicides is used at the installation to control pests. Table II-1 shows usage of pesticides and herbicides for the period 1 August 1976 through 31 August 1977.

TABLE II-1. Pesticide and Herbicide Usage
(1 August 1976 Through 31 August 1977)

TRADE NAME	FORM	AMOUNT USED
Carbaryl	Suspension	5320 gallons
Malathion	Emulsion	2 gallons
Chlordane	Emulsion	139 gallons
Pentaur	Solution	208 gallons
Bendomyl	Suspension	247 gallons
Dyrene	Suspension	82 gallons
Methyl Bromide	Liquid	72 pounds
Promethone/2,4,5-T	Emulsion	7815 gallons
Bromacil/Dinron/2,4,5-T	Suspension	6440 gallons
MBC	Powder	2992 pounds
Bnomyls	Suspension	100 gallons
Baygon	Emulsion	60 gallons
Diazinon	Emulsion	17 gallons
Dursban	Emulsion	25 gallons
Pyrethrum	Aerosol	58 pounds
Pyrethrum	Solution	25 gallons

2. Sanitary Landfills

Prior to 1971, two landfill areas in the northwest sector were used for solid waste disposal. One was for lumber, old trees, and rubble from construction operations. The other was the depository for daily refuse which was burned. Both locations are inactive and are covered with soil.

Operation of the present landfill began in 1971, utilizing the trench method. As a trench is filled with refuse, it is compacted and then covered with impervious soil and seeded. Certain areas have been designated as "hot beds" which contain toxic or contaminated waste. As waste is placed in these trenches, a neutralizing agent is added before the placement of the soil cover. The quantity of contaminated waste placed in this area has been very small.

Surface seepage has been detected from the landfill area. A drainage system (similar to a storm drainage system, with manholes) has been completed to collect this seepage in a basin where the leachate can be analyzed. Monitoring wells have been placed around the perimeter of the landfill to monitor the subsurface in respect to leachate migration.

H. Geological Migration Potential

Present day technology and restraints placed on manufacturing processes utilizing contaminated agents have reduced the possiblity of contamination leaving a military installation either by surface or subsurface means. Prior to these practices, it was likely that some surface migration of contaminants reached the boundary and even migrated beyond the boundary. The most susceptible area for contaminant migration was east of the Rockeye Plant where the red water was allowed to be discharged into natural drainageways. The amount of residue that has settled out in pockets and slack water areas of the drainageways has not been determined nor has it been determined what effect flushing action by intense rainfall would have in moving the residue further downstream or even off the installation.

From the available subsurface soil data, the NWSC is underlain by a silty to sandy clay that ranges in thickness from a few inches to 26 feet. Because the soil thickness is determined by the topography, the valley bottoms of the larger creeks could contain clays in excess of the 26-foot depth. No permeability for inogganic silts and mixtures of sand, silt, and clay ranges from 10^{-3} to 10^{-7} cm/sec. These values represent movement rates of 3 to 0.0003 feet per day, respectively. The lower range of 10^{-3} cm/sec is for a homogenous sand and silt that is found in the subsurface. The controlling factor in respect to fluid movement is the presence of clay zones that would retard the movement considerably.

I. Environmental Indicators

1. Land Indicators

Plants along the streams near the Bomb and Mine Filling Area do not seem adversely affected by TNT spillage, but in the immediate vicinity

of the plant, the ground vegetation is strongly affected and is either depauperate or missing (with patches of bare ground). The TNT spillage seems to be deep; perhaps 1 to 3 feet of the top soil is apparently heavily contaminated.

2. Waterways Indicators

Small streams in the immediate vicinity of the Bomb and Mine Filling Area A are apparently contaminated to a great degree by the explosive waste spillage. The streams and ditches show a pink color and although the larger aquatic flowering plant vegetation does not seem affected by the explosive wastes, the animal life (e.g., insects, snails, amphibians, fish) is not present, indicating very heavy pollution.

III. FINDINGS

A. Crane Army Ammunition Activity (CAAA) License

A license, NF(R)-36943, was granted by NWSC to the Army, effective 1 October 1977 which authorizes the use by CAAA of a significant portion of the facilities at NWSC, Crane. The license was required for the establishment of the CAAA as Single Manager of conventional ammunition with assigned responsibilites as set forth in DOD Directive 5160.65 of 26 November 1975. Facilities are to be utilized for the accomplishment of Army functions required in the procurement, production, storage, supply, demilitarization and maintenance/renovation of conventional ammunition. A copy of the subject license is included as Appendix F of this report.

B. Industrial and Production Operations

1. Production areas of the installation potentially contaminated with waste from explosive and pyrotechnic operations include the 3-inch (Rockeye) and 40mm explosive loading complexes, the booster area, mine filling areas A and B, and the old 16-inch loading and demilitarization facility, see Chapter IIA of report. Contaminants identified include TNT, RDX, tetryl, lead styphnate, Composition A and B, Explosive D, HMX, aluminum, alkaline nitrates, lead chromate, and other explosive/pyrotechnic waste products.

2. Potentially contaminated wastewaters from manufacturing and demilitarization operations are dumped initially into sumps with the overflow going directly into open ditches. Prior to the recent installation of efficient dust collectors, considerable quantities of explosive powders were vented directly into the atmosphere. The soil in the vicinity of these sites is heavily contaminated and vegetation in the area of the plant is either missing or in a state of stress (i.e., dying, stunted, discolored).

C. Testing and Firing Ranges

1. Extensive testing of explosive and pyrotechnic munitions has been conducted and is being conducted at several locations on the installation. The principal ranges include three pyrotechnic ranges, a rocket range, a rifle range, an explosive demolition area, a small arms testing area, and an ordnance burning area. Types of munitions tested include small arms, 40mm grenades, pyrotechnic flares and smoke signaling devices, mortar, bomb and projectile ammunition, and experimental devices.

2. Unexploded ordnance (UXO) were reported at several of the ranges and the demolition pits. UXO munitions include small pyrotechnic devices, aerial dispensed devices, mortar rounds, and other naval artillery shells. At the demolition area, explosive munitions are scattered as a result of demilitarization operations. During the Team's ground tour, UXO with parachutes were observed hanging from trees.

3. Lake Greenwood, which is the source of drinking and production water at NWSC, was used from the early 1940's to the late 1960's for the testing of floating pyrotechnic devices including signaling smokes and flares. Four locations were identified at Lake Greenwood where testing was conducted.

D. Disposal Operations

1. Two landfills are presently active at the installation; they are the sanitary landfill and the McComish Gorge landfill. The sanitary landfill began operations in 1971, replacing the old open burning pit as a means of disposing of daily refuse. This landfill has a leaching problem and the installation is attempting to rectify the problem by constructing a pond to hold the leachate. The McComish Gorge landfill is utilized for timbers and other large items not suitable for the main sanitary landfill. Personnel interviewed by the Team indicated that a potential exists for both landfills to be contaminated by waste materials.

2. Contaminated waste from installation activities is disposed of by burial or burning at various locations on the installation. Disposal areas include a chemical agent burial ground (1947), an ordnance burning area used since 1965, an old pyrotechnic burning pit used from the early 1940's to 1970, and a pit where approximately 50,000 pounds of smoke dyes were buried in 1969. Some of these dyes (auramine hydrochloride, yellow dye) are reported to be carcinogenic in the lastest Register of Toxic Chemical Substance published by National Institute for Occupational Safety and Health.

3. The chemical agent burial ground is located in the southeast quarter of the NWSC. Several hundred pounds of mustard agent and several pounds of radioactive thorium were buried here in 1947. One of the mustard pits was excavated in 1974 and several bombs were found to contain live mustard agent. The bombs were sealed by an Army Technical Escort Team and stored. Total number of pits is not known and a project is being conducted by the installation to determine if migration of mustard agent is occurring. The thorium was removed from the site in 1974 and shipped to an AEC (DOE) site for storage. The site was then surveyed and certified free of radioactive contamination by the Material and Safety Department of NWSC, Crane.

E. Storage Operations

1. There are approximately 2300 storage magazines at NWSC. Materials stored within these structures include explosive and pyrotechnic powders, explosive and pyrotechnic munitions ranging from small arms to large bombs and naval projectiles, anti-riot munitions, initiators, fuzes, munition components, and subassemblies.

2. Approximately 2808 chemical agent identification kits, which contain small quantities of various chemical agents in ampules, are stored in magazines. These kits are scheduled to be moved to another site for demilitarization.

F. Biological Agent Operations

Biological Warfare agents and weapons were never developed, manufactured, tested or stored at the installation.

G. Radiological Operations

Radiological materials and weapons were developed, manufactured, or tested on the installation. The installation is licensed to use small quantities of radiological materials for biological tracers (carbon 14), lead detection (krypton 85), radiography (cobalt 60), iridium 192, and nickel 63. Weapons equipped with Promethium-147 sights are stored at NWSC.

H. Water and Water Quality

1. The installation is drained by several surface water drainageways. The central portion of the installation is drained by Boggs and Turkey Creeks; the eastern portion by Sulphur Creek; and the northern and western portions by Furst and Culpepper Creeks.

2. A water quality monitoring program is conducted by the installation at six locations within the Boggs, Turkey, Furst, and Culpepper Creek drainage areas. However, no water quality monitoring is conducted on the waterways that exit the installation's eastern boundary. The six monitor locations are in the northern and central areas of the installation. No monitoring is done on Boggs Creek in the southern portion of the install neither are the waters impounded by Boggs Dam monitored. At the time of Team's visit (September 1977), available water quality data for the six monitoring locations indicated that the installation is having difficul complying with EPA discharge permits. (See Chapter IEla of report).

3. Lake Greenwood is monitored intermittently by the installation. The water quality data provided by the installation, and collected in 1970, indicate that the lake water was potable. No current analysis was available to the team for explosive manufacturing wastes such as TNT and RDX. Due to the lake's location in the northern section of the installation, only limited amounts of wastewaters from the manufacturing areas reach the lake via drainageways and creeks. The State Health Department conducts a water quality program that includes Lake Greenwood; however, analyses are not conducted for potential pyrotechnic and explosive contaminants.

4. Big Sulphur Creek, which drains the Rockeye manufacturing area, exits the installation to the east and receives wastewaters that are heavily contaminated by explosive manufacturing wastes including red water (TNT). The Records Search Team, during its ground tour, tracked the wastewaters for over a mile and the red color was visually detectable over the whole distance. Little Sulphur Creek drains the ordnance burning area where an estimated 25 tons of pyrotechnic dyes are buried. No water monitoring is conducted in this area.

5. Data on subsurface waters (groundwater) is limited. The installation has data from five wells which indicate groundwater depths of between 141 to 313 feet. Only limited water quality data are available on four of these wells and consist of a 1970 report that addresses alkalinity, pH, and hardness. General regional dip of the bedrock is approximately 20 feet per mile to the west-southwest.

IV. CONCLUSIONS

A. Past Explosive Operations

Several areas of the installation (including the explosive and pyrotechnic areas, burial and burning sites, landfills, and test ranges) are suspected of being contaminated with toxic and hazardous materials. No firm conclusions can be drawn regarding migration of contaminants from past manufacturing, demilitarization, and disposal operations because of limited surface and subsurface water data.

B. Current Manufacturing Operations

A potential exists for contamination from current manufacturing operations to exit the installation via unmonitored surface and subsurface waters. Of particular concern is explosive waste (Red Water) from the Rockeye operation which is dumped into Sulphur Creek. This creek is one of several creeks in the eastern and southern areas of the installation not monitored under the installation's water quality program. In addition, NWSC is exceeding discharge limits imposed by NPDES permits.

C. Lake Greenwood

Since Lake Greenwood is not monitored by the installation for the presence of explosive or pyrotechnic waste materials, a potential exists for the lake to be contaminated by those waste materials.

D. Chemical Agent Burial Ground

An unknown quantity of mustard munitions is still buried at the Chemical Agent Burial Ground. The area is fenced, however, the exact location and number of burial pits is not known. Based on location of the burial ground, contaminant migration beyond installation boundaries is considered remote.

E. Burial of Pyrotechnic Dyes

An estimated 50,000 pounds of pyrotechnic smoke is buried at the Ordnance Burning Ground. During periods of heavy rain, colored materials seep from the filled pits. Since the dyes remain buried a potential exists for them to migrate via surface and subsurface waters.

F. Water Monitoring Program

The installation's present water monitoring program does not include analysis for explosive waste materials nor does it monitor all streams exiting the installation.

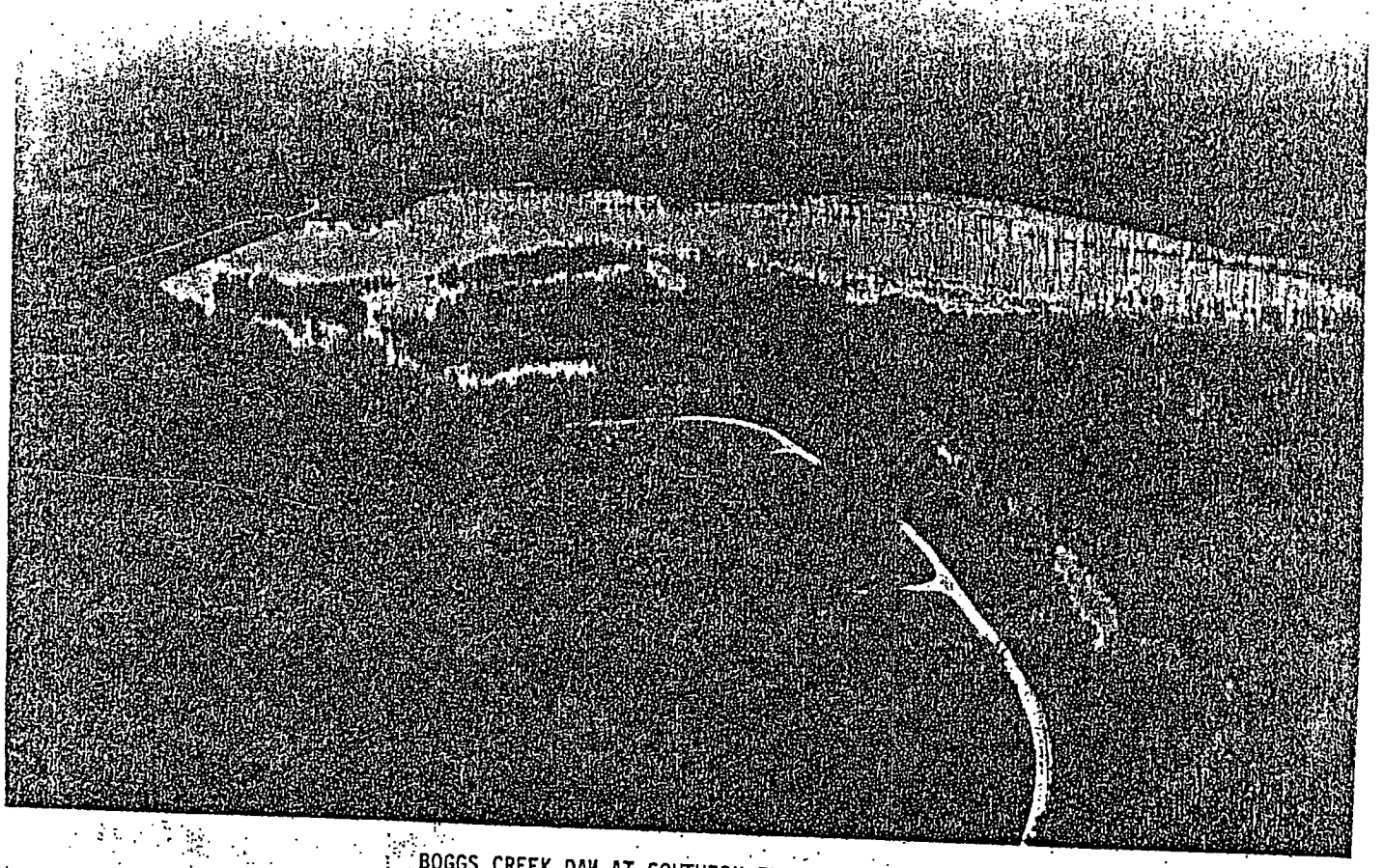
APPENDIX A

PHOTOGRAPHS

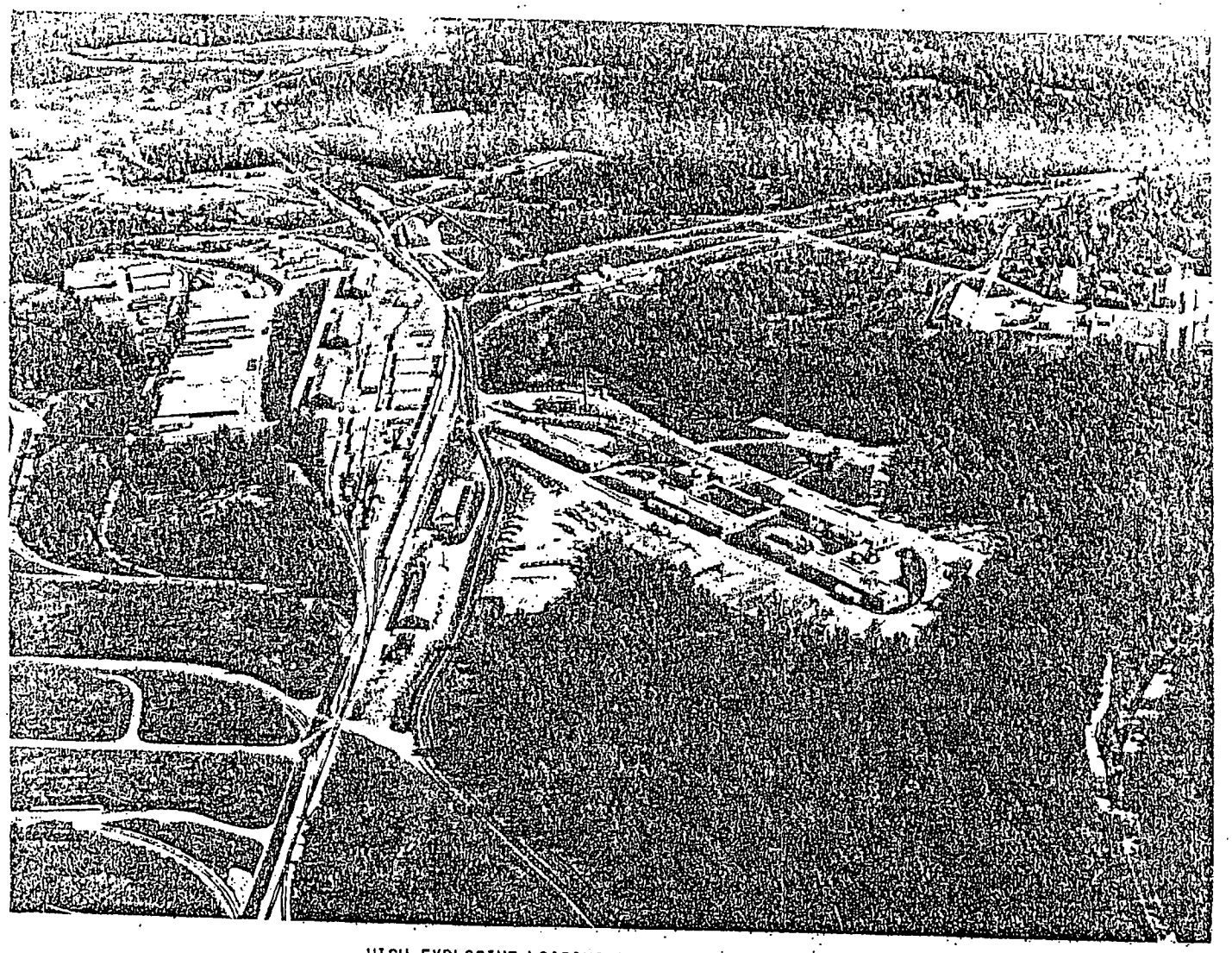
OF

NAVAL WEAPONS SUPPORT CENTER

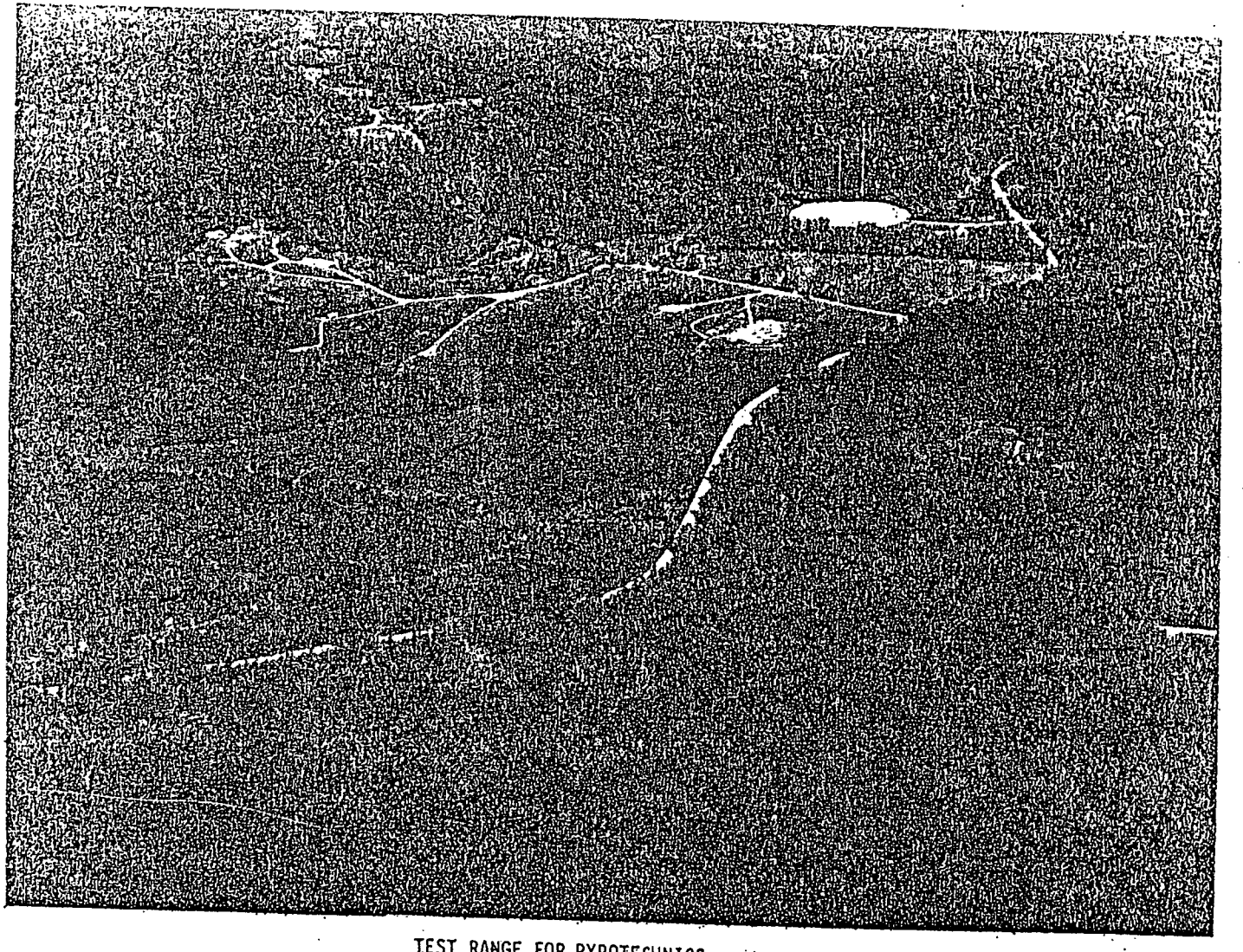
CRANE, INDIANA



BOGGS CREEK DAM AT SOUTHERN END OF NWSC



HIGH EXPLOSIVE LOADING AND FILLING AREA



TEST RANGE FOR PYROTECHNICS

APPENDIX G

OPERATIONS

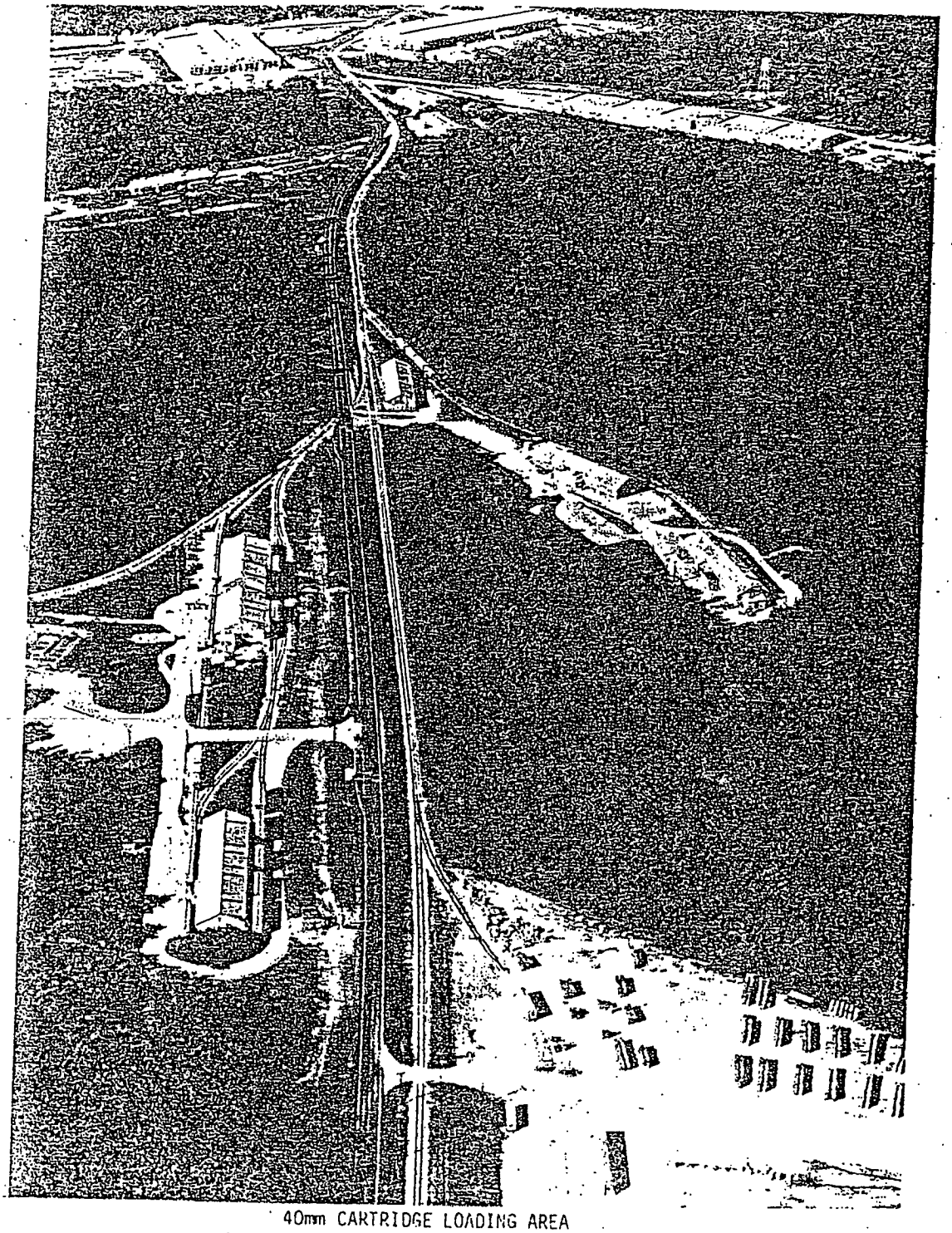
WEAPONS SUPPO

CRANE, INDI

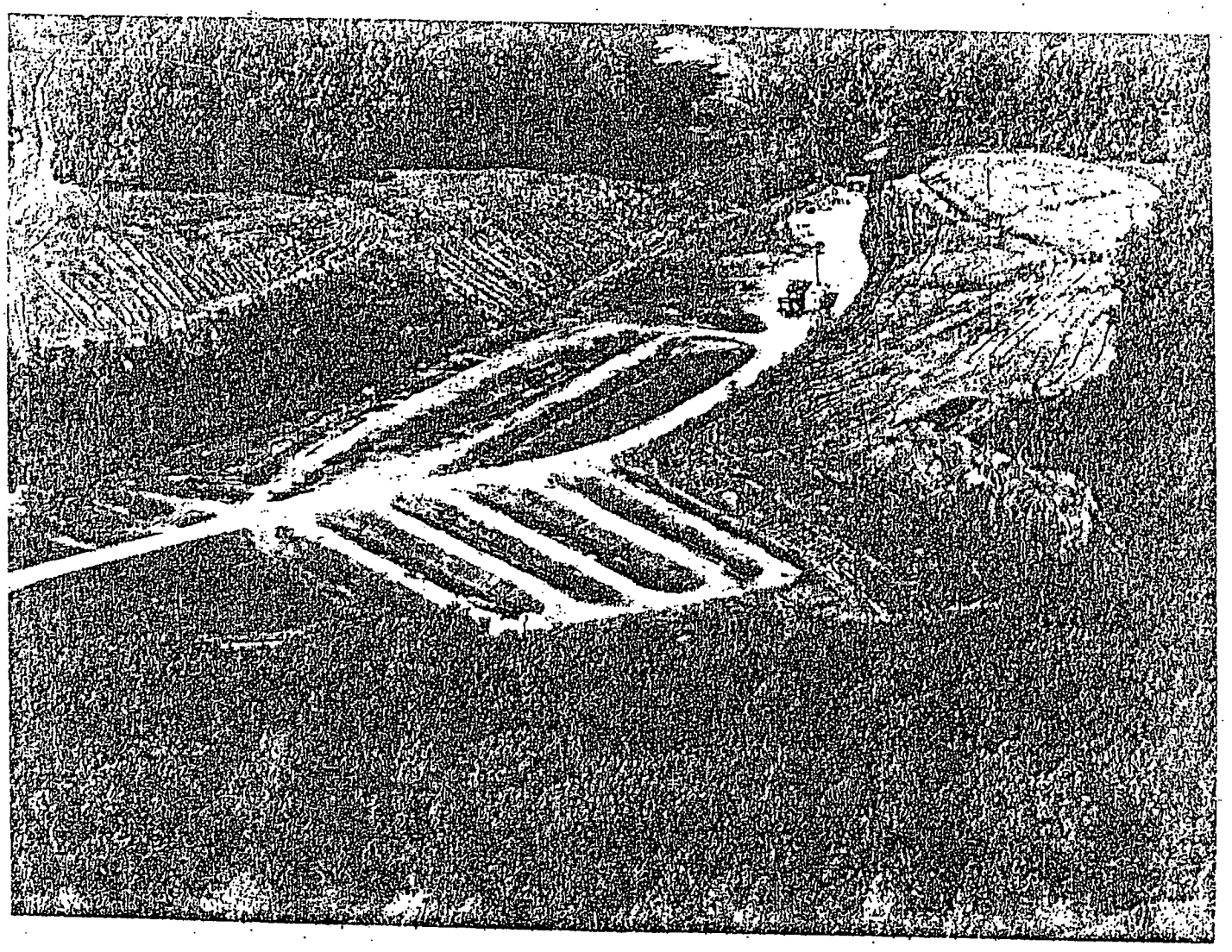
OF DOCUMENT

NAVAL W

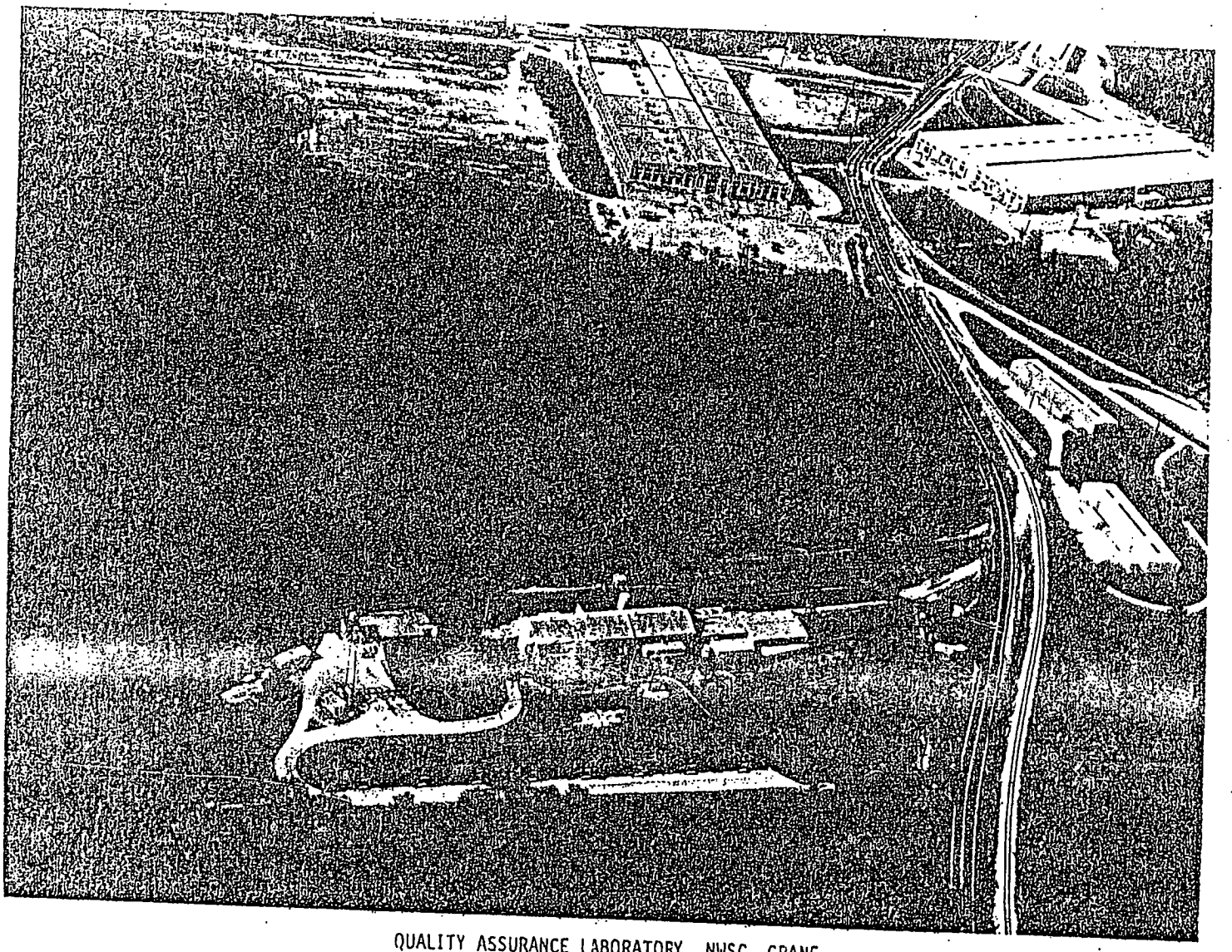
CRANE,



40mm CARTRIDGE LOADING AREA



BURNING GROUND AT NAVAL WEAPONS SUPPORT CENTER, CRANE



QUALITY ASSURANCE LABORATORY, NWSC, CRANE

APPENDIX B

BIOTA

OF

NAVAL WEAPONS SUPPORT CENTER

CRANE, INDIANA

PARTIAL LIST OF TREES AT NWSC

Black Ash
White Ash
Large-toothed Aspen
Baldcyrpess
Basswood
Deech
River Birch
Blackgum
Boxelder
Ohio Buckeye
Butternut
Balck Cherry
Balck Maple
Red Maple
Sugar Maple
Yellow Poplar
Black Oak
Chestnut Oak
Chinquapin Oak
Pin Oak
Red Oak
Scarlet Oak
Shingle Oak
Cottonwood

American Elm
Red Elm
Hackberry
Bitternut Hickory
Monhernut Hickory
Pignut Hickory
Shagbank Hickory
Shellbark Hickory
Honeylocust
Black Locust
White Oak
Austrian Pine
Jack Pine
Pitch Pine
Scotch Pine
Shortleaf Pine
Virginia Pine
White Pine
Yellow Poplar
Sweetgum
Black Walnut

Amphibians and Reptiles of US Naval Weapons
Support Center Crane, Indiana

Species known to occur, i.e. seen or heard

SALAMANDERS	
Eastern Newt	Notophthalmus viridescens
Redbacked	Plethodon cinereus
Two-lined	Eurycea bislineata
FROGS AND TOADS	
Fowlers toad	Bufo woodhousei fowleri
Chorus frog	Psuedacris triseriata
Cricket frog	Acris crepitans
Spring peeper	Hyla crucifer
Grey treefrog	Hyla versicolor
Leopard frog (southern)	Rana pipiens sphenocephola
Bullfrog	Rana catesbliana
Green frog	Rana clamitans
TURTLES	
Spring softshell	Trionyx s. spinifer
Snapping turtle	Chelydra serpentina
Box turtle (eastern)	Terrapene carolina
Painted turtle	Chrepemys picta
LIZARDS	
Five lined shink	Eumeces fasciatus
Fence lizard	Sceloporus undulatus
Ground shink	Scincella laterale
SNAKES	
Garter snake (eastern)	Thamnophis sirtalis
Banded watersnake	Natrix sipedon
Dekays snake	Storeria dekayi
Black racer	Coluber constrictor priapus
Black rat snake	Elaphe obsoleta
Milk snake (eastern)	Lampropeltis doliata triangulum
Rough green snake	Opheodrys aestivus
Hognose (eastern)	Heterodon platyrhinos
Copperhead	Aghistrodon contortrix

Species believed to occur

SALAMANDERS

Waterdog	Necturus maculosus
Tiger	Ambystoma tigrinum
Spotted	Ambystoma maculatum
Marbled	Ambystoma opacum
Jefferson's	Ambystoma jeffersonianum
Bluespotted	Ambystoma laterale
Small-mouthed	Ambystoma texanum
Slimy	Plethodon glutinosus
Zigzag	Plethodon dorsalis
Cave*	Eurycea lucifuga

FROGS AND TOADS

American toad	Bufo americanus

TURTLES

Musk turtle	Sternotherus odoratus
Redeared	Pseudymys scripta elegans
Map	Graptemys geographica

LIZARDS

Broad-headed shink	Eumeces laticeps

SNAKES

Ribbon snake	Thamnophis sauritus
Kirtlands	Natrix kirtlandi
Red-bellied	Storeria occipitomaculata
Earth	Virginia valeriae
Black kingsnake	Lampropeltis getulus niger
Ring-neck	Diadophis punctatus edwardsi
Worm	Carphophis amoena
Crowned	Tantilla coronata
Timber rattlesnake*	Crotalus h. horridus

* indicates unconfirmed report

APPENDIX C

INDIANA WATER QUALITY STANDARDS

OF

NAVAL WEAPONS SUPPORT CENTER

CRANE, INDIANA

COPY OF DOCUMENT CAN BE OBTAINED FROM:
NAVAL WEAPONS SUPPORT CENTER,
CRANE, INDIANA 47522

APPENDIX D

BORING LOGS

OF

NAVAL WEAPONS SUPPORT CENTER

CRANE, INDIANA

COPY OF DOCUMENT CAN BE OBTAINED FROM:
NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA 47522

APPENDIX E

LICENSE NF(R)-36943

TO

CRANE ARMY AMMUNITION ACTIVITY (CAAA)

DEPARTMENT OF THE NAVY
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PENNSYLVANIA 19112

TELEPHONE NO.
Area Code 215
755-4845

Code 2415.1
11011/R9-LIC-IN
CRANE-36943

12 OCT 1977

From: Commanding Officer, Northern Division, Naval Facilities Engineering Command
To: District Engineer, Omaha District, Corps of Engineers, Omaha, NE 68102

Subj: NWSC Crane, IN; License NF(R)-36943 to Crane Army Ammunition Activity (CAAA) covering the use of real property

Encl: (1) Subject license, less/exhibits (fully executed cy)

1. Enclosure (1) has been executed on behalf of the Department of the Navy and is forwarded for your records. The exhibits to enclosure (1) were furnished earlier under separate cover by NWSC Crane.

2. The subject license which became effective for operations on 1 October 1977, authorizes the use by CAAA of a significant portion of the facilities at NWSC Crane. It implements the requirement for the establishment of CAAA as single manager of conventional ammunition with assigned responsibilities as set forth in DOD Directive 5160.65 of 26 November 1975.

3. All future correspondence pertaining to said license should refer to number NF(R)-36943.

Copy to: w/encl
NAVFACENGCOMHQ (CODE 205)
NAVSEASYSCOM (SEA-04J)
ARRCOM (DARSAR-ISF-R) ROCK ISLAND, IL 61201
NWSC (CODE 09CC) CRANE, IN
CAAA CRANE, IN

LICENSE FOR USE OF REAL PROPERTY BY OTHER FEDERAL AGENCIES
NAVFAC Form 11011/30(6-75)

THIS LICENSE TO USE THE U. S. GOVERNMENT PROPERTY HEREIN DESCRIBED IS ISSUED BY THE DEPARTMENT OF THE NAVY TO THE LICENSEE NAMED BELOW FOR THE PURPOSE HEREIN SPECIFIED UPON THE TERMS AND CONDITIONS SET FORTH BELOW AND THE GENERAL PROVISIONS ON THE REVERSE SIDE HEREOF. BY THE EXECUTION HEREOF THE LICENSEE AGREES TO COMPLY WITH ALL SUCH TERMS, CONDITIONS AND GENERAL PROVISIONS.

(Refer to Bulbs. Instructions 11011.18 and any succeeding changes)

LICENSE NUMBER: NF (R)-36-43

1. NAVAL ACTIVITY *(Property Location)*
Naval Weapons Support Center
Crane, Indiana 47522

2. DATES COVERED *(Indefinite)*
FROM 1 October 1977 TO Indefinite

3. DESCRIPTION OF PROPERTY *(Include room and building number when appropriate)*
Licensee shall have exclusive use of the buildings, areas and facilities delineated with legend on NAVFAC Drawings 571668 through 571679, and 718751 through 718762, marked Exhibit "A"; as tabulated and described in the listing of buildings and structures, marked Exhibit "B"; attached hereto and made a part hereof. Logistical and administrative support will be provided in accordance with the specific provisions of the separate support agreement (DD Form 1144).

4. PURPOSE OF LICENSE *(Include specific use, and specify terms and if to be used in sharing partition basis)*
License is required for the establishment of the Crane Army Ammunition Activity as Single Manager of conventional ammunition with assigned responsibilities as set forth in DOD Directive 5160.65 of 26 November 1975, Subj: Single Manager Assignment for Conventional Ammunition. Facilities are to be utilized for the accomplishment of Army functions required in the procurement, production, storage, supply, demilitarization, and maintenance/renovation of conventional ammunition.

5. LICENSOR
DEPARTMENT OF THE NAVY

5a. LOCAL REPRESENTATIVE – DEPT OF NAVY OFFICIAL *(Name and address)*
Commanding Officer
Naval Weapons Support Center
Crane, IN

6. LICENSEE *(Name and address, zip, full agency designation)*
District Engineer,
US Army Engineer District, Omaha
7410 USPO and Courthouse
215 North 17th Street
Omaha, Nebraska 68102

6a. LOCAL REPRESENTATIVE OF LICENSEE *(Name and address)*
Commander
Crane Army Ammunition Activity
Crane, IN

7. GENERAL PROVISIONS *(See Reverse Side)*
(see attached)

8. EXECUTION OF LICENSE

FOR	NAME AND TITLE (Typed)	BY SIGNATURE	DATE
DEPARTMENT OF THE NAVY	PAUL SNYDER Director, Real Estate Division Northern Division, Naval Facilities Engineering Command	Paul Snyder	12 OCT 1977
LICENSEE	KENNETH W. CHELF Chief, Real Estate Division Omaha District, Corps of Engineers	Kenneth W. Chelf	7 OCT 1977

General Provisions on reverse of NAVFAC Form 11011/30(6-75) are hereby deleted and the following is substituted in lieu thereof:

7. GENERAL PROVISIONS:

a. The intent of the general provisions contained herein is to establish policies, procedures, authority and responsibilities for administrative and logistical support; and the operation and/or utilization of all facilities licensed hereunder. Definitions of terms as used in establishing these General Provisions are as follows:

(1) "Licensor" means Commander, Naval Facilities Engineering Command for the Department of the Navy, under the direction of the Chief of Naval Operations and the Chief of Naval Material; or as said authority and responsibility, redelegated as appropriate, to either Northern Division, Naval Facilities Engineering Command or the Commanding Officer, Naval Weapons Support Center, Crane.

(2) "Licensee" means District Engineer, US Army Engineer District, Omaha, 7410 USPO and Courthouse, 215 North 17th Street, Omaha, Nebraska 68102, under the direction of the Chief of Engineers, Department of the Army, or as said authority and responsibility, redelegated as appropriate, to either Headquarters, U. S. Army Armament Materials Readiness Command or Commander, Crane Army Ammunition Activity.

(3) "NWSC" means Commanding Officer, Naval Weapons Support Center, Crane; and as used in these General Provisions, is to be considered synonymous with the terms "host" or "provider."

(4) "CAAA" means Commander, Crane Army Ammunition Activity; and as used in these General Provisions, is to be considered synonymous with the terms "tenant" or receiver."

(5) "ISSA" means Interservice Support Agreement as executed on DD Form 1144, Support Agreement and in accordance with SECNAVINST 7020.4C/AR 37-19/AFR 172-3 of 27 December 1974. The Support Agreement is not a part of this real estate instrument, but is a separate document prescribing the respective services and support to be provided by the Naval Weapons Support Center, Crane and the establishment of procedures, policies, and costs for financial reimbursement by the Crane Army Ammunition Activity.

b. The Licensor hereby grants the Licensee exclusive permission to use the facilities specified in Exhibits "A" and "B" together with the necessary rights of ingress or egress.

c. The use and occupation of said premises will be under the general supervision of the Crane Army Ammunition Activity (CAAA) which shall have immediate jurisdiction over the premises, subject to such rules and regulations as may be prescribed by the Licensor.

d. This License shall be effective during the period stated in Item 2, or until it is terminated by mutual consent.

Enclosure (1)

e. This License shall be reviewed at least annually by each party to evaluate its effectiveness and determine need for modification.

f. This License is subject to modification or termination as mutually agreed in accordance with the following:

(1) Request for modification will be furnished by one party to the other by written notice at least 60 days prior to effective date such modification is desired. Changes in custody of individual buildings and structures as determined necessary to improve effectiveness of operations and/or security by mutual consent of NWSC and CAAA shall be accomplished by the following procedures. The original NAVFAC drawing in Exhibit "A" will be replaced by a revised drawing depicting the custody change of the facility. The buildings and structures listing, marked Exhibit "B", will be revised either by pen and ink changes or by replacing the individual page where required. Approved changes to Exhibits "A" and "B" shall be forwarded to all parties concerned prior to the first week of each quarter of the fiscal year. All modifications to this license shall be effected by the aforesaid Northern Division.

(2) Notification of the intention of either party to terminate this License prior to the date set forth in Item 2 will be in the form of a written notice submitted to the other party at least 180 days in advance of the proposed date of termination. In the event of mobilization or other emergency, this License will remain in force subject to termination upon mutual agreement.

g. This License shall be neither assignable nor transferable by the Licensee. Permits granting use and occupancy of one or more buildings and structures specified in Exhibits "A" and "B" may be issued by the Licensee, however, in accordance with the following:

(1) Notification by the Licensee of the intention to issue a Permit for use and occupancy of specific property contained within this License to another Government or non-Government agency will be in the form of a written request submitted to the Licensor for approval at least 60 days prior to the effective date of the Permit.

(2) Upon approval by the Licensor, utilization of the property conveyed by Permit shall be restricted to specific functions as required to support the accomplishment of the task assignments and mission of the Licensee.

(3) CAAA will assume full responsibility for the performance of the Permittee and compliance with established policies and regulations for utilizing real property controlled by the Department of the Navy, and including specific rules and regulations as set forth by NWSC. CAAA will be responsible for any loss of or damage to Government property, and for death, injury or property damage resulting from property use or functions performed under the Permit.

(4) Issuance of said Permit shall be for a specific period of occupancy not to exceed, in any event, the term of this License. The Permit shall provide for restriction on capital investments by the

Permittee that could be construed as a reliance on the continuing use of the property. The Permit shall be revocable without prior notice to the Permittee.

(5) Any such permit shall specifically be made subject to the terms and conditions of this License.

h. Protection and Maintenance; Support Services

CAAA shall be responsible for the protection and maintenance (including long-term maintenance) of the licensed premises and facilities in good order. NWSC shall provide the support service required by CAAA necessary to accomplish its assigned tasks. Cyclical maintenance and repairs will be provided as required, and at a level equivalent to and comparable with NWSC's program for its own needs. NWSC shall continue the established level of maintenance in accordance with Chapter 6, titled "Uniform Maintenance Levels for Public Works and Public Utilities" of NAVFAC MO-322, Volume 1, Inspection for Maintenance of Public Works and Public Utilities; and as based on the maintenance levels established by the Department of Defense for military activities within CONUS. Such support services which shall be furnished on a reimbursable basis in accordance with the ISSA, shall consist of the following:

(1) Utilities - heat, electrical power and lighting, water, sewage, telephone and other communication capabilities.

(2) Maintenance and Repair Services - Maintenance and repair of all structures and facilities, railroads, highways, and roads licensed hereunder and/or utilized by or directly in support of CAAA, e.g., for access, as well as all grounds, maintenance, mowing and snow removal. Cost of maintenance and repair of highways, roads, and railroads utilized "exclusively" by and/or for CAAA will be reimbursed 100%; other such facilities used jointly with NWSC shall be reimbursed on a prorata share established by the Licensor and Licensee during the annual review of the existing license. Consultation between NWSC and CAAA on maintenance and repair programs shall be held far enough in advance to provide adequate budgeting and planning. NWSC shall also coordinate the scheduling of maintenance and repair items to preclude unnecessary adverse impact on the accomplishment of assigned tasks by the CAAA. In addition to the reimbursement of all costs for maintaining the standard level of maintenance and repair, costs of all maintenance and repair, above the standard level of the Licensor, which would not otherwise be accomplished by NWSC and which CAAA specifically requests in connection with its occupancy hereunder shall be reimbursed to NWSC in accordance with the established rates set forth in the ISSA.

(3) Equipment - Including but not limited to rail and highway transportation and materials handling Equipment.

(4) Pollution Control and Abatement Energy Conservation - The established Pollution Control Program and Energy Conservation Program shall remain the responsibility of the Licensor for management, compliance, and implementation, except for the operation of individual facilities by the Licensee. The CAAA is responsible for ensuring all personnel assigned comply with the established policies and regulations for energy conservation and pollution control. Cost for operation and maintenance of pollution control or abatement and energy conservation equipment shall be reimbursed by CAAA in accordance with the provisions set forth in the ISSA.

(5) Other Assistance and Support Services - All other necessary administrative assistance and logistical support services, in addition to those individually identified above shall be provided by NWSC on a reimbursable basis as specifically delineated in the ISSA. The Licensee shall be responsible for financing the performance of all functions within the mission and tasks assignments of CAAA which are not specifically enumerated in the ISSA. CAAA shall obtain the necessary funding for new facilities and operating support requirements as required for expanded or new mission assignments identified subsequent to licensing.

(6) Fire Protection and Security - CAAA shall be responsible for compliance by all personnel assigned to CAAA as well as by any Permittees, with all fire, safety and security regulations promulgated by NWSC.

NOTE: The furnishing of support services as provided for in this paragraph 7h is contingent upon the availability to NWSC of necessary utilities, equipment and other resources and upon the ability of NWSC to obtain the necessary personnel complement to carry out its assigned support functions. CAAA will provide written program requirements as far into the future as is practical so that the NWSC can project support requirements for budget submissions. Continued review of programs by both parties shall be required to ensure that the mutual interest of both are served. In addition to advising NAVSEASYSCOM when NWSC cannot adequately support CAAA as in accordance with paragraph G (Policy) 1 of DOD manual 4000.19M, NWSC shall also provide written notice to CAAA when it lacks, or will potentially lack, the capability to satisfactorily perform or provide the support functions as delineated in the ISSA.

i. Alterations and New Facilities - Any additions to, or alterations of, the premises or facilities which the Licensee shall consider necessary or desirable in connection with its use and occupancy shall be made only with the prior approval and written consent of the Licensor and solely at the cost and expense of the Licensee. Costs of all new construction, alterations and improvements shall be reimbursed to the Licensor in accordance with the established rates as set forth in the ISSA. Upon revocation, expiration or surrender of this license, and to the extent directed by the Licensor, the Licensee shall remove all alterations, additions, betterments and improvements made or installed, and restore the premises or facilities to the same or as good condition as existed on the date of entry under this License, reasonable wear and tear excepted.

APPENDIX F

"GREEN WATER" REPORT

20 September 1976

COPY OF DOCUMENT CAN BE OBTAINED FROM:
NAVAL WEAPONS SUPPORT CENTER,
CRANE, INDIANA 47522

Request for site approvals shall be in accordance with the policies and regulations of the Licensor and site approvals shall be obtained for all facilities regardless of size or type funding utilized, as follows:

(1) For any new building or structure whether permanent, semi-permanent, temporary, portable or relocatable;

(2) Any addition to an existing facility;

(3) A rehabilitation of an existing facility;

(4) Replacement of a facility at the same site;

(5) Redesignation of the use of an existing facility when the change is not compatible with the previously approved land use, and

(6) Relocation of an existing building or structure.

Siting and/or location of any facility for CAAA will conform to the master plan of NWSC Crane, or as agreed upon for the proposed location and/or changes by both parties. Standards of design and construction shall conform with criteria and directives of both Army and Navy. Any conflict will be resolved by the construction agencies of both services. Particular interest is imperative for projects generating or requiring changes to electromagnetic or explosive quantity/distance requirements. NWSC shall be responsible for requesting and obtaining site approval of proposed facilities required by CAAA. The CAAA shall provide notification of proposed new construction and/or alterations far enough in advance to ensure adequate time is available for NWSC to obtain the required site approval. Quantity/distance requirements generated by hazardous material shall be determined in accordance with OPNAVINST 8020.8F, Subject: Responsibilities of Naval Commands with respect to the Department of Defense Explosive Safety Board (DDESB); and NAVFACINST 8020.2A, Subj: Site Approvals for Ammunition Facilities. The proposed revision of established quantity/ distance requirements or the establishment of new requirements shall be mutually reviewed and approved by both parties prior to the submission of an official request to DDESB for approval.

Real property accounting will be in accordance with existing procedures under the cognizance of the Licensor. New facilities constructed by the Licensee and existing facilities licensed hereunder, and subsequent improvements thereto, will, accordingly, be carried on the Navy Depart-partment's Real Property Inventory.

j. Naval Facilities Engineering Command - Cognizance of Contracts - All contracts for new construction, including Military Construction projects, alterations, improvements, maintenance, repairs, equipment, installations, and support services for facilities, utilities and grounds as licensed hereunder shall be administered by Naval Facilities Engineering Command.

k. Natural Resources Management - for all land areas impacted by the location of all facilities licensed hereunder shall remain the responsibility of NWSC; including soil, water, forests and woodlands, fish and wildlife, grasslands, landscaping, outdoor recreation, and conservation and beautification. CAAA shall comply with the intent of the established natural resources management programs, including:

(1) Long Range Soil and Water Conservation Management Plan

(2) Boggs Creek Watershed Project

(3) Long Term Forest Management Plan

(4) Fish and Wildlife Management Program

NWSC shall coordinate the scheduling of work in support of the natural resources program to preclude unnecessary impact on the accomplishment of assigned tasks by CAAA

l. NWSC shall consult with CAAA prior to the implementation of new policies or regulations affecting the utilization of all facilities licensed hereunder.

NAVY ASSESSMENT AND CONTROL OF INSTALLATION POLLUTANTS:

INITIAL ASSESSMENT STUDY
of
Naval Weapons Support Center
Crane, Indiana
UIC: N00164

May 1983

Prepared by:

Wallace Eakes, Chemist, Team Leader
Jeffery Heath, Environmental Engineer
Martha Cavit, Biologist
Kip Rimm, Health Physicist
William Powers, Supvy. Environmental Engineer, NACIP Dept. Head
Chris Connelly, Environmental Engineer
John Anderson, Chemist
Marian Johnson, Technical Editor
Naval Energy and Environmental Support Activity
Code 112N
Port Hueneme, CA 93043

H. A. Dodohara, Chemical Engineer
T. J. Sullivan, Chemical Engineer
Ordnance Environmental Support Office
Indian Head, MD 20640

Jerald D. Broughton,
Research Geological Engineer
U.S. Army Engineer
Waterways Experiment Station
Vicksburg, MS 39180

6.1.10.3 Building 600, Transfer Depot

At this munitions transfer depot, an open storage and trailer parking area to the southwest contains a hose and truck washout facility. Explosives-carrying vehicles are hosed down in this area. The 1979 study gave the following values for soil samples taken in the vicinity of the washrack.

	TNT, ppm	RDX, ppm	HMX, ppm
Soil (surface)	6.0	2	3.0
Soil (surface)	2.8	1,032	12.4
Soil (1-ft. depth)	1.7	418	60.0

6.1.10.4 Conservation Dam No. 2845

This conservation pond, located south of the Pyrotechnic Test Area, was reportedly used for testing floating-type pyrotechnics in the past. Only limited testing was conducted, and the potential contamination is minimal.

6.1.10.5 Old Phyrotechnic Test Area

This test area, inactive since the early 1970s, is located on the north side of Highway H-5 northeast of Building 2940. Extensively used for testing flares, ignition devices, and smoke markers, the area has small potential for significant contamination.

2930?

6.1.10.6 Lake Greenwood

Some four sites were reported as past test areas for floating-type markers and flares on this 800-acre lake. Also reported was testing of MK25 and MK72 flares in the 1950s, as well as the testing of mine location markers in the late 1960s. The testing of bombs in the lake during World War II is documented, but could not be substantiated as to type, quantity, or whether the rounds were live or inert.

archive letter bombs

6.1.10.7 Miscellaneous Summary

The comparatively low volume of operations throughout these miscellaneous facilities results in low potential for contamination. The high concentrations from soil samples near Building 181 and the washrack near Building 600 are localized. Soil samples taken some distance from the facilities give contaminant levels below 1.0 ppm.

6.1.11 Explosives Operating Building

The following subparagraphs list buildings that have housed significant explosives operations, e.g., black powder, smokeless powder, and explosives compositions. The present building title is listed, with the past title or function, along with ordnance material handled, enclosed in parentheses.

Major Tree Species at NWSC Crane

Black Ash	American Elm
White Ash	Red Elm
Large-toothed Aspen	Hackberry
Baldcypress	Bitternut Hickory
Basswood	Monhernut Hickory
Beech	Pignut Hickory
River Birch	Shagbark Hickory
Boxelder	Honeylocust
Ohio Buckeye	Black Locust
Butternut	White Oak
Black Cherry	Austrian Pine
Black Maple	Jack Pine
Red Maple	Pitch Pine
Sugar Maple	Scotch Pine
Yellow Poplar	Shortleaf Pine
Black Oak	Virginia Pine
Chestnut Oak	White Pine
Chinquapin Oak	Yellow Poplar
Pin Oak	Sweetgum
Red Oak	Black Walnut
Scarlet Oak	Sycamore
Shingle Oak	Willow
Cottonwood	

Received Jul-08-2003 10:41am From-3174090030 To-MALCOLM PIRNIE WASHI Page 002

Partial List of Rare Plants at NWSC Crane (Not listed as threatened or endangered)	
Showy Orchis	Sessile Trillium
Lesser Fringed Orchis	Twinleaf
Ginseng	Sullivantia sullvantii
Nodding Trillium	Asplenium penvatifidum
Large White Trillium	Asplenium trechomanes
Yellow Trillium	Vittaria lineata

Partial List of Fauna at NWSC Crane

Reintroduced Mammals

- White-tailed deer
- Beaver

Small Mammals

- Opossum
- Mice
- Raccoon
- Cottontail rabbit
- Red fox
- Gray fox
- Long-tailed weasel
- Striped skunk
- Mink
- Coyote

Larger Rodents

- Muskrat
- Woodchuck (Groundhog)
- Gray squirrel
- Fox squirrel
- Eastern chipmunk
- Flying squirrel

Water Fowl and Shore Birds

- Canada goose
- Mallard duck
- Ringnecked duck
- Lesser scaup
- Hooded mergansers
- Black duck
- Redhead
- Common merganser
- Bufflehead
- Common loon

Game Birds

- Wild turkey
- Ruffed grouse
- Bobwhite quail
- Woodcock

Raptors that Rest on Center

- Red tailed hawk
- Red-shouldered hawk
- Broad-winged hawk
- Sparrow hawk
- Coopers hawk
- Sharp-shinned hawk
- Great horned owl
- Barred owl
- Screech owl
- Turkey vulture

Fall and Winter Raptor Visitors

- Rough legged hawk
- Marsh hawk
- Short-eared owl
- Long-eared owl
- Saw whet owl
- Bald eagle
- Golden eagle

Other Birds

- American coot
- Rock dove
- Common flicker
- Yellow-bellied sapsucker
- Blue jay
- Tufted titmouse
- Red-breasted nuthatch
- Mockingbird
- Golden-crowned kinglet
- House sparrow
- Rufous-sided towhee
- Field sparrow
- Red-winged blackbird
- Song sparrow
- Killdeer
- Mourning dove
- Hairy woodpecker
- Downy woodpecker
- Common crow
- Brown creeper

Partial List of Fauna at NWSC Crane (Continued)

Other Birds (Continued)

Winter wren
American robin
Cedar waxwing
Cardinal
Dark-eyed junco
Whippoorwill
Swamp sparrow
Great blue heron
Herring gull
Belted kingfisher
Red-bellied woodpecker
Horned lark
Carolina chickadee
White-breasted nuthatch
Carolina wren
Eastern bluebird
Starling
American goldfinch
Tree sparrow
Purple martin
White-throated sparrow
Ruby-throated hummingbird

Salamanders

Eastern newt
Redbacked salamander
Two-lined salamander

Frogs and Toads

Fowlers toad
Chorus frog
Cricket frog
Spring frog
Grey tree frog
Leopard frog
Bull frog
Green frog

Turtles

Spring softshell turtle
Snapping turtle
Box turtle
Painted turtle

Lizards

Five lined skink
Fence lizard
Ground skink

Snakes

Garter snake
Bended water snake
Dekays snake
Black racer
Black rat snake
Milk snake
Rough green snake
Hognose snake
Copper head
Rattle snake

Aquatic Animals

Crayfish
Freshwater mussels
Golden shiner
Redear sunfish
Channel catfish
Spotted sucker
Carp
Yellow perch
Warmouth
Largemouth bass
White bass
Brown bullhead
Bluegill sunfish
Walleye pike
White crappie
Yellow bullhead
Longear sunfish

List of Pyrotechnic Items Produced

Title
Signal, Illumination, Marine, Mk 2 Mod 0.....
Signal, Smoke, Marine, Mk 2 Mods 0.....
Signal, Illumination, Aircraft, AN-M37A2 Thru AN-M42A2; AN-43A2 thru AN-M45A2 AN-M53A2 thru AN-M58A2.....
Signal, Smoke, Ground, M62, M64 and M65.....
Signal, Smoke and Illumination, Marine, Mk 13 Mod 0.....
* Signal, Smoke and Illumination, Marine, Mk 38 Mod 0.....
Signal, Illumination, Ground, Green, M125A1.....
Signal, Smoke, Ground, M128A1 and M129A1...
Signal, Hand Fired, Mk 80 Mods 0 and 1.....
Signal, Illumination, Aircraft, Mk 6 Mod 0.....
Signal, Smoke, Aircraft, Mk 7 Mod 0.....
Fuse, Warning, Railroad M72
Cartridge, Signal, Mk 130, Mk 138, Mk 139, and Mk 140 Mods 0.....
Cartridge, Signal, Mk 121, Mk 122, and Mk 123 Mods.
Flare, Aircraft, Parachute, Mk 5 Mods.....
Flare, Aircraft, Parachute, Mk 6 Mods 3 thru 6.....
Projectile Load, Illuminating, Mk 7 Mod 0.....
Flare, Aircraft, Parachute, Mk 24 Mods 2, 2A, 3 and 4
Projectile Load, Illuminating Mk 4 Mods.....
Projectile Load, Illuminating Mk 9 Mods 0 and 1.....
* Projectile Load, Illuminating Mk 11 Mod 0.....
Projectile Load, Illuminating Mk 12 Mod.....
Flare, Surface, High Altitude, Parachute Mk 20.....
Cartridge, 81MM Illuminating M301A2.....
* Flare, Surface M49
Grenade, Hand Illuminating Mk 1 Mods 2 and 3.....
* Flare, Aircraft, Parachute Mk 45 Mod 0.....
Warhead, 5.0 Inch Rocket, Illuminating Mk 33 Mod 1
* Marker, Location, Marine Mk 2 Mods 0 and 1.....
Signal, Smoke and Illuminating, Aircraft Mk 5 Mods 3 and 4...
Signal, Smoke and Illumination, Aircraft Mk 6 Mod 3.....
Marker, Location, Marine Mk 7 Mods 2 and 3.....
Marker, Location, Marine Mk 9 Mod 0.....
* Marker, Location, Marine Mk 25 Mods 0, 1, 2 and 3
* Marker, Location, Marine Mk 58 Mod 0.....
* Signal, Smoke, Aircraft Mk 89 Mod 0.....
Signal, Illumination, Marine, Mk 3 Mods 1, 2 and 3.....
Signal, Smoke and Illumination, Marine Mks 51, 52, and 53 Mods
Marker, Location, Marine, Mk 26 Mod 0 and Marker Location, Submarine,... Mk 75 Mod 0.....

(Continued)

*Major items produced

List of Pyrotechnic Items Produced (Continued)

Title

Signal, Smoke, Marine (Submarine) Mk 2 Mods 0, 1 and 2.....
* Marker, Location, Submarine Mks 21, 22, 23, 24, 76, 77, 78 and 79 Mods 0.....
* Signal, Smoke and Illuminating, Marine Mks 66, 67 and 68..... Mods 0.....
Signal, Illumination, Marine Mks 41, 45 and 46 Mods 0..
* Marker, Location, Marine, Mk 28 Mod 0 and Marker, Location, Submarine, Mk 80 Mod 0.....
False Target, Submarine Mk 2 Mod 0.....
Marker, Location, Marine AN-Mk 1 Mods 0 and 1..
* Marker, Location, Marine, Mk 1 Mods 2 (Green) and 3 (Yellow).....
Marker, Location, Marine Mk 8 Mod 0.....
Bomb, Photoflash M120 and M120A1.....
Cartridge, Photoflash M112A1 Series.....
Cartridge, Photoflash M123A1 Series.....
Cartridge, Signal, Practice Bomb Mk 4 Mods 3 and 4...
Cartridge, Signal, Practice Bomb, Mk 111 Mod 0.....
* Marker, Location, Marine Mk 38 Mod 0.....
Signal Assembly Mk 25 Mod 2
Unit, Color Burst Mk 7 Mod 0.....
Signal Assembly Mks 39, 40, 43 and 44 Mod 0.....
Signal, Smoke and Illumination, Marine Mk 55 Mod 0.....
Signal, Flash, Guided Missile Mk 33 Mods 0 and 1.....
Signal, Flash, Guided Missile Mk 37 Mod 1.....
Signal, Flash, Guided Missile Mk 42 Mod 0.....
Unit, Color Burst Mk 1, Mk 2 Mods 0.....

Title

Unit, Color Burst Mk 3 Mods 0 and 1.....
Unit, Color Burst Mk 5 Mod 0.....
Unit, Color Burst Mk 6 Mod 0.....
Marker Kit, Location Mk 19 Mod 0.....
Projector, Marker Mk 23 Mod 0.....
Signal, Float, Torpedo Mk 21 Mod 1.....
* Flare, Target, Mk 28.....
Flare, Guided Missile Mk 21 Mod 0.....
Tracer Mk 21 Mod 0.....
Flare, Guided Missile Mk 27 Mod 0.....
Tracking Device, Smoke, Mk 1 Mod 0.....
Flare, Guided Missile Mk 25 Mod 0.....
* Flare, Decoy, Mk 42, Mk 43, Mk 46 and Mk 47 Mod 0....
Flare, Guided Missile Mk 23 Mod 0.....
Simulator, Detonation, Explosive Mk 2.....
Simulator, Booby Trap, Flash M117.....
Simulator, Booby Trap, Illuminating M118...
Simulator, Booby Trap, Whistling M119.....
Simulator, Projectile, Air Burst M74A1.....
Simulator, Projectile, Ground Burst M115A2.....
Smoke Pot, HC, Mk 3 Mod 0....
Grenade, Hand, Smoke, WP, M15.....
Smoke Pot M6.....
Cartridge, Igniter, Turbo-Jet Engine Mk 243 Mod 2.....
Flare, Ground, Parachute XM-184.....
Light, Chemical, Aerosol Mk 11 Mod 0.....
* Marker, Location, Chemical, Mk 46 Mod 0.....

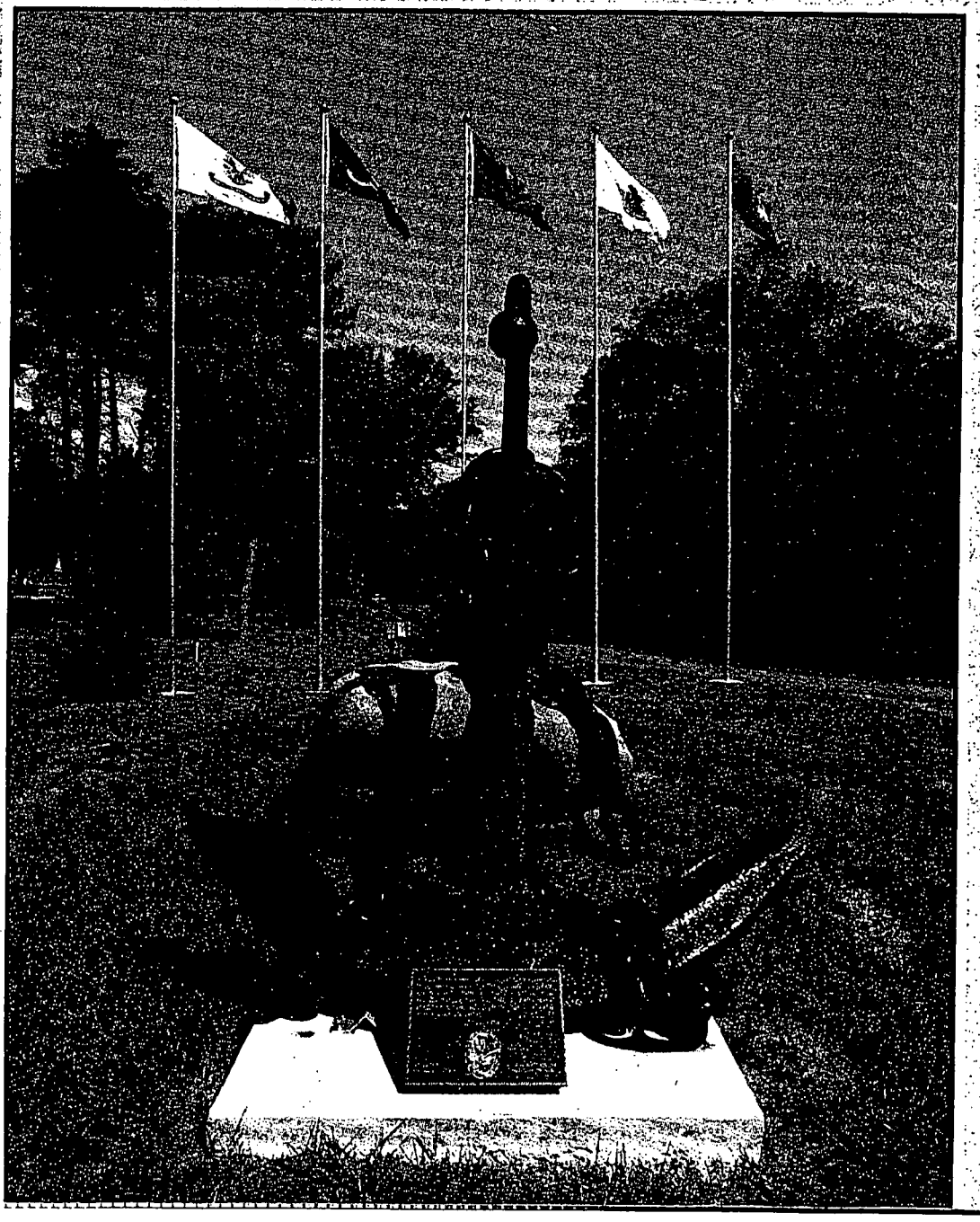
*Major items produced

A GOOD NEIGHBOR:

THE FIRST FIFTY YEARS AT CRANE

1941–1991

BY ROBERT L. REID AND THOMAS E. RODGERS



United States
Department of
Agriculture

Soil
Conservation
Service

In cooperation with
United States Department of
Agriculture, Forest Service;
Purdue University
Agricultural Experiment
Station; and Indiana
Department of Natural
Resources, Soil and Water
Conservation Committee

Soil Survey of Martin County, Indiana

Appendix C: Project Source Data – Site Specific

Interview Record

Installation/Range or Site: NSWC Crane, Indiana

Date/Time: March 20, 2003

Person Conducting the Interview/Title/Organization: Julie Grim, Malcolm Pirnie

Person Being Interviewed/Title/Organization: John Allen

Reason for Selecting Person to Interview (i.e., Years at Installation, Position, Previous History, etc.): Base Historian

---

Interview Notes (i.e., Range History, Ordnance Types, Land Use, Historical Records/Maps Available):

-1952 Public Works

-Oberlin & Greenwood, fired off dams; ended because employee was killed in the late 1940s or early 1950s and that was the last time used

-Captain's Pond, late 1970s, dye testing (greens) (orange) marking dye on lifevests; doesn't recall pyro testing; Jim Short planner for pyro testing in pad now part-time with SAIC (ext. 6796); Hank Webster may recall some info about pond; built in approx. 1974; never dredged

-Not familiar with work @ sedimentation pond

-Captain's Pond has never been dredged

-Conservation Dam No. 2845 was built in 1962

Interview Notes Continued:

-Off-post: Dugger lake, Camp Asbury, Plane drops into Lake Greenwood, from R&D, drift testing, video, may not have been active b/c interested in drift, late 70s, only a few passes, from Washington, IN, Hank Webster

-Boundaries: 40 acres in Davies County, no improvements, other areas to straighten fence, H 45 and H 58 sold triangle (approx. 200 acres) to Dr in early 1990s, no improvement except fence

-Crane Village, under housing office (Crane Village S.) Crane Village north, Dr. Elias bought from GSA, MOA to supply water, sewer, etc.

-Understand no testing outside boundaries

-Burial grounds for mustard, phosgene, gas, removed in 70s, repacked and sent away, SWMU, WWII items

-EOD gold course response in 2002

-14" projectile in front of building 1

-WWII, Vietnam, Korea hard to get info

Interview Notes Continued:

Interview Record

Installation/Range or Site: NSWC Crane, Indiana

Date/Time: August 4, 2003

Person Conducting the Interview/Title/Organization: Julie Grim, Malcolm Pirnie

Person Being Interviewed/Title/Organization: Mr. Bart Barthold/Ordnance Test Group

Reason for Selecting Person to Interview (i.e., Years at Installation, Position, Previous History, etc.): Responsible for conducting testing and dive recovery at the Dugger Lake Facility

---

Interview Notes (i.e., Range History, Ordnance Types, Land Use, Historical Records/Maps Available):

Bart stated that testing was conducted at Dugger when it was only a strip mine pit prior to the 1970s. Once the pit filled with water, Crane began underwater testing. Testing ending in 1992: b/c the testing was transferred to the Glendora Lake test facility.

The majority of the testing conducted at Dugger was sonobouy component testing. All testing was directly underneath the test barge w/in a 50' radius. The components tested included listening devices. A very small sample of the complete sonobouy would have been tested at Dugger because the full function flight tests were conducted in the Virgin Islands.

Very little explosives testing was conducted at Dugger. Mr. Barthold performed numerous dives at Dugger and did not observe any remaining explosives on the bottom of the lake.

He indicated that a swimmer recall device was a M60 igniter pull-ring device attached to (Taped) to a M80. (He had many of those explode over his head throughout the years...)

MALCOLM PIRNIE

Interview Record

Installation/Range or Site: NSWC Crane, Indiana

Date/Time: February 18, 2004

Person Conducting the Interview/Title/Organization: Julie Grim, Malcolm Pirnie

Person Being Interviewed/Title/Organization: Mr. Mel Jackoway/Glendora Test Facility

Reason for Selecting Person to Interview (i.e., Years at Installation, Position, Previous History, etc.): Currently located on the test barge that was formerly used at the Dugger Lake Facility now located at the Glendora Test Facility and is familiar with testing conducted at the Dugger Lake Facility

---

Interview Notes (i.e., Range History, Ordnance Types, Land Use, Historical Records/Maps Available):

Mr. Jackoway indicated that Dugger Lake is 100 feet deep. The lake was opened in June 1974 and was closed in June 1994. The test barge is two story barge that is approximately 54 feet long and 32 feet wide.

Hydroacoustic testing was primarily conducted at Dugger. Mel was responsible for sound pressure level testing during testing activities. Mel confirmed that SEC, ECD, swimmer recall devices, cable cutters, MK-58, etc. were tested at Dugger. He indicated that when tests were successful (i.e. explosion occurred), nothing was left to recover except for small debris that would have landed on the bottom of the lake. When the tests were unsuccessful, the cable was pulled from the water and the devices were recovered.

When Dugger was abandoned he was at Dugger removing anything along the beach area or lake that identified the Navy. They did not send divers into the water to recover, but recovered anything that could visually be seen.

Interview Record

Installation/Range or Site: NSWC Crane, Indiana

Date/Time: February 25, 2004

Person Conducting the Interview/Title/Organization: Julie Grim, Malcolm Pirnie

Person Being Interviewed/Title/Organization: Mr. Tom Laughlin/Glendora Test Facility

Reason for Selecting Person to Interview (i.e., Years at Installation, Position, Previous History, etc.): Currently located at the Glendora Test Facility and is familiar with testing conducted at the Dugger Lake Facility

---

Interview Notes (i.e., Range History, Ordnance Types, Land Use, Historical Records/Maps Available):

Mr. Laughlin stated that a fence is located around the north and west portions of Dugger Lake and that the east and south were heavily wooded.

99% of the testing conducted at Dugger Lake was hydroacoustic and production (non-explosive) testing.

Divers were at Dugger Lake approximately one time a year or on certain occasions, but they were not there specifically for recovery operations.

A lot of items were testing at Dugger, and does not know exact quantities. (they may have only testing a product one time or a one test period may have only included 1-5 unit)

He has no knowledge of any recovery or cleanup of Dugger Lake.

The lake is approximately 100 feet at its deepest location.

The lake had not been dredged during the time NSWC Crane utilized it nor since they left it.

He did not know exactly what SEC & ECD stood for, but said that ECDs do not exist anymore. (he said they may stand for "explosive capsulated device")

OES ... O CENTER

DEPARTMENT OF THE NAVY
NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA 47522-5000

IN REPLY REFER TO:
4330
095

ACTIVITY FILES DEC 10 1991

From: Commanding Officer, Naval Weapons Support Center Crane
To: Chief of Naval Operations (Logistics) (OP-44EPI)
Via: Commander, Naval Sea Systems Command (SEA-654E)

Subj: GLENDORA LAKE ENVIRONMENTAL ASSESSMENT

Encl: (1) Glendora Lake Environmental Assessment

1. Enclosed is the Final Environmental Assessment for the Glendora Lake Hydroacoustic Test Facility.

2. NWSCC point of contact is Mr. Thomas J. Brent, Code 09510, AVN 482-3114.

Sincerely,

J. W. HAYS

Copy to:
NORTHNAVFACENGCOM, Philadelphia (Code 202.2)
NORTHNAVFACENGCOM, Philadelphia (Code 24)

1.0 SUMMARY

1.1 PROPOSED ACTION

The United States Navy is proposing to relocate its hydroacoustic test facility. Currently the Navy is leasing part of Dugger Lake for the testing activities, but the dimensions of the lake and interference from pumps and recreational activities in the unleased portion of the lake have imposed serious restrictions on the testing.

The purchase of the Glendora Lake Site at the Minnehaha Coal Mine has been proposed for relocation of the testing facilities. The Glendora Lake Site actually has two pits that will be allowed to fill with water creating two lakes. After filling, the large pit will become Glendora Lake, and the small pit will be known as the Test Lake. This site would provide conditions that more closely approximate an ocean environment, and would allow for greater flexibility and fewer restrictions on testing. The new site would also eliminate the inherent disadvantages of sharing a body of water with the public. Parking lots will be constructed at each of the three testing areas to accommodate personnel. A gravel road will be constructed around the entire area. In addition, a 3,000 sq. ft. office building will be built on the north end of Glendora Lake.

1.2 ALTERNATIVES

The Glendora Lake Site is considered the preferred site of several other possible sites in west-central Indiana for several reasons. Evaluation of the sites was based on the following criteria: dimensions of the lake (a minimum depth of 100 feet is required); proximity to Dugger Lake for purposes of facilitating the transportation of the bulky pier and flotation equipment; proximity to the Naval Weapons Support Center Crane (NWSCC), Crane, Indiana; availability of the site; and time of completion of mining. Based on these factors, the Glendora Lake Site was recommended as the best site for the proposed relocation.

The proposed site occupies 359 acres of property which includes a large and a small pit which will be flooded to form the lakes. Testing will be conducted in both lakes. Glendora Lake will be used for vertical and horizontal motion studies (bob and tow line) and general testing. The Test Lake will be used for testing the deployment and initial descent of the sonobuoy sensor, as well as general testing. Upon termination of surface mining, augering and reclamation activities the pit mines will be allowed to fill with water naturally, and the piers and necessary equipment will be constructed or moved to the new site, which is approximately 5 miles from Dugger Lake.

(b) Depth and horizontal extent limitations at Dugger Lake. At Dugger Lake, large sonobuoy arrays are too wide for testing at the lake since they would physically contact the walls. Furthermore, shallow or irregular bottom surfaces can cause sound reflecting interference.

(c) The Navy does not own Dugger Lake, but leases a portion of it. Public access is therefore allowed in the section of the lake not leased by the government. This results in security problems, and an inability to control the ambient noise levels in the water.

(d) AMAX is considering Dugger as a possible site for the deposition of slurry from AMAX's coal scrubbing operations. This would render the lake unusable for any type of testing.

(e) Dugger Lake is co-owned by AMAX and a private individual. Both have announced their intentions to discontinue their lease agreements with the government by March of 1993.

These are problems which would be eliminated by the Navy owning and having complete control over the entire body of water in which testing is done.

2.3 PROPOSED ACTION DESCRIPTION

The United States Navy is proposing to move its present testing operation on Dugger Lake, approximately 5 miles east to the Glendora Lake Site. This will involve relocating existing resources at Dugger Lake which are appropriate to the new site, and construction of some new facilities. Therefore, there will be no demolition of structures. Since the new facility will eliminate the need for the existing hydroacoustics facility at Dugger Lake the facility will be closed and the lease allowed to expire.

2.3.1 Facilities Relocation

The pier and barge, which are too large to transport over two-lane roads, will be hoisted on a trailer and moved over existing wide mining access roads to the new site. The testing facility barge, now on Dugger Lake consists of a steel structure 60 feet in length, 30 feet in height, and 40 feet in width (Figure 2-3). The floor has removable dock plates so that a mechanical arm suspended from the ceiling can move the sensors vertically, and horizontally the length of the pier. The floats extend another 10 feet below the floor of the structure. The structure houses very sophisticated electrical equipment for measuring and monitoring hydroacoustical impulses. The testing facility barge will be placed on the north end of Glendora Lake.

2.3.2 Proposed Construction

The proposed project also includes the construction of a primary shore facility and a test lake facility in order to support testing requirements, accommodate personnel, equipment, and hardware to be tested. Other construction will include the drive facility and tow range.

4.10 SURFACE MINING CONTROL AND RECLAMATION ACT AND INDIANA SURFACE COAL MINING AND RECLAMATION LAW, I.C. 13-4.1

The Federal Act and State Law provide to protect society and the environment from the adverse effects of surface coal mining operations and provide to assure that reclamation of coal mining operations is feasible, beneficial to the environment and protects health and safety of the public. Reclamation of the project site is in accordance with post mining land use criteria. The reclamation to a permanent water impoundment (Glendora Lake) is compatible with adjacent land uses, will not present hazards to public health and safety, will not adversely affect the environment, and is consistent with conditions which would support the proposed use prior to mining. The reclamation and proposed use are in accordance with the criteria set forth in the Federal and State regulations.

Initial post-mining land uses permitted for Glendora Lake described the permanent water impoundments as having the utility and capacity to support a variety of water based uses. Reclamation to permanent water impoundments for recreational uses does not require different procedures or satisfaction of different policies and regulations for impoundments created for industrial uses. The ultimate use of the permanent water impoundment should, however, be compatible with adjacent land uses. It has been previously shown that proposed plans for the Glendora Lake Site are in fact compatible with such adjacent land uses.

5.0 DESCRIPTION OF EXISTING ENVIRONMENT

This section details the environment surrounding the Glendora Lake Site. The physical environment and man-made environment shall be discussed separately. Since mining has irrevocably changed some properties of the natural environment, these changes shall be discussed as they apply to the filling of, and testing in, the Glendora Lakes.

5.1 PHYSICAL ENVIRONMENT

5.1.1 Geology

The site is situated on rocks of Pennsylvania age. The regional physiography is characterized by nearly level to steep uplands. Figure 5-1 shows a geologic cross section of the site, before mining.

This was the site of the Borden Delta, which represents the western limit of sea transgression in middle Pennsylvanian time. The Cincinnati Arch served as the sediment source, and this detritus was deposited in the classic Pennsylvanian coal-forming deltas. Deltaic deposits consists of laterally discontinuous, finger-like deposits of sandstone, siltstone, limestone, shale, and coal.

Underlying bedrock consists of siltstones and shales of the Dugger Formation, and below these, siltstones, shales, limestones, and coal beds of the

the lower. The subsoil is about 28 inches in thickness and is brownish-gray colored. It is silty loam in the upper part and becomes more clayey with depth in the subsoil. The underlying material is yellowish-brown, friable silt loam.

Permeability is low for Iva soils, surface runoff is slow, and available moisture capacity is high. The organic matter content is low. The surface layer is slightly acidic.

The Cincinnati soils consist of deep, well-drained soils that have a medium-textured surface layer and a moderately fine-textured subsoil. A firm, brittle fragipan occurs at a depth of 26 to 32 inches. These soils exist on uplands, and are formed in 10 to 40 inches of loess over a weathered till. A typical profile has an 11-inch surface layer of silt loam, dark gray in the upper 6 inches and yellowish-brown in the lower part. The subsoil extends to a depth of 130 inches, and has a dark yellowish brown silty clay loam above a thick yellowish brown fragipan. Below the fragipan is a very thick layer of yellowish-brown loam to clay loam.

Permeability is low, and surface runoff is moderate to rapid. The available moisture capacity is medium, and the organic matter content is low. These soils occur on gentle to very steep slopes on uplands.

It should be noted that the replacement of the soils around the lake will be in the form of a more homogeneous mixture of these soils types that have been stored on site in stock piles. Many physical properties of the replacement soils will be different from the pre-mining soils. The replacement soils will have greater permeability and allow less runoff. This will tend to replenish or increase groundwater levels in the vicinity of the Glendora Lake Site. Though these soils need to be acidic in the surface layers, the material placed under the soils has more than enough neutralization potential to insure that acid groundwaters will not develop, as discussed in section 5.1.6.2. AMAX is responsible for replacing the soil in accordance with normal reclamation activities.

5.1.3 Air Quality

The existing air quality has been affected by the surface mining activities though air quality standards have been met. Table 5-1 shows the U.S.E.P.A. ambient air quality standards, and table 5-2 shows attainment of the various parameters.

Well D551PJ

Test	1/8/87	4/6/87	7/6/87	4/11/88
Field temp (C)		13.00		
Field pH		6.95		6.800
Elevation (ft)	479.300	480.000	478.600	483.500
Lab pH		7.96		6.750
Alkalinity		423.10		432.700
Total Acidity		0.00		0.000
Total iron		0.68		0.870
Dissolved iron		<0.050		<0.050
Manganese		0.09		<0.050
Tot dis solids		1036.00		1200.000
Sulfates		256.00		662.000
Condo.(µmhos/cm)		1300.00		1537.000
Hardness		526.10		925.000
Chloride		4.40		10.800
Fluoride		<0.100		0.160
Calcium		47.60		194.000
Magnesium		98.90		95.400
Sodium		35.90		50.000

*mg/l unless otherwise noted.

Included in Appendix B is geochemical core hole data from well X10MG. This data gives test results of the neutralization potential of the Pennsylvanian bedrock at specific intervals. It shows a positive net neutralization potential for the majority of the intervals tested. This bedrock forms the walls of the large pit and also constitutes the spoil material created during mining, through which water must pass on its movement down to the water table. These results, combined with the alkalinity data of the wells, shows that there is significant acid-consuming potential in these materials to reduce the formation of acid water from mine drainage.

The water table elevation data in Table 5-4 shows that well X10MG, though at approximately the same elevation as D551PJ, has a much lower water table elevation. This is due to the pumping in the large pit to lower the water table for mining. Well D551PJ also aids in estimating the final pool elevation of Glendora Lake when filling is complete. Information on pre-mining water table elevations in the immediate vicinity do not exist. An estimated final pool elevation of 470 feet above sea level is used as a conservative estimate. Filled strip mines north of Dugger and 3 miles east of the pit have reached pool elevations of 485 feet, with ground elevations similar to those at Glendora Lake. Lake Sullivan (less than a mile west of the site) has a pool elevation of 470 feet. Well D551PJ has water table elevations of about 480 feet.

5.1.7.4 UNDEVELOPED LAND

This includes land which has never been developed or land which has been allowed to return to a natural state. All undeveloped areas are dominated by trees and grasses. Some of the most abundant weedy plants include Asters (*Aster*), Goldenrods (*Solidago*), Medicks (*Medicago*), Yarrows (*Achillea*), Bonesets (*Eupatorium*), and Selfheals (*Prunella*). Invasive woody vegetation commonly seen in undeveloped areas includes Blackberries (*Rubus*), Multiflora Rose (*Rosa multiflora*), Grapes (*Vitis*), Trumpet Creeper (*Campsis radicans*), Poison Ivy (*Toxicodendron radicans*), Sassafras (*Sassafras albidum*), Boxelder (*Acer negundo*), Sumacs (*Rhus*), Hazels (*Corylus*), Black Walnut (*Juglans nigra*), and Elms (*Ulmus*).

5.1.8 Rare and Endangered Species

The habitat types in southwestern Indiana typically do not support rare and endangered plant or animal species. No such species were found by AMAX scientists during their field survey.

5.1.9 Wetlands

A small area of wetlands 5000 feet northwest of the Glendora Lake Site has been left undisturbed by mining. It is not known to what extent, if any, the mining has caused negative impacts to these wetlands.

5.2 MAN-MADE ENVIRONMENT

5.2.1 Regional Land Use

The region surrounding the Glendora Lake Site is rural in character. The urban areas around the site, which are quite small (Table 5-5), are primarily centers for commercial and retail trade, supporting services to existing industry and agriculture, and education and health centers. As a nonmetropolitan area, the region in which the site is located relies heavily upon agriculture and related activities. Corn, soybeans, wheat, cattle, and hogs are the primary agricultural products in the region. Coal mining and limestone quarrying is also a major land use, especially in the vicinity of the site.

Table 5-5
POPULATION IN REGION OF THE GLENDORA Lake Site

Name	1960	1970	1980	1987
Sullivan County				
Sullivan	4979	4683	4774	4460
Dugger	1062	1150	1118	1050
Farmersburg	1027	962	1240	1250
Shelburn	1299	1281	1259	1220
Merom	352	305	360	340
Carlisle	755	714	717	700
Hymera	1050	907	1054	1020

will work closely with the Indiana Department of Environmental Management should at some point it become necessary to obtain permits.

The proposed activity of filling the pit and testing in it, would have no negative impact on any wetlands in the area.

6.4.2 Groundwater

As the Glendora lakes fill, the water table in the vicinity will be restored to its premining state. This is a natural process that consists of turning the mining de-watering pumps off. This will conclude the groundwater imbalance around the pits caused by pumping. The final groundwater level (surface elevation of the Glendora lakes) is expected to be 470 feet above mean sea level.

The pits themselves will not have a negative impact on groundwater or surface water quality. The walls are sheer bedrock which has significant neutralization potential, and so serves as a buffer against any potential acid water formation. Calcium chloride is also a chemical constituent of the groundwater.

The testing facility will require construction of three parking lots which will temporarily add some dissolved solids and suspended solids to the lakes as soil is removed. Some petrochemicals may also find their way to the groundwater. The locally reduced surface water infiltration may slightly lower the water table. Due to the small size of the parking lots, these impacts will be minor.

6.5 ECOLOGY

Vegetation will be slightly influenced by construction of the parking lots. Wildlife (especially aquatic) will be affected by the filling of the lakes.

6.5.1 Vegetation

During the construction of the parking lots there will be a temporary loss of some vegetative cover due to the operation of heavy machinery. With the loss of this cover the erosion potential of the influenced area will be increased. This will be minimized by hydroseeding the affected areas as soon as the machinery is removed from the impacted area, and using silt fences and hay bale barriers throughout construction. Long term impacts include complete loss of some vegetation due to asphalting, and species substitution from existing species to landscaped plants. The existing vegetation that would be impacted by the proposed project depends on how the land is reclaimed after mining. Therefore, the impact on vegetation from the proposed project is expected to be negligible.

6.5.2 Terrestrial Wildlife

The effects on terrestrial wildlife caused by parking lot construction will have both short-term and long-term consequences. During the short-term construction phase some terrestrial wildlife will move out of the immediate

APPENDIX A

WATER QUALITY DATA FOR WELL X10MG

SUPPLEMENT TABLE II.C.2.a

GEOCHEMICAL DATA FOR CORE HOLE - XIONG

MINNEHAHA MINE - GLENDORA FIELD

Sample #	Depth (ft)	Thickness (ft)	Lithology	Pyritic Sulfur (%)	IAPP (tons/1000 tons)	INPA (tons/1000 tons)	NNP (Excess or Deficiency) (tons/1000 tons)	Weighting Factor (tons-ft/1000 tons)
20	136.0-140.0	4.0	Sandstone	0.12	3.8	70.0	+ 66.2	+264.8
21	140.0-143.3	3.3	Sandstone	0.13	4.2	42.5	+ 38.3	+126.4
22	143.3-146.6	3.3	Shale	0.15	4.8	86.3	+ 81.5	+269.0
23	146.6-148.5	1.9	Shale	0.45	14.4	186.3	+171.9	+326.6
24	148.5-150.5	2.0	Shale	1.42	45.4	131.3	+ 85.9	+171.8
25	150.5-152.5	2.0	Shale	1.48	47.4	135.0	+ 87.6	+175.2
26	152.5-155.8	3.3	Shale	4.05	129.6	143.8	+ 14.2	+ 46.9
	155.8-163.7	7.9	HYMERA COAL VI					
27	163.7-165.7	2.0	Shale	3.46	110.7	43.8	- 66.9	-133.8
28	165.7-167.8	2.1	Clay Shale	0.70	22.4	17.5	- 4.9	10.3
29	167.8-170.8	3.0	Clay Shale	0.97	31.0	28.8	- 2.2	- 6.6
30	170.8-173.7	2.9	Clay Shale	0.95	30.4	136.3	+105.9	+307.1

Total of (No.VI Coal) Overburden = 109.3 ft. (excluding unconsolidated material and VII Coal)

WEIGHTING FACTOR TOTAL = 4041.0

Total Consolidated Overburden Thickness = 109.3 ft.
Weighting Factor Total = 4041.0

Composite Net Neutralization Potential = $\frac{\text{Weighting Factor}}{\text{Thickness}}$

= 37.0 tons $CaCO_3$ equivalent/1000 tons material

Details of Headings

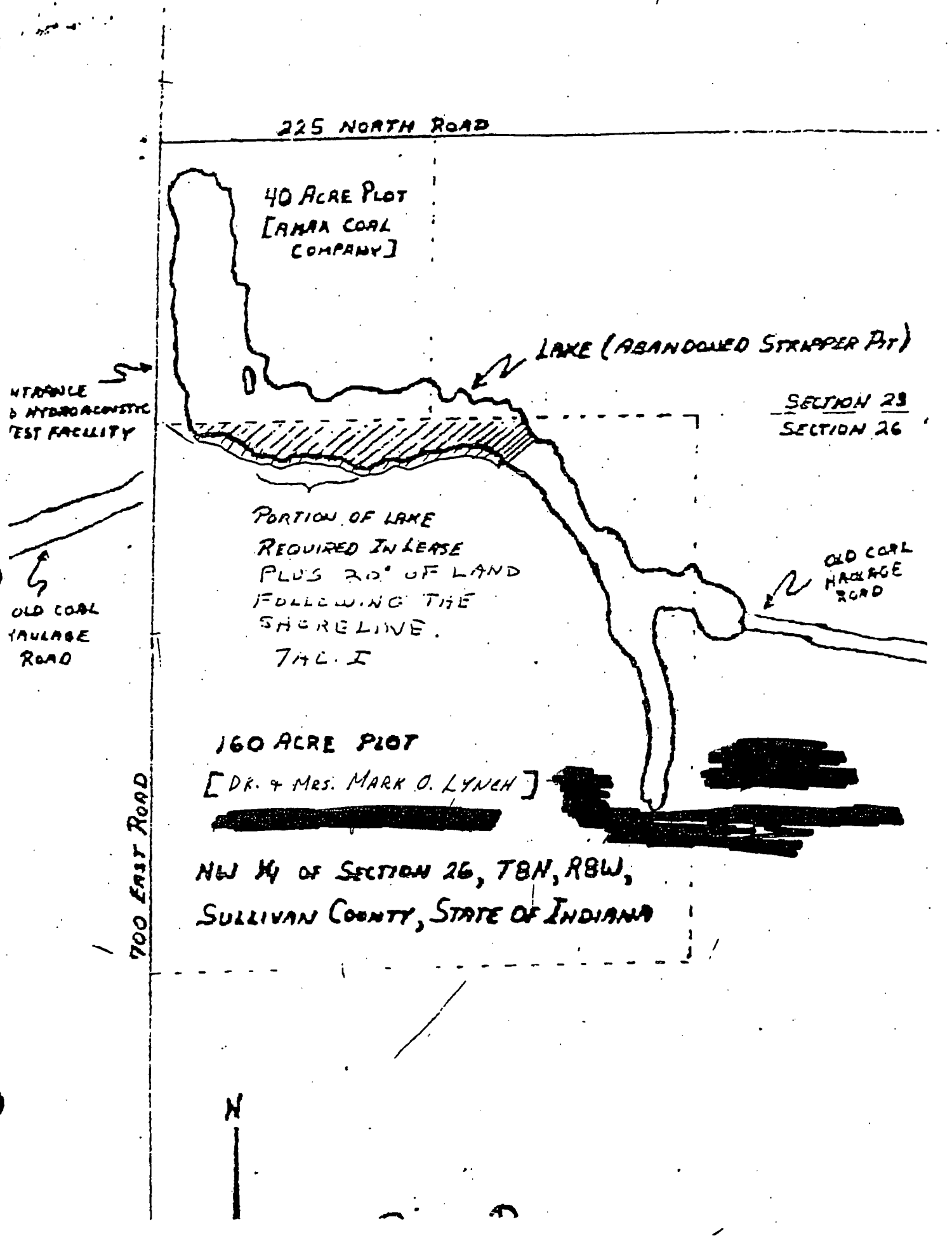
IAPP = Inherent Acid Production Potential
INPA = Inherent Neutralization Potential Available
NNP = Net Neutralization Potential
(tons/1000 tons) = tons $CaCO_3$ equivalent/1000 tons material

MINNEHAHA MINE - ALENDORA FIELD
GEOCHEMICAL DATA FOR CORE HOLE X10MG

Samples	Depth (ft)	Lithology	Paste pH	TDS mg/L	Pyritic Sulfur (%)	Fe meq/L	Mn meq/L	Al meq/L	Na meq/L	Ca meq/L	Mg meq/L	SAR
24	148.5-150.5	Shale	9.5	19240	1.42				49.18	76.18	10.72	7.46
25	150.5-152.5	Shale	8.8	3700	1.48				74.10	5.23	2.49	37.72
26	152.5-155.8	Shale	7.7	12000	4.05							
	155.8-163.7	COAL VI										
27	163.7-165.7	Shale	6.2	27525	3.46							
28	165.7-167.8	Shale	8.8	5470	0.70				47.73	13.30	3.47	16.48
29	176.8-170.8	Clay Shale	9.3	11180	0.97				101.46	93.89	15.66	13.71
30	170.8-173.7	Clay Shale	9.5	19100	0.95				67.25	128.89	17.49	7.86

NOTE: Paste pH determined by standard methods.
Other parameters determined from the analysis of water extract filtered from saturated paste.
mg = milligrams per liter
meq = milliequivalents per liter
SAR = Sodium Absorption Ratio
TDS = Total Dissolved Solids

Dragger Lake



Dugger Lake
Explosives Tests

7/94 D/L Dugger
8/94 G/L Glendora

1231	6/77	SEC		
1241	8/77	SEC / ECD		
1247	8/77	SEC Army	R. Coyle X-5501	
1251	8/77	ECD	Bill Felton X-5976	WQEC
1252	8/77	SEC		
1682	6/82	ECD	John Perkins	/ Army
3194	11/91	Mk-58 Mod2	5042	D. LaGrange X-2836
3199	12/91	(Cable Cutter Mk-3, Mod 1) mechanical	5052	G. Fish X-5475
3238	3/92	"	5052	"
3245	4/92	Swimmer Recall Device	5022	K. Hamm X-5589
3256	5/92	"	4027	K Hamm
3270	6/92	"	"	G. Raney X-5390
3280	7/92	"	"	"
3281	7/92	Cable Cutter Mk-3	"	Greg Fish
3299	9/92	Swimmer Recall	"	K. Hamm
3300	8/92	cable Cutter Mk-3	4052	G. Fish
3345	11/92	Mk-58 Inert Plug	40	S. Johnson X-2823 or X-5799

Tim Moody
Acoustic Test Facility Mgr.
X-4270

Code
6074