Five-Year Review Report

Metals Areas Operable Unit
Crab Orchard National Wildlife Refuge Superfund Site
Marion, Illinois

September 2001

PREPARED BY:

The United States Environmental Protection Agency, Region 5
Chicago, Illinois

Approved By: Date:

Wm. E. Muno 9/27/01

William Muno, Director
Superfund Division
U.S. EPA Region V

Five-Year Review Report

Table of Contents

List of Tables

List of Figures

Attachment A

List of Documents Reviewed

List of Acronyms

ARARs	Applicable or Relevant and Appropriate Requirements
AUS OU	Additional and Uncharacterized Sites Operable Unit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DA	Department of the Army
DOD	Department of Defense
DOI	Department of the Interior
EMMA OU	Explosive/Munitions Manufacturing Areas Operable Unit
FFA	Federal Facility Agreement
FWS	United States Fish and Wildlife Service
LMOU	Lake Monitoring Operable Unit
MAOU	Metals Areas Operable Unit
MISC OU	Miscellaneous Areas Operable Unit
MCLs	Maximum Contaminant Levels
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	Operation and Maintenance
OUs	Operable Units
PCB	Polychlorinated biphenyl
PCB OU	PCB Areas Operable Unit
PRP	Potentially Responsible Party
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SVOC	Semi-Volatile Compound
USACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WTOU	Water Towers Operable Unit

Executive Summary

The five-year review of the remedial actions implemented at the Metals Areas Operable Unit (MAOU) of the Sangamo Electric Dump/ Crab Orchard National Wildlife Refuge NPL Site (also known as Crab Orchard Site) in Carterville, Illinois was completed in August 2001. The results of the five-year review indicate that the remedy is expected to be protective of human health and the environment. Overall, the MAOU landfill cover is effective in containing waste materials and is generally in good condition.

Preliminary information from the Additional and Uncharacterized Sites Operable Unit (AUS OU)'s Site Investigation showed elevated concentrations of metals at a former dry cleaning building in the vicinity of the West Shop Area of the MAOU. Further investigation and cleanup of this area, if necessary, will be addressed as part of the AUS OU.

The MAOU is one of seven operable units (OUs) within the Crab Orchard Site. The other OUs include the PCB Areas OU, Explosives/Munitions Manufacturing Areas (EMMA) OU, Miscellaneous Areas (MISC) OU, Water Towers OU, AUS OU, and the Lake Monitoring OU. Because a major portion of the PCBOU cleanup activities were completed in 1997, U.S. EPA completed the first five-year review of the PCB OU in September 2000. The remaining five operable units are in various stages of investigation and/or construction completion. Remedial and removal activities at the EMMA OU are nearing completion. Records of Decision for two of the MISC OU sites are expected to be signed before the end of 2001. Removal activities at the Water Towers OU are expected to be completed in 2003. Preliminary Assessment and Site Investigations of the AUS OU and Lake Monitoring OU are nearing completion. Future five-year review reports will include all seven operable units.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Sangamo Electric Dump/Crab Orchard National Wildlife Refuge		
Name of Operable Unit: Metals Areas Operable Unit		
EPA ID: IL8143609487		
Region: 5	**State:** Illinois	**City:** Carterville
SITE STATUS		
NPL Status: Final		
Remedial Status: Complete for Metals Areas Operable Unit		
Multiple Operable Units? Yes	**Total Number of Operable Units**: 7	
Construction Completion date: 12-29-1998		
Has site been put into reuse? No		
REVIEW STATUS		
Reviewing Agency: U.S. EPA		
Author name: Nan Gowda		
Author title: Remedial Project Manager	**Author affiliation:** U.S. EPA	
Review period: April 26, 2000 through August 15, 2001		
Dates of Site Inspection: April 26, 2000		
Type of review: Statutory		
Review number: 1 (first)		

Five-Year Review Summary Form

Deficiencies:

Based on a preliminary site investigation conducted as part of the Additional and Uncharacterized Sites Operable Unit (AUS OU), elevated levels of metals may be present at a former dry cleaning building in the vicinity of the West Shop Area.

Recommendations and Follow-up Actions:

Since the dry cleaning building area is currently being investigated as part of the AUS OU, no action is required as part of the Metals Areas OU.

Protectiveness Statement:

No lead, cadmium, or chromium-contaminated soil or sediments are present above cleanup levels at any of the remediated sites. The MAOU Landfill is effective in containing the waste and contaminants. The remedial actions at Sites 15, 22, and 29 are expected to be protective of human health and the environment.

Other Comments:

The Crab Orchard Site consists of a total of seven operable units. In addition to this report, U.S. EPA has completed the first five-year review of the PCB Areas Operable Unit of the Crab Orchard Site. Future five-year reports will include all seven operable units.

Metals Areas Operable Unit
Crab Orchard National Wildlife Refuge Superfund Site, Marion, Illinois
First Five-Year Review Report

I. Introduction

EPA Region 5 has conducted a five-year review of the remedial actions implemented at the Metals Areas Operable Unit (MAOU) of the Sangamo Electric Dump/Crab Orchard National Wildlife Refuge NPL Site (also known as Crab Orchard Site) in Carterville, Illinois. This review was conducted from April 26, 2000 through August 15, 2001. This report documents the results of the review. The purpose of five-year reviews is to determine whether the remedy at the site is protective of human health and the environment. The methods, findings, and conclusions of reviews are documented in five-year review reports. In addition, five-year review reports identify deficiencies found during the review, if any, and identify recommendations to address them. The MAOU is one of seven Operable Units at the Crab Orchard Site..

This review is required by statute. EPA must implement five-year reviews consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). CERCLA §121(c), as amended, states:

> If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each five years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented.

The NCP part 300.430 (f) (ii) of the Code of Federal Regulations (CFR) states:

> > If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure, the lead agency shall review such action no less often than every five years after the initiation of the selected remedial action.

This is the first five-year review for the MAOU Crab Orchard Site. The triggering action for this statutory review is the date of the initiation of remediation, June 1993. A review is required as contaminants remain at the site in an on-site landfill.

II Site Chronology

Table 1 lists chronology of events for the Crab Orchard site.

Table 1 Chronology of Events

Date	Event
1984	Site proposed for NPL
2/86	U.S. EPA and FWS entered a Federal Facility Initial Compliance Agreement for the performance of an RI/FS.
5/86	RI/FS began at the Refuge
7/87	Site finalized for NPL
8/88	RI/FS complete
3/30/90	ROD signature for Metals Areas OU
8/01/90	ROD signature for PCB OU
5/13/91	Consent Decree signed for PCB OU
9/13/91	Federal Facilities Agreement signature
2/19/97	ROD signature for EMMA OU
1/11/00	ESD for the EMMA OU
6/23/00	ESD for the PCBOU
9/27/00	First Five-Year Review completion for the PCB OU

III Background

The Crab Orchard National Wildlife Refuge (Refuge) lies near Marion, Carterville and Carbondale, Illinois, primarily within Williamson County, extending into Jackson and Union Counties in southern Illinois. The general location of the Refuge is shown in Figure 1. The Refuge consists of approximately 43,500 acres of multiple-use land. Since 1947, the U.S. Fish and Wildlife Service (FWS) has operated the Refuge under the authority of the U.S. Department of the Interior (DOI). The land is used as a wildlife refuge, and also for recreational, agriculture and industrial purposes. The western end of the Refuge around Crab Orchard Lake is used for recreational purposes while the eastern end is used for manufacturing facilities. Access to the eastern portion is closed to the public, except for limited access to workers at the industrial sites and restricted access to hunters. The study sites which were the focus of the Remedial Investigation (RI) and Feasibility Study (FS) are located in the eastern, closed portion of Refuge. There are twelve lakes, including Crab Orchard Lake located within the Refuge. Although currently not used, the 7,000 acre Crab Orchard Lake is a potential drinking water supply source and supports a large population of sport fish. Wetlands are found in some areas adjacent to the

lakes. Wildlife on the Refuge include many game and non-game species. The Refuge has habitat suitable for one endangered specie: the Indiana bat.

In the early 1940's, the War Department, the predecessor to the Department of Defense (DOD), used the area at the east end of Crab Orchard Lake, for the manufacturing of bombs, land mines, and explosives. Manufacturing stopped at the end of World War II. The War Assets Department transferred administration of the area to DOI in 1947, with the exception of the ammonia nitrate plant (which was transferred to DOI in 1951) for use as a National Wildlife Refuge. The enacting legislation, which created the Refuge, required DOI to continue leasing former wartime industry buildings to industrial tenants (as was initiated by the War Assets Department). The industrial manufacturing operations, which continue to the present, included at various times ammunition and explosives, metal fabrication, plating, and manufacturing of printing inks, fiberglass boats, and electrical components. Over the years these tenants have disposed of their waste at several areas within the Refuge.

Tests performed in the eastern portions of the Refuge during the late 1970s and early 1980s indicated that contaminants such as PCBs, lead, and cadmium were present. Based on these findings and the potential threat of these contaminants to human health and the environment, U.S. EPA placed the Crab Orchard Site on the National Priorities List (NPL) in July 1987.

On February 26, 1986, the FWS and U.S. EPA entered into a Federal Facility Initial Compliance Agreement, which required the performance of a Remedial Investigation/Feasibility Study (RI/FS). FWS and Sangamo Weston, Inc, which was one of the former industrial tenants at the Refuge, entered into a Cooperative Agreement to conduct the RI/FS at the Refuge. FWS and Sangamo Weston began the RI/FS of the Refuge in 1986 and completed it in August 1988. The RI Report investigated thirty-three study sites at the Refuge, including two background sites. Based on the results of the RI Report, U.S. EPA, in consultation with DOI and Illinois EPA, made available to the public the draft-final FS Report and two Proposed Plans for remedial action. The first Proposed Plan was for three study sites contaminated primarily with metals. These are designated as the Metals Areas Operable Unit (MAOU). The second Proposed Plan addressed four study sites that were primarily contaminated with PCBs, lead, and cadmium. These are designated as the PCB Areas Operable Unit (PCB OU).

Pursuant to Section 120 (e) of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), U.S. EPA, Department of the Army (DA), Illinois EPA, and DOI signed a Federal Facility Agreement (FFA) on September 13, 1991. Because the study sites differ in terms of contamination problems, types of remedies and schedules that may be appropriate, or potentially responsible parties (PRPs) etc., and because site problems are spatially distinct, FFA partners created two additional OUs. These are the Explosive/Munitions Manufacturing Areas Operable Unit (EMMA OU) and the Miscellaneous Areas Operable Unit (MISC OU). EMMA OU included those areas physically associated with explosive/munitions manufacturing and disposal sites at the Crab Orchard Cemetery and Crab Orchard Plant areas

within the Refuge. MISC OU included those study sites that were proposed in the August 1998 RI Report as needing further investigation. DOI created a Water Towers Areas Operable Unit (WTOU) to remove lead-contaminated soil in the vicinity of three existing water towers and two previous Water Tower areas within the Refuge.

In 1997, DOI created two more OUs, the Additional and Uncharacterized Sites Operable Unit (AUS OU) and the Lake Monitoring Operable Unit (LMOU). The purpose of the AUS OU is to investigate any remaining uncharacterized areas within the Refuge that were previously not investigated in the 1988 RI Report. The AUS OU also included several additional sites that may be suspected of contamination due to past disposal practices by several industrial tenants. The purpose of the LMOU is to verify and take appropriate action, if the Crab Orchard Lake is affected by the past waste disposal activities at the Refuge.

DOI is the lead agency for the MAOU, MISC OU, PCB OU, WTOU, AUS OU, and the LMOU. DA is the lead agency for the EMMA OU. Schlumberger, as a Settling Defendant, signed a Consent Decree (CD) with U.S. EPA and DOI. Under the terms of the Consent Decree, Schlumberger agreed to perform the cleanup set out in the Record of Decision (ROD) for the PCBOU. U.S. EPA is the lead agency for the implementation of the remedial action required under the PCB OU ROD and enforcement of the terms of the Consent Decree.

U.S. EPA is responsible for conducting separate five-year reviews for all of the remaining OUs except for the EMMA OU. Under the Executive Order 12580, DA is responsible for the five-year review of the EMMA OU. The MAOU was completed in 1998. The remaining six Operable Units are in various stages of site investigation and/or construction completion.

PCBOU: U.S. EPA signed the ROD for the PCBOU at the Crab Orchard Site on August 1, 1990. This OU consists of four sites totaling approximately fifty acres. Cleanup activities for PCBs, lead, and cadmium-contaminated soil meeting the requirements of the ROD were completed in July 1997. Approximately 117, 000 tons of PCB-contaminated soil were incinerated. Incinerator ash containing hazardous levels of lead and cadmium were stabilized and disposed of in an on-site engineered landfill. Further investigation at the site indicated the presence of elevated levels of chlorinated solvents including trichloroethylene in groundwater at the site. On June 23, 2001, U.S. EPA issued an Explanation of Significant Differences (ESD) to the PCBOU ROD to address the groundwater contamination at the site. The ESD selected multi-phase extraction of chlorinated solvents, with limited phytoremediation and monitored natural attenuation as the remedial technology. Because most of the cleanup activities meeting the ROD requirements were finished in 1997, U.S. EPA completed the first five-year review of this OU in September 2000. Currently, preliminary design activities to meet the requirements of the ESD are in progress.

EMMA OU: U.S. EPA and the Department of the Army (DA) signed a ROD for the EMMA OU on February 1997. The ROD selected excavation and off-site disposal of contaminated soils containing explosives and lead, and capping at two sites. In addition, the DA conducted removal

activities to address unexploded ordnance at the Crab Orchard Site. The response included surveying and excavation for unexploded ordnance over 20 acres and reforestation of 83 acres to eliminate intrusive land use activities. Both the remedial and removal activities at the EMMA OU Sites are complete. The DA is in the process of finalizing a remedial action completion report.

MISC OU: An RI/FS conducted to investigate thirteen sites as part of the MISC OU within the Crab Orchard Site concluded that three of the sites (Sites 14, 22A, and 36) required cleanup. The DOI conducted a removal action in 1996 to address pentachlorophenol/dioxin-contaminated soil at Site 22A. Site 14 is a former industrial site where soil and groundwater are contaminated primarily with toluene, ethylbenzene, xylene, and methylene chloride. U.S. EPA and the DOI are expected to sign a ROD for Site 14 before September 30, 2001. Site 36 is an existing wastewater treatment area within the Crab Orchard Site. The site's primary contaminants are PCBs, cadmium, and chromium. The ROD for Site 36 and other no further action sites within the MISC OU is expected to be signed before the end of 2001.

Water Towers OU: The DOI conducted a removal action to address lead contamination in soil in the vicinity of three water towers within the Crab Orchard Site. In addition, DOI also conducted a removal action to address lead contamination in soil near the Visitors Center of the Crab Orchard Refuge. One of the water towers (Water Tower No. 3) is scheduled for removal in 2002. Removal action to address lead contamination in soil at this water tower will be addressed after the removal of the Water Tower No. 3.

AUS OU: DOI is in the process of completing a Preliminary Assessment and Site Investigation (PA/SI) by the end of September 2001. The purpose of the PA/SI is to screen out sites that pose little or no potential threat to human health and the environment and to retain sites that warrant further remedial investigation.

LMOU: DOI is in the process of completing a Preliminary Screening Analysis (PSA) Report for the Lake Monitoring OU by the end of September 2001. The purpose of the PSA is to screen out areas that pose little or no potential threat to human health and the environment and to retain areas that may warrant further monitoring or investigation.

This five-year review pertains only to MAOU. Future five-year reviews will include all seven OUs at the Crab Orchard Site. The following is the background information for the MAOU Site:

The MAOU includes the following three study sites investigated in the 1988 RI Report:

Plating Pond Area (also known as Site 15)
Fire Station Landfill (also known as Site 29)
Old Refuge Shop Area (also known as Site 22)

Figure 1 shows the locations of the above sites.

Site 15 - Plating Pond: This pond was designated a plating pond during the 1988 RI, but the source of the contamination was not established. It was probably constructed and used for a few years during the 1970s, to accept liquid waste from a manufacturing operation in Area 7. The pond was approximately 50 feet long and 30 feet wide. Water depth was estimated at 4 feet at the time of the RI, resulting in approximately 45,000 gallons of water in the pond. Sediment sampling from the Plating Pond indicated the presence of chromium, with other organic and inorganic contaminants of less concern found in the sediments, pond water and groundwater. The RI estimated 280 cubic yards of contaminated pond sediment and underlying soil.

Site 29 - Fire Station Landfill: The Fire Station Landfill was a dump used by industrial tenants during the 1960s and probably also during the 1950s. It was located on the east side of Route 148, across from the Shop Area, near the former Refuge Fire Station. The Fire Station Landfill was L-shaped, with leg dimensions of about 300 feet in the east-west direction and 150 feet in the north-south direction. The width of the legs was estimated at 75 feet, and the thickness of fill was estimated to range from about 2 to 7 feet. The RI (1988) estimated 14,600 cubic yards of contaminated soil Results of the 1988 RI indicated that the area was contaminated with lead (960 to 2,355 mg/kg), mercury (0.023 to 0.29 mg/kg), and zinc (23 to 929 mg/kg) above background. Results of the groundwater investigation indicated the presence of iron (388 to 4,000 µg/L), manganese (43 to 1,790 µg/L), and selenium (not-detect to 41µg/kg total). The dissolved levels of selenium were, however, below its MCL (50µg/L). The primary contaminant of concern was lead.

Site 22 - Old Refuge Shop: The Old Refuge Shop Channel was contaminated with wastes from a plating operation in the former shop area. The channel was contaminated with cadmium, chromium, lead and cyanide from the shop area to Pigeon Creek, a distance of about 4,450 feet. The RI (1988) estimated 5,200 cubic yards of contaminated soil and sediment. Sediments in the drainage channel flowing toward Pigeon Creek were contaminated with cadmium (less than 0.68 mg/kg to 780 mg/kg), chromium (10 to 889 mg/kg), cyanide (130 to 392 mg/kg), and lead (93 to 166 mg/kg). In general, the levels were highest near the drainage sump at the upstream end of the site and decreased downstream. Groundwater in one well showed cadmium (25 µg/L) above its MCL of 5 Mg/L.

Additional investigation conducted during remediation indicated the presence of contamination in many of the ditches and the connecting network of an underground storm drain system upgradient of the channel in an area known as the West Shop Area (Figure 1). The boundaries of the Old Refuge Shop Area were extended during remediation to address this upgradient source. This extended portion was named "West Shop Area". Results of the investigation indicated that the sediments in the inlet structures of the storm sewers were contaminated with cadmium (7.8 to 1300 mg/kg) and that the surficial soil in the drainage ditches were contaminated with cadmium levels ranging from 1.5 to 618 mg/kg.

IV Remedial Actions

A. Remedy Selection

U.S. EPA signed the ROD for the MAOU at the Crab Orchard Site on March 30, 1990. The selected remedy included:

- Excavation of contaminated soil and sediments;
- Treatment by stabilization/fixation of all excavated soil and sediment contaminated with metals (if determined to be RCRA hazardous because of the metals leachability) to render them non-hazardous;
- On-site disposal of non-RCRA hazardous stabilized/fixed material and untreated residues exceeding the cleanup targets in a landfill meeting the requirements of RCRA Subtitle D and 35 Illinois Administrative Code Part 807; and
- Environmental monitoring during and after remedial construction to ensure the effectiveness of the remedial action.

In addition, the ROD required the four sites to be remediated to the following cleanup levels:

- Lead to 450 mg/kg dry soil at the Fire Station Landfill
- Cadmium to 10 mg/kg dry soil at the Old Refuge Shop
- Chromium to background levels at the Plating Pond; (background levels for chromium established at 30.7 mg/kg)
- Old Refuge Shop: Risk from all of the chemical contaminants present above naturally occurring background levels in the soil and sediment shall not exceed an excess cancer risk of one in one million (10^{-6}) and shall not exceed any non-cancer chronic health effects.
- Discharge standards for the pond water (Plating Pond) and for water from the drainage stream (Old Refuge Shop Area) will be established to comply with the effluent standards and water quality standards of the Clean Water Act and State requirements.
- Old Refuge Shop and Fire Station Landfill: Groundwater shall be monitored during and after remediation of the sites. The monitoring results shall be evaluated to assure that after completion of the remediation of the contaminated soils and sediments, the risk from all of the contaminants in the groundwater above naturally occurring background

levels shall not exceed an excess cancer risk of one in one million (10^{-6}) and shall not exceed any non-cancer chronic health effects.

B. Remedy Implementation

The remedial design process for the MAOU was started in October 1990 and completed in March 1993 by FWS. As part of the remedial design and during remedial implementation activities, several site investigations and studies were conducted. These investigations included the following:

- Quantification Investigation to delineate extent, quantify the volumes of material requiring excavation, and to determine background concentrations of metals in the soils at the Refuge.

- Treatability Study to identify appropriate treatment processes to render the hazardous waste materials non-hazardous by Toxicity Characteristic Leaching Procedure.

- Disposal Site Investigation to obtain the data necessary for the design of the landfill and groundwater monitoring system.

- Groundwater Impact Assessment to confirm that the landfill would not have an adverse impact on groundwater.

- West Shop Area investigation to determine the extent of contamination in the storm sewers, drainage, and a suspected source beyond and upstream of the boundaries of the Old Refuge Shop Channel.

The U.S. Army Corps of Engineers (USACE), on behalf of DOI, awarded the contract to Heritage Remediation (Heritage) for implementation of the remedial action at the Metals Areas Operable Unit. Heritage began the construction activities on May 12, 1994 and completed the construction of the on-site landfill disposal cell in August 1994. In accordance with the design, on-site clay soil was used for the three-foot thick clay liner. The leachate collection system, composite liner, and layer of select fill material were constructed. During the remedial investigation activities of the Miscellaneous Areas OU in early 1994, dioxin and pentachlorophenol-contaminated soil was detected within the Old Refuge Shop site. Heritage refused to work with dioxin-contaminated soil at the Old Refuge Shop area. Their contract was subsequently terminated in August 1994. No waste material was placed in the cell at that time. The landfill cell was seeded to help prevent erosion, and left till the following year. In February 1995, USACE awarded the remaining portion of the work to a new contractor, R&R International. R&R International began the construction activities in August 1995 and completed in September 1996.

C. Excavation of Contaminated Soil and Sediments

Plating Pond: Excavation commenced in February 1996 and was completed in March 1996. Approximately, 194 cubic yards of chromium contaminated soil was excavated from the Plating Pond area and disposed of in the on-site landfill. Confirmatory samples were taken to ensure that cleanup levels were met. The excavated area was restored to a pond. Grading and seeding were completed in August 1996.

Fire Station Landfill: Excavation commenced in November 1995 and was completed in March 1996. Approximately, 552 cubic yards of lead contaminated material (determined to be RCRA hazardous because of metals leachability) was excavated, stabilized to render it non-hazardous, and disposed of in the on-site landfill. Approximately, 9310 cubic yards of excavated untreated (non-hazardous) material was also disposed of in the on-site landfill. Confirmatory samples were taken to ensure that cleanup levels were met. The excavated area was backfilled with clean soil. Grading and seeding were completed in July 1996.

Old Refuge Shop: Excavation commenced in August 1995 and was completed in December 1995. The contaminants of concern included cadmium, chromium, lead, and cyanide. Approximately, 10,635 cubic yards of contaminated material (determined to be RCRA hazardous because of metals leachability) was excavated, stabilized to render it non-hazardous, and disposed of in the on-site landfill. Approximately, 11,980 cubic yards of excavated untreated (non-hazardous) material was also disposed of in the on-site landfill. Confirmatory samples were taken to ensure that cleanup levels were met. The excavated areas were backfilled with clean soil. Grading and seeding were completed in July 1996.

West Shop Area: Prior to remediating the soil and sediments at the West Shop Area, the storm water system was cleaned by vacuum methods and flushed. Subsequently, this system was sealed closed. Excavation commenced in January 1996 and was completed in March 1996. The contaminants of concern included cadmium, chromium, lead, and cyanide. Approximately, 1,621 cubic yards of contaminated material (determined to be RCRA hazardous because of metals leachability) was excavated, stabilized to render it non-hazardous, and disposed of in the on-site landfill. Approximately, 2,067 cubic yards of untreated (non-hazardous) material was disposed of in the on-site landfill. Confirmatory samples were taken to ensure that cleanup levels were met. Excavated areas were backfilled with clean soil. Grading and seeding were completed in June 1996.

D. Metals Areas Landfill

The ROD required the disposal of nonhazardous stabilized/fixed material and untreated residues exceeding the cleanup targets in an on-site landfill meeting the requirements of RCRA Subtitle D and 35 Illinois Administrative Code Part 807. The on-site landfill was constructed in the Northwest corner of the intersection of Ogden and Fishpond Roads. At the time of the ROD signature, March 30, 1990, the Illinois solid waste landfill requirements were codified as 35 IAC

807. Subsequently, Illinois State promulgated new landfill requirements (i.e., 35 IAC 810 through 815). FWS complied with substantive requirements of this newly promulgated requirements by conducting a Groundwater Impact Assessment of the Metals Areas Landfill. The landfill construction commenced in May 1994 and was completed in September 1996. The total volume of treated and untreated (non-hazardous) material from the three study sites (i.e., Plating Pond Area, Fire Station Landfill, and the Old Refuge Shop Area) was approximately 36,359 cubic yards.

In addition, DOI conducted a removal action at Site 22A, which was part of the Miscellaneous Areas Operable Unit. Under this removal action, approximately 6,400 cubic yards of dioxin/furan and pentachlorophenol-contaminated soil was excavated from Site 22A and disposed of in the Metals Areas Landfill.

E. Operation and Maintenance

Remediated Study Sites

FWS has been conducting periodic inspections of the remediated sites to verify the condition of vegetation and identify erosion damage to the remediated sites. In 1998, FWS took corrective action to repair gullies, place protective erosion matting, and install water flow checks at the eastern part of the Old Refuge Shop Channel.

FWS conducted groundwater monitoring at both the Fire Station Landfill and the Old Refuge Shop areas during the time frame of 1996 - 1998. The monitoring results were evaluated to assure that after completion of the remediation of the contaminated soils and sediments, the risk from all of the contaminants in the groundwater above naturally occurring background levels do not exceed an excess cancer risk of one in one million (10^{-6}) and do not exceed any non-cancer chronic health effects.

Metals Areas Landfill

FWS is implementing long term O&M activities to ensure that the components of the remedy which require maintenance for proper functioning are maintained for the protection of human health and the environment. Maintenance of the integrity of the remedy is implemented primarily through the quarterly and annual inspections of the landfill, and implementation of required maintenance identified during inspections. O&M requirements include:

- Landfill Cover: Quarterly visual inspection and minor repairs as necessary of the landfill cover.
- Earthwork: Quarterly inspection for surface diversions upgradient of the landfill.
- Mowing: Twice yearly mowing of the landfill and surrounding areas.
- Erosion Damage: Quarterly visual inspections for erosion damage to the landfill and repairs as necessary.

- Animal Barrier: Quarterly inspections to verify that no borrowing or digging has occurred into the top of the landfill.
- Settlement/Subsidence: Quarterly visual inspection of the entire landfill and perimeter for excessive settlement.
- Quarterly inspection of the vegetation within the landfill limits; repairs, as necessary, including removal of deep rooted or woody vegetation, and revegetation of any bare areas.
- Drainage Ditch/Outlets Repair: Quarterly inspection of the landfill drainage ditches.
- Site Fencing: Quarterly inspection to ensure that the fencing has not been damaged.
- Leachate Collection Piping: Cleaning of the leachate collection piping on an annual basis.

V. Five-Year Review Process

The Sangamo Electric/ Crab Orchard National Wildlife Refuge five-year review was led by Nan Gowda, Remedial Project Manager for the Sangamo Electric/Crab Orchard National Wildlife Refuge. The following team members assisted in the review:

- Paul Lake, Remedial Project Manager, Illinois EPA
- Elaine L. Moore, CERCLA Project Coordinator, U.S. Fish & Wildlife Service
- Matthew Vick, U.S. Fish and Wildlife Service

This five-year review included a review of all relevant documents (see Attachment A), interview with FWS representatives, and a site inspection. This completed report is available in the information repository. Notice of its completion will be placed in the local newspaper and local contacts will be notified by letter.

VI. Five-Year Review Findings

A. Interviews

The following individuals were contacted as part of the five-year review:

B. Elaine L. Moore, CERCLA Coordinator, Fish and Wildlife Service

C. Matthew Vick, Biologist, Fish Wildlife Service (Interviewed April 26, 2000)

Both Ms. Moore and Mr. Vick stated that there were some minor erosion problems noted at the Metals Areas Landfill. Leachate levels at the Metals Areas Landfill are checked on a quarterly basis and leachate removed and disposed of as necessary.

B. Site Inspection

Representatives of U.S. EPA, Illinois EPA and Fish and Wildlife Service took part in a site inspection on April 26, 2000. During the site inspection, remediated sites and the Metals

Areas Landfill were inspected. Conditions during the inspections were favorable with mild temperatures and no precipitation.

Inspections of the remediated sites indicated signs of erosion of the backfilled areas. FWS is currently implementing erosion control measures.

Metals Areas Landfill: The landfill cap was generally found to be in good condition. The vegetative cover was thorough and abundant, with no distressed areas, trees or shrubs. No noticeable depressions, excessive cracks, leachate seeps, odors, or other indications of distress were noted. The fence which surrounds both the PCB and the Metals Areas Landfills is in good shape. All monitoring wells were in good condition. With the exception of minor erosion problems, no intrusive activities were noted on the cover system and no landfill waste or other contaminants were exposed or appeared to be exposed. As part of the maintenance, FWS personnel will address any erosion problems at the Metals Areas Landfill.

C. Risk Information Review

The following standards were identified as applicable or relevant and appropriate requirements (ARARs) in the ROD. They were reviewed for changes that could affect protectiveness:

Surface Water Discharge

- Clean Water Act: 40 CFR Parts 122.41 and 122.44

Excavation of Soil and Sediment

- Resource Conservation and Recovery Act (RCRA), Subtitle C: 40 CFR 262.34; 264, Subparts B, C, G, I, J, and L; 40 CFR 268; and any more stringent State of Illinois equivalent provisions of 35 IAC Part 724)
- Clean Air Act: 40 CFR 50.6 and 50.12

Stabilization/Fixation

- RCRA Subtitle C: 40 CFR 268; 40 CFR Subparts I, J, L or X; and must meet any more stringent regulatory design standards of the State of Illinois 35 IAC 724

Clean Air Act: 40 CFR 50.6 and 50.12

Disposal or Decontamination of Equipment

- RCRA Subtitle C: 40 CFR 264.114; and must meet any more stringent regulatory decontamination or disposal standards of the State of Illinois 35 IAC 724

Industrial Landfill or Caps

- RCRA Subtitle D: 40 CFR 241, Subpart B and must meet any more stringent technical regulations of the State of Illinois 35 IAC Part 807.

Backfill Excavation

- Clean Air Act: 40 CFR 50.6

Monitoring and Maintenance

- RCRA Subtitle C: 40 CFR Subpart F

- RCRA Subtitle D: 40 CFR 241.204; and must meet any more stringent technical regulations of the State of Illinois 35 IAC 807

Personal Protection

- Occupational Safety and Health Act (OSHA): 29 CFR 1910.120 and Subparts C, D, E, and P

Remediation Goals

- Crab Orchard Enabling Legislation (16 U.S.C. 666f and g)

- National Wildlife Refuge Administration Act (16 U.S.C. 668 dd)

Standards for the contaminants of concern have not become more stringent since the signing of the ROD in 1990, except for Illinois State's new landfill regulations 35 IAC 810 through 815, which superceded 35 IAC 807. These changes do not affect the protectiveness, because DOI complied with the substantive requirements of the State of Illinois' newly promulgated landfill requirements 35 IAC 810 through 815.

There were no changes in either the Chemical-Specific or Action Specific ARARs.

D. Data Review

Soil Remediation

A review of records and monitoring reports through July, 2000, indicates the following:

- Approximately, 36,359 cubic yards of metal contaminated soil and sediments were excavated, stabilized as necessary, and disposed in an on-site landfill. An additional 6,400 cubic yards of pentachlorphenol and dioxin contaminated soil from Site 22A, part of the Miscellaneous Areas Operable Unit, was disposed in the landfill.

- Study sites, Sites 22 and 29, are remediated to less than 450 mg/kg lead and 10 mg/kg cadmium. Study site 15 is remediated to less than 30.7 mg/kg chromium.

- The previous West Shop Area investigations and remediation done under the Metals Area Operable Unit, were confined mostly to the ditches and sewers surrounding the buildings at the West Shop Area. Except for the former dry cleaning building, the areas immediately surrounding the buildings had not been investigated. These areas along with the rest of the West Shop area were included in the AUS OU Site Inspection (SI). Review of preliminary information for the AUS OU SI show elevated concentrations of metals including cadmium, chromium, lead, mercury, and zinc at the former dry cleaning building in Area 4. These areas are being addressed as part of the AUS OU and no further discussion is made in this report.

- The on-site disposal landfill was constructed in accordance with the substantive requirements of the State of Illinois' newly promulgated landfill requirements 35 IAC 810 through 815.

Groundwater Monitoring Results

The ROD required monitoring of groundwater at the Fire Station Landfill and the Old Refuge Shop sites. Groundwater samples were collected from August 1996 through March 1998, and in February 2001. Results of the groundwater monitoring (1996 - 1998) at the Fire Station Landfill and Old Refuge Shop Sites are summarized in Tables 2 and 3, respectively. Groundwater samples collected in August 1996 and August 1997 were analyzed for volatile organic compounds (VOCs), semi-volatile compounds (SVOCs), PCBs/pesticides, and metals. No VOCs, SVOCs, or PCBs/pesticides were detected during these sampling events. Therefore, groundwater samples collected in March 1998 and February 2001 were analyzed only for metals.

Fire Station Landfill (Site 29)

Three post-remediation groundwater monitoring wells (RA-29-1, RA-29-2, and RA-29-3) were installed in 1996. RA-29-1 is the upgradient well. Results of the February 2001 groundwater monitoring are summarized in Table 4. Locations of the monitoring wells are shown

in Figure 2. These results indicated the presence of several inorganic compounds including aluminum, arsenic, bārium, chromium, lead, manganese, selenium, and zinc. The results show a significant reduction in contaminant levels when compared with the groundwater monitoring results conducted in 1996, 1997, and 1998. Aluminum levels have decreased from 421,000 ppb in 1996 to 5230 ppb. Arsenic levels have decreased from 67.2 ppb in 1997 to 5.81 ppb (below its MCL of 50 ppb). Barium levels have decreased from 4,590 ppb in 1996 to 52.2 ppb (below its MCL of 2000 ppb). Chromium levels have decreased from 808 ppb in 1996 to 21.4 ppb (below its MCL of 100 ppb). Lead levels have decreased from 232 ppb in 1996 to 5.5 ppb (below its action level of 15 ppb). Manganese levels have decreased from 23,500 ppb in 1996 to 136 ppb. Zinc levels have also decreased from 3,040 ppb in 1996 to 26.7 ppb. Although selenium levels have increased from 2.6 ppb in 1997 to 10.6 ppb, these levels are well below the MCL of 50 ppb.

Old Refuge Shop (Site 22)

Five post-remediation groundwater monitoring wells (RA-22-1, RA-22-2, RA-22-3, RA-22-4, RA-22-5) were installed in 1996. Monitoring well RA-22-1 is the upgradient well. Results of the February 2001 groundwater monitoring are summarized in Table 4. The locations of the monitoring wells are shown in Figure 2. These results indicated the presence of several inorganic compounds including aluminum, arsenic, barium, cadmium, chromium, lead, manganese, selenium, thallium, and zinc. The results show a significant reduction in contaminant levels when compared with the groundwater monitoring results conducted in 1996, 1997, and 1998. Aluminum levels have decreased from 308,000 ppb in 1996 to 8,840 ppb. Arsenic levels have decreased from 92.6 ppb in 1997 to 6.9 ppb (below the MCL of 50 ppb). Barium levels have decreased from 5,260 ppb in 1996 to 180 ppb (below the MCL of 2,000 ppb). Cadmium levels have decreased from 4.6 ppb in 1997 to 1.0 ppb (below the MCL of 5 ppb). Chromium levels have decreased from 491 ppb in 1996 to 15.2 ppb (below the MCL of 100 ppb). Lead levels have decreased from 133 ppb in 1996 to 6.9 ppb (below the action level of 15 ppb). Manganese levels have decreased from 62,300 ppb in 1996 to 13,100 ppb. Selenium levels have decreased from 8.1 ppb in 1997 to 5.4 ppb (slightly above the MCL of 5 ppb). Zinc levels have decreased from 1,260 ppb to 23.1 ppb. Thallium was detected at 12.7 ppb in one of the downgradient monitoring wells RA-22-4 (above the MCL of 2 ppb). Thallium was not detected in any of the other four monitoring wells.

Metals Areas Landfill Leachate and Groundwater Monitoring

The Post Remedial Action Monitoring Report (April 2001) presents the results of leachate and groundwater monitoring results. The leachate sample collected in November 1999 from the MAOU landfill was analyzed for VOCs, Semi-VOCs, PCBs/Pesticides, and metals. There were no VOC, Semi-VOCs, PCB/Pesticides detected in the leachate sample. Concentrations of all metals for which Illinois Class I Groundwater Standards have been established were below those standards, except for cadmium, iron, and manganese. Cadmium was detected at 0.0052 mg/l, compared to the Class I Groundwater Standard of 0.005 mg/l. Iron was detected at 8.77 mg/l,

compared with the Class I Groundwater Standard of 5.0 mg/l. Manganese was detected at 4.04 mg/l, compared with the Class I Groundwater Standard of 0.150 mg/l. These concentrations are considered to be within the statistical background concentration at the landfill.

Leachate samples were also collected in June 2001 and analyzed for metals. Results of the June 2001 leachate samples are shown in Table 5. Concentrations for all metals, with the exception of Iron and Manganese, were below the Illinois State Class I Groundwater Standards. Iron and manganese were detected at 9180 ppb and 4070 ppb compared with the Class I Groundwater Standards of 5000 ppb and 150 ppb, respectively.

Groundwater samples at the Metals Area OU landfill were collected in June 2001 and analyzed for metals and cyanide. The locations of the landfill monitoring wells are shown in Figure 3. Results of the June 2001 groundwater monitoring are shown in Table 5. With the exception of antimony, none of the metals exceeded their respective MCLs/action levels, or the Illinois Class I Groundwater Standards. Antimony was detected at only one monitoring well NL2A-1 at a concentration of 9.2 ppb above its MCL of 6.0 ppb.

Metals Area Landfill Leachate Disposal

FWS continues to monitor the leachate level in the landfill sump on a quarterly basis. Leachate has accumulated in the landfill sump above the maximum allowed one-foot level. FWS obtained a provisional variance from the Illinois Pollution Control Board in September, 1998 and April, 1999 that allowed the leachate to be pumped into the Refuge sewer system. Approximately, 90,000 gallons of leachate was removed and discharged to the WWTP over the two 45 day variance periods. The leachate level was at that time below the level requiring removal. A NPDES permit modification for the refuge WWTP was completed January 2000. Landfill leachate will be discharged to the system and monitored as an internal outfall in accordance with the NPDES permit. Subsequent to the January, 2000 permit, monitoring results for iron and manganese have been above permit standards. FWS has disposed of leachate through transport to the Metropolitan St. Louis Sewer District.

Summary of Data Review

In summary, all contaminants of concern at Sites 15, 22, and 29, including lead, cadmium, and chromium, have been remediated to the cleanup levels required by the ROD. The results of groundwater monitoring indicate a significant reduction in contaminant concentrations in groundwater at the remediated sites with the exception of Thallium which was detected (12.7 ppb) in one of the downgradient wells at the Old Refuge Shop Site. Currently, groundwater at the Crab Orchard National Wildlife Refuge is not being used for drinking water purposes. The remediated sites do not pose any unacceptable risk to the human health or the environment. The results of the on-site landfill groundwater monitoring are within the statistical range of background groundwater concentrations.

VII. Assessment

The following conclusions support the extent to which the remedy selected in the ROD for the Metals Areas OU remains protective of human health and environment:

- **Implementation of Institutional Controls and Other Measures:** The landfill is restricted to public access. The landfill is located within the closed area, fenced, and posted with signs restricting access to the public. There are no planned changes in land use at the remediated sites. Access to these areas remains closed to the public, except for limited access to workers at the industrial sites and restricted access to hunters.

- **Remedial Action Performance:** The landfill cover system has been effective in isolating waste and contaminants as supported by leachate and groundwater concentrations. Concentrations in the leachate and groundwater are within acceptable concentrations indicating no adverse impacts.

- **Operation and Maintenance:** Leachate elevation levels at the MAOU Landfill are above the maximum allowed level. Leachate must be continued to be removed and disposed to reduce the leachate level in the landfill. Sample results indicate no adverse impacts to groundwater quality.

- **Opportunities for Optimization:** There has been no significant or consistent detection of volatile organic compounds or semi-volatile organic compounds. Based on these findings, the monitoring program may be altered to eliminate parameters and reduce frequency of monitoring. There were no noticeable erosions problems at the landfill.

- **Changes in Standards:** This five-year review identified Illinois State's new landfill regulations 35 IAC 810 through 815, which had been promulgated since the ROD was signed. However, these changes do not affect the protectiveness, because DOI complied with the substantive requirements of the State of Illinois' newly promulgated landfill requirements 35 IAC 810 through 815.

- **Changes in Exposure Pathways:** No contaminated soil or sediments above cleanup levels remain at the remediated sites. The decrease of contaminant levels in groundwater at the site indicate the remediation is successful in restoring groundwater to its potential beneficial use.

- **Changes in Risk Assessment Methodologies:** Changes in the risk assessment methodologies since the time of the ROD do not call into question the protectiveness of the remedy since all contaminants of concern were removed from the remediated sites.

No additional information has been identified that would call into question the protectiveness of the remedy.

VIII. Deficiencies

Based on a preliminary investigation conducted as part of AUS OU, elevated levels of cadmium, chromium, and lead may be present at a former dry cleaning building near the West Shop Area.

VIII. Recommendations and Required Actions

No recommendation is necessary since the former dry cleaning building area is currently being investigated as part of the AUS OU.

IX. Protectiveness Statements

The protectiveness of human health and the environment by the remedial actions at the MAOU are discussed below. No lead, cadmium, or chromium-contaminated soil or sediments are present above cleanup levels at any of the remediated sites. The MAOU Landfill is effective in containing the waste and contaminants. The remedial actions at Sites 15, 22, and 29 are expected to be protective of human health and the environment.

X. Next Review

This is a statutory site that requires on going five-year reviews. The next review will be conducted within five years of the completion of this five-year report and will address all OUs at the site. The completion date is the date of the signature shown on the signature cover attached to the front of the report.

XI. Other Comments

The Crab Orchard Site consists of a total of seven operable units. In addition to this report for the Metals Areas OU, U.S. EPA has completed a five-year review of the PCB OU in September 2000. The remaining five operable units are in various stages of investigation and/or construction completion. Future Five-Year Reports will include all seven operable units.

Table 2. Groundwater Monitoring Results for the Fire Station Landfill (1996-1998).

Monitoring Well	RA-29-1	RA-29-1	RA-29-1	RA-29-1	RA-29-2	RA-29-2	RA-29-2	RA-29-3	RA-29-3	RA-29-3	RA-29-3
Sampling Date	08/20/1996	08/07/1997	08/07/1997	03/05/1998	08/21/1996	08/07/1997	03/05/1998	08/21/1996	08/07/1997	03/05/1998	03/05/1998
Target Compounds/Analytes			(Duplicate)								Duplicate
Volatile Organic Compounds											
Chloromethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Bromomethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Vinyl Chloride (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Chloroethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Methylene Chloride (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Acetone (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Carbon Disulfide (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,1-Dichloroethene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,1-Dichloroethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,2-Dichloroethene (total) (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Chloroform (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,2-Dichloroethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
2-Butanone (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,1,1-Trichloroethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Carbon Tetrachloride (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Bromodichloromethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,2-Dichloropropane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
cis-1,3-Dichloropropene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Trichloroethene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Dibromochloromethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,1,2-Trichloroethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Benzene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
trans-1,3-Dichloropropene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Bromoform (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
4-Methyl-2-pentanone (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
2-Hexanone (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Tetrachloroethene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,1,2,2-Tetrachloroethane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Toluene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Chlorobenzene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Ethylbenzene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Styrene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Xylene (total) (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Semivolatile Organic Compounds											
Phenol (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
bis(2-Chloroethyl)ether (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
2-Chlorophenol (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,3-Dichlorobenzene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
1,4-Dichlorobenzene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA

Table 2. Groundwater Monitoring Results for the Fire Station Landfill
(1996-1998).

Monitoring Well	RA-29-1	RA-29-1	RA-29-1	RA-29-1	RA-29-2	RA-29-2	RA-29-2	RA-29-3	RA-29-3	RA-29-3	RA-29-3
Sampling Date	08/20/1996	08/07/1997	08/07/1997	03/05/1998	08/21/1996	08/07/1997	03/05/1998	08/21/1996	08/07/1997	03/05/1998	03/05/1998
Target Compounds/Analytes			(Duplicate)								Duplicate
Pesticides/PCBs											
gamma-Chlordane (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Toxaphene (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Aroclor-1016 (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Aroclor-1221 (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Aroclor-1232 (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Aroclor-1242 (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Aroclor-1248 (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Aroclor-1254 (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Aroclor-1260 (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Inorganics											
Cyanide (ug/L)	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND
Silver (ug/L)	ND	ND	ND	NA	ND	ND	NA	2.5J	67.2	NA	NA
Aluminum (ug/L)	20400J	22700	23200	NA	421000	50500	NA	ND	ND	NA	NA
Arsenic (ug/L)	5.8J	13.5	14.1	NA	ND	39.1	NA	2.5J	67.2	NA	NA
Barium (ug/L)	449	412	443	NA	4590	465	NA	47.6	806	NA	NA
Beryllium (ug/L)	ND	1.3	1.4	NA	30.3	4.1	NA	ND	7.2	NA	NA
Calcium (ug/L)	92400	112000	122000	NA	370000	50500	NA	33600	188000	NA	NA
Cadmium (ug/L)	ND	ND	ND	1.0	ND	ND	2.0	ND	1.5	0.73	0.66
Cobalt (ug/L)	19.5	18.8	20.8	NA	464	82.9	NA	ND	99.4	NA	NA
Chromium (ug/L)	99.2	74.4	78.2	79.9	808	127	67.4	35.5	167	40.8	49.2
Copper (ug/L)	67.7	58.2	64.2	NA	858	105	NA	ND	174	NA	NA
Iron (ug/L)	43000	43400	46100	NA	1220000	109000	NA	8280	207000	NA	NA
Mercury (ug/L)	ND	ND	ND	NA	0.68	ND	NA	ND	ND	NA	NA
Potassium (ug/L)	4780	5920	5900	NA	33300	7300	NA	1570	12100	NA	NA
Magnesium (ug/L)	34600	43000	46300	NA	272000	33400	NA	16400	114000	NA	NA
Manganese (ug/L)	1580	1440	1690	NA	23500	2990	NA	123	4970	NA	NA
Sodium (ug/L)	117000	123000	118000	NA	96800	69800	NA	74900	89100	NA	NA
Nickel (ug/L)	ND	65.4	71.4	NA	1100	211	NA	ND	232	NA	NA
Lead (ug/L)	16.6	19.0J	20.0J	13.6	232	56.8J	37.8	2.6J	97.3J	19.6	20.4
Antimony (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Selenium (ug/L)	ND	ND	ND	NA	ND	2.6	NA	2.3J	ND	NA	NA
Thallium (ug/L)	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	NA
Vanadium (ug/L)	55.4	56.4	60.4	NA	913	132	NA	ND	190	NA	NA
Zinc (ug/L)	118	114	125	NA	3040	297	NA	23.6	618	NA	NA

NA = Not Analyzed
ND = Not Detected
J = Estimated
R = Rejected

Table 3: Groundwater Monitoring Results for the Old Refuge Shop Site

(1996 - 1998)

Monitoring Well	RA-22-1	RA-22-1	RA-22-1	RA-22-2	RA-22-2	RA-22-2	RA-22-2	RA-22-3	RA-22-3	RA-22-3	RA-22-4	RA-22-4	RA-22-4	RA-22-5	RA-22-5	RA-22-5
Sampling Date	08/20/1996	08/07/1997	03/05/1998	08/20/1996	08/20/1996 (Duplicate)	08/07/1997	03/04/1998	08/20/1996	08/07/1997	03/04/1998	08/20/1996	08/07/1997	03/04/1998	08/20/1996	07/30/1997	03/04/1998
Target Compounds/Analytes																
Volatile Organic Compounds																
Chloromethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Bromomethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Vinyl Chloride (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Chloroethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Methylene Chloride (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Acetone (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Carbon Disulfide (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,1-Dichloroethene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,1-Dichloroethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,2-Dichloroethene (total) (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Chloroform (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,2-Dichloroethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
2-Butanone (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,1,1-Trichloroethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Carbon Tetrachloride (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Bromodichloromethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,2-Dichloropropane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
cis-1,3-Dichloropropene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Trichloroethene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Dibromochloromethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,1,2-Trichloroethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Benzene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
trans-1,3-Dichloropropene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Bromoform (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
4-Methyl-2-pentanone (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
2-Hexanone (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Tetrachloroethene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,1,2,2-Tetrachloroethane (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Toluene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Chlorobenzene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Ethylbenzene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Styrene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Xylene (total) (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Semivolatile Organic Compounds																
Phenol (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
bis(2-Chloroethyl)ether (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
2-Chlorophenol (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,3-Dichlorobenzene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,4-Dichlorobenzene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
1,2-Dichlorobenzene (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
2-Methylphenol (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
2,2'-oxybis(1-Chloropropane) (ug/L)	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA

Table 3: Groundwater Monitoring Results for the Old Refuge Shop Site

(1996 - 1998)

Monitoring Well	RA-22-1	RA-22-1	RA-22-1	RA-22-2	RA-22-2	RA-22-2	RA-22-2	RA-22-3	RA-22-3	RA-22-3	RA-22-4	RA-22-4	RA-22-4	RA-22-5	RA-22-5	RA-22-5
Sampling Date	08/20/1996	08/07/1997	03/05/1998	08/20/1996	08/20/1996	08/07/1997	03/04/1998	08/20/1996	08/07/1997	03/04/1998	08/20/1996	08/07/1997	03/04/1998	08/20/1996	07/30/1997	03/04/1998
Target Compounds/Analytes					(Duplicate)											
Inorganics																
Cyanide (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver (ug/L)	6.2UJ	0.60U	NA	3.1UJ	ND	ND	NA	ND	ND	NA	ND	0.98	NA	ND	ND	NA
Aluminum (ug/L)	308000	125000	NA	102000	9520	62300	NA	127000	107000	NA	56100	33800	NA	52000	96200	NA
Arsenic (ug/L)	14.2J	92.6	NA	7.8J	3.1J	41.7	NA	42.8J	81.8	NA	17.6J	17.6	NA	9.2J	32.2	NA
Barium (ug/L)	5260	2240	NA	614J	74.7J	398	NA	751	755	NA	1410	1370	NA	460	866	NA
Beryllium (ug/L)	ND	7.8	NA	ND	ND	5.4	NA	ND	6.9	NA	ND	2.2	NA	ND	4.0	NA
Calcium (ug/L)	423000	345000	NA	225000	142000	271000	NA	196000	211000	NA	112000	101000	NA	46200	52200	NA
Cadmium (ug/L)	ND	3.6	5.0	ND	ND	3.2	0.53	ND	1.2	1.6	ND	1.7*	2.2	ND	4.6	0.75*
Cobalt (ug/L)	232	103	NA	115J	ND	84.1	NA	60.6	64.4	NA	40.8	52.0	NA	ND	37.6	NA
Chromium (ug/L)	491	216	159	262J	38.4J	119	10.0	183	163	33.7	93.9	57.0	28.0	79.0	165	26.9
Copper (ug/L)	408	224	NA	168J	ND	115	NA	155	176	NA	79.9	70.9	NA	46.3	103	NA
Iron (ug/L)	581000	255000	NA	265000J	21500	170000	NA	190000	175000	NA	73100	53400	NA	56800	109000	NA
Mercury (ug/L)	0.57	ND	NA	0.18	ND	ND	NA	0.26	ND	NA	0.17	ND	NA	0.10	ND	NA
Potassium (ug/L)	28400	18500	NA	13500J	3740J	10800	NA	10800	12100	NA	6500	4350	NA	5310	9520	NA
Magnesium (ug/L)	222000	168000	NA	167000	12400	184000	NA	157000	168000	NA	62300	61400	NA	27900	37100	NA
Manganese (ug/L)	15400	7030	NA	5250J	954J	3960	NA	5040	6450	NA	9630	17500	NA	1200	2980	NA
Sodium (ug/L)	327000	328000	NA	162000	155000	146000	NA	168000	169000	NA	150000	136000	NA	138000	128000	NA
Nickel (ug/L)	565	262	NA	282J	ND	167	NA	178	191	NA	118	95.6	NA	63.3	132	NA
Lead (ug/L)	133	126J	76.0	73.5J	2.8J	55.2J	ND	111	91.0J	20.1	48.0	31.9J	16.2	32.6	55.2	10.0
Antimony (ug/L)	14.4R	ND	NA	15.7J	14.4R	ND	NA	14.4R	ND	NA	14.4R	ND	NA	14.4R	ND	NA
Selenium (ug/L)	18.0R	ND	NA	9.0R	1.8R	ND	NA	18.0R	ND	NA	1.8R	2.4	NA	1.8R	8.1	NA
Thallium (ug/L)	7.5UJ	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA
Vanadium (ug/L)	657	280	NA	247J	27.9J	143	NA	260	210	NA	128	69.8	NA	108	197	NA
Zinc (ug/L)	1260	645	NA	1010J	79.3J	698	NA	498	529	NA	196	150	NA	167	350	NA

NA = Not Analyzed
ND = Not Detected
J = Estimated
R = Rejected

Table 4: Groundwater Monitoring Results for the Old Refuge Shop and Fire Station Landfill Sites
(February 2001)

Monitoring Well	RA-22-1	RA-22-2	RA-22-3	RA-22-4	RA-22-5	RA-29-1	RA-29-2	RA-29-2	RA-29-3
Sampling Date	02/15/01	02/15/01	02/15/01	02/15/01	02/15/01	02/15/01	02/15/01	02/15/01	02/15/01
								(Duplicate)	
Inorganics									
Aluminum	452	4070	948	8840	1760	506	2860	5230	908
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	6.4	6.9	ND	ND	5.8	ND
Barium	61.6	36.1	33.4	180	46.4	81.7	37	52.2	45.5
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	1	ND	0.6	ND	ND	ND	ND	ND
Calcium	117000	209000	166000	93600	34000	70200	149000	148000	26700
Chromium	15.2	12	10.4	15.2	4.6	6.5	12	21.4	6.1
Cobalt	ND	3.6	ND	20.8	ND	ND	2.2	3	ND
Copper	62.8	23.7	19.6	42.8	13.7	24.9	66.1	73.8	15.4
Cyanide, Total	ND	ND	ND	ND	ND	ND	ND	ND	ND
Iron	273	5020	513	18500	1310	425	3530	7190	935
Lead	3.2	ND	ND	6.9	ND	ND	3.8	5.5	ND
Magnesium	62000	204000	145000	56500	15300	27100	83900	83400	14400
Manganese	208	304	1060	13100	38.4	78.6	78.5	136	13.8
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	10.8	13.2	14.7	28.1	5.2	10.4	10	16.6	7.8
Potassium	1880	2850	1750	2420	623	1530	1930	2700	992
Selenium	ND	ND	ND	5.4	4.7	ND	9.5	7.2	10.6
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	384000	125000	184000	143000	110000	127000	112000	111000	56300
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	3.1	9.7	3.3	15.8	5	2.4	7.1	11.9	3.3
Zinc	11.4	23.1	7.5	31.4	7.8	18.4	15.5	26.7	6.2

ND = Not detected
All units in UG/L

Table 5: Landfill Leachate and Groundwater Monitoring Results
(June 2001)

Monitoring Well	NL-2A-1	NL-2A-2	NL-2A-3	NL-2A-4	NL-2A-5	NL-2A-5	NL-2A-6	NL-2A-7	NL-2A-8	Leachate
Sampling Date	06/06/01	06/06/01	06/06/01	06/06/01	06/06/01	06/06/01	06/06/01	06/06/01	06/06/01	06/06/01
						Duplicate				
Inorganics (ug/l)										
Aluminum	250	283	371	228	528	434	408	946	489	56.1
Antimony	9.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	5.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	39.5	57.7	44.4	71.1	54	51	39.4	47.1	52.5	23.3
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	0.69	ND	0.87	ND	ND	ND	ND	ND	ND
Calcium	69800	59400	24700	90000	77600	74800	45400	26700	48600	366000
Chromium	1.8	1.7	1.5	6.6	2.9	2.6	1.3	3.4	1.3	2.2
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.2
Copper	8.9	9	15.3	10.1	9.8	12.6	10.1	19.6	12	4.1
Iron	43.3	246	258	145	434	312	309	772	347	9180
Lead	ND	2.7	ND	ND	ND	ND	ND	1.7	ND	ND
Magnesium	28100	23900	13400	43700	26700	25300	16400	13400	20400	107000
Manganese	6.6	8.4	4	18.8	10.2	9.3	6.4	13.9	9.2	4070
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	3.7	ND	ND	ND	ND	ND	9.1
Potassium	ND	ND	ND	1520	ND	ND	ND	ND	ND	6290
Selenium	ND	ND	ND	ND	1.8	1.4	ND	ND	ND	1.4
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	38600	39900	29100	83500	52800	50200	21700	48300	26800	533000
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	ND	ND	ND	ND	1.9	ND	ND
Zinc	3.1	10.1	4.9	27.4	13	4.4	8.3	7	14.2	2.8
Cyanide, Total	ND	ND	ND	ND	ND	ND	ND	ND	ND	160

ND = Not detected
All units in UG/L

Figure 1. Location of the Plating Pond, Fire Station Landfill, Old Refuge Shop, and the Metals OU Landfill.

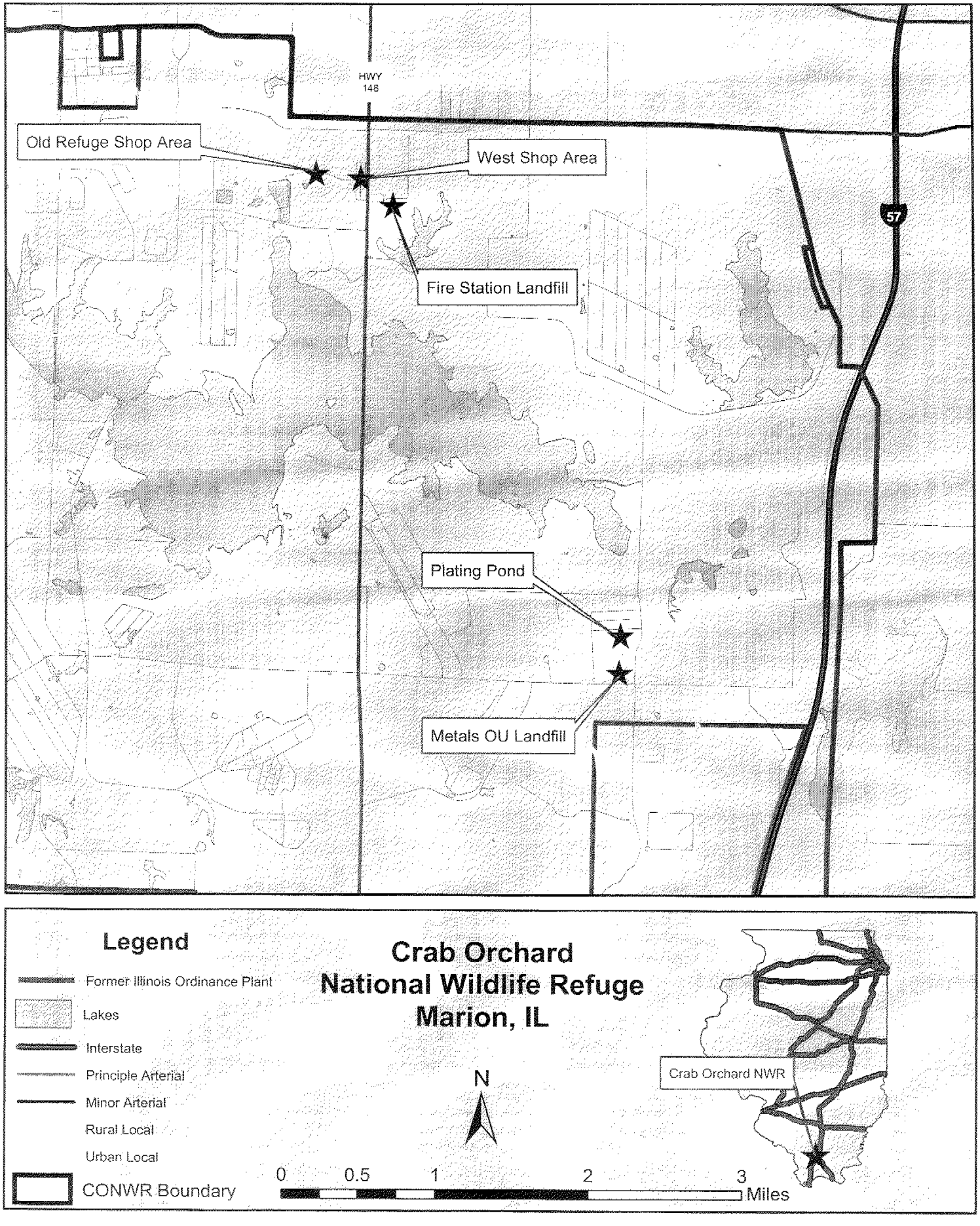


Figure 2. Location of Fire Station and Old Refuge Shop Groundwater Monitoring Wells.

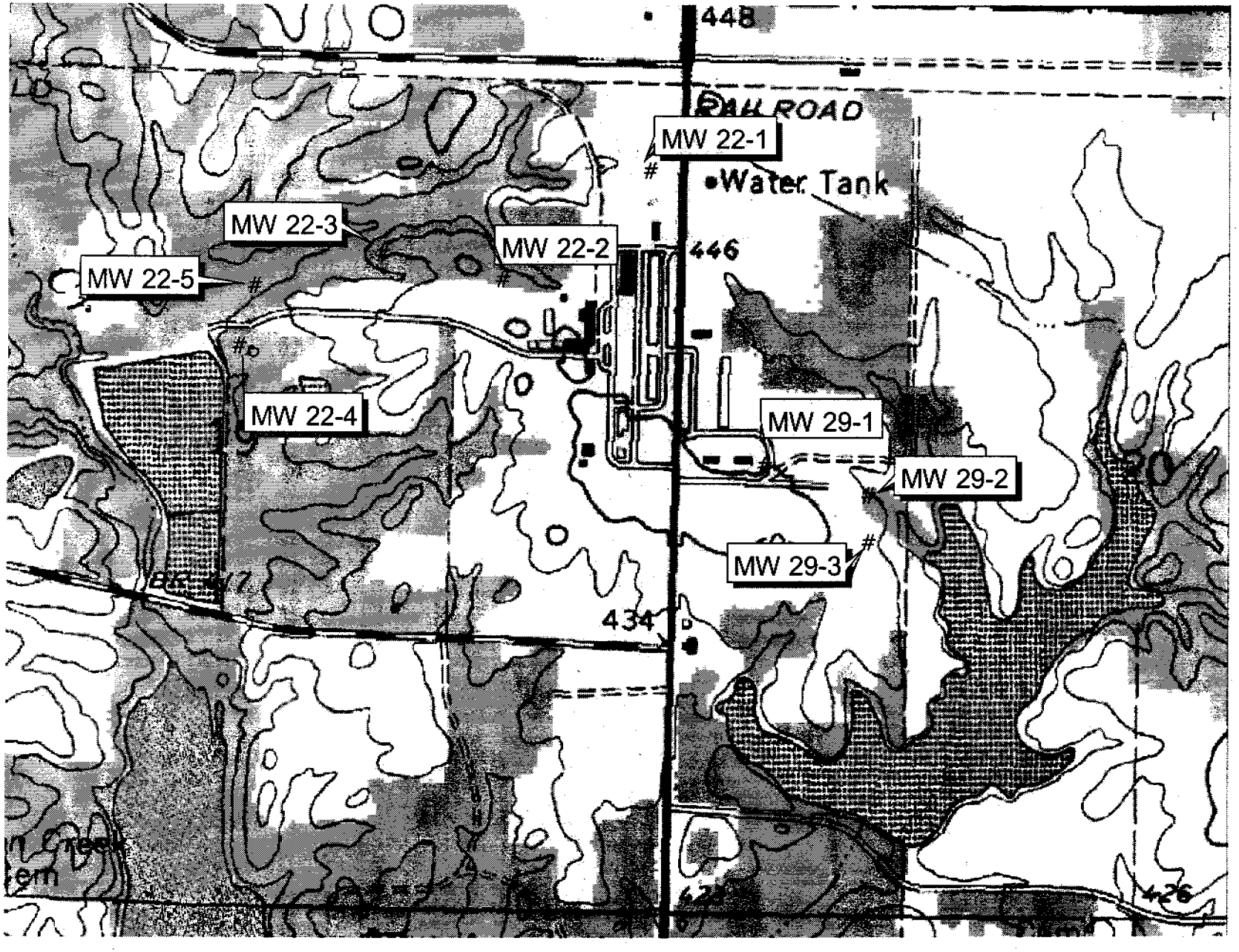
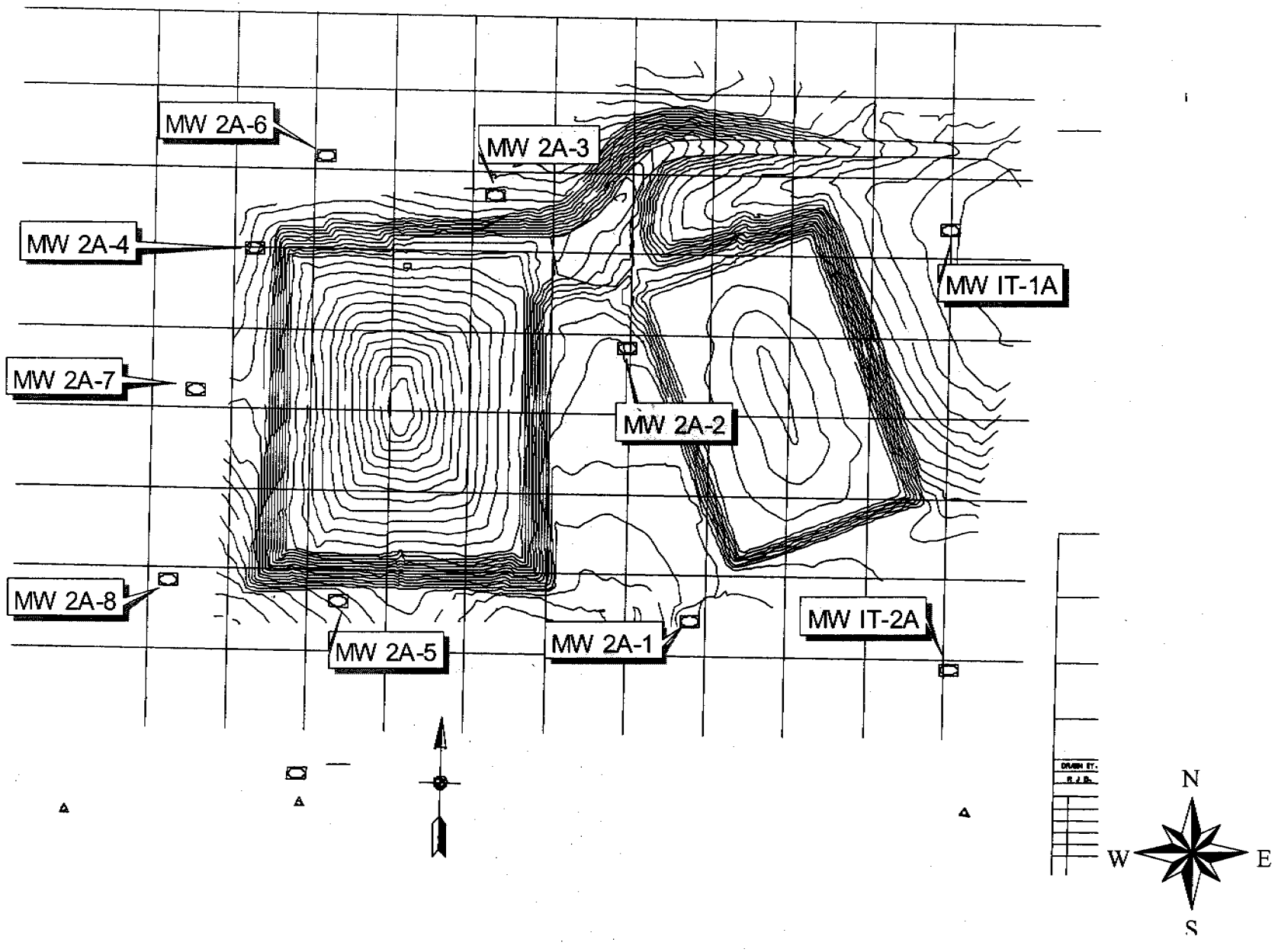


Figure 3 - Location of Metals Area Landfill Groundwater Monitoring Wells.



Attachment A

List of Documents Reviewed

(All documents pertain to Crab Orchard National Wildlife Refuge Superfund Site)

Remedial Investigation Report by O'Brien & Gere (August 1988)

Feasibility Study Report by O'Brien & Gere (August 1989)

Record of Decision for the Metals Areas Operable Unit (March 30, 1990)

Federal Facilities Agreement (September 1991)

Closeout Report for the Metals Areas Operable Unit (February 1997)

Post Remedial Action Monitoring Report for the Metals Areas Operable Unit (April 2001)