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Final
Work Plan
for
Operable Unit 3
Remedial Investigation/Feasibility Study

Naval Industrial Reserve
Ordnance Plant
Fridley, Minnesota

Volume I of IV

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 0003

June 1997

FINAL
WORK PLAN
FOR
OPERABLE UNIT 3
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT
FRIDLEY, MINNESOTA

VOLUME I OF IV

REVISION 2
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ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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PREFACE

This Work Plan (WP) describes the Remedial Investigation (RI)/Feasibility Study (FS) Field Investigation for Operable Unit 3 at the Naval Industrial Reserve Ordnance Plant (NIROP) located in Fridley, Minnesota. The WP is composed of four volumes. Volume I is the Work Plan, Volume II is the Field Sampling Plan (FSP), Volume III is the Quality Assurance Project Plan (QAPP), and Volume IV is the Site Security and Health and Safety Plan (SS and HASP). This WP was prepared by Brown & Root Environmental (B&R Environmental) for the United States Department of the Navy (Navy).

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ACRONYMS/ABBREVIATIONS

1,1-DCA	1,1-dichloroethane
AF	Adherence Factor
AOC	Area of Concern
ARARs	Applicable, Relevant, and Appropriate Requirements
B&R Environmental	Brown & Root Environmental
BW	Body Weight
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action, Navy
COC	Contaminant Of Concern
COPC	Chemical of Potential Concern
cPAHs	Carcinogenic polyaromatic hydrocarbons
CTO	Contract Task Order
DCE	dichloroethene
DNAPL	dense nonaqueous-phase liquid
DQO	Data Quality Objective
ED	Exposure Duration
EF	Exposure Frequency
FFA	Federal Facilities Agreement
FIG	Franconia/Ironton/Galesville
FMC	FMC Corporation
FOL	Field Operations Leader
FS	Feasibility Study
FSP	Field Sampling Plan
GOCO	Government-owned, contractor-operated
HBV	Health Based Value
HNUS	Halliburton NUS
HRL	Health Risk Limit
HSM	Health and Safety Manager
IAS	Initial Assessment Study
IR	Installation Restoration
IR	Intake Rate
MCES	Metropolitan Council Environmental Service
MCL	Maximum Contaminant Level
MEK	Methyethylketone
MHF	Mount Simon/Hinckley/Fond du Lac
MPCA	Minnesota Pollution Control Agency
NACIP	Navy Assessment and Control of Installation Pollutants
NAVFACENGCOM	Naval Facilities Engineering Command
Navy	United States Department of the Navy
NEESA	Naval Energy and Environmental Support Activity
NIROP	Naval Industrial Reserve Ordnance Plant
NOD	Northern Ordnance Division
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List

ACRONYMS/ABBREVIATIONS (Continued)

OU	Operable Unit
OU1	Operable Unit 1
OU2	Operable Unit 2
OU3	Operable Unit 3
PCB	Polychlorinated Biphenyl
PCE	tetrachloroethene
PCJ	Prairie du Chien/Jordan
PID	Photoionization Detector
POC	Point of Contact
PRG	preliminary remediation goal
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Remedial Action
RAB	Restoration Advisory Board
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMT	RMT, Inc.
ROD	Record of Decision
RPM	Remedial Project Manager
SA	Surface Area
SCS	Soil Conservation Service
SP	poorly graded sand
SS and HASP	Site Security and Health and Safety Plan
SSO	Site Safety Officer
SWMU	Solid Waste Management Unit
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TOM	Task Order Manager
TRC	Technical Review Committee
U.S. EPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	United States Geological Survey
VOC	Volatile Organic Compound
WP	Work Plan

1.0 INTRODUCTION

1.1 AUTHORIZATION

This Work Plan for the Naval Industrial Reserve Ordnance Plant (NIROP) Fridley Operable Unit 3 (OU3) Remedial Investigation/Feasibility Study (RI/FS) was prepared by Brown & Root Environmental (B&R Environmental) for Contract Task Order (CTO) 0003, under Comprehensive Long-term Environmental Action Navy (CLEAN), Contract Number N62467-94-D-0888.

1.2 REASONS FOR THE RI/FS

The RI/FS is a requirement of the Federal Facilities Agreement (FFA), dated March 27, 1991, between the Minnesota Pollution Control Agency (MPCA), the United States Environmental Protection Agency (U.S. EPA), and the United States Department of the Navy (Navy).

1.3 GOALS OF THE RI/FS PROCESS

As stated in Section IV, page 3 of Attachment A to the FFA, "the purposes of RIs are (1) to identify all sources of contamination; (2) to identify the extent and magnitude of soil, subsoil, surface water, and ground water contamination; (3) to gather all necessary data to support the FS and Risk Assessment, and (4) to provide information and data needed for the selection and implementation of response actions at the Site".

As stated in Section V, page 11 of Attachment A to the FFA, "the purpose of Feasibility Studies are to evaluate the feasibility and effectiveness of implementing alternative Response Actions at the Site."

1.4 ORGANIZATION OF WORK PLAN

The RI/FS Work Plan is presented as four separate volumes composing a single document. The four volumes are the Work Plan (Volume I), Field Sampling Plan (Volume II), Quality Assurance Project Plan (Volume III), and Site Security and Health and Safety Plan (Volume IV). Material that is duplicated in the outlines of each volume is referenced to one location rather than repeated.

The Work Plan outline is based on Table 2-3, Suggested RI/FS Work Plan Format from U.S. EPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, October 1988, OSWER Directive 9355.3-01, as specified in the FFA. The Work Plan (Volume I) is organized as follows:

- Section 1.0 provides a general explanation of the reasons for the RI/FS and the expected results or goals of the RI/FS process.
- Section 2.0 provides the current understanding of the physical setting of the site, the site history, and the existing information on the condition of the site.
- Section 3.0 presents the conceptual site model describing the potential migration and exposure pathways and the preliminary assessment of human health and environmental impacts.
- Section 4.0 presents the data requirements for the RI/FS, and the work plan approach is presented to illustrate how the activities will satisfy data needs.
- Section 5.0 presents the tasks to be performed during the RI/FS.
- Section 6.0 presents the project schedule.
- Section 7.0 provides the names and responsibilities of project team members.

The Field Sampling Plan (Volume II) outline is based on covering the elements specified in the Draft U.S. EPA Region V Model QAPP (latest guidance), as specified in the FFA. The Field Sampling Plan (Volume II) is organized as follows:

- Section 1.0 presents a summary of the planned sampling activities.
- Section 2.0 presents the sampling network design and rationale.
- Section 3.0 presents sample custody procedures. The laboratory custody procedures and final evidence files subsections are referenced to and presented in Section 5.2 and 5.3 of the Quality Assurance Project Plan (Volume III), respectively.

- Section 4.0 presents sample container, preservation, maximum holding time, and volume requirements.

- Section 5.0 presents sample handling, packaging, and shipment procedures.

- Section 6.0 presents decontamination procedures.

- Section 7.0 presents sampling equipment and procedures.

- Section 8.0 presents field-related quality control sample procedures.

- Section 9.0 presents field measurement/screening procedures.

- Section 10.0 presents field instrument preventive maintenance and field corrective action procedures.

- Section 11.0 presents sample disposal procedures.

The Quality Assurance Project Plan (Volume III) outline is based on the Draft U.S. EPA Region V Model QAPP (latest guidance), as specified in the FFA. The Quality Assurance Project Plan (Volume III) is organized as follows:

- Section 1.0 presents a project description, including an introduction, site/facility description and history, project objectives, sample network design and rationale, and project schedule. The site/facility description and history are referenced to and presented in Section 2.0 of the Work Plan (Volume I). A portion of the project objectives (Data Quality Objectives) is referenced to and presented in Section 4.1 of the Work Plan. The sample network design and rationale is referenced to and presented in Section 2.0 of the Field Sampling Plan (Volume II). The project schedule is referenced to and presented in Section 6.0 of the Work Plan.

- Section 2.0 presents the project organization and personnel responsibilities. This information is referenced to and presented in Section 7.0 of the Work Plan.

- Section 3.0 presents the quality assurance objective for measurement data in terms of precision, accuracy, completeness, representativeness, and comparability.

- Section 4.0 presents sampling procedures. This information is referenced to and presented in the Field Sampling Plan (Volume II).

- Section 5.0 presents custody procedures. The field custody procedure subsection is referenced to and presented in Section 3.1 of the Field Sampling Plan (Volume II).

- Section 6.0 presents calibration procedures and frequency. The field instrument calibration subsection is referenced to and presented in Section 9.1 of the Field Sampling Plan (Volume II).

- Section 7.0 presents analytical and measurement procedures. The field analytical and measurement procedures subsection is referenced to and presented in Section 9.2 of the Field Sampling Plan (Volume II).

- Section 8.0 presents internal quality control checks. The field QC checks subsection is referenced to and presented in Section 8.0 of the Field Sampling Plan (Volume II).

- Section 9.0 presents data reduction, validation, and reporting.

- Section 10.0 discusses field and laboratory audits.

- Section 11.0 presents preventive maintenance. The field instrument preventive maintenance subsection is referenced to and presented in Section 10.1 of the Field Sampling Plan (Volume II).

- Section 12.0 presents specific routine procedures used to assess data precision, accuracy, and completeness.

- Section 13.0 discusses corrective action during field investigations, laboratory analyses, data validation, and data assessment. The field corrective action subsection is referenced to and presented in Section 10.2 of the Field Sampling Plan (Volume II).

- Section 14.0 discusses quality assurance reports to management.

The Site Security and Health and Safety Plan (Volume IV) outline is based on (1) OSHA requirements 29 CFR Part 1910 (General and Emergency Response; Interim Final Rule), (2) OSHA requirements 29 CFR Part 1910 (General Industry Standards) and 1926 (Construction Industry Standards), and (3) OSHA Guidance Manual for Hazardous Waste Activities, NIOSH/OSHA/USOG/EPA, DHHS (NIOSH) Publication Number 85-115, October, 1985 as specified in the FFA. The Site Security and Health and Safety Plan (Volume IV) is organized as follows:

- Section 1.0 presents the project organization and personnel assignments. This information is referenced to and presented in Section 7.0 of the Work Plan (Volume I).
- Section 2.0 presents the emergency action plan.
- Section 3.0 presents the current site status. This information is referenced to and presented in Section 2.6 of the Work Plan (Volume I).
- Section 4.0 presents the scope of work. This information is referenced to and presented in Section 2.0 of the Field Sampling Plan (Volume II).
- Section 5.0 presents the tasks/hazards/associated control measures summarization.
- Section 6.0 presents the chemical and physical hazard assessment.
- Section 7.0 discusses air monitoring.
- Section 8.0 discusses training and medical surveillance requirements.
- Section 9.0 discusses site control.
- Section 10.0 discusses the spill containment program.
- Section 11.0 discusses confined-space entry procedures.
- Section 12.0 discusses materials and documentation.

2.0 SITE BACKGROUND AND SETTING

This section presents the current understanding of the physical setting of the site, the site history, and the existing information on the condition of the site. Existing data are used to develop a site description, which includes location, ownership, topography, geology, land use, and other pertinent details. The site description includes a chronology of significant events such as chemical storage and disposal practices, previous site visits, sampling events, regulatory violations, legal actions, and changes in ownership.

2.1 LOCATION

The NIROP Fridley is located in the City of Fridley, on the southernmost tip of Anoka County, Minnesota (Figure 2-1). The plant is situated approximately one-quarter mile east of the Mississippi River and less than 1 mile south of Interstate 694.

2.2 FACILITY OWNERSHIP

NIROP Fridley dates back to 1940 when Northern Pump Company negotiated with the Navy for the construction of a new manufacturing plant on approximately 83 acres of land situated in the northern portion of the Minneapolis-St. Paul metropolitan area. Northern Pump had been under contract to the Navy throughout the 1930s. These defense contracts eventually reached a level where Northern Pump's existing plant in Minneapolis was inadequate. When Northern Pump received a contract from the Navy to produce 100 five-inch gun mounts, the move to a new manufacturing plant was needed (Envirodyne, June 1983).

The arrangement to construct the new plant was unique in that the plant was partially owned by the government and partially by Northern Pump Company. NIROP Fridley was the first Government-owned, Contractor-operated (GOCO) facility. The site chosen for the plant was a cornfield just north of the Minneapolis city limits, within the Township of Fridley, as shown on Figure 2-1. The new plant was completed in just 60 days with machinery, office equipment, and records moved intact by flat car from the old plant. By January 1941, the plant was in full production (Envirodyne, June 1983). Figure 2-2 shows the layout of the NIROP facility.

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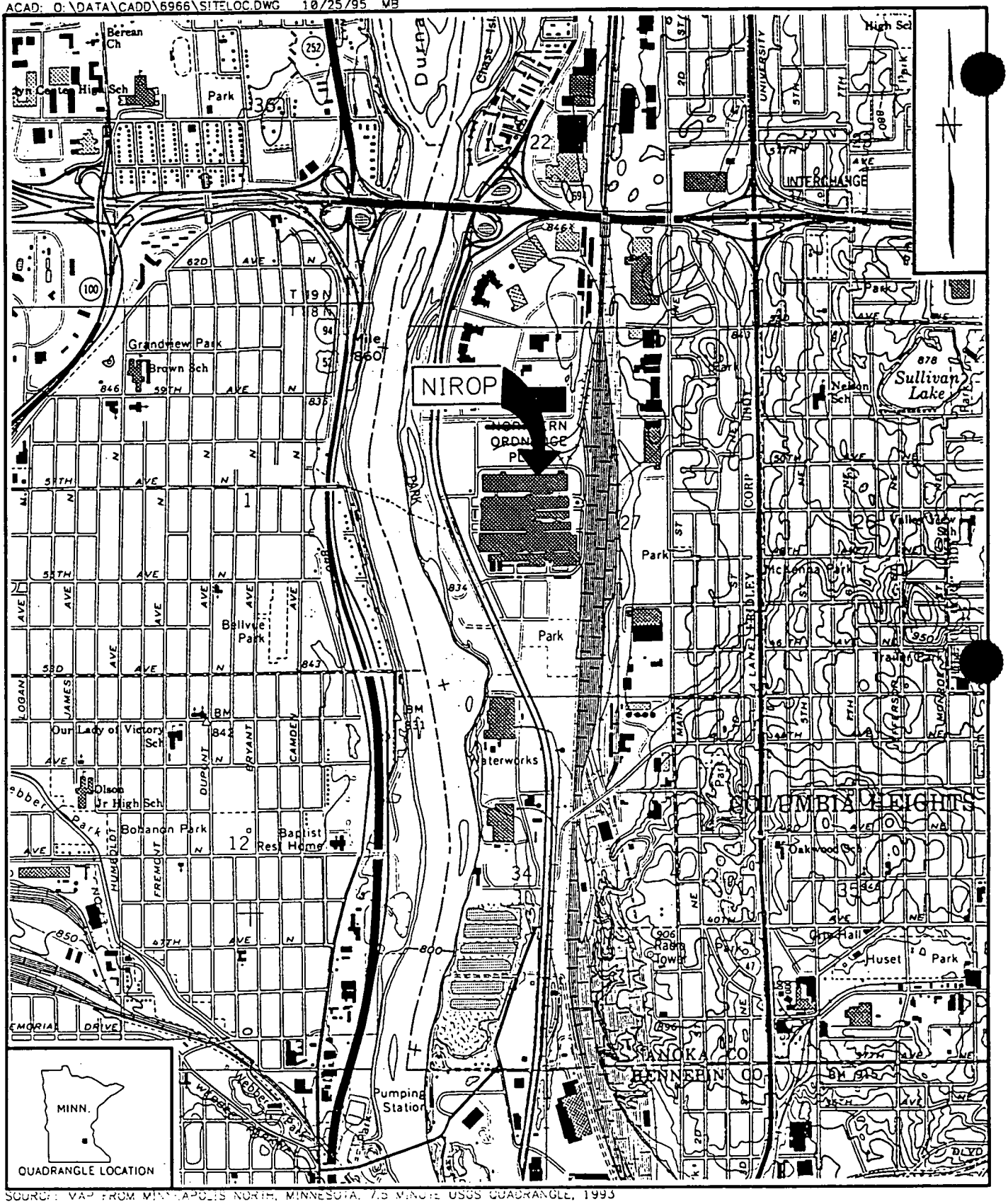

SOURCE: MAP FROM MINNEAPOLIS NORTH, MINNESOTA, 7.5 MINUTE USGS QUADRANGLE, 1993

SITE LOCATION MAP
NIROP, FRIDLEY
FRIDLEY, MINNESOTA

0 2000 4000
SCALE IN FEET

FIGURE 2

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CTO 0003

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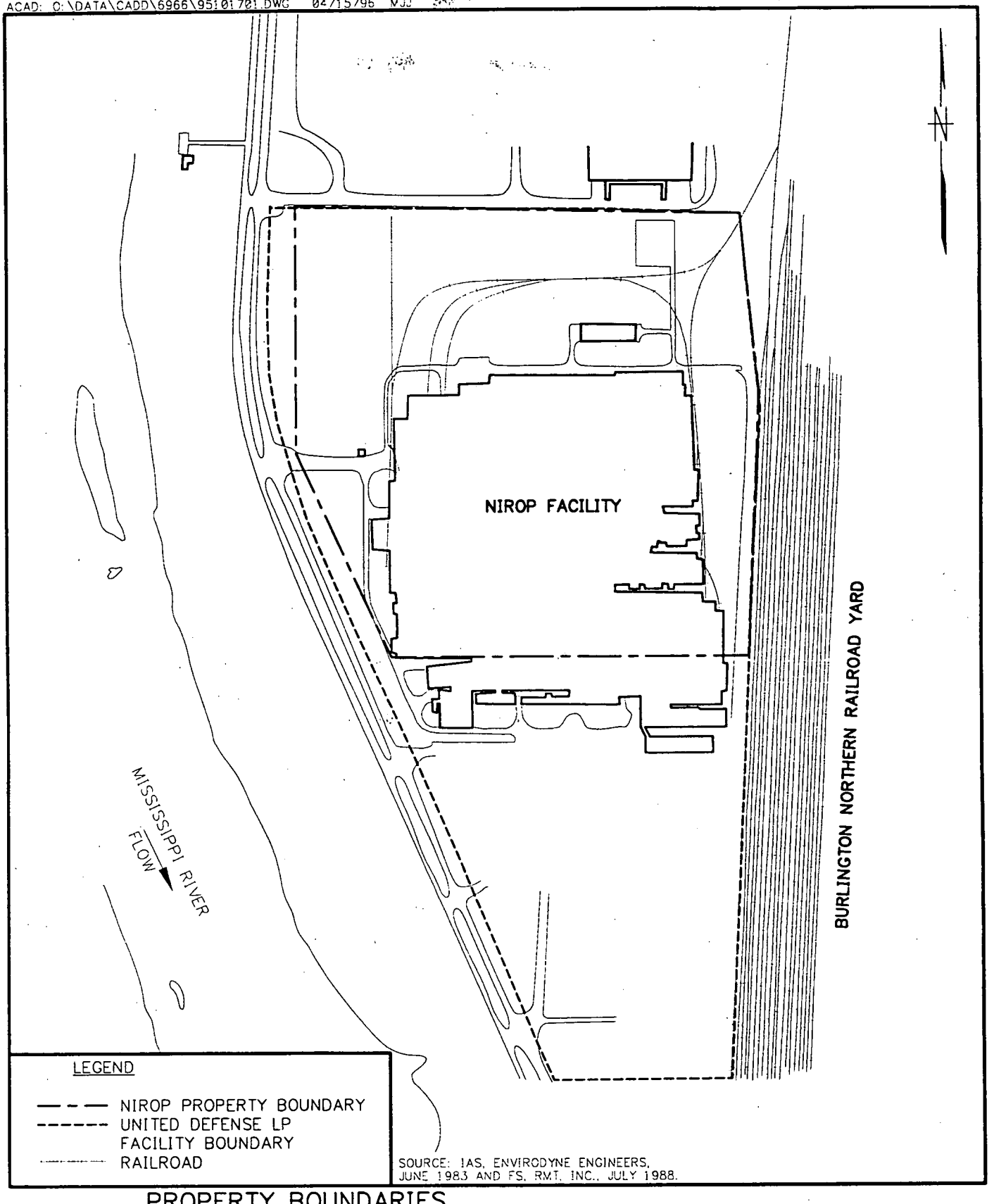

PROPERTY BOUNDARIES

NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT

FRIDLEY, MINNESOTA

0 600 1200

SCALE IN FEET

FIGURE 2-2

Brown & Root Environmental

CTO 0003

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In June of 1942, Northern Pump Company established Northern Ordnance, Incorporated, as an operating subsidiary to conduct the government portion of Northern Pump's business. Thereafter, the facility was often referred to as Northern Ordnance, Inc., and later as Northern Ordnance Division (NOD) (Envirodyne, June 1983).

On January 31, 1964, Northern Ordnance was acquired from Northern Pump Company by FMC Corporation (FMC). Northern Ordnance was assigned divisional status within FMC's Ordnance Group (Envirodyne, June 1983).

The contracted operator is currently United Defense, LP.

2.3 FACILITY SIZE AND BORDERS

The site is currently active and consists of 82.6 acres of government-owned land, of which approximately 50 acres are paved or covered with buildings. The plant is bordered on the east by the Burlington Northern rail yard, on the north by various industrial facilities, on the south by United Defense, LP, and on the west by East River Road (Figure 2-1). The area adjacent to the southern border of the site, approximately 55 acres, is owned by United Defense, LP, the NIROP operator. The United Defense, LP property, U.S. EPA Superfund site Number 17 on Update 6 of the National Priorities List (NPL), is located south of the NIROP site (RMT, July 1988). The area encompassed within a 3-mile radius of the NIROP site includes part of Minneapolis/St. Paul, New Brighton, St. Anthony, and most of Fridley and Brooklyn Center. The NIROP Fridley and adjacent properties to the north, east, and south are zoned heavy industrial. The Anoka County Riverfront Regional Park is located between East River Road and the Mississippi River. The park is a day-use recreation facility on the river's edge, consisting of approximately 60 acres (RMT, September 1993).

2.4 FACILITY OPERATIONS

Production at the NIROP facility began in January 1941. During World War II, the plant was operated in two 12-hour shifts, 365 days a year, producing gun mounts. A production level of about 150 single gun mounts and 20 twin gun mounts per month was eventually reached. During the height of the war, 11,400 people were employed at the plant. By the end of the war, more than 6,000 gun mounts were produced, and the plant had received awards annually from 1941 through 1946 from the Navy for meritorious production (Envirodyne, June 1983).

Following the end of the war, production of gun mounts dropped substantially, and the work force at the plant was reduced to its pre-war level of less than 1,000 employees. The plant undertook various overhaul projects for the Navy and designed a new, dual-purpose, 5-inch, 54-caliber, single gun mount, the Mark 42. This was one of the first fully automated gun mounts in the world. Production of the Mark 42 commenced in 1948 and was the major production activity at the plant for the next 10 years (Envirodyne, June 1983).

During the 1950s, the Navy had demand for new and advanced missile launching systems. Northern Ordnance responded to this need by producing the first automatic guided missile launching system in the world in 1956, the Mark 4. Other missile launching systems--the Mark 7, Mark 10, Mark 13, and Mark 22 - were also produced at the plant. These were all highly reliable shipboard systems designed to store, transfer, warm up, position, and launch the missiles. All of these systems were designed for the "3-T Missiles": Talos, Terrier, and Tarter (Envirodyne, June 1983). During this same period, a series of torpedo launching tubes, the Mark 23, Mark 24, and Mark 25, were produced at the plant (Envirodyne, June 1983).

After FMC Corporation's takeover of Northern Ordnance in 1964, the plant continued to produce gun mounts and advanced missile launching systems. However, there was a shift toward smaller, lighter systems. The plant produced a 5-inch, 54-caliber gun mount, the Mark 45, which was the smallest and lightest 5-inch gun mount in the world. This gun mount was used on the Navy's latest cruisers and destroyers. The Mark 75, which was a fast firing, 76-millimeter, 62-caliber gun mount, was also produced at the plant (Envirodyne, June 1983).

The guided missile launching systems that were produced at the plant in the 1980s, the Mark 13 and Mark 26, were designed for the Navy's newer, smaller class ships. These products are the main launching systems on the Navy's latest frigates, destroyers, and cruisers (Envirodyne, June 1983).

Currently, the mission at the NIROP Fridley facility continues.

There were no major functional changes in the industrial operations at NIROP since the plant was constructed in 1941, although some of the operations were modernized or relocated. The processing, assembly, and manufacturing operations associated with the facility include plating, welding, heat treating, machining, and foundry. Each of these areas (referred to as production areas) is shown on Figure 2-3.

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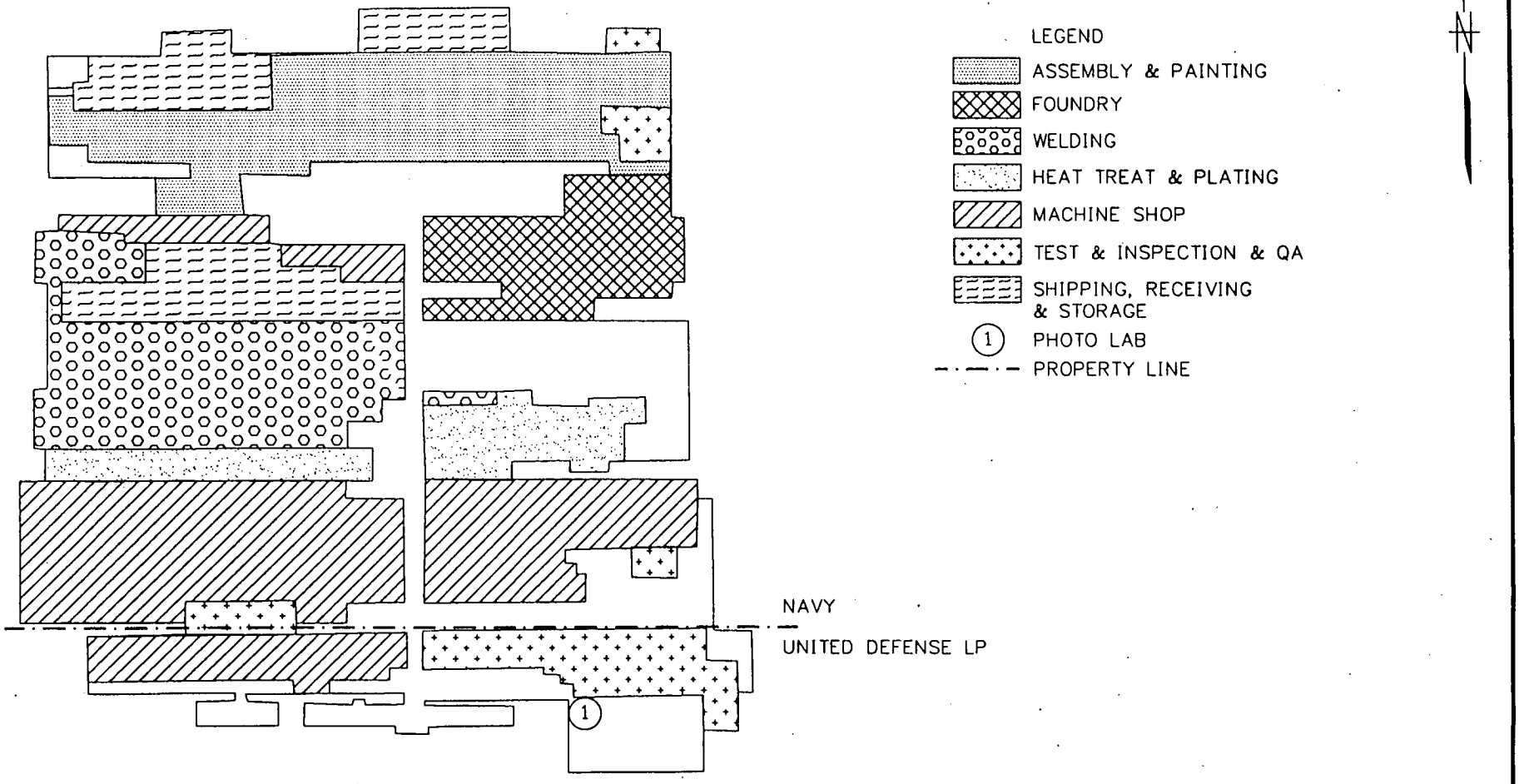

NOTE: LOCATIONS OF THE PRODUCTION AREAS HAVE VARIED OVER TIME. THE DATE OF THE PROCESS AREA LAYOUT SHOWN IS NOT KNOWN.

REFERENCE: REMEDIAL INVESTIGATION REPORT, RMT, JUNE 1987

INDUSTRIAL PROCESS AREAS
WITHIN THE MAIN INDUSTRIAL PLANT BUILDING
NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT
FRIDLEY, MINNESOTA

FIGURE 2-3

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Testing facilities include an electronics laboratory, a metallurgical laboratory, hydraulic test bays, and shock/vibration test equipment (Envirodyne, June 1983).

The plant layout consists of avenues that run west to east and north to south. First through 29th Avenues extend from the southernmost portion of the plant to the northernmost portion. Broadway is the main avenue; it is located in the center of the plant and extends north to south. East of Broadway, building columns are numbered from 1E to 21E, to the west columns are numbered 1W to 29W.

2.5 FACILITY HISTORY

The NIROP Fridley site is divided into three Operable Units (OUs): OU1 addresses groundwater; OU2 addresses soil contamination outside the footprint of the building; and OU3 originally only addressed soil contamination under the footprint of the building. In a letter dated August 30, 1995, the MPCA requested that OU2 be incorporated into OU3 and that contamination sources (e.g., dense nonaqueous phase liquids or DNAPLs) within the saturated zone be added to OU3. The MPCA believes that the best course of action for the site is to proceed in a more holistic approach to investigating and remediating the site. The Navy agreed to this. Therefore, OU3 now includes all sources in the unsaturated and saturated zones.

Previous investigations have identified contaminants of concern (COCs) for OU1 and OU2. COCs identified for OU1 (groundwater) include trichloroethene (TCE), tetrachloroethene (PCE), and 1,2-dichloroethene (1,2-DCE) (RMT, Inc., July 1988). COCs identified for OU2 include toluene, carcinogenic polyaromatic hydrocarbons (cPAHs), ethylbenzene, TCE, PCE, 1,2-DCE, 1,1-dichloroethene (1,1-DCE), 1,1,1-trichloroethane (TCA), and 1,1-dichloroethane (1,1-DCA) (MPCA, January 1995). The following paragraphs and Table 2-1 are chronological summaries of events that have occurred at the NIROP facility from 1940 to the present.

In September 1980, Navy officials implemented the nationwide Navy Assessment and Control of Installation Pollutants (NACIP) program to identify and control environmental contamination from past waste management and disposal practices (U.S. EPA, March 1991).

In March 1981, an anonymous telephone call to the MPCA led to the discovery of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substance TCE in the three NIROP Fridley water supply wells finished in the Prairie du Chien/Jordan Dolomite aquifer. These

TABLE 2-1

CHRONOLOGICAL SUMMARY OF EVENTS
NIROP FRIDLEY, MINNESOTA
PAGE 1 OF 4

Date	Event
1940 - 1941	Naval ordnance manufacturing facility was constructed.
1947	U.S. Navy purchased what is now the federally-owned portion of the NIROP.
1942 - 1964	Northern Ordnance, Inc., a subsidiary of Northern Pump Company; operated the naval ordnance manufacturing complex.
1964	FMC Corporation purchased the southern portion of the manufacturing facility property from Northern Pump Company.
Early 1970s	Limited disposal at the NIROP of paint sludge and chlorinated solvents in pits and trenches was performed.
1980	
September	U.S. Navy implemented the NACIP program to identify and control environmental contamination from past use and disposal practices.
1981	
March	Anonymous phone call to the MPCA regarding disposal practices at the FMC-operated facility.
March 16 - April 23	Three production wells at the site were sampled by the MPCA. Analysis results showed 0.035 to 0.200 milligrams per liter (mg/L) of TCE detected (RMT, July 1988).
April 24	Wells FMC-1 and NIROP -2 and -3 were discontinued for drinking water usage. Well FMC-1 was intermittently used for process cooling water until June 1983.
December 31	TCE was detected at 0.0012 mg/L at the Minneapolis water supply intake. Earlier in 1981, TCE was detected at unquantifiable levels during four sample rounds.
	Storm sewer outfalls were sampled for several constituents. Quantifiable levels of volatiles were detected in the sanitary sewer and at National Pollutant Discharge Elimination System (NPDES) outfall 20200.
	The site was divided into the North Study area (government-owned property) and South Study Area (FMC-owned property) for additional investigations by Hickok and Associates (Hickok, 1981).
1982	
March 31	Investigation of the North Study area began.
1983	
May	U.S. Navy authorized the Installation Restoration (IR) Program.
June	Initial Assessment Study (IAS) for the NIROP site was completed by Envirodyne Engineers (June 1983).
	As a result of the IAS, the U.S. Army Corps of Engineers (USACE) was assigned to manage site remediation. The Corps installed 33 monitoring wells on and around the site over the next 3 years.

TABLE 2-1

CHRONOLOGICAL SUMMARY OF EVENTS
NIROP FRIDLEY, MINNESOTA
PAGE 2 OF 4

Date	Event
1983 - 1984	
November - March	Approximately 1,200 cubic yards of soil considered hazardous and 43 drums were excavated from the North 40 area and disposed of at an offsite Resource Conservation and Recovery Act (RCRA)-permitted facility. Samples were analyzed from the soils at the base of each excavation. Trenches 3, 6, and 7 showed greater than 1 mg/L total volatiles.
May 22, 1984	The MPCA issued a Request for Response Action at the site to the U.S. Navy and FMC Corporation.
1983 - 1986	Eight rounds of groundwater sampling were completed. The last round was conducted in November 1986 by RMT, Inc. (RMT).
1986	
June	RMT, Inc. was retained by the USACE to complete the Remedial Investigation/Feasibility Study for OU1 (groundwater).
	FMC established an agreement with the MPCA to pump contaminated groundwater until total volatile levels in certain wells were less than 0.270 mg/L. Pumped water was discharged to the Pig's Eye Wastewater Treatment Plant.
1987	
March	All use of trichloroethene at the NIROP was discontinued. 1,1,1-trichloroethane was put into use in place of trichloroethene.
June	Remedial Investigation Report (RMT, June 1987) issued for OU1.
September	During excavation of an onsite utility trench, a strong odor was detected in the trench by construction workers. Soil exposed during the excavation was later monitored by MPCA using an HNu photoionization detector (PID). The trench is along the northern property line of the NIROP.
	An anonymous phone call to FMC directed the MPCA's attention to a potential hazardous waste site in the vicinity of the Dealers Manufacturing facility located approximately 1,000 feet to the east of the NIROP.
November	Results of soil pore gas survey included in the A-E Quality Control Summary Report for the Soil Gas Survey (RMT, February 1988).
1988	
July	Feasibility Study Report (RMT, July 1988) issued for OU1.
1989	
February 8	The U.S. Navy established the Technical Review Committee (TRC) for the project and convened the first meeting.
July 14	NIROP listed as a proposed site on the NPL by the U.S. EPA.
November 21	NIROP listed as a final site on NPL by U.S. EPA.

TABLE 2-1

CHRONOLOGICAL SUMMARY OF EVENTS
NIROP FRIDLEY, MINNESOTA
PAGE 3 OF 4

Date	Event
1990	
September	A Record of Decision (ROD) was signed for OU1. A groundwater pump-and-treat alternative was the alternative selected in the ROD.
October - November	Fifty-five soil borings were advanced to assess the extent of soil contamination in four specific areas (background area, North 40 area, Hazardous Waste Storage Area C, and the southeast area near Well 9-S). The North 40 area included 22 soil borings to investigate potential soil contamination due to past disposal practices, the locations of former Hazardous Waste Storage Area C included 28 soil borings to investigate potential soil contamination associated with the storage area, and the Southeast Area included four soil borings to attempt to delineate the source(s) of volatiles reported in groundwater monitoring wells in the area. The results reported the highest concentrations of volatiles, up to 62,000 micrograms per kilogram (µg/kg), from near the decontamination pad (RMT, February 1991)
1991	
March	Federal Facility Agreement (U.S. EPA, March 1991) issued for NIROP Fridley
August	An initial aerial photographic review was conducted by RMT staff that included photographs spanning the period from 1945 to 1977.
	The installation of four groundwater recovery and containment wells, as well as additional groundwater monitoring wells, was completed in late 1991 for OU1.
December	A second review of the aerial photographs, including additional photographs, was performed jointly by representatives of the Navy, the U.S. EPA, the MPCA, FMC, and RMT. As a result of the review and subsequent discussions, additional areas of investigation were included as part of the OU2 Remedial Investigation.
1992	
January	A Remedial Action Work Plan (RMT, January 1992) was issued for OU2. The RI of the soils operable unit addresses soil contamination in the unsaturated zone (i.e., above the water table) in areas of the NIROP Fridley that are not covered by buildings or other surface structures. The scope of the soil RI was intended to investigate potential outdoor sources that may contribute to groundwater contamination.
August 20	Emergency Removal Operation (Bay West, August 1992) report issued which discussed the investigation of the area referred to as the North 40 area. A total of 31 drums were excavated, sampled, and overpacked, and the drums, along with approximately 900 cubic yards of soil and debris, were removed from the excavation. Excavated drums were disposed of via incineration at U.S. EPA Superfund RCRA-licensed facility. Associated debris (screened material) was disposed of at a sanitary landfill or a RCRA-secure landfill according to analytical results.
September	The groundwater recovery system and monitoring for OU1 was started.
December	A 90-Day Determination Document (RMT, December 1992) was prepared which evaluated the effectiveness of the OU1 recovery system's operation over the first few months.

TABLE 2-1

CHRONOLOGICAL SUMMARY OF EVENTS
NIROP FRIDLEY, MINNESOTA
PAGE 4 OF 4

Date	Event
1993	
September	A Remedial Investigation Report (RMT, September 1993) was issued for OU2. Results indicated that volatile, semivolatile, pesticide, hydrocarbon, and metal contamination was present in the soils at several locations.
1994	
September	Results of East Plating Shop soil sampling were issued to the Southern Division of the Naval Facilities Engineering Command (NAVFACENGCOM) in a letter report (Bay West, September 1994). Two soil borings were completed, and several metals and cyanide were identified at concentrations greater than background levels determined during the OU2 RI.
1995	
March	A Work Plan (Halliburton NUS, March 1995) was issued for the East Plating Shop. Proposed field activities for the soil and groundwater investigation included the installation of six soil borings and three temporary monitoring wells.
April 16	First NIROP Fridley Restoration Advisory Board meeting was held.
May	Results of East Plating Shop soil and groundwater investigation were issued (Halliburton NUS, May 1995). The report identified soil and groundwater contamination under the East Plating Shop. TCE was the primary contaminant found. Other volatile organic compounds, including 1,1,1-trichloroethane (TCA), acetone, styrene, and metals such as chromium, lead, and cyanide, were detected at concentrations greater than background levels determined during the OU2 RI.
June	Thirty former areas of concern, located within the NIROP facility, were identified on a Solid Waste Management Unit (SWMU) map (United Defense, LP, June 1995).
September	Results of a site evaluation conducted at the NIROP facility in August 1995 were presented in the Site Evaluation Report (Brown & Root Environmental, September 1995). Fifty-nine areas of concern, the sanitary sewer system, and the storm sewer system were identified as potential areas requiring further investigation.
1996	
February	Revisions to the Final Site Evaluation Report (Brown & Root Environmental, September 1995) identified nine additional potential areas of concern (AOCs 60-68) which were identified but not previously reported because they were not suspected sources of TCE contamination.

onsite water supply wells were shut down on April 24, 1981. The groundwater flows west/southwest from NIROP Fridley, and then enters the Mississippi River. Sampling at the City of Minneapolis Mississippi River water intake plant also revealed measurable concentrations of TCE. The city of Minneapolis draws its municipal water from the Mississippi River approximately 2,000 feet downstream from the NIROP site (U.S. EPA, March 1991).

The Navy Energy and Environmental Support Activity (NEESA) initiated the Initial Assessment Study (IAS) in June 1983. The IAS report (Envirodyne, June 1983) determined that drummed wastes had occasionally been buried in trenches or pits 8 to 10 feet below the surface on site in the northern portion of the NIROP Fridley and that the area beneath the NIROP Fridley production building might be contributing to groundwater contamination. The exact site location of the buried wastes was not recorded. As a result of the IAS recommendations, the Navy contracted with the U.S. Army Corps of Engineers (USACE), Omaha District, to continue investigations (U.S. EPA, March 1991).

The cleanup activities involved excavation of nine areas that contained 43 drums and 1200 cubic yards of underlying soils. The 43 drums and 1200 cubic yards of underlying soils were found to contain volatile organic compounds (volatiles), polychlorinated biphenyls (PCBs), oil and grease, pesticides, and metal-bearing wastes. The excavated materials were disposed of at a U.S. EPA-approved landfill (U.S. EPA, March 1991).

Four phases of groundwater monitoring well installation were initiated in June 1983. The network consists of 53 monitoring wells. Shallow, intermediate, and deep monitoring wells were installed in the unconsolidated aquifer underlying the NIROP Fridley. Monitoring wells were also installed in the Prairie du Chien/Jordan Dolomite aquifer, which underlies the unconsolidated aquifer under the NIROP Fridley. The objective of the monitoring well network is to determine the physical and chemical characteristics of the unconsolidated and Prairie du Chien/Jordan Dolomite aquifers underlying NIROP and adjacent areas (U.S. EPA, March 1991).

The OU1 Remedial Investigation Report (RMT, June 1987) was issued in June 1987 in partial fulfillment of an MPCA Request for Response Action issued to the Navy in May 1984. The purpose of the report was to use existing information to evaluate the impacts of past disposal practices on subsoils and groundwater. The report included evaluations of the eight sampling rounds and the no-action alternative. Results of the RI confirmed earlier findings that groundwater was contaminated with volatiles (primarily TCE) and that groundwater flow was primarily to the southwest toward the Mississippi River.

To address the need for further information defining the nature and extent of contamination, the Navy issued a Conceptual Work Plan for Additional Investigations in June 1987. Implementation of the Conceptual Work Plan was completed between November 1987 and March 1988. The work consisted of installation and sampling of 16 new groundwater monitoring wells, soil pore gas testing, installation of two shallow aquifer pumping wells, and sampling of two storm sewers. The results of these investigations were included in the addendum to the Remedial Investigation (RI) Report issued for groundwater (OU1) in July 1988 (U.S. EPA, March 1991).

RMT conducted a soil pore gas survey at the site to screen and identify areas of potential volatile-contaminated soil that might be contributing to groundwater contamination. The results were included in the A-E Quality Control Summary Report for the Soil Gas Survey (RMT, February 1988) and concluded that the following three contiguous areas had the greatest concentrations in the pore space of the near-surface soils:

- Former disposal trench
- Permanent decontamination pad
- New water main trench area

The OU1 Feasibility Study (FS) Report (RMT, July 1988) was issued in July 1988. Based on the initial screening of alternatives, three remedial alternatives were recommended for detailed evaluations and comparison. These alternatives consisted of two source-control alternatives and an alternative addressing management of contaminant migration (U.S. EPA, March 1991).

In August 1988, an Addendum to the Feasibility Report (RMT, August 1988) for OU1 was issued. This report accounted for the changes found in the Addendum to the RI Report and recommended a pumping and treating remedial action that was to be implemented in two phases (U.S. EPA, March 1991).

On February 8, 1989, the Navy held the initial Technical Review Committee (TRC) meeting at NIROP Fridley. TRC membership included the following: U.S. EPA, MPCA, U.S. Navy, Corps of Engineers, Anoka County (Minnesota), City of Fridley, FMC Corp., Metropolitan Waste Control Commission, Minnesota Department of Natural Resources, and RMT, Inc. The committee periodically met at NIROP Fridley to review progress of the RI/FS and Remedial Design/Remedial Action (RD/RA) (U.S. EPA, March 1991).

Hazardous Waste Storage Area C, located on NIROP Fridley, was used for hazardous waste storage and was addressed by FMC Corporation, a Navy contractor. Soils in the storage area were remediated under the hazardous waste permit that was issued to FMC Corporation and the Navy pursuant to Minn. Rules Ch. 7045. The closure plan and schedule in the permit required the removal and disposal of contaminated soil beneath the storage area. During April 1989, approximately 317 tons of contaminated soil and debris were excavated and disposed of from Hazardous Waste Storage Area C. No soils outside the perimeter of Hazardous Waste Storage Area C were removed.

The Navy held a public information meeting to discuss the preferred alternative for groundwater remediation on May 22, 1989 (U.S. EPA, March 1991).

On July 14, 1989, NIROP Fridley was proposed for placement on the National Priorities List (54 Fed. Reg. 29820, July 14, 1989) (U.S. EPA, March 1991).

On July 31, 1989, the U.S. Navy established a Public Information Repository for documents relating to the NIROP Fridley. The repository is located at the Anoka County Branch Library, 410 N.E. Mississippi Street, Fridley, Minnesota. The Transcript of Proceedings from the Public Forum held on May 22, 1989, was placed in the Information Repository at the Anoka County Branch Library, Fridley, Minnesota (U.S. EPA, March 1991).

On November 21, 1989, NIROP Fridley was placed on the National Priorities List (U.S. EPA, March 1991) because of receiving an HRS score of 28.5 or greater. Initial discovery/notification documented a release of volatile organic compounds (VOCs) into the groundwater beneath NIROP (U.S. EPA, March 1991).

On May 1, 1990, the Proposed Plan for groundwater remediation was made available to the public by placing a copy of the Proposed Plan in the Public Information Repository. Prior to and on May 1, 1990, notice of the commencement of a period of public comment was provided by publication of a notice in local newspapers. Members of the public were notified that they had a period of 30 days in which they could provide oral or written comments to the U.S. EPA or Navy concerning the Proposed Plan. A public meeting was held on May 9, 1990, in Fridley, Minnesota, during which representatives of the Navy, U.S. EPA, and MPCA answered questions and solicited both written and oral comments from members of the public. The public comment period continued until May 30, 1990 (U.S. EPA, March 1991).

A CERCLA ROD (U.S. EPA, June 1986) was signed for OU1, groundwater remediation at NIROP, on September 28, 1990. The U.S. Navy entered into a Federal Facilities Agreement (FFA) with the U.S. EPA, the United States Department of the Navy (Navy), and the MPCA in March 1991.

On April 16, 1995, the first NIROP Fridley Restoration Advisory Board (RAB) meeting was held. The RAB was the expansion of the TRC with the addition of community members. The mission of the RAB is to establish and maintain a forum for the exchange of information, in an open and constructive atmosphere, concerning restoration activities at the NIROP Fridley and to provide advice/comment on such activities.

Initial investigative activities related to environmental issues at the NIROP Fridley began in 1981. After an initial assessment and focused drum removal action, the site issues were divided into three operable units (OUs). OU1 addressed the groundwater beneath the site. The OU1 Remedial Investigation/Feasibility Study (RI/FS) and Record of Decision (ROD) are complete, and implementation of the selected remedy is under way. The selected remedy includes installation and operation of groundwater containment and recovery wells, with a two-phased plan for disposal of the groundwater from the well system.

Under Phase I, the contaminated groundwater from the containment and recovery well system will be discharged directly to the existing sanitary sewer system, for treatment at the local wastewater treatment facility. Under Phase II, design documents for a groundwater treatment system will be completed to permit discharge of treated groundwater to the Mississippi River via an NPDES storm sewer discharge.

A groundwater extraction (and containment) system has been constructed, based on design documents approved by the U.S. EPA Region V and the MPCA. A pumping capacity test was performed during construction at each of the four extraction wells and included groundwater sampling and analysis. The results indicated that groundwater pretreatment was required prior to discharge to the sanitary sewer to meet discharge limits. Therefore, a pretreatment system was also constructed at the NIROP as part of the original facilities, for use during the interim Phase I discharge to the sanitary sewer.

The groundwater extraction system and pretreatment facilities began operating in September 1992. During the first 90 days of recovery system operation, data were collected to determine whether hydraulic containment of contaminated groundwater from the site was achieved. This determination was summarized in a document that was sent to the U.S. EPA and MPCA in December 1992 (RMT, December 1992) for review and approval. In that document, it is concluded that one or more additional groundwater extraction wells would be needed to achieve effective hydraulic containment. A work plan for upgrading

the original groundwater extraction system was prepared (RMT, January 1995) and approved by the U.S. EPA and the MPCA. As provided in that Work Plan, two additional extraction wells were constructed, and were placed into operation in June 1995. The combined groundwater extraction system, consisting of six extraction wells, is currently in operation.

The concentrations of TCE and other VOCs in the combined discharge from the extraction wells have decreased significantly since startup of the system in 1992. The concentrations decreased to levels where pretreatment of the groundwater is not necessary to comply with the Metropolitan Council Environmental Service (MCES) discharge permit limits. With the approval of the MCES, the pretreatment system was shut down in March 1995. The combined flow from the extraction well system has been discharged directly to the sanitary sewer without pretreatment since March 1995. (RMT, April 1996).

As specified in the FFA (U.S. EPA, March 1991), an Annual Monitoring Report was submitted by the Navy to the U.S. EPA and the MPCA in October 1995 (RMT, October 1995) to satisfy the requirement that an annual evaluation of the effectiveness of the groundwater extraction system be performed. The upgraded extraction well system flow rate is high enough to substantially improve the capture zone coverage over the pre-upgrade conditions, although the combined flowrate from the six wells is slightly less than the target flowrate (660 gpm) (RMT, October 1995). It was recommended that efforts be made to achieve sustainable pumping rates that total approximately 660 gpm, so that the extraction well system will continue to effectively control the contaminant plume. The MPCA suspended review of the report pending receipt of particle tracking modeling output figures. The results of particle tracking are key to determine capture effectiveness. The Navy is required by the MPCA to modify the Evaluation of Groundwater Containment System Effectiveness Report (RMT, October 1995) to adequately indicate the capture effectiveness of the groundwater system and accurately locate the capture boundary. Determining capture effectiveness is a prerequisite to starting the Phase II design phase.

An Annual Monitoring Report for 1995 Groundwater Extraction and Pretreatment System (RMT, Inc., April 1996) was submitted to the U.S. EPA and MPCA in April 1996, as specified in the FFA, to fulfill the requirements for submittal of data and information describing operation, maintenance, and monitoring of the groundwater extraction and pretreatment system from startup (September 1992) through 1995.

Under Phase II, within 365 days after the U.S. EPA and MPCA approve the determination that the groundwater containment and recovery system is effective, design documents for a groundwater

pretreatment system will be completed by the Navy and approved by the U.S. EPA and MPCA. Treated groundwater will be discharged to the Mississippi River via an NPDES storm sewer discharge.

OU2 addresses the unsaturated soils outside of the building footprint area. The OU2 RI has been completed. A Draft FS for OU2 was submitted to the U.S. EPA and MPCA for review (RMT, 1995). It was agreed that OU2 would be combined with OU3 and, therefore, the OU2 FS was not finished.

The final operable unit, OU3, has been defined to address sources in the unsaturated and saturated zones at NIROP Fridley. OU3 is the subject of this RI Field Investigation.

In August 1995, efforts began to address OU3. Due to the size of the NIROP main building and limited understanding of past operations that could have released TCE into the environment, a site evaluation was conducted for OU3 and the Site Evaluation Report (Brown & Root Environmental, September 1995) presented the findings. The site evaluation consisted of a site visit, records search, and a personnel interview survey at the NIROP main building. The primary objective of the site evaluation was to identify sites that could have been sources of potential TCE releases to the soil beneath the main building. The Site Evaluation Report (Brown & Root Environmental, September 1995) described and located 59 areas that were considered potential sources of TCE contamination within specific industrial operations. In addition, the sanitary and storm sewer systems were considered potential source areas for contamination. Nine additional potential areas of concern (AOCs 60-68) which were identified during the site evaluation but not included in the Site Evaluation Report because they were not suspected sources of TCE contamination were added later. In addition, the location of several previously identified AOCs were modified. An updated list of AOCs, updated AOC locations and a description of each newly identified AOC was issued (Brown & Root Environmental, February 1996). The list of AOCs was further modified (Brown & Root Environmental, January 1997) to include seven additional areas of concern (AOCs 69-75). If additional contamination sources are identified, then they will be included in the OU3 RI/FS.

2.6 CURRENT STATUS

Investigations and cleanup operations at NIROP Fridley are under way. The first phase of a pump-and-treat remedy for OU1 was implemented in September 1992. Table 2-2 summarizes the compliance dates for OU1. OU2 work was in the FS stage when it was decided that OU2 would be made a subpart of OU3.

TABLE 2-2

COMPLIANCE DATES FOR OU1
NIROP FRIDLEY, MINNESOTA

Task	Date
U.S. Navy delivers determination document on whether hydraulic containment is being effectively achieved to U.S. EPA and MPCA.	90 days after start of recovery system
U.S. EPA and MPCA provide written approval of, or comments on, the determination document.	30 days after receipt of determination document
U.S. Navy delivers revised determination document to U.S. EPA and MPCA.	60 days after notification of deficiencies in determination document
U.S. Navy delivers written plan to U.S. EPA and MPCA for upgrading recovery system and implement final approved plan.	After approval of determination document by U.S. EPA and MPCA and if it indicates that effective hydraulic containment is not being provided.
U.S. Navy completes design documents for a groundwater treatment system.	365 days after U.S. EPA and MPCA approve the determination that the groundwater containment and recovery system is effective.
Review conducted by the Navy, the U.S. EPA, and the MPCA.	5 years after startup of the groundwater containment and recovery well system.

OU3 is in the RI stage. Table 2-3 is a summary of the compliance dates for OU3. The compliance dates listed in Tables 2-2 and 2-3 are in accordance with the FFA requirements.

The NIROP Fridley has a NPDES Storm Sewer Discharge. An amendment to the NPDES Permit MN 0000710 has been issued to allow the discharge of treated groundwater from the OU1 treatment system into the Mississippi River via currently permitted sewer outfalls.

The NIROP Fridley has a RCRA Part B permit.

2.7 NATURAL AND MANMADE FEATURES

The following sections describe the natural features on the NIROP site, including the geology, hydrogeology, surface water hydrology, topography, facility ecosystems, and weather and climate. In addition, this section presents the land use and population distribution of the area, water usage, and facility access.

2.7.1 Regional Geology

The NIROP site lies on the northwestern side of a roughly circular structural basin that is known as the Twin Cities Basin. At the NIROP, the dip of the bedrock is approximately 50 feet per mile to the south-southeast. There are no known, regionally significant faults in the bedrock in the vicinity of NIROP (Envirodyne, June 1983).

2.7.1.1 Stratigraphic Units

The following subsections briefly describe the stratigraphic units that exist on a regional scale at NIROP Fridley. Figure 2-4 presents a depiction of the generalized stratigraphic column for the site.

Quaternary Age Units

The site lies on an alluvial terrace formed during the Pleistocene Epoch (a subdivision of the Quaternary Period), when glacial melt-water caused the nearby Mississippi River to flow at a higher elevation than at present. The resulting terrace deposits consist of a heterogeneous mixture of gravel, sand, silt, and clay.

TABLE 2-3

COMPLIANCE DATES FOR OU3
NIROP FRIDLEY, MINNESOTA

Task	Date
U.S. Navy delivers Draft RI Work Plan to U.S. EPA and MPCA.	12/29/95
U.S. Navy delivers Draft RI Report to U.S. EPA and MPCA.	365 days from final RI Work Plan
U.S. Navy delivers Draft Alternatives Report to U.S. EPA and MPCA.	90 days from final RI Report
U.S. Navy delivers Draft FS Report to U.S. EPA and MPCA.	90 days from final Alternatives Report
U.S. Navy delivers Draft Proposed Plan to U.S. EPA and MPCA.	60 days from final FS Report
U.S. Navy delivers Draft Responsiveness Summary of Proposed Plan and Draft ROD to U.S. EPA and MPCA.	90 days from end of public comment period

SYSTEM	GROUP	FORMATION	APPROX. THICKNESS (FEET)	COLUMNAR SECTION	DEPTH BGS (FEET)	LITHOLOGIC DESCRIPTION
QUATERNARY			100 - 130			medium to coarse SAND with gravel to clay interbeds.
					~50	clay interbeds typical between 50 - 90 feet.
					~90	
					~100	(unconformity)
ORDOVICIAN	St. Peter Group	St. Peter Sandstone	10 - 65			medium-to-fine grained friable white to yellow SANDSTONE with beds of siltstone and shale
					~130	
	Prairie du Chien Group	Shakopee Dolomite	45 - 75			drab, DOLOMITE with cavities filled with calcite
					~185	
		Oneota Dolomite	45 - 60			drab to buff (in places pink) DOLOMITE
					~240	
CAMBRIAN		Jordan Sandstone	75 - 175			medium-to-coarse-grained white SANDSTONE

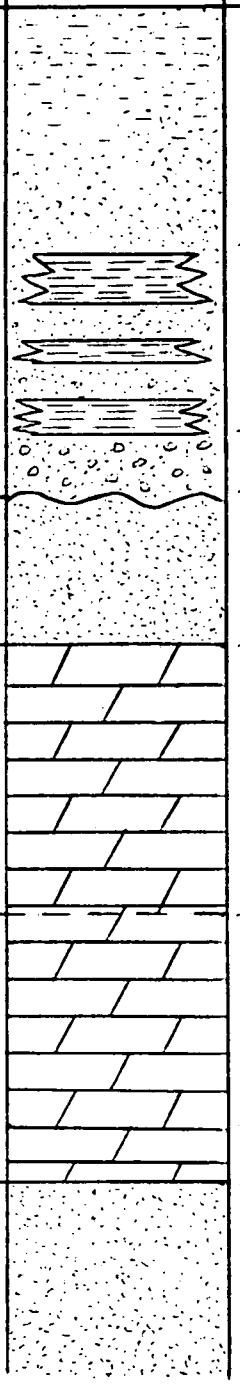

FIGURE 2-4

GENERALIZED STRATIGRAPHIC COLUMN
NIROP, FRIDLEY, MN

Brown & Root Environmental

Based on numerous boring logs from the site, these deposits consist primarily of medium to coarse sand with gravel to clay interbeds. Finer grained deposits (i.e., sandy clay, silty sand) were encountered in several borings. These finer grained deposits exist primarily from the ground surface to approximately 25 feet below ground surface (bgs). Fill material of a similar grain size was also encountered in several borings at shallow depths. In several of the borings, two to three closely spaced, fine-grained interbeds consisting of clay to sandy clay were encountered. The tops of these interbeds lie from approximately 50 to 60 feet bgs with the bases at approximately 85 to 90 feet bgs. The individual interbeds range from 2 to 15 feet in thickness and generally thin with depth.

Coarse-grained deposits (gravel to cobbles) were encountered sporadically throughout the entire terrace sequence, but the overall percentage of these deposits generally increases with depth. The maximum depth of the terrace deposits ranged from approximately 90 to 130 feet. The base of the terrace deposits lies unconformably (i.e., an erosional surface) above the Ordovician age St. Peter Sandstone.

Ordovician Age Units

The unconsolidated Quaternary age terrace deposits directly overlie Ordovician age bedrock, a fact which indicates a significant geological unconformity between the two units. At NIROP, the upper surface of the bedrock was eroded prior to and during deposition of the overlying terrace deposits. The erosion resulted in an uneven bedrock surface that slopes slightly toward the south. The bedrock formation that immediately underlies most of the NIROP facility is the St. Peter Sandstone.

The St. Peter Sandstone consists of a fine- to medium-grained, friable, well-sorted, white to yellow sandstone, with beds of siltstone and shale in the lower part of the formation. Texturally and mineralogically the St. Peter Sandstone is very mature (uniform), an indication that its sands were well sorted prior to and during deposition. Most of the quartz grains are from one-eighth to one-half millimeter in diameter. The sandstone is poorly cemented and consequently has a high porosity. A number of porosity determinations have been made, showing an average of approximately 28 percent for the upper half of the formation. Because of the small size of its quartz grains, the formation is not highly permeable (Theil, 1944).

As mentioned previously, much of the original thickness of the St. Peter Sandstone was eroded prior to and during deposition of the overlying unconsolidated terrace deposits. Therefore, only the lower portion of the formation is present beneath the site. In the southwestern portion of the NIROP, the St. Peter

Sandstone has been completely eroded, and the underlying Prairie du Chien Group has been exposed. The Prairie du Chien Group consists of the Shakopee Dolomite and the underlying Oneota Dolomite. No bedrock crops out in the immediate vicinity of the site (Envirodyne, June 1983).

Limestone is a sedimentary rock that is composed of calcium and/or magnesium carbonate. Dolomite is the term used to refer to those limestones that possess 15 percent or greater magnesium carbonate. The Shakopee Dolomite is much less dolomitic (less magnesium) than the Oneota Dolomite. The basal beds of the Shakopee are sandy and, in many places, the succeeding layers are thinly bedded. Much of the formation is a massive, drab, dolomitic limestone with cavities filled with crystalline calcite. Calcareous ooids may be found throughout the Shakopee, although many of the ooids have been chemically altered to flint (Theil, 1944).

The Oneota Dolomite is thick-bedded, drab to buff, and in places pink, and may contain interbeds of sandstone or shale. The upper part may be cherty and, in many locations, is porous to cavernous. Many of the cavities and joints are lined with quartz crystals, and huge, calcite-lined pockets are common. In the southeastern counties where massive dolomite forms bluffs of the Mississippi and its tributaries, there are extensive solution channels, some of which reach the dimensions of caves penetrable for some distance (Theil, 1944).

Small quantities of water are found in the upper and more porous portion of the Oneota Dolomite, but great volumes are contained in the larger solution passages, such as enlarged joints or bedding planes. Some underground streams that issue as springs from the dolomite flow at a rate of more than 350 cubic feet per minute. The unit is typically nonpermeable and yields little water to wells except from the solution passages (Theil, 1944).

Cambrian Age Units

At the site, the Oneota Dolomite represents the base of the Ordovician System. The Jordan Sandstone (Cambrian Period) underlies the Oneota Dolomite throughout the region. The Jordan Sandstone is underlain, in turn, by the St. Lawrence Formation, the Fanconia Formation, and the Dresbach Formation. For this report, descriptions of rock units beneath the Jordan Sandstone are not necessary. Detailed descriptions of the deeper bedrock units are presented in the Initial Assessment Study (Envirodyne, June 1983).

The Jordan Sandstone is a loosely cemented, medium- to coarse-grained, white sandstone, which becomes yellow or brown by oxidation at outcrops and along jointing plans. It ranges from 75 to nearly 175 feet in thickness and is exposed in the valleys of the Minnesota River and tributary streams and in the lower part of the bluffs of the Mississippi River and its branches from near Hastings southward to the Iowa state line. Elsewhere it is deeply buried beneath younger rocks (Envirodyne, June 1983).

The Jordan Sandstone is made up of two members, the Norwalk below and the Van Oser above. The upper Van Oser Member is the coarser of the two. It consists of friable gray, white, pink, or brown sand grains, many which have recrystallized grain surfaces. The lower Norwalk Member is not present in the region (Envirodyne, June 1983).

2.7.1.2 Soils

The soil in the area of the NIROP, as well as many of the soils in the Minneapolis-St. Paul area, is developed on Quaternary-age, glacial-fluvial deposits that resulted from deposition in a fluvial (river) environment during higher stages of the Mississippi River during glacial melting. These deposits consist of coarse sand, fine to medium sand, and some gravelly sand. Discontinuous layers of silt and clay occur at some locations. These unconsolidated outwash deposits are up to 130 feet thick in the vicinity of NIROP. Generally, sand in the study area is classified as poorly graded sand (SP) under the Unified Soil Classification System (USCS).

Recent alluvial deposits occur in areas adjacent to the Mississippi River. These deposits show little development, and the texture varies widely. These deposits are frequently subjected to flooding (Envirodyne, June 1983).

The NIROP is located in the southwesternmost portion of Anoka County in a small strip of land referred to as the "Anoka County Boot". The Soil Conservation Service (SCS) has previously provided information on the soils present at the NIROP. The SCS indicated that the NIROP was located within the Hubbard-Nymore soil association, which is characterized by nearly level to gently sloping, excessively drained, sandy soils. The majority of the NIROP site has Hubbard soils, whereas small areas close to the Mississippi River are occupied by Becker and Chaska soils (Envirodyne, June 1983). A description of each of these soil types, obtained from the Anoka County soil survey, is provided as follows:

Hubbard Series

The Hubbard series consists of nearly level to slightly sloping, excessively drained soils formed in broad outwash sands. These soils are located on broad flats adjacent to drainage ways and large depressions in the sandy outwash plains. Hubbard soils have a black and very dark grayish-brown, coarse sandy surface layer approximately 20 inches thick. The subsoil is dark brown and yellowish-brown coarse sand. The underlying material, at a depth of approximately 44 inches, is pale brown, gravelly coarse sand. The permeability of these soils is high (Envirodyne, June 1983).

Becker Series

The Becker series consists of nearly level, moderately well drained to well-drained soils formed in loamy sediments underlain by sand. These soils are found on bottom land along rivers and streams. Permeability of these soils is moderately high, and the available water capacity is moderate. This soil is occasionally flooded for short periods. The surface layer is very dark brown, black, or dark grayish-brown, fine, sandy loam approximately 27 inches thick. The subsoil is dark brown and dark yellowish-brown, friable, very sandy loam approximately 17 inches thick. The underlying material is mottled, yellowish-brown, loose, coarse sand (Envirodyne, June 1983).

Chaska Series

The Chaska series consists of deep, poorly and somewhat poorly drained soils formed in loamy alluvium on flood plains. The surface layer is very dark gray silt loam approximately 8 inches thick. The substratum is 30 inches of very dark grayish-brown and very dark gray, mottled sand and silt loams. Slopes on these soils range from 0 to 2 percent. These soils are commonly subjected to periods of flooding. The permeability of these soils is moderate to moderately high (Envirodyne, June 1983).

2.7.2 Regional Hydrogeology

At the NIROP, four aquifers underlie the site as identified by the Minnesota Geological Survey (University of Minnesota, 1979). These aquifers consist of (from deep to shallow) the Mount Simon/Hinckley/Fond du Lac (MHF) aquifer, the Franconia/Ironton/Galesville (FIG) aquifer, the Prairie du Chien/Jordan aquifer (PCJ), and the surficial Quaternary aquifer (Envirodyne, June 1983).

The MHF and the FIG are both confined aquifers. Because of the depth of these aquifers (greater than 400 feet bgs), they are not used for water supply purposes in the immediate vicinity of the NIROP. The MHF, however, is used rather extensively as a water supply source north of the site, where it is more shallow (Envirodyne, June 1983).

Under the northern and eastern portions of the NIROP, the PCJ (approximately 130 to 400 feet bgs) is confined by the lower portion of the St. Peter Sandstone. Under the southwestern part of the site, the St. Peter Sandstone is fully eroded, and the PCJ exists as an unconfined (or semi-confined) aquifer. Where this occurs, the PCJ and the Quaternary aquifer may act as a single, hydraulically connected unit (Envirodyne, June 1983).

The PCJ aquifer is used for water supply purposes in the immediate vicinity of the NIROP. There are two wells at the plant which tap this aquifer (NIROP-2 and NIROP-3). These wells date back to the 1940s and were used to supply potable and industrial water for the NIROP. The average pumping rate for these wells was 760 gallons per minute (gpm). TCE contamination problems led to the shutdown of these wells in April 1981. There is also a well just south of the Navy Property, within the main industrial building, that taps the PCJ aquifer (FMC-1). This well was also shut down in April 1981 because of TCE contamination. The well was re-opened in August of 1981 and was intermittently used for non-contact cooling water for the NIROP facility until June 1983 (Envirodyne, June 1983). The three onsite production wells are no longer in use (RMT, November 1995). Currently, all water used at the NIROP Fridley is obtained from the city. The City of Fridley has a well just beyond the northwest corner of the NIROP (Fridley-13) that taps the PCJ and is used for municipal water supply on a standby basis. This well dates back to 1970. It has a gas-powered pump and is used during power outages and during periods of peak demand. TCE has not been detected in well Fridley-13. The total population served by groundwater within a 3-mile radius of the NIROP is 29,000 residents (RMT, November 1995). Several other water supply wells in the general vicinity of the NIROP are believed to tap the PCJ aquifer (Envirodyne, June 1983). There are no groundwater supply wells or users downgradient of the NIROP Fridley between the facility and the Mississippi River (RMT, November 1995).

As mapped by Kanivetsky (University of Minnesota, 1979), the Quaternary aquifer at the NIROP is capable of a sustained yield of 100 to 500 gallons per minute (gpm) to a properly developed well. The Quaternary aquifer, though capable of yielding fairly high quantities of water to wells, is not commonly used for water supply purposes. It is easily contaminated, and water of good quality and even higher yields is commonly available at comparable cost in the underlying PCJ aquifer (Envirodyne, June 1983).

Wells tapping the PCJ aquifer typically yield 500 to 1,000 gpm (University of Minnesota, 1978). Other hydrogeologic parameters for the bedrock aquifers are shown in Table 2-4.

The depth to the water table in the Quaternary aquifer at the NIROP is typically 25 feet bgs and may range from approximately 22 feet to 34 feet, depending upon precipitation levels. Groundwater flow in the Quaternary and the PCJ aquifers is generally toward the west and discharges to the Mississippi River (Envirodyne, June 1983). As mentioned in Section 2.6.1.1 (Quaternary Age Units) and shown on Figure 2-4, two to three, closely spaced, fine-grained interbeds consisting of clay to sandy clay are present beneath the NIROP site. The tops of these interbeds lie from approximately 50 to 60 feet bgs with the bases at approximately 85 to 90 feet bgs. The individual interbeds range from 2 to 15 feet in thickness and generally thin with depth. The importance of these fine-grained interbeds is that they may impede the natural vertical migration of fluids in the aquifer. Downward migration of dense nonaqueous-phase liquids (DNAPLs) such as TCE can be redirected, even against the natural direction of groundwater flow.

2.7.3 Regional Surface Water Hydrology

The NIROP is situated on an alluvial terrace east of the Mississippi River. Much of this very flat surface is covered by buildings and pavement. Runoff from these hard-surfaced areas is collected by a series of storm sewers, which discharge into the Mississippi River, located approximately 800 feet west of the plant boundary (Envirodyne, June 1983).

As mentioned previously, the soils are very sandy and highly permeable. As such, and because of the flat topography, essentially all of the precipitation falling on these areas either soaks into the ground or is evaporated. There is essentially no runoff from these areas, and no significant water courses, either perennial or intermittent, are present on the site (Envirodyne, June 1983).

The Mississippi River in the vicinity of the site flows to the south, where it is joined by the Minnesota River at a point approximately 15 river miles downstream from the NIROP. At the U.S. Geological Survey (USGS) gaging station near Anoka (upstream from the NIROP), the Mississippi River has had an average discharge of approximately 7,600 cubic feet per second (cfs) (Envirodyne, June 1983).

TABLE 2-4

HYDROGEOLOGIC PARAMETERS OF THE BEDROCK AQUIFER
NIROP FRIDLEY, MINNESOTA

Aquifer	Specific Capacity		Hydraulic Conductivity		Transmissivity		Storage Coefficient	Hydraulic Diffusivity	
	(gpm/ft)	(1/sec/m)	(gpd/ft^2)	(m/day)	(gpd/ft)	(m^2/day)		(gpd/ft)	(m^2/day)
St. Peter									
Mode	4	0.8	80	3	8,000	100			
Range of values:									
Low	1	0.2	25	1	2,500	30	10^{-3}	2.5×10^6	3×10^4
High	10	2	250	10	37,000	450	10^{-5}	3×10^9	4×10^7
Prairie du Chien-Jordan									
Mode	34	7	350	14	70,000	870			
Range of values:									
Low	3	0.7	40	1.5	7,000	90	10^{-3}	7.6×10^6	9×10^4
High	118	24	500	20	250,000	3,100	10^{-6}	2×10^9	2.5×10^7
Franconia-Ironton-Galesville									
Mode	15	3	200	8	30,000	370			
Range of values:									
Low	2	0.4	30	1	4,000	50	10^{-4}	4×10^6	5×10^4
High	37	8	250	10	80,000	1,000	10^{-6}	8×10^9	1×10^8
Mt. Simon-Hinckley-Fond du Lac									
Mode	15	3	200	8	30,000	370			
Range of values:									
Low	1	0.2	15	0.6	2,000	25	10^{-2}	2×10^4	2.5×10^2
High	33	7	175	7	70,000	870	10^{-6}	7×10^9	9×10^7

Source: University of Minnesota, 1979

2.7.4 Regional Topography

The NIROP facility is located on a broad, flat, alluvial terrace of the Mississippi River at an elevation of approximately 835 feet (National Geodetic Vertical Datum). Slopes throughout the site are five percent or less (Envirodyne, June 1983).

2.7.5 Land Use and Population Distribution

The site of NIROP and properties surrounding the site to the north, east, and south are zoned "heavy industrial." The Mississippi River lies to the west. Access to the NIROP Fridley site is strictly limited by an 8-foot-high fence and security patrols.

Also located between East River Road and the Mississippi River (west of the site) is the "Anoka County Islands of Peace Mississippi Riverfront Park." The park is a day-use recreational facility on the river's edge, consisting of approximately 60 acres (RMT, June 1987). The County Park is separated from the NIROP Fridley facility by East River Road, a four-lane highway.

The NIROP is located in the Township of Fridley, in the southern-most tip of Anoka County, Minnesota. Fridley's population was estimated at 28,000 residents in 1990. Anoka County's population, according to 1990 estimates, was 244,000 people (RMT, September 1993).

The NIROP facility is located near the northern boundary of the metropolitan statistical area (as defined by the U.S. Bureau of Census) for Minneapolis-St. Paul, Minnesota-Wisconsin. The statistical area was estimated to contain a population of 2,350,000 people in 1990 (Rand McNally, 1992).

2.7.6 Facility Ecosystems

The NIROP Fridley is an industrial facility, surrounded on three sides by other industrial facilities. Much of this area is covered by either buildings or pavement. The remaining areas were extensively altered through grading and filling operations and were used for open storage purposes (Envirodyne, June 1983). There are few trees or shrubs on the site, and the grasses on the site are controlled by frequent mowing and herbicide spraying. The site presents little favorable habitat for terrestrial biota (RMT, September 1993).

No aquatic environments exist within or immediately adjacent to the site. Wildlife in the vicinity of the NIROP Fridley would potentially include those species indigenous to southeastern Minnesota that have adapted to the industrial presence of humans. Small mammals and birds would be the most likely wildlife occupants of or visitors to the site because of the barrier posed by the fence surrounding the facility. These mammals could include, but would not be limited to, ground squirrels, mice, and gophers. Table 2-5 lists the mammals of Minnesota that have been reported in Anoka County. Birds would have access to the site, although the lack of shelter, nesting sites, food sources, and surface water would make the site less attractive than other areas for most bird species. Killdeer nest on the site; and carnivorous birds, such as eagles or hawks, could hunt rodents or small mammals there (RMT, September 1993).

A review of the Minnesota Heritage Database has produced the following listing of rare plants, animals, or natural features within a 1-mile radius of the site:

- Dry Sand Prairie Ecosystem - Threatened Status
- *Heteredon Nasicus* (Western Hognose Snake) - Special Concern Status
- *Aristida Tuberculosa* (Sea-Beach Neddlegrass) - Special Concern Status

These significant species and the natural feature (the dry sand prairie) are all associated with the Moore Lake Natural Area, located 1 mile from the NIROP facility site (RMT, September 1993).

Additionally, there is a Bald Eagle nesting area not listed in the Natural Heritage database review because it is just north of the 1-mile search radius project review. The eagles could potentially feed downstream of their nesting site, near the Fridley NIROP (RMT, September 1993).

2.7.7 Weather and Climate

The continental climate of the Minneapolis-St. Paul area is characterized by warm summers with ample rainfall; rather long, cold winters; and variable wind over the course of the year. The terrain is generally flat or gently rolling and is dotted by many lakes. These lakes are, for the most part, small and shallow, exerting little or no influence upon the air masses that pass over the area.

Temperature variations are quite extreme from season to season. Summer temperatures range from the upper 70s to low 80s, whereas winters are very cold with lows averaging between 3 and 7°F for January and February. The temperature extremes for the area range from -34 to 104°F.

TABLE 2-5

THE MAMMALS OF MINNESOTA
NIROP FRIDLEY, MINNESOTA

Specimens Seen or Authentic Records of Species in Anoka County
COMMON MOLE, *Scalopus aquaticus*
CINEREOUS SHREW, *Sorex cinereus*
SADDLE-BACKED SHREW, *Sorex arcticus*
WATER SHREW, *Sorex palustris*
PIGMEY SHREW, *Microsorex hoyi*
SHORT-TAILED SHREW, *Blarina brevicauda*
SILVER-HAIRED BAT, *Lasionycteris noctivagans*
WHITE-TAILED JACK RABBIT, *Lepus townsendii*
SNOWSHOE RABBIT, *Lepus americanus*
COTTONTAIL RABBIT, *Sylvilagus floridanus*
WOODCHUCK, *Marmota monax*
STRIPED GROUND SQUIRREL, *Citellus tridecemlineatus*
FRANKLIN'S GROUND SQUIRREL, *Citellus franklinii*
EASTERN CHIPMUNK, *Tamias striatus*
RED SQUIRREL, *Tamiasciurus hudsonicus*
GRAY SQUIRREL, *Sciurus carolinensis*
FOX SQUIRREL, *Sciurus niger*
LITTLE FLYING SQUIRREL, *Glaucomys volans*
NORTHERN FLYING SQUIRREL, *Glaucomys sabrinas*
MISSISSIPPI VALLEY POCKET GOPHER, *Geomys bursarius*
POCKET MOUSE, *Perognathus flavescens*
BEAVER, *Castor canadensis*
WHITE-FOOTED MOUSE, *Peromyscus maniculatus*
NORTHERN WHITE-FOOTED MOUSE, *Peromyscus leucopus noveboracensis*
RED-BACKED MOUSE, *Clethrionomys gapperi*
PENNSYLVANIA MEADOW MOUSE, *Microtus pennsylvanicus*
MUSKRAT, *Ondata zibethica*
MEADOW JUMPING MOUSE, *Zapus hudsonius*
RACCOON, *Procyn lotor*
SHORT-TAILED WEASEL, *Mustela erminea*
LONG-TAILED WEASEL, *Mustela frenata*
MINK, *Mustela vision*
SPOTTED SKUNK, *Spilogale interrupta*
STRIPED SKUNK, *Mephitis mephitis*
BADGER, *Taxidea taxus*
RED FOX, *Vulpes fulva*
GRAY FOX, *Urocyon cinereoargenteus*
WHITE-TAILED DEER, *Odocoileus virginianus*

Source: Gundersen, H. L., and J. R. Rear, 1959, The Mammals of Minnesota.

The Minneapolis-St. Paul area lies near the northern edge of the influx of moisture from the Gulf of Mexico. The average annual precipitation is 25.94 inches. Of this annual precipitation, approximately 65 percent (16.9 inches) occurs during the months of May through September. Thunderstorms are the principal source of precipitation during these months. Winter snowfall can be very heavy and averages more than 40 inches per year.

Wind directions vary throughout the year. Northwesterly winds prevail from November through April; southeasterly winds are dominant in May, June, August, and October; and southerly winds dominate in July and September. Wind speeds are fairly constant throughout the year, averaging 10.5 miles per hour (Envirodyne, June 1983).

2.7.8 Water Usage

The Moore Lake Natural Area is approximately 1 mile from the facility. Significant waterways in the vicinity include Rice Creek, approximately 2 miles to the north, and the Mississippi River, approximately 800 feet to the west (RMT, June 1987).

The Mississippi River provides active recreational opportunities to boaters and anglers as well as passive recreation because of its aesthetics and historical significance.

The Mississippi River also serves as a source of public and private water supply. The City of Minneapolis waterworks facility is located approximately 2,000 feet south (downstream) of the NIROP. The St. Paul water intake is located approximately 3 1/2 miles upstream from the site (RMT, June 1987).

The NIROP facility is situated over four aquifers capable of yielding significant quantities of water. These aquifers are generally restricted to the Mississippi River Valley.

The NIROP plant has three bedrock wells completed into the Prairie du Chien/Jordan aquifer. This is the only aquifer used in the immediate vicinity of the NIROP. These wells, which date back to the 1940s, were used as a potable water supply and for all of the industrial water needs for the plant until April 1981 (Envirodyne, June 1983).

Following closure of the wells, the plant switched to the Minneapolis water supply system for its potable water and industrial water needs. In August of 1981, the plant began reusing one of its wells for non-contact cooling water (Envirodyne, June 1983).

2.7.9 Facility Access

The NIROP restricts access to the facility via a fence. Non-plant personnel are screened by guards entering the visitor's gate.

3.0 INITIAL EVALUATION

This section presents the conceptual site model developed during scoping, describing the potential migration and exposure pathways and the preliminary assessment of human health and environmental impacts. The conceptual site model includes known and suspected sources of contamination, types of contaminants and affected media, known and potential routes of migration, and known and potential human and environmental receptors. This section, in addition to assisting in identifying locations where sampling is necessary, will also assist in the identification of potential remedial technologies.

3.1 TYPES AND VOLUMES OF WASTE PRESENT

Hazardous materials were used in the industrial operations within the production areas of the main industrial plant building at NIROP Fridley (Envirodyne, June 1983). The major operations conducted at the NIROP generated waste materials. Table 3-1 is a list of wastes that were produced in each of these areas. One of the most common hazardous materials used was trichloroethene (TCE), which was used as a solvent to degrease parts for various activities, such as welding, etc. TCE was used at NIROP until 1987, when 1,1,1-trichloroethane (TCA) was substituted for TCE as a solvent for degreasing activities.

The disposal methods for the wastes generated at the production areas in NIROP Fridley varied depending on the area and time frame. In the machine shop there was some recycling, and approximately 50,000 to 150,000 gallons/year of liquids were discharged to the sanitary sewer. Approximately 8 barrels/year of sludges from the machine shop were disposed of off site. Prior to 1973, waste liquids from metal plating were pumped directly to the sanitary sewer or disposed of off site. In 1973, an industrial wastewater pretreatment system was installed for treating wastewater generated from metal plating operations. After 1973, the plating shop wastewater was treated and then discharged to the sanitary sewer. The continuous treatment system automatically treated approximately 100,000 gallons per day of liquid plating wastes (Envirodyne, June 1983). The treatment operations during the 1980s generated approximately 25 barrels/year of plating sludges, which were disposed off site (Envirodyne, June 1983). There was some onsite disposal of plating sludges prior to 1973. Plant-wide cleaning and degreasing operations generated approximately 40 barrels/year of TCE, which was sold to a reclaimer, and approximately 120 barrels/year of stoddard solvent was disposed off site. In 1981 there were seven operational vapor degreasers, primarily used for cleaning purposes, with an average trichloroethene use for all operational degreasers of 2,146 gallons per month (Lindahl, March 1981). Also, from these plant-wide operations, approximately 75 barrels/year of 1,1,1-trichloroethane was disposed of off site. During

TABLE 3-1

WASTE PRODUCED AT INDUSTRIAL PROCESS AREAS
NIROP FRIDLEY, MINNESOTA

Production Area	Waste Type
Machine Shop	Metal scrap and shavings Water-soluble organic machine coolants Lubricating and cutting oils Oil from machines' hydraulic systems
Metal Plating	Acids Caustic compounds Sulfuric acids Manganese Zinc Phosphate Sodium cyanide TCE Plating sludges
Paint Shop	Paint sludge Alkaline cleaner Phosphatizing solution Chromic acid rinse Naphthalene, methylethylketone, and toluene Rinsewater TCE
Assembly	Stoddard solvent TCA Parts wash water
Foundry	Nonreclaimable sand TCE
Heat Treating	Waste quench oils Water based oils Non-cyanide-bearing quenching salts Cyanide-bearing salts Grit/bead blast
Photo Shop	Rinse water containing: • Fixer • Developer • Silver
Welding Department	Solid wastes: • Rod stubs • Flux • Slag Lime carbide
Boiler Plant	Blowdown condensate
Nondestructive Test Area	TCE
Cleaning/Degreasing (Plant-wide)	TCE Stoddard solvent 1,1,1-Trichloroethane

the 1960s, the paint shop produced 2 to 3 barrels/year of sludges, which were disposed of off site along with some presumed onsite disposal in pits and trenches. During the 1970s, a filter system was installed and the filters from this system were disposed of off site. Cleaner, phosphatizer, and rinse water used in the paint shop were discharged directly to the sanitary sewer, and chromic acid was collected and processed with the plating effluent pretreatment. Approximately 20 gallons/day of cleaners containing methyl ethyl ketone (MEK), toluene, or naphtha from the paint shop were disposed off site. Stoddard solvent and 1,1,1-trichloroethane wastes generated in the assembly area were included with the barrels of wastes generated from the cleaning and degreasing operations throughout the plant. Wash water generated in assembly was discharged directly to the sanitary sewer, and solvent-soaked rags were collected in closed containers and washed on site. Most of the sand from the foundry was reclaimed; however, non-reclaimable sand (core butts) was disposed of off site. Reportedly, some core butts were disposed on site at north property prior to 1970. After 1970 the core butts were disposed of by a contract hauler. The quench oil wastes used in heat treating were burned in the boilers, and waste water-based oils were discharged directly to the sanitary sewer. Approximately 1,200 pounds/year each of waste salts (non-cyanide and cyanide) and an unknown quantity of grit/bead blast wastes generated in heat treating were disposed of off site. Approximately 300,000 gallons of photo shop rinsewater were discharged annually, and wastes generated in the welding department were collected and disposed off site. In addition, 300,000 gallons of condensate blowdown from the boiler plant were discharged annually to the sanitary sewer. (RMT, June 1987)

In the late 1980s, approximately 4,000 tons per year of general plant waste (nonhazardous) were disposed of at an offsite sanitary landfill. During the 1940s through the 1970s, small, burnable material (nonhazardous) was incinerated on site in limited quantities, with offsite ash disposal. Pre-1973, some offsite landfill disposal of industrial wastes (hazardous), such as paint sludges and chlorinated solvents, occurred. In the early 1970s there was limited disposal of some industrial wastes (hazardous) in onsite pits and trenches in the northern portion of the site. Current practice involves collecting hazardous waste in 55-gallon drums for offsite disposal by a contractor. Approximately 30 drums per month of hazardous material have been generated since the early 1970s. In 1983, approximately 0.3 to 0.5 million gallons per day (mgd) of wastewater were discharged to the sanitary sewer.

Tanks and stockrooms were historically used for the storage of raw materials, and are located throughout the facility. Numerous hazardous materials, including metal conditioners, stripping and cleaning agents, solvents, paints, acids, bases, and photographic chemicals, were used at the NIROP Fridley. Specific

materials that were previously used at the NIROP Fridley for which material safety data sheets have previously been provided to other contractors by the USACE include the following (RMT, June 1987):

Product:	Ingredients:	Use:
Reliasolv 564	90% Tetrachloroethene	Cleaner and resin flux remover
Diko	Mixed Phenols	Molding sand binder
23-75 Coreactant	Biphenyl isocyanate Aromatic hydrocarbons	Phenolic-based resin binder used in molding sands
Various Pepset Formulations	Aromatic and aliphatic Hydrocarbons, phenol, formaldehyde, polymeric diisocyante, and pyridine	Phenolic-based resin binder used in molding sands
Various Isocure Formulations	Aromatic and aliphatic Hydrocarbons, triethylamine, polymeric diisocyanate, phenol, formaldehyde, alcohol, and aromatic acid derivatives	Foundry operations, resins, amines
Rust-Lick G-25-JA	Amines, nitrate, polyoxyethylene (dimethylimino) ethylene dichloride	Machine coolant
Trimsol	Petroleum oil, chlorinated wax, emulsifiers, odorants, and dye	Machine coolant

Commercial or technical grade TCE can contain other compounds that are also considered hazardous substances. These include chloroform and 1,1,1-trichloroethane.

The following paragraphs discuss potential onsite sources of contamination at the NIROP Fridley (RMT, July 1988).

3.1.1 Potential Sources Inside the Main Industrial Plant Building

As was stated in Section 2.5, 75 potential source areas of concern (AOCs) have been identified inside the main industrial plant building. The AOCs can be grouped according to facility operations to yield 7 major groupings and 22 miscellaneous AOCs that do not fall into a group. The 7 main groups are (1) TCA/TCE

tank storage, (2) degreasing, (3) heat treatment, (4) machining, (5) painting, (6) Pepset tank storage, and (7) plating. There are three mechanisms which could have resulted in releases of chemicals from the AOCs to the environment; direct release through a drywell, diffusion through concrete-lined sumps and pits, and leaks in sanitary and storm sewers.

3.1.2 Potential Sources Outside the Main Industrial Plant Building

- Drummed waste. Past waste disposal practices included occasional burying of drummed wastes in pits and trenches in the northern portion of the NIROP property.

  Between December 1983 and March 1984, 39 drums were excavated from trench 3 along with enough 1-gallon cans to fill two overpacks supplied by a contractor. In addition, two drums were excavated from trench 17. Of the 41 drums, hazardous substance were detected in 39. Hazardous constituents detected in samples from the drums include metals and several organic compounds including PCBs, TCE, benzene, xylenes, and MEK.

  About 1,200 cubic yards of soil from the areas of drum disposal were also excavated and removed from the NIROP.

- Hazardous Waste Storage Area C. Drainage from this area was formerly discharged into a dry well. Soil and water samples from the dry well had detectable levels of TCE, 1,1,1-TCA, 1,2-DCE, and PCE, along with other volatile organics and heavy metals.

The waste disposal site areas were addressed in the OU2 RI.

3.2 POTENTIAL PATHWAYS OF CONTAMINANT MIGRATION/PRELIMINARY PUBLIC HEALTH AND ENVIRONMENTAL IMPACTS

The development of a Conceptual Site Model is an essential component of the project planning, Data Quality Objective development, and exposure assessment processes. Figure 3-1 provides the Conceptual Site Model for Operable Unit 3. The model has been prepared based on current site conditions and on future land and water use.

As shown in Figure 3-1, near-surface and subsurface soils beneath the plant building constitute the source of interest for OU3. Three primary chemical release mechanisms have been identified for the soil matrix: (1) leachate generation; (2) fugitive dust generation (after exposure of the soils); and (3) emission of volatile organic chemicals. Environmental transport media associated with these release mechanisms include air and groundwater. The only secondary chemical release mechanism that has been identified, based on site physical conditions, is the discharge of groundwater to the Mississippi River.

Of the potential exposure pathways for OU3, only three are considered to be potentially complete under current land use conditions. Exposure of construction and/or utility workers could occur as a result of excavations involving disturbance of the slab in the plant building. Such workers could then be exposed as a result of incidental ingestion, direct dermal contact, or as a result of inhalation of volatile organics chemicals or fugitive dust.

Additional potential exposure pathways could occur under a residential future land use scenario. Such potential exposure routes include ingestion of groundwater or surface water, inhalation of volatile organics emitted from surface water or groundwater during showering or other household uses, and dermal contact with surface water or groundwater used for bathing. In addition, the exposure routes identified for the construction and utility workers could also exist under a residential land use scenario. Both adult and child receptors could be exposed under the residential scenarios. These potential exposure pathways are not reasonable because: (1) land use will be industrial for the foreseeable future; (2) surface water contamination has not been identified for several years; (3) the Navy controls the property over potential source zones; and (4) the Navy is required, under the OU1 Record of Decision, to provide alternative water sources or treatment in the event there is development of the groundwater within the offsite contaminant plume.

3.3 IDENTIFICATION OF OPERABLE UNITS

The operable units are defined in Section 2.5.

3.4 PRELIMINARY IDENTIFICATION OF RESPONSE OBJECTIVES AND REMEDIAL ACTION ALTERNATIVES

Based on the contaminated media, the potential pathways and receptors of concern, and the reasonably anticipated future land use (industrial), the preliminary response objectives are as follows:

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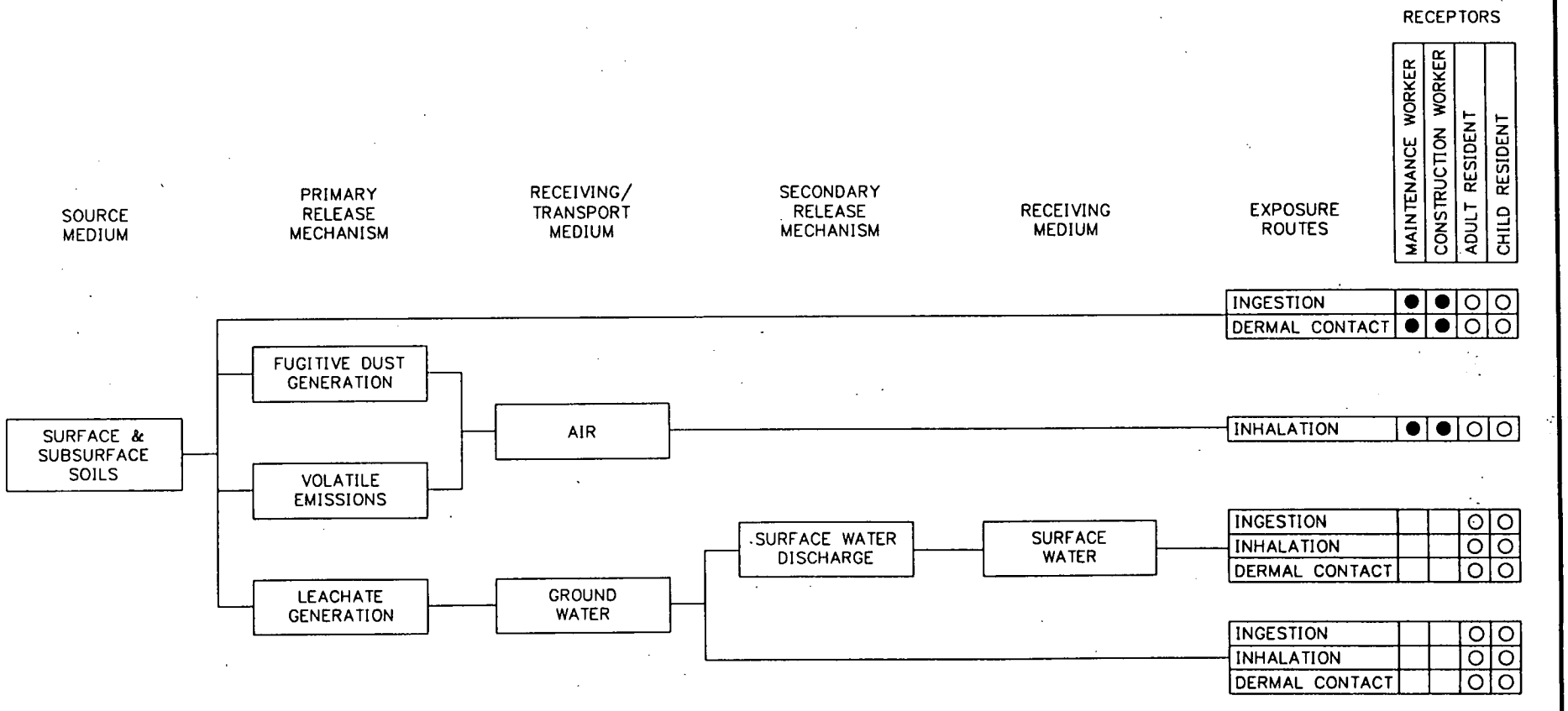

KEY:

● POTENTIALLY COMPLETE EXPOSURE PATHWAY.

○ INCOMPLETE HYPOTHETICAL EXPOSURE PATHWAY.

CONCEPTUAL SITE MODEL
OPERABLE UNIT 3
NIROP, FRIDLEY

FIGURE 3-1

Brown & Root Environmental

- Protection of construction and utility workers from unacceptable risk levels that may result from incidental ingestion of soils, direct dermal contact with soils, or as a result of inhalation of volatile organic chemicals or fugitive dust.

- Protection of groundwater from chemical sources that could contribute to groundwater contamination above acceptable levels.

The purpose of this section is to identify preliminary remedial action alternatives that may be appropriate. This initial discussion is intended to focus the scope of the RI so that data necessary for future decision-making can be collected. These preliminary remedial action alternatives are based on available site data and are subject to change as the RI progresses.

This section should not be considered a list of technologies or alternatives that have been agreed upon by the FFA parties. The selection of a remedy will be made by the FFA parties during later stages of the remedial investigation/feasibility study.

The FS will evaluate the feasibility and effectiveness of implementing remedial action alternatives. It will contain sufficient information and analysis to make the determination of the appropriate extent of remedy. The FS will use and build upon the information generated during the RI and will include an Alternatives Report and treatability studies (as appropriate). The Alternatives Report will provide an evaluation of each possible remedial action alternative identified in the initial screening of possible alternatives (a section of the RI Report), and any other reasonable alternative identified by the FFA parties.

It is assumed that remedial action alternatives for the area outside the building footprint may be different from those for the area beneath the building footprint. For the VOC-contaminated soils located outside the building footprint, the U.S. EPA developed presumptive remedies of soil vapor extraction, thermal desorption, and incineration. These presumptive remedies may or may not be appropriate for addressing the cPAH contamination which has been identified.

Currently available data suggest that some of the presumptive remedies for VOCs are inappropriate for the area beneath the building footprint. Because the area is covered by an operating facility having a 12-inch concrete slab floor, ex-situ techniques (thermal desorption and incineration) are not considered to be practical. In addition, capping alternatives are not considered to be necessary.

A containment and treatment alternative (hydraulic barrier [groundwater pumping combined with ex-situ treatment]) is currently in place and effective. Improvement on the existing hydraulic barrier through the installation of additional recovery wells may be considered. In-situ treatment alternatives, such as air sparging/vapor extraction, steam injection/vapor extraction, in-well stripping, and biodegradation, are retained for future consideration. The remedial action alternatives mentioned above are aimed at addressing the known contaminants of concern (i.e., VOCs). If other contaminants of concern are identified during the RI, such as metals, then additional remedial action alternatives may be appropriate.

4.0 WORK PLAN RATIONALE

This section identifies the outputs of the Data Quality Objective (DQO) process. DQOs are qualitative and quantitative statements designed to (1) clarify the objectives of the study, (2) define the most appropriate type of data to gather, (3) determine applicable conditions for data collections, and (4) specify tolerable limits or decision errors to establish the quantity and quality of the data needed to support the decisions. The OU3 RI/FS DQOs were developed by a multi-disciplinary planning team of professionals in accordance with current U.S. EPA guidance (U.S. EPA, September 1994). The planning team included engineers, geologists, hydrogeologists, chemists, statisticians, risk assessors, and representatives of the Navy, MPCA, and U.S. EPA.

Based on current knowledge of the site history and operations, and the site conceptual model presented in earlier sections of this Work Plan (Sections 2.0 and 3.0), the DQOs are organized to address two basic issues. The first relates to the potential human health risks from exposure to chemicals in soils. The second relates to groundwater protection from chemical sources in either the unsaturated or saturated zone that could contribute to groundwater concentrations above regulatory levels. The following sections summarize the DQOs for each problem.

4.1 HUMAN HEALTH RISKS

Given that the current and future land use at NIROP Fridley is industrial, a principal study question relating to human health risk is whether chemicals in soils underlying the NIROP building pose a health risk to workers. Potential health risks from soils outside the NIROP building were addressed in the OU2 RI and are not considered further in this Work Plan. Consideration of potential health risks from exposure to soils under the NIROP building is required and leads to the following decision statement:

> "If chemicals exist in unsaturated soils at concentrations that could pose a health risk to workers under an industrial land use scenario, then consider the feasibility of implementing appropriate remedies."

Actions that could be taken include remedial alternatives implemented upon analysis versus the nine criteria outlined in the FFA (see Section 5.3.2.1 of this Work Plan).

The Field Sampling Plan (FSP) Volume II outlines the data acquisition strategy to resolve the decision statement. Primary data needs are the identity, location, and concentration of Chemicals of Potential Concern (COPCs). The study boundaries for this decision statement are the soils under the entire NIROP building to a depth of 12 feet. Historical operations have involved movement or installation of equipment throughout the plant. In addition, utility lines traverse much of the building footprint. The 12-foot depth is based on the maximum excavation depth likely for heavy equipment foundations. These boundaries define the exposure unit for the decision. (It should be noted that areas of concern within the NIROP building may be identified as a result of sampling and analysis conducted during the RI and may be evaluated separately during the RI baseline risk assessment.)

Required data are generally obtainable via common investigation technologies, sampling and analysis techniques, existing site studies, or through open literature. Collection of on-site environmental data is constrained to some extent by physical conditions (e.g., machinery and underground utilities) and ongoing operations. There is also a concern that investigation activities could cause further spreading of potential DNAPLs underneath the building.

The data acquisition strategy (FSP Volume II) is designed to characterize the soils under the building footprint (or exposure units). A representative concentration will be calculated for each COPC in the exposure unit or area of concern being evaluated. The EPA 1992 Office of Solid Waste and Emergency Response guidance document, Publication 9285.7-081, will be consulted in the calculation of the representative concentration.

4.1.1 Receptors of Concern/Exposure Assessment

Preliminary decision rules for human health risks are proposed for three receptors assuming the current and future land use scenario for NIROP Fridley is industrial:

- **The Typical Industrial Worker** - Because the soils being evaluated are underneath the cement slab of the main NIROP Fridley building, this receptor is hypothetical only. The receptor is included for purposes of completeness and because the State of Minnesota has indicated that this receptor should be evaluated to determine if any access restrictions/deed restrictions (i.e., land use restrictions) are necessary. Exposure estimates for this receptor will be calculated per Minnesota Pollution Control Agency (MPCA) risk assessment methodology.

- **Major-Infrequent Construction Worker (MPCA Methodology)** - Under current site conditions, the construction worker who occasionally contacts soils underlying the building slab is the most plausible receptor for the RI baseline risk assessment. MPCA exposure assessment methodology will be used to evaluate exposures hypothetically incurred by one type of construction worker, an individual who will be referred to as the major-infrequent construction worker. The exposure estimates developed for this receptor will reflect exposures incurred by independent contractors who perform "major modifications" of the building slab and foundations.

- **Minor-Frequent Construction Worker (NIROP Specific)** - The second type of construction worker evaluated in the RI baseline risk assessment will be referred to as the minor-infrequent construction (or maintenance) worker. Exposure estimates developed for this receptor will reflect exposures incurred by a United Defense employee involved in routinely performed "minor maintenance activity" throughout the building.

Under the expected industrial land use scenario and current site conditions, worker exposure to unsaturated soils is limited. Routine worker exposure to soils is limited by a 12-inch reinforced concrete floor inside the building. Thus, typical industrial workers at NIROP Fridley are not currently exposed to soils underlying the cement slab. Routine exposure to soils would only occur if the cement slab was permanently removed. However, construction/utility/maintenance workers may be exposed to soils during construction (e.g., new equipment foundations) or maintenance and repair of underground utilities. Two types of construction/maintenance activities have been described by NIROP personnel: 1) Major modifications, and 2) Minor maintenance activity. A "major construction project or modification" is defined by NIROP Fridley as a disruption of the flooring of the building for the purposes of installation or modification of a foundation for machine tools. Based on historical data, major modification projects can occur 2-3 times per year; the work is performed by independent contractors. Major excavation/construction activities may last for periods exceeding 10 days (60 to 90 days was suggested as an upper bound by NIROP personnel). The depth of a major foundation modification is typically 8 feet. Exposure duration assumptions by MPCA for a construction worker (Table 4-1) are somewhat similar to actual exposure durations experienced by the independent contractors and will be used to calculate exposure estimates for this receptor. In keeping with the MPCA methodology, it will be assumed that the major-infrequent construction worker (working for an independent contractor) is exposed to NIROP soils during one major construction activity only. NIROP personnel indicate that the same contractor and

TABLE 4-1

EXPOSURE SCENARIOS
NIROP FRIDLEY, MINNESOTA
PAGE 1 OF 2

Utilization of Site and Adjoining Areas	Environmental Media	Route of Exposure	Example of Exposure	Exposure Model Assumptions	Comments/References
The NIROP Fridley facility is an industrial facility. The reasonably anticipated future land use for the property underlying the NIROP facility is also industrial.	Soils	Ingestion	Incidental ingestion while eating or smoking.	• Soil intake rate (IR) - Typical adult worker - 100 mg/day - Construction worker (MPCA)[1] - 480 mg/day - Construction worker (NIROP)[2] - 200 mg/day • Exposure Frequency (EF) - Typical adult worker - 250 days/year - Construction Worker (MPCA) - 65 days/year - Construction Worker (NIROP) - 80 days/year • Exposure Duration (ED) - Typical adult worker - 25 years - Construction worker - 0.25 year (MPCA) - Construction worker - 25 years (NIROP) • Body Weight (BW) - Adult - 70 kg • Fraction Ingested from Contaminated Area - Worker - 1.0	• Exposure assumptions per MPCA guidance except that the ingestion rate for the construction worker (NIROP) is based on professional judgment. The exposure frequency for the NIROP construction worker is based on NIROP-specific information.
		Dermal Contact	Dermal Contact with soils/dust while working.	• Skin Surface Area (SA) - Typical adult worker - 3,000 cm^2 - Construction workers - 4,900 cm^2 • Adherence factor of soil to skin (AF) - 0.3 mg/cm^2-event • EF - Typical adult worker - 250 days/year - Construction Worker (MPCA) - 65 days/year - Construction worker (NIROP) - 80 days/year • ED - Typical adult worker - 25 years - Construction worker (MPCA)- 0.25 year - Construction worker (NIROP) - 25 years • BW - Adult - 70 kg	• Exposure assumptions per MPCA guidance except that the exposure frequency for the NIROP worker is based on NIROP specific conditions. Chemical absorption factors will be chemical specific.

TABLE 4-1
EXPOSURE SCENARIOS
NIROP FRIDLEY, MINNESOTA
PAGE 2 OF 2

Utilization of Site and Adjoining Areas	Environmental Media	Route of Exposure	Example of Exposure	Exposure Model Assumptions	Comments/References
(Continued)	Soils (Continued)	Inhalation	Inhalation of volatile organics and particulates emitted from soils.	• Inhalation Rate (IR) - Typical adult worker - 20 m^3 - Construction workers - 20 m^3 • EF - Typical adult worker - 250 days/year - Construction worker (MPCA) - 65 days/year - Construction worker (NIROP) - 80 days/year • ED - Typical adult worker - 25 years - Construction worker (MPCA) - 0.25 year - Construction worker (NIROP) - 25 years • BW - Adult - 70 kg • Volatilization Factor - Chemical and site specific • Particulate Emission Factor - Chemical and site specific	• Exposure assumptions per MPCA guidance except that the exposure frequency for the NIROP worker is based on NIROP specific conditions.

1 Construction worker (MPCA) = Major-Infrequent Construction Worker
2 Construction worker (NIROP) - Minor-Frequent Construction Worker

personnel are not used repeatedly. "Minor maintenance activity" is defined by NIROP Fridley as floor modifications where the soil is exposed for periods less than 10 days. Typically, the area exposed is less than 200 square feet. The depth of the soil disruption is around 2-4 feet. This type of activity occurs 5 to 8 times a year throughout the building; the work is performed by United Defense employees (i.e., the minor-frequent construction worker). According to NIROP personnel, and in contrast to the major-infrequent construction worker scenario, the same work crews are used repeatedly. Exposure dose assumptions for these industrial worker and construction worker receptors are summarized in Table 4-1. Preliminary remediation goals (PRGs) will be developed for COPCs for each of these receptors. (Example calculations are provided in Appendix A.) It should be noted that exposure dose methodology may be refined as site-specific information (e.g., the size of an area of concern, the total organic carbon content of soils) becomes available.

Assuming that distinct areas of contamination are identified as a result of RI sampling and analysis and that these areas are sizeable enough to hypothetically encompass a major construction activity, such areas will be evaluated using the major-infrequent construction worker scenario. ("Representative concentrations" for specific areas of concern will used to evaluate the major-infrequent construction worker and typical industrial worker receptors.) Given that the minor-infrequent construction worker is potentially exposed to soils throughout the building over the course of a 25 year working lifetime, some area or time weighting strategy may be used to calculate the representative concentration for this receptor. The Navy will evaluate the appropriateness and details of such a strategy with the MPCA once the analytical data have been plotted for visual inspection.

4.1.2 Chemicals of Potential Concern

It is anticipated that the chemicals present in the near-surface soils within the confines of the plant building are similar to those detected in the East Plating Shop (Halliburton NUS, May 1995) and in the exterior soils (OU2) (MPCA, January 1995). Based on historical data, the following are identified as COPCs:

- Ethylbenzene
- Toluene
- Trichloroethene
- Tetrachloroethene
- 1,1-Dichloroethane
- 1,2-Dichloroethene

- 1,1,1-Trichloroethane
- 1,1-Dichloroethane
- Bis(2-ethylhexyl)phthalate
- Benzo(a)pyrene
- Barium
- Chromium
- Lead
- Zinc

The preceding list is not all inclusive of the COPCs, but is sufficient for preliminary planning purposes. The list includes primary chemicals detected in groundwater and representative chemicals for the volatile, semivolatile, and inorganic fractions. The final list of COPCs to be evaluated in the baseline risk assessment will be selected based on a comparison of maximum contaminant concentrations in soils to PRGs developed for the typical industrial worker and other relevant factors (e.g., background concentrations):

- Any carcinogen detected at a maximum concentration exceeding the PRG established at 1×10^{-6} cancer risk level for a typical industrial worker will be selected as a COPC for quantitative risk assessment.

- Any noncarcinogen detected at a maximum concentration exceeding one-tenth the PRG for a typical industrial worker for noncarcinogenic health effects will be selected as a COPC for quantitative risk assessment.

Metals not detected at concentrations exceeding naturally occurring background concentrations will not be selected as COPCs.

4.1.3 Risk Characterization and Decision Rules

PRGs calculated for each of the receptors previously defined will be used to estimate risks associated with COPC concentrations in soils. Cumulative risk estimates will be developed and evaluated using decision rules. For example, the need for action will be contingent upon the cumulative incremental cancer risk or the cumulative Hazard Index exceeding risk action levels (1×10^{-5} and 1.0, respectively).

Cumulative risk estimates for the typical industrial worker, the major-infrequent construction worker, and the minor-frequent construction/maintenance worker will be computed according to Equations 1 and 2 for carcinogens and noncarcinogens, respectively.

$$LICR = \sum_{ij} \frac{C_i}{PRG_i} x1E-6 \quad (1)$$

$$HI = \sum_{ij} \frac{C_i}{PRG_i} \quad (2)$$

LICR	Lifetime Incremental Cancer Risk (dimensionless)
Ci	Representative concentration of the ith chemical (mg/kg or mg/L)
PRGi	Preliminary Remediation Goal for the ith chemical (mg/kg or mg/L)
HI	Hazard Index (dimensionless)
Σ	Sigma i denoting the summation over i
i	Chemicals of Potential Concern

Thus, risks are summed across the multiple exposure routes used to develop the PRGs and across all of the COPCs.

Based on the action levels proposed above and the decision statement, the following decision rules will be applied:

(1a) If the cumulative incremental cancer risk determined for the typical industrial worker using Equation 1 exceeds $1x10^{-5}$ for an exposure unit or area of concern, the need for access restrictions, zoning restrictions, and deed notifications will be evaluated.

(1b) If the cumulative Hazard Index determined for the typical industrial worker using Equation 2 exceeds 1.0 for an exposure area or area of concern, reevaluate the Hazard Index based on toxic endpoints/target organs. If the cumulative Hazard Index still exceeds 1.0, the need for access restrictions, zoning restrictions, and deed notifications will be evaluated. If the Hazard Index for any individual COPC exceeds 0.2, the need for access restrictions, zoning restrictions, and deed notifications will be evaluated.

(2a) If the cumulative incremental cancer risk determined for a construction worker (either the major-infrequent construction worker or minor-frequent construction worker) using Equation 1 exceeds $1x10^{-5}$ for an exposure unit or area of concern, then evaluate the need for and the feasibility of implementing appropriate remedies.

(2b) If the cumulative Hazard Index determined for a construction worker (either the major-infrequent construction worker or minor-frequent construction worker) using Equation 2 exceeds 1.0 for an exposure unit or area of concern, then reevaluate the cumulative Hazard Index based on toxic endpoints/target organs. If the cumulative Hazard Index stills exceeds 1.0, then evaluate the need for and the feasibility of implementing appropriate remedies. If the Hazard Index for any individual COPC exceeds 0.2, the evaluate the need to include the parameter in the Feasibility Study.

4.2 GROUNDWATER PROTECTION

The OU1 RI/FS resulted in the implementation of a record of decision (ROD) to install a series of extraction wells (pump and treat system) to remediate and prevent further offsite migration of volatile organic compounds (VOCs). The OU1 ROD also requires the Navy to either treat or provide an alternative water source should anyone develop the downgradient groundwater within the offsite plume. While these remedies have resulted in the elimination of potential routes of exposure, several questions remain. Questions include:

"Are there COPCs in the unsaturated or saturated zone beneath the building at concentrations that would result in exceedance of groundwater concentrations designed to be protective of human health?"

"How long must the existing pump and treat system be operated to protect human health?"

"Are there other remedial alternatives that would result in a cost-beneficial reduction in the time to restore the groundwater to levels protective of human health?"

Consideration of these questions yields the following decision statement:

> "If COPC sources exist in the unsaturated or saturated zone beneath the building at concentrations that could result in exceedances of groundwater standards, then evaluate alternatives for source control/removal that would result in a beneficial reduction in the overall time for groundwater restoration as measured by the nine criteria."

Actions that could be taken include remedial alternatives implemented upon analysis versus the nine criteria outlined in the FFA. Because a remedial alternative (pump-and-treat) has already been implemented for groundwater, remedial alternatives in the unsaturated or saturated zones directed at the protection of groundwater would only be implemented if the alternative would result in a cost-beneficial reduction in the overall time for groundwater restoration, when compared to the remedy outlined in the OU1 ROD.

The data acquisition strategy to support this decision statement is presented in Volume II FSP. Data to be collected in support of the human health risk assessment (Section 4.1) also support this decision statement. Groundwater data also are needed to determine the identity, location, and concentration of COPCs in the saturated zone. In addition, the following data are necessary to support the evaluation of potential remedies (see Section 3.4):

- Chemical and physical data (e.g., total suspended solids, hardness, alkalinity, iron and manganese content, etc.).

- Information regarding the biodegradation potential in the saturated and unsaturated subsurface (e.g., dissolved oxygen, sulfate, reduced iron, and dissolved methane).

- Physical information necessary to model unsaturated zone transport (e.g., distribution coefficients for inorganics constituents, organic partition coefficients for organic constituents, soil porosity, bulk soil density, infiltration rates, organic carbon content, infiltration rates for percolating precipitation, etc.).

- Physical information necessary to model saturated zone transport (e.g., stratigraphy, groundwater flow direction, hydraulic gradient, hydraulic conductivity, porosity, bulk density estimates of hydrodynamics dispersivities, etc.).

- Information necessary to complete a risk assessment; i.e., dose response (toxicity data) for COPCs.

The same data sources and constraints discussed in Section 4.1 are applicable to support this decision statement. In addition to geologic information gained from soil borings and monitoring well installations, the seismic survey completed outside the building will be used to help understand the nature of subsurface geologic conditions. The three seismic survey lines correlated well with existing boring logs and confirmed that the geology beneath the site is complex and can differ significantly over relatively small distances. The boundaries of this study include the entire saturated zone beneath NIROP Fridley.

Action levels for the protection of groundwater will be based on fate and transport modeling combined with groundwater Maximum Contaminant Levels (MCLs) or Minnesota Health Risk Limits (HRLs) for site-specific COPCs. If an MCL and an HRL exist for a parameter, then the more conservative value will be used. If an MCL and HRL do not exist, then Minnesota Health Based Values (HBVs) will be used. The MCL, HRL and HBVs are as follows:

COPC	HRL (µg/L)	MCL (µg/L)	HBV (µg/L)
Ethylbenzene	700	700	--
Toluene	1000	1000	--
Trichloroethene	30	5	--
Tetrachloroethene	7	5	--
1,1-Dichloroethene	6	7	--
cis-1,2-Dichloroethene	70	70	--
trans-1,2-Dichloroethene	100	100	--
1,1,1-Trichloroethane	600	200	--
1,1-Dichloroethane	70	NA	--
Bis(2-ethylhexyl)phthalate	NA	NA	300
Benzo(a)pyrene	NA	2	--
Barium	2000	2000	--
Chromium	100 (Cr^{+6})	100	--
Lead (Action Level)	NA	15	--
Zinc	2000	NA	--

Criteria for the protection of groundwater for soils beneath the building will be developed after the Phase I results are available. It is expected that the approach will be similar to the one recently taken to redevelop the OU2 clean up numbers, with the exception that there would be little or no infiltration of water because the soils are covered by the building.

Based on the groundwater protection criteria and the decision statement, the following decision rule is proposed.

> "If the unsaturated or saturated zone source concentrations exceed the criteria for protection of groundwater, then evaluate alternatives for source control/removal that would result in a beneficial reduction in the overall time for groundwater restoration as measured by the nine criteria."

The potential impacts on the Prarie du Chien Aquifer will be evaluated if concentrations found in the deep portion of the surficial aquifer indicate the presence of DNAPL.

5.0 RI/FS TASKS

This section presents the tasks to be performed during the RI/FS. This description incorporates the RI site characterization tasks identified in the QAPP and the FSP, the data evaluation methods identified during scoping, and the preliminary determination of tasks to be conducted after site characterization.

5.1 OVERVIEW OF FFA ATTACHMENT A TASKS

Attachment A to the FFA outlines tasks required under the RI/FS process. These tasks are as follows:

- Retain Consultants.
- Site Security and Health and Safety Plan.
- Remedial Investigation.
  - Submit an Initial Evaluation Report, Remedial Investigations Work Plans, Quality Assurance Project Plans, Sampling and Analysis Plans, and Surface Water Investigation Plan.
  - Report Results of Remedial Investigations.
- Feasibility Studies.
  - Alternatives Report.
  - Treatability Studies.
  - Review of Alternatives Report and any associated Treatability Studies.
  - Feasibility Study Report.
- Proposed Plan and Record of Decision, including Responsiveness Summary.

Attachment A also states that RI Work Plans, which follow a phased approach (as does OU3), contain the following elements:

- Hazardous Substance, Pollutant, or Contaminant Characterization.
- Source Investigation.

- Hydrologic Investigation.
- Soils Investigation.

Section IV, Task A, of Attachment A specifies that a QAPP and a SAP be submitted, and item 3 of Task A states that the QAPP shall include the SAP. It was agreed during the pre-QAPP meeting, described on page 7 of Attachment A to the FFA (U.S. EPA, March 1991), that the U.S. EPA Region V Model QAPP be used. This model does not specify the preparation of a SAP but allows for the development of a Field Sampling Plan. The QAPP, along with the FSP, includes the elements of the SAP specified in the FFA.

5.2 TASKS COMPLETED

Previously submitted reports, as described below, address some of the specified requirements of the FFA (U.S. EPA, March 1991).

5.2.1 Initial Evaluation Report

As stated in Attachment A, in June of 1983, the Initial Assessment Study (Envirodyne Engineers, Inc., June 1983) of Naval Industrial Reserve Ordnance Plant was published. This document serves as the Initial Evaluation Report.

5.2.2 Hazardous Substance, Pollutant or Contaminant Characterization

The Initial Assessment Study (Envirodyne Engineers, Inc., June 1983) referenced above and the Site Evaluation Report (B&R Environmental, September 1995) published in September of 1995 and amended (B&R Environmental, February 1996) to address U.S. EPA and MPCA comments, serves as the hazardous substance, pollutant or contaminant characterization to date. The RI will complete the characterization of the site.

5.2.3 Source Investigation

The Initial Assessment Study (Envirodyne Engineers, Inc., June 1983), the Site Evaluation Report (B&R Environmental, September 1995), and the Site Evaluation Report Amendment (B&R Environmental, February 1996), along with the SWMU/AOC comparison and the former SWMU/active SWMU comparison (B&R Environmental, January 1997), serve as the source investigation to date. The SWMU/AOC

comparison documents which areas were considered and provides the reasoning for not including certain SWMUs as AOCs for the OU3 investigation. The RI will complete the source investigation.

5.2.4 OU1 Hydrologic Investigation

A substantial amount of work has been done to characterize groundwater flow and contaminant transport in the area of the site during the OU1 RI/FS, Record of Decision (ROD), Remedial Design (RD), and Remedial Action (RA). Numerous groundwater monitoring wells have been installed at the site. There are monitoring wells in the shallow drift, intermediate drift, deep drift, and bedrock aquifer. The shallow drift at the site has been defined as the unconfined aquifer interval from water surface to a depth of 30 feet; the intermediate drift is from 30 to 60 feet below the water surface; and the deep drift is from 60 to 100 feet below the water surface (RMT, Inc., April 1996). There are at least 42, 19, 40 and 12 monitoring wells located in the shallow drift, intermediate drift, deep drift, and bedrock aquifer, respectively. The known shallow drift, intermediate drift, deep drift and bedrock aquifer monitoring well locations are shown on Figures 5-1, 5-2, 5-3, and 5-4, respectively. Twenty shallow drift monitoring wells, ten intermediate drift monitoring wells, thirteen deep drift monitoring wells, and one bedrock aquifer monitoring well are monitored for groundwater chemical characteristics. The discharge from each of the six extraction wells is also sampled during each groundwater sampling round. Water-level data are collected from the monitoring and extraction wells, the river, and from the United Defense site located south of NIROP Fridley. The groundwater monitoring information, including TCE isoconcentration maps for the shallow, intermediate, and deep drifts and hydraulic head maps for the shallow, intermediate, and deep drifts and bedrock aquifer, is compiled annually in a report.

In addition, tests (i.e. aquifer/pump tests) have been conducted to determine the hydraulic properties (i.e. groundwater flow rates in the horizontal and vertical directions) of the water-bearing formations. An upward gradient from the bedrock to the overlying sand, which tends to prevent the migration of contaminants into the bedrock, has been observed (RMT, Inc., April 1996).

5.2.5 OU2 Soils Investigation

The OU2 RI has been finalized and approved. An OU2 FS is currently being finalized; however it will not be approved because OU2 will be incorporated into OU3 for remediation purposes. Information included in the OU2 FS will be used, as appropriate, during development of the OU3 FS. OU2 included an investigation of sources within the unsaturated zone outside the building footprint contributing to

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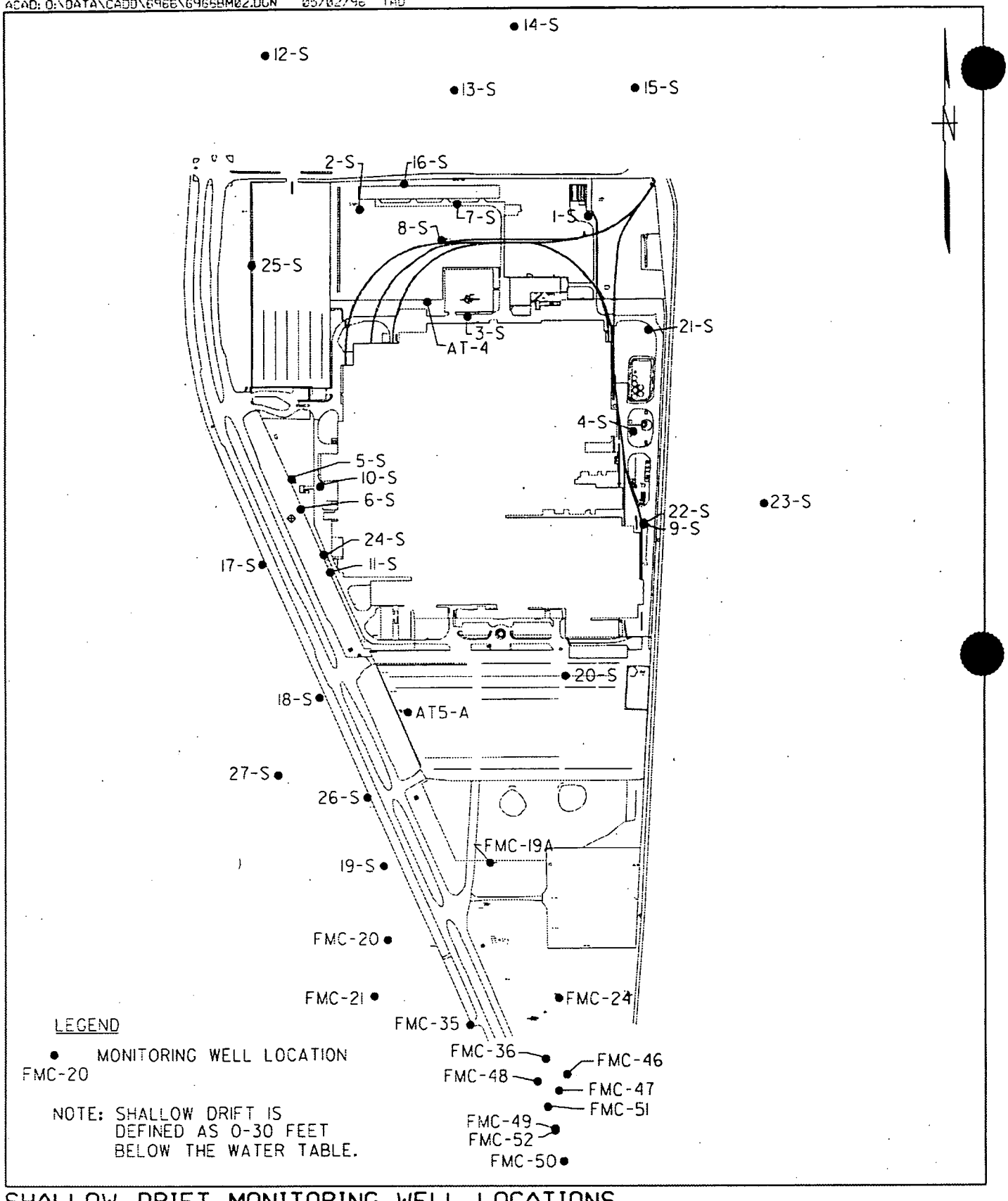

SHALLOW DRIFT MONITORING WELL LOCATIONS

NIROP FRIDLEY

FRIDLEY, MINNESOTA

0 650 1300

SCALE IN FEET

FIGURE 5-1

Brown & Root Environmental

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CTO 0003

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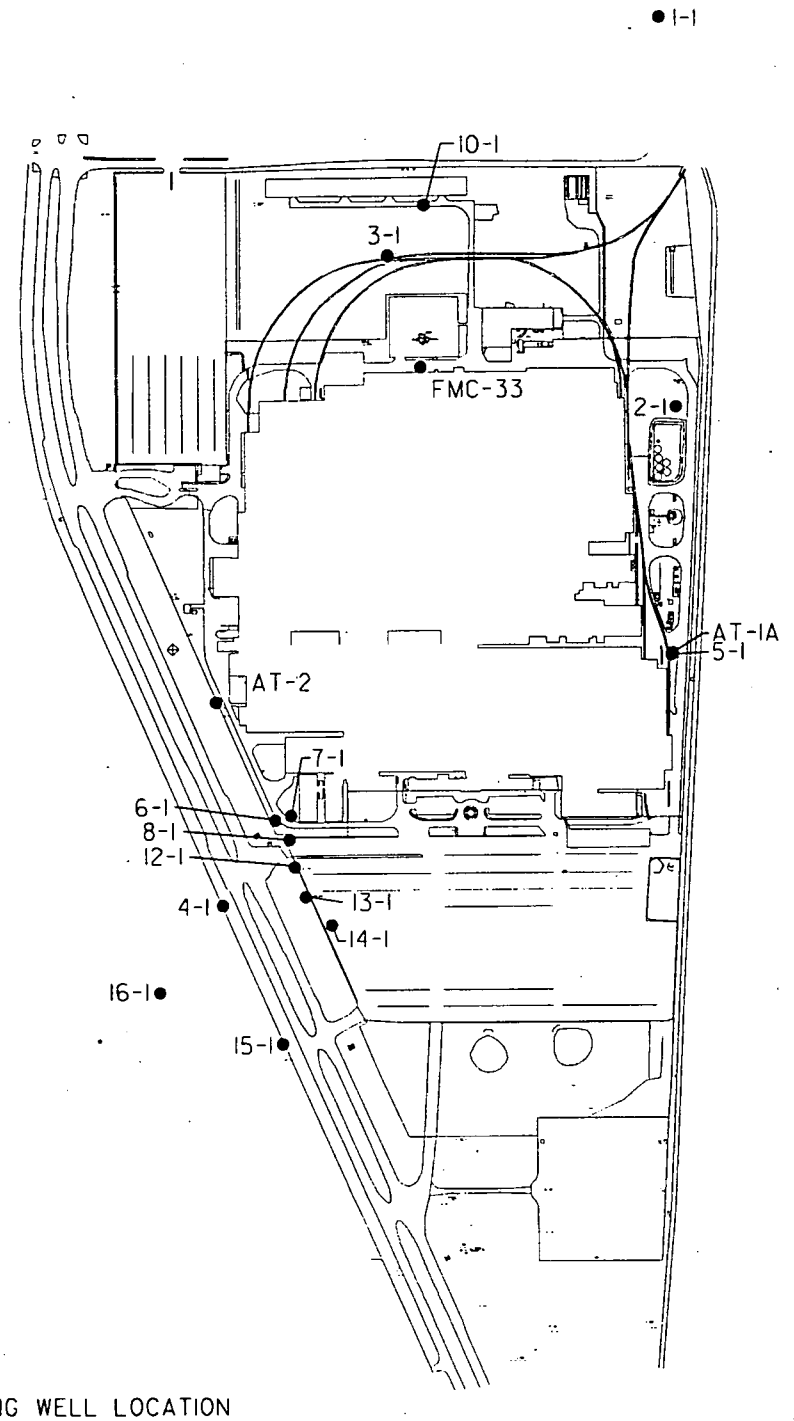

LEGEND

● MONITORING WELL LOCATION
15-1

NOTE: INTERMEDIATE DRIFT IS DEFINED AS 30 - 60 FEET BELOW THE WATER TABLE.

INTERMEDIATE DRIFT MONITORING WELL LOCATIONS

FIGURE 5-2

NIROP FRIDLEY

FRIDLEY, MINNESOTA

0 650 1300

SCALE IN FEET

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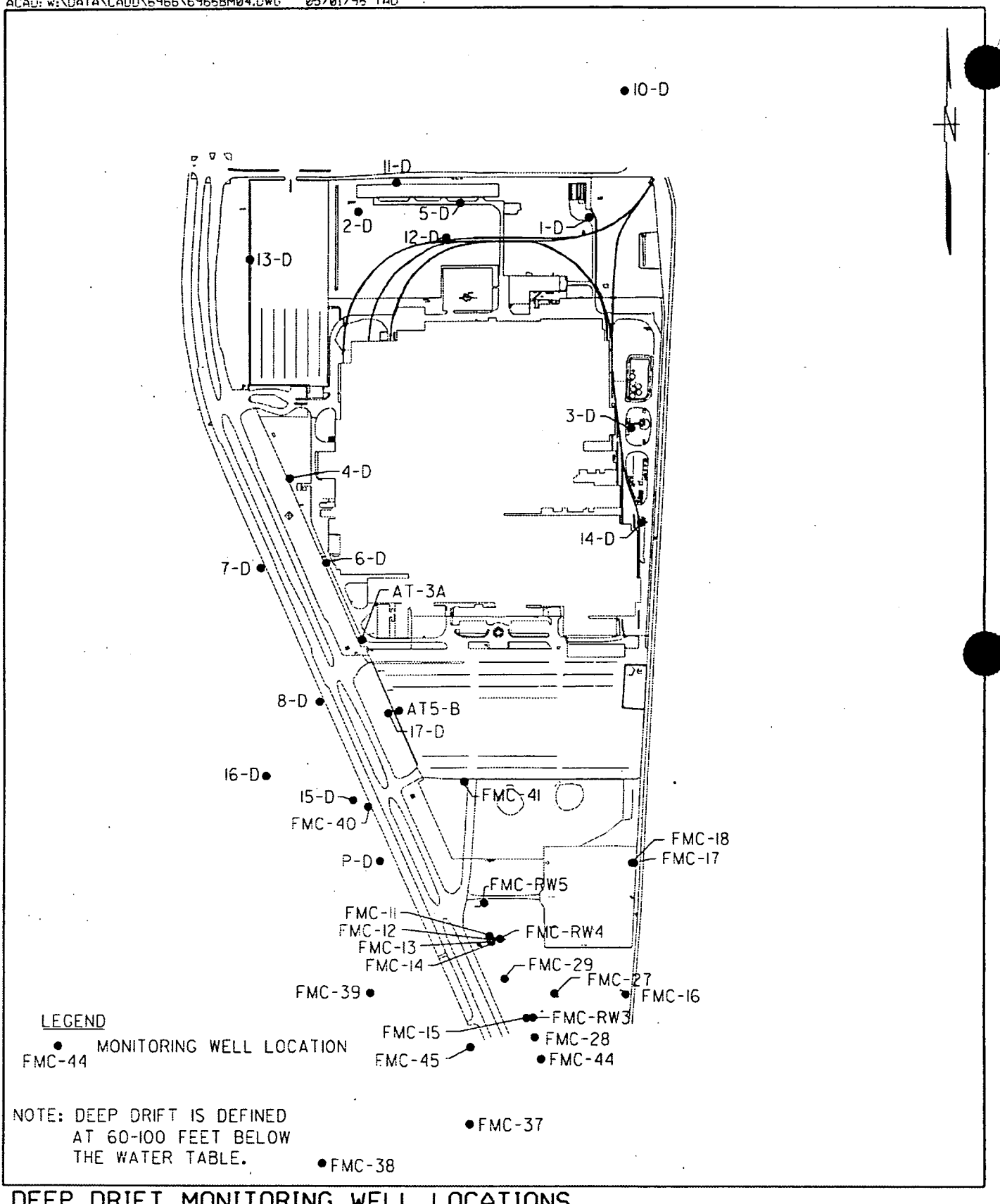

DEEP DRIFT MONITORING WELL LOCATIONS

NIROP FRIDLEY

FRIDLEY, MINNESOTA

FIGURE 5-2

0 650 1300

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Brown & Root Environmental

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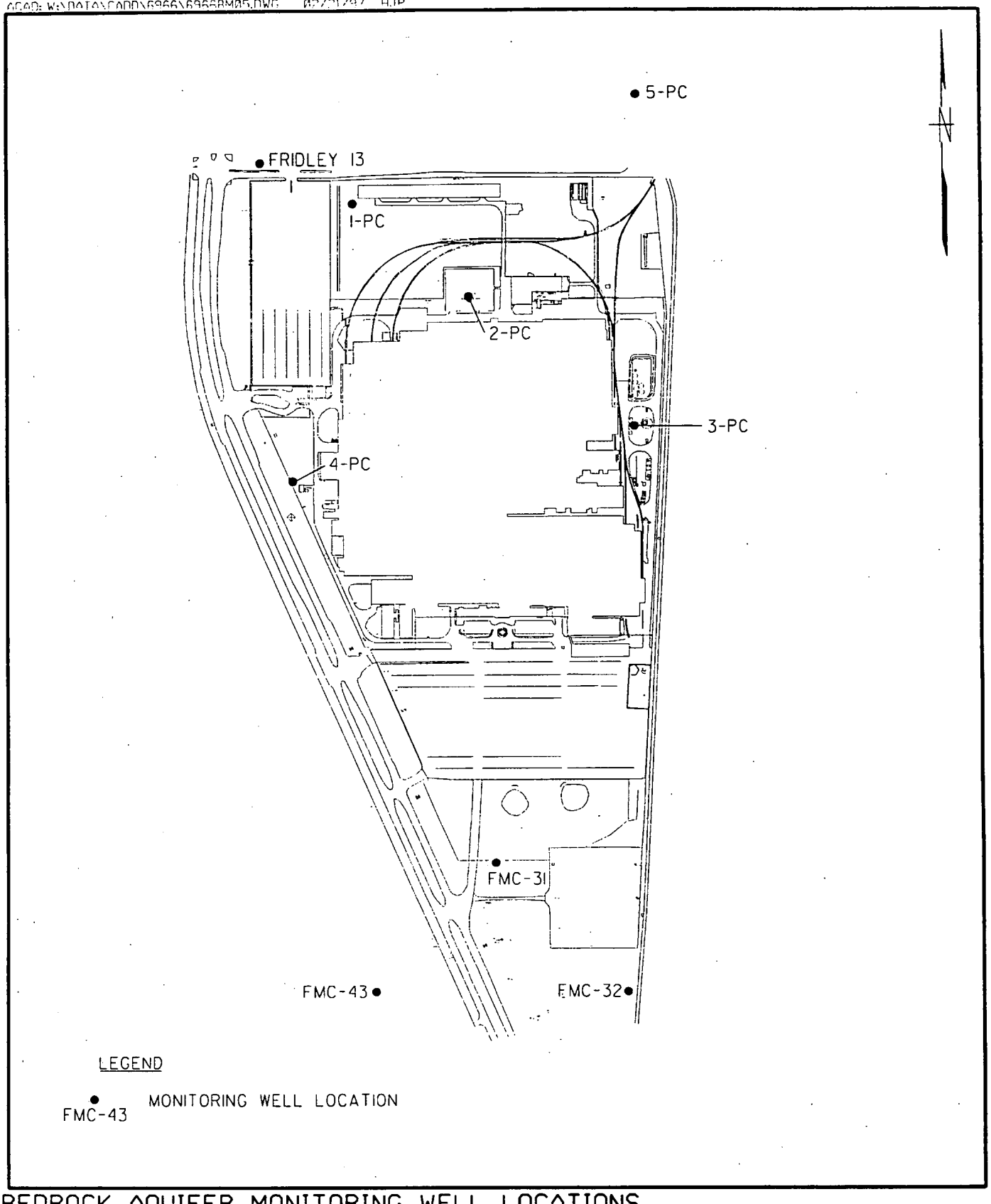

BEDROCK AQUIFER MONITORING WELL LOCATIONS
NIROP FRIDLEY
FRIDLEY, MINNESOTA

0 650 1300
SCALE IN FEET

FIGURE 5-4

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groundwater and soil contamination. Six areas located to the north of the main industrial plant building are identified on RMT Figure 1, dated October 1995 (RMT, Inc., October 9, 1995), as requiring cleanup based on the presence of VOCs (primarily TCE) above the MPCA soil-leaching model results (e.g., not protective of groundwater). The total estimated VOC contaminated soil volume is 12,000 cubic yards (RMT, Inc., October 9, 1995). Six soil borings located to the north of the main industrial plant building and one unidentified soil boring are identified on RMT Figure 2, dated October 1995 (RMT, Inc., October 9, 1995), as requiring cleanup based on the presence of cPAHs above risk based remedial goals for industrial land use under present site conditions. The total estimated cPAH contaminated soil volume is 350 cubic yards (RMT, Inc., October 9, 1995). New data, collected subsequent to completion of the OU2 RI, including the "North 40 Barrel Removal Project", the recently redeveloped soil clean up numbers based on the protection of groundwater, and any changes to the risk assessment methodology (e.g., the residential land use scenario no longer applies), will be incorporated into the OU3 RI Report, as appropriate.

5.2.6 Surface Water Investigation Plan

The surface water investigation was completed for OU1 and OU2. The investigation demonstrated that contaminants from NIROP Fridley are not entering or about to enter the Mississippi River via surface drainage or storm sewer outfalls. Therefore, a surface water investigation plan to quantify the migration of such material and the impact on nearby surface water will not be prepared for OU3. The surface water investigation results from OU1 and OU2 are summarized below.

No TCE was detected in samples collected annually by FMC at the Minneapolis water treatment plant intake for the 3 years prior to completion of the OU1 ROD (U.S. EPA, March 1991). The NIROP facility is situated on an alluvial terrace of the Mississippi River. Much of this very flat surface is covered by buildings and pavement. Runoff from these hard-surfaced areas is collected by a series of storm sewers, which discharge into the Mississippi River, located approximately 800 feet west of the plant boundary (RMT, Inc., June 1987). One round of samples was collected from the storm sewers serving the NIROP, and no VOCs were found (U.S. EPA, March 1991).

The constituents of concern for migration via surface water are those identified at elevated levels in the near-surface soils. The constituents found in near-surface soils are not expected to migrate via surface water because the site does not exhibit a significant slope in any direction that would transport suspended sediment or dissolved constituents off site. Therefore, this potential contaminant migration route is not important (RMT, Inc., September 1993).

5.3 OU3 REMAINING WORK

Based on the information provided in Sections 5.1 and 5.2, the work which remains to be completed for OU3 includes a hydrologic and soils investigation beneath the main industrial plant building, an RI report, an alternatives report, treatability studies, a feasibility study report, a proposed plan, and a record of decision including a responsiveness summary.

5.3.1 Remedial Investigation

The RI portion of the OU3 work includes the hydrologic and soils investigation and RI report.

5.3.1.1 Hydrologic Investigation

A significant amount of hydrologic information exists from the OU1 work, which has allowed for the inference of the hydrologic conditions beneath the main industrial plant building. In addition, a shallow groundwater investigation was conducted at the former East Plating Shop (HNUS, May 1995). The objective of the hydrologic investigation is to provide information in addition to the existing database to refine the existing characterization of groundwater flow and contaminant transport beneath the main industrial plant building and identify any contaminant sources within the saturated zone. In addition, parameters will be collected to evaluate natural attenuation of chlorinated ethenes. Shallow, intermediate, and deep drift groundwater samples will be collected and analyzed. Shallow groundwater samples will be collected from temporary wells via direct-push technology. Shallow, intermediate, and deep samples will be collected from permanent monitoring wells. Water elevations/levels will be measured at each sampling point. Elevations of the permanent monitoring wells will be surveyed. Groundwater flow rates will be determined. The results of a seismic imaging study will be incorporated into the OU3 RI/FS. Details of the hydrologic investigation are presented in the Field Sampling Plan (Volume II).

A decision regarding the installation of monitoring wells in the bedrock aquifer will be made following review of the results from the hydrologic investigation proposed in the Work Plan.

Addition of any of the shallow, intermediate, or deep monitoring wells to the existing groundwater monitoring network will be evaluated and presented in the Annual Monitoring Report for 1996.

5.3.1.2 Soils Investigation

The soils investigation is a process to investigate the sources contributing to groundwater and soil contamination beneath the main industrial plant building. The existing amount of information on soil includes the results of the former East Plating Shop soils investigation and results from three soil samples collected at the southeastern corner of the building in an excavation for new production assembly pit foundations. Soil samples will be collected and analyzed. Details of the soils investigation are presented in the Field Sampling Plan.

5.3.1.3 RI Report

All data, analytical results, boring logs, and results will be organized and presented in the OU3 RI Report. The RI Report will include the following:

- Study Area Investigation
- Physical Characteristics of the Study Area
- Nature and Extent of Contamination
- Contaminant Fate and Transport
- Risk Assessment

Conclusions from OU2 will be incorporated into the OU3 RI Report (and the FS Report discussed below). This includes a discussion of contaminated areas, calculation of contaminated soil volumes, and source area discussions as they relate to groundwater contamination.

5.3.2 Feasibility Study

The FS portion of the OU3 work includes the alternatives report, treatability studies, and the FS Report.

5.3.2.1 Alternatives Report

Following finalization of the RI Report, an Alternatives Report will be developed. The primary objective of the Alternatives Report phase of the FS is to develop an appropriate range of waste management options that will be analyzed more fully in the FS Report. The Alternatives Report will include the following:

- Remedial Action Objectives
- General Response Actions
- Screening of Technologies and Process Options
- Development of Remedial Alternatives
- Screening of Alternatives through Evaluation of Effectiveness, Implementability, and Relative Cost, if necessary

5.3.2.2 Treatability Studies

As stated in the FFA, following finalization of the RI Report and prior to completion of the FS Report, any appropriate treatability studies will be developed. Treatability studies may also be developed after the FS during the Remedial Design/Remedial Action (RD/RA) phase of remediation. If a treatability study is performed, the following factors will be addressed and presented:

- Effectiveness in treating the hazardous substances, pollutants, and contaminants of concern.
- Reliability and past success of technologies under consideration and use of past data results associated with the technology.
- Availability of the specified technology.

If treatability studies are identified prior to finalization of the RI Report, then the Navy may choose to initiate them at that time. No treatability studies have been identified yet. The Navy, however, does plan to make use of the knowledge which has been gained during ongoing remedial actions (pump-and-treat, soil vapor extraction) during evaluation of alternatives at the site. In addition, parameters will be collected to evaluate natural attenuation of chlorinated ethenes.

5.3.2.3 FS Report

The FS Report will include the detailed analysis of individual alternatives, carried forward from the Alternatives Report, with respect to the specified criteria.

- Overall Protection of Human health and Environment
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
- Long-term Effectiveness and Permanence
- Toxicity, Mobility, and Volume Reduction through Treatment

- Short-term Effectiveness
- Technical Feasibility and Implementability
- Cost
- State Acceptance
- Community Acceptance

A detailed conceptual design will be prepared only for the preferred remedial alternative.

5.3.3 Proposed Plan and Record of Decision, Including Responsiveness Summary

Following finalization of the FS Report, a Proposed Plan will be prepared and published for public review and comment. At the close of the public review period, community and state acceptance will be evaluated in a Responsiveness Summary. A Record of Decision will then be prepared.

6.0 PROJECT SCHEDULE

This section presents the project schedule for the OU3 RI to be conducted at NIROP Fridley. Included in the following sections are the anticipated date of project mobilization and a task bar chart and associated time frames.

6.1 ANTICIPATED DATE OF PROJECT MOBILIZATION

The anticipated date of mobilization for the field investigation is June 1997.

6.2 TASK BAR CHART AND ASSOCIATED TIME FRAMES

The project schedule is shown on Figure 6-1. The project schedule is based on specific activity schedules specified in the FFA. The premobilization meeting will be held once the draft final Work Plan has been submitted in an effort to initiate field work as soon as possible. However, mobilization will not occur until the Work Plan is final. Very few changes to the draft final are anticipated. However, any changes made between draft final and final that are different from what was discussed during the premobilization will be discussed and adjustments made as necessary prior to mobilization.

The official overall project schedule is contained in the Site Management Plan, which is currently being prepared by the Navy. As part of the Site Management Plan, the FFA parties will meet at least quarterly to assess the project progress. Schedule impacts will be noted and will be discussed at these quarterly meetings. It is anticipated that revised project schedules will be issued periodically. The most recent Site Management Plan update should be consulted for the most recent project schedule.

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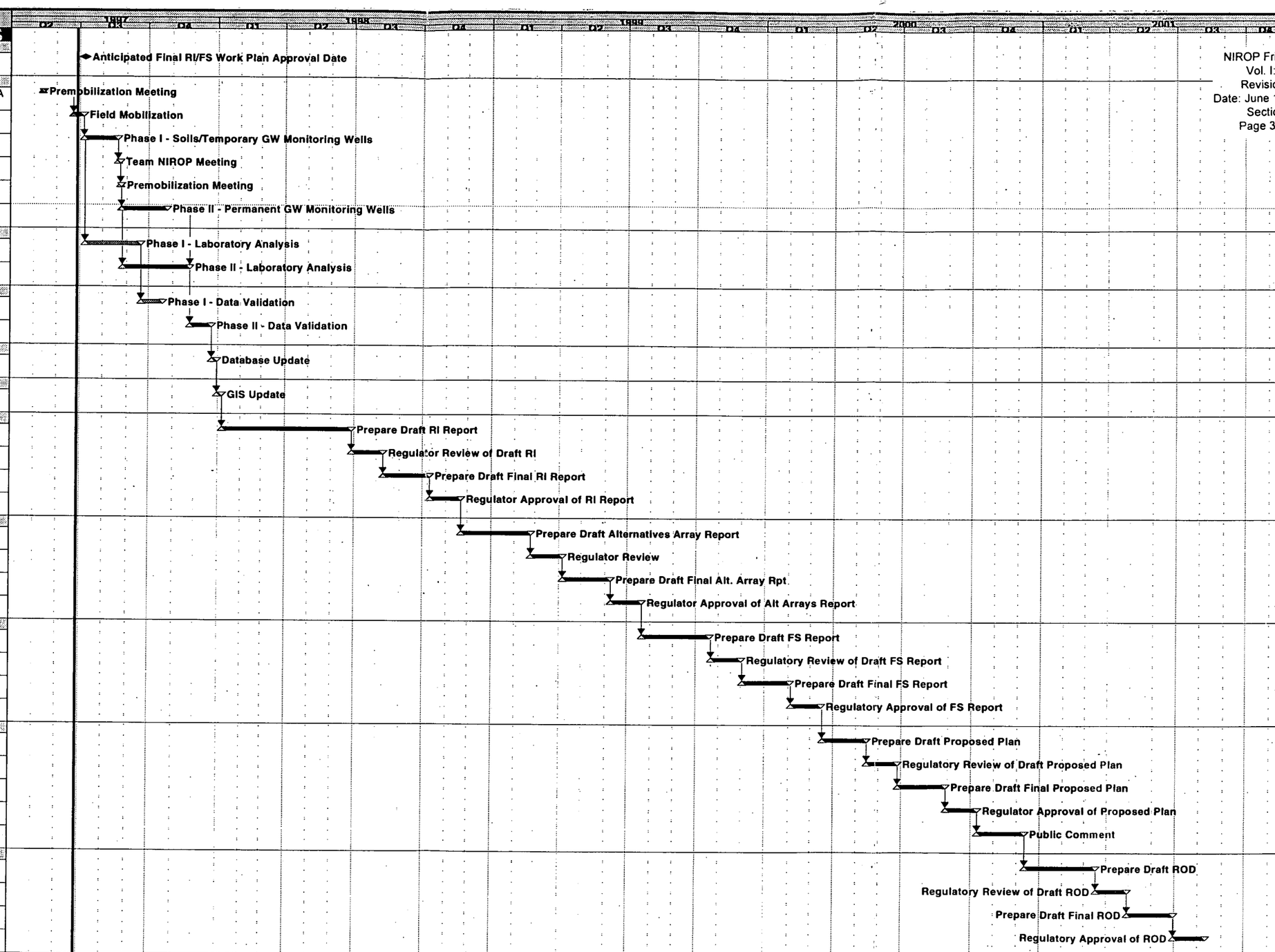
NIROP FRIDLEY MN - CTO 003 RI/FS

Activity Description	Early Start	Early Finish
PLANNING DOCUMENTS		
Anticipated Final RI/FS Work Plan Approval Date		07JUL97*
FIELD INVESTIGATIONS		
Premobilization Meeting	13MAY97A	14MAY97A
Field Mobilization	23JUN97A	06JUL97
Phase I - Soils/Temporary GW Monitoring Wells	07JUL97	20AUG97
Team NIROP Meeting	21AUG97	23AUG97
Premobilization Meeting	24AUG97	25AUG97
Phase II - Permanent GW Monitoring Wells	26AUG97	24OCT97
LABORATORY ANALYSIS		
Phase I - Laboratory Analysis	08JUL97	19SEP97
Phase II - Laboratory Analysis	27AUG97	23NOV97
DATA VALIDATION		
Phase I - Data Validation	20SEP97	19OCT97
Phase II - Data Validation	24NOV97	23DEC97
DATABASE UPDATE		
Database Update	24DEC97	30DEC97
GIS UPDATE		
GIS Update	31DEC97	06JAN98
REMEDIAL INVESTIGATION REPORT		
Prepare Draft RI Report	07JAN98	27JUN98
Regulator Review of Draft RI	28JUN98	08AUG98
Prepare Draft Final RI Report	09AUG98	10OCT98
Regulator Approval of RI Report	11OCT98	21NOV98
ALTERNATIVES ARRAY REPORT		
Prepare Draft Alternatives Array Report	22NOV98	22FEB99
Regulator Review	23FEB99	05APR99
Prepare Draft Final Alt. Array Rpt	06APR99	07JUN99
Regulator Approval of Alt Arrays Report	08JUN99	19JUL99
FEASIBILITY STUDY REPORT		
Prepare Draft FS Report	20JUL99	19OCT99
Regulatory Review of Draft FS Report	22OCT99	30NOV99
Prepare Draft Final FS Report	03DEC99	01FEB00
Regulatory Approval of FS Report	04FEB00	14MAR00
PROPOSED PLAN		
Prepare Draft Proposed Plan	17MAR00	15MAY00
Regulatory Review of Draft Proposed Plan	16MAY00	26JUN00
Prepare Draft Final Proposed Plan	27JUN00	28AUG00
Regulator Approval of Proposed Plan	29AUG00	09OCT00
Public Comment	10OCT00	11DEC00
RECORD OF DECISION		
Prepare Draft ROD	12DEC00	16MAR01
Regulatory Review of Draft ROD	17MAR01	27APR01
Prepare Draft Final ROD	28APR01	29JUN01
Regulatory Approval of ROD	30JUN01	10AUG01



Project Start	13MAY97
Project Finish	10AUG01
Data Date	28JUN97
Run Date	27JUN97

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Early Bar
Progress Bar
Critical Activity

WORK

Sheet 1 of 1

Figure 6-1
NIROP, FRIDLEY, MN - RI/FS
Draft Final Work Plan Schedule

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7.0 PROJECT MANAGEMENT

This section presents the project management for the OU3 RI to be conducted at NIROP Fridley. Included in the following sections are the staffing and coordination requirements.

7.1 PROJECT ORGANIZATION CHART

At the direction of the U.S. Navy Remedial Project Manager, B&R Environmental is responsible for the overall management, implementation, and inspection of contract field activities. Personnel from the Navy will be actively involved and will coordinate with B&R Environmental personnel in a number of areas. The authorities and organizational relationship of key personnel are depicted in Figure 7-1. Responsibilities for program management, project management, field operations, and laboratory operations are discussed in the following sections.

7.2 MANAGEMENT RESPONSIBILITIES

Remedial Project Managers/State Project Manager

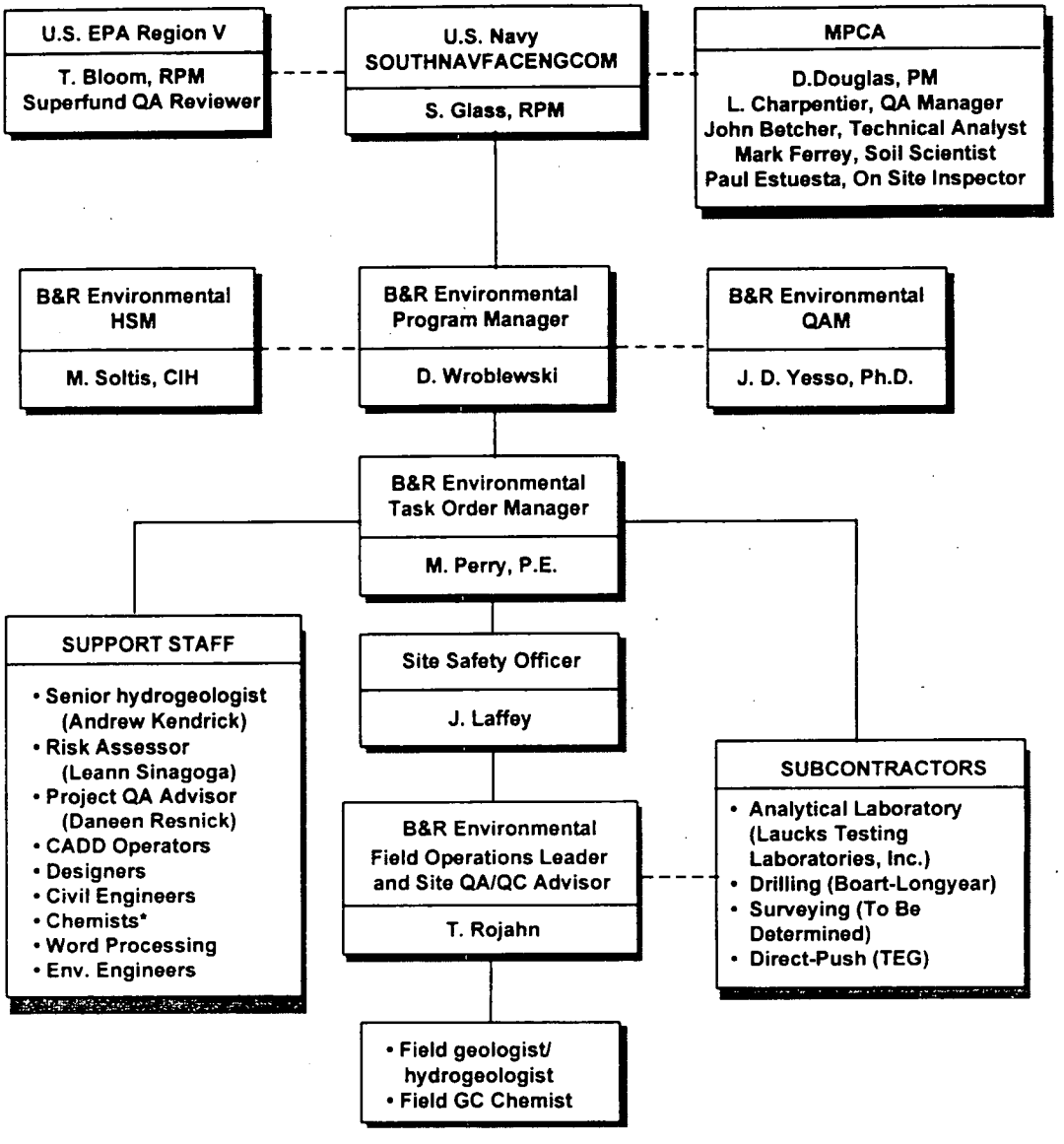
The following people have been designated as project managers for the purpose of overseeing the implementation of the FFA for NIROP Fridley. Thomas Bloom has been designated as the U.S. EPA Remedial Project Manager (RPM), David Douglas has been designated the MPCA Project Manager, and Scott Glass has been designated the Navy RPM. In general, the Navy RPM acts as the focal representative for the U.S. Navy, providing management, technical direction, and oversight for all NIROP Fridley project activities performed by contractors and their subcontractors. In matters such as facilitation of access, oversight, etc., the Navy RPM is assisted by the Facility Point of Contact (POC), Patrick K. Morrow. The U.S. EPA RPM and MPCA Project Manager represent Agency considerations and will provide input from this perspective, as well as lend general historical and technical assistance to the NIROP Fridley field activities. Roles and responsibilities of the Project Managers are further described in Sections 14.10 and 19 of the FFA.

Program Manager

The B&R Environmental CLEAN Program Manager, Debbie Wroblewski, provides operations, technical, and administrative leadership, and oversees and supports quality policies. The Program Manager assigns

FIGURE 7-1

PROJECT ORGANIZATION CHART
NIROP FRIDLEY, MINNESOTA



project Task Order Managers (TOMs) and oversees their performance. The Program Manager also ensures the availability of technical and clerical resources for Program operations, and maintains consistency in procedures and projects amongst Contract Task Order (CTO) assignments. In these matters, the Program Manager is assisted by the Task Order Manager.

Task Order Manager

The B&R Environmental Task Order Manager (TOM), Mark Perry, has the overall responsibility for project (i.e., scope, schedule, budget) and technical management, and is responsible for identifying and ensuring the availability of qualified onsite personnel. Additional responsibilities of the TOM are:

- Ensuring timely resolution of project-related technical, quality, safety, or waste management issues.
- Functioning as primary interface with the contract RPM, field personnel, laboratory point-of-contact, and subcontractors.
- Monitoring and evaluating subcontractor performance.
- Coordinating and overseeing work performed by technical staff (including risk assessment and modeling).
- Coordinating and overseeing maintenance of all project records.
- Coordinating and overseeing review of project deliverables.
- Preparing and issuing final deliverables to the client.

Health and Safety Manager

The B&R Environmental Health and Safety Manager (HSM), Matthew Soltis, is responsible for the following:

- Implementation of the Site Security and Health and Safety Plan.
- Overseeing the development and review of the Site Security and Health and Safety Plan.

- Assigning the Site Safety Officer and supervising his/her performance.
- Conducting Health and Safety audits.
- Preparing Health and Safety reports for management.

7.3 QUALITY ASSURANCE RESPONSIBILITIES

This section identifies the quality assurance responsibilities for the NIROP Fridley OU3 RI/FS. Responsibilities of the U.S. EPA Region V, the Minnesota Pollution Control Agency (MPCA), B&R Environmental personnel, and the analytical laboratory are discussed.

U.S. EPA Region V Superfund Quality Assurance Reviewer

The U.S. EPA Region V Superfund Quality Assurance Reviewer has the responsibility to review and approve the Quality Assurance Project Plan and provide overall Quality Assurance support and review throughout the RI/FS process.

MPCA Quality Assurance Manager

The MPCA Quality Assurance Manager, Luke Charpentier, has the responsibility to review and approve the Quality Assurance Project Plan and provide overall Quality Assurance support and review throughout the RI/FS process.

B&R Environmental Quality Assurance Manager

The B&R Environmental Quality Assurance Manager (QAM), David Yesso, is responsible for overall quality assurance for the project. The QAM has the responsibility for the following specific activities:

- Developing, maintaining, and monitoring quality assurance policies and procedures.
- Providing training to B&R Environmental staff in Quality Assurance/Quality Control (QA/QC) policies and procedures.
- Conducting systems and performance audits to monitor compliance with environmental regulations, contractual requirements, Project Plan requirements, and corporate policies and procedures.

- Conducting audits of project records.
- Ensuring external audits of subcontracted laboratories, and monitoring subcontractor quality controls and records.
- Assisting in the development of corrective action plans; ensuring correction of nonconformances reported in internal or external audits.
- Overseeing the implementation of the QAPP.
- Overseeing and reviewing the development and revision of the QAPP.
- Overseeing the responsibilities of the B&R Environmental Site QA/QC Advisor.
- Preparing quality assurance reports for management.

7.4 LABORATORY RESPONSIBILITIES

The subcontract analytical laboratory, Laucks Testing Laboratories, Inc., shall have the responsibility for analyzing all OU3 RI samples in accordance with the specified analytical methods and the attendant Quality Assurance Project Plan (Volume III) and for reporting data in accordance with the requirements outlined under the Contract Laboratory Program. It shall be the responsibility of the analytical laboratory to properly dispose of unused sample and to report the receipt of any broken sample bottles or other problems relative to samples (e.g., headspace in volatile organic vials) to the Task Order Manager. The laboratory's organization and personnel responsibilities are discussed in Section 3 of the Laucks Testing Laboratories, Inc., Quality Assurance Plan.

7.5 FIELD RESPONSIBILITIES

The B&R Environmental field investigation team will be organized according to the activities planned. Field team members will be selected based on the type and extent of effort required. All team members will be appropriately skilled and trained for the tasks they are assigned to perform. The team will consist of a combination of the following personnel:

- Field Operations Leader (FOL)
- Site QA/QC Advisor
- Site Safety Officer (SSO)
- Field hydrogeologist/geologist(s)

The proposed OU3 NIROP Fridley field activities will be performed by B&R Environmental personnel and subcontractors, overseen by Mr. David Yost, the B&R Environmental Field Operations Leader (FOL). A general discussion of the FOL's responsibilities follows.

The FOL is responsible for coordinating all onsite personnel and for providing technical assistance, when required. The FOL or designee will coordinate and be present during all sampling activities and will ensure the availability and maintenance of all sampling materials/equipment. The FOL is responsible for the completion of all sampling, boring, well construction, field, and chain-of-custody documentation and will assume custody of all samples and ensure the proper handling and shipping of samples. The FOL is responsible for providing oversight and technical supervision of the drilling and direct-push subcontractor. Other duties of the FOL include the following:

- Functions as communications link between field crew members, the Site QA/QC Advisor, Site Safety Officer, and the TOM.
- Oversees the mobilization and demobilization of all field equipment and subcontractors.
- Resolves logistical, weather, personnel, and equipment problems.
- Bears responsibility for maintenance of the site logbook.
- Initiates field task modification requests when necessary.

The FOL (or his assistant) will act as the Site QA/QC Advisor, who is responsible for ensuring adherence to all QA/QC guidelines as defined in the FSP and QAPP. Strict adherence to these procedures is critical to the collection of acceptable and representative data. The following is a summary of the Site QA/QC Advisor's responsibilities:

- Ensures that field duplicates and field quality control blanks are collected with the proper frequency.

- Ensures that additional volumes of sample are supplied to the analytical laboratory with the proper frequency to accommodate laboratory QA/QC analyses.

- Ensures that measuring and test equipment (MTE) are calibrated, used, and maintained in accordance with applicable procedures.

- Acts as liaison between site personnel, laboratory personnel, and the QAM.

- Manages bottleware shipments; oversees field preservation and in-field filtration activities.

Mr. Yost (or his assistant) will also serve as the Site Safety Officer (SSO). The duties of the SSO are detailed in the Site Security and Health and Safety Plan. As SSO, Mr. Yost has stop-work authority which can be executed upon the determination of an imminent safety hazard.

To accomplish these duties effectively, the FOL will be assisted by a yet-to-be-determined B&R Environmental field geologist/hydrogeologist.

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APPENDIX A

EXAMPLE PRELIMINARY REMEDIATION GOAL CALCULATIONS

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT	JOB NUMBER
US Navy - CLEAN	6966

SUBJECT: NIROP - Industrial Worker (Hypothetical)

BASED ON: Minnesota Pollution Control Agency (MPCA) Protocol

DRAWING NUMBER:

BY	CHECKED BY	APPROVED BY	DATE
L.A. Sinagoga	KAJ		12/5/96

Purpose: Calculation of Preliminary Remediation Goal (PRG) for typical industrial worker.

Step 1: Calculate risk to receptor exposed to 1mg/Kg trichloroethene in soil.

Exposure dose for ingestion route of exposure (mg/Kg/d) = $(C_s \times IR \times 0.75 \times CF \times FI \times EF \times ED)/(BW \times AT)$

Where:
- C_s = Soil concentration (1 mg/Kg TCE)
- IR = Ingestion rate - 100 mg soil/day
- 0.75 = MPCA adjustment for climatic conditions
- CF = Conversion factor - 1.0E-06 Kg/mg
- FI = Fraction ingested from area of concern - 1
- EF = Exposure frequency - 250 days/year
- ED = Exposure duration - 25 years
- BW = Body weight - 70Kg
- AT = Averaging time:
  - Noncancer evaluation - 9125 days (365 X 25)
  - Cancer evaluation - 25550 days

Exposure Dose (mg/Kg/d) (Cancer Evaluation):

$$= \frac{1mg/Kg \times 100mg/d \times 0.75 \times 1.0E\text{-}06\ Kg/mg \times 1.0 \times 250d/yr \times 25yrs}{70Kg \times 25550\ days}$$

$= 2.62E\text{-}07$ mg/Kg/d

Cancer risk associated w/ 1mg/Kg TCE $= 2.62E\text{-}07$ mg/Kg/d $\times$ $1.10E\text{-}02\ (mg/Kg/d)^{-1}$ (Cancer slope factor)

$= 2.88E\text{-}09$

Exposure Dose (mg/Kg/d) (Noncancer Evaluation)

$$= \frac{1mg/Kg \times 100mg/d \times 0.75 \times 1.0E\text{-}06\ Kg/mg \times 1.0 \times 250d/yr \times 25yrs}{70Kg \times 9125\ days}$$

$= 7.34 \times 10^{-7}$ mg/Kg/day

Hazard Quotient Associated with 1mg/Kg TCE $= 7.34 \times 10^{-7}$ mg/Kg/d / 6.0E-03 mg/Kg/d $= 1.2E\text{-}04$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT	JOB NUMBER
US Navy - CLEAN	69166
SUBJECT: NI ROP - Industrial Worker (Hypothetical)	
BASED ON: Minnesota Pollution Control Agency (MPCA) Protocol	DRAWING NUMBER
BY: LASINAGOGA / CHECKED BY: KAJ	APPROVED BY / DATE: 12/5/96

Exposure dose for dermal route of exposure (mg/Kg/d) $= \frac{(C_s \times CF \times SA \times AF \times ABS \times EF \times ED)}{BW \times AT}$

where:

C_s = Soil concentration (1 mg/Kg TCE)
CF = Conversion Factor - 1E-06 Kg/mg
SA = Skin surface area in contact w/ soil 3000 cm^2
AF = Skin adherence factor - 0.3 mg/cm^2
ABS = Chemical specific Absorption Factor - 0.05
EF = Exposure frequency - 90 days/year
ED = Exposure duration - 25 years
BW = Body weight - 70 Kg
AT = Averaging time:
Noncancer evaluation - 9125 days (365 d/yr × 25 yrs)
Cancer evaluation - 25550 days

Exposure Dose (mg/Kg/d) (Cancer Evaluation) $= \frac{1 mg/Kg \times 1E\text{-}06 Kg/mg \times 3000 cm^2 \times 0.3 mg/cm^2 \times 0.05 \times 90 d/yr \times 25 yrs}{70 Kg \times 25550 days}$

$= 5.66E\text{-}08$ mg/Kg/d

oral CSF 1.1E-02 / 0.9 Adjustment for Gastrointestinal Absorption

Cancer risk associated with 1 mg/Kg TCE $= 5.66E\text{-}08$ mg/Kg/d × 1.2E-2 $(mg/Kg/d)^{-1}$ (dermal slope factor)

$= 6.8E\text{-}10$

Exposure dose (mg/Kg/d) (Noncancer Evaluation) $= \frac{1 mg/Kg \times 1E\text{-}06 Kg/mg \times 3000 cm^2 \times 0.3 mg/cm^2 \times 0.05 \times 90 d/yr \times 25 yrs}{70 Kg \times 9125 days}$

Hazard Quotient Associated with 1 mg/Kg TCE $= 1.59E\text{-}07$ mg/Kg/d / 5.4E-03 mg/Kg/d

Oral RFD: 6.0E-03 mg/Kg/d × 0.9 =

2.94E-05

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: US Navy CLEAN	JOB NUMBER: 6966
SUBJECT: NIROP - Industrial Worker (Hypothetical)	
BASED ON: MPCA Protocol	DRAWING NUMBER:
BY: L.A. SINAGOGA / CHECKED BY: KAJ	APPROVED BY: / DATE: 12/5/96

⊙ Exposure dose for Inhalation route of exposure (mg/Kg/d)

$$= \frac{C_s \times IR \times \left[\frac{1}{VF} + \frac{1}{PEF}\right] \times EF \times ED}{BW \times AT}$$

where:

C_s = Soil concentration (1 mg/Kg TCE)

IR = Inhalation rate (20 m³/day)

1/PEF = Inverse of the particulate emission factor (3E-09 Kg/m³)

1/VF = Inverse of volatilization factor (Kg/m³) (Chemical specific) (TCE → 1/VF = 3E-04)

EF = Exposure frequency - 250 days/year

ED = Exposure duration - 25 years

AT = Averaging time:

Noncancer evaluation - 9125 days (365 × 25)

Cancer evaluation - 25550 days.

Exposure Dose (mg/Kg/d) (Cancer Evaluation)

$$= \frac{1\,mg/Kg \times 20\,m^3/day \times \left[3E\text{-}04\,\frac{Kg}{m^3} + 3E\text{-}09\,\frac{Kg}{m^3}\right] \times 250\,days/year \times 25\,yrs}{\underbrace{70\,Kg \times 25550\,days}_{1.79E+6}}$$

$= 2.1E\text{-}05$ mg/Kg/d

Cancer risk associated w/ 1 mg/Kg: $2.1E\text{-}05\,mg/Kg/d \otimes 6.0E\text{-}03\,(mg/Kg/d)^{-1}$

$= 1.26E\text{-}07\,(mg/Kg)/day)^{-1}$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT	JOB NUMBER
US Navy CLEAN	6966
SUBJECT: NIROP - Industrial Worker (Hypothetical)	
BASED ON: MPCA Protocol	DRAWING NUMBER
BY: L.A. SINAGOGA	CHECKED BY: APPROVED BY: DATE:

⊙ Calculation of VF for TCE

$VF_{(m^3/Kg)} = (QC)_{UCL} \times [(3.14 \times A \times T)^{0.5} / (2 \times Dei \times Pa \times Kas)] \times 10^{-4}\ m^2/cm^2$

where:

VF (m^3/Kg) = Chemical specific volatilization factor

(QC)UCL = Inverse of the mean concentration at the center of a 5 acre source (g/m^2-s per Kg/m^3) ⇒ 61.03 g/m^2-s / Kg/m^3

$A = (Dei \times Pa) / [Pa + (Ps \times (1-Pa)) / Kas]$

$A = (5.96E-03 \times 0.28) / [0.28 + (2.65 \times (1-0.28)) / 0.59] = 4.75E-04$

Dei = Effective Diffusivity (cm^2/sec)

= Di (Pa ^ 3.33 / Pt ^ 2)

= 0.07638 cm^2/sec · ($0.28^{3.33} / 0.43^2$) = 5.96E-03 cm^2/sec

Pa = Air filled soil porosity = Pt − (Om * B) = 0.28

Pt = Total soil porosity = 1 − (B/Ps) = 0.43

Om = Soil moisture content (cm^3-water/g-soil) = 0.1 cm^3-water/g-soil

B = Soil bulk density (Kg/l) = 1.5 Kg/l

Ps = True soil density or particle density (g/cm^3) = 2.65 g/cm^3

Di = Diffusivity in air (cm^2/s) - TCE at 10°C = 0.07633 cm^2/sec

Kas = Soil-air partition coefficient (g-soil/cm^3-air) = (H/Kd) × 41

= (9.1E-03 atm-m^3/mol / 0.63 cm^3/g) × 41 = 0.59 (g-soil/cm^3-air)

H = Henrys' Law Constant (atm-m^3/mol) - TCE = 9.1E-03 atm-m^3/mol

Kd = Soil-water partition coefficient (cm^3/g) = Koc × Oc

= 126 cm^3/g × 0.005 = 0.63 cm^3/g

Koc = Organic carbon partition coefficient (cm-3/g) = 126 cm^3/g

Oc = Organic carbon content of soil = 0.005

T = Exposure interval(s) ⇒ 7.88 E+8

∴

$VF = 61.03 g/m^2\text{-}s / Kg/m^3 \times [\underbrace{(3.14 \times 4.75E-04 \times 7.88E+8s)^{0.5}}_{1084} / \underbrace{(2 \times 5.96E-03\ cm^2/s \times 0.28 \times 0.59\ (g\text{-}soil/cm^3\text{-}air))}_{0.002}] \times 10^{-4}\ m^2/m^2$

= 3.31 E+03

1/VF = 3E-04

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: US Navy CLEAN		JOB NUMBER	
SUBJECT: NIROP - Industrial Worker (Hypothetical)			
BASED ON: MPCA Protocol		DRAWING NUMBER	
BY: L.A. SINAGOGA	CHECKED BY: KAJ	APPROVED BY	DATE: 12/5/96

⊙ Calculation of Saturation limit (Volatilization model is only applicable if $C_s < C_{sat}$)

$$C_{sat} = (S/B) \times [(K_d \times B) + P_w + (H' \times P_a)]$$

(mg/Kg) where:

C_{sat} = Soil saturation concentration (mg/Kg)

K_d = $K_{oc} \times OC$ = 0.63 cm^3/g or L/Kg

S = Solubility in water (mg/L) = 1.1E+03 mg/L

B = Soil bulk density (Kg/l) = 1.5 Kg/l

P_w = Water filled soil porosity (unitless) = 0.15

P_t = Total soil porosity (unitless) = $1 - B/P_s$ = 0.43

P_s = True soil density or particulate density (Kg/l) = 2.65

P_a = Air-filled soil porosity (unitless) = $P_t - O$ = 0.28

O = Average unsaturated zone soil gravimetric water content = $O_m \times B/D_w$ = 0.
(L water/L soil)

O_m = Average unsaturated zone soil gravimetric water content = 0.1
(Kg water/Kg soil)

D_w = Density of water (Kg water/L water) = 1.0

H = Henry's Law Constant (atm-m^3/mol) - TCE = 9.1E-03 atm-m^3/mol

H' = Modified Henry's constant (atm-m^3/mol) =
$41 \times H$ = 41 × 9.1E-03 atm-m^3/mol = 3.73E-01

$$C_{sat} = \frac{(1.1E+3\ mg/L)}{1.5\ Kg/L} \times [(0.63\ cm^3/g) + 0.15 + (3.73E-01 \times 0.28)]$$

L/Kg ×1.5 Kg/l

~~atm-m³/mol~~

7.33E+2 × (0.945 + 0.104) = 1.2

= 8.8E+2

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: US Navy - CLEAN	JOB NUMBER: 6966
SUBJECT: NIKOP - Industrial Worker - Hypothetical	
BASED ON: MPCA protocol	DRAWING NUMBER:
BY: L.A. SINAGOGA / CHECKED BY: KAJ	APPROVED BY: / DATE: 12/5/96

STEP 2: Calculate Preliminary Remediation Goal

RISK Associated w/ 1mg/Kg TCE =

Cancer risk:

Ingestion = 2.88 E-09 (mg/Kg/d)$^{-1}$

Dermal route = 6.8 E-10 (mg/Kg/d)$^{-1}$

Inhalation = 1.26 E-07 (mg/Kg/d)$^{-1}$

Total 1.3 E-07

IF: 1mg/Kg TCE yields a cancer risk = 1.3 E-07

? → 1 E-06

7.7mg/Kg

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT	JOB NUMBER		
US Navy - CLEAN	6966		
SUBJECT: NIROP - Construction Worker (MPCA Protocol)			
BASED ON: MPCA Protocol		DRAWING NUMBER	
BY: L.A. SINAGOGA	CHECKED BY: KAJ	APPROVED BY	DATE: 12/5/96

Purpose: Calculation of Preliminary Remediation Goal (PRG) for Construction Worker (MPCA)

Step 1: Calculate risk to receptor exposed to 1mg/kg TCE

Exposure dose for ingestion route of exposure (mg/kg/d) = $(C_s \times IR \times CF \times FI \times EF \times ED)/(BW \times AT)$

where:

C_s = Soil Concentration (1mg/kg TCE)
IR = Ingestion rate - 480 mg soil/day
CF = Conversion factor 1 E-06 Kg/mg
FI = Fraction Ingested from contaminated area = 1.0
EF = Exposure Frequency - 65 days
ED = Exposure duration - <1 year (0.25 yrs)
BW = Body weight - 70 Kg
AT = Averaging time
Noncancer evaluation - 91 days (365 × 0.25)
Cancer evaluation - 25550 days.

Exposure Dose (mg/kg/d) (Cancer Evaluation) $= \dfrac{1mg/kg \times 480 mg/d \times 10^{-6} kg/mg \times 1.0 \times 65 d/yr \times 0.25 yr}{70 kg \times 25550 days}$

$= 4.36E-09$ mg/kg/d

Cancer slope factor

Cancer risk associated w/ 1mg/kg TCE $= 4.36E-09 mg/kg/d \times 1.0E-02 (mg/kg/d)^{-1} = 4.8E-11$

Exposure Dose (mg/kg/d) (Noncancer Evaluation) $= \dfrac{1 mg/kg \times 480 mg/d \times 10^{-6} kg/mg \times 1.0 \times 65 d/yr \times 0.25}{70 kg \times 91 days}$

$= 1.22E-06$ (mg/kg/d)

Hazard Quotient Associated with 1mg/kg TCE $= 1.22E-06 mg/kg/d / 6.0E-03 mg/kg/d = 2.03E-04$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT	JOB NUMBER		
US Navy CLEAN	6966		
SUBJECT: NTROP - Construction Worker (MPCA Protocol)			
BASED ON: MPCA Protocol		DRAWING NUMBER	
BY: L. A. SINABOGA	CHECKED BY: KAJ	APPROVED BY	DATE: 12/5/96

Exposure dose for dermal route of exposure (mg/Kg/d) $= \frac{(C_s \times CF \times SA \times AF \times ABS \times EF \times ED)}{BW \times AT}$

where:

C_s = Soil concentration (1 mg/Kg TCE)
CF = Conversion Factor - 1E-06 Kg/mg
SA = Skin surface area in contact w/ soil - 4900 cm^2
AF = Skin adherence factor - 0.3 mg/cm^2·day
ABS = Chemical specific absorption factor - 0.05
EF = Exposure frequency - 65 d/yr
ED = Exposure duration - 0.25 yr
BW = Body weight - 70 Kg
AT = Averaging time
Noncancer evaluation - 91 days (365 × 0.25)
Cancer evaluation - 25550 days.

Exposure Dose (mg/Kg/d) (Cancer Evaluation) $= \frac{1\,mg/Kg \times 10^{-6}\,Kg/mg \times 4900\,cm^2 \times 0.3\,mg/cm^2\cdot day \times 0.05 \times 65\,d/yr \times 0.25}{70\,Kg \times 25550\,days}$

$= 6.68 \times 10^{-10}$ mg/Kg/d

Cancer risk associated with 1 mg/Kg TCE $= 6.68 \times 10^{-10}$ mg/Kg/d × 1.2 E-2 $(mg/Kg/d)^{-1}$ (dermal slope factor)

$= 8.0E-12$

Exposure dose (mg/Kg/d) (Noncancer Evaluation) $= \frac{1\,mg/Kg \times 10^{-6}\,Kg/mg \times 4900\,cm^2 \times 0.3\,mg/cm^2\cdot day \times 0.05 \times 65\,d/yr \times 0.25\,y}{70\,Kg \times 91\,days}$

$= 1.88E-07$ mg/Kg/d

Hazard Quotient associated w/ 1 mg/Kg TCE $= 1.88E-07$ mg/Kg/d / 5.4 E-03 mg/Kg/d

$= \underline{\underline{3.49E-05}}$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT		JOB NUMBER	
US Navy CLEAN		6966	
SUBJECT: NIROP- Construction Worker (MPCA Protocol)			
BASED ON: MPCA Protocol		DRAWING NUMBER	
BY: L.A. SINAGOGA	CHECKED BY: KAJ	APPROVED BY	DATE: 12/5/96

⊙ Exposure dose for Inhalation route of exposure (mg/kg/d) = $C_s \times IR \times \left[\frac{1}{VF} + \frac{1}{PEF}\right] \times EF \times ED$

where:

C_s = Soil concentration (1 mg/Kg TCE)

IR = Inhalation Rate (20 m³/d)

Y_{PEF} = Inverse of the particulate emission factor (4.0E-08 Kg/m³)

YVF = Inverse of Volatilization factor (Kg/m³) (Chemical Specific) (TCE → YVF =)

EF = Exposure frequency = 65 d/yr.

ED = Exposure duration = 0.25 yr

AT = Averaging time

Noncancer evaluation - 91 days - (365 X 0.25)

Cancer evaluation - 25550 days

Exposure Dose (mg/Kg/d) (Cancer Evaluation)

$$= \frac{1\,mg/Kg \times 20\,m^3/d \times \left[2.17E\text{-}03\,\frac{Kg}{m^3} + 4.0E\text{-}08\,Kg/m^3\right] \times 65\,d/y \times 0.25\,yr}{\underbrace{70\,Kg \times 25550\,days}_{1.79E+6}}$$

= 3.94E-07 mg/Kg/d

Cancer risk associated w/ 1 mg/Kg TCE : = 3.94E-07 (mg/Kg/d) ⊗ 6.0E-03 (mg/Kg/d)⁻¹

= 2.37E-09

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: DS Navy		JOB NUMBER: 6966	
SUBJECT: NIROP - Construction Worker (MPCA Protocol)			
BASED ON: MPCA Protocol		DRAWING NUMBER:	
BY: L. A. SINAGOGA	CHECKED BY: KAJ	APPROVED BY:	DATE: 12/5/96

⊙ Calculation of VF for TCE

$VF\ (m^3/Kg) = (QC)_{UCL} \times [(3.14 \times A \times T)^{0.5} / (2 \times D_{ei} \times P_a \times K_{as})] \times 10^{-4}\ m^2/cm^2$

where:

VF (m^3/Kg) = Chemical specific volatilization factor

$(QC)_{UCL}$ = Inverse of the mean concentration at the center of a 1 acre square source (g/m^2-sec per Kg/m^3) = 60 $\frac{g/m^2 \cdot s}{Kg/m^3}$

$A = (D_{ei} \times P_a) / [P_a + (P_s \times (1 - P_a)) / K_{as}]$

$A = (5.96E\text{-}03 \times 0.28) / [0.28 + (2.65 \times (1 - 0.28)) / 0.59] = 4.75E\text{-}04$

D_{ei} = Effective Diffusivity (cm^2/sec)

$= D_i (P_a \wedge 3.33 / P_t \wedge 2)$

$= 0.07638\ cm^2/sec \cdot (0.28^{3.33} / 0.43^2) = 5.96E\text{-}03\ cm^2/sec$

P_a = Airfilled soil porosity = $P_t - (O_m * B) = 0.28$

P_t = Total soil porosity = $1 - (B/P_s) = 0.43$

O_m = Soil moisture content (cm^3-water/g-soil) = 0.1 cm^3-water/g soil

B = Soil bulk density (Kg/L) = 1.5 Kg/L

P_s = True soil density or particle density (g/cm^3) = 2.65 g/cm^3

D_i = Diffusivity in air (cm^2/s) - TCE at 10°C = 0.07638 cm^2/sec

K_{as} = Soil-air partition coefficient (g-soil)/(cm^3-air) = $(H/K_d) \times 41$

$= (9.1E\text{-}03\ atm\text{-}m^3/mol / 0.63\ cm^3/g) \times 41 = 0.59$ (g-soil/cm^3-air)

H = Henry's Law Constant (atm-m^3/mol) - TCE = 9.1E-03 atm-m^3/mol

K_d = Soil-water partition coefficient (cm^3/g) = $K_{oc} \times O_c$

$= 126\ cm^3/g \times 0.005 = 0.63\ cm^3/g$

K_{oc} = Organic carbon partition coefficient (cm-3/g) = 126 cm^3/g

O_c = Organic carbon content of soil = 0.005

T = 1.58E+07 s

$VF = 60 \frac{g/m^2 \cdot sec}{Kg/m^3} \times [\underbrace{(3.14 \times 4.75E\text{-}04 \times 1.58E+07\ s)}_{154}^{0.5} / \underbrace{(2 \times 5.96E\text{-}03 \times 0.28 \times 0.59)}_{0.002}] \times 10^{-4}\ m^2/cm^2$

$= 4.61E+02\ m^3/Kg$

$VF = 2.17E\text{-}03\ Kg/m^3$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: U.S. Navy CLEAN		JOB NUMBER	
SUBJECT: NIROP - Construction Worker (MPCA Protocol)			
BASED ON: MPCA Protocol		DRAWING NUMBER	
BY: L.A. SINAGOGA	CHECKED BY: KAJ	APPROVED BY	DATE: 12/5/96

Step 2: Calculate Preliminary Remediation Goal

Risk associated w/ 1mg/kg TCE =

Cancer risk:

Ingestion	-	4.8 E-11
Dermal contact	-	8.0 E-12
Inhalation	-	2.37E-09
		2.42E-09

IF: $\frac{1mg/kg}{?}$ TCE yields a cancer risk $= \frac{2.42E-09}{1E-06}$

? = 413mg/kg

Hazard Index:

Ingestion	-	2.03E-04
Dermal contact	-	3.49 E-05
		2.38 E-04

if $\frac{1mg/kg}{?}$ yields a hazard index of $\frac{2.38E-04}{1}$

? = 420mg/kg

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: US Navy - CLEAN	JOB NUMBER: 6966
SUBJECT: NIROP - Construction Worker (NIROP Protocol)	
BASED ON: NIROP Site Specific Conditions	DRAWING NUMBER:
BY: L.A. SINAGOGA / CHECKED BY: KAJ	APPROVED BY: / DATE: 12/5/96

Purpose: Calculation of Preliminary Remediation Goal (PRGs) for construction worker (NIROP Specific Conditions)

STEP 1: Calculate risk to receptor exposed to 1 mg/kg TCE.

Exposure dose for ingestion route of exposure (mg/kg/d) = $(C_s \times IR \times CF \times FI \times EF \times ED) / (BW \times AT)$

where:

C_s = Soil concentration (1 mg/kg TCE)

IR = Ingestion rate - 200 mg soil/day

CF = Conversion factor - 1.0 E-06 kg/mg

FI = Fraction ingested from area of concern - 1

EF = Exposure frequency - 80 days/year

ED = Exposure duration - 25 years

BW = Body weight - 70 kg

AT = Averaging time:

Noncancer evaluation - 9125 days (365 x 25)

Cancer evaluation - 25550 days

Exposure dose (mg/kg/d) (Cancer Evaluation) = $\frac{1\,mg/kg \times 200\,mg/day \times 1.0E\text{-}06\,kg/mg \times 1.0 \times 80\,days/yr \times 25}{70\,kg \times 25550\,days}$

= 2.24 E-07

Cancer risk associated w/ 1 mg/kg TCE = 2.24 E-07 mg/kg/d ⊗ 1.1 E-02 $(mg/kg/d)^{-1}$ (Cancer slope factor)

= 2.46 E-09

Exposure Dose (mg/kg/d) (Noncancer Evaluation) = $\frac{1\,mg/kg \times 200\,mg/day \times 1.0E\text{-}06\,kg/mg \times 1.0 \times 80\,days/yr \times 25\,yr}{70\,kg \times 9125\,days}$

= 6.26 E-07 mg/kg/d

Hazard Quotient associated w/ 1 mg/kg TCE = 6.26E-07 mg/kg/d / 6.0E-03 mg/kg/d = 1.0E-04

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT	JOB NUMBER		
USNavy CLEAN	69166		
SUBJECT: NIROP- Construction Worker			
BASED ON: NIROP Site Specific Conditions		DRAWING NUMBER	
BY: LA. SINAGOGA	CHECKED BY: KAJ	APPROVED BY	DATE: 12/5/96

(1) Exposure dose for dermal route of exposure (mg/Kg/d) $= \dfrac{Cs \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$

where: Cs = Soil concentration (1 mg/Kg TCE)
CF = Conversion Factor (1E-06 Kg/mg)
SA = Skin surface area in contact w/ soil - 4900 cm^2
AF = Skin adherence factor - 0.3 mg/cm^2 · day
ABS = Chemical specific absorption factor - 0.05
EF = Exposure frequency - 80 days/year
ED = Exposure duration - 25 years
BW = Body weight - 70 Kg
AT = Averaging time: Noncancer evaluation - (365 d/yr × 25 yrs) 9125 days
Cancer evaluation - 25550 days.

Exposure Dose (mg/Kg/d) (Cancer Evaluation) $= \dfrac{1\,mg/Kg \times 1E\text{-}06\,Kg/mg \times 4900\,cm^2 \times 0.3\,mg/cm^2 \cdot d \times 0.05 \times 80\,d/yr \times 25\,yrs}{70\,Kg \times 25550\,days}$

$= 8.22E\text{-}08$ mg/Kg/d

Cancer risk associated w/ 1 mg/Kg TCE $= 8.22E\text{-}08$ mg/Kg/d × 1.2E-2 mg/Kg/d (dermal slope factor)
$= 9.86E\text{-}10$

Exposure dose (mg/Kg/d) (Noncancer Evaluation) $= \dfrac{1\,mg/Kg \otimes 1E\text{-}06\,Kg/mg \otimes 4900\,cm^2 \otimes 0.3\,mg/cm^2 \cdot d \otimes 0.05 \otimes 80\,d/yr \times 25\,yr}{70\,Kg \times 9125\,days}$

$= 2.30E\text{-}07$

Hazard Quotient Associated with 1 mg/Kg $= 2.30E\text{-}07$ (mg/Kg/d) / 5.4E-03 mg/Kg/d
$= 4.26E\text{-}05$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: US Navy CLEAN	JOB NUMBER: 69166
SUBJECT: NIROP - Construction Worker (NIROP Protocol)	
BASED ON: NIROP Site Specific Conditions	DRAWING NUMBER:
BY: LASINAGOGA / CHECKED BY: KAJ	APPROVED BY: / DATE: 12/5/96

Exposure dose for Inhalation route of Exposure (mg/kg/d) $= C_s \times IR \times \left[\frac{1}{VF} + \frac{1}{PEF}\right] \times EF \times ED$

where:

C_s = Soil Concentration (1 mg/kg TCE)

IR = Inhalation Rate (20 m^3/d)

VPEF = Inverse of the particulate emission factor (4.0E-08 Kg/m^3)

VVF = Inverse of the Volatilization factor (Kg/m^3) (Chemical Specific) (TCE → VVF = 3.1E-04)

EF = Exposure frequency = 80 days/year

ED = Exposure duration = 25 years

BW = Body weight - 70 Kg

AT = Averaging time - Noncancer evaluation - 9125 days
Cancer evaluation - 25550 days

Exposure Dose (mg/kg/d) (Cancer Evaluation)

$$= \frac{1\,mg/kg \times 20\,m^3/d \times \left[3.1E\text{-}04\,Kg/m^3 + 4.0E\text{-}08\,Kg/m^3\right] \times 80\,\frac{d}{yr} \times 25\,yr}{70\,Kg \times 25550\,days}$$

$= 6.9E\text{-}06$ mg/kg/d

Cancer risk associated with 1 mg/kg $= 6.9E\text{-}06\,mg/kg/d \otimes 6.0E\text{-}03\,(mg/kg/d)^{-1} = 4.16E\text{-}08$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: USNavy CLEAN	JOB NUMBER: 6966
SUBJECT: NIROP - Construction Worker (NIROP Protocol)	
BASED ON: NIROP Specific Conditions	DRAWING NUMBER:
BY: LA SINAGOGA / CHECKED BY: KAJ	APPROVED BY: / DATE: 12/5/96

⊙ Calculation of VF for TCE [Use same input parameters and assumptions as noted for typical industrial worker except (QC)UCL = 60 g/m²s / Kg/m³]

∴

$$VF = 60\ g/m^2 \cdot s / Kg/m^3 \otimes \left[\left(3.14 \otimes 4.75E\text{-}04 \otimes 7.88E{+}8\ sec \right)^{0.5} / \left(2 \otimes 5.96E\text{-}03 \times 0.28 \times 0.59 \right) \right] \times 10^{-4}$$

cm^2/sec

$= 3.25\ E{+}03$

$1/VF = 3.07E\text{-}04$

CALCULATION WORKSHEET Order No. 19116 (01-91)

CLIENT: US Navy CLEAN	JOB NUMBER: 6966
SUBJECT: NIROP - Construction Worker (NIROP Protocol)	
BASED ON: NIROP Specific Conditions	DRAWING NUMBER:
BY: LA Sinagoga / CHECKED BY: KAJ	APPROVED BY: / DATE: 12/5/96

Step 2: Calculate Preliminary Remediation Goal

Risk Associated w/ 1 mg/kg TCE:

Cancer Risk —

Ingestion :	2.46E-09
Dermal Contact :	9.86E-10
Inhalation :	4.16E-08
	4.5E-08

IF : 1 mg/kg TCE yields a cancer risk = $\frac{4.5E-08}{1E-06}$

?

? = 22.2