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Reference: CLEAN Contract No. N62467-94-D-0088
Contract Task Order No. 0003
Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota
OU2 Feasibility Study

Subject: Submittal of Final OU2 Feasibility Study

As directed by the Navy under the reference contract, the subject document is transmitted as final.

The OU2 Feasibility Study was revised to address regulatory comments.

Please contact me at (412) 921-8216 if you have any questions.

Very truly yours,

Mark Sladic, P.E.
Task Order Manager

MS/dt

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Project File 6966

Feasibility Study
Soils Operable Unit (OU2)
Naval Industrial Reserve
Ordnance Plant
Fridley, Minnesota

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0179

April 1997

Brown & Root Environmental

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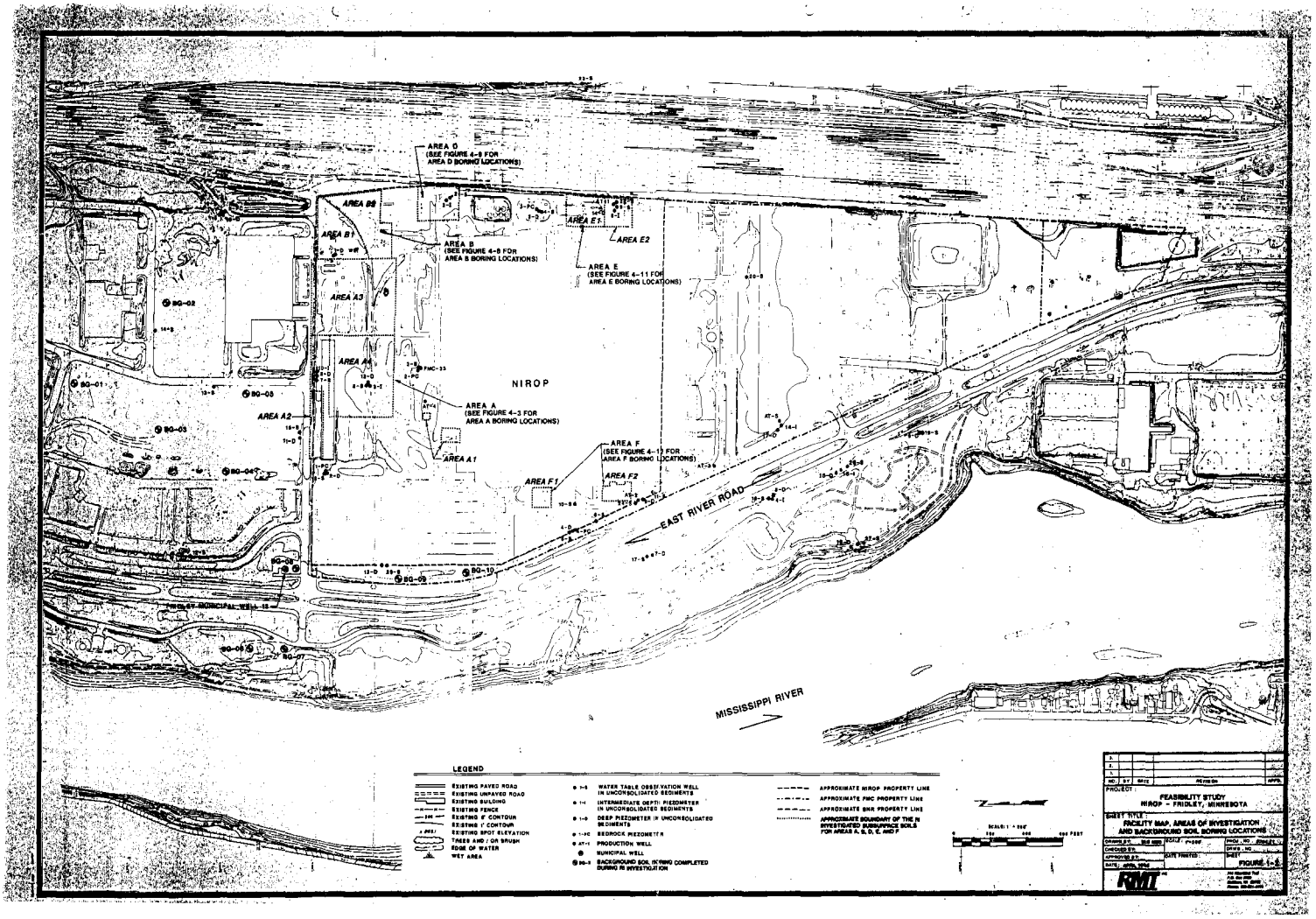
AREA D
(SEE FIGURE 4-8 FOR
AREA D BORING LOCATIONS)
AREA B2
AREA B1
AREA B
(SEE FIGURE 4-8 FOR
AREA B BORING LOCATIONS)
AREA E1
AREA E2
AREA E
(SEE FIGURE 4-11 FOR
AREA E BORING LOCATIONS)
AREA A3
AREA A4
NIROP
AREA A
(SEE FIGURE 4-3 FOR
AREA A BORING LOCATIONS)
AREA A2
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(SEE FIGURE 4-13 FOR
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AREA F2
AREA F1
EAST RIVER ROAD
MISSISSIPPI RIVER
BG-01
BG-02
BG-03
BG-04
BG-05
BG-06
BG-07
BG-08
BG-09
BG-10
FWC-33
LEGEND
EXISTING PAVED ROAD
EXISTING UNPAVED ROAD
EXISTING BUILDING
EXISTING FENCE
EXISTING 6' CONTOUR
EXISTING 1' CONTOUR
EXISTING SPOT ELEVATION
TREES AND / OR BRUSH
EDGE OF WATER
WET AREA
WATER TABLE OBSERVATION WELL IN UNCONSOLIDATED SEDIMENTS
INTERMEDIATE DEPTH PIEZOMETER IN UNCONSOLIDATED SEDIMENTS
DEEP PIEZOMETER IN UNCONSOLIDATED SEDIMENTS
BEDROCK PIEZOMETER
PRODUCTION WELL
MUNICIPAL WELL
BACKGROUND SOIL BORING COMPLETED DURING RI INVESTIGATION
APPROXIMATE NIROP PROPERTY LINE
APPROXIMATE FWC PROPERTY LINE
APPROXIMATE BNR PROPERTY LINE
APPROXIMATE BOUNDARY OF THE RI INVESTIGATED SUBSURFACE SOILS FOR AREAS A, B, D, E, AND F
SCALE: 1" = 200'
0
100
200
400 FEET
NO. BY DATE REVISION APPR.
PROJECT: FEASIBILITY STUDY
NIROP - FRIDLEY, MINNESOTA
SHEET TITLE: FACILITY MAP, AREAS OF INVESTIGATION AND BACKGROUND SOIL BORING LOCATIONS
DRAWN BY:
CHECKED BY:
APPROVED BY:
DATE PRINTED:
DATE: APRIL 1992
SHEET FIGURE 1-5
RMT

FEASIBILITY STUDY
SOILS OPERABLE UNIT (OU2)

NAVAL INDUSTRIAL RESERVE
ORDNANCE PLANT
FRIDLEY, MINNESOTA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted by:
Brown & Root Environmental
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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0179

APRIL 1997

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LIST OF ACRONYMS/ABBREVIATIONS

1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
1,2-DCE	1,2-dichloroethene
AAD	alternatives array document
ARARs	Applicable or Relevant and Appropriate Requirements
ATc	averaging time (carcinogens)
ATn	averaging time (noncarcinogens)
BDAT	Best Demonstrated Technologies
BTU	British Thermal Unit
BWa	body weight (adult)
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	code of federal regulations
COC	constituents of concern
CPA	cancer potency/slope (inhalation)
cPAHs	carcinogenic polycyclic aromatic hydrocarbons
ED	exposure duration
EFr	exposure frequency (residential)
FS	Feasibility study
hp	horse power
HRL	Minnesota Health Risk Limits
IFadj	inhalation factor (adjusted for child plus adult)
IRa	inhalation rate (adult)
MCL	Maximum Contaminant Level
MPCA	Minnesota Pollution Control Agency
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NIROP	Naval Industrial Reserve Ordnance Plant
OM&M	operations, maintenance and monitoring

LIST OF ACRONYMS/ABBREVIATIONS (CONTINUED)

OU1	Groundwater operable unit
OU2	Soils operable unit - on-site subsurface source areas, in the unsaturated zone, outside the NIROP manufacturing building
OU3	Soils operable unit - on-site subsurface source areas beneath the NIROP manufacturing building and on-site subsurface source areas, in the saturated zone, outside the NIROP manufacturing building
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenols
PCE	tetrachloroethene
PRGs	Preliminary Remediation Goals
QA/QC	Quality Assurance/Quality Control
RA	Risk Assessment
RBCs	Risk-Based Concentrations
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RfDi	reference dose (inhalation)
RI	Remedial Investigation
ROD	Record of Decision
SACFM	Superfund Accelerated Cleanup Model
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
TBC	To Be Considered
TCE	trichloroethene
TCL	Target Cleanup Level
THQ	Target Hazard Quotient
TR	Target Risk
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds

Section 1
INTRODUCTION

This feasibility study (FS) is a detailed evaluation of the presumptive remedies that are applicable to the Non-Building Area Soils Operable Unit (OU2) at the Naval Industrial Reserve Ordnance Plant (NIROP) in Fridley, Minnesota. The presumptive remedy approach for CERCLA sites with volatile organic compounds (VOCs) in soils (USEPA, September 1993) has been applied to the NIROP Fridley. This approach is appropriate because the most significant and pervasive group of constituents on-site are the VOCs. Common solvents found on-site, including tetrachloroethylene, trichloroethylene, ethylbenzene, and toluene, are listed as typical VOCs that can be addressed using the presumptive remedy streamlined approach. The presumptive remedy alternatives were identified as applicable in the Alternatives Array Document (AAD) (RMT, Inc., 1994), and approved by the United States Environmental Protection Agency (USEPA) and Minnesota Pollution Control Agency (MPCA) on December 30, 1994.

The three presumptive remedies for this FS are soil vapor extraction (SVE), thermal desorption, and incineration. The evaluation in this FS is based upon the results of the Remedial Investigation (RI) for OU2, and regulatory summaries and guidance documents published by the Minnesota Pollution Control Agency (MPCA), the United States Environmental Protection Agency (USEPA), and other technical resources. Along with the objectives of this FS, the development of soil cleanup goals are presented to evaluate remedial activities. A systematic evaluation of a "no action" alternative, institutional controls that prevent subsurface intrusion (basements and tunnels) in contaminated areas, and three presumptive remedies was made.

1.1 SITE SETTING

The NIROP Fridley is owned by the Navy and operated by the Armament Systems Division of United Defense, L.P., formerly Northern Ordnance Division of FMC Corporation. The plant has produced naval guns since 1941 and has expanded into the production of guided missile launching systems, torpedo tubes, and hydraulic and electric power drive and control systems.

The NIROP Fridley is located on the southernmost tip of Anoka County. The plant is situated approximately one-quarter mile east of the Mississippi River and less than 1 mile south of Interstate 694. The plant is bordered on the west by East River Road and on the east by the Burlington Northern railyard. The government-owned, contractor-operated portion of the plant encompasses 83 acres. The remainder of the facility is owned and operated by United Defense Corporation and

and encompasses approximately 55 acres. Figure 1-1 is a topographical map showing the location of the NIROP facility.

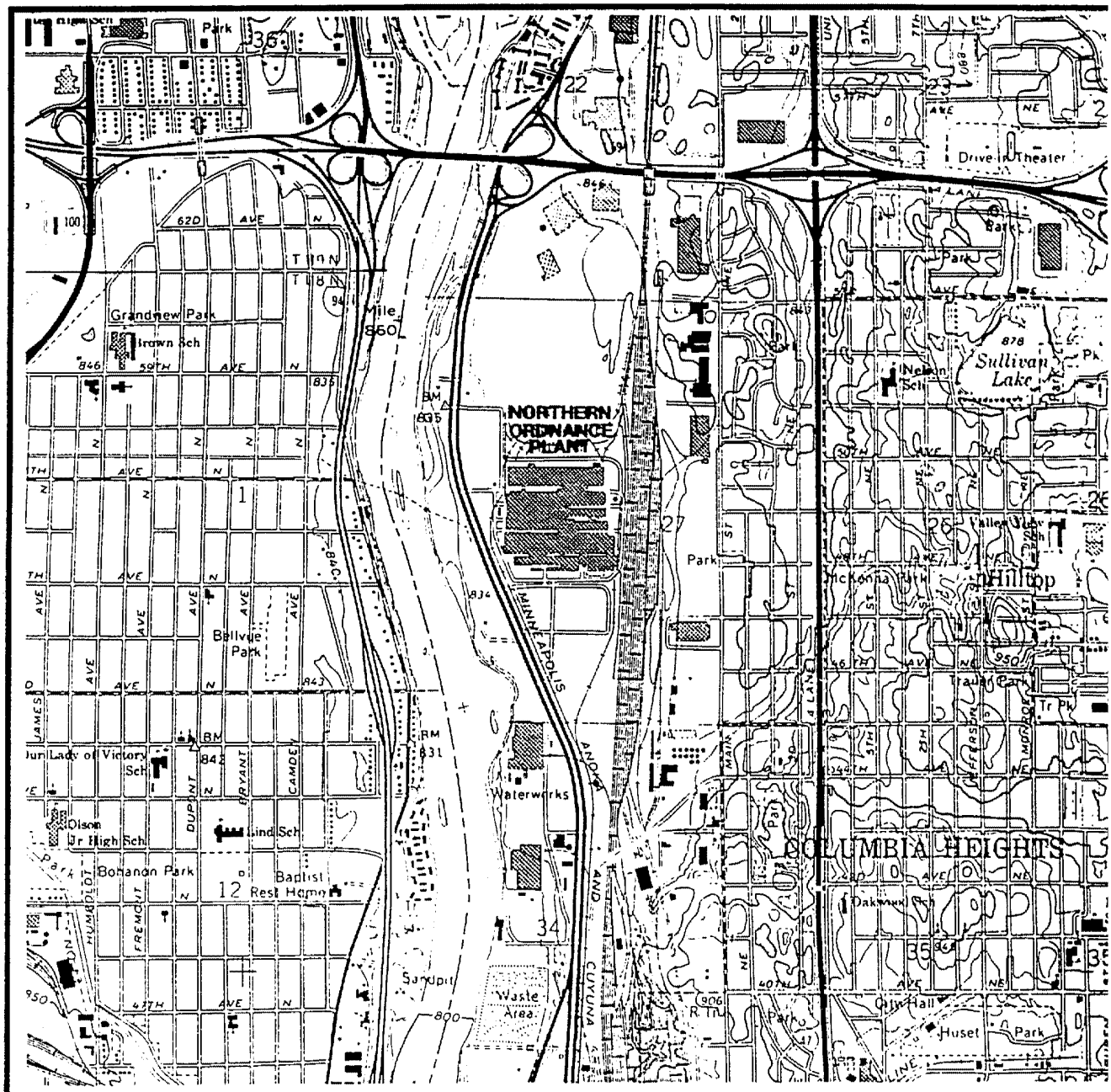
The NIROP Fridley and adjacent properties to the north, east, and south are zoned heavy industrial. The Anoka County Riverfront Regional Park is located between East River Road and the Mississippi River (west of the site). The park is a day-use recreation facility on the river's edge, consisting of approximately 60 acres.

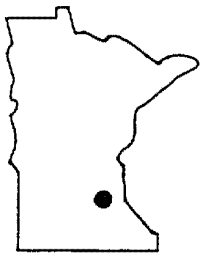
Fridley's population was estimated at 28,000 residents in 1990. Anoka County's population, according to 1990 estimates, was 244,000 people. The NIROP Fridley is located near the northern boundary of the metropolitan statistical area (as defined by the U.S. Bureau of Census) for Minneapolis-St. Paul, Minnesota. The area was estimated to contain a population of 2,350,000 people in 1990 (Rand McNally, 1992).

Two significant waterways are near the site: the Mississippi River, approximately 1,000 feet to the west, and Rice Creek, approximately 2 miles to the north. The Mississippi River provides active recreational opportunities to boaters and anglers as well as passive recreation because of its aesthetics and historical significance. The river also serves as a source of public drinking water. The water intake for the City of Minneapolis Waterworks facility is located approximately 2,000 feet south (downstream) of the NIROP Fridley's southern property line.

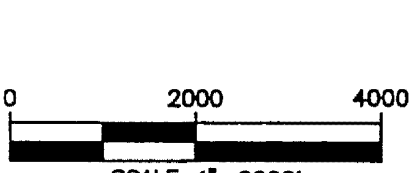
The NIROP Fridley is situated over a sand and gravel aquifer capable of yielding significant quantities of water for residential or municipal supplies. The Quaternary alluvial aquifer, though capable of yielding fairly high quantities of water to wells, is not commonly used for water supply purposes. The Prairie du Chien/Jordan aquifer is more commonly used (RMT, 1987). The aquifer is generally restricted to the Mississippi River Valley.

The natural soils in the area of the NIROP Fridley are primarily composed of sandy glacial deposits. The glacial deposits occurring at the site consist primarily of coarse sand, fine to medium sand, and some gravelly sand, with hydraulic conductivities that are relatively high, indicating permeable conditions (RMT, 1993). Discontinuous layers of silt and clay occur at some locations. Sandy fill occurs over a broad area of OU2, to an average depth of about 4 feet (RMT, 1993). In total, these unconsolidated deposits are up to 150 feet thick in the vicinity of the site (Envirodyne, 1983). Generally, sand in OU2 is classified as poorly graded sand (SP) under the Unified Soil Classification System (USCS). The water table occurs at a depth ranging from about 20 to 30 feet at the site,





STATE LOCATION



SITE LOCATION MAP
NIROP

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

RMT INC.

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FIGURE 1-1

within the sandy soils. The bedrock unit immediately underlying most of the unconsolidated deposits at the site is the St. Peter Sandstone, although it is not continuous under the NIROP. Successive units underlying the St. Peter Sandstone are the Prairie du Chien Group and the Jordan, St. Lawrence, Franconia, and Ironton/Galesville Sandstones. Area geology and groundwater flow are discussed in detail in Section 5 of the Remedial Investigation report for the groundwater operable unit (RMT, 1987).

The climate in the area of the site is characterized by warm summers with average temperatures ranging from the upper 70s°F to the low 80s°F, with moderate rainfall averaging about 17 inches per year. Winter temperatures average between 3°F and 7°F for January and February. Precipitation during the months of October through April averages about 9 inches. Temperature extremes for the area range from -34° to 104°F (Envirodyne, 1983). Wind directions vary throughout the year. Northwest winds prevail from November through April; southeast winds are dominant in May, June, August, and October; and southern winds dominate in July and September. Wind speeds are fairly constant throughout the year, averaging 10.5 miles per hour (Envirodyne, 1983).

1.2 INVESTIGATION ACTIVITIES

The initial sampling activities related to environmental issues at the Fridley NIROP began in 1981. After an initial assessment and focused drum removal action, the site was divided into operable units (OU) by the U.S. Navy, U.S. EPA, and MPCA. OU1 addressed the groundwater conditions and activities at OU1 are ongoing. At this time, the Remedial Investigation/Feasibility Study (RI/FS), Record of Decision (ROD), and Remedial Design (RD) for OU1 are completed, and remedial actions, including system upgrades, are on-going. OU2 addresses the unsaturated soils outside of the building footprint area. The RI and baseline risk assessment have been completed at this time for OU2. This FS addresses OU2. OU3 has been defined to address the saturated and unsaturated soils beneath the manufacturing building, and saturated subsurface source areas outside Building 1.

A summary of the various investigation and remedial site activities that have occurred at the NIROP Fridley property follows. More details regarding the results of any of these activities are available in reports referenced here, and in the RI document. The administrative record is available at NIROP by contacting Kerry Morrow at (612) 572-6360.

1.3 SUMMARY OF OU2 - REMEDIAL INVESTIGATION

The most recent soil investigation as reported in the soils operable unit RI consisted of evaluating the extent of contamination in 11 sub-areas and in establishing site-specific background concentrations in the NIROP Fridley area. Table 1-1 summarizes the site activities since 1981.

1.3.1 Summary of Removal Actions

During the investigations conducted at the NIROP Fridley property, buried drums were discovered on two occasions. The drums were removed along with contaminated soil.

The first incident occurred in 1983 when excavation of nine out of 20 conductivity anomalies was performed. Nine areas were chosen based on a review of the electrical conductivity and magnetometer survey data and were considered the areas with the highest probability of containing buried drums.

During excavation of the anomalies, a total of 43 drums were excavated and removed at the time. The drums were classified as follows:

Classification	Number of Drums
Empty	4
Inert liquid	4
Base solid	1
PCB waste	6
Flammable solid	2
Inert Solid	26
Total	43

All empty drums were crushed and disposed, along with 2,100 cubic yards of excavated hazardous soils, at Evergreen Landfill, Northwood, Ohio. The remaining drums were trucked to Emelle, Alabama, and disposed at the Chemical Waste Management Facility.

Documentation of the excavation and removal was completed in the Draft Project Report of the Hazardous Waste Clean-up at the NIROP Fridley by the USACE in 1984. The final version of this report was prepared by RMT in September 1986 (RMT, 1986).

TABLE 1-1
SUMMARY OF ACTIVITIES - NIROP FRIDLEY, MINNESOTA

Date	Event
Overall Site	
March 1981	Initial sampling initiated after telephone call
March 1982	Initiation of investigation of North Study Area
June 1983	Completion of Initial Assessment Study (Envirodyne Engineers, Inc.)
	Initiation of U.S. Corps. of Engineers (USACE) conductivity study
November 1983	First Drum Removal Action by Chemical Waste Management (43 drums removed)
September 1986	Final Report of the Hazardous Waste Cleanup (RMT, Inc.)
Groundwater Operable Unit	
Late 1986	Initiation of Groundwater RI activities (RMT, Inc.)
June-July 1988	Completion of Groundwater RI Report and Addendum (RMT, Inc.)
July 1988-August 1988	Completion of Feasibility Study Report and Addendum for Groundwater (RMT, Inc.)
September 1990	Issuance of Record of Decision for the Groundwater Operable Unit
September 1992	Start-up of groundwater recovery system
December 1992	90-day Determination Document (RMT, Inc.)
June 1994	Submittal of Proposed Workplan for Upgrading Groundwater Recovery System
Soils Operable Unit	
November 1987	Pore Gas Survey to evaluate shallow VOC impacts
October-November 1990	Initial soil investigation consisting of 55 soil borings
February 1991	Quality Control Summary Report (RMT, Inc.)
August 1991	Historical aerial photograph review to identify other areas for investigation
November 1991	Discovery of impacts near hazardous materials storage building
January 1992	Final RI Workplan
January 1992	Final Quality Assurance Plan Approved On-site removal action of 31 drums and 900 yards of soil
September 1993	Final Remedial Investigation Report
November 1994	Alternatives Array Document (RMT, Inc.)

The second removal action was conducted as a time-critical removal action that was performed in Area A near the permanent decontamination pad. The removal action was a result of having encountered a subsurface void containing free liquid (this was later identified as a buried drum) while installing a soil boring immediately east of the decontamination pad. Bay West, Inc., of St. Paul, Minnesota, performed the removal action. Approximately 900 cubic yards of soil and debris and 31 drums were excavated. The 31 drums were sampled and overpacked. Bay West submitted a documentation report which was provided in Appendix A of the Final Remedial Investigation Report (RMT, 1993).

1.3.2 Summary of Remedial Investigation

The investigation consisted of the advancement of 105 soil borings extended to various depths, 12 background soil borings, and the excavation of 12 test pits at focused locations. Samples were collected and analyzed for various constituents and included analysis of volatile organics, semivolatile organics, pesticides/PCBs, and total organic carbon. Three hundred and twenty-nine samples were analyzed for volatile organics, 152 samples for semivolatile organics, 151 samples for pesticides and PCBs, 151 samples for inorganics, and 299 samples for total organic carbon. On the basis of these data and the data from previous investigations, it was concluded that there was soil contamination in seven of the areas studied (A-1, B-1, B-2, E-1, E-2, F-1, and F-2). One area (D) had less contamination, and three areas (A-2, A-3, and A-4) were found to have significant soil impacts. Figure 1-2 is a facility map showing the areas of investigation.

The primary constituents of concern in soils at the NIROP Fridley are chlorinated VOCs. Their presence is consistent with the findings associated with the groundwater OU. Some pesticides were identified in surficial soil, likely attributable to on-site maintenance activities; however, they were not found to present an unacceptable level of risk. Selected semivolatile organic compounds (SVOCs), most specifically PAHs, and isolated metals were quantified in some surface and intermediate depth soil samples. Two smaller areas were identified where low to moderate concentrations of petroleum-based hydrocarbons were detected.

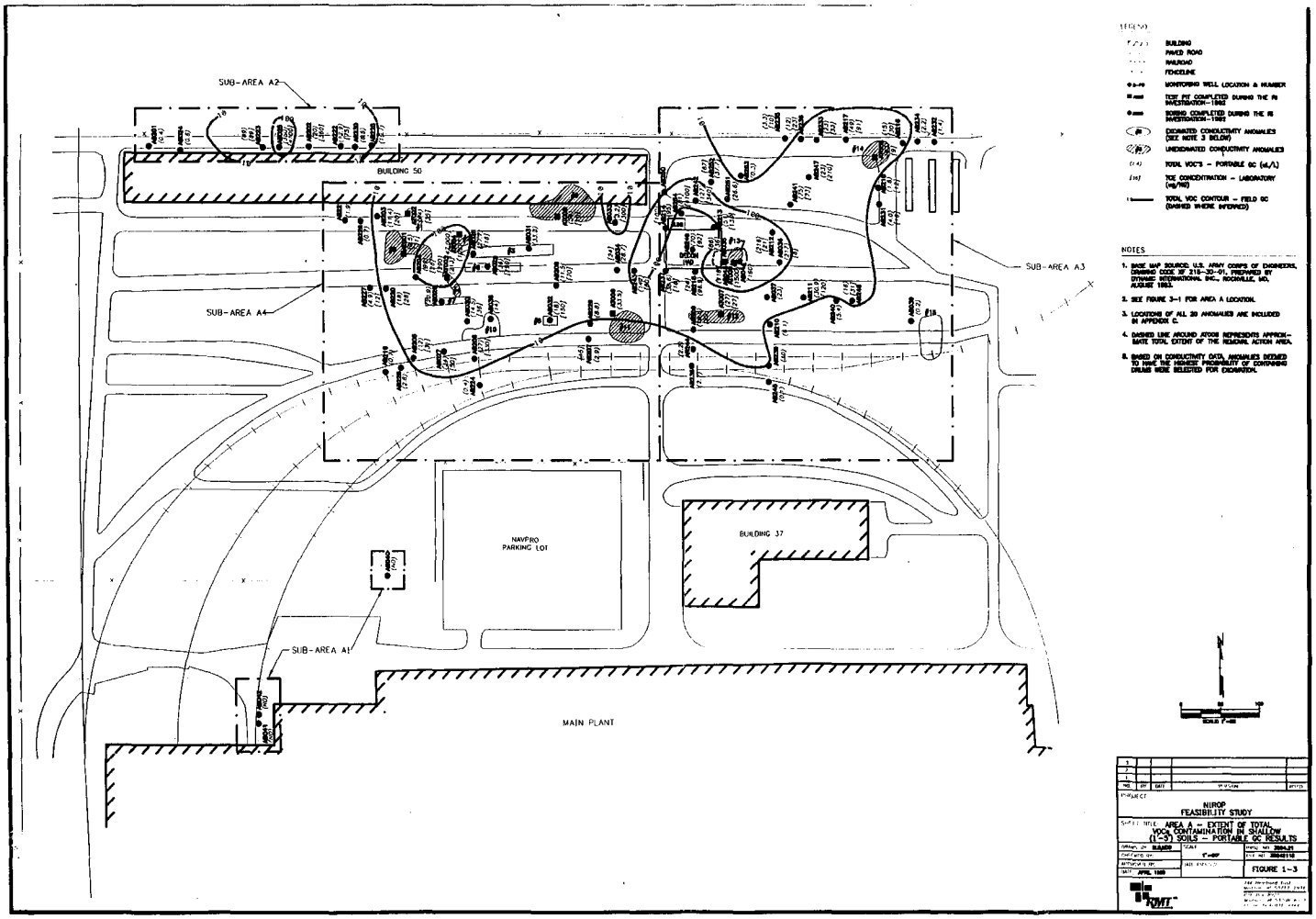
Concentrations reported were variable depending upon the soil depth and type of constituents. VOCs in the soil were generally quantified in the range of low (<20) to high (100,000) parts per billion. In the soil pore gas, concentrations of VOCs were generally in the parts per million range over most of Area A, as well as over some of the other areas (D and E). SVOCs in the soil had similar variability, while metals and pesticide concentrations remained near background levels. Three sub-areas were significantly impacted (A-2, A-3, and A-4) by VOCs. The depths and type of

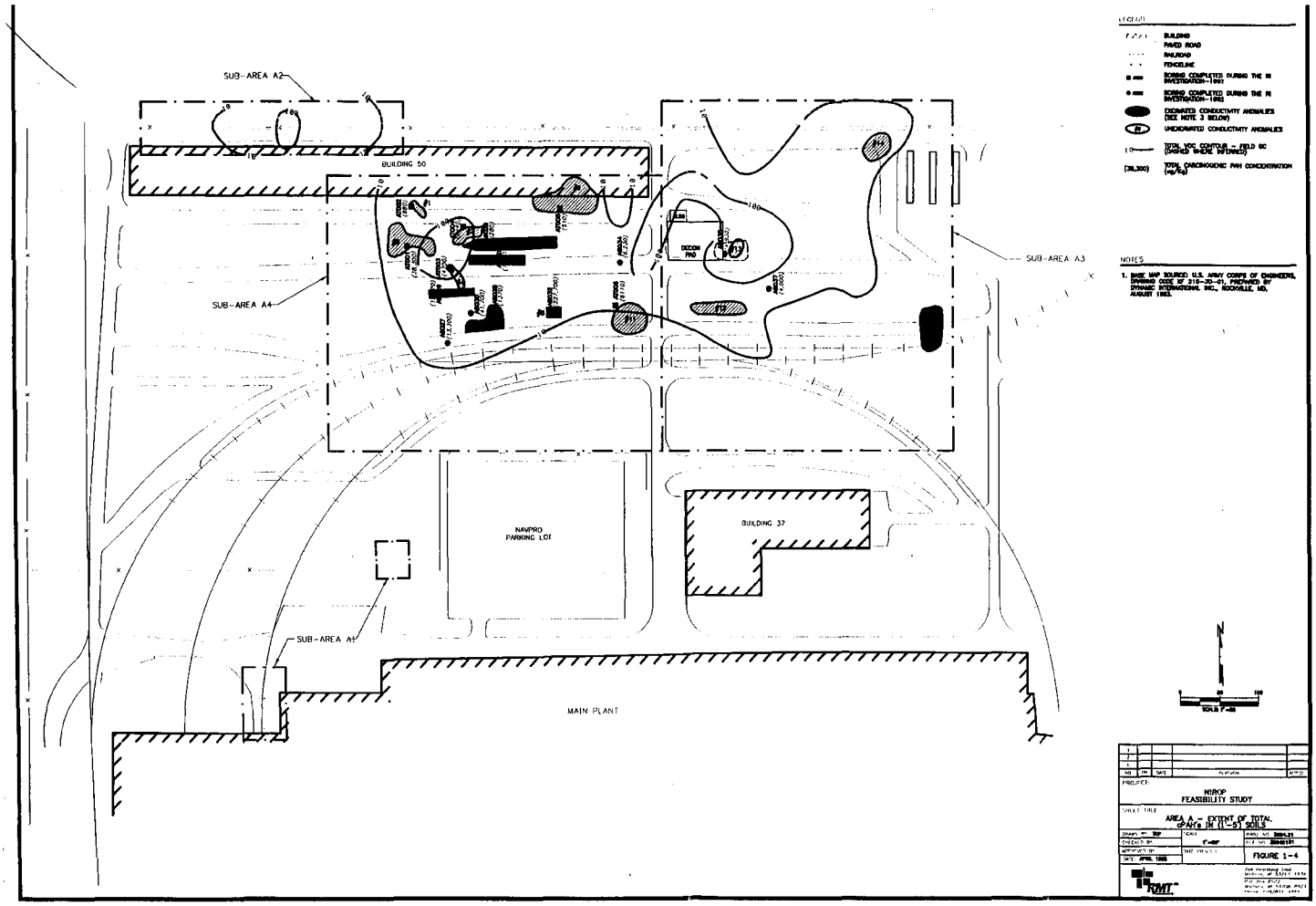
contamination varied in the three areas. In Area A-2, which is approximately 0.6 acre in size, the concentrations of VOCs were highest in shallow layers and decreased with depth in the sandy subsurface soil. Pesticides and metals were also detected in higher concentrations in the surface samples. Approximately half of Area A-3 (approximately 4.1 acres) was contaminated with VOCs. The depth of VOC contamination varied with location. In this area, the mid-depth (6 to 12 feet below ground surface) concentrations were highest, which is consistent with locations where drums had been disposed in trenches. Where disposal trenches were not suspected, the highest concentrations were again present in the shallow sampling interval. Area A-4 (approximately 3.4 acres) had widespread VOC contamination. The horizontal distribution of VOC contamination was generally consistent in the three depth ranges. SVOCs were not found in most samples, and where present, they were in the form of polycyclic aromatic hydrocarbons (PAHs) and were usually in the near surface (fill) deposits. Metals and pesticides were generally limited to surficial soil with no evidence of vertical migration. Figure 1-3 shows the extent of total VOC contamination and TCE contamination in shallow soils in Area A determined during the Remedial Investigation. Figure 1-4 shows the concentrations of total cPAHs in shallow soils in Area A. Other areas where cPAHs were identified, but to a less extent, include Areas D and E. More details of these results are available in the RI Report (RMT, 1993).

The toxicity factors used to calculate the baseline risk assessment were taken from the USEPA-approved databases. The exposure assumptions were based upon USEPA default values, which were adjusted for site conditions and the input concentrations, and the general maximum on-site parameter concentrations. Under current land use scenarios, two potential exposure pathways were identified. These were: 1) incidental ingestion, dermal adsorption, and inhalation of soil particulates; and 2) inhalation of VOCs by workers in subsurface tunnels through pore gas migration. The estimated site risk for both pathways was calculated to be less than Minnesota guidelines (1×10^{-5} cancer risk) or the hazard index (HI) level of concern (HI = 1).

For the future land use scenario, the site was divided into two areas on which a home could potentially be built. These two areas included a residence in either sub-areas A-2, A-3, and A-4 (areas of highest impacts), or the areas outside of sub-areas A-2, A-3, and A-4.

Under the future land use scenario, the estimated site risk associated with carcinogens for a hypothetical resident in sub-areas A-2, A-3, and A-4 was found to be 4×10^{-3}, which is above the 10^{-5} acceptable risk level. The site risk is primarily associated with the inhalation of soil pore gas, specifically of PCE and TCE, that could infiltrate through soil into the basement of a home


SUB-AREA A2
BUILDING 50
SUB-AREA A3
SUB-AREA A4
NAVPRO PARKING LOT
BUILDING 37
SUB-AREA A1
MAIN PLANT
LEGEND
BUILDING
PAVED ROAD
RAILROAD
FENCELINE
MONITORING WELL LOCATION & NUMBER
TCEF PIT COMPLETED DURING THE RI INVESTIGATION-1992
BORING COMPLETED DURING THE RI INVESTIGATION-1992
DESIGNATED CONDUCTIVITY ANOMALIES (SEE NOTE 3 BELOW)
UNDESIGNATED CONDUCTIVITY ANOMALIES
TOTAL VOC'S - PORTABLE GC (ug/L)
TCE CONCENTRATION - LABORATORY (ug/kg)
TOTAL VOC CONTOUR - FIELD GC (DASHED WHERE INFERRED)
NOTES
1. BASE MAP SOURCE: U.S. ARMY CORPS OF ENGINEERS, DRAWING CODE W 216-30-01, PREPARED BY DYNAMIC INTERNATIONAL INC., ROCKVILLE, MD. AUGUST 1993.
2. SEE FIGURE 3-1 FOR AREA A LOCATION.
3. LOCATIONS OF ALL 20 ANOMALIES ARE INCLUDED IN APPENDIX C.
4. DASHED LINE AROUND AT008 REPRESENTS APPROXIMATE TOTAL EXTENT OF THE REMOVAL ACTION AREA.
5. BASED ON CONDUCTIVITY DATA, ANOMALIES DEEMED TO HAVE THE HIGHEST PROBABILITY OF CONTAINING DRUMS WERE SELECTED FOR EXCAVATION.
NO. BY DATE REVISION APPD.
PROJECT
NIROP
FEASIBILITY STUDY
SHEET TITLE: AREA A - EXTENT OF TOTAL VOCs CONTAMINATION IN SHALLOW (1'-3') SOILS - PORTABLE GC RESULTS
DRAWN BY: BJAMES
SCALE: 1"=60'
PROJ. NO: 3004.01
FILE NO: 3004B10
DATE: APRIL 1995
FIGURE 1-3
FMT


SUB-AREA A2
BUILDING 50
SUB-AREA A3
SUB-AREA A4
NAVPRO PARKING LOT
BUILDING 37
SUB-AREA A1
MAIN PLANT
LEGEND
BUILDING
PAVED ROAD
RAILROAD
FENCELINE
BORING COMPLETED DURING THE RI INVESTIGATION-1992
BORING COMPLETED DURING THE RI INVESTIGATION-1993
DESIGNATED CONDUCTIVITY ANOMALIES (SEE NOTE 3 BELOW)
UNDESIGNATED CONDUCTIVITY ANOMALIES
TOTAL VOC CONTOUR - FIELD GC (DASHED WHERE INFERRED)
TOTAL CARCINOGENIC PAH CONCENTRATION (ug/kg)
NOTES
1. BASE MAP SOURCE: U.S. ARMY CORPS OF ENGINEERS, DRAWING CODE IF 210-30-01, PREPARED BY DYNAMIC INTERNATIONAL INC., ROCKVILLE, MD. AUGUST 1993.
PROJECT
NIROP
FEASIBILITY STUDY
SHEET TITLE
AREA A - EXTENT OF TOTAL CPAHs IN (1'-5') SOILS
FIGURE 1-4
FMT

constructed on the site. The risk, based on VOC contamination, associated with a home built outside of sub-areas A-2, A-3, and A-4 was calculated at 6×10^{-4}, which is also greater than the acceptable level. TCE and PCE in soil pore gas were the two principal contributors to the risk value. Any additional risk attributable to cPAH will be investigated in the OU3 Feasibility Study.

Under the future land use scenario, the hazard associated with noncarcinogens to a hypothetical future resident in sub-areas A-2, A-3, and A-4 was found to be 6.0. A hazard index greater than 1.0 indicates levels of potential concern. The contributions to the hazard in these sub-areas were primarily ethylbenzene and toluene measured in the soil pore gas, and secondarily, manganese in soil. The estimated hazard for a resident located outside of sub-areas A-2, A-3, and A-4 was 0.4.

Other pathways were at least one order of magnitude less in their potential risk in this scenario. These included inhalation, dermal adsorption, and ingestion of surficial soil. The constituents that drove these risk factors were SVOCs and selected metals.

Overall, the baseline risk assessment indicates that the present status of contaminated areas at the NIROP does not result in unacceptable risks to either on-site or off-site workers. The baseline risk assessment also indicates that unacceptable risks are associated with the NIROP under a residential setting (future land use). Currently, contaminated areas in OU2 are undeveloped.

1.4 CONSTITUENTS OF CONCERN

During the Remedial Investigation, samples were collected for VOCs, metals, pesticides/PCBs, and SVOCs/PAHs. VOCs were consistently found over most of Areas A, D, and E. Metals and pesticides were detected in isolated samples. PCBs were not detected in any of the samples. PAH compounds were found in surface soil samples and in areas related to the buried anomalies. The PAH compounds are likely associated with waste or fill materials (e.g., asphalt, roofing debris, etc.) that may have been buried in pits and trenches in the past at the NIROP. On the basis of the information gathered during the Remedial Investigation (RMT, 1993), the MPCA developed the constituents of concern for OU2 soils at the NIROP (MPCA, 1995). The constituents of concern are:

- Toluene
- Carcinogenic PAHs (cPAHs)
- Ethylbenzene
- Trichloroethene (TCE)
- Tetrachloroethene (PCE)
- 1,2-Dichloroethene (1,2-DCE)
- 1,1-Dichloroethene (1,1-DCE)
- 1,1,1-Trichloroethane (1,1,1-TCA)
- 1,1-Dichloroethane (1,1-DCA)

Remaining sections of this FS focus on developing ARARs, cleanup goals, and remedial alternatives for the COC in OU2.

1.5 REMEDIAL TECHNOLOGIES SELECTION

To accelerate cleanups at contaminated sites, the EPA developed the presumptive remedy approach within the Superfund Accelerated Cleanup Model (SACM). The presumptive remedies are preferred technologies for common categories of contaminants, based on historical patterns of remedy selection and the EPA's scientific and engineering evaluation of performance data on technology implementation. The presumptive remedy approach eliminates the need for the initial step of identifying and screening a variety of alternatives during the Feasibility Study. EPA's analysis of feasibility studies for VOC-contaminated soil sites found that certain technologies are routinely screened out based on effectiveness, implementability, or excessive costs, consistent with the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). Since a presumptive remedy is a technology that the EPA believes will be the most appropriate remedy for a specific type of site, the approach accelerates site-specific remedies by focusing the feasibility study efforts. For VOC sites, the presumptive remedies are soil vapor extraction, thermal desorption, and incineration.

Presumptive remedies apply primarily to the VOC constituents in the unsaturated soils. If contaminants other than VOCs exist, then the Presumptive Remedy Guidance indicates that the analysis can be supplemented or modified to include site-specific concerns. Therefore cPAH removal with respect to each remedial alternative was evaluated in this FS. The intent of the analysis was to determine if any of the presumptive remedy alternatives selected for VOCs were appropriate.

1.6 FEASIBILITY STUDY PURPOSE AND OBJECTIVES

The purpose of this Feasibility Study is to evaluate the feasibility and effectiveness of implementing alternative Response Actions at the site. The FS shall contain sufficient information and analysis to make the determination of the appropriate extent of remedy. The specific objectives for this feasibility study are the following:

- To incorporate target soil cleanup levels based upon both the MPCA Soil Leaching Model results and risk-based analysis, to be protective of human health and the environment and to not adversely affect groundwater.
- To evaluate remedial alternatives that may apply utilizing presumptive remedy guidance for VOC-contaminated soils.

- To compare technologies following USEPA guidance and the requirements of the National Contingency Plan (NCP) (40 CFR 400.300)

1.7 REPORT ORGANIZATION

This feasibility study includes the following major sections.

Section 1:

Is this introduction

Section 2:

Summary of Applicable or Relevant and Appropriate Requirements - Identifies applicable regulations and outlines regulatory requirements, including air pollution control permits, construction/operating permits, and waste handling/disposal permits.

Section 3:

Remedial Action Objectives and Target Cleanup Goals - Develops target soil cleanup goals based on health risk-based concentrations and protection of groundwater.

Section 4:

Remedial Alternatives for OU2 Soils - Presents details of each remedial treatment technology, including system performance, residuals handling, operation and maintenance requirements, and implementation schedules.

Section 5:

Detailed Analysis of Remedial Alternatives - Assesses the presumptive remedies to determine if they comply with criteria such as the protection of human health and the environment, long- and short-term effectiveness, implementability, and cost.

Section 6:

Comparative Analysis of Remedial Alternatives - Presents a comparison of the selected technologies and makes recommendations regarding the technology that should be considered for the project.

Section 2

SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

2.1 INTRODUCTION

The assessment of ARARs is an integral part of the remediation process mandated under the Comprehensive Environmental Response, Compensation and Liability Act, and the Superfund Amendments and Reauthorization Act (42 U.S.C. § 9601-9675)(1991). As the preamble of CERCLA states, the purpose of the law is "to provide for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous waste disposal sites." In addressing hazardous substances and sites, CERCLA provides that on-site remedial actions must meet the standards and criteria that are otherwise legally applicable to the substance, pollutant, or contaminant or that are relevant and appropriate under the circumstances (42 U.S.C. § 9621[d][2][a]) (1991).

Guidance for assessing and selecting ARARs is provided in the U.S. Environmental Protection Agency (USEPA) manual "CERCLA Compliance With Other Laws" (USEPA, 1988) and "CERCLA Compliance With Other Laws Manual: Part II, Clean Air Act and Other Environmental Statutes and State Requirements" (USEPA, 1989). These guidance documents were used to identify potential federal ARARs. Information from the MPCA and the Minnesota Department of Health was also obtained to identify potential state ARARs.

CERCLA remedial actions may trigger several different types of requirements or ARARs. These are organized into three categories: chemical-specific, action-specific, and location-specific. However, these categories are not always mutually exclusive and there may be some overlap. Chemical-specific ARARs are numeric requirements typically derived from health- or risk-based values for different chemical substances (USEPA, 1988). Action-specific ARARs are usually technology- or activity-based requirements or limitations (USEPA, 1988). Location-specific ARARs are requirements or limitations based on the physical setting of the site.

In order to be classified as an ARAR, a requirement must be **applicable** or **relevant and appropriate**. As defined in the National Contingency Plan (NCP), applicable requirements are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that

specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site" (40 CFR § 300.5)(1991).

Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 CFR § 300.5)(1991).

An applicable or a relevant and appropriate requirement for on-site remedial action must be substantive. Compliance with administrative requirements is not mandated for on-site actions (USEPA, 1988). Administrative requirements are those procedures "that facilitate the implementation of the substantive requirements of a statute or regulation" (USEPA, 1988). For example, CERCLA specifically exempts on-site actions from federal, state, and local permitting requirements (42 USC § 9621[e][1])(1991). Furthermore, only those state requirements that are more stringent than federal requirements are ARARs (40 CFR § 300.5) (1991). "More stringent" would also necessarily include those state laws or programs that have no federal counterpart as, "they add to the federal law requirements that are specific to the environmental conditions in the State" (USEPA, 1989). State requirements must be adopted by formal means (i.e., promulgated) and generally acceptable (i.e., not just to Superfund sites, but to all circumstances addressed in the requirement (42 USC § 9621[d][2][C][iii][I]) (1991).

Finally, there is a category of requirements called **"To Be Considered" (TBC)** guidance that may appear in this section. These are guidelines or advisories that are issued by the federal, state, or local government, but which are neither legally binding nor promulgated (USEPA, 1988). However, these guidelines may be used when they are necessary to ensure protection of public health and the environment and when they have not been superseded (USEPA, 1988). If no ARARs address a particular circumstance at a CERCLA site (such as soil standards), then TBCs can be used to establish remedial guidelines or targets. Even when TBCs are used, the other requirements imposed on the remedy still apply.

This section presents the potential ARARs identified for the OU2 at the NIROP Fridley facility. The OU includes soil containing VOCs and cPAHs. Contaminated soils located under the buildings at the NIROP facility are not addressed in this FS and are separated into Operable Unit 3 (OU3).

Chemical-specific, action-specific, and location-specific ARARs are identified for later use in remedy evaluation (Section 5).

2.2 FEDERAL AND STATE ARARS

Tables 2-1, 2-2, and 2-3 present the potential chemical-specific, action-specific, and location-specific ARARs for the Soils OU, respectively. To meet ARARs for OU2, presumptive remedies for CERCLA sites with VOCs were considered in the AAD. Since the development of the AAD, cPAHs have also been identified as constituents of concern in OU2. Therefore, remedial alternatives developed in this FS also address cPAH-containing soil.

Chemical-Specific ARARs

Table 2-1 summarizes the potential chemical-specific ARARs for the soils OU. The State of Minnesota has a soil cleanup standard for lead, which is not an identified constituent of concern at this site. Target cleanup levels for the soil medium were developed using health-based, site-specific information.

Action-Specific ARARs

Action-specific ARARs are based on the remedial alternatives developed in this FS. The remedial alternatives for the site include the following:

- Soil vapor extraction (SVE) (i.e., in-place treatment)
- Thermal desorption of soil and replacement in the excavation (i.e., on-site treatment and clean closure)
- Incineration conducted either on- or off-site

These remedial alternatives are listed in Table 2-2 with their respective action-specific ARARs identified. National Ambient Air Quality Standards (NAAQSs) are relevant and appropriate for air emissions resulting from the CERCLA remedial actions. USEPA Guidance (USEPA, 1989) interprets CERCLA activities as non-major sources of air emissions; therefore, the NAAQSs are not considered applicable.

Action-specific state ARARs identified beyond the federal regulations included VOC air emission limitations, particulate emission limitations, and off-site transportation of hazardous waste regulations (if appropriate).

TABLE 2-1

SUMMARY OF POTENTIAL CHEMICAL-SPECIFIC ARARS

Pathway	Requirement	Prerequisite(s)	Citation	Comments
Groundwater[1]	Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) for 75 compounds, radioactivity, bacteria, and turbidity, which are enforceable for public drinking water systems.	Public water systems defined as piped water serving at least 25 persons.	40 CFR 141.11 through 141.16	Relevant and appropriate under current land use conditions (i.e., the groundwater at the site is not used for drinking purposes). Relevant and appropriate under future land use scenario for groundwater used as drinking water.
	SDWA MCL Goals for 75 compounds, radioactivity, bacteria, and turbidity.	Public water systems defined as piped water serving at least 25 persons.	40 CFR 141.50 through 141.51	To be considered. MCL goals are non-enforceable for public drinking water systems.
	Hazardous substance concentrations in the aquifer should not exceed the Minnesota health risk limits (HRLs) for drinking water.	Groundwater concentrations at drinking water wells exceed the HRLs.	Minnesota Groundwater Protection Act, 1989.	Relevant and appropriate under current land use conditions (i.e., the groundwater at the site is not used for drinking purposes). Applicable under future land use scenario for groundwater used as drinking water.
Surface Water	Water quality standards must be achieved to protect humans, aquatic life, or wildlife.	Discharges of groundwater or surface water run-off from the site to water bodies exceed the water quality standards.	Clean Water Acts 303 and 304. Minnesota Rules Ch. 7050, Standards for the Protection of the Quality and Purity of the Waters of the State.	Relevant and appropriate if groundwater or surface water run-off from the site discharges to water bodies and exceeds the water quality standards. Accounting to MPCA 7050.470, Subpart 4, the Mississippe River at Fridley is designated as a Class I Municipal water supply.
Soil	Surficial soil remediation must achieve cleanup level for lead of less than 100 parts per million (ppm) for the top 2 cm in bare soil.	Bare soil on residential property or playground contains lead and is remediated.	Minnesota Rules Parts 4761.0100 and 4761.0300, Subpart 4	Relevant and appropriate under current land use conditions (i.e., the soil is not used as residential property or a playground) if lead concentrations exceed 100 ppm in surficial soil. Applicable under future land use scenario if lead concentrations exceed 100 ppm in surficial soil.

NOTES:

[1] The State of Minnesota MCLs for drinking water supply are identical to the federal MCLs and thus are not listed because they are not more stringent. The State incorporated the National Primary Drinking Water Regulations (Code of Federal Regulations, Title 40, Parts 141 and 142.40 to 142.64) into the Rules of the Minnesota Department of Health Governing Public Water Supplies, Parts 4720.0200 to 4720.3970.

[2] Groundwater standards apply to OU2 since these standards were utilized in the MPCA soil leaching model approach to identifying Target Clean-up Levels.

TABLE 2-2

SUMMARY OF POTENTIAL ACTION-SPECIFIC ARARS

Remedial Alternative	Requirement	Prerequisite(s)	Citation	Comments
Soil Vapor Extraction (i.e., in-place treatment)	Air emissions must achieve compliance with air quality standards.	Major stationary source as defined in 40 CFR Section 52.21(b)(1)(i)(a).	National Ambient Air Quality Standards (NAAQS)[1] 40 CFR 52 and 40 CFR 61 Clean Air Act Title V Requirements under 40 CFR 70	Relevant and appropriate for criteria pollutants related to the site. Attainment of NAAQS is required for "major sources." NIROP is a major source.
	Engineering control measures must be used to control the release of VOCs and particulates.	Emission of VOCs from a stationary source or group of stationary sources that have the potential to emit 100 tons per year of VOCs or 10 tons per year of any hazardous pollutant. Emission of particulates from thermal desorbers are limited to a 25 lb/yr threshold.	Minnesota Statute Chapter 7007	Applicable for remedial alternatives that release VOCs in excess of the air emission standards.[4]
Thermal Desorption of Soil and Replacement in the Excavation (i.e., on-site treatment and clean closure)	Air emissions must achieve compliance with air quality standards.	Major stationary source as defined in 40 CFR Section 52.21(b)(1)(i)(a).	National Ambient Air Quality Standards (NAAQS)[1] 40 CFR 52 and 40 CFR 61 Clean Air Act Title V Requirements under 40 CFR 70	Relevant and appropriate for criteria pollutants related to the site. Attainment of NAAQS is required for "major sources." NIROP is a major source.
	Thermal desorption of chlorinated compounds may be restricted by the MPCA; therefore, the process will likely require emission tests to verify destruction efficiency. Potential application emission limits include 0.0004 lbs/yr 2,3,7,8-TCDD for stacks not subject to building downwash, and 0.0001 lbs/yr 2,3,7,8-TCDD for stacks subject to building downwash.	Source combusts chlorinated compounds.	MPCA screening emission rates	Applicable if thermal desorption results in emissions of air toxics for which the MPCA has established screening emission rates.
	Thermal desorption must comply with RCRA removal, storage, and treatment requirements.	Excavated soil is determined to be a RCRA hazardous waste.	40 CFR 264	Applicable if excavated soil is determined to be a RCRA hazardous waste.[3]
	Best management practices (i.e., sediment and erosion controls) for surface water control measures must be used during soil excavation.	Construction activities disturb greater than 5 acres of total land area.	40 CFR 122	Applicable if the total area of soil excavation is greater than 5 acres. Relevant and appropriate if less than 5 acres are disturbed.

TABLE 2-2

SUMMARY OF POTENTIAL ACTION-SPECIFIC ARARS

Remedial Alternative	Requirement	Prerequisite(s)	Citation	Comments
Soil Vapor Extraction (i.e., in-place treatment)	Air emissions must achieve compliance with air quality standards.	Major stationary source as defined in 40 CFR Section 52.21(b)(1)(i)(a).	National Ambient Air Quality Standards (NAAQS)[1] 40 CFR 52 and 40 CFR 61 Clean Air Act Title V Requirements under 40 CFR 70	Relevant and appropriate for criteria pollutants related to the site. Attainment of NAAQS is required for "major sources." NIROP is a major source.
	Engineering control measures must be used to control the release of VOCs and particulates.	Emission of VOCs from a stationary source or group of stationary sources that have the potential to emit 100 tons per year of VOCs or 10 tons per year of any hazardous pollutant. Emission of particulates from thermal desorbers are limited to a 25 lb/yr threshold.	Minnesota Statute Chapter 7007	Applicable for remedial alternatives that release VOCs in excess of the air emission standards.[4]
Thermal Desorption of Soil and Replacement in the Excavation (i.e., on-site treatment and clean closure)	Air emissions must achieve compliance with air quality standards.	Major stationary source as defined in 40 CFR Section 52.21(b)(1)(i)(a).	National Ambient Air Quality Standards (NAAQS)[1] 40 CFR 52 and 40 CFR 61 Clean Air Act Title V Requirements under 40 CFR 70	Relevant and appropriate for criteria pollutants related to the site. Attainment of NAAQS is required for "major sources." NIROP is a major source.
	Thermal desorption of chlorinated compounds may be restricted by the MPCA; therefore, the process will likely require emission tests to verify destruction efficiency. Potential application emission limits include 0.0004 lbs/yr 2,3,7,8-TCDD for stacks not subject to building downwash, and 0.0001 lbs/yr 2,3,7,8-TCDD for stacks subject to building downwash.	Source combusts chlorinated compounds.	MPCA screening emission rates	Applicable if thermal desorption results in emissions of air toxics for which the MPCA has established screening emission rates.
	Thermal desorption must comply with RCRA removal, storage, and treatment requirements.	Excavated soil is determined to be a RCRA hazardous waste.	40 CFR 264	Applicable if excavated soil is determined to be a RCRA hazardous waste.[3]
	Best management practices (i.e., sediment and erosion controls) for surface water control measures must be used during soil excavation.	Construction activities disturb greater than 5 acres of total land area.	40 CFR 122	Applicable if the total area of soil excavation is greater than 5 acres. Relevant and appropriate if less than 5 acres are disturbed.

TABLE 2-2

SUMMARY OF POTENTIAL ACTION-SPECIFIC ARARS

Remedial Alternative	Requirement	Prerequisite(s)	Citation	Comments
Incineration Conducted Either On- or Off-Site (continued)	Engineering control measures must be used to control the release of VOCs and particulates.	Emission of VOCs from a stationary source or group of stationary sources that have the potential to emit 100 tons per year of VOCs or 10 tons per year of any hazardous pollutant. Emission of particulates from incinerators are limited to a 25 lb/yr threshold.	Minnesota Statute Chapter 7007	Applicable for remedial alternatives that release VOCs in excess of the air emission standards.[4]
	Transportation of hazardous waste or treatment residuals off-site must meet the requirements of Minnesota Statutes, Sections 221.033, 221.034, and 221.035.	Waste/Treatment Residuals are hazardous as defined in Minnesota Statutes 116.06, Subdivision 13.	Minnesota Regulation Chapter 7045.0371	Applicable if hazardous waste or treatment residuals are transported off-site.[4]

NOTES:

1 All of the Clean Air Act ARARs that have been established by the Federal Government may be covered by matching state regulations. The State may have the authority to manage these programs through the approval of its implementation plans (40 CFR 52 Subpart G).

2 CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements, EPA 540/G-89/009.

3 The classification of the contaminated soil as a solid or hazardous waste is unknown at this time. If the soil is determined to be a RCRA characteristically hazardous waste, thermal desorption and incineration treats hazardous waste to BDAT levels; therefore, there are no land disposal restrictions for residuals.

4 Minnesota has state statutes for air emission standards and the removal, storage, treatment, and disposal of RCRA hazardous waste that parallel the federal regulations.

TABLE 2-3

SUMMARY OF POTENTIAL LOCATION-SPECIFIC ARAR

Site Setting	Requirement	Prerequisite(s)	Citation	Comments
Within 100-year flood plain	Facility to be designed, constructed, operated, and maintained to avoid washout during flooding.	Remediation activities that involve treatment, storage, or disposal of RCRA hazardous waste.	40 CFR 264.18(b)	Not Applicable. NIROP is not within the 100-year floodplain.[1]
Within flood plain	Avoid adverse effects, minimize potential impacts, and preserve natural beneficial value of flood plain.	Action that will affect a flood plain.	Protection of flood plains, 40 CFR 6, Appendix A	Not Applicable. NIROP is not within the 100-year floodplain..[1]
	Storage of potentially hazardous materials and actions that cause pollution of waters are prohibited. The action must also comply with local ordinances.	Action undertaken in flood plain as defined in MS 103F.111, Subd. 4 and 5.	Minnesota Statute 103F.101-.165 and 6120.5000-.6200.	Not Applicable. NIROP is not within the 100-year floodplain..[1]
Within area affecting national wild, scenic, or recreational river	Avoid taking or assisting in action that will have direct adverse effect on wild, scenic, or recreational river.	Action that will affect or may affect any of the rivers specified in Section 1276(a).	Scenic Rivers Act (16 USC 1271 et seq. Section 7(a); 40 CFR 6.302(e)	Not Applicable. According to 40 CFR 6.302(e), the Mississippi river along the NIROP is not a national wold, scenic or recreational river[1].

NOTES:

1 Appropriate agencies were contacted to determine if floodplain areas or national wild, scenic, or recreational river areas exist that could potentially be affected by remediation.

One of the unknowns at the NIROP site is the classification of the contaminated soil as a solid or hazardous waste. *In situ* treatment through SVE would not trigger any of the potential RCRA removal, treatment, storage, transportation, or disposal requirements.

Ex situ treatment of the soil through thermal desorption or incineration must comply with RCRA removal, storage, and treatment requirements if the excavated soil is determined to be characteristically hazardous. In addition, off-site transportation of the untreated hazardous soil must also comply with appropriate RCRA requirements. Once the soil is treated, RCRA land disposal restrictions for the residuals (e.g., ash) would not apply because thermal desorption and incineration are considered best demonstrated available technologies (BDATs) (USEPA, 1989).

Best management practices for the control of surface water would also be applicable for the excavation of the soil that would be required for the thermal desorption and incineration alternatives.

Location-Specific ARARs

As presented in Table 2-3, the potential location-specific ARARs identified include the protection of flood plains and national wild, scenic, or recreational rivers. The following conditions must be met for these location-specific ARARs to be applicable:

1. Flood plain or national wild, scenic, or recreational river environments exist at or near the site.
2. The remedial action could adversely affect these environments.

Appropriate agencies have been contacted to determine if flood plain areas or national wild, scenic, or recreational river environments exist at or near the site.

Remedial actions that involve the treatment, storage, or disposal of RCRA hazardous waste (e.g., excavated soil determined to be hazardous) and that are conducted within the 100-year flood plain must also be designed and maintained to avoid washout during flooding. Wetlands, endangered species, and national historical features were determined not to be present at the site during the RI; therefore, they are not listed in Table 2-3.

2.3 TO BE CONSIDERED STANDARDS

Table 2-4 presents the "To Be Considered" standards (TBCS) for OU2. TBC standards consist of target cleanup levels for VOCs and cPAHs developed using Minnesota's soil leaching model. The

TABLE 2-4

TO BE CONSIDERED SOIL CLEANUP CRITERIA

Requirement	Prerequisite(s)	Citation	Comments
Soil cleanup goals for VOCs and PAHs could consider levels developed using Minnesota's leaching model which are to set soil cleanup levels protective of groundwater.	Completed migration pathways exist for soil contaminants.	Minnesota Pollution Control Agency Procedures for Establishing Soil Cleanup Levels, Version 1.	To be considered in establishing soil cleanup levels.[1]

NOTES:

[1] See Section 3.1 for resulting soil cleanup goals calculated using Minnesota's leaching model.

objective of this model is groundwater protection from contaminants present in unsaturated soil above the water table. These TBC standards apply at the NIROP Fridley since there are no federal or state promulgated soil standards. TBC standards need to be developed on a site-specific basis using information collected during the RI. Site-specific cleanup goals for VOCs and cPAHs were developed during this FS using the Minnesota Pollution Control Agency's Soil Leaching Model and information presented in the Baseline Risk Assessment (RMT, 1993) for the OU2.

Section 3

REMEDIAL ACTION OBJECTIVES AND TARGET CLEANUP GOALS

Based on the nature and extent of soil contamination at the NIROP Fridley, the remedial action objectives for the Soil OU2 have been established. As stated in Subsection 9.2 of the RI Report of the Soils OU2 (RMT, 1993), these remedial action objectives are as follows:

- To minimize/control risks and hazards associated with the migration of volatilized gases through soil pores.
- To minimize/control risks and hazards associated with direct contact, ingestion, and inhalation of near-surface soil.

An additional objective for this Feasibility Study is as follows:

- To minimize/control risks and hazards associated with the migration of volatile compounds to the groundwater via leaching from the soils of OU2;

The focus of the remedial activities will be to: 1) control the potential migration of hazardous concentrations of VOCs from the unsaturated soil and residuals from past drum burial into the groundwater; and 2) to reduce soil pore gas concentrations of VOCs and cPAH concentrations in soil to levels that would not pose an unacceptable health risk in future land use scenarios. These two objectives require the remedy to be focused upon the reduction of VOC and cPAH concentrations in OU2 soils.

Target cleanup goals that will protect groundwater from eight VOCs identified in the unsaturated soils at the NIROP Fridley have been developed using the Minnesota Pollution Control Agency's (MPCA) Soil Leaching Model. Target cleanup levels based upon groundwater protection criteria (MPCA soil leaching model) have not been developed for cPAH compounds because cPAHs have not been detected in the groundwater system at this time and because of their high absorbability to soils. A second set of Target Cleanup Goals for minimizing the risk to humans from exposure to soil contaminants at the NIROP has been developed, by considering unacceptable human health risks under the future residential land use assumptions. These assumptions are described in the Baseline Risk Assessment (Section 6 of the Remedial Investigation Report [RMT, 1993]) but were modified in that soil ingestion exposure to noncarcinogens is based only on child exposure. The following is a discussion of the results of the MPCA Soil Leaching Model and the Risk Assessment Cleanup Goal calculations used to determine the target cleanup goals for OU2 soils.

3.1 GROUNDWATER PROTECTION–BASED TARGET CLEANUP GOALS

This section describes the Soil Leaching Model and how it will be used to calculate target cleanup goals for VOCs in OU2 soils at the NIROP.

3.1.1 Soil Leaching Model

In 1992, the Minnesota Pollution Control Agency (MPCA) developed a mathematical model for calculating soil cleanup levels to be protective of groundwater. The soil cleanup level determined by the model is a threshold concentration of a contaminant in the soil that would not leach sufficient amounts to impact groundwater above the Maximum Contaminant Level (MCL). During preparation of this Feasibility Study, RMT used the MPCA Soil Leaching Model as a guide to develop appropriate target cleanup goals for OU2 soils that were impacted by previous disposal activities at the NIROP. An updated model will be available for the OU-3 FS.

Previous assumptions which are expected to be included in the model are as follows:

- A finite amount of soil contamination exists at depth beneath the site, and the contamination may extend from the surface to the water table.
- The surface soil is exposed to weather conditions typical of the Minneapolis area.
- There is an uppermost aquifer beneath the site that is not protected by an impermeable barrier between the contaminated soil and the aquifer.
- Percolating rainfall moves through the contaminated soil, mobilizes some of the contamination, and may carry the contamination (leachate) to the aquifer.
- A portion of the contamination remains strongly adsorbed to the soil.
- The portion of the contaminants that is not permanently adsorbed is available for biodegradation, volatilization, leaching, or other physical and chemical processes.
- The rate of leaching of contaminants from the soil has reached a steady state.
- The soils represent the only source of contaminants to the groundwater at the site. (It should be noted that additional investigations are planned for the spring of 1996 to determine whether anomalies identified by recent (July 1995) geophysical surveys are drums, which could represent additional sources of contamination.)
- Soil samples collected during the Remedial Investigation (RMT, 1993) are representative of the concentration of contaminants in OU2 soils.

- Vapors emanating from the contaminants in the soil are moving primarily upwards to the ground surface and there is no perched saturated zone above the contaminated soils.

- There is no unknown leachate plume beneath the contaminated soil zone which has not yet reached the water table.

- Eight constituents of concern were identified by the MPCA as potential contaminant sources to the groundwater. These constituents include trichloroethene (TCE), tetrachloroethane (PCE), 1,2-dichloroethene (1,2-DCE), 1,1-dichloroethene (1,1-DCE), 1,1,1-trichloroethene (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), toluene, and ethylbenzene.

- Total soil organic carbon data collected during the Remedial Investigation (RMT, 1993) were used to calculate the adsorption constants (K_d) for each of the constituents identified by MPCA as a potential threat to groundwater. Organic carbon data were collected at 2-foot intervals from land surface to the water table (approximately 20 feet). Soil organic carbon averaged 0.3 percent in the soil interval where the majority of contamination was found; therefore, this value was used to calculate adsorption constants. Table 3-1 presents the adsorption constants for each of the constituents of concern at the NIROP.

- Biodegradation half-life values for each of the constituents of concern were selected from published data sources. A search of the literature indicated that limited data are available regarding the biodegradation of the constituents of concern in soil, and published half-life values for biodegradation vary significantly. In order to choose a reasonable value for MPCA's Soil Leaching Model, several sources of data were evaluated. Table 3-2 shows the half-life values found in two sources, Howard et al. (1990) and Dragun (1988), as well as the half-life values used by RMT. The MPCA has stated their opinion that all biodegradation rate estimates should be based on data from soil incubation tests rather than from static culture flask tests; therefore, only the soil incubatory test data from references available in James Dragun, 1988, "The Soil Chemistry of Hazardous Materials," were used in the soil leaching model. The biodegradation rate values used in the model are the means of the published rates in Dragun et al. (1988), using data only from soil incubation studies.

- To estimate the travel time of contaminants through the subsurface, the groundwater recharge rate was estimated, based on climatological data for the Minneapolis, Minnesota, area. According to the data, the soil recharge rate from rainfall is 6 inches (15.24 cm) per year. A soil moisture content of 20 percent for the sandy soils at NIROP was also assumed for estimation of travel time.

3.2 RISK-BASED SOIL TARGET CLEANUP LEVELS

In 1993, RMT performed a Baseline Risk Assessment (Baseline RA) to characterize the nature and estimate the magnitude of potential adverse public health effects caused by constituents identified in the soils operable unit at the NIROP Fridley. Assumptions and exposure variables used in the risk assessment are described in Section 6 of the Remedial Investigation (RI) Report (RMT, 1993). The risk assessment considers health effects which may result under current site conditions and

TABLE 3-1

ADSORPTION CONSTANTS FOR EACH OF THE CONTAMINANTS OF CONCERN AT NIROP

Compound	Log K_{oc}	Average Log K_{oc}	K_d
TCE	1.81 (2) 2.1 (2) 2.03 (2) 2.1 (3)	2.02	0.315
PCE	2.42 (2) 2.56 (2) 2.32 (2) 2.56 (4) 2.56 (3)	2.49	0.936
1,2-DCE	1.77 (2) 2.18 (2) 1.77 (3)	1.98	0.270
1,1-DCE	1.81 (2) 1.81 (3)	1.81	0.195
1,1,1-TCA	2.23 (4) 2.18 (2) 2.02 (2) 2.18 (3)	2.16	0.438
1,1-DCA	1.15 (2) 1.28 (2) 1.48 (3)	1.32	0.063
Xylene	2.38 (3)	2.38	0.72
Ethylbenzene	1.98 (2) 2.41 (2) 3.04 (3)	2.25	1.45

REFERENCES:

A J.H. Montgomery and L.M. Wolkan. Groundwater Chemicals Desk Reference. Lewis Publishers, Inc., Chelsa, MI. 1990.

B Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response. Washington, D.C., EPA 540/1-86-060.

C J. Dragun. The Soil Chemistry of Hazardous Materials. The Hazardous Materials Control Research Institute, Silver Spring, MD. 1988.

TABLE 3-2

PUBLISHED BIODEGRADATION HALF-LIFE VALUES AND HALF LIFE VALUES USED BY RMT TO CALCULATE SOIL CLEANUP GOALS

Constituent	Howard et al. (1991)[a]	Dragun (1988)[b] (Soil Incubation Studies)	RMT Values Used in Model[c]
TCE	180-365	136, 209, 402	226
PCE	180-365	267, 536	402
1,2-DCE	28-180	56, 154	105
1,1-DCE	180-280	154	154
1,1,1-TCA	140-273	149, 439	294
1,1-DCA	32-154	184, 402	293
Xylenes	7-28	21, 33, <420	158
Ethylbenzene	3-10	< 420	420

NOTES:

a Howard, 1991. Handbook of Environmental Degradation Rates
b Dragun, 1988. The Soil Chemistry of Hazardous Materials
c Average half-life value from soil incubation studies by Dragun.

also considers potential future adverse health effects by evaluating assumptions of unrestricted future land use which may increase exposure to chemicals. The future land use scenario assumed residential exposure. For the purpose of the Baseline RA, it was assumed that no further remedial actions would be implemented with regard to the soils operable unit under both current and future land use scenarios. In addition, because disposal practices have ceased at the NIROP, it was assumed that, with no remedial action, the site was at a steady-state, worst-case condition.

RMT's 1993 Baseline RA was performed in general accordance with USEPA guidelines in the Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (HHEM), Part A and Supplemental Guidance (USEPA, 1991c and d). The assumptions used in the Baseline RA and the resulting conclusions were approved by the USEPA and the MPCA in 1993. In general, the Baseline RA was performed by evaluating the data collected during the Remedial Investigation (RI) to identify constituents of potential concern in affected on-site soils that are likely to be related to site activities, rather than related to background conditions or sampling or laboratory procedures. Routes of migration and populations potentially exposed to the constituents of potential concern were then evaluated in the exposure assessment. In the toxicity assessment, the information from the exposure assessment was then integrated with toxicological information to estimate intake for a given population. From this information, an estimate of a health hazard quotient (due to noncarcinogens) or risk (due to carcinogens) was calculated.

Based on the baseline risk assessment in the RI and on MPCA's comments (January 1995), the constituents of concern that require target cleanup goals for the site are as follows:

Volatile organics:	ethylbenzene tetrachloroethene (PCE) trichloroethene (TCE) toluene
Semivolatile organics:	carcinogenic polycyclic aromatic hydrocarbons (cPAHs)

Preliminary Remediation Goals (PRGs) have been calculated to derive risk-based target cleanup goals for these constituents of concern in the NIROP Fridley Soils OU. The PRGs were calculated based on a target risk of 10^{-5} and a target hazard quotient of 1.0. The PRGs were adjusted, where necessary, to account for the additive risk from multiple constituents to arrive at target cleanup goals. PRGs and target cleanup goals were developed for two separate media, soil pore gas and soil. The route of exposure used to calculate the PRGs for soil pore gas was inhalation; the route of exposure for soil was ingestion. This approach is consistent with USEPA current soil screening guidelines (USEPA, 1994) which present an approach to developing chemical concentrations in soil

that are not of concern for ingestion, inhalation, and migration to groundwater. The migration to groundwater has been dealt with in the leaching model presented in the previous subsection of this report.

3.2.1 Soil Pore Gas Cleanup Goals

Preliminary Remediation Goals

Risk-Based Concentrations (RBCs) for indoor air were used to derive Preliminary Remediation Goals (PRGs) for soil pore gas. RBCs and PRGs are presented for the constituents of concern in Table 3-3 along with the exposure assumptions used to derive the RBCs. Standard default exposure factors were used in the calculations presented in Table 3-3. The PRGs for soil pore gas were calculated as follows:

- An age-adjusted inhalation factor was used for calculating RBCs for carcinogens, by analogy to the model that the USEPA recommends for ingestion of carcinogens in soil (USEPA, 1991d).
- For noncarcinogens, adult indoor exposure to contaminants in air was assumed, which is consistent with the future land use exposure scenario of the NIROP Baseline Risk Assessment.
- The RBCs were converted to PRGs by dividing by 0.0016. This number is the ratio of the indoor concentration to the soil pore gas concentration, estimated based on studies conducted with the conservative gas, radon (Little, et al., 1992). This value is an update of the value used for this ratio in the NIROP Baseline Risk Assessment (0.01), and is considered more appropriate, based on the previously referenced study.
- The PRGs are presented in units of mg/m^3 and ppm v/v. The conversion to ppm was made using the compound's molecular weight and the assumptions of standard temperature and pressure.

The PRGs presented in Table 3-3 were not adjusted for the effects of multiple contaminants and potential additivity of risk.

Adjusting Preliminary Remediation Goals for Additivity

Where multiple contaminants occur at the same location and affect the same target endpoint (e.g., carcinogenicity), the PRGs must be adjusted downward (MPCA, 1995). In order to evaluate the effect of additivity on risk and hazard from soil pore gas at the NIROP Soils Operable Unit, the database from the Remedial Investigation (RI) was screened to flag those locations that had exceedances of the individual PRGs in Table 3-3. Additionally, the database was screened a second time to flag those locations with concentrations in excess of the PRGs divided by 10, to evaluate

TABLE 3-3

NIROP SOILS OPERABLE UNIT
PRELIMINARY REMEDIATION GOALS FOR CONSTITUENTS OF CONCERN
SOIL PORE GAS

Constituent of Concern	TR	THQ	AT_c (days)	AT_n (days)	EF_r (days)	BW_a (kg)	IF_{adj} (m^3y/kg-d)	IR_a (m^3/d)	ED (yr)	RfDi (mg/kg-d)	CPSi (mg/kg-d)$^{-1}$	RBC (mg/m^3)	PRG (mg/m^3)	PRG ppm v/v
Ethylbenzene	--	1.0	--	10950	350	70	--	15	30	0.3	--	1.46	912	210
Tetrachloroethene	10^{-5}	1.0	25550	10950	350	70	11.66	15	30	--	2.0×10^{-3}	0.0315	19.7	2.9
Trichloroethene	10^{-5}	1.0	25550	10950	350	70	11.66	15	30	--	6.0×10^{-3}	0.0105	6.56	1.2
Toluene	--	1.0	--	10950	350	70	--	15	30	0.1		0.487	304	81

Preliminary Remediation Goals (PRGs) - inhalation

$$PRG = \frac{RBC}{\alpha}$$ where α = Concentration indoor/concentration source
$\alpha = 0.0016$

Carcinogens: RBC: $$\frac{(TR \times AT_c)}{(EF_r \times IF_{adj} \times CPSi)}$$

Noncarcinogens: RBC: $$\frac{(THQ \times RFDi \times BW_a \times AT_n)}{(EF_r \times ED_{tot} \times IR_a)}$$

NOTES:

TR	Target Risk = 10^{-5}
THQ	Target Hazard Quotient = 1.0
AT_c	Averaging Time (carcinogens) = 70 yrs x 365 days/yr = 25550 days
AT_n	Averaging Time (noncarcinogens) = ED x 365 days/yr
EF_r	Exposure Frequency (residential) = 350 days
BW_a	Body Weight (adult) = 70 kg
IF_{adj}	Inhalation Factor (adjusted for child plus adult) = 11.66 m^3 x yr/kg x day
IR_a	Inhalation Rate (adult) = 15 m^3/day
ED	Exposure Duration = 30 yr
RfDi	Reference Dose (inhalation)
CPS	Cancer Potency/Slope (inhalation)

the potential impacts of additivity at individual locations. Appendix B presents the results of that screening. Appendix C presents the sample-specific risk calculations for soil pore gas. Because additivity must be addressed separately for noncarcinogenic and carcinogenic effects, the results of the screening are presented separately. These results are summarized as follows:

Noncarcinogenic Effects

- Samples did not exceed the PRGs for ethylbenzene or toluene, the constituents of concern in soil pore gas with potential noncarcinogenic effects.
- At one location (AB031), in two samples (samples C and E), ethylbenzene concentrations exceeded the PRG/10 (at 37 ppm and 36 ppm, respectively).
- In only one sample (AB031E), ethylbenzene and toluene exceeded the PRG/10. The ethylbenzene concentration in AB031E was reported at 36 ppm (the PRG is 210 ppm); the toluene concentration was reported at 27 ppm (the PRG is 81 ppm).

These results indicate that the PRGs for ethylbenzene and toluene in soil pore gas can act as target cleanup goals without being adjusted downward for additive effects.

Carcinogenic Effects

- TCE and PCE are the identified constituents of concern in soil pore gas with potential carcinogenic effects.
- The PRGs for TCE and PCE were exceeded at numerous locations in Areas A, D, and E. However, TCE exceedances of the PRG were more common than PCE exceedances.
- No concentrations were reported above the PRGs in area B and F. These areas both had reported concentrations over the PRG/10 of TCE only. Therefore, additivity of risk is not a concern in Areas B and F.
- The PRGs for TCE and PCE were selected to ensure that the cumulative risk remained below 10^{-5}.

There is no unique solution that will result in a cumulative risk of 10^{-5} for TCE plus PCE. For example, concentrations of TCE and PCE of 1.0 and 0.5 ppm, respectively, yield the same risk as concentrations of 0.5 and 1.7 ppm TCE and PCE, respectively. Based on a review of the relative volatility and existing concentrations of TCE and PCE in OU2, and for practical application of the

standard for assessing cleanup effectiveness, a single cleanup goal for TCE and PCE is presented here. The Target Cleanup Levels for the carcinogenic VOCs are as follows:

Constituent	TCL		Risk
Trichloroethene	5.4 mg/m^3	1.0 ppm	8.2×10^{-6}
Tetrachloroethene	3.4 mg/m^3	0.5 ppm	1.8×10^{-6}
		Cumulative risk:	1×10^{-5}

3.2.2 Cleanup Goals Based on Direct Human Contact With Soil

Preliminary Remediation Goals (PRGs)

Of the exposure routes based on direct human contact (that is, compositional concentrations), the ingestion route of exposure was calculated in the Baseline Risk Assessment to pose the highest risk compared to inhalation and dermal adsorption. For this reason, the ingestion route is the most sensitive, and the PRGs based on the ingestion route are the lowest concentrations, and are the most protective.

PRGs for the constituents of concern are presented in Table 3-4 along with the exposure variables that were used to calculate the PRGs. Standard, default exposure factors were used in these calculations. The PRGs were calculated based on the ingestion route of exposure as follows:

- PRGs for ingestion of soil containing carcinogens were based on an adjusted, cumulative child/adult exposure factor (USEPA, 1991d).
- PRGs for ingestion of soil containing noncarcinogens were based on childhood exposure only.
- PRGs for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) were based on the relative potency factor scheme (USEPA, 1993) in reference to benzo(a)pyrene, using the MPCA's list of cPAHs.

The PRGs presented in Table 3-4 were not adjusted for the effects of multiple contaminants and the potential additivity of risk. Effects of additive risk will be completely assessed in the OU3 Feasibility Study. The following data will be incorporated into that assessment.

Adjusting PRGs for Additivity

The concentrations of the constituents of concern in soil that are volatile organic compounds (VOCs) are summarized in Appendix C. In order to evaluate the effects of additivity on cumulative risk from VOCs in soil, the data presented in Appendix D were evaluated to identify those locations

TABLE 3-4

NIROP SOILS OPERABLE UNIT
PRELIMINARY REMEDIATION GOALS FOR CONSTITUENTS OF CONCERN
SOIL DIRECT CONTACT

Constituent of Concern	TR	THQ	AT (days)	EF (days)	BW_c (kg)	ED_c (yr)	IF_{adj} (mg-y/kg-d)	IR_c (mg/d)	RfD_o (mg/kg-d)	CPS_o (mg/kg-d)	PRG_n (mg/kg)	PRG_c (mg/kg)
Volatiles												
Ethylbenzene	--	1.0	2190	350	15	6	--	200	0.1	--	7800	--
Tetrachloroethene	10^{-5}	1.0	25550	350	15	6	114	200	0.01	5.2×10^{-2}	780	123
Trichloroethene	10^{-5}	1.0	25550	350	15	6	114	200	0.006	1.1×10^{-2}	469	582
Toluene	--	1.0	2190	350	15	6	--	200	0.2	--	16000	--
Semivolatiles (cPAHs)												
Benzo(a)anthracene	10^{-5}	--	25550	350	--	--	114	--	--	0.73	--	9.0
Benzo(a)pyrene	10^{-5}	--	25550	350	--	--	114	--	--	7.3	--	0.9
Benzo(b)fluoranthene	10^{-5}	--	25550	350	--	--	114	--	--	0.73	--	9.0
Benzo(k)fluoranthene	10^{-5}	--	25550	350	--	--	114	--	--	0.073	--	90
Chrysene	10^{-5}	--	25550	350	--	--	114	--	--	0.0073	--	880
Dibenz(a,h)anthracene	10^{-5}	--	25550	350	--	--	114	--	--	7.3	--	0.9
Indeno(1,2,3-cd)pyrene	10^{-5}	--	25550	350	--	--	114	--	--	0.73	--	9.0
Benzo(j)fluoranthene[a]	10^{-5}	--	25550	350	--	--	114	--	--	0.73	--	9.0

TABLE 3-4

NIROP SOILS OPERABLE UNIT
PRELIMINARY REMEDIATION GOALS FOR CONSTITUENTS OF CONCERN
SOIL DIRECT CONTACT

Preliminary Remediation Goals (PRGs) - ingestion

c: Carcinogens: RBC: $$\frac{(TR \times AT_c)}{(EF_r \times \frac{IF_{adj}}{10^6\ mg/kg} \times CPS_o)}$$

n: noncarcinogens: RBC: $$\frac{(THQ \times RFD_o \times BW_c \times AT_n)}{(EF_r \times ED_c \times \frac{IR_c}{10^6\ mg/kg})}$$

NOTES:

TR	Target Risk = 10^{-5}
THQ	Target Hazard Quotient = 1.0
AT	Averaging Time
	carcinogens: AT = 70 yrs x 365 days/yr = 25550 days
	noncarcinogens: AT = ED x 365 days/yr
EF	Exposure Frequency (residential exposure = 350 days/yr)
BW_c	Body Weight of a child = 15 kg
ED_c	Exposure Duration for a child = 6 years
IF_{adj}	Ingestion Factor adjusted for child plus adult exposure = 114 mg x yr/kg x day
IR_c	Ingestion Rate for a child: 200 mg/day
RfD_o	Reference Dose (oral)
CPS_o	Cancer potency/Slope (oral)
PRG_n	Preliminary Remediation Goal - noncarcinogenic effects
PRG_c	Preliminary Remediation Goal - carcinogenic effects

(a) This compound is included for completeness because it is identified by the MPCA as a carcinogenic PAH. However, it was not on the list of analytes for the NIROP Soils Operable Unit.

with concentrations that exceeded the PRGs, and were evaluated a second time to flag those locations with concentrations that exceeded the PRGs divided by 10. Additionally, the RI database was evaluated for soil concentrations over the published (USEPA, 1994) soil saturation concentrations for ethylbenzene (260 mg/kg) and toluene (520 mg/kg). At the soil saturation concentration, soil pore gas, pore water, and sorption sites are saturated. That is, nonaqueous phase liquids may be present. Because risk-based concentrations can sometimes be higher than the soil saturation concentration but the presence of nonaqueous phase liquids is not acceptable from the perspective of site cleanup, the RI database was compared to the soil saturation levels as well as the RBCs. The results of the evaluation are as follows:

Noncarcinogenic Effects

- The VOCs identified as constituents of concern have potential noncarcinogenic effects from soil ingestion.
- The PRGs for ethylbenzene and toluene were not exceeded at any of the sampling locations.
- The soil saturation concentrations for ethylbenzene and toluene, which are lower than the PRGs, were not exceeded at the site.
- Samples AT004B, AB043D, and AT009D1 had reported concentrations equivalent to or over the PRG/10 for noncarcinogenic effects of TCE. AT009D1 also contained PCE over the noncarcinogen PRG.

Carcinogenic Effects

Volatile Organic Compounds (VOCs)

- Along with the cPAHs (see below), PCE and TCE have potential carcinogenic effects.
- Only one sample (AT009D1) contained a concentration of a volatile organic chemical that exceeded a PRG. The PCE concentration at this location was reported to be 1,200 mg/kg.
- Two additional locations had concentrations reported over the PRG/10. AB043D had reported concentrations of PCE (17 mg/kg) and TCE (69 mg/kg) over the PRG/10.
- AT009B1 DUP had a PCE reported concentration (25 mg/kg) over the PRG/10. The original sample from this location did not exceed this screening level; AT009D1 had a reported concentration of PCE over the PRG (see above) and TCE (210 mg/kg) over the PRG/10; AT009D2 had a reported concentration of PCE (28 mg/kg) over the PRG/10.

The pattern of occurrence of the VOCs in soil at the NIROP (only one location with reported VOC concentrations over the PRG, and only one additional location with TCE and PCE reported over the PRG/10) indicates that the PRGs for the carcinogenic VOCs in soil can adequately serve as target cleanup goals without being adjusted downward.

Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)

Sample locations with detectable cPAHs are presented in Appendix E, along with their cPAH concentrations and associated risk estimates. The RI database was screened to flag those locations that had exceedances of the PRGs (Table 3-4). These locations are as follows:

- Ten sample locations in Area A. Only one of these samples (AB034D) was not taken from the shallowest (A) interval. Interval A samples may have been affected by undetected asphalt contamination while sampling. All of these samples (including the one from the deeper interval) were described in the soil boring log as being taken from fill, which may have been impacted by cPAHs, from asphalt, or from fallout from fossil fuel burning (such as coal-fired power plants, diesel exhaust, etc.), prior to its placement at the NIROP (Bradley et al., 1994).

- Seven additional samples in Area A had concentrations of cPAHs in excess of the PRG/10. Only one of these samples (AT003A) had a cumulative risk in excess of the target risk of 10^{-5}, but this result indicates that the PRGs for cPAHs should be adjusted for additivity of risk.

- None of the four samples in Area B with cPAHs had reported concentrations that exceeded the PRGs. Three of the four contained a cPAH (benzo[a]pyrene) at concentrations greater than the PRG/10.

- One sample location in Area D (DB029A) was reported to have cPAH concentrations over the PRG. This sample is also reported to contain cinders, a cPAH source related to the composition of the fill, rather than site activities.

- Area E had two samples (EB001A and EB004A) that had cPAH concentrations over the PRGs. As in Area A, these samples are from the first interval (A) and are described in the soil boring log as fill. Two additional samples from Area E contained concentrations of benzo(a)pyrene above the PRG/10, EB002A and EB004D. Only one sample, EB004D, was not described as being in fill.

- Sample FB001A (Area F) contained benzo(a)pyrene concentrations above the PRG/10. None of the remaining eight samples from Area F contained cPAHs.

- cPAHs were not detected in the site-specific background samples for the NIROP. These background samples, which were selected to acquire background data for VOCs and metals (the target compounds at the NIROP), were specifically not taken from fill and, to be consistent with the site samples, were collected from the "A" interval (1 to 2 feet below ground surface). In natural soil deposits (as opposed to fill), this depth would not likely be affected by the common sources of cPAHs in the urban environment, and therefore may not adequately define background for the surface soils for the NIROP area.

- A plot of total cPAH concentrations versus estimated total cPAH risk for the NIROP data is presented on Figure 3-1. This plot indicates that the relationship between the cPAH risk and cPAH concentrations is linear in the target risk range, even though individual cPAH concentrations and relative potencies change between the samples. This plot indicates that the target risk of 10^{-5} corresponds to a log total cPAH concentration of 3.6 (in units of μg/kg), which converts to a total cPAH concentration of 4,000 μg/kg. Therefore, 4 mg/kg is proposed as the target cleanup goal for total cPAHs, adjusted for additivity.

- The sample locations with total cPAH concentrations over 4 mg/kg are marked in the summary table in Appendix E. They include the following: 12 locations in Area A, one location in Area D, and two locations in Area B.

3.2.3 Summary of Risk-Based Target Cleanup Goals

A summary of all of the derived risk-based cleanup goals is presented in Table 3-5. The most conservative (lowest) cleanup goals for the NIROP Soils OU2 constituents of concern are in bold type on the table. The VOCs have risk-based target cleanup goals for two media: soil and soil pore gas. The final risk-based target cleanup goals for VOCs in soil were chosen from the lowest PRGs (carcinogenic versus noncarcinogenic) listed in Table 3-4 and adjusted for additivity.

Specific locations where the risk-based cleanup goals are exceeded have been discussed in the development of the adjustments for additivity and are listed in the Attachments. General conclusions include the following:

- The soil pore gas target cleanup goals were exceeded for TCE and PCE, but not for ethylbenzene or toluene. To address this issue, widespread remediation of TCE and PCE is needed in the pore gas in areas A, D, and E. Areas B and F do not require remediation of soil pore gas.

- For the soil (as opposed to soil pore gas), ethylbenzene and toluene concentrations did not exceed the target cleanup goals or the saturation concentrations. Therefore, these constituents of concern do not require remediation in the soil.

- For PCE, the risk-based target cleanup goal for soil was exceeded in only one location, where the TCE target cleanup goal was not exceeded. Additionally, the location of the PCE exceedance (sample AT009D1) is in Area A, which will require remediation for soil pore gas.

- For soil, the risk-based target cleanup goal for TCE was not exceeded at any sampling location.

- The target cleanup goal for total cPAHs was exceeded in Areas A and E. The single sample in Area D that exceeded the target cleanup goal reportedly contained cinders and is clearly not related to drum pit and trench activities.

Figure 3-1

TOTAL cPAH CONCENTRATION VERSUS cPAH RISK

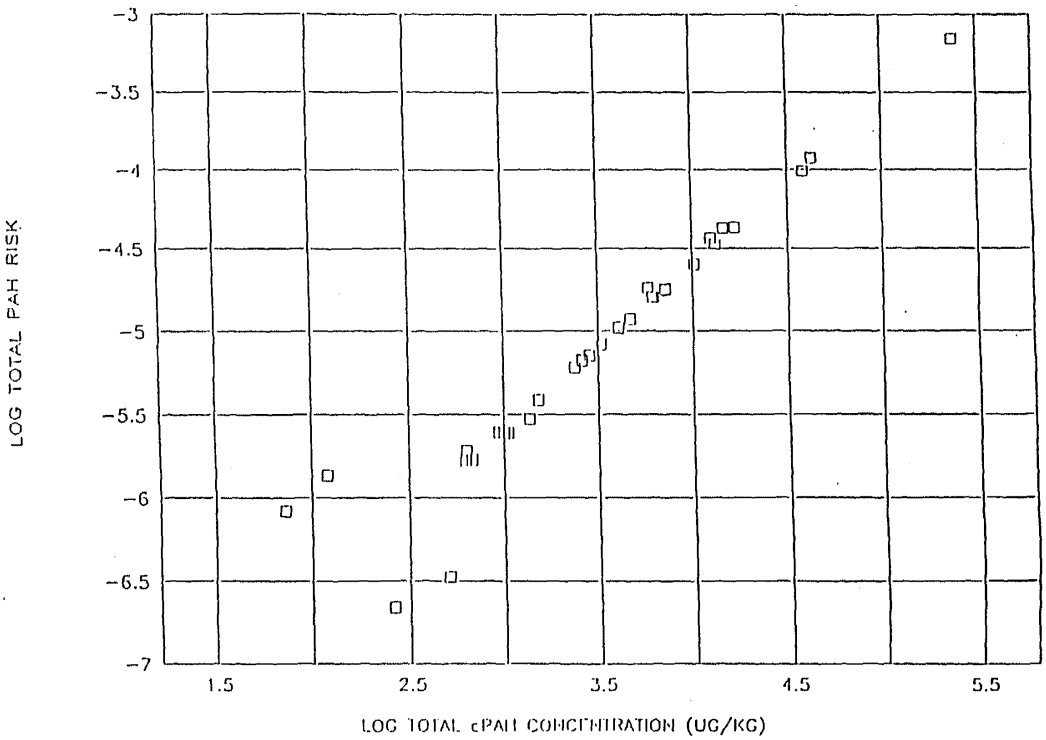


TABLE 3-5

NIROP SOILS OPERABLE UNIT
RISK BASED TARGET CLEANUP LEVELS

Constituent of Concern	Direct Contact (mg/kg)	Soil Pore Gas	
		mg/m^3	ppm
Ethylbenzene	**7,800**	910	**210**
Tetrachloroethene (PCE)	**120**	3.4	**0.5**
Trichloroethene (TCE)	**470**	5.4	**1.0**
Toluene	**16,000**	300	**81**
cPAHs	**4**	NA	NA

NOTES:

NA Not applicable

- The target cleanup goal for cPAHs (4 mg/kg) is lower than is typical for the urban environment. Bradley, et al. (1994), reported an upper 95 percent confidence interval on the mean for total cPAH at 12 mg/kg for 60 soil samples from urban locations in New England.

3.3 OVERALL TARGET CLEANUP GOALS FOR OU2

A summary of the target cleanup goals for OU2 is presented in Table 3-6. Target cleanup goals have been developed for two different media: soils (for VOCs and cPAHs) and pore gas (for VOCs). Target cleanup goals for VOCs and cPAHs adsorbed to soils are the most conservative values (the lowest) obtained from either the soil leaching model or the risk-based calculations. Target cleanup goals for soil pore gas are based on risk. These target cleanup goals will be considered in the derivation of OU3 cleanup goals. However, OU3 cleanup goals may vary from OU2 cleanup goals.

The risk-based soil target cleanup goals for OU2 are conservative, in that they have been developed assuming future residential land use. Urban background soil samples that were used for comparison to the on-site soil samples were collected from a nearby park and at a depth of 1 to 2 feet below the land surface. Typically, cPAH compounds found in urban settings are a result of fall-out from fossil fuel combustion and are therefore found in the first few inches of topsoil. Therefore, the risk-based target cleanup goals developed for cPAH compounds in this Feasibility Study may be conservative.

3.4 EXTENT OF EXCEEDANCES OF TARGET CLEANUP GOALS

Comparing the soil data collected during the Remedial Investigation (RMT, 1993) to the final target cleanup goals for soil and soil pore gas, listed in Table 3-6, shows areas of OU2 that exceed one or more of the target cleanup goals. Figure 3-2 is a site map showing OU2 soils that exceed the target cleanup goals. Nearly all of Area A, as well as Areas D and E, exceed the target cleanup goals for pore gas. In some locations, exceedances of the target cleanup goals in the pore gas extend to the water table (at a depth of approximately 27 feet) (RMT, 1993). For the soil, only one soil sample location in Area A had a reported concentration in excess of the target cleanup goals for VOCs (PCE specifically). For cPAH compounds in soil, scattered samples in Area A, and two isolated samples in Area E, exceeded the target cleanup goals.

TABLE 3-6

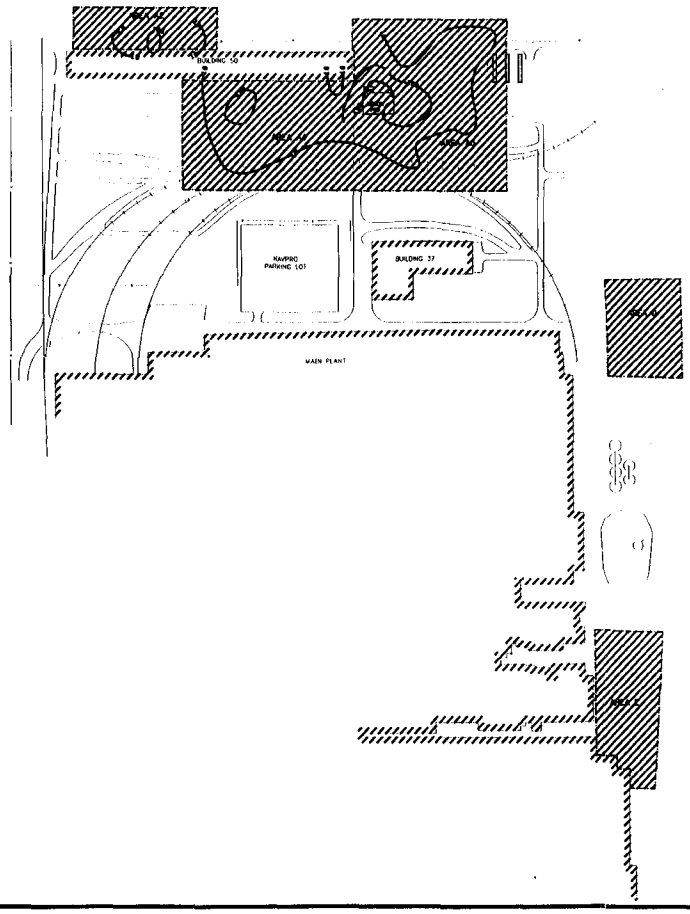
CLEANUP GOALS FOR OU2 SOILS AT NIROP

Constituent of Concern	(Soil Leaching Model) (mg/kg)[a]	Risk Based Target Cleanup Goal		Overall[b] Target Cleanup Goal	
		Direct Contact(mg/kg)	Pore Gas (ppm (v/v))	Soil (mg/kg)	Pore Gas (ppm (v/v))
Ethylbenzene	TBD	7,800	210	7,800	210
Tetrachloroethylene	TBD	120	0.5	120	0.5
Trichloroethylene	TBD	470	1.0	470	1.0
Toluene	TBD	1,600	81	1,600	81
cPAHs	TBD	4	NA	4	NA
1,1-Dichloroethane	TBD	NA	NA	TBD	NA
1,1-Dichloroethene	TBD	NA	NA	TBD	NA

NOTES:

[a] A single soil leaching model will be applied for all on-site sources. Details will be provided in the OU3 Feasibility Study.

[b] Overall cleanup goals were derived from the lowest value obtained from the MPCA Leaching Model Results and the Risk-Based Target Cleanup Goals.



LEGEND

- BUILDING
- PAVED ROAD
- RAILROAD
- FENCELINE
- AREA REQUIRING CLEAN-UP
- TOTAL VOC CONTOUR — PER 3 MO (DASHED WHERE INFERRED)

NOTES

1. BASE MAP SOURCED U.S. ARMY CORPS OF ENGINEERS, DRAWING CODE 37 DOD-00-91, PREPARED BY DYNAMIC INFORMATION, INC., ROCKVILLE, MD. SCALE 1"=50'.

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0 100 200

SCALE 1"=100'

NO	BY	DATE	REVISION	APPD
3				
2				
1				

PROJECT: NIROP FEASIBILITY STUDY

SHEET TITLE: AREA OF SOIL REQUIRING CLEAN-UP BASED ON MPCA LEACHING MODEL RESULTS AND THE HEALTH RISK ASSESSMENT

DRAWN BY: MSB
CHECKED BY:
APPROVED BY:
DATE: APRIL 1995
SCALE: 1"=100'
PROJ. NO. 3996J3
FILE NO. 3996F130
FIGURE 3-2

FOWT

Section 4
REMEDIAL ALTERNATIVES FOR OU2 SOILS

The potentially feasible remedial alternatives identified for OU2 are the no action alternative, institutional controls, and three presumptive remedies: soil vapor extraction, thermal desorption, and incineration. This section presents a description of each alternative, describes the potential impact of site-specific geologic conditions on its application, and discusses residuals handling, design data, and operation and maintenance requirements. Time factors associated with implementation are also presented.

The remedial alternative description has been expanded to include a discussion of the potential applicability to both VOCs and cPAHs. The presumptive remedy directive for "CERCLA Sites With VOCs in Soils" (USEPA, 1993a and b), which states that presumptive remedies should be considered if they can also be effective in removing the non-VOC contaminants. The potential effectiveness of cPAH treatment using presumptive remedy technologies will be further addressed in the OU3 Feasibility Study in addition to the preliminary assessment discussed from a process perspective in this section, and against evaluation criteria in Section 5.

4.1 NO ACTION ALTERNATIVE (ALTERNATIVE 1)

The no-action alternative is required by the National Contingency Plan (NCP) and will be used as a baseline against which the other alternatives will be evaluated. This alternative involves no additional actions regarding the unsaturated soil in OU2. This alternative involves continuing current property use with no special restrictions on future land use.

4.2 INSTITUTIONAL CONTROLS ALTERNATIVE (ALTERNATIVE 2)

The institutional controls alternative involves applying land use restrictions at the NIROP Fridley to prevent residential use of the site, which is projected to exceed acceptable risk values. The land use restrictions include both deed restrictions, which require a future industrial property use, and building type restrictions, which would limit excavation for building construction in highly impacted site locations.

This alternative is also not impacted by geologic conditions, and has no residuals handling, design data needs, or operation and maintenance requirements. The legal restrictions may take up to 1 year to implement, and their permanence would depend on the power and consistency of local

government agencies, as well as on the willingness of the Navy to agree to long-term deed restrictions.

4.3 SOIL VAPOR EXTRACTION (ALTERNATIVE 3)

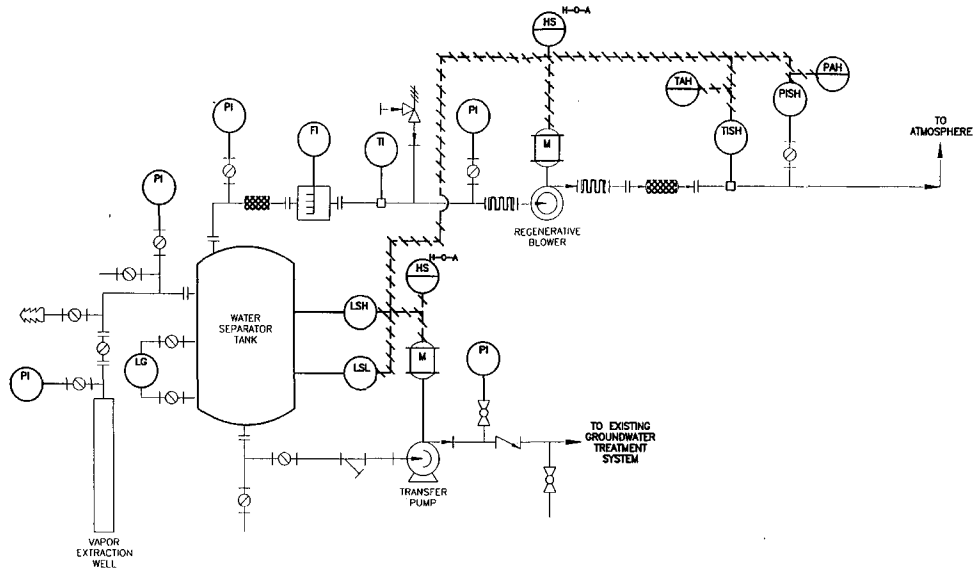
4.3.1 Process Overview

The primary treatment mechanism for soil vapor extraction (SVE) is stripping or removing gaseous contaminants from soil pore spaces by causing air to flow through the subsurface environment. The volatilization effect of an SVE system would not treat cPAHs, however the increased air flow may enhance biological activity which could result in biological treatment of the cPAHs. The effectiveness of SVE on cPAHs would have to be determined by a pilot-scale test.

The process is usually applied *in situ* to a site by installing SVE wells in the unsaturated contaminated soil zone. A vacuum pump is attached to the wells to draw air from the contaminated soil zone to the surface for treatment or discharge. Ancillary equipment is normally installed to protect the pump from water and solid particles. The wells are situated within the affected soil zone and screened to draw the maximum amount of contaminants to the surface (USEPA, 1991e). Additional wells may be placed outside the affected soil zone to supply fresh air, actively or passively, to the affected zone. Figure 4-1 is a process and instrumentation diagram of a typical soil vapor extraction system. Both the system design details and operating variables (i.e., airflow rate, pulsing, etc.) can be modified to enhance either the stripping or bioremediation removal mechanisms or both.

The physical and chemical properties of the contaminants affect their movement from the soil micropores into pore water and subsequently into the vapor space surrounding the soil particles, and hence contact occurs with air transferred across the soil pores by SVE. The degree to which any contaminant partitions into the various phases is determined by the contaminant's volatility, its tendency to become adsorbed to soil particles, and its ability to dissolve in the pore water (USEPA, 1991e).

One important contaminant characteristic affecting the SVE removal efficiency for stripping volatile constituents is a constituent's volatility or tendency to transfer to the gaseous phase. Vapor pressure is the force exerted by the vapor of the chemical in equilibrium with its solid or liquid form. Henry's law governs the volatilization of a dilute solvent in an aqueous/adsorbed phase, rather than a pure product. The Henry's law constant is a more meaningful air/water partitioning constant for evaluating partitioning outside of the free product zone, where product is likely to exist in solution



LEGEND

	BALL VALVE		THERMOWELL	PI	PRESSURE INDICATOR	HS	HAND SWITCH	TISH	TEMPERATURE INDICATING SWITCH HIGH
	HOSE BARB		FLEXIBLE CONNECTION	FI	FLOW INDICATOR	LSH	LEVEL SWITCH HIGH	PISH	PRESSURE INDICATING SWITCH HIGH
	STRAINER		VACUUM RELIEF VALVE	TI	TEMPERATURE INDICATOR	LSL	LEVEL SWITCH LOW	PAH	PRESSURE ALARM HIGH
	CHECK VALVE		ANNUBAR	LG	LEVEL GLASS	TAH	TEMPERATURE ALARM HIGH	TAH	TEMPERATURE ALARM HIGH
	GLOBE VALVE		SILENCER		ELECTRIC BINARY SIGNAL	M	ELECTRIC MOTOR		
	AIR FILTER	H-O-A	HAND-OFF-AUTO						

PROCESS AND INSTRUMENTATION DIAGRAM FOR A TYPICAL SOIL VAPOR EXTRACTION SYSTEM

NIROP
FEASABILITY STUDY

RMT INC.

DWN BY TCP
APPROVED BY
DATE APRIL 1995
PROJ # 3094.21
FILE # 30942101

FIGURE 4-1

with pure water. The higher these constants, the more effective SVE is for stripping VOCs (USEPA, 1991e).

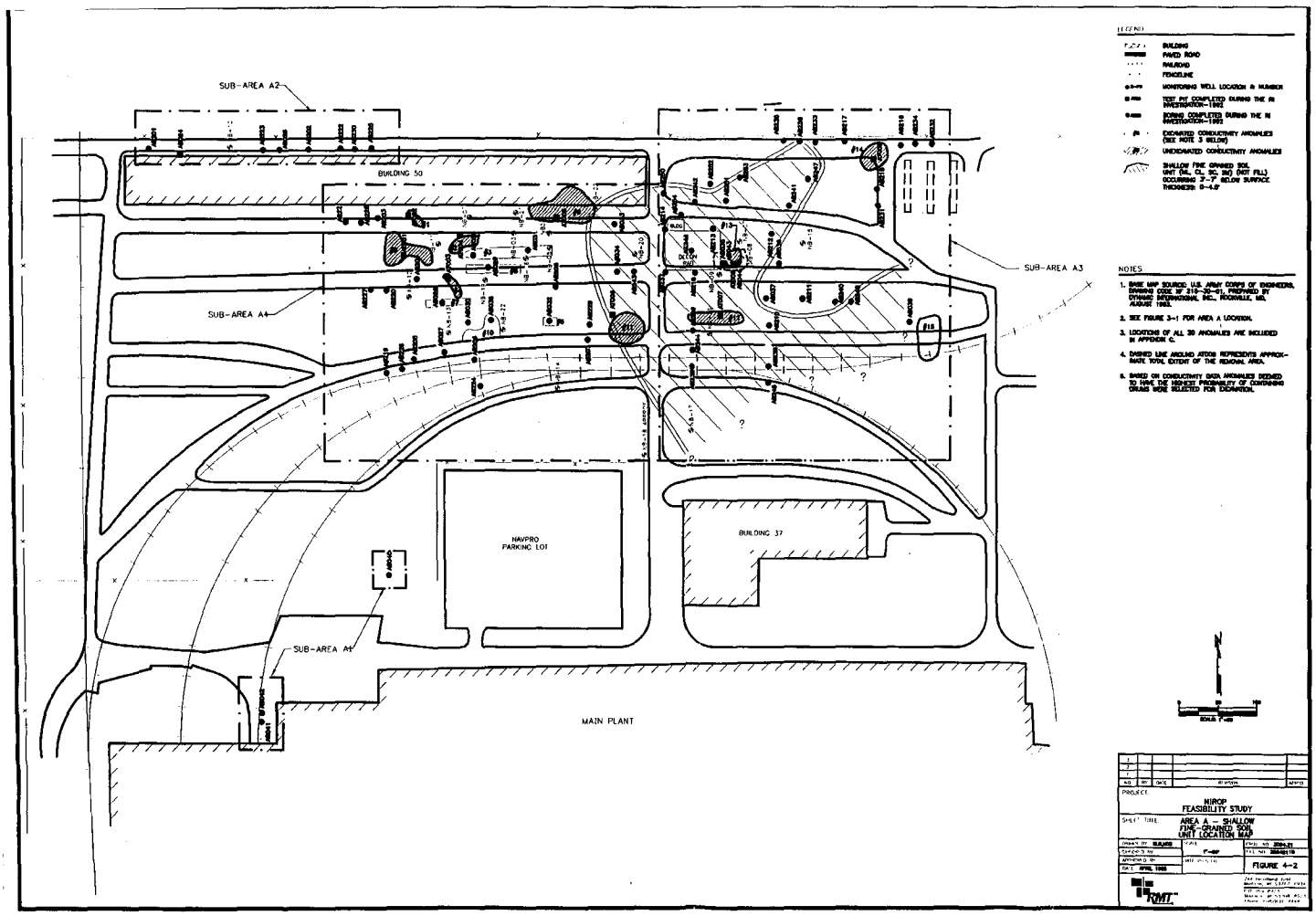
Adsorption of contaminants to soil particles and organic matter will also influence distribution and movement of released products. The soil organic carbon content, which is the soil component with the most impact on organic adsorption, is generally used in equations to predict partitioning of contaminants between soil and the aqueous phase, as shown in MPCA's Soil Leaching Model (Section 3). Lower organic contents, such as those present at NIROP Fridley, are beneficial to the application of SVE in either a stripping or bioremediation mode.

Coarse-textured, highly permeable soils are best suited to SVE because they allow higher airflow over the contaminant zone. SVE has worked successfully, however, in clays and silts, where interbedded permeable layers are present or macropores and secondary structures exist. Soil water content also has a significant effect on the permeability for air. In general, higher water content reduces the air-filled porosity, thereby decreasing the connected pores through which air can flow by advection. SVE is generally more successful at lower moisture contents since high water content reduces the air-filled porosity available for airflow. However, biological activity may be reduced at lower moisture contents. Therefore, optimum moisture contents must be maintained for volatilization and biodegradation to proceed simultaneously.

Adequate vapor flow through the contaminated soil zone is a key element for the success of the SVE technology for remediating soil at NIROP Fridley. Vapor flow rates are dependent upon soil characteristics such as porosity, moisture content, and permeability, as well as the gases' viscosity, density, and pressure gradients.

4.3.2 Geologic Conditions Affecting System Performance

In general, the OU2 soils at the NIROP range from fine to coarse sand (RMT, 1993). Relatively high permeability values, in the range of 10^{-3} cm/s for hydraulic conductivity are typical. These conditions are generally highly favorable for the implementation of SVE. However, there is a relatively narrow band of fine-grained soil material present under much of Area A3 and the east-central part of Area A4. Figure 4-2 shows the location of this fine-grained soil layer at the NIROP. VOCs represent the most significant type of chemical contamination associated with the areas where the fine-grained layer exists. The fine-grained soils occur at a depth of 3 to 7 feet below surface and vary in thickness from 0 to 4.5 feet. Based on analytical results collected during the RI, it appears that no significant or consistent vertical trends in the VOC concentrations are associated with the


SUB-AREA A2
BUILDING 50
SUB-AREA A4
SUB-AREA A3
NAVPRO PARKING LOT
BUILDING 37
SUB-AREA A1
MAIN PLANT
LEGEND
BUILDING
PAVED ROAD
RAILROAD
FENCELINE
MONITORING WELL LOCATION & NUMBER
TEST PIT COMPLETED DURING THE RI INVESTIGATION-1992
BORING COMPLETED DURING THE RI INVESTIGATION-1992
EXCAVATED CONDUCTIVITY ANOMALIES (SEE NOTE 3 BELOW)
UNEXCAVATED CONDUCTIVITY ANOMALIES
SHALLOW FINE GRAINED SOIL UNIT (ML, CL, SC, SM) (NOT FILL) OCCURRING 7-7' BELOW SURFACE THICKNESS: 0-4.5'
NOTES
1. BASE MAP SOURCE: U.S. ARMY CORPS OF ENGINEERS, DRAWING CODE NF 210-30-01, PREPARED BY DYNAMO INTERNATIONAL INC., ROCKVILLE, MD, AUGUST 1993.
2. SEE FIGURE 3-1 FOR AREA A LOCATION.
3. LOCATIONS OF ALL 39 ANOMALIES ARE INCLUDED IN APPENDIX C.
4. DASHED LINE AROUND AT200 REPRESENTS APPROXIMATE TOTAL EXTENT OF THE REMOVAL AREA.
5. BASED ON CONDUCTIVITY DATA ANOMALIES DEEMED TO HAVE THE HIGHEST PROBABILITY OF CONTAINING DRUMS WERE SELECTED FOR EXCAVATION.
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SCALE 1"=400'
NO. BY DATE REVISION APVD
PROJECT: NIROP FEASIBILITY STUDY
SHEET TITLE: AREA A -- SHALLOW FINE-GRAINED SOIL UNIT LOCATION MAP
DRAWN BY: SUJAKO
SCALE: 1"=40'
DWG. NO: 2004-11
FILE NO: 2004-11B
APPROVED BY:
DATE: APRIL 1995
FIGURE 4-2
RMT

fine-grained soil. In general, similar concentrations were detected in shallow soils (0 to 5 feet deep) located within and above the fine-grained soil interval and in intermediate soils (6 to 12 feet deep) and deep soils (13 to 20 feet deep) beneath the fine-grained interval.

In general, this fine-grained soil layer is not expected to significantly affect the overall performance of SVE at the NIROP Fridley. The poorly to well graded sand, both above and below the fine-grained layer should easily release contaminants due to the low organic content of the soil (RMT, 1993) and its relatively high permeability. SVE extraction wells will be installed through the fine-grained layer; therefore, contaminants will be pulled out of the fine-grained soil from above and below, as illustrated by Figure 4-3. Over time, contaminants in the fine-grained layer should move from the fine-grained layer toward the extraction well and diffuse into the more permeable soils above and below. Figure 4-3 also illustrates how dissolved VOCs in the groundwater will provide a continuing source of VOCs to OU2 soils for as long as the groundwater is significantly contaminated. Evidence for this was found during the RI, with locally elevated VOC concentrations in pore gas in the vicinity of the water table (RMT, 1993). As a vacuum is applied at the extraction well, contaminant concentrations will decrease in the soils, creating a concentration gradient between the soil and groundwater. This gradient will cause VOCs to diffuse from the groundwater and capillary fringe into the soil. As long as the groundwater under OU2 contains significant VOC contamination, VOC concentrations in the soil pore gas immediately above the groundwater fringe of OU2 will be elevated.

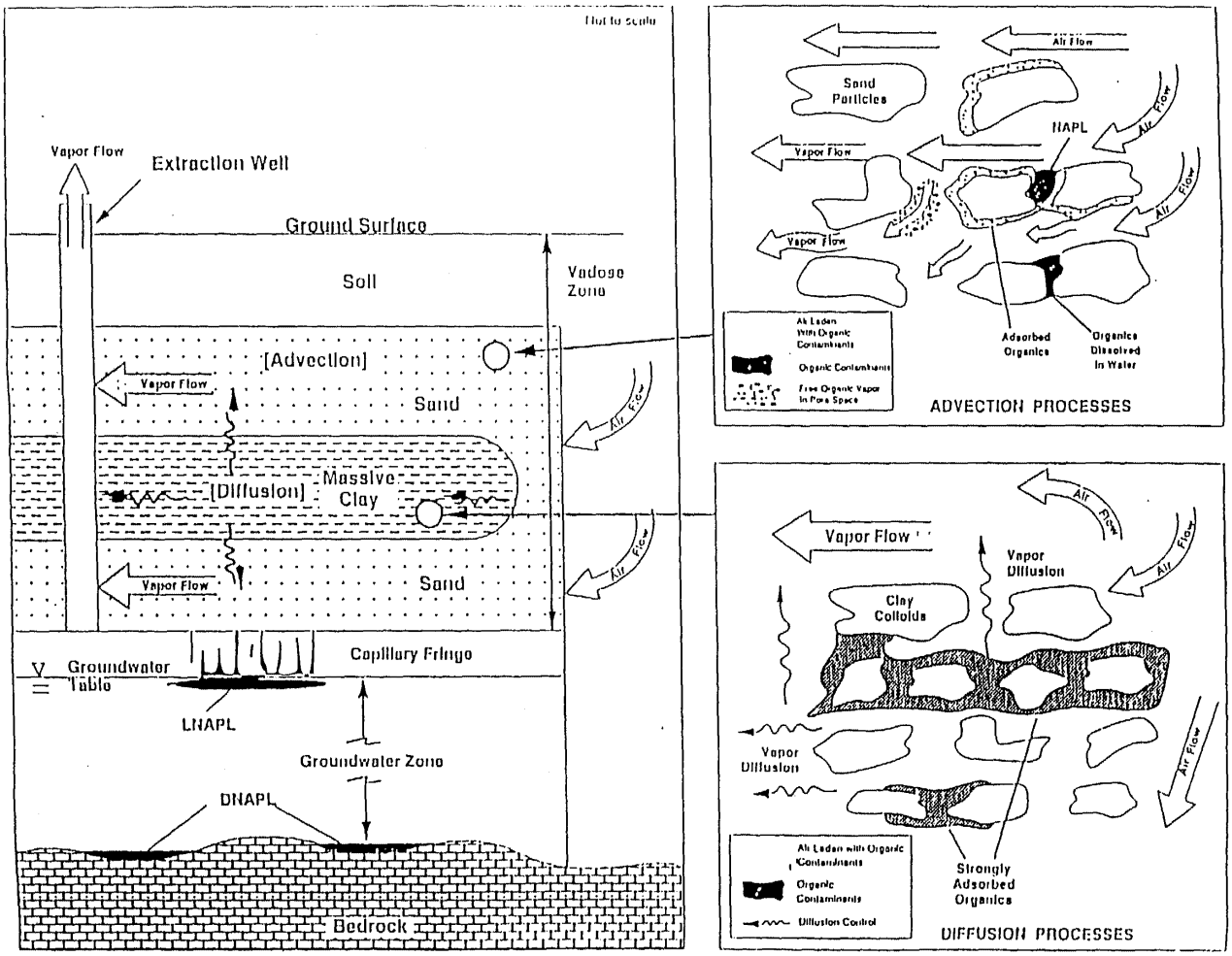
4.3.3 Additional Data Requirements

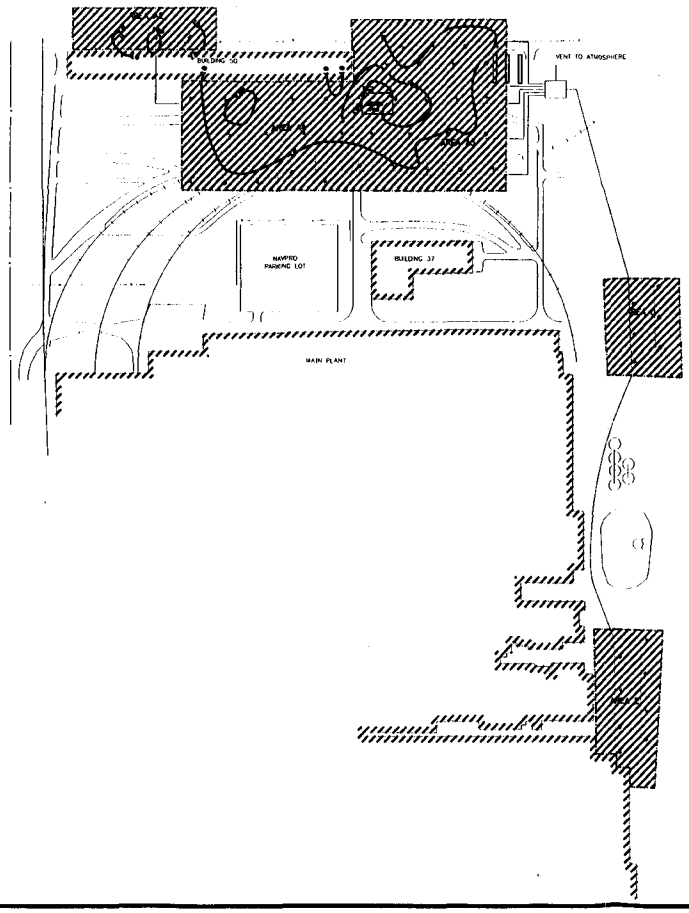
Procedures for conducting SVE treatability studies at CERCLA sites are outlined in EPA's Interim Guidance Document (USEPA, 1991b). One of the most important parameters determined during the pilot test is the air permeability of the subsurface soil. Air permeability tests will be used to determine the distance from the vapor extraction wells that subsurface vapor can be impacted. By knowing the area of influence of one vapor extraction well, the total number of wells needed for remediation of the soils can be calculated. A detailed description of the SVE design considerations is attached in Appendix F. Figure 4-4 is a drawing showing the estimated locations of vapor extraction wells in the areas where contaminant concentrations are above cleanup goals (see Section 3). The drawing indicates that approximately 54 vapor extraction wells will be required for the NIROP Fridley.

Another important design requirement determined by the pilot test is the rate that contaminants are removed from the subsurface. During pilot testing, the concentration of VOCs will be monitored in

Figure 4-3

Soil Vapor Extraction Process Removing VOCs from Fine-Grained Soils and the Effect of DNAPLs





LEGEND

- BUILDING
- PAVED ROAD
- RAILROAD
- PERIMETER
- AREA REQUIRING CLEAN-UP
- TOTAL VOC CONTOUR - FIELD OC (CHANGE WHERE DATERMINED)
- SVE EXTRACTION WELL

NOTES

1. BASE MAP SOURCED U.S. ARMY CORPS OF ENGINEERS, DRAWING CODE 37 210-30-41, PREPARED BY PRIMARY ENGINEERING INC., BUCHANAN, VA, AUGUST 1988.

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SCALE 1"=100'

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PROJECT
NIROP
FEASIBILITY STUDY

SHEET TITLE
CONCEPTUAL LAYOUT OF THE SVE SYSTEM FOR OU-2 SOILS

DRAWN BY MED	SCALE 1"=100'	SHEET NO. 3004L01
DESIGNED BY		FILE NO. 20042113
APPROVED BY	DATE ISSUED	FIGURE 4-4
DATE APRIL 1992		

RMT

the vacuum pump off-gas. Typically, the concentration of contaminants will be high at the beginning of the test but will drop off rapidly as the test progresses. From the pilot-scale information, the time required for VOC concentrations in the subsurface to reach asymptotic conditions can be estimated. The pilot-scale information can then be used to operate the full-scale SVE system more economically. Instead of applying a continuous vacuum to the extraction well, vacuum can be pulsed on a regular basis. Pulsing allows the concentration of contaminants on the soil particles to reach equilibrium with the soil pore gas during periods when the vacuum is shut off to the extraction well. By pulsing the system, the same amount of contaminants can be removed from the subsurface; however, the high electrical costs that result from continued operation of the vacuum pump are reduced (USEPA, 1991e).

4.3.4 Operation, Maintenance, and Monitoring Requirements

Once the SVE system is designed, constructed, and installed, the startup consists of turning on the SVE blower(s) or vacuum pumps. Vacuum gauges installed at various locations on the wells and manifold network are monitored during startup so that the flows and pressures can be adjusted to be compatible with the system design. Several hours, to several days, of system operation are required to establish steady-state flow conditions, depending on the air permeability of the formation, (Johnson et al., 1990). After the startup period, the SVE system may be left in continuous operation essentially unattended except for daily checks on the water level in the air water separator and occasional tank draining. In addition, the blower must be serviced periodically by checking the drive belts and lubricating the bearings. In general, maintenance requirements are highest at system startup and decline over time.

The VOC extraction rate is measured by sampling the VOC concentrations in the exhausted air and measuring the flow. Removal rates, measured in pounds per day, will typically be large at the beginning of vapor extraction, but decrease with time. This decrease may signal the transfer to a diffusion-limited system. In other words, the saturated vapors present in the soil pore gas at system startup are quickly removed. Removal of contaminants thereafter may be diffusion limited as shown on Figure 4-3. Since diffusion rates are much lower than advection, removal rates drop over time.

Because groundwater will be a continuing source of contamination to the soils above, remediation of OU2 soils is expected to continue until the groundwater is remediated. In order to limit the overall operational costs once remediation becomes diffusion limited (from groundwater to soil), "pulse venting" is anticipated for the NIROP, and system designs will consider automated valves and programmable logic controllers to start and stop the system as needed.

4.3.5 Enhanced Bioremediation of PAHs using SVE

The literature data indicate that PAHs in OU2 soils at the NIROP can potentially be biologically degraded with adequate air supply and nutrient addition. The rate of biodegradation of PAHs depends on the complexity of the PAH chemical structure and the extent of enzymatic adaptation. In general, PAHs containing two or three aromatic rings are readily degradable and PAHs containing four or more aromatic rings are refractory (Genes, et al., 1993). Real-time biodegradation of PAHs appears to occur only in oxidizing conditions; therefore, oxygen supply can be a limiting factor. The sandy soils found at the NIROP are conducive to supporting an aerobic environment. The supply of oxygen is likely to be enhanced with SVE in operation, because the SVE system will pull in atmospheric oxygen to the soil zone. Further enhancements of PAH biodegradation rates would be accomplished utilizing nutrient addition to the soils, if appropriate. Soil nutrients, such as ammonia and phosphorus, could enhance bioremediation of PAHs at NIROP, along with pH adjustment during the course of remediation.

4.4 EXCAVATION AND THERMAL DESORPTION (ALTERNATIVE 4)

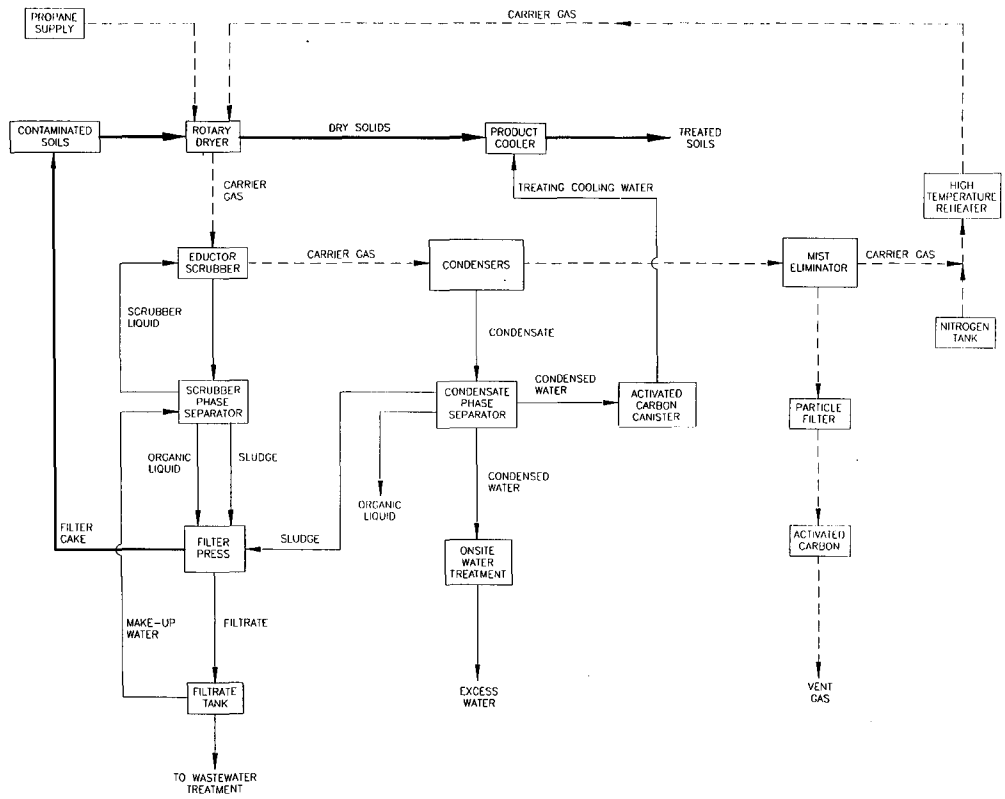
4.4.1 Process Overview

Thermal desorption is a physical separation process that drives semivolatile and volatile organic contaminants from the soil by directly or indirectly heating the soil to temperatures greater than the boiling point temperatures of the contaminants, thereby separating them from the soil and forcing them into the gas phase. As depicted on Figure 4-5, this is an *ex situ* process in which the contaminated soil is excavated, stockpiled, and fed into the desorption unit where it is heated to a temperature that ranges from 200°F to 1,000°F. The evaporated contaminants are removed by circulating carrier gas (e.g., air, nitrogen, combustion gas, etc.), and are subsequently treated, usually with follow-on treatment technologies such as incineration, condensation, or adsorption. Typically, an inert gas, such as nitrogen, is used as the carrier gas to maintain an atmosphere that does not support combustion (i.e., less than 6 percent oxygen). The treated soils are, in turn, frequently used as backfill in the excavated site.

The following types of thermal desorption units exist:

- The rotary dryer or rotary drum type unit uses a rotating drum that is either heated indirectly by a tube in shell system or by direct injection of hot gases into the drying cylinder. The ability to rapidly exchange heat allows relatively high processing rates in the range of 5 to 55 tons per hour.

- The thermal screw unit uses hollow-stemmed augers to transport soil through an enclosed, heated trough. Hot oil or steam is circulated through the augers to



NIROP
THERMAL DESORPTION WITH
ROTARY DRYER

RMT INC.

DWN BY	MHS
APPROVED BY	
DATE	APRIL 1995
PROJ #	3094.21
FIG #	30942105

FIGURE 2-1

indirectly heat the soil. These units are relatively simple to operate and generate a smaller amount of fines and dust. Processing rates range from 3 to 13 tons per hour.

- Vapor extraction systems mix hot gasses directly with the soil to volatilize the contaminants. Hot gasses are injected into the unit through a series of gas jets at a rate sufficient to fluidize the feed material soil. Processing rates are medium to relatively high and range from 10 to 73 tons per hour.

- Distillation chambers are a series of cylindrical chambers (typically 3 to 5) that are heated externally to successively increasing temperatures. This allows the vaporization, condensation, and recovery of specific contaminants from each temperature range. Augers convey the soil through each chamber, and nitrogen sweep gas is used to transport the volatilized contaminants. The processing rate for this type of unit ranges from 1 to 17 tons per hour.

Thermal desorption vendor information supplied by Midwest & Soil Remediation, Inc. is attached in Appendix H.

All thermal desorption systems require excavation and transport of the contaminated soil, using handling/classification equipment and feeding of the material into the desorption unit. Excavation is accomplished by backhoe, front-end loader, or similar equipment. Belt conveyors are typically used to transfer the medium from a hopper to vibratory screens (or similar device) to remove large objects such as rocks, glass, and metal from the medium. Consolidated media larger than about 38 mm (1.5 inches) on any edge are typically rejected. Large objects may restrict the passages in some desorption units and can result in uneven heating of the media. If the rejected objects are contaminated, they may be crushed and fed separately through the desorption unit. If the rejected materials are not processed by the treatment unit, they are typically containerized, such as in a roll-off dumpster, and sampled so that an alternative disposal method can be selected. Additionally, some soil types may tightly agglomerate and require milling or shearing operations to prepare the medium for thermal adsorption equipment. This problem should be identified during the excavation process. The classified media is conveyed, via belt or bucket conveyors, to a feed hopper and is then metered into the desorber.

The primary technical factors affecting the applicability of thermal desorption are as follows: contaminant characteristics; operating residence time; operating temperature of the desorption unit; and soil properties, including particle size, moisture, and organic content.

Perhaps the most important contaminant characteristic affecting thermal desorption performance is its boiling point. Table 4-1 lists the boiling points of the target compounds in OU2 soils, (Riddick

TABLE 4-1

BOILING POINTS FOR THE VARIOUS CONSTITUENTS OF CONCERN[a,b,c]

Constituent of Concern	Boiling Point °C
Ethylbenzene	136.2
Tetrachloroethylene	121.2
Trichloroethylene	87.2
Toluene	110.6
1,1-Dichloroethane	57.3
1,1-Dichloroethene	31.6
Dibenzo(a,h)anthracene	524
Benzo(a)pyrene	495
Chrysene	448
Benzo(a)anthracene	Sublimes
Benzo(b)fluoranthene	481
Benzo(a)fluoranthene	480
Benzo(j)fluoranthene	480
Indeno(1,2,3-cd)pyrene	Sublimes

NOTES:

[a] American Petroleum Institute, Public 4379
[b] Handbook of Chemistry and Physics, 68th Edition
[c] Riddick and Bunger, 1970

and Bunger, 1970; American Petroleum Institute, 1984). Low boiling materials (less than 200°F), such as chlorinated solvents, are easily removed by thermal desorption. High boiling materials (greater than 700°F) are not good candidates for thermal desorption. To determine the proper residence times and optimum operational temperatures for VOC and cPAH removal, the Navy must perform bench- or pilot-scale thermal desorption tests prior to full-scale implementation. Bench-scale tests will determine the degree to which cPAHs can be removed by thermal desorption under proper operating conditions.

4.4.2 Excavation and Thermal Desorption Design Considerations

The thermal desorption process for the NIROP will require excavation of contaminated soils followed by on-site treatment with a vendor-supplied trailer-mounted thermal desorption unit, including material feed/screening equipment, a thermal processor, and VOC control equipment. Areas of the NIROP where VOCs and cPAHs are above cleanup goals and will require excavation and thermal treatment were previously shown on Figure 3-2 (see Section 3). Soil pore gas readings and compositional analyses collected from many of the borings during the Remedial Investigation (RMT,1993) revealed a distribution of VOC concentrations in the soils above target cleanup goals from near the ground surface to a depth of up to 20 feet. Therefore, RMT has estimated that the total soil volume requiring excavation and thermal desorption will be approximately 300,000 cubic yards (450,000 tons). Calculations showing the estimated soil volume are attached in Appendix H.

A considerable portion of the areas to be excavated are crossed by roadways and railroad tracks. Prior to excavation, the railroad tracks must be removed and any active roadways abandoned or moved. In addition, any subsurface utilities must be moved prior to the start of excavation.

Precautions to minimize fugitive dust (particulates) and volatile releases may be required during excavation of contaminated soil. As stated in Section 3, the critical human exposure pathways for carcinogenic PAHs are dermal adsorption and ingestion; therefore, minimizing contact by construction workers during excavation is important. To prevent exposure to the community during excavation, weather conditions should be considered. Physical enclosures and independent dust/vapor controls over the excavation and feed system are required to prevent excessive dust generation. Additional precautions, such as windscreens and water sprinkling equipment, may also be required. Real-time air monitoring may be needed to assess air impacts, along with air monitoring at the perimeter of the site to determine off-site migration.

Thermal desorption has proven effective in treating soils, shales, and sediments contaminated with VOCs, PAHs, and even higher boiling point compounds, such as polychlorinated biphenols (PCBs) (Freeman, et al., 1989; USEPA, 1992).

The primary design considerations affecting thermal desorption performance are the maximum bed temperature, the total residence time, the organic and moisture content, the contaminant characteristics, and soil properties. Since the basis of the process is physical removal from the soil by volatilization, bed temperature directly determines the final concentration of the contaminant in the soil. The degree of mixing and, where applicable, the sweep gas rate also affect removal rate. If the system is directly heated, flammability of the contaminant must also be considered in order to prevent explosions.

Material handling of soils that are tightly aggregated or largely clay, or that contain rock fragments or particles greater than 1.5 inches can result in poor process performance. This can be minimized by media pretreatment, such as screening, crushing, mulching, shredding, etc. Also, if a high proportion of fine silt or clay exists in the soil matrix, excessive dust may be generated, which places a greater dust loading on the downstream air pollution control equipment. Because OU2 soils at NIROP are mostly sand, material handling issues should not be a concern.

Thermal desorption technology is most effective for soils with a moisture content of less than 20 to 30 percent. Typically, if the moisture content of the soil exceeds 20 percent, dry solids may need to be blended with the contaminated soil to provide for adequate processing. Treated soils will typically contain less than 1 percent moisture. Dust can easily form in the transfer of the treated soil from the desorption unit, but can be controlled by water sprays. An enclosure may be required to control fugitive dust if water sprays are not effective.

Treated soil should be backfilled carefully, since the treatment process can alter the physical properties of the soil. For example, treated soil may be susceptible to destabilization forces, such as liquefaction, where pore pressures are able to weaken the material to the point of failure. It may be advantageous to avoid backfilling of treated soil on sloped areas or places where materials must support a load (i.e., roads for vehicles, subsurfaces for structures, etc.). To achieve or increase the required stability, the treated soil may be mixed with other stabilizing materials or compacted in a layered fashion. A thorough geotechnical evaluation of the treated soil, based on treatability tests, can provide the necessary design resolution to post-treatment soil stabilization. At the NIROP, contaminated areas are flat; therefore, slope stability should not be a major issue. However,

because the Navy may consider alternative property uses after remediation, soil stabilization to support building foundations or roadways should be considered.

Because the rate of VOC emissions from the thermal desorption unit may exceed 5.7 pounds per hour (40 CFR Part 70), VOCs must be removed from the exhaust stream prior to discharge to the atmosphere. Options for control of VOC emissions include various selections and configuration of the following: condensers, activated carbon, and an afterburner. The process flow diagram previously shown on Figure 4-5 depicted a configuration that controls the VOC emissions with a scrubber in series with condensers, a mist eliminator, a particle filter, and activated carbon. Alternatively, some thermal desorption systems have a cyclone in series with a baghouse, followed by an afterburner. For the purpose of this feasibility study, it is assumed that the various control configurations associated with vendor-supplied mobile thermal desorption systems will achieve comparable VOC and particle removal efficiencies.

4.4.3 Geologic Conditions Affecting Performance of Thermal Desorption

The soils in OU2 consist primarily of coarse sand, fine to medium sand, and some gravelly sand. Discontinuous layers of silt and clay occur at some locations, and a shallow zone (approximately 3 to 7 feet below ground surface) of variable fine-grained soils underlies much of Area A3 and the west-central part of Area A4 (see Figure 4-2). Because the on-site soils are generally coarse sands, the moisture content of the soil mass is expected to be less than 20 percent during the summer months. However, in early spring after the snow melt, the soil moisture content may increase to the field capacity.

In situations where the soil moisture content reaches the field capacity, excavation and thermal treatment should be discontinued until the moisture content is less than 20 percent. The organic content of the soil is approximately 0.3 percent (as determined during the soils RI); therefore, it would not interfere with thermal desorption of the constituents of concern at the NIROP.

4.4.4 Additional Design Data Requirements

Prior to remedial design, bench-scale testing must be performed on representative NIROP soils to determine the combined boiling points of the contaminants to be treated. The results of these tests will be used to determine the optimum operating temperature and residence time for the thermal desorption system. Data collected in the bench-scale test will be used during on-site pilot testing at the NIROP. The pilot test will confirm that the target contaminants can be removed from OU2

while evaluating handling requirements associated with moisture content and compatibility of treated soils.

4.4.5 Thermal Desorption Implementation

Table 4-2 lists the various project elements that must be considered for thermal treatment of OU2 soils at the NIROP. Initially, plans and specifications must be prepared by a qualified engineer in order to allow various vendors of thermal treatment systems to provide accurate costs. In addition, health and safety programs and quality assurance/quality control (QA/QC) programs must be established before any field activities can occur. Once plans and specifications have been established and a vendor has been secured, the Navy's representative and the vendor must prepare the operational permits for submittal to the State of Minnesota. Normally, the permitting process can be completed in approximately 10 to 12 weeks; however, this process could extend much longer, depending on the State of Minnesota's ability to promptly respond with comments.

Site preparation at the NIROP is expected to last approximately 12 weeks and will involve removal of the existing railroad lines that cross Area A, and possible relocation of the existing propane tanks. In addition, any other structures, such as fences or concrete foundations, must be removed prior to the start of excavation activities.

Mobilization of equipment from the vendor's facility and commissioning at the NIROP will require approximately 12 weeks. Once the system has arrived on-site, the vendor's personnel will hook up the electrical and water systems and check systems, such as fire protection and emergency procedures, and will start up the unit to bring the process into equilibrium. After the unit has reached equilibrium, the vendor will collect trial soil samples from areas that have been highly contaminated by both cPAHs and VOCs to verify that the operating temperatures and residence times, determined during the bench-scale tests, are sufficient for removal of the target constituents. After the trial burn, the system will be shut down until all laboratory data have been received and a trial burn report can be prepared for submittal to the USEPA and the MPCA. The estimated time to obtain site closure at the NIROP by thermal desorption will range from 1 to 2 years.

4.4.6 Operation and Maintenance Requirements

Mobile thermal desorption units used for OU2 soil remediation will be supplied by a vendor and will include trained operators. Operation and maintenance will include soil excavation, stockpiling, thermal treatment, backfilling of treated soil, and compaction. In addition, the thermal treatment

TABLE 4-2

PROJECT ELEMENTS FOR SITE REMEDIATION USING MOBILE THERMAL TREATMENT TECHNOLOGIES

Major Project Phase	Specific Activities
Planning and Procurement	Survey the site and develop layout drawings and design foundations, design utility and waste disposal systems, plan transportation and mobilization, plan health and safety and QA/QC programs, implement public relations program, develop site-security plan, develop operations plan and procedures, and develop environmental monitoring plan.
Permitting	Identify permits and specific information requirements, prepare draft permit applications and trial burn plans, conduct client and agency review, finalize permit applications, conduct public hearings, and negotiate final operating permits.
Site Preparation	Mobilize site-preparation equipment; set up site containment and security; grade, grub, and fill site; pour foundations and pads; construct access roads and parking; connect utilities; install environmental monitoring system; set up support facilities; and prepare waste- and residuals-handling facilities.
Equipment Mobilization	Transport the process and utility equipment and personnel to the facilities, unload equipment, erect all equipment modules, interconnect instruments and control system, interconnect electrical distribution system, connect emission-monitoring system, and interconnect all utility systems.
Commissioning	Conduct site personnel training, check out electrical and instrumentation systems, conduct hydrostatic testing, align rotating equipment, check containment systems, check winterization systems, check fire protection systems, check emergency procedures, start up the plant, and bring the process into equilibrium.
Trial Burns	Check out monitoring systems; deploy sampling teams; prepare waste feeds; excavate and execute trial burns; conduct laboratory analyses of feeds, treated ashes and wastewater, and gaseous emissions; analyze results and prepare report to agency; and conditionally operate or mothball system during agency review.
Operation	Excavate waste; analyze waste; pretreat and blend wastes; thermally treat wastes; store, analyze, and delist residuals; dispose of treated ashes, treated wastewater, and residuals from the gas-cleaning and wastewater-treatment systems; and sample and analyze groundwater well samples.
Equipment Demobilization	Clean and decontaminate equipment; dispose of wastes generated during decontamination; conduct required equipment maintenance; disconnect power, electrical, utility, and stack-monitoring systems; disassemble process modules; and load and transport equipment to next site.
Site Disassembly and Closure	Disconnect and remove site utilities, remove personnel support facilities, remove waste-handling facilities, demolish and remove foundations, remove access roads and parking, grade and vegetate the site.

NOTES:

From Freeman, Standard Handbook of Hazardous Waste Treatment and Disposal, Section 8.13 - Mobile Thermal Treatment Systems

contractor will be responsible for all residuals generated during soil remediation. Operations and maintenance of the system will not require involvement of NIROP personnel.

4.5 EXCAVATION AND INCINERATION (ALTERNATIVE 5)

4.5.1 Process Overview

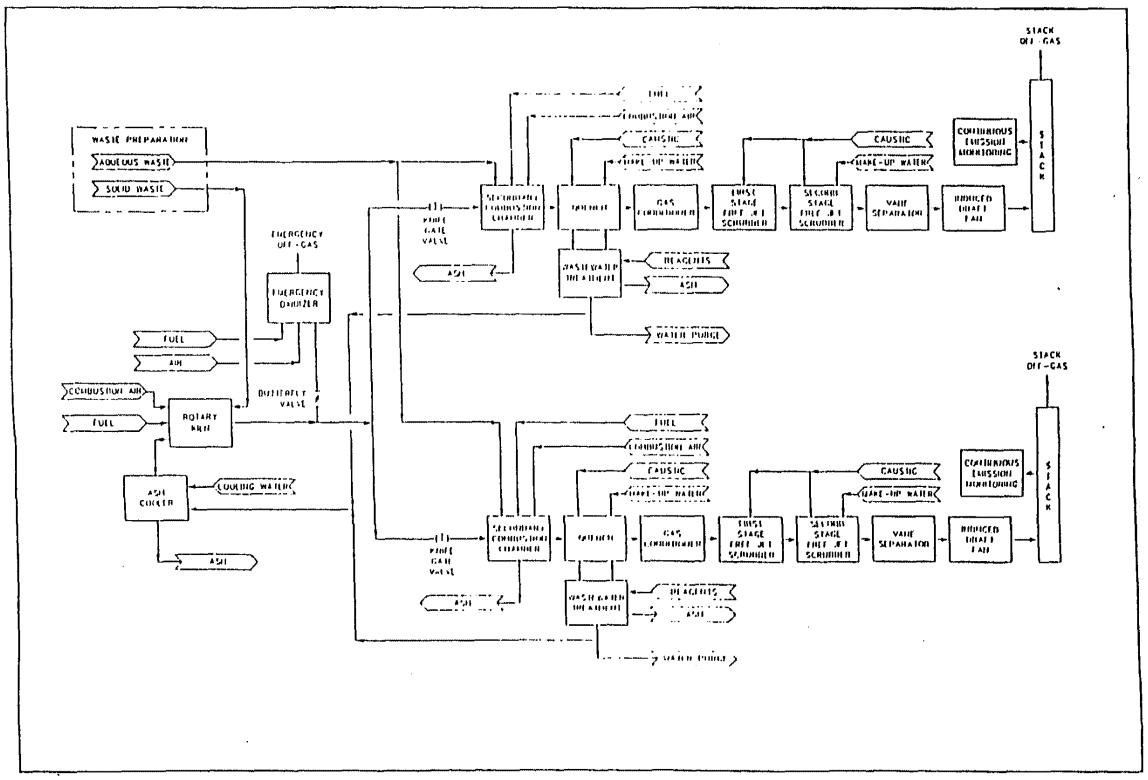
Incineration is a process whereby organic contaminants are removed via decomposition by directly heating the soil. As depicted in the block diagram shown on Figure 4-6, this is an *ex situ* process in which the contaminated soil is excavated, stockpiled, and treated. Excavated contaminated soils can be transported to a fixed incinerator located off-site. Alternatively, excavated soil can be fed into a mobile incineration unit that uses temperatures ranging from 800°F to 2,500°F to destroy various forms of contaminants. Several types of incineration technologies exist to treat contaminated soils. The two types of incineration technologies that are typically best suited and commercially available for addressing contaminated soil are rotary kilns and fluidized-bed incinerators.

Rotary kiln incinerators typically use an inclined rotating cylindrical kiln with burners located at the front or rear of the oxidation chamber to heat the soil to temperatures ranging from 1,450°F to 2,500°F at excess air levels ranging from 25 to 150 percent. Combustion air from the refractory-lined kiln flows into a secondary refractory-lined combustion chamber in which auxiliary fuel is burned to raise the temperature of the flue gas between 200°F to 600°F above the temperature of the flue gas at the kiln exit (Freeman, 1989).

The flow of combustion air can be either concurrent or countercurrent with the flow of contaminated soil. However, for the purpose of this feasibility study, it is assumed that the mode of operation will be countercurrent because this approach provides several advantages offered over conventional concurrent rotary kilns, including higher soil processing capacity, lower off-gas volume to treat, and the potential for more consistent and higher-quality ash residue (Freeman, 1989). The residence time and mixing with combustion air is controlled by the rate of rotation. Ash is withdrawn from the rear of the oxidation chamber, while off-gas is typically drawn through a scrubber prior to discharge to the atmosphere. The primary technical factors affecting the applicability of rotary kiln incineration are the rate of kiln rotation and the control of the supply of combustion air.

Fluidized-bed incinerators can be configured as either a bubbling-bed type or a circulating-bed type. In either case, inert granular material (e.g., sand) is used as the medium for heat transfer and waste agitation. A typical fluidized bed utilizes a refractory-lined vessel in which the inert material is kept

Figure 4-6. Block Diagram of a Typical Soil Incineration System (IT Corporation)



in motion by fluidizing air at temperatures ranging from 800°F to 1,500°F with excess air requirements ranging from 20 to 40 percent. Bed temperatures are limited by the softening point of the inert material, which is approximately 1,600°F for sand.

Fluidized-bed incinerators use high-velocity combustion air to either fluidize the bed (i.e., for bubbling bed type) or entrain the bed (i.e., for circulating bed type). Generally, all soils require pre-screening or crushing to less than 2 to 3 inches to allow for effective distribution within the bed and removal of solids from the bed after treatment (Freeman, 1989). Contaminated soil and auxiliary fuel are injected radially in proportionally small amounts and mixed to facilitate heat transfer to the soil material. The material combusts and returns energy to the bed. Residual ash is removed from the base of the bed, and fine particulate is collected via a cyclone and/or a filter in the flue gas treatment unit. Similar to rotary kilns, the primary technical factors affecting the applicability of fluidized-bed incinerators include proper operating temperatures to combust the contaminants and control the supply of combustion air to ensure adequate fluidization of the bed to allow for efficient gas-to-solids heat transfer and uniform temperatures throughout the bed.

4.5.2 Excavation and Incineration Design Concepts

The major elements for implementing a thermal treatment system at the NIROP for OU2 soils were outlined previously in Table 4-2. Typically, a mobile incinerator is a state-of-the-art system, which is a self-sufficient hazardous waste management facility, operated 24 hours per day, 7 days per week. Some of the activities that must be considered when designing the remediation program for OU2 soils are site preparation, equipment mobility, commissioning, demobilization, site closure, and possibly the trial burn and permitting activities. More detailed descriptions of incineration provided by the vendor is attached in Appendix I.

4.5.3 Geologic Conditions Affecting Performance

Of the three presumptive remedies outlined in the AAD, excavation and incineration is the least affected by soil conditions. Because of the extremely high temperatures used in the process, most natural organic matter in the soil is destroyed, leaving nothing for the VOCs to adsorb. At the NIROP, the majority of soils consist primarily of coarse sand, fine to medium sand, and some gravelly sand. Discontinuous layers of silt and clay occur at some locations. Therefore, none of the soils at NIROP are expected to negatively impact the performance of the mobile incineration system.

4.5.4 Additional Design Data Requirements

Mobile incineration systems are generally truck mounted, have minimal field erection requirements, and can be relatively easy to mobilize and demobilize. Transportable thermal treatment systems are large by comparison and constructed as pre-assembled, skid-mounted modules. Mobilization, erection, and demobilization requires more effort than truly mobile systems because some of the high capacity unit operations may require interconnections of multiple skids and construction of proper foundations.

For a project as large as the NIROP, a transportable incinerator rather than a mobile incinerator will likely be used. Mobile systems have an economic advantage at small sites (e.g., 5,000 tons), because of the lower capital, mobilization, and demobilization costs. However, the unit treatment costs become less sensitive to capital mobilization and demobilization costs at medium (10,000 to 25,000 tons) and large sites (25,000 to 100,000 tons). At NIROP, the estimated amount of soil that will require incineration is 450,000 tons. Calculations showing the volume of soil that requires treatment are attached in Appendix I. The areas requiring treatment were previously shown on Figure 3-2.

The primary factor that will affect throughput or processing capacity at the NIROP will be the moisture content of the soil. The processing rate will fall as the amount of moisture requiring evaporation rises. In spring, following the snow melt, the moisture content of the soil could be as high as 30 percent. In summer, the moisture content could drop as low as 10 percent. This moisture difference of 20 percent could result in a decrease in the soil processing rate of nearly 30 percent.

Prior to full-scale processing of soils at the NIROP, bench-scale tests will be conducted to determine the residence times and temperature needed to reach the soil cleanup goals and the BTU content of the untreated soil in order to accurately predict fuel requirements, and to verify off-gas treatment requirements. To obtain the necessary operating permit, a trial burn will be conducted at the NIROP. The trial burn will consist of excavation and treatment of soils, disposal of residuals, compaction tests for treated soils, collection and analysis of gaseous emissions, and preparation of a trial burn report to the agency. The estimated time to remediate the site will range from 1 to 2 years and is based on a typical large thermal incinerator processing nearly 1,000 tons per day.

4.5.5 Operation and Maintenance Requirements

Normally, thermal treatment units are supplied by a contractor along with field operators. Operation and maintenance will include soil excavation, stockpiling, thermal treatment, backfilling, and compaction. In addition, the thermal treatment contractor will be responsible for residuals generated during soil remediation. No operation and maintenance costs above those charged for processing each ton of soil would be incurred by the NIROP.

Section 5

DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The objective of this section is to evaluate the "no action" alternative, institutional controls for the site, and the three presumptive remedies against the criteria set forth in the National Oil and Hazardous Substance Contingency Plan (NCP), 40 CFR Part 300.430(e)(9)(iii), and various guidance documents, including USEPA Guidance for Conducting Remedial Investigation and Feasibility Studies under CERCLA (USEPA, 1988). In this section, each remedial alternative is evaluated individually with respect to the FS criteria. Each alternative is then carried forward to a comprehensive comparative analysis of the remedies in Section 6.

The remedial alternatives identified for soils at the NIROP are consistent with presumptive remedy guidance and the NCP. The presumptive remedy guidance identifies three potentially viable alternatives for remediating soils that have been contaminated by VOCs. A fourth alternative, institutional controls, has been added to the NIROP FS to incorporate a more limited action into one alternative. The remedial alternatives are as follows:

Alternative 1: No Additional Action
Alternative 2: Institutional Controls
Alternative 3: Soil Vapor Extraction
Alternative 4: Excavation and Thermal Desorption
Alternative 5: Excavation and Incineration

Each of these alternatives will be evaluated against the FS criteria shown in Table 5-1 to develop the rationale for a remedy selection. The process of analyzing each alternative against the FS criteria has been developed based on statutory requirements of CERCLA, the National Oil and Hazardous Substance Contingency Plan 40 CFR Part 300.430(e)(9)(iii), and site-specific experience gained in the Superfund program (USEPA, 1988). The seven criteria presented in Table 5-1 encompass statutory requirements, technical effectiveness, costs, and institutional considerations that the CERCLA program has determined appropriate for a thorough evaluation. Two additional criteria, state acceptance and community acceptance, are not presented in this FS. The community acceptance criteria, not shown in Table 5-1, will be addressed after the comment period. State acceptance is incorporated into the approval process since the site is overseen by both the USEPA and the MPCA.

TABLE 5-1

EVALUATION CRITERIA USED IN THE DETAILED ANALYSIS OF EACH ALTERNATIVE

Overall protection of human health and the environment	Provides a final check to assess whether each alternative provides adequate protection of human health and the environment.
Compliance with ARARs	Assesses compliance with the following: • Chemical-specific ARARs (e.g., cleanup goals) • Location-specific ARARs (e.g., preservation of historic sites) • Action-specific ARARs (e.g., RCRA minimum technology standards).
Long-term effectiveness and permanence	Assesses the long-term effectiveness of alternatives in monitoring protection of human health and the environment after response objectives (e.g., cleanup goals) have been met.
Reduction of toxicity, mobility, and volume through treatment	Assesses the treatment process used and the materials treated, the degree to which treatment is irreversible, the type and quantity of residuals remaining after treatment, and the degree of expected reductions in toxicity, mobility, and volume.
Short-term effectiveness	Examines the effectiveness of the alternative in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met.
Implementability	Examines the ability to construct and operate the technology, reliability of the technology, availability of the necessary equipment and specialists, ability to monitor effectiveness, ease of undertaking additional remedial actions (if necessary), and ability to obtain approvals from agencies.
Cost	Examines the capital costs, operating, maintenance and monitoring costs, and the present worth costs of each alternative.

5.1 ALTERNATIVE 1 - NO ACTION

5.1.1. Performance Evaluation Criteria

Evaluation of a "no action" alternative is specifically required by the NCP to provide a baseline against which other alternatives can be compared. At the NIROP, the majority of the areas of contaminated soils are exposed, allowing for infiltration of precipitation and potential exposure through dermal contact, incidental ingestion of soil particulates, and inhalation of VOCs by workers. However, these current exposure pathways, evaluated in the Risk Assessment conducted during RI activities, did not exceed Minnesota threshold values for unacceptable risk (RMT, 1993). Under the assumption of future residential land use, there would be an unacceptable risk associated with exposure to contaminants in OU2. Those scenarios are presented in more detail previously in Section 3 of this FS, where a number of areas that exceed target cleanup goals for soils and soil pore gas are identified, based primarily on risk associated with future land use (see Figure 3-2). Since the no action alternative does not limit future land use, it would be ineffective at long-term protection of human health and the environment, and thus does not meet threshold criteria for alternative consideration. Figure 5-1 evaluates the "no action" alternative in relation to the remaining evaluation criteria.

5.1.2 Cost Effectiveness

No additional costs are associated with this alternative.

5.2 ALTERNATIVE 2 - INSTITUTIONAL CONTROLS

5.2.1 Performance Evaluation

A summary of the evaluation for Alternative 2 is presented on Figure 5-2 and is further discussed in this section. Institutional controls would restrict future building activities and land use, as outlined in Section 4.2; therefore, this alternative would result in an acceptable degree of risk to humans, based on the results of the baseline risk assessment that was conducted for OU2 (RMT, 1993). With institutional controls in place, a residential scenario would be prohibited and future land use would result in an exposure no greater than current land use. Then, the overall risk to humans would be below Minnesota guidelines of 1×10^{-5} cancer risk and below the hazard index level of concern (1.0) (RMT, 1993).

A second criterion to be evaluated is whether institutional controls can effectively protect groundwater from contaminants leaching from OU2. A comparison of groundwater protection-based target cleanup goals to soils analytical data from OU2 shows that only two

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARs	LONG-TERM EFFECTIVENESS AND PERMANENCE	REDUCTION OF TOXICITY MOBILITY, AND VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST
• Migration of VOCs to groundwater would continue, as predicted by the soil leaching model. • The "No Action" alternative will not prevent inhalation exposure to VOCs in pore gas if sub-surface structures such as basements and tunnels are constructed in contaminated areas. • The "No Action" alternative will not prevent ingestion of cPAHs and VOCs in the soil.	• Without restrictions to prevent subsurface intrusion into contaminated areas at NIROP, unacceptable risks (greater than 10^{-5}) to workers cannot be prevented.	• The "No Action" alternative does not prevent potential future exposure to VOCs or cPAHs, above health risk limits	• None	• There are no short-term effectiveness concerns for the "No Action" alternative.	• There are no implementation concerns for the "No Action" alternative.	TOTAL CAPITAL ($): none OM&M ($/year): none PRESENT WORTH ($): none UNIT COST ($/ton): none

ALTERNATIVE SUMMARY:
NO ACTION

RMT, INC.

DWN. BY: MHS
APPROVED BY:
DATE: APRIL 1995
PROJ # 3094.21
FILE # 30942117

FIGURE 5-1

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARs	LONG-TERM EFFECTIVENESS AND PERMANENCE	REDUCTION OF TOXICITY MOBILITY, AND VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST
• Protective of human health by preventing residential land use and subsurface activities such as tunneling or excavating in contaminated areas. • Deed restrictions preventing groundwater use at NRADP would prevent exposure to contaminated groundwater.	• Location specific ARARs will be met, since institutional controls will require that the site be restricted to its current land use. • Deed restrictions placed on contaminated areas will allow the site to be maintained under its current use status. • If changes in the current land use are requested by the NAVY, the deed restrictions must be renegotiated with MPCA and USEPA. If deed restrictions will not comply with ARARs then another remedial alternative may be initiated that is protective of human health and the environment under the proposed land use scenario.	• Deed restrictions depend on the ability of the U.S. Navy to maintain ownership and control on the future use of the property. • A 5 year site review would be required because contaminants are left untreated.	• None	• Institutional controls such as negotiated deed restrictions will be immediately effective. • Institutional controls can immediately prevent exposure via any subsurface intrusion into contaminated areas. • Institutional controls will not present risks to on-site workers or the community during implementation.	• Institutional controls are implemented by negotiating deed restrictions between the NAVY and MPCA. • Institutional controls will not hinder present operations at the NRADP facility during implementation but may restrict future site activities.	TOTAL CAPITAL (1): 100,000 ANNUAL (1/year) (1): 50,000/ 5 Years PRESENT WORTH (1) (2): [illegible] TOTAL COST ($/ton): 0.50

NOTES:

(1) OM&M Costs assume a 5-year status review of the site by the NAVY, MPCA and USEPA.

(2) Present Worth costs assume an interest rate of 5% and a 20 year operational period.

ALTERNATIVE SUMMARY: INSTITUTIONAL CONTROLS

RMT INC.

DWN. BY: MHS
APPROVED BY:
DATE: APRIL 1995
PROJ # 3094.21
FILE # 30942116

FIGURE 5-2

samples out of 150 total samples in Area A exceeded the cleanup goal for 1,1-DCA, and no samples exceeded groundwater protection-based cleanup criteria for the other VOCs.

Institutional controls that would restrict land use would be effective almost immediately and would maintain the current land use conditions that exist for OU2. The long-term effectiveness would be maintained as long as the institutional controls are in place. The long-term use of institutional controls would depend on the ability of the U.S. Navy to maintain ownership of the property and its ability to restrict land use at the site.

5.2.2 Cost Effectiveness

The institutional control alternative would be highly cost effective, in that no significant engineering costs would be incurred. Legal costs to develop land use restrictions for OU2 are estimated to be $100,000. An additional $50,000 will be required at 5-year intervals for a site status review by the Navy, the MPCA, and the USEPA. Indirect costs to the property owner due to the restrictions on land use could be significant, but cannot be estimated with any certainty at this time.

5.3 ALTERNATIVE 3 - SOIL VAPOR EXTRACTION

This section evaluates the soil vapor extraction (SVE) process against the feasibility criteria outlined in EPA general guidance for conducting RI/FS (USEPA, 1988), as well as the EPA guidance on presumptive remedies for CERCLA sites with VOCs in soils (USEPA, 1993b). Figure 5-3 presents each of the performance criteria and cost information for SVE, and the following text summarizes highlights.

5.3.1 Performance Evaluation

SVE is expected to reduce the concentrations of VOCs to levels that are protective of human health and the environment. The SVE system will apply a vacuum to soils, continually extracting VOCs out of the soils and away from subsurface structures, such as basements and tunnels. Removal of contaminants from pore gas surrounding soil particles will cause a shift in equilibrium, such that contaminants adsorbed on soil particles will desorb into the pore water and then into the vapor phase. SVE will be effective in reducing the concentrations of VOCs in OU2 soils by air stripping, and may reduce the concentrations of cPAHs in the soil by enhanced biodegradation. An EPA site demonstration (USEPA, 1991a), conducted in Groveland, Massachusetts, showed that air stripping by SVE reduced TCE levels to less than detection in various soil strata, including fine-grained soils

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- SVE will capture and treat VOCs in soil pore gas therefore limiting their migration into subsurface structures such as basements and tunnels.
- SVE will continue to remove VOCs that volatilize from contaminated groundwater below OU2 soils controlling recontamination of pore gas.
- SVE will control migration of VOCs from soil particles, therefore preventing additional contamination of groundwater by leaching.

COMPLIANCE WITH ARARs

- SVE will decrease the concentration of VOCs and potentially the cPAHs in soils to levels that should not impact human health via inhalation, dermal contact or ingestion (see section 3). In addition, SVE will decrease the concentration of VOCs in soils to levels that should not impact groundwater quality at NIROP.
- Use of vapor-phase GAC is expected to achieve compliance with appropriate air quality standards.
- Location specific ARARs will be met.

LONG-TERM EFFECTIVENESS AND PERMANENCE

- SVE can reduce or effectively eliminate the vadose zone VOC source.
- Long term operation will include periodically starting and stopping the blowers, removing water from the air/water separator and monitoring the VOC content in the off-gas.
- The effectiveness of SVE for removing the contaminants of concern from OU2 soils can be measured by long-term monitoring of the VOC pore gas concentrations.
- SVE is a well proven technique for removing VOCs from soils.
- Residuals left in place will require a 5 year review.

REDUCTION OF TOXICITY MOBILITY, AND VOLUME THROUGH TREATMENT

- Approximately 3.6 ton/yr of total VOCs removed from soils and thermally destroyed (100% irreversibility) by off-site regeneration of spent vapor-phase GAC.

SHORT-TERM EFFECTIVENESS

- SVE is minimally intrusive to contaminated soils. During construction, the potential release of VOCs or cPAHs to on-site and off-site receptors is minimal.
- SVE will be effective in remediating under roadways and adjacent buildings, without excavations.
- SVE can be preformed while NIROP-Fridley operations are on going.

IMPLEMENTABILITY

- SVE is a reliable and readily available technology for the removal of VOCs from soils.
- Many of the major pieces of equipment (regenerative blowers, air/water separation vessels) are standard off-the shelf items.
- Hydraulic conductivities of soils at NIROP are conducive to vapor extraction.
- Installation of the SVE system will not significantly disrupt NIROP activities.
- Multiple equipment vendors are available to obtain competitive bids.
- Will require soil sampling and analysis to verify clean up levels.
- Pilot scale treatability studies are typically required, and bench scale biodegradation studies would be required for cPAHs.

COST

TOTAL CAPITAL ($)	O&M ($/year) (1)	PRESENT WORTH ($) (2)	UNIT COST ($/ton)
919,000	115,000	2,956,000	5,2[illegible]

ALTERNATIVE SUMMARY:
SOIL VAPOR EXTRACTION

RMT INC.

DWN. BY: TCP
APPROVED BY:
DATE: APRIL 1995
PROJ. # 3094.21
FILE # 30942102

NOTES:

(1) OM&M Costs assume a 5-year status review of the site by the NAVY, MPCA and USEPA.

(2) Present Worth costs assume an interest rate of 5% and a 20 year operational period.

like those which comprise a small portion of the soils in Area A at the NIROP. The EPA site demonstration at the Groveland site lasted for 56 days. Table 5-2 presents the results of the SVE demonstration study at the Groveland site. Based on these results and many other successful applications, it appears that SVE will reduce the concentrations of VOCs in soils at the NIROP to the target cleanup levels. Thus, the SVE system is designed to remove VOCs directly from the pore gas, control migration of pore gas, and remove VOCs from the soil particles and pore water. SVE may also be used to promote flow of oxygen to soil microbes, resulting in bioremediation of cPAHs. Numerous case studies that are reported in the literature indicate that total cPAH concentrations can be reduced to the target cleanup goals with enhanced biodegradation (Section 4.3). SVE will provide short-term and long-term protection of human health and the environment and will reduce the mobility and volume of soil contamination over time. The risk assessment showed that inhalation of VOCs migrating through the soil into subsurface structures, such as basements and tunnels, posed the greatest health risk, assuming the land use at OU2 would be residential at some future time (RMT, 1993). SVE will be effective in reducing the risk through inhalation of VOCs by extracting pore gas from contaminated soil and preventing it from migrating into subsurface structures. Approximately 3-4 tons/yr of total VOCs are expected to be removed from the soils and captured in the vapor-phase GAC used for off-gas treatment. The spent GAC would be transported offsite for thermal regeneration where the VOCs would be destroyed 100 percent irreversibly to form relatively innocuous gases, namely carbon dioxide, water vapor and hydrogen chloride.

The SVE system will become immediately effective upon startup at controlling exposure to VOCs in pore gas, which constitutes the greatest risk associated with OU2 soils. The SVE system will provide long-term effectiveness, and will continue to control VOC migration and reduce concentrations in the pore gas and soils for as long as the system operates, or until the VOC and cPAH concentrations become so low they no longer constitute a hazard. Under current land use, the risk associated with VOCs and cPAHs in OU2 soils is already below Minnesota guidelines (RMT, 1993); however, it would take a number of years before the soils VOC and cPAH concentrations are reduced below target cleanup goals that are based on residential land use assumptions (see Section 3). If land use at the NIROP becomes residential in the future, the SVE system will likely need to be in operation to control VOC migration until the groundwater OU2 is remediated, because volatilization of VOCs from the groundwater is a continuing source of contamination to the soils.

Soil vapor extraction is a common treatment technology for removing VOCs from soils, with well-established methods for implementation. A skid-mounted treatment system that contains blowers, air/water separators, and control equipment can be purchased from various environmental

TABLE 5-2

TCE REDUCTION IN SOIL STRATA
EPA SITE DEMONSTRATION (GROVELAND, MA) [EPA/540/2-91/006]

Depth (feet)	Description of Strata	Hydraulic Conductivity (cm/s)	Soil TCE Concentration (mg/kg)	
			Pre-Treatment	Post-Treatment
0 - 2	Medium sand with gravel	10^{-4}	2.94	ND
2 - 4	Light-brown fine sand	10^{-4}	29.90	ND
4 - 6	Medium stiff light-brown fine sand	10^{-5}	260.0	39.0
6 - 8	Soft dark-brown fine sand	10^{-5}	303.0	9.0
8 - 10	Medium stiff brown sand	10^{-4}	351.0	ND
10 - 12	Very stiff light-brown medium sand	10^{-4}	195.0	ND
12 - 14	Very stiff brown fine sand with silt	10^{-4}	3.14	2.3
14 - 16	Medium stiff green-brown clay with silt	10^{-5}	ND	ND
16 - 18	Soft wet clay	10^{-5}	ND	ND
18 - 20	Soft wet clay	10^{-5}	ND	ND
20 - 22	Very stiff brown medium-coarse sand	10^{-4}	ND	ND
22 - 24	Very stiff brown medium-coarse sand with gravel	10^{-3}	6.17	ND

NOTE:
1) Demonstration test was conducted for 56 days.
ND Nondetectable level

equipment vendors. Most of the contaminated area contains a sandy soil cover, and typical vapor extraction well construction and trenching techniques can be used for installation of equipment. Contaminated soils that are brought to the surface during installation of SVE wells and trenches will be thin-spread over the contaminated areas as they were during the OU2 RI field boring program, in order to facilitate their remediation, rather than disposing off-site.

During development of the Alternatives Array Document, questions were raised regarding the effect of a shallow zone (approximately 3 to 7 feet below ground surface) of fine-grained soil that underlies much of Area A3 and the west-central part of Area A4. This fine-grained soil represents only about 5 percent of the volume of contaminated soil in OU2, with the remainder being coarse-grained sands. VOCs represent the most significant type of chemical contamination associated with the fine-grained layer. VOC concentrations in the fine-grained soil are similar to concentrations in other soils above and below the fine-grained soil. Soil vapor extraction wells will be screened above, through, and below this layer, resulting in remediation of sandy soils above and below while simultaneously remediating the fine-grained soil layer. Design details for the SVE system and the effect of the fine-grained layer were presented in Subsection 4.3.2.

Production operations at the NIROP facility have placed it into a "major source" category under the Clean Air Act's (CAA) Title V regulations for hazardous air pollutants (HAPs). Since SVE will add another source of HAPs, the NIROP should consider building sufficient flexibility into their CAA Title V operating permit in order to avoid future permit modifications that could stall installation of the soil treatment system.

5.3.2 Cost Effectiveness

Costs estimated for the SVE system were developed based on information provided in EPA's Presumptive Remedy Guidance for VOC-Contaminated Soil (USEPA, 1993b) and vendor supplied information (see Appendix J). Capital costs consist of direct costs (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for equipment, labor, and materials necessary to install the remedial systems. Indirect costs include expenditures for engineering, financial, and other services that are not part of actual installation activities but are required to complete the installation of the remedial alternative.

Capital costs for the SVE system are based on areas identified as needing remediation, previously shown on Figure 3-2. Placement of vapor extraction wells can be adjusted to allow soil remediation beyond the areas outlined on Figure 3-2. Prior to the design of the SVE system, limited additional

investigation may be required to further define the outer extent of the impacted areas, although these areas will generally have relatively low concentrations. In addition, pilot-scale testing will be required to determine the number and spacing of SVE wells and the trenching and blower sizes.

Capital cost estimates for the SVE system at the NIROP are presented in Table 5-3. Direct capital costs include SVE recovery well installation, trenching and piping, blowers, water knock-out pots, and off-gas control equipment. Indirect capital costs include pilot-scale testing, engineering design, construction/operational permits, start-up, and a 30 percent contingency. The estimated installed capital cost for the SVE system at the NIROP is $919,000. The basis of the estimate is included in Appendix H. A breakdown of unit costs for the SVE system is included as Appendix J. Construction costs for items such as trenching and piping and installation of a building to house the equipment were obtained from vendor quotations, Means Building and Construction Data, and from personal experience in designing and installing similar-type systems.

Annual operation, maintenance, and monitoring (O&M) costs are also presented in Table 5-3. These costs include operating labor, maintenance, and energy. Labor costs assume a total of 16 hours per week by an employee at the NIROP to remove water from the air/water separator, measure off-gas VOC concentrations, and monitor airflows from each vapor extraction well. Annual maintenance costs assume 10 percent of the equipment costs. Electrical costs are based on operation of the four 10-hp blowers for 8,760 hours per year. In addition, a 5-year review cost has also been included assuming a 20-year operational period. The estimated annual operating costs for the SVE system are $115,000 per year. A summary of operational costs are attached in Appendix J.

A present worth analysis has been conducted to evaluate expenditures that occur over different time periods by discounting all future costs to the current year. This allows all remedial alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life.

The present worth analysis was conducted for an operational period of 20 years. This relatively long operational period was selected because VOCs in groundwater and potential VOCs under the building will continue to recontaminate the soils in OU2. The present worth analysis assumed an interest rate of 5 percent (EPA/540/G-89/004). Therefore, the total present worth cost of the SVE system is $2,355,000.

TABLE 5-3

REMEDIAL ALTERNATIVE - SOIL VAPOR EXTRACTION
ESTIMATED CAPITAL AND OM&M COSTS

DIRECT CAPITAL COSTS	
Vapor extraction wells ($1,080/well)[a]	$58,400
Trenching/Piping ($25.34/foot)[a]	$86,200
Regenerative blowers[b]	$12,000
Vapor/Liquid separators	$2,500
Liquid transfer pumps	$2,400
Carbon Adsorbers	$15,800
Solenoid valves[c]	$12,400
Vacuum gauges[c]	$2,700
Flow gauges[c]	$6,500
Buildings with HVAC ($50 ft^2)[d]	$13,000
Equipment Cost (EC)	**$262,700**
Freight (2% of EC)	$5,200
Equipment Delivered Cost (EDC)	**$268,000**
Installation (50% of EDC)	$133,900
Electrical (10% of EDC)	$26,800
Instrumentation/Controls (10% of EDC)	$26,800
Subtotal of Direct Capital Costs (TDC)	**$455,000**
INDIRECT CAPITAL COSTS	
Engineering (15% of direct costs)	$68,000
Construction Supervision (15% of direct costs)	$68,000
Pilot-scale design and testing	
Licenses, permits, and approvals (10% of direct costs)	$45,000
System start-up (10% of direct costs)	$45,000
Subtotal of Indirect Costs	$252,000
Total Estimated Capital Cost (Direct + Indirect Costs)	**$707,000**
30% Contingency	$212,000
Total Estimated Project Capital Costs	**$919,000**

TABLE 5-3

REMEDIAL ALTERNATIVE - SOIL VAPOR EXTRACTION
ESTIMATED CAPITAL AND OM&M COSTS

OPERATING, MAINTENANCE, AND MONITORING (OM&M) COSTS[f]	
Electrical (assume four blowers at 10 hp at $0.08/each)	$22,000.00
General maintenance (assume 10% of equipment costs)	$25,000.00
Monitoring labor (assume 16 hours/wk at $30/hr)	$25,000.00
Sample analysis (assume 1 sample/wk at $100/sample)	$6,500.00
5-year review cost	$10,000.00
Subtotal of Indirect Costs	**$88,500.00**
30% Contingency	$26,500.00
Total Estimated Project Capital Costs	**$115,000.00**
Equal Series OM&M Costs[e]	**$1,436,000.00**
Total Present Worth (Capital Plus OM&M Present Worth)[e]	**$2,355,000.00**

NOTES:

[a] Costs are based on a quotation from M.L. Furman Co., Fond du Lac, Wisconsin.
[b] Costs are based on an estimate from EG&G Rotron.
[c] Costs were obtained from Grainger Industrial Equipment.
[d] Cost Estimate was obtained from Mean's Building Construction Cost Data, 1992.
[e] Present worth costs assume a 20-year operational period and a 5% interest rate.
[f] Excalation factors for indirect costs and OM&M costs are based on RMT's experience with similar type projects.

5.4 ALTERNATIVE 4: EXCAVATION AND THERMAL DESORPTION OF SOILS

This section discusses the effectiveness of excavation and thermal desorption to protect human health and the environment, its implementability in relation to the physical characteristics of the site, permanence, and estimated costs. Figure 5-4 summarizes the evaluation.

5.4.1 Performance Evaluation

Thermal desorption has proved to be an effective technology for the removal of various contaminants, including VOCs, SVOCs, PCBs, cPAHs, pesticides, and volatile metals. VOC removal efficiencies of 99.99 percent can be achieved with thermal treatment units (Freeman, 1989). Furthermore, cPAH removal efficiencies greater than 99 percent (USEPA, 1992) have been demonstrated in treatability tests. Trailer-mounted mobile treatment systems containing material feed equipment, thermal processor (e.g., rotary dryer, thermal screw unit, vapor extraction systems, distillation chambers), and VOC control equipment can be rented from environmental equipment vendors or environmental consultants. Alternatively, excavated soil can be transported off-site for treatment at a fixed facility. However, commercial availability of mobile thermal desorption units tends to make off-site treatment less cost-effective due to soil transportation costs.

Approximately 300,000 cubic yards of contaminated soil would be processed to thermally desorb the VOCs and cPAHs. The desorbed organic compounds would be destroyed (100 percent irreversibly) by catalytic oxidation of the off-gas, to form relatively innocuous gases, namely carbon dioxide, water vapor and hydrogen chloride. Bench-scale treatability studies coupled with contaminant data and soil characteristics data are useful in determining the overall effectiveness of thermal desorption to the site. Separate characterizations will need to be performed on distinctly different areas of the site to determine the implementability and appropriateness of thermal desorption throughout the site. Specifically, the combined boiling points of the VOCs and cPAHs to be removed should be determined from these treatability studies to ascertain the optimum operating residence time and temperature.

During the excavation and stockpiling of soil, workers involved in the excavation activities will be required to wear appropriate PPE in accordance with an approved health & safety plan. Onsite and perimeter monitoring will be required to ensure protection of the workers and surrounding community.

Following remediation, treated soils will be placed back into the excavation and compacted. Excavation and thermal desorption will prevent exposure to VOCs and cPAHs following remediation.

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- Excavation and thermal desorption will remove VOCs and cPAHs currently present in the soil, thereby preventing short-term exposure to contaminants.
- Excavation and thermal desorption prevents further groundwater contamination and off-site migration by VOCs, currently present in the unsaturated soils of OU2.
- Excavation and thermal desorption will not prevent VOCs in the groundwater, or from areas beneath buildings from recontaminating pore gas and treated soils.
- Excavation and stock-piling of contaminated soils will increase the risk of worker exposure via inhalation, dermal absorption and incidental ingestion of VOCs and cPAHs. Measures must be instituted during treatment to protect workers and the community from exposure.
- Contaminated soil beneath buildings and roadways which is not excavated because of site constraints will remain untreated.

COMPLIANCE WITH ARARs

- Thermal desorption will decrease the existing concentrations of VOCs and some cPAHs in the unsaturated treated soils to target clean-up levels.
- Thermal treatment of chlorinated compounds is restricted by the MPCA; therefore, emission tests may be required to verify the removal/destruction efficiency of the equipment and the associated air emission control devices. Air emissions must achieve air quality standards. A variance to existing requirements will be needed.
- May require compliance with RCRA storage and treatment provisions if localized areas of soils are classified as hazardous.
- Best management practices (i.e., sediment and erosion controls) for surface water control measures must be used during excavation.
- If treatment residuals are transported off-site, they must meet the requirements of Minnesota Statutes, Sections 221.033, 221.034 and 221.035.
- Excavation and thermal desorption can meet location specific ARARs. Since the natural beneficial value of the flood plain can be maintained after treated soils are backfilled and compacted within the excavation.

LONG-TERM EFFECTIVENESS AND PERMANENCE

- Effectively removes contaminant sources in OU2 current soils.
- Long term monitoring of soil pore gas will be required to determine when concentrations achieve risk based clean-up goals.
- Soils under buildings and roadways which are not excavated will not be treated.
- May involve the disposal or treatment of residuals such as scrubber water and sludge.

REDUCTION OF TOXICITY MOBILITY, AND VOLUME THROUGH TREATMENT

- Approximately 300,000 cu. yd. of contaminated soil treated by volatilization of over 99% of VOC's and PAH's followed by catalytic oxidation (100% irreversibly) of over 99% of organics.
- Will require on-site testing to verify operating conditions and removal efficiency.

SHORT-TERM EFFECTIVENESS

- Thermal desorption requires extensive sub-surface excavation. Such excavation will likely result in higher ambient air concentrations of VOCs as well as increased risks to workers from dermal absorption and ingestion of both VOCs and cPAHs.
- Excavation and stock-piling of contaminated soils will temporarily increase the risk of worker exposure via inhalation, dermal absorption and incidental ingestion of VOCs and cPAHs.

IMPLEMENTABILITY

- Thermal desorption units are normally mobile systems which are leased to the client for the remediation period.
- Multiple vendors of excavation and thermal desorption equipment are available to obtain competitive bids.
- Thermal desorption will be subject to regulatory requirements including, amendment to existing air permit; inclusion in Title V air permit for facility; and applicable air toxic emission limits under MPCA screening emission rates.
- Combustion of chlorinated compounds is restricted by the MPCA; therefore emission tests will be required to verify the removal/destruction efficiency of the equipment and the associated air emission control devices.
- Process will disrupt NRDP activities during excavation.
- Excavations as deep as 20 feet in the sandy soils at NRDP will present significant engineering difficulties. The sandy soil will tend to collapse readily, forcing the excavation sidewalls to be sloped substantially.
- Treatability studies would be required.

COST

TOTAL CAPITAL ($)	O&M ($/year) (1)	PRESENT WORTH ($)	UNIT COST ($/ton)
32,124,000	None	32,124,000	71.39

NOTES:

(1) Excavation and Thermal Desorption is a one-time Capital cost and does not require annual O&M.

ALTERNATIVE SUMMARY:
EXCAVATION & THERMAL DESORPTION

RMT INC.

DWN. BY: MHS
APPROVED BY:
DATE: APRIL 1995
PROJ. # 3094.21
FILE # 30942107

FIGURE 5-4

Proper civil engineering guidelines should be followed during excavation of the large soil volume in the sandy soil conditions predominant at NIROP to prevent sidewalls from collapsing. Sidewalls in unstable soils (Type C), such as the sandy soils at the NIROP, should be sloped at a ratio of 1.5 feet horizontally to 1 foot vertical to a maximum depth of 20 feet (Code of Federal Regulations, 1989). In addition, excavations near building foundations will require mechanical stabilization such as sheetpiling to prevent the building from collapsing. Estimated costs presented in Subsection 5.4.2 have included the sloped excavation and mechanical supports, such as sheetpiling to stabilize buildings.

Regulatory constraints affecting the implementability of thermal desorption at the site include air emission regulations as well as the potential for hazardous waste handling. The NIROP production operations result in hazardous air pollutant (HAP) emissions that classify the facility as a *major source* pursuant to the Clean Air Act Title V requirements under 40 CFR Part 70; therefore, the NIROP's existing air permit will have to be amended to provide for thermal desorption of contaminated soils. An amendment may require public notice and a subsequent comment period of approximately 90 days depending on the applicable permitting rules and the controversy of the operation (i.e., excavation resulting in the production of malodorous emissions). Since thermal treatment of chlorinated compounds is currently restricted by the MPCA, it will likely be necessary to perform emission tests of the thermal desorption system to verify the adequacy of the control equipment and to determine if the operation does not result in additional emissions of concern. In addition, the thermal desorption operation will have to be included as a source of HAPs, VOCs, and particulate matter, unless otherwise exempt by applicable CERCLA exemptions regarding thermal desorption of soils relative to air pollution requirements.

The Navy may also need to follow the requirements of a RCRA Part B permit since some soils in localized areas at the NIROP may be classified as hazardous waste once they have been excavated. As a result of stockpiling excavated soil, there would be an increased risk of worker exposure to high levels of contaminants through inhalation of VOCs and soil particles contaminated by cPAHs, dermal absorption, and incidental ingestion.

The total amount of soil required to be excavated could potentially disrupt normal plant operations; thereby limiting the use of this technology to selected areas of the site. For example, contaminated soil underlying roads and buildings might not be able to be excavated for treatment since this would jeopardize the structural integrity.

5.4.2 Cost Effectiveness

Project costs for excavation and thermal desorption of soils at NIROP will include site preparation, thermal treatment, and site closure. The thermal process supplied by the vendor will consist of excavation of soils, operation of the thermal treatment equipment, and operation off-gas control equipment.

Project costs are based on excavation and thermal desorption of the areas presented previously on Figure 3-2. Calculations showing the soil volumes and the sidewall slopes are included in Appendix H.

Prior to engineering, additional investigative work should be conducted to further define the outer extent of VOCs in pore gas contamination, and therefore the costs. In addition, field-screening must be conducted during excavation to determine when non-VOC-impacted soils are encountered.

Estimated project costs for excavation and thermal treatment of soils shown on Figure 3-2 are $32,124,000. A summary of costs is presented in Table 5-4. The total estimated volume of soil that requires excavation and thermal treatment is 450,000 tons. Total project costs include site preparation (vegetation removal, decontamination pad removal, removal of railroad tracks), thermal treatment, site closure (grading, a surface water drainage system, re-vegetation, construction of an access road), and a 30 percent contingency. A breakdown of the individual costs is provided in Appendix J.

Excavation and thermal desorption is a one-time service; therefore, no annual operating, maintenance, and monitoring charges are incurred.

Another factor that may increase the overall project cost is the moisture content of the soils. If high moisture content conditions are encountered (>20 percent) in the NIROP soils, additional residence time in the thermal desorption unit will be required, thereby slowing the rate of soil treatment and increasing the overall project costs. If high moisture contents are encountered, dry solids may need to be mixed with contaminated soils to achieve adequate processing rates. However, given the sandy nature of the soils, high moisture conditions are not expected to be encountered.

During remedial design (RD), bench-scale testing will be performed to determine the combined boiling points of the contaminants to be treated from selected zones of contamination. The results of these tests will be used to determine the optimum operating temperature and residence time for

TABLE 5-4

ESTIMATED CAPITAL COSTS FOR EXCAVATION AND THERMAL DESORPTION OF SOIL

DIRECT COSTS	
Site preparation[a]	$521,000
Mobilization/Demobilization[b]	$15,000
Excavation of soil ($2.00/ton)[b,c]	$900,000
Thermal desorption ($48.00/ton) (includes backfill and compaction)[b,c]	$21,600,000
Site closure[a]	$45,000
Subtotal of Direct Capital Costs	$23,081,000
INDIRECT COSTS	
Engineering (1% of direct costs)	$231,000
Thermal desorption air compliance report	$15,000
Construction oversight (5% of direct costs)	$1,154,000
Licenses, permits, and approval (1% of direct costs)	$231,000
Subtotal of Indirect Costs	$1,631,000
Total estimated costs (direct + indirect)	$24,712,000
30% Contingency	$7,412,000
TOTAL ESTIMATED PROJECT COSTS	$32,124,000

NOTES:

[a] Costs from Means Building and Construction Data.
[b] Costs for mobilization, excavation, and thermal desorption provided by Soil Remediation Sources, Inc., of Butler, Wisconsin.
[c] Estimated soil volume is 450,000 tons.

the thermal desorption system, and therefore the actual costs to thermally desorb a ton of contaminated NIROP soil.

5.5 ALTERNATIVE 5: EXCAVATION AND INCINERATION OF SOILS

This section outlines the short- and long-term effectiveness of excavation and incineration (incineration) for protecting human health and the environment, the implementability of excavation and incineration in relation to the physical characteristics of the site, and the estimated costs for remediation of OU2 soils. Figure 5-5 summarizes the advantages and disadvantages of soil incineration in relation to the evaluation criteria.

5.5.1 Performance Evaluation

Excavation and incineration of soil is expected to reduce the concentration of VOCs in both compositional soils and pore gas and cPAHs in soil to levels that are protective of human health and the environment. Excavation and incineration will also prevent any further deterioration of groundwater quality at the NIROP, which would be due to leaching of additional constituents from the soil. ARARs relative to excavation and incineration were developed in Section 2.

Approximately 300,000 cubic yards of contaminated soil would be processed to incinerate over 99 percent of the VOCs and cPAHs. Organic compounds would be destroyed (100 percent irreversibly) by high temperature thermal oxidation of the soils to yield relatively innocuous gases, namely carbon dioxide, water vapor, and hydrogen chloride.

Following remediation, treated soils will be placed back into the excavation and compacted. VOCs contained in the groundwater below the clean soil may continue to volatilize, causing soil pore gas to become recontaminated. If possible, the Navy should consider excavation and thermal treatment.

Mobile thermal treatment systems can be transported to the NIROP for soil incineration, making this aspect of the treatment relatively easy to implement. Rotary kilns tend to be the most common incineration technology used because they represent a commercially proven technology that offers the capability of handling a wide variety of contaminants with minimal feed pretreatment and provides thorough mixing with long residence times for solids. Mobile treatment systems containing material feed equipment, the incineration unit (e.g., rotary kiln, fluidized-bed), and VOC and particulate matter control equipment can be leased from environmental equipment vendors or environmental consultants (see Appendix I). Alternatively, excavated soil can be transported off-site for treatment at a fixed facility. However, compared to mobile incineration units, off-site treatment

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- Excavation and incineration will remove VOCs and cPAHs currently present in the soil, there by preventing short-term exposure to contaminants.
- Excavation and incineration prevents further groundwater contamination and off-site migration by VOCs, currently present in the unsaturated soils of OU2.
- Excavation and incineration will not prevent VOCs in the groundwater, or from areas beneath buildings from re-contaminating the pore gas and treated soils.
- Excavation and stock-piling of contaminated soils will increase the risk of worker exposure via inhalation, dermal absorption and incidental ingestion of VOCs and cPAHs, during remediation. Measures must be instituted during treatment to protect workers and the community from exposure.
- Contaminated soil beneath buildings and roadways which is not excavated because of site constraints will remain untreated.

COMPLIANCE WITH ARARs

- Excavation and incineration will decrease the existing concentrations of VOCs and cPAHs in the unsaturated soils to target clean-up levels. However, incineration does not prevent re-contamination of the soil from VOCs in the soil under buildings or in the groundwater.
- Combustion of chlorinated compounds is restricted by the MPCA; therefore it will likely be necessary to perform emission tests of the incinerator to verify removal/destruction efficiency of the equipment and the associated emission control devices, and to determine if operation of the incinerator results in the generation of additional emissions of concern. A variance to existing requirements will be needed.
- Best management practices (i.e., sediment and erosion controls) for surface water control measures must be used during excavation.
- May require compliance with RCRA storage and treatment provisions if localized areas of soils are classified as hazardous.
- Excavation and incineration can meet location specific ARARs. Since the natural beneficial value of the flood plain can be maintained after treated soils are backfilled and compacted within the excavation.
- If treatment residuals are transported offsite they must meet the requirements of Minnesota Statutes, Sections 221.033, 221.034 and 221.035.

LONG-TERM EFFECTIVENESS AND PERMANENCE

- Effectively removes current contaminant sources in OU2 soils.
- Is a well-demonstrated techinique for treating VOCs and cPAHs in soil.
- Incineration will not provide long-term effectiveness. Contaminated groundwater below OU2 will eventually recontaminate soil due to volatilization.
- Soils under buildings or roads which are not excavated will not be treated.
- Because VOCs from the groundwater will recontaminate soil pore gas after remediation, the long term effectiveness is limited until after groundwater clean-up is completed.
- May involve disposal or treatment of residuals such as scrubber water ash and sludge.

REDUCTION OF TOXICITY MOBILITY, AND VOLUME THROUGH TREATMENT

- Approximately 300,000 cu. yd. of contaminated soil treated by incineration with destruction efficiencies exceeding 99% for the VOC's and CPAH's of concern.
- Incineration generates additional wastes, including ash or "residuals", which may be hazardous, and must be disposed of in an approved landfill.

SHORT-TERM EFFECTIVENESS

- Incineration requires extensive sub-surface excavation. Such excavation will likely result in higher ambient air concentrations of VOCs, as well as increased risks to workers from dermal absorption and ingestion of both VOCs and cPAHs.
- Incineration will remove existing VOCs from soil limiting further leaching and impacts to groundwater.
- Excavation and stock-piling of contaminated soils will temporarily increase the risk of worker exposure via inhalation, dermal absorption and incidental ingestion of VOCs and cPAHs.

IMPLEMENTABILITY

- Incinerator units are normally mobile systems which are leased by the client for the remediation period.
- Multiple vendors of excavation and incineration equipment are available to obtain competitive bids.
- Incineration will be subject to regulatory requirements including: amendment to existing air permit; inclusion in Title V air permit for facility; and applicable air toxic emission limits under MPCA screening emission rates.
- Combustion of chlorinated compounds is restricted by the MPCA. Therefore it will likely be necessary to perform emission tests of the incinerator to verify removal/destruction efficiency of the equipment and the associated emission control devices, and to determine if operation of the incinerator results in the generation of additional emissions of concern.
- Incineration of OU2 soils will disrupt NIROP activities during excavation.
- Excavations as deep as 20 feet in the sandy soils at NIROP will present significant engineering difficulties. The sandy soil will tend to collapse readily, forcing the excavation sidewalls to be sloped substantially.
- Typical trial burns are required.

COST

TOTAL CAPITAL ($)(1)	OM&M ($/year)(1)	PRESENT WORTH ($)	UNIT COST ($/ton)
125,000,000	none	125,000,000	278

NOTES:

(1) Excavation and incineration of soil is a one-time Capital cost and does not require annual OM&M.

ALTERNATIVE SUMMARY:
EXCAVATION & INCINERATION

RMT INC.

DWN. BY: MHS
APPROVED BY:
DATE: APRIL 1995
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is oftentimes more expensive due to the lack of vendor competition and the high cost of soil transportation.

Proper civil engineering guidelines should be followed during excavation to prevent sidewalls from collapsing or destabilizing building foundations. Sidewalls in unstable soils (Type C), such as the sandy soils at the NIROP, should be sloped at a ratio of 1.5 feet horizontal to 1 foot vertical to a maximum depth of 20 feet (29 CFR 1926, Appendix B to Subpart P). When excavating near building foundations, sheetpiling may be required to stabilize the soils.

Regulatory constraints affecting the implementability of incineration at the site, as well as hazardous material handling, were discussed in Section 2. One primary concern is that production operations at the NIROP Fridley would likely result in hazardous air pollutant (HAP) emissions that classify the facility as a *major source* pursuant to the Clean Air Act Title V requirements under 40 CFR Part 70. Therefore, the incineration operation would have to be included as a source of HAPs, VOCs, and particulate matter under Minnesota's Part 70 permit program.

The NIROP's existing air permit would have to be amended to provide for incineration of contaminated soils and a waiver of ARARs obtained for incinerations of chlorinated solvents in Minnesota. An amendment may require public notice and a subsequent comment period of approximately 90 days depending on the applicable permitting rules and the controversy of the operation (i.e., excavation resulting in the production of malodorous emissions). Because combustion of chlorinated compounds is restricted by the MPCA, it will likely be necessary to perform emission tests of the incinerator to verify the removal efficiency of the control equipment and to determine if operation of the incinerator does not result in additional emissions of concern (e.g., dioxins). These design and permitting criteria will be determined during the trial burn. Monitoring will also likely be required pursuant to air toxics regulations. In the case of combustion operations, this typically entails monitoring the operating temperature to ensure adequate destruction of contaminants.

The Navy may also need to comply with RCRA Part B permit requirements since some soils in localized areas at the NIROP may be classified as a hazardous waste once they have been excavated. As a result of stockpiling excavated soil, there would be an increased risk to worker exposure to high levels of contaminants through inhalation of VOCs and soil particles contaminated by cPAHs, dermal absorption, and incidental ingestion. Additionally, the total amount of soil

required to be excavated could potentially disrupt normal plant operations, thereby limiting the use of this technology to selected areas of the site.

Incineration generates additional wastes that must also be managed, including ash or "residuals" and possibly sludges or wastewater from air pollution control devices. If the residuals are considered nonhazardous, they may be used as backfill material or managed as a solid waste; otherwise, they may be required to be disposed in an approved hazardous waste landfill. The proper disposal of sludges and wastewater must also be addressed if considered to be hazardous.

5.5.2 Cost Effectiveness

Estimated treatment costs for incineration of OU2 soils are presented in Table 5-5. Costs are based on excavation of the areas presented previously on Figure 3-2 and the calculations attached in Appendix I. Because the outer area where pore gas VOCs and cPAHs exceed the cleanup goals was not entirely defined during the Remedial Investigation, the actual volume of soil that would be excavated during remediation may be somewhat larger (up to 30 percent) than that shown on Figure 3-2. Prior to engineering, additional investigative work may need to be conducted to further define the extent of contamination and therefore the costs. In addition, field-screening must be conducted during excavation to determine when nonimpacted soils are encountered. The total estimated cost (direct plus indirect) of incineration of soil is approximately $97,000,000. Assuming a 30 percent contingency, the total project cost could approach $125,000,000. The major contributor to the cost is the very large volume of soil (450,000 tons) and the high cost for incineration of chlorinated solvents. Estimated costs for incineration of soil contaminated with chlorinated solvents range from $200 to $225 per ton (estimated costs from IT Corporation, Knoxville, TN). Other direct costs include site preparation, such as removal of the decontamination pad and any existing railroad tracks. Estimated costs for site closure include installation of a subsurface drainage system to remove surface water, grading and backfilling, revegetating, and installation of an access road. A breakdown of the individual costs are included in Appendix J. Calculations showing the estimated volume of soil that requires thermal treatment are included in Appendix I.

TABLE 5-5

REMEDIAL ALTERNATIVE - EXCAVATION AND INCINERATION OF SOIL ESTIMATED CAPITAL COSTS

DIRECT COSTS	
Site preparation[a]	$44,000
Soil incineration ($212.50/ton)[b,c]	$94,350,000
Site closure[a]	$45,000
Subtotal of Direct Capital Costs	$94,439,000
INDIRECT COSTS	
Engineering and procurement (0.1% of direct costs)	$94,000
Incineration trial burn air compliance report	$20,000
Construction oversight (1% of direct costs)	$944,000
Licenses, permits, and approval (0.1% of direct costs)	$94,000
Subtotal of Indirect Costs	$1,152,000
Total estimated costs (direct + indirect)	$95,590,000
30% Contingency	$28,700,000
TOTAL ESTIMATED PROJECT COSTS	$124,290,000

NOTES:

[a] Site preparation costs from Means Building and Construction Data
[b] Incineration cost estimate provided by IT Corporation of Knoxville, Tennessee. Estimated incineration costs range between $200 and $225/ton and include mobilization/demobilization, excavation, incineration, backfilling, compaction, grading, trial burns, and operational permits.
[c] Estimated mass of soil is 444,000 tons.

Section 6

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

6.1 OVERVIEW

Alternatives for the NIROP Fridley were individually compared to evaluation criteria in Section 5. The objective of this section is a comparative analysis between the alternatives, to assist in the selection that meets the ARARs and protects human health and the environment. To accomplish this comparison, the USEPA has identified nine evaluation criteria in the NCP, which were considered separately by alternative previously. The nine criteria are as follows:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume
5. Short-term effectiveness
6. Implementability
7. Cost
8. Support agency (USEPA and MPCA) acceptance
9. Community acceptance

The first two criteria must be met for any alternative to be considered further. These include the overall protectiveness of the alternative, and the ability to achieve compliance with the ARARs. Criteria numbers 3 through 7, sometimes referred to as the "balancing criteria," can be the differentiating criteria from a technical perspective.

The final two criteria are modifying considerations that are typically taken into account when the ROD is prepared following the public comment period on the Proposed Plan and the RI/FS reports. Since both the USEPA and the MPCA share an equal role on this project, the agency acceptance criteria is incorporated into dual agency approval.

This section presents a comparative analysis of the five remedial alternatives. First, the threshold criteria are considered, and then each alternative is compared based on the following general categories:

- Effectiveness of the remedy on a long-term basis.
- Reduction of toxicity, mobility, or volume through treatment.
- Effectiveness of the remedy on a short-term basis, including worker and community protection during remediation.
- Implementability of the remedy, including implementation difficulties, and the availability of materials or services needed.
- Cost of the remedy, including capital costs, operation and maintenance costs, and present worth costs.

6.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES BASED UPON THRESHOLD CRITERIA

6.2.1 Protection of Human Health and the Environment

The no action alterative is the only alternative being reviewed that does not provide actions that will ensure protection of human health and the environment. The other four alternatives are protective in different ways. Alternative 2, Institutional Controls, protects human health by restricting land uses that could create a human health exposure above acceptable levels. Alternative 3, Soil Vapor Extraction, is protective for VOCs immediately, and may potentially be over time for cPAHs. Alternative 3 can be implemented concurrently to the groundwater remediation since operation over time allows continual removal of pore gas vapors from contaminated groundwater. Alternatives 4 and 5 are protective for cPAH compounds and VOCs in compositional soils above the groundwater.

6.2.2 Compliance with ARARs

Numerical soil standards for the contaminants of concern do not exist under either federal or state rules (promulgated ARARs). The MPCA has developed their soil leaching model to help establish site-specific target cleanup levels. This approach is a "to be considered" (TBC) regulatory policy and as such provides the basis for target cleanup goals. Similarly, risk-based cleanup criteria may be relevant or appropriate but not required by formal regulations. TBC policies can be incorporated into the evaluation of alternatives.

Alternatives 3, 4, and 5 are expected to achieve cleanup goals in a relatively short time when Target Cleanup Levels (TCLs) are developed based upon residential exposure scenarios, assuming groundwater treatment is complete. Since Alternative 2 restricts site use from residential exposure this control eliminates the residential exposure pathway. Alternative 1 (no action) allows potential unacceptable levels of risk from residential exposures if the site is redeveloped to a residential land use.

The TCLs calculated for protection of groundwater quality were only exceeded in locations on-site. Alternatives 3 through 5 effectively remediate the soils to below groundwater protection TCLs. Alternatives 1 and 2 would allow groundwater contamination to continue at levels exceeding TCLs.

ARARs that are associated with implementation of each alternative include hazardous waste management issues, emission controls, flood plain protection, and general construction requirements. In general, individual ARARs can be met by all the alternatives. One exception may be the current MPCA policy opposing thermal treatment for soils impacted with chlorinated compounds. This restriction would need to be waived if either Alternative 4 or Alternative 5 is selected.

6.3 COMPARATIVE ANALYSIS OF ALTERNATIVES BASED ON BALANCING CRITERIA

A comparison of alternatives based on their effectiveness in reducing the risks to human health and the environment, the implementability of each alternative at the NIROP Fridley, and the associated cost for each alternative is presented on Figure 6-1.

6.3.1 Long-Term Effectiveness and Permanence

With the exception of the "no action" alternative, each alternative will provide a degree of effectiveness and permanence. Institutional controls such as deed restrictions would be effective by preventing subsurface intrusion by facility and public personnel into contaminated areas. This will prevent risks to humans, as long as the Navy maintains ownership of the property and imposes deed restrictions.

A comparison of the three presumptive technologies shows that the technologies offer equivalent degrees of permanence. Both excavation technologies offer greater than 99 percent destruction of VOCs and cPAHs from the excavated soils to yield relatively innocuous gases, namely carbon dioxide, water vapor, and hydrogen chloride. The soil vapor extraction, followed by off-gas catalytic oxidation, offers destruction of VOCs and PAHs achieving the target cleanup levels to yield the same

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	COST: TOTAL CAPITAL ($)	COST: OM&M ($/year)	COST: PRESENT WORTH ($)	COST: UNIT COST ($/ton)
No Action	• Does not protect future site users from exposure in residential scenarios or subgrade construction.	• There are no implementability concerns.	None	None	None	None
Institutional Controls	• Restricts future land use therefore protecting human health. • Effectiveness depends on the ability of the U.S.Navy to maintain ownership and control on future use of the property. • Requires periodic review (5 year).	• Institutional controls can be implemented immediately • Does not disrupt NIROP operations. • No worker or possibly community exposure during construction. • Is compatible with the groundwater system.	100,000	10,000	230,000	0.53
Soil Vapor Extraction	• Prevents recontamination of soil from groundwater. • Meets USEPA preference for treatment • Treats soils under roadways and buildings. • Proven technology for removal of VOCs. • 95% of soils are ideally suited for SVE. The remaining 5% can be effectively treated over time • Requires periodic review (5 year).	• Limited disruption to NIROP operations. • Requires on-going OM&M. • Requires treatability studies for biodegradation of PAHs. • Limited worker exposure during construction. • Is compatible with the groundwater system.	919,000	115,000	2,355,000	5.23
Excavation and Thermal Desorption	• Can not treat unexcavated soils under roadways or buildings. • Proven technology for VOCs and some cPAHs. • Effective for all on-site soil types.	• Disruptive to NIROP operations. • Requires over excavation to prevent sidewall collapse and shoring to stabilize building foundations. • Control measures will be required to prevent worker and possibly community exposure to VOCs and cPAHs during construction. • Requires waiver of ARARs to implement. • No on-going OM&M. • Requires disposal of off-gas treatment residues. • Requires capture and treatment of particulate emissions. • Requires treatability studies.	32,000,000	None	32,000,000	71.39
Excavation and Incineration	• Can not treat unexcavated soils under roadways or buildings. • Proven technology for VOCs and cPAHs. • Effective for all on-site soil types. • Would not be initiated until groundwater treatment is at or near completion.	• Disruptive to NIROP operations. • Requires over excavation to prevent sidewall collapse and shoring to stabilize building foundations. • Control measures will be required to prevent worker and possibly community exposure to VOCs and cPAHs during construction. • Requires waiver to ARARs to implement. • No on-going OM&M. • Requires disposal of ash, gas stream treatment residuns and possible soil stabilization after back fill and compaction. • Requires a trial burn.	125,000,000	None	125,000,000	278.00

NIROP
FEASIBILITY STUDY
COMPARISON OF
ALTERNATIVES FOR OU2

RMT

DWN. BY: TCP
APPROVED BY:
DATE: APRIL 1995
PROJ. # 3094.21
FILE # 30942119

NOTES:
(a) Present worth costs assume a 20 year operational period and a 5% interest rate.
(b) Unit costs assume the estimated mass of soil is 450,000 tons.

FIGURE #5

gases as the excavation technologies would yield. All three presumptive technologies would be 100 percent irreversible with regard to VOC and cPAH destruction.

The SVE technology provides the additional benefit of treating soils below roadways and Building 50. The excavation technologies are limited to treating soils accessible to excavation.

All three technologies have the potential to provide permanent removal of the soil contaminants provided the groundwater is treated prior to completion of the soil remediation. Because the groundwater is a possible source of contamination, the soils could be recontaminated if the groundwater remains untreated.

6.3.2 Reduction of Toxicity, Mobility, and Volume Through Treatment

There is no reduction of toxicity, mobility or volume other than due to natural attenuation in Alternatives 1 and 2. Each of the other alternatives employs a method of treatment to reduce the toxicity and mobility of contaminants in the soils.

In Alternative 3 (Soil Vapor Extraction) approximately 3 to 4 ton/year of total VOCs are expected to be removed from the soils and captured on the vapor-phase GAC adsorber. The VOCs would be destroyed during thermal regeneration of the spent GAC offsite. Potentially, biodegradation of cPAHs may also occur.

In Alternative 4 (Thermal Desorption) approximately 300,000 cubic yards of contaminated soil would be processed to desorb typically over 99.99 percent of VOCs and over 99 percent of most cPAHs. The desorbed organics would be destroyed (100 percent irreversibly) by catalytic oxidation of the off-gases.

In Alternative 5 (Incineration) approximately 300,000 cubic yards of contaminated soil would be processed to thermally oxidize typically well over 99 percent of all organics. The organics would be destroyed (100 percent irreversibly) by high temperature oxidation.

6.3.3 Short-Term Effectiveness

Short-term effectiveness addresses safety and monitoring concerns, as well as environmental impacts, during remediation. Because Alternative 1 (No Action) and Alternative 2 (Institutional Controls) involve no remediation, this criterion is not applicable to these Alternatives.

Comparison of the three presumptive technologies shows that Alternative 3 (SVE) has the least safety and monitoring concerns of the three. This is primarily due to Alternative 3 being an in-situ remediation, thus the potential worker exposure will be limited to the drilling and pipe construction. These activities will be short in duration, thus limiting the potential of the drilling resulting in particulate contaminant emissions during a dry or windy day. There would be a minimal potential for volatiles emissions to occur during the operation of the SVE system with the use of off-gas controls.

During the short potential exposure period of Alternative 3, risks could be limited by the use of personal protection equipment and by air monitoring. All risks to the community could be minimized through air monitoring.

Alternatives 4 and 5 (Thermal Desorption and Incineration) are excavation technologies. These Alternatives present risks of exposure to the workers throughout the remediation due to the amount of soil handling required. Risks to the community include the potential for dry or windy conditions to create dust emissions during the excavation and soil handling.

Risks to the workers could be limited by the use of personal protection equipment and by air monitoring. Any potential for the workers to be exposed to high temperatures can be minimized by the use of adequate controls and fail-safe measures in the design and operation of the treatment systems. Off-gas controls in Alternatives 4 and 5 will also minimize the potential for workers and the community to be exposed to contaminants. Risks to the community could be reduced through air monitoring. Risks to the community could be further reduced by limiting work to days in which the weather conditions are conducive to minimizing the potential for dust emissions or through the use of engineering controls such as spraying dust suppressants.

6.3.4 Implementability

Each of the alternatives presented on Figure 6-1 is implementable at the NIROP. The no action alternative does not have any implementability concerns. However, because this alternative is not effective in protecting human health, it will not be given further consideration. Alternative 2, institutional control, which restricts land use in contaminated areas of the NIROP is implemented by putting restrictions on soil and groundwater use. Restrictions on land use by the NAVY can be implemented immediately. Institutional controls will not disrupt the present operations of the NIROP, but would limit future land use options. Institutional controls would not disrupt the present groundwater treatment system.

Comparison of the three presumptive remedies (Alternatives 3, 4, and 5) for OU2 shows that soil vapor extraction would be the least complex (with regard to excavated soil handling and logistics) of these three alternatives to implement. During construction of the SVE system, worker exposure to contaminated soil will be limited by use of personnel protection equipment when drilling and constructing piping. Conversely, if all contaminated soils are excavated and treated thermally (Alternatives 4 and 5), the volume of contaminated soil that must be handled will increase substantially, increasing potential exposures of construction workers. In addition, uncontrollable weather conditions, such as high winds, could result in exposure of other on-site workers and possibly the community to high levels of VOCs or cPAH, and therefore treatment operations may need to be discontinued during these periods.

Each of the three presumptive remedies may require off-gas treatment to remove VOCs prior to discharge of off-gases; however, excavation and thermal treatment may require a waiver to the ARARs from the State of Minnesota, prior to implementation. One disadvantage of Alternative 3 when compared to the other presumptive remedies is the continued need for on-going operations, and maintenance and monitoring (OM&M) of the system. The presumptive remedies would also require treatability studies.

6.3.5 Cost

Of the four alternatives that are protective of human health and the environment, institutional controls is the least expensive, as shown on Figure 6-1. The estimated present worth cost for Alternative 2 ($225,000) includes initial legal fees to prepare the appropriate deed restrictions, and costs incurred for the 5-year review of the site. Estimated present worth costs for Alternative 3 ($2,274,000) includes direct and indirect capital expense, operation and maintenance costs over a 20-year operational period, and costs incurred for the first 5-year review of the site.

Both of the excavation and thermal desorption/incineration technologies are orders of magnitude more costly. Using an estimated cost of $71.39/ton of soil, the total estimated cost for excavation and thermal desorption will be $32,124,000. Based on a unit cost of $278/ton of soil, excavation and incineration costs are approximately $125,000,000 for OU2 soil.

6.4 COMPARATIVE ANALYSIS OF ALTERNATIVES BASED UPON MODIFYING CRITERIA

As discussed previously, modifying criteria will be addressed in the Record of Decision (ROD) after comments on the FS and proposed plan have been received. The following sections address the current status of each modifying criterion

6.4.1 State Acceptance

State review and acceptance has been an ongoing aspect of the NIROP Fridley project because of the joint agency lead between the USEPA and the MPCA.

6.4.2 Community Acceptance

To date, Restoration Advisory Committee (RAB) meetings have been conducted quarterly to inform interested parties, including community members and representatives, of the overall remediation status and progress at the NIROP Fridley The ongoing transfer of information should limit the number of unanticipated concerns regarding site issues.

Section 7

REFERENCES

American Petroleum Institute. 1984. The Land Treatability of Appendix VIII Constituents Present in Petroleum Industry Wastes. Publication 4379.

Cerniglia, C.E. 1981. Bioremediation of Polycyclic Aromatic Hydrocarbons. Current Opinion in Biotechnology, Volume 4, No. 3, pps 331-338.

Code of Federal Regulations. 1989. 29 CFR Part 126, OSHA Subpart P, Excavations and Trenches.

Dagley, S. 1971. Catabolism of Aromatic Compounds by Microorganisms. Advances in Microbiology and Physiology 6(1), pp. 1-46.

Dragun, J. 1988. The Soil Chemistry of Hazardous Materials.

Envirodyne Engineering, Inc. 1983. Initial Assessment of Naval Industrial Reserve Ordnance Plant, Minneapolis, Minnesota. For Naval Energy and Environmental Support Activity, Port Hueneme, California. NEESA 13-029. June 1983.

Fleming, J.T., J. Sanseverino, and G.S. Sayler. 1993. Quantitative Relationship Between Naphthalene Catabolic Gene Frequency Expression in Predicting PAH Degradation in Soils at Town Gas Manufacturing Sites. Environmental Science and Technology. 27(6): 1068-1074.

Freeman, H. 1989. Standard Handbook of Hazardous Waste Treatment and Disposal, Chapter 8. McGraw-Hill Book Company, New York, New York.

Genes, B.R., and C.C. Cosentini. 1993. Bioremediation of Polycyclic Aromatic Hydrocarbon Contaminated Soils at Three Sites. In: Hydrocarbon Contaminated Soils, Chapter 18. pps 323-330, Lewis Publishers, Ann Arbor, Michigan.

Gibson, D.T. 1977. Biodegradation of Aromatic Petroleum Hydrocarbons. Fate and Effect of Petroleum Hydrocarbons in Marine Ecosystems and Organisms, D.A. Wolfe, ed. Penguin Press, New York.

Handbook of Chemistry and Physics, 68th edition. 1987. Robert Weast, editor. CRC Press, Inc., Boca Raton, Florida.

Howard, R. 1991. Handbook of Environmental Degradation Rates.

Johnson, P.C., M.W. Kemblowski, J.D. Colhart, and D.L. Byers. 1990. A Practical Approach to the Design, Operation, and Monitoring of In-Situ Soil Venting Systems. Groundwater Monitoring Review, 10(2): 150-178.

Little, John C., Joan Daisey, and W.M. Nazaroff. 1992. Transportation of Subsurface Contaminants Into Buildings. Environmental Science and Technology, v. 26, No. 11, pps 2058-2065.

Luthy, R.G., D.A. Dzombak, and C.A. Peters. 1994. Remediating Tar Contaminated Soils at Manufactured Gas Plant Sites. Environmental Science and Technology. 28(6): 266A-276(a).

Montgomery, J.H. and L.M. Wolkon. 1990. Groundwater Chemicals Desk Reference. Lewis Publishers, Inc., Chelsa, MI.

MPCA. 1992. Office Memorandum from James L. Werner. Site Response Soil Cleanup Procedures.

MPCA. 1995. January 26, 1995, Letter from James L. Warner to Mr. David Cabiness.

Means Building Construction Cost Data, 51st Edition. 1993.

Park, K., R. Sims, R. Dupont. 1990. Transformation of PAHs in Soil Systems. Journal of Environmental Engineering 116, pps 632-640.

Rand McNally. 1992. Commercial Atlas and Marketing Guide. 123rd edition.

Ridlick, J.A., and W.B. Bunger. 1978. Organic Solvents, Physical Properties, and Methods of Purification. Wiley-Interscience, New York, New York.

RMT, Inc. 1987. Remedial Investigation Report for Remedial Investigation/Feasibility Study at the Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota. June 1987.

RMT, Inc. 1993. Remedial Investigation Report of the Soils Operable Unit - The Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota. September 1993.

RMT, Inc. 1994. Alternatives Array Document for Soils Operable Unit, Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota. November 1994.

Sims, R.C., and M. R. Overcash. 1983. Fate of Polynuclear Aromatic Compounds in Soil-Plant Systems. Residue Review, 88, pp. 1-68.

U.S. Department of Health and Human Services. 1993. Toxicological Profile for Polycyclic Aromatic Hydrocarbons. Clement International Corporation Under Contract No. 205-88-0608. October 1993.

USEPA. 1986. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response. Washington, D.C. EPA 540/1-86/060.

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, EPA/540/G-89/004. October 1988.

USEPA. 1989. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part A: Baseline Risk Assessment. December 1989, EPA/540/1-89/002.

USEPA. 1991a. Engineering Bulletin - In-Situ Soil Vapor Extraction Treatment. EPA/540/2-91/006, May 1991.

USEPA. 1991b. Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction. Interim Guidance. EPA/540/2-91/019A, September 1991.

USEPA. 1991c. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals. Oswer Directive 9285. 7-01B.

USEPA. 1991d. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part A and Supplemental Guidance: Standard Default Exposure Factors: Interim Final. OSWER Directive 9285.6-03, March 1991

USEPA. 1991e. Soil Vapor Extraction Technology: Reference Handbook. EPA/540/2-91/003. February 1993.

USEPA. 1992. Guide for Conducting Treatability Studies Under CERCLA: Thermal Desorption Remedy Selection. Interim Guidance. EPA/540/R-92/074A, September 1992.

USEPA 1993a. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. EPA/600-R-93/089. July 1993.

USEPA. 1993b. Presumptive Remedies Policies and Procedures. EPA 540-F-93-047, September 1993.

USEPA. 1993c. Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in soils. EPA 540-F-93-048, September 1993.

USEPA. 1994. Technical Background Document for Soil Screening Guidance EPA/540/R-94/106 Review Draft. December, 1994.

Wilson, D.E., and R E. Montgomery 1982 A Mathematical Model for Removing Volatile Subsurface Hydrocarbons by Miscible Displacement Water, Air, and Soil Pollution. 33(3-4): pp. 231-235.

APPENDIX A

MINNESOTA POLLUTION CONTROL AGENCY PROCEDURES FOR ESTABLISHING SOIL CLEANUP GOALS

Current guidance for establishing soil cleanup goals will be provided in the OU3 Feasibility Study (FS). This is appropriate since the OU3 FS is where the guidance will actually be applied to establish these numerical cleanup goals.

This guidance is not necessary in this OU2 FS since no numerical cleanup standards are being established at this time.

APPENDIX B

SCREENING RESULTS TO FLAG LOCATIONS WITH CONCENTRATIONS IN EXCESS OF THE PRGS

ATTACHMENT 1

SOIL PORE GAS DATABASE SCREENING FOR PRG AND PRG/10 EXCEEDANCES

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB024B	TRICHLOROETHENE	0.56	R6
AB024C	TRICHLOROETHENE	0.35	R6
AB024D	TRICHLOROETHENE	0.65	R6
AB024D DUP	TRICHLOROETHENE	0.72	R6
AB024E	TRICHLOROETHENE	0.9	R6
AB024F	TRICHLOROETHENE	3	R5 R6
AB024G	TRICHLOROETHENE	4.3	R5 R6
AB024G DUP	TRICHLOROETHENE	6.3	R5 R6
AB024H	TRICHLOROETHENE	1.2	R6
AB024H DUP	TRICHLOROETHENE	2.4	R5 R6
AB025A	TRICHLOROETHENE	280	R5 R6
AB025A DUP	TRICHLOROETHENE	210	R5 R6
AB025B	TRICHLOROETHENE	350	R5 R6
AB025C	TRICHLOROETHENE	22	R5 R6
AB025C DUP	TRICHLOROETHENE	58	R5 R6
AB025D	TRICHLOROETHENE	10	R5 R6
AB025E	TRICHLOROETHENE	5.9	R5 R6
AB025F	TRICHLOROETHENE	14	R5 R6
AB025G	TRICHLOROETHENE	24	R5 R6
AB025H	TRICHLOROETHENE	30	R5 R6
AB026B	TRICHLOROETHENE	14	R5 R6
AB026C	TRICHLOROETHENE	13	R5 R6
AB026C DUP	TRICHLOROETHENE	11	R5 R6
AB026D	TRICHLOROETHENE	12	R5 R6
AB026E	TRICHLOROETHENE	10	R5 R6
AB026F	TRICHLOROETHENE	9.3	R5 R6
AB026G	TETRACHLOROETHENE	3.2	R5 R6
AB026G	TRICHLOROETHENE	60	R5 R6
AB026H	TRICHLOROETHENE	29	R5 R6
AB027A	TRICHLOROETHENE	34	R5 R6
AB027B	TRICHLOROETHENE	8.4	R5 R6
AB027C	TRICHLOROETHENE	2.4	R5 R6
AB027D	TRICHLOROETHENE	2.7	R5 R6
AB027E	TRICHLOROETHENE	5.8	R5 R6
AB027F	TRICHLOROETHENE	5.1	R5 R6
AB027G	TRICHLOROETHENE	5.4	R5 R6
AB027H	TRICHLOROETHENE	42	R5 R6
AB028A	TRICHLOROETHENE	10	R5 R6
AB028B	TETRACHLOROETHENE	2	R6
AB028B	TRICHLOROETHENE	24	R5 R6
AB028C	TRICHLOROETHENE	14	R5 R6
AB028D	TRICHLOROETHENE	16	R5 R6
AB028E	TRICHLOROETHENE	17	R5 R6
AB028F	TRICHLOROETHENE	13	R5 R6
AB028G	TRICHLOROETHENE	350	R5 R6
AB028H	TRICHLOROETHENE	21	R5 R6
AB029A	TRICHLOROETHENE	25	R5 R6

(1) R5=EXCEEDS 1E-5 RISK; R6=EXCEEDS 1E-6 RISK; Z.1=EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB029B	TRICHLOROETHENE	18	R5 R6
AB029C	TRICHLOROETHENE	48	R5 R6
AB029D	TRICHLOROETHENE	17	R5 R6
AB029E	TRICHLOROETHENE	15	R5 R6
AB029F	TRICHLOROETHENE	7.2	R5 R6
AB029F DUP	TRICHLOROETHENE	7.3	R5 R6
AB029G	TRICHLOROETHENE	18	R5 R6
AB029H	TRICHLOROETHENE	200	R5 R6
AB030A	TRICHLOROETHENE	3.7	R5 R6
AB030B	TRICHLOROETHENE	13	R5 R6
AB030C	TRICHLOROETHENE	14	R5 R6
AB030D	TRICHLOROETHENE	2.7	R5 R6
AB030F	TRICHLOROETHENE	16	R5 R6
AB030F DUP	TRICHLOROETHENE	12	R5 R6
AB030G	TRICHLOROETHENE	16	R5 R6
AB030H	TRICHLOROETHENE	20	R5 R6
AB031C	ETHYLBENZENE	37	Z.1
AB031E	ETHYLBENZENE	36	Z.1
AB031E	TETRACHLOROETHENE	36	R5 R6
AB031E	TOLUENE	27	Z.1
AB031E	TRICHLOROETHENE	6.2	R5 R6
AB032A	TRICHLOROETHENE	18	R5 R6
AB032B	TRICHLOROETHENE	3.6	R5 R6
AB032B DUP	TRICHLOROETHENE	1.2	R6
AB032C	TRICHLOROETHENE	5.5	R5 R6
AB032D	TRICHLOROETHENE	6.3	R5 R6
AB032E	TRICHLOROETHENE	2.5	R5 R6
AB032F	TRICHLOROETHENE	2.3	R5 R6
AB032G	TRICHLOROETHENE	5.3	R5 R6
AB032H	TRICHLOROETHENE	6.9	R5 R6
AB033B	TRICHLOROETHENE	1.9	R5 R6
AB033C	TRICHLOROETHENE	7.2	R5 R6
AB033D	TRICHLOROETHENE	3.6	R5 R6
AB033E	TRICHLOROETHENE	2.7	R5 R6
AB033F	TRICHLOROETHENE	2.9	R5 R6
AB033G	TRICHLOROETHENE	3.6	R5 R6
AB033H	TRICHLOROETHENE	14	R5 R6
AB034A	TRICHLOROETHENE	11	R5 R6
AB034B	TRICHLOROETHENE	27	R5 R6
AB034C	TRICHLOROETHENE	16	R5 R6
AB034D	TRICHLOROETHENE	23	R5 R6
AB034E	TRICHLOROETHENE	8.8	R5 R6
AB034F	TRICHLOROETHENE	1.6	R5 R6
AB034G	TRICHLOROETHENE	3.9	R5 R6
AB034H	TRICHLOROETHENE	1.5	R5 R6
AB035A	TRICHLOROETHENE	51	R5 R6
AB035B	TRICHLOROETHENE	53	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB036B	TRICHLOROETHENE	87	R5 R6
AB036C	TRICHLOROETHENE	41	R5 R6
AB036D	TRICHLOROETHENE	26	R5 R6
AB036E	TRICHLOROETHENE	32	R5 R6
AB036F	TRICHLOROETHENE	25	R5 R6
AB036G	TRICHLOROETHENE	49	R5 R6
AB036H	TRICHLOROETHENE	140	R5 R6
AB037B	TRICHLOROETHENE	11	R5 R6
AB037B DUP	TRICHLOROETHENE	10	R5 R6
AB037C	TRICHLOROETHENE	9.7	R5 R6
AB037D	TRICHLOROETHENE	97	R5 R6
AB037E	TRICHLOROETHENE	24	R5 R6
AB037F	TRICHLOROETHENE	22	R5 R6
AB037G	TRICHLOROETHENE	49	R5 R6
AB037H	TRICHLOROETHENE	62	R5 R6
AB038A	TRICHLOROETHENE	3.9	R5 R6
AB038B	TRICHLOROETHENE	14	R5 R6
AB038B DUP	TRICHLOROETHENE	7.7	R5 R6
AB038C	TRICHLOROETHENE	3.8	R5 R6
AB038D	TRICHLOROETHENE	4.7	R5 R6
AB038E	TRICHLOROETHENE	3.6	R5 R6
AB038F	TRICHLOROETHENE	13	R5 R6
AB038G	TRICHLOROETHENE	20	R5 R6
AB038H	TRICHLOROETHENE	31	R5 R6
AB039B	TRICHLOROETHENE	0.15	R6
AB039C	TRICHLOROETHENE	0.19	R6
AB039D	TRICHLOROETHENE	0.3	R6
AB039E	TRICHLOROETHENE	0.35	R6
AB039F	TRICHLOROETHENE	0.23	R6
AB039G	TRICHLOROETHENE	0.46	R6
AB039H	TRICHLOROETHENE	0.5	R6
AB043B	TETRACHLOROETHENE	15	R5 R6
AB043B	TRICHLOROETHENE	45	R5 R6
AB043C	TETRACHLOROETHENE	130	R5 R6
AB043C	TRICHLOROETHENE	600	R5 R6
AB043C DUP	TETRACHLOROETHENE	65	R5 R6
AB043C DUP	TRICHLOROETHENE	340	R5 R6
AB043D	TETRACHLOROETHENE	150	R5 R6
AB043D	TRICHLOROETHENE	800	R5 R6
AB043E	TETRACHLOROETHENE	120	R5 R6
AB043E	TRICHLOROETHENE	550	R5 R6
AB043F	TETRACHLOROETHENE	35	R5 R6
AB043F	TRICHLOROETHENE	62	R5 R6
AB043G	TETRACHLOROETHENE	220	R5 R6
AB043G	TRICHLOROETHENE	420	R5 R6
AB043G DUP	TETRACHLOROETHENE	180	R5 R6
AB043G DUP	TRICHLOROETHENE	380	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB043H	TETRACHLOROETHENE	44	R5 R6
AB043H	TRICHLOROETHENE	110	R5 R6
AB044B	TETRACHLOROETHENE	32	R5 R6
AB044B	TRICHLOROETHENE	70	R5 R6
AB044B DUP	TETRACHLOROETHENE	20	R5 R6
AB044B DUP	TRICHLOROETHENE	53	R5 R6
AB044C	TETRACHLOROETHENE	48	R5 R6
AB044C	TRICHLOROETHENE	270	R5 R6
AB044D	TETRACHLOROETHENE	81	R5 R6
AB044D	TRICHLOROETHENE	490	R5 R6
AB044E	TETRACHLOROETHENE	12	R5 R6
AB044E	TRICHLOROETHENE	110	R5 R6
AB044F	TETRACHLOROETHENE	120	R5 R6
AB044F	TRICHLOROETHENE	120	R5 R6
AB044F DUP	TETRACHLOROETHENE	72	R5 R6
AB044F DUP	TRICHLOROETHENE	70	R5 R6
AB044G	TETRACHLOROETHENE	21	R5 R6
AB044G	TRICHLOROETHENE	32	R5 R6
AB044H	TETRACHLOROETHENE	34	R5 R6
AB044H	TRICHLOROETHENE	95	R5 R6
AB201B	TRICHLOROETHENE	0.37	R6
AB201C	TRICHLOROETHENE	0.24	R6
AB201C DUP	TRICHLOROETHENE	0.37	R6
AB201D	TRICHLOROETHENE	0.64	R6
AB201E	TRICHLOROETHENE	0.31	R6
AB201F	TRICHLOROETHENE	0.74	R6
AB201G	TRICHLOROETHENE	2.1	R5 R6
AB201H	TRICHLOROETHENE	1.8	R5 R6
AB202A	TRICHLOROETHENE	4.6	R5 R6
AB202B	TRICHLOROETHENE	20	R5 R6
AB202C	TRICHLOROETHENE	0.96	R6
AB202D	TRICHLOROETHENE	3.2	R5 R6
AB202D DUP	TRICHLOROETHENE	3.4	R5 R6
AB202E	TRICHLOROETHENE	4.9	R5 R6
AB202F	TRICHLOROETHENE	9.6	R5 R6
AB202G	TETRACHLOROETHENE	0.59	R6
AB202G	TRICHLOROETHENE	10	R5 R6
AB202H	TETRACHLOROETHENE	0.4	R6
AB202H	TRICHLOROETHENE	9.5	R5 R6
AB203A	TETRACHLOROETHENE	0.63	R6
AB203A	TRICHLOROETHENE	2	R5 R6
AB203B	TETRACHLOROETHENE	1.8	R6
AB203B	TRICHLOROETHENE	9.6	R5 R6
AB203C	TRICHLOROETHENE	1.5	R5 R6
AB203D	TRICHLOROETHENE	1.4	R5 R6
AB203E	TETRACHLOROETHENE	0.34	R6
AB203E	TRICHLOROETHENE	3.4	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB203F	TETRACHLOROETHENE	0.44	R6
AB203F	TRICHLOROETHENE	2.9	R5 R6
AB203G	TETRACHLOROETHENE	0.88	R6
AB203G	TRICHLOROETHENE	7	R5 R6
AB203G DUP	TETRACHLOROETHENE	0.63	R6
AB203G DUP	TRICHLOROETHENE	5.1	R5 R6
AB203H	TETRACHLOROETHENE	0.82	R6
AB203H	TRICHLOROETHENE	5.6	R5 R6
AB204A	TRICHLOROETHENE	21	R5 R6
AB204B	TRICHLOROETHENE	31	R5 R6
AB204B DUP	TRICHLOROETHENE	30	R5 R6
AB204C	TRICHLOROETHENE	8.3	R5 R6
AB204D	TRICHLOROETHENE	8.5	R5 R6
AB204E	TRICHLOROETHENE	5.3	R5 R6
AB204F	TRICHLOROETHENE	18	R5 R6
AB204G	TRICHLOROETHENE	5.1	R5 R6
AB204H	TRICHLOROETHENE	20	R5 R6
AB205A	TRICHLOROETHENE	12	R5 R6
AB205B	TRICHLOROETHENE	0.89	R6
AB205C	TRICHLOROETHENE	1.8	R5 R6
AB205D	TRICHLOROETHENE	1.1	R6
AB205E	TRICHLOROETHENE	1.4	R5 R6
AB205F	TRICHLOROETHENE	4.8	R5 R6
AB205G	TRICHLOROETHENE	34	R5 R6
AB205H	TRICHLOROETHENE	17	R5 R6
AB206A	TRICHLOROETHENE	7.7	R5 R6
AB206B	TRICHLOROETHENE	27	R5 R6
AB206C	TRICHLOROETHENE	1.2	R6
AB206D	TRICHLOROETHENE	6.5	R5 R6
AB206E	TRICHLOROETHENE	2.1	R5 R6
AB206F	TRICHLOROETHENE	3.8	R5 R6
AB206G	TRICHLOROETHENE	24	R5 R6
AB206H	TRICHLOROETHENE	13	R5 R6
AB207A	TRICHLOROETHENE	2.9	R5 R6
AB207B	TRICHLOROETHENE	1.2	R6
AB207C	TRICHLOROETHENE	1.6	R5 R6
AB207D	TRICHLOROETHENE	1.5	R5 R6
AB207E	TRICHLOROETHENE	2.2	R5 R6
AB207F	TRICHLOROETHENE	1.6	R5 R6
AB207F DUP	TRICHLOROETHENE	1.5	R5 R6
AB207G	TRICHLOROETHENE	5	R5 R6
AB207H	TRICHLOROETHENE	6.3	R5 R6
AB208A	TRICHLOROETHENE	1.6	R5 R6
AB208B	TRICHLOROETHENE	9.3	R5 R6
AB208C	TRICHLOROETHENE	52	R5 R6
AB208D	TRICHLOROETHENE	13	R5 R6
AB208E	TRICHLOROETHENE	9.3	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB208F	TRICHLOROETHENE	11	R5 R6
AB208F DUP	TRICHLOROETHENE	9	R5 R6
AB208G	TRICHLOROETHENE	22	R5 R6
AB208H	TRICHLOROETHENE	49	R5 R6
AB209B	TRICHLOROETHENE	15	R5 R6
AB209C	TETRACHLOROETHENE	0.42	R6
AB209C	TRICHLOROETHENE	4	R5 R6
AB209D	TRICHLOROETHENE	2.6	R5 R6
AB209E	TETRACHLOROETHENE	0.49	R6
AB209E	TRICHLOROETHENE	3.9	R5 R6
AB209F	TETRACHLOROETHENE	0.39	R6
AB209F	TRICHLOROETHENE	3.1	R5 R6
AB209G	TETRACHLOROETHENE	1	R6
AB209G	TRICHLOROETHENE	7.9	R5 R6
AB209G DUP	TETRACHLOROETHENE	0.61	R6
AB209G DUP	TRICHLOROETHENE	4.3	R5 R6
AB209H	TETRACHLOROETHENE	1.9	R6
AB209H	TRICHLOROETHENE	12	R5 R6
AB210C	TRICHLOROETHENE	3	R5 R6
AB210C DUP	TRICHLOROETHENE	3.1	R5 R6
AB210D	TETRACHLOROETHENE	0.56	R6
AB210D	TRICHLOROETHENE	11	R5 R6
AB210E	TETRACHLOROETHENE	0.81	R6
AB210E	TRICHLOROETHENE	9.9	R5 R6
AB210F	TETRACHLOROETHENE	0.9	R6
AB210F	TRICHLOROETHENE	11	R5 R6
AB210G	TRICHLOROETHENE	6.8	R5 R6
AB210H	TRICHLOROETHENE	6.2	R5 R6
AB211A	TRICHLOROETHENE	16	R5 R6
AB211B	TRICHLOROETHENE	23	R5 R6
AB211C	TRICHLOROETHENE	5.1	R5 R6
AB211C DUP	TRICHLOROETHENE	9.2	R5 R6
AB211D	TRICHLOROETHENE	15	R5 R6
AB211E	TRICHLOROETHENE	7.2	R5 R6
AB211F	TRICHLOROETHENE	6.8	R5 R6
AB211G	TRICHLOROETHENE	11	R5 R6
AB211H	TRICHLOROETHENE	11	R5 R6
AB212A	TRICHLOROETHENE	0.4	R6
AB212B	TRICHLOROETHENE	110	R5 R6
AB212C	TRICHLOROETHENE	79	R5 R6
AB212D	TRICHLOROETHENE	37	R5 R6
AB212E	TRICHLOROETHENE	26	R5 R6
AB212F	TRICHLOROETHENE	12	R5 R6
AB212G	TRICHLOROETHENE	81	R5 R6
AB212H	TRICHLOROETHENE	77	R5 R6
AB213A	TRICHLOROETHENE	2.1	R5 R6
AB213B	TRICHLOROETHENE	51	R5 R6

(1) R5=EXCEEDS 1E-5 RISK; R6=EXCEEDS 1E-6 RISK; Z.1=EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB213D	TRICHLOROETHENE	8.9	R5 R6
AB213E	TRICHLOROETHENE	2.9	R5 R6
AB213F	TRICHLOROETHENE	16	R5 R6
AB213G	TRICHLOROETHENE	13	R5 R6
AB213H	TRICHLOROETHENE	18	R5 R6
AB214A	TRICHLOROETHENE	60	R5 R6
AB214B	TRICHLOROETHENE	130	R5 R6
AB214B DUP	TRICHLOROETHENE	180	R5 R6
AB214C	TRICHLOROETHENE	280	R5 R6
AB214D	TRICHLOROETHENE	40	R5 R6
AB214E	TRICHLOROETHENE	54	R5 R6
AB214F	TRICHLOROETHENE	19	R5 R6
AB214G	TRICHLOROETHENE	50	R5 R6
AB214H	TRICHLOROETHENE	32	R5 R6
AB215A	TRICHLOROETHENE	1.6	R5 R6
AB215B	TRICHLOROETHENE	1.6	R5 R6
AB215C	TRICHLOROETHENE	3.2	R5 R6
AB215D	TRICHLOROETHENE	6.7	R5 R6
AB215E	TRICHLOROETHENE	18	R5 R6
AB215E DUP	TRICHLOROETHENE	5.4	R5 R6
AB215F	TRICHLOROETHENE	11	R5 R6
AB215G	TRICHLOROETHENE	8.2	R5 R6
AB215H	TRICHLOROETHENE	15	R5 R6
AB216A	TRICHLOROETHENE	8	R5 R6
AB216B	TRICHLOROETHENE	15	R5 R6
AB216C	TRICHLOROETHENE	15	R5 R6
AB216D	TRICHLOROETHENE	21	R5 R6
AB216E	TRICHLOROETHENE	17	R5 R6
AB216E DUP	TRICHLOROETHENE	19	R5 R6
AB216F	TRICHLOROETHENE	3.5	R5 R6
AB216G	TRICHLOROETHENE	2.4	R5 R6
AB216H	TRICHLOROETHENE	5.8	R5 R6
AB217A	TRICHLOROETHENE	45	R5 R6
AB217B	TRICHLOROETHENE	49	R5 R6
AB217C	TRICHLOROETHENE	51	R5 R6
AB217D	TRICHLOROETHENE	86	R5 R6
AB217E	TRICHLOROETHENE	86	R5 R6
AB217F	TRICHLOROETHENE	21	R5 R6
AB217G	TRICHLOROETHENE	12	R5 R6
AB217H	TRICHLOROETHENE	19	R5 R6
AB218A	TRICHLOROETHENE	4.4	R5 R6
AB218B	TETRACHLOROETHENE	2.8	R6
AB218B	TRICHLOROETHENE	70	R5 R6
AB218C	TRICHLOROETHENE	110	R5 R6
AB218D	TETRACHLOROETHENE	4.9	R5 R6
AB218D	TRICHLOROETHENE	120	R5 R6
AB218D DUP	TETRACHLOROETHENE	5.4	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB218D DUP	TRICHLOROETHENE	120	R5 R6
AB218E	TRICHLOROETHENE	44	R5 R6
AB218F	TRICHLOROETHENE	79	R5 R6
AB218G	TRICHLOROETHENE	41	R5 R6
AB218H	TRICHLOROETHENE	170	R5 R6
AB219A	TRICHLOROETHENE	0.65	R6
AB219B	TRICHLOROETHENE	0.56	R6
AB219C	TRICHLOROETHENE	0.44	R6
AB219D	TRICHLOROETHENE	0.76	R6
AB219E	TRICHLOROETHENE	1.1	R6
AB219F	TRICHLOROETHENE	1.8	R5 R6
AB219G	TRICHLOROETHENE	1.6	R5 R6
AB219H	TRICHLOROETHENE	3.8	R5 R6
AB220A	TRICHLOROETHENE	18	R5 R6
AB220B	TRICHLOROETHENE	6.2	R5 R6
AB220C	TRICHLOROETHENE	3.7	R5 R6
AB220D	TRICHLOROETHENE	2.4	R5 R6
AB220E	TRICHLOROETHENE	4.4	R5 R6
AB220F	TRICHLOROETHENE	3.6	R5 R6
AB220F DUP	TRICHLOROETHENE	2.6	R5 R6
AB220G	TRICHLOROETHENE	15	R5 R6
AB220H	TRICHLOROETHENE	9.4	R5 R6
AB221B	TETRACHLOROETHENE	0.53	R6
AB221B	TRICHLOROETHENE	1.4	R5 R6
AB221C	TRICHLOROETHENE	0.68	R6
AB221D	TRICHLOROETHENE	0.48	R6
AB221D DUP	TRICHLOROETHENE	0.66	R6
AB221E	TRICHLOROETHENE	0.51	R6
AB221F	TRICHLOROETHENE	0.93	R6
AB221G	TETRACHLOROETHENE	0.63	R6
AB221G	TRICHLOROETHENE	3.7	R5 R6
AB221H	TETRACHLOROETHENE	0.88	R6
AB221H	TRICHLOROETHENE	4.2	R5 R6
AB222A	TETRACHLOROETHENE	3.3	R5 R6
AB222A	TRICHLOROETHENE	9.6	R5 R6
AB222B	TETRACHLOROETHENE	1.7	R6
AB222B	TRICHLOROETHENE	2.4	R5 R6
AB222C	TETRACHLOROETHENE	3	R5 R6
AB222C	TRICHLOROETHENE	5.8	R5 R6
AB222D	TETRACHLOROETHENE	0.72	R6
AB222D	TRICHLOROETHENE	1.9	R5 R6
AB222E	TETRACHLOROETHENE	0.57	R6
AB222E	TRICHLOROETHENE	1.3	R5 R6
AB222F	TETRACHLOROETHENE	0.76	R6
AB222F	TRICHLOROETHENE	2.1	R5 R6
AB222G	TETRACHLOROETHENE	1.2	R6
AB222G	TRICHLOROETHENE	2.8	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB222H	TETRACHLOROETHENE	1.9	R6
AB222H	TRICHLOROETHENE	4.1	R5 R6
AB222H DUP	TETRACHLOROETHENE	2.1	R6
AB222H DUP	TRICHLOROETHENE	5.2	R5 R6
AB223A	TRICHLOROETHENE	42	R5 R6
AB223B	TRICHLOROETHENE	49	R5 R6
AB223B DUP	TRICHLOROETHENE	54	R5 R6
AB223C	TRICHLOROETHENE	85	R5 R6
AB223D	TRICHLOROETHENE	14	R5 R6
AB223E	TRICHLOROETHENE	4.9	R5 R6
AB223F	TRICHLOROETHENE	7	R5 R6
AB223G	TRICHLOROETHENE	8.4	R5 R6
AB223H	TRICHLOROETHENE	28	R5 R6
AB224A	TRICHLOROETHENE	0.37	R6
AB224B	TRICHLOROETHENE	0.15	R6
AB224B DUP	TRICHLOROETHENE	0.17	R6
AB224C	TRICHLOROETHENE	0.38	R6
AB224D	TRICHLOROETHENE	0.51	R6
AB224E	TRICHLOROETHENE	0.95	R6
AB224F	TRICHLOROETHENE	0.92	R6
AB224G	TRICHLOROETHENE	2.2	R5 R6
AB224H	TRICHLOROETHENE	6.2	R5 R6
AB225A	TETRACHLOROETHENE	9.1	R5 R6
AB225A	TRICHLOROETHENE	1.6	R5 R6
AB225B	TETRACHLOROETHENE	2.5	R6
AB225B	TRICHLOROETHENE	1.1	R6
AB225C	TETRACHLOROETHENE	3.1	R5 R6
AB225C	TRICHLOROETHENE	1.1	R6
AB225D	TETRACHLOROETHENE	0.36	R6
AB225D	TRICHLOROETHENE	0.33	R6
AB225E	TETRACHLOROETHENE	0.49	R6
AB225E	TRICHLOROETHENE	0.57	R6
AB225F	TETRACHLOROETHENE	0.67	R6
AB225F	TRICHLOROETHENE	0.81	R6
AB225G	TETRACHLOROETHENE	1.8	R6
AB225G	TRICHLOROETHENE	2.4	R5 R6
AB225H	TETRACHLOROETHENE	1.5	R6
AB225H	TRICHLOROETHENE	2	R5 R6
AB225H DUP	TETRACHLOROETHENE	1.9	R6
AB225H DUP	TRICHLOROETHENE	2.5	R5 R6
AB226B	TRICHLOROETHENE	0.73	R6
AB226C	TRICHLOROETHENE	0.88	R6
AB226D	TRICHLOROETHENE	1.5	R5 R6
AB226E	TRICHLOROETHENE	1	R6
AB226F	TRICHLOROETHENE	1.5	R5 R6
AB226G	TETRACHLOROETHENE	0.52	R6
AB226G	TRICHLOROETHENE	3.7	R5 R6

(1) R5=EXCEEDS 1E-5 RISK; R6=EXCEEDS 1E-6 RISK; Z.1=EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB226H	TETRACHLOROETHENE	0.51	R6
AB226H	TRICHLOROETHENE	2.9	R5 R6
AB227A	TRICHLOROETHENE	4.9	R5 R6
AB227A DUP	TRICHLOROETHENE	4.2	R5 R6
AB227B	TRICHLOROETHENE	2.8	R5 R6
AB227C	TRICHLOROETHENE	1.3	R5 R6
AB227D	TRICHLOROETHENE	1.8	R5 R6
AB227E	TRICHLOROETHENE	2.6	R5 R6
AB227F	TRICHLOROETHENE	8.1	R5 R6
AB227G	TRICHLOROETHENE	8.3	R5 R6
AB227H	TETRACHLOROETHENE	0.36	R6
AB227H	TRICHLOROETHENE	7.5	R5 R6
AB228A	TRICHLOROETHENE	2.6	R5 R6
AB228B	TRICHLOROETHENE	2.4	R5 R6
AB228C	TRICHLOROETHENE	2.8	R5 R6
AB228D	TRICHLOROETHENE	0.94	R6
AB228E	TRICHLOROETHENE	32	R5 R6
AB228F	TRICHLOROETHENE	35	R5 R6
AB228G	TRICHLOROETHENE	3.1	R5 R6
AB228H	TRICHLOROETHENE	11	R5 R6
AB228H DUP	TRICHLOROETHENE	18	R5 R6
AB229A	TRICHLOROETHENE	8.8	R5 R6
AB229B	TRICHLOROETHENE	4.4	R5 R6
AB229C	TRICHLOROETHENE	1.8	R5 R6
AB229D	TRICHLOROETHENE	3.2	R5 R6
AB229E	TRICHLOROETHENE	2.5	R5 R6
AB229E DUP	TRICHLOROETHENE	4.6	R5 R6
AB229F	TRICHLOROETHENE	3.5	R5 R6
AB229G	TRICHLOROETHENE	5.7	R5 R6
AB229H	TRICHLOROETHENE	6	R5 R6
AB230A	TETRACHLOROETHENE	4.5	R5 R6
AB230A	TRICHLOROETHENE	2	R5 R6
AB230B	TETRACHLOROETHENE	2.5	R6
AB230B	TRICHLOROETHENE	1.3	R5 R6
AB230C	TETRACHLOROETHENE	3.3	R5 R6
AB230C	TRICHLOROETHENE	2.2	R5 R6
AB230C DUP	TETRACHLOROETHENE	2.8	R6
AB230C DUP	TRICHLOROETHENE	1.7	R5 R6
AB230D	TRICHLOROETHENE	0.81	R6
AB230E	TETRACHLOROETHENE	0.77	R6
AB230E	TRICHLOROETHENE	0.96	R6
AB230F	TETRACHLOROETHENE	3.3	R5 R6
AB230F	TRICHLOROETHENE	4.2	R5 R6
AB230G	TETRACHLOROETHENE	2	R6
AB230G	TRICHLOROETHENE	2.5	R5 R6
AB230H	TETRACHLOROETHENE	1.8	R6
AB230H	TRICHLOROETHENE	2.4	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB230H DUP	TETRACHLOROETHENE	2	R6
AB230H DUP	TRICHLOROETHENE	2.6	R5 R6
AB231A	TRICHLOROETHENE	4	R5 R6
AB231B	TRICHLOROETHENE	3.7	R5 R6
AB231C	TRICHLOROETHENE	3.1	R5 R6
AB231D	TRICHLOROETHENE	4.6	R5 R6
AB231E	TRICHLOROETHENE	3.8	R5 R6
AB231F	TRICHLOROETHENE	6.5	R5 R6
AB231F DUP	TRICHLOROETHENE	6.2	R5 R6
AB231G	TRICHLOROETHENE	4.9	R5 R6
AB231H	TRICHLOROETHENE	8.3	R5 R6
AB232A	TRICHLOROETHENE	1.1	R6
AB232B	TRICHLOROETHENE	1.4	R5 R6
AB232C	TRICHLOROETHENE	2.7	R5 R6
AB232D	TRICHLOROETHENE	2	R5 R6
AB232E	TRICHLOROETHENE	2.5	R5 R6
AB232F	TRICHLOROETHENE	0.18	R6
AB232G	TRICHLOROETHENE	0.25	R6
AB232H	TRICHLOROETHENE	0.4	R6
AB233A	TRICHLOROETHENE	22	R5 R6
AB233B	TRICHLOROETHENE	23	R5 R6
AB233C	TRICHLOROETHENE	22	R5 R6
AB233D	TRICHLOROETHENE	23	R5 R6
AB233E	TRICHLOROETHENE	3.5	R5 R6
AB233F	TRICHLOROETHENE	9.2	R5 R6
AB233G	TRICHLOROETHENE	12	R5 R6
AB233H	TRICHLOROETHENE	25	R5 R6
AB234A	TRICHLOROETHENE	2.2	R5 R6
AB234B	TRICHLOROETHENE	1.4	R5 R6
AB234C	TRICHLOROETHENE	3	R5 R6
AB234D	TRICHLOROETHENE	1.9	R5 R6
AB234D DUP	TRICHLOROETHENE	1.5	R5 R6
AB234E	TRICHLOROETHENE	0.63	R6
AB234F	TRICHLOROETHENE	0.92	R6
AB234G	TRICHLOROETHENE	0.58	R6
AB234H	TRICHLOROETHENE	1	R6
AB235A	TRICHLOROETHENE	2.7	R5 R6
AB235B	TRICHLOROETHENE	3.3	R5 R6
AB235C	TRICHLOROETHENE	2.7	R5 R6
AB235D	TRICHLOROETHENE	0.71	R6
AB235E	TRICHLOROETHENE	1.5	R5 R6
AB235F	TRICHLOROETHENE	1.4	R5 R6
AB235G	TRICHLOROETHENE	1.8	R5 R6
AB235H	TRICHLOROETHENE	11	R5 R6
AB235H DUP	TRICHLOROETHENE	6.8	R5 R6
AB236A	TRICHLOROETHENE	10	R5 R6
AB236B	TRICHLOROETHENE	12	R5 R6

(1) R5=EXCEEDS 1E-5 RISK; R6=EXCEEDS 1E-6 RISK; Z.1=EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB236B DUP	TRICHLOROETHENE	10	R5 R6
AB236C	TRICHLOROETHENE	8.5	R5 R6
AB236D	TRICHLOROETHENE	7.6	R5 R6
AB236E	TRICHLOROETHENE	3.5	R5 R6
AB236F	TRICHLOROETHENE	2	R5 R6
AB236F DUP	TRICHLOROETHENE	1.9	R5 R6
AB236G	TRICHLOROETHENE	7.4	R5 R6
AB236H	TRICHLOROETHENE	21	R5 R6
AB236H DUP	TRICHLOROETHENE	14	R5 R6
AB237A	TRICHLOROETHENE	3.5	R5 R6
AB237B	TRICHLOROETHENE	30	R5 R6
AB237C	TETRACHLOROETHENE	2.3	R6
AB237C	TRICHLOROETHENE	52	R5 R6
AB237C DUP	TETRACHLOROETHENE	2	R6
AB237C DUP	TRICHLOROETHENE	38	R5 R6
AB237D	TRICHLOROETHENE	21	R5 R6
AB237E	TRICHLOROETHENE	6.1	R5 R6
AB237F	TETRACHLOROETHENE	0.7	R6
AB237F	TRICHLOROETHENE	14	R5 R6
AB237G	TRICHLOROETHENE	16	R5 R6
AB237H	TETRACHLOROETHENE	1.7	R6
AB237H	TRICHLOROETHENE	20	R5 R6
AB238A	TRICHLOROETHENE	0.17	R6
AB238B	TETRACHLOROETHENE	0.37	R6
AB238B	TRICHLOROETHENE	2.3	R5 R6
AB238B DUP	TETRACHLOROETHENE	0.41	R6
AB238B DUP	TRICHLOROETHENE	1.9	R5 R6
AB238C	TRICHLOROETHENE	0.71	R6
AB238D	TRICHLOROETHENE	0.34	R6
AB238E	TRICHLOROETHENE	2.1	R5 R6
AB238F	TETRACHLOROETHENE	0.35	R6
AB238F	TRICHLOROETHENE	2.3	R5 R6
AB238G	TRICHLOROETHENE	1.5	R5 R6
AB238G DUP	TRICHLOROETHENE	0.93	R6
AB238H	TETRACHLOROETHENE	0.95	R6
AB238H	TRICHLOROETHENE	10	R5 R6
AB239A	TRICHLOROETHENE	0.72	R6
AB239B	TRICHLOROETHENE	10	R5 R6
AB239C	TRICHLOROETHENE	4.2	R5 R6
AB239D	TRICHLOROETHENE	3.8	R5 R6
AB239E	TRICHLOROETHENE	2.8	R5 R6
AB239E DUP	TRICHLOROETHENE	2.8	R5 R6
AB239F	TETRACHLOROETHENE	0.53	R6
AB239F	TRICHLOROETHENE	5.9	R5 R6
AB239G	TETRACHLOROETHENE	1	R6
AB239G	TRICHLOROETHENE	12	R5 R6
AB239H	TETRACHLOROETHENE	0.53	R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB239H	TRICHLOROETHENE	6.8	R5 R6
AB240A	TRICHLOROETHENE	5.1	R5 R6
AB240B	TRICHLOROETHENE	1.5	R5 R6
AB240C	TRICHLOROETHENE	1.8	R5 R6
AB240D	TRICHLOROETHENE	4	R5 R6
AB240E	TRICHLOROETHENE	4	R5 R6
AB240E DUP	TRICHLOROETHENE	4	R5 R6
AB240F	TRICHLOROETHENE	9.8	R5 R6
AB240G	TRICHLOROETHENE	6.4	R5 R6
AB240H	TRICHLOROETHENE	15	R5 R6
AB241A	TRICHLOROETHENE	38	R5 R6
AB241B	TRICHLOROETHENE	61	R5 R6
AB241B DUP	TRICHLOROETHENE	53	R5 R6
AB241C	TRICHLOROETHENE	64	R5 R6
AB241D	TRICHLOROETHENE	5.4	R5 R6
AB241E	TRICHLOROETHENE	5.1	R5 R6
AB241F	TRICHLOROETHENE	22	R5 R6
AB241G	TRICHLOROETHENE	25	R5 R6
AB241G DUP	TRICHLOROETHENE	16	R5 R6
AB241H	TRICHLOROETHENE	25	R5 R6
AB242A	TRICHLOROETHENE	52	R5 R6
AB242B	TRICHLOROETHENE	110	R5 R6
AB242C	TRICHLOROETHENE	43	R5 R6
AB242D	TRICHLOROETHENE	15	R5 R6
AB242D DUP	TRICHLOROETHENE	12	R5 R6
AB242E	TRICHLOROETHENE	20	R5 R6
AB242F	TRICHLOROETHENE	22	R5 R6
AB242G	TRICHLOROETHENE	19	R5 R6
AB242H	TRICHLOROETHENE	17	R5 R6
AB243A	TRICHLOROETHENE	0.58	R6
AB243B	TETRACHLOROETHENE	32	R5 R6
AB243B	TRICHLOROETHENE	110	R5 R6
AB243C	TRICHLOROETHENE	33	R5 R6
AB243D	TRICHLOROETHENE	8.2	R5 R6
AB243D DUP	TRICHLOROETHENE	6.9	R5 R6
AB243E	TRICHLOROETHENE	7.3	R5 R6
AB243F	TRICHLOROETHENE	28	R5 R6
AB243G	TRICHLOROETHENE	19	R5 R6
AB243H	TRICHLOROETHENE	19	R5 R6
AB243H DUP	TRICHLOROETHENE	35	R5 R6
AB244A	TRICHLOROETHENE	0.21	R6
AB244B	TRICHLOROETHENE	1.9	R5 R6
AB244C	TRICHLOROETHENE	1	R6
AB244D	TETRACHLOROETHENE	0.49	R6
AB244D	TRICHLOROETHENE	3.6	R5 R6
AB244E	TETRACHLOROETHENE	0.31	R6
AB244E	TRICHLOROETHENE	2.3	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB244F	TETRACHLOROETHENE	2.1	R6
AB244F	TRICHLOROETHENE	17	R5 R6
AB244F DUP	TETRACHLOROETHENE	1.9	R6
AB244F DUP	TRICHLOROETHENE	14	R5 R6
AB244G	TETRACHLOROETHENE	1.2	R6
AB244G	TRICHLOROETHENE	8.7	R5 R6
AB244H	TETRACHLOROETHENE	2.6	R6
AB244H	TRICHLOROETHENE	29	R5 R6
AB245C	TRICHLOROETHENE	1.7	R5 R6
AB245C DUP	TRICHLOROETHENE	1.6	R5 R6
AB245D	TRICHLOROETHENE	0.79	R6
AB245E	TRICHLOROETHENE	0.91	R6
AB245E DUP	TRICHLOROETHENE	1.1	R6
AB245F	TRICHLOROETHENE	2.3	R5 R6
AB245G	TRICHLOROETHENE	5.1	R5 R6
AB245H	TRICHLOROETHENE	3.9	R5 R6
AB246A	TRICHLOROETHENE	1.8	R5 R6
AB246B	TRICHLOROETHENE	11	R5 R6
AB246B DUP	TRICHLOROETHENE	15	R5 R6
AB246C	TRICHLOROETHENE	4.8	R5 R6
AB246D	TRICHLOROETHENE	1.6	R5 R6
AB246E	TRICHLOROETHENE	3.7	R5 R6
AB246F	TRICHLOROETHENE	5.6	R5 R6
AB246G	TRICHLOROETHENE	4.2	R5 R6
AB246G DUP	TRICHLOROETHENE	4.2	R5 R6
AB246H	TRICHLOROETHENE	3.9	R5 R6
AB247A	TRICHLOROETHENE	0.79	R6
AB247B	TRICHLOROETHENE	14	R5 R6
AB247B DUP	TRICHLOROETHENE	23	R5 R6
AB247C	TRICHLOROETHENE	21	R5 R6
AB247D	TRICHLOROETHENE	12	R5 R6
AB247E	TRICHLOROETHENE	5.4	R5 R6
AB247F	TRICHLOROETHENE	6.3	R5 R6
AB247F DUP	TRICHLOROETHENE	7.4	R5 R6
AB247G	TRICHLOROETHENE	5	R5 R6
AB247H	TRICHLOROETHENE	11	R5 R6
AB248A	TRICHLOROETHENE	60	R5 R6
AB248B	TRICHLOROETHENE	43	R5 R6
AB248C	TETRACHLOROETHENE	9.7	R5 R6
AB248C	TRICHLOROETHENE	130	R5 R6
AB248D	TETRACHLOROETHENE	1.2	R6
AB248D	TRICHLOROETHENE	12	R5 R6
AB248D DUP	TETRACHLOROETHENE	1.6	R6
AB248D DUP	TRICHLOROETHENE	14	R5 R6
AB248E	TETRACHLOROETHENE	1.5	R6
AB248E	TRICHLOROETHENE	14	R5 R6
AB248F	TETRACHLOROETHENE	3.8	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AB248F	TRICHLOROETHENE	31	R5 R6
AB248G	TETRACHLOROETHENE	4.8	R5 R6
AB248G	TRICHLOROETHENE	40	R5 R6
AB248H	TETRACHLOROETHENE	2.7	R6
AB248H	TRICHLOROETHENE	21	R5 R6
AB248H DUP	TETRACHLOROETHENE	3.6	R5 R6
AB248H DUP	TRICHLOROETHENE	22	R5 R6
AB251A	TRICHLOROETHENE	1.8	R5 R6
AB251B	TRICHLOROETHENE	20	R5 R6
AB251C	TETRACHLOROETHENE	2.2	R6
AB251C	TRICHLOROETHENE	59	R5 R6
AB251C DUP	TRICHLOROETHENE	74	R5 R6
AB251D	TRICHLOROETHENE	11	R5 R6
AB251D DUP	TRICHLOROETHENE	7.7	R5 R6
AB251E	TRICHLOROETHENE	7.6	R5 R6
AB251F	TRICHLOROETHENE	8.9	R5 R6
AB251G	TETRACHLOROETHENE	0.73	R6
AB251G	TRICHLOROETHENE	13	R5 R6
AB251H	TRICHLOROETHENE	25	R5 R6
AB252A	TRICHLOROETHENE	36	R5 R6
AB252A DUP	TRICHLOROETHENE	35	R5 R6
AB252B	TRICHLOROETHENE	6.8	R5 R6
AB252C	TRICHLOROETHENE	5.1	R5 R6
AB252D	TRICHLOROETHENE	6	R5 R6
AB252E	TRICHLOROETHENE	5.5	R5 R6
AB252F	TRICHLOROETHENE	11	R5 R6
AB252G	TRICHLOROETHENE	9.8	R5 R6
AB252H	TRICHLOROETHENE	20	R5 R6
AB253A	TRICHLOROETHENE	0.19	R6
AB253C	TRICHLOROETHENE	31	R5 R6
AB253C DUP	TRICHLOROETHENE	44	R5 R6
AB253D	TRICHLOROETHENE	4.2	R5 R6
AB253E	TRICHLOROETHENE	5.1	R5 R6
AB253F	TRICHLOROETHENE	8.8	R5 R6
AB253G	TRICHLOROETHENE	49	R5 R6
AB253H	TRICHLOROETHENE	54	R5 R6
AB253H DUP	TRICHLOROETHENE	60	R5 R6
AB254A	TRICHLOROETHENE	62	R5 R6
AB254B	TRICHLOROETHENE	51	R5 R6
AB254C	TRICHLOROETHENE	53	R5 R6
AB254C DUP	TRICHLOROETHENE	49	R5 R6
AB254D	TRICHLOROETHENE	22	R5 R6
AB254E	TRICHLOROETHENE	8.4	R5 R6
AB254F	TRICHLOROETHENE	22	R5 R6
AB254F DUP	TRICHLOROETHENE	19	R5 R6
AB254G	TRICHLOROETHENE	35	R5 R6
AB254H	TRICHLOROETHENE	20	R5 R6

(1) R5=EXCEEDS 1E-5 RISK; R6=EXCEEDS 1E-6 RISK; Z.1=EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
AT001A	TRICHLOROETHENE	7.2	R5 R6
AT001B	TRICHLOROETHENE	3	R5 R6
AT001C	TRICHLOROETHENE	7.7	R5 R6
AT001D	TRICHLOROETHENE	4.4	R5 R6
AT001E	TRICHLOROETHENE	4.4	R5 R6
AT001E DUP	TRICHLOROETHENE	2.2	R5 R6
AT002A	TRICHLOROETHENE	18	R5 R6
AT002B	TRICHLOROETHENE	44	R5 R6
AT002C	TRICHLOROETHENE	20	R5 R6
AT002C DUP	TRICHLOROETHENE	14	R5 R6
AT002D	TRICHLOROETHENE	6.6	R5 R6
AT002E	TRICHLOROETHENE	6.4	R5 R6
AT003A	TRICHLOROETHENE	4.3	R5 R6
AT003B	TETRACHLOROETHENE	20	R5 R6
AT003B	TRICHLOROETHENE	160	R5 R6
AT003C	TRICHLOROETHENE	47	R5 R6
AT003D	TRICHLOROETHENE	63	R5 R6
AT003E	TRICHLOROETHENE	65	R5 R6
AT004B	TETRACHLOROETHENE	14	R5 R6
AT004B	TRICHLOROETHENE	9000	R5 R6
AT004C	TRICHLOROETHENE	1000	R5 R6
AT004D	TRICHLOROETHENE	120	R5 R6
AT004D DUP	TRICHLOROETHENE	120	R5 R6
AT004E	TRICHLOROETHENE	110	R5 R6
AT005A	TRICHLOROETHENE	22	R5 R6
AT005B	TRICHLOROETHENE	36	R5 R6
AT005C	TRICHLOROETHENE	51	R5 R6
AT005D	TRICHLOROETHENE	28	R5 R6
AT005E	TRICHLOROETHENE	16	R5 R6
AT006A	TRICHLOROETHENE	2.2	R5 R6
AT006B	TRICHLOROETHENE	31	R5 R6
AT006C	TRICHLOROETHENE	4.2	R5 R6
AT006D	TRICHLOROETHENE	3.8	R5 R6
AT006E	TRICHLOROETHENE	4.4	R5 R6
AT007A	TRICHLOROETHENE	3.4	R5 R6
AT007B	TRICHLOROETHENE	15	R5 R6
AT007C	TRICHLOROETHENE	82	R5 R6
AT007D	TRICHLOROETHENE	95	R5 R6
AT007E	TRICHLOROETHENE	84	R5 R6
AT008A	TRICHLOROETHENE	23	R5 R6
AT008B	TRICHLOROETHENE	11	R5 R6
AT008C	TRICHLOROETHENE	15	R5 R6
AT008D	TRICHLOROETHENE	230	R5 R6
AT008E	TRICHLOROETHENE	280	R5 R6
BB002A	TRICHLOROETHENE	0.21	R6
BB002B	TRICHLOROETHENE	0.77	R6
BB205B	TRICHLOROETHENE	0.18	R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
DB029A	TETRACHLOROETHENE	0.63	R6
DB029A	TRICHLOROETHENE	3.7	R5 R6
DB029B	TRICHLOROETHENE	0.15	R6
DB029D	TRICHLOROETHENE	0.83	R6
DB029E	TRICHLOROETHENE	0.18	R6
DB029F	TRICHLOROETHENE	0.32	R6
DB031A	TRICHLOROETHENE	0.18	R6
DB031B	TRICHLOROETHENE	0.43	R6
DB031C	TRICHLOROETHENE	1.1	R6
DB031D	TRICHLOROETHENE	1	R6
DB031H	TRICHLOROETHENE	1.8	R5 R6
DB032C	TRICHLOROETHENE	0.33	R6
DB032D	TRICHLOROETHENE	0.51	R6
DB032E	TRICHLOROETHENE	0.53	R6
DB032F	TRICHLOROETHENE	0.4	R6
DB033C	TRICHLOROETHENE	0.56	R6
DB033D	TRICHLOROETHENE	0.24	R6
DB033E	TETRACHLOROETHENE	1.8	R6
DB033E	TRICHLOROETHENE	15	R5 R6
DB033F	TRICHLOROETHENE	1.5	R5 R6
DB033G	TETRACHLOROETHENE	0.55	R6
DB033G	TRICHLOROETHENE	3.9	R5 R6
DB033H	TETRACHLOROETHENE	0.6	R6
DB033H	TRICHLOROETHENE	4.5	R5 R6
DB034A	TRICHLOROETHENE	0.85	R6
DB034B	TETRACHLOROETHENE	0.5	R6
DB034B	TRICHLOROETHENE	4.2	R5 R6
DB034C	TETRACHLOROETHENE	0.97	R6
DB034C	TRICHLOROETHENE	11	R5 R6
DB034D	TRICHLOROETHENE	0.85	R6
DB034D DUP	TRICHLOROETHENE	1.8	R5 R6
DB034E	TRICHLOROETHENE	1.8	R5 R6
DB034F	TRICHLOROETHENE	1	R6
DB034G	TRICHLOROETHENE	1.3	R5 R6
DB034H	TETRACHLOROETHENE	0.6	R6
DB034H	TRICHLOROETHENE	3.9	R5 R6
EB001A	TRICHLOROETHENE	1.1	R6
EB001C	TRICHLOROETHENE	3.4	R5 R6
EB001D	TRICHLOROETHENE	3.4	R5 R6
EB001E	TRICHLOROETHENE	18	R5 R6
EB001F	TRICHLOROETHENE	3.4	R5 R6
EB001G	TRICHLOROETHENE	0.92	R6
EB001G DUP	TRICHLOROETHENE	0.92	R6
EB001H	TRICHLOROETHENE	0.99	R6
EB002A	TRICHLOROETHENE	0.25	R6
EB002B	TRICHLOROETHENE	0.46	R6
EB002C	TRICHLOROETHENE	3.4	R5 R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
EB002D	TRICHLOROETHENE	1.3	R5 R6
EB002D DUP	TRICHLOROETHENE	1.5	R5 R6
EB002E	TRICHLOROETHENE	0.46	R6
EB002F	TRICHLOROETHENE	0.85	R6
EB002G	TRICHLOROETHENE	1.7	R5 R6
EB002H	TRICHLOROETHENE	0.83	R6
EB003B	TRICHLOROETHENE	0.2	R6
EB003C	TRICHLOROETHENE	7.4	R5 R6
EB003E	TRICHLOROETHENE	3.8	R5 R6
EB003F	TETRACHLOROETHENE	2.2	R6
EB003F	TRICHLOROETHENE	10	R5 R6
EB003G	TRICHLOROETHENE	2.1	R5 R6
EB003H	TETRACHLOROETHENE	1.2	R6
EB003H	TRICHLOROETHENE	9.7	R5 R6
EB004A	TRICHLOROETHENE	1.3	R5 R6
EB004B	TRICHLOROETHENE	0.95	R6
EB004C	TRICHLOROETHENE	0.5	R6
EB004G	TRICHLOROETHENE	0.2	R6
EB004H	TETRACHLOROETHENE	0.68	R6
EB004H	TRICHLOROETHENE	1.5	R5 R6
EB201A	TRICHLOROETHENE	0.19	R6
EB201B	TRICHLOROETHENE	2.1	R5 R6
EB201C	TRICHLOROETHENE	7	R5 R6
EB201C DUP	TRICHLOROETHENE	6.6	R5 R6
EB201D	TRICHLOROETHENE	1.6	R5 R6
EB201E	TRICHLOROETHENE	1.6	R5 R6
EB201F	TRICHLOROETHENE	1.3	R5 R6
EB201G	TRICHLOROETHENE	1.1	R6
EB201H	TRICHLOROETHENE	2.8	R5 R6
EB202A	TRICHLOROETHENE	0.4	R6
EB202B	TRICHLOROETHENE	0.83	R6
EB202C	TRICHLOROETHENE	0.87	R6
EB202E	TRICHLOROETHENE	0.17	R6
EB202F	TRICHLOROETHENE	0.2	R6
EB203A	TRICHLOROETHENE	17	R5 R6
EB203B	TRICHLOROETHENE	12	R5 R6
EB203C	TRICHLOROETHENE	9.2	R5 R6
EB203D	TRICHLOROETHENE	0.81	R6
EB203E	TRICHLOROETHENE	0.34	R6
EB203F	TRICHLOROETHENE	0.62	R6
EB204B	TRICHLOROETHENE	0.62	R6
EB204C	TRICHLOROETHENE	4.9	R5 R6
EB204D	TRICHLOROETHENE	6.8	R5 R6
EB204E	TRICHLOROETHENE	2.6	R5 R6
EB204G	TRICHLOROETHENE	2.9	R5 R6
EB204H	TETRACHLOROETHENE	0.49	R6
EB204H	TRICHLOROETHENE	1.2	R6

(1) R5-EXCEEDS 1E-5 RISK; R6-EXCEEDS 1E-6 RISK; Z.1-EXCEEDS 0.1 HAZARD.

SOIL HEADSPACE SAMPLES THAT EXCEED PRELIMINARY REMEDIATION GOALS
NIROP FIDLEY SOIL SAMPLES

SAMPLE ID	CHEMICAL PARAMETER	RESULT PPM(V/V)	PRG EXCEEDANCE (1)
EB205A	TRICHLOROETHENE	1.5	R5 R6
EB205B	TRICHLOROETHENE	0.2	R6
EB205C	TRICHLOROETHENE	1	R6
EB205C DUP	TRICHLOROETHENE	0.22	R6
EB205E	TRICHLOROETHENE	1.9	R5 R6
EB205F DUP	TRICHLOROETHENE	0.13	R6
EB206A	TRICHLOROETHENE	7	R5 R6
EB206B	TRICHLOROETHENE	5.6	R5 R6
EB206B DUP	TRICHLOROETHENE	4.5	R5 R6
EB206C	TRICHLOROETHENE	8.4	R5 R6
EB206D	TRICHLOROETHENE	1.2	R6
EB206E	TRICHLOROETHENE	1.4	R5 R6
EB206F	TRICHLOROETHENE	0.93	R6
EB206G	TRICHLOROETHENE	0.47	R6
EB206H	TRICHLOROETHENE	0.97	R6
EB207A	TRICHLOROETHENE	0.59	R6
EB207B	TRICHLOROETHENE	1.8	R5 R6
EB207D	TRICHLOROETHENE	1.6	R5 R6
EB207D DUP	TRICHLOROETHENE	2.1	R5 R6
EB207E	TRICHLOROETHENE	2	R5 R6
EB207F	TRICHLOROETHENE	1.2	R6
EB207G	TRICHLOROETHENE	1	R6
EB207H	TRICHLOROETHENE	1.1	R6
EB208A	TRICHLOROETHENE	0.14	R6
EB208B	TRICHLOROETHENE	0.26	R6
EB208C	TRICHLOROETHENE	0.18	R6
EB208D	TRICHLOROETHENE	0.41	R6
EB208G	TRICHLOROETHENE	2	R5 R6
EB208H	TRICHLOROETHENE	1.2	R6
EB209A	TRICHLOROETHENE	0.17	R6
EB209B	TRICHLOROETHENE	0.52	R6
EB209C	TRICHLOROETHENE	0.58	R6
EB209D	TRICHLOROETHENE	0.17	R6
EB209E	TRICHLOROETHENE	0.4	R6
EB209F	TRICHLOROETHENE	0.22	R6
EB209G	TRICHLOROETHENE	0.29	R6
EB209H	TRICHLOROETHENE	0.17	R6
EB210E	TRICHLOROETHENE	0.14	R6
EB210F	TRICHLOROETHENE	0.33	R6
EB210G	TRICHLOROETHENE	0.16	R6
EB210H	TRICHLOROETHENE	0.33	R6
FB002C	TRICHLOROETHENE	0.59	R6
FB002E	TRICHLOROETHENE	0.22	R6

(1) R5=EXCEEDS 1E-5 RISK; R6=EXCEEDS 1E-6 RISK; Z.1=EXCEEDS 0.1 HAZARD.

APPENDIX C

SAMPLE-SPECIFIC RISK CALCULATIONS FOR SOIL PORE GAS

See the OU3 FS for up-to-date sample-specific risk calculations

APPENDIX D

EFFECTS OF ADDITIVITY ON CUMULATIVE RISK FROM VOCS IN SOIL

SUMMARY OF COMPOSITIONAL ANALYSIS DETECTS FOR
FOUR VOLATILE ORGANIC CONSTITUENTS
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	SAMPLE DATE	UNITS	ETHYL-BENZENE	TOLUENE	TRICHLORO-ETHENE	TETRACHLORO-ETHENE	PRG OR PRG/10 EXCEEDED (*)
AB024A	06/09/92	UG/KG					
AB024G	06/09/92	UG/KG					
AB025A	06/09/92	UG/KG			920		
AB025B	06/09/92	UG/KG			4100		
AB026A	06/10/92	UG/KG			15		
AB026G	06/10/92	UG/KG			45	2	
AB027A	06/09/92	UG/KG			50		
AB027H	06/09/92	UG/KG			5		
AB028A	06/08/92	UG/KG			18		
AB028G	06/08/92	UG/KG			6100	610	
AB029A	06/10/92	UG/KG			190		
AB029H	06/10/92	UG/KG			89	6	
AB030A	06/09/92	UG/KG			36		
AB030G	06/09/92	UG/KG			2		
AB030G DUP	06/09/92	UG/KG			4		
AB031A	06/15/92	UG/KG	380	10	9		
AB031G	06/15/92	UG/KG	3400	45	2	56	
AB032A	06/09/92	UG/KG			150		
AB032D	06/09/92	UG/KG			2		
AB033B	06/08/92	UG/KG			300		
AB033H	06/08/92	UG/KG			2		
AB034A	06/08/92	UG/KG			24		
AB034D	06/08/92	UG/KG			5		
AB035A	06/10/92	UG/KG			36	7	
AB036A	06/15/92	UG/KG			8		
AB036H	06/15/92	UG/KG			15	2	
AB037A	06/10/92	UG/KG			0.8		
AB037D	06/10/92	UG/KG			9	1	
AB038A	06/10/92	UG/KG			4		
AB038G	06/10/92	UG/KG			9		
AB039A	06/10/92	UG/KG		27	2		
AB039H	06/10/92	UG/KG			0.6		
AB039H DUP	06/10/92	UG/KG					
AB040A	06/15/92	UG/KG	3				
AB040D	06/15/92	UG/KG					
AB041A	06/08/92	UG/KG					
AB041C	06/08/92	UG/KG					
AB042A	06/09/92	UG/KG					
AB042G	06/09/92	UG/KG					
AB042G DUP	06/09/92	UG/KG					
AB043D	07/20/92	UG/KG	1600	1300	69000	17000	*
AB043H	07/20/92	UG/KG			1400	2800	
AB044D	07/20/92	UG/KG	25	58	11000	2800	
AB044H	07/20/92	UG/KG			2300	590	
AB201A	07/08/92	UG/KG					
AB201H	07/08/92	UG/KG					
AB202A	07/08/92	UG/KG			0.9		

SUMMARY OF COMPOSITIONAL ANALYSIS DETECTS FOR
FOUR VOLATILE ORGANIC CONSTITUENTS
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	SAMPLE DATE	UNITS	ETHYL-BENZENE	TOLUENE	TRICHLORO-ETHENE	TETRACHLORO-ETHENE	PRG OR PRG/10 EXCEEDED (*)
AB202B	07/08/92	UG/KG			360	25	
AB203A	07/08/92	UG/KG					
AB203B	07/08/92	UG/KG			20	7	
AB204A	07/08/92	UG/KG			26	1	
AB204A DUP	07/08/92	UG/KG			18	0.7	
AB204B	07/08/92	UG/KG			4		
AB205A	07/08/92	UG/KG			31	1	
AB205G	07/08/92	UG/KG			230	8	
AB206A	07/08/92	UG/KG			2		
AB206B	07/08/92	UG/KG			330	9	
AB207A	07/09/92	UG/KG			15		
AB207H	07/09/92	UG/KG			3		
AB208A	07/13/92	UG/KG			70		
AB208A DUP	07/13/92	UG/KG			73		
AB208H	07/13/92	UG/KG			52	2	
AB209A	07/23/92	UG/KG			0.8		
AB209B	07/23/92	UG/KG			29	3	
AB210A	07/23/92	UG/KG			1		
AB210D	07/23/92	UG/KG			3		
AB211A	07/23/92	UG/KG			120		
211B	07/23/92	UG/KG			1		
AB212A	07/24/92	UG/KG			2		
AB212B	07/24/92	UG/KG			21	2	
AB213A	07/23/92	UG/KG			35	2	
AB213A DUP	07/23/92	UG/KG			90	4	
AB213B	07/23/92	UG/KG			130	13	
AB214A	07/28/92	UG/KG			100		
AB214C	07/28/92	UG/KG			7700	120	
AB215A	07/09/92	UG/KG			12		
AB215H	07/09/92	UG/KG			5		
AB216A	07/13/92	UG/KG			30		
AB216D	07/13/92	UG/KG			92		
AB217A	07/13/92	UG/KG			91		
AB217D	07/13/92	UG/KG			700		
AB218A	07/24/92	UG/KG			24		
AB218H	07/24/92	UG/KG			31	11	
AB219A	07/09/92	UG/KG					
AB219F	07/09/92	UG/KG					
AB220A	07/09/92	UG/KG			28	1	
AB220G	07/09/92	UG/KG			3		
AB221A	07/09/92	UG/KG					
AB221G	07/09/92	UG/KG			0.8		
AB222A	07/09/92	UG/KG			75	26	
AB222A DUP	07/09/92	UG/KG			85	35	
AB222C	07/09/92	UG/KG			5	3	
23A	07/09/92	UG/KG			89		
AB223C	07/09/92	UG/KG			150	0.7	

SUMMARY OF COMPOSITIONAL ANALYSIS DETECTS FOR
FOUR VOLATILE ORGANIC CONSTITUENTS
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	SAMPLE DATE	UNITS	ETHYL-BENZENE	TOLUENE	TRICHLORO-ETHENE	TETRACHLORO-ETHENE	PRG OR PRG/10 EXCEEDED (*)
AB224A	07/13/92	UG/KG					
AB224H	07/13/92	UG/KG					
AB226B	07/10/92	UG/KG			2		
AB226G	07/10/92	UG/KG					
AB227A	07/13/92	UG/KG			12		
AB227A DUP	07/13/92	UG/KG			18	0.6	
AB227G	07/13/92	UG/KG					
AB228A	07/10/92	UG/KG			5		
AB228F	07/10/92	UG/KG			3		
AB229A	07/10/92	UG/KG			110		
AB229H	07/10/92	UG/KG			3		
AB230A	07/10/92	UG/KG				1	
AB230B	07/10/92	UG/KG			2	4	
AB231A	07/14/92	UG/KG			18		
AB231H	07/14/92	UG/KG			7		
AB233A	07/14/92	UG/KG			33		
AB233H	07/14/92	UG/KG			10		
AB234A	07/15/92	UG/KG			3		
AB234A DUP	07/15/92	UG/KG			4		
AB234D	07/15/92	UG/KG			3		
AB235A	07/15/92	UG/KG			10		
AB235H	07/15/92	UG/KG			71		
AB236A	07/15/92	UG/KG			23		
AB236H	07/15/92	UG/KG			14		
AB237A	07/27/92	UG/KG			16		
AB237C	07/27/92	UG/KG			18	3	
AB238A	07/27/92	UG/KG					
AB238H	07/27/92	UG/KG			2		
AB238H DUP	07/27/92	UG/KG			4		
AB239A	07/27/92	UG/KG			6		
AB239G	07/27/92	UG/KG			19	2	
AB240A	07/27/92	UG/KG			3		
AB240H	07/27/92	UG/KG			10		
AB241A	07/27/92	UG/KG			73		
AB241C	07/27/92	UG/KG					
AB242A	07/28/92	UG/KG			140	5	
AB242B	07/28/92	UG/KG			340	17	
AB243A	07/28/92	UG/KG					
AB243B	07/28/92	UG/KG			80	2	
AB244A	07/28/92	UG/KG					
AB244H	07/28/92	UG/KG			4		
AB244H DUP	07/28/92	UG/KG			3		
AB245A	07/29/92	UG/KG					
AB245G	07/29/92	UG/KG			1		
AB246A	07/29/92	UG/KG			6		
AB246B	07/29/92	UG/KG			31		
AB247A	07/29/92	UG/KG			210		

SUMMARY OF COMPOSITIONAL ANALYSIS DETECTS FOR
FOUR VOLATILE ORGANIC CONSTITUENTS
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	SAMPLE DATE	UNITS	ETHYL-BENZENE	TOLUENE	TRICHLORO-ETHENE	TETRACHLORO-ETHENE	PRG OR PRG/10 EXCEEDED (*)
AB247C	07/29/92	UG/KG			20		
AB248A	07/30/92	UG/KG			92	6	
AB248C	07/30/92	UG/KG			1200	160	
AB248C DUP	07/30/92	UG/KG			700	89	
AB251A	07/29/92	UG/KG			5		
AB251C	07/29/92	UG/KG			4000	140	
AB252A	07/30/92	UG/KG			67	0.8	
AB252H	07/30/92	UG/KG			3		
AB253A	07/29/92	UG/KG					
AB253H	07/29/92	UG/KG			1800	62	
AB254A	07/30/92	UG/KG			4100	13	
AB254A DUP	07/30/92	UG/KG			660		
AB254C	07/30/92	UG/KG			370	9	
AT001A	06/12/92	UG/KG			31		
AT001C	06/12/92	UG/KG			3		
AT002A	06/12/92	UG/KG			10		
AT002B	06/12/92	UG/KG			35	2	
AT002B DUP	06/12/92	UG/KG			31	2	
AT003A	06/16/92	UG/KG			38		
AT003B	06/16/92	UG/KG			290	28	
AT004A	06/16/92	UG/KG			1		
AT004B	06/16/92	UG/KG	72	20	47000	2700	*
AT005A	06/16/92	UG/KG		16	10		
AT005C	06/16/92	UG/KG		17	8		
AT005C DUP	06/16/92	UG/KG			11	0.9	
AT006A	06/17/92	UG/KG			5		
AT006B	06/17/92	UG/KG					
AT007A	06/17/92	UG/KG			27		
AT007C	06/17/92	UG/KG			280	21	
AT008A	06/17/92	UG/KG			9		
AT008D	06/17/92	UG/KG			11000		
AT008D DUP	06/17/92	UG/KG			7500		
AT009B1	06/23/92	UG/KG			1500	11000	
AT009B1 DUP	06/23/92	UG/KG			2700	25000	*
AT009D1	06/24/92	UG/KG	140000	190000	120000	1200000	*
AT009D2	06/24/92	UG/KG			8800	28000	*
AT009D3	06/24/92	UG/KG			5	2	
AT009E1	06/25/92	UG/KG			7	3	
AT009E2	06/26/92	UG/KG			3	2	
BB001A	06/15/92	UG/KG					
BB001B	06/15/92	UG/KG					
BB001C	07/07/92	UG/KG					
BB002B	06/15/92	UG/KG			4		
BB002G	06/15/92	UG/KG					
BB002G DUP	06/15/92	UG/KG					
BB003A	06/16/92	UG/KG					
BB003D	06/16/92	UG/KG					

SUMMARY OF COMPOSITIONAL ANALYSIS DETECTS FOR
FOUR VOLATILE ORGANIC CONSTITUENTS
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	SAMPLE DATE	UNITS	ETHYL-BENZENE	TOLUENE	TRICHLORO-ETHENE	TETRACHLORO-ETHENE	PRG OR PRG/10 EXCEEDED (*)
BB202B	07/16/92	UG/KG					
BB204A	07/16/92	UG/KG					
BB204G	07/16/92	UG/KG			27	14	
BB205A	07/16/92	UG/KG					
BB205G	07/16/92	UG/KG					
BB206A	07/17/92	UG/KG					
BB206A DUP	07/17/92	UG/KG					
BB206G	07/17/92	UG/KG					
BG001A	06/03/92	UG/KG					
BG001D	06/03/92	UG/KG					
BG002A	06/03/92	UG/KG					
BG002D	06/03/92	UG/KG					
BG003A	06/03/92	UG/KG					
BG003D	06/03/92	UG/KG					
BG004A	06/03/92	UG/KG					
BG004D	06/03/92	UG/KG					
BG005A	06/03/92	UG/KG					
BG005D	06/03/92	UG/KG					
BG005D DUP	06/03/92	UG/KG					
BG006A	06/03/92	UG/KG					
[illegible]006D	06/03/92	UG/KG					
[illegible]007A	06/04/92	UG/KG					
BG007D	06/04/92	UG/KG					
BG008A	06/04/92	UG/KG					
BG008D	06/04/92	UG/KG					
BG009A	06/04/92	UG/KG					
BG009D	06/04/92	UG/KG					
BG009D DUP	06/04/92	UG/KG					
BG010A	06/04/92	UG/KG					
BG010D	06/04/92	UG/KG					
BT001A	06/18/92	UG/KG					
BT001B	06/18/92	UG/KG					
BT002A	06/17/92	UG/KG					
BT002B	06/17/92	UG/KG					
BT003A	06/18/92	UG/KG					
BT003D	06/18/92	UG/KG					
BT004A	06/18/92	UG/KG					
BT004D	06/18/92	UG/KG					
BT004D DUP	06/18/92	UG/KG					
DB029A	06/11/92	UG/KG			9	2	
DB029E	06/11/92	UG/KG					
DB029E DUP	06/11/92	UG/KG					
DB030A	06/12/92	UG/KG					
DB030E	06/12/92	UG/KG					
DB031A	06/11/92	UG/KG					
[illegible]31F	06/11/92	UG/KG				9	
[illegible]032A	06/11/92	UG/KG					

SUMMARY OF COMPOSITIONAL ANALYSIS DETECTS FOR
FOUR VOLATILE ORGANIC CONSTITUENTS
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	SAMPLE DATE	UNITS	ETHYL-BENZENE	TOLUENE	TRICHLORO-ETHENE	TETRACHLORO-ETHENE	PRG OR PRG/10 EXCEEDED (*)
DB032C	06/11/92	UG/KG					
DB033A	07/07/92	UG/KG				1	
DB033E	07/07/92	UG/KG			46	11	
DB034A	07/07/92	UG/KG			7	2	
DB034C	07/07/92	UG/KG			63	10	
EB001A	06/16/92	UG/KG					
EB001E	06/16/92	UG/KG			3		
EB002A	06/16/92	UG/KG					
EB002D	06/16/92	UG/KG			2		
EB003A	06/18/92	UG/KG					
EB003F	06/18/92	UG/KG			2	0.7	
EB004A	06/18/92	UG/KG			3		
EB004D	06/18/92	UG/KG			0.6	3	
EB203A	07/21/92	UG/KG			31		
EB203B	07/21/92	UG/KG			27	2	
EB206A	07/17/92	UG/KG			8		
EB206E	07/17/92	UG/KG					
EB207A	07/21/92	UG/KG			6	2	
EB207F	07/21/92	UG/KG					
EB208A	07/21/92	UG/KG					
EB208A DUP	07/21/92	UG/KG					
EB208F	07/21/92	UG/KG					
EB209A	07/22/92	UG/KG			0.7		
EB209B	07/22/92	UG/KG			2		
EB210A	07/22/92	UG/KG					
EB210A DUP	07/22/92	UG/KG					
EB210E	07/22/92	UG/KG					
FB001A	06/12/92	UG/KG					
FB001E	06/12/92	UG/KG					
FB002A	06/11/92	UG/KG					
FB002C	07/07/92	UG/KG					
FB002H	06/11/92	UG/KG					
FB003A	06/11/92	UG/KG					
FB003E	06/11/92	UG/KG					
FB004A	06/11/92	UG/KG					
FB004G	06/11/92	UG/KG					

APPENDIX E

SAMPLE LOCATIONS WITH DETECTABLE CPAHS

CARCINOGENIC PAH CONCENTRATIONS AND ASSOCIATED INGESTION RISK IN
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	BENZO(A) ANTHRACENE	RISK	BENZO(A) PYRENE	RISK	BENZO(B) FLUORANTHENE	RISK	BENZO(K) FLUORANTHENE	RISK	CHRYSENE	RISK	DIBENZ(A,H) ANTHRACENE	RISK	INDENO(123-CD) PYRENE	RISK	cPAH CONC	PAH RISK	ABOVE 1E-5 RISK
CSF:	0.73		7.3		0.73		0.073		0.0073		7.3		0.73				
AB024A	140	1.6E-07	120	1.4E-06	130	1.5E-07	87	9.9E-09	150	1.7E-09					627	1.7E-06	
AB024G																	
AB025A																	
AB025B																	
AB026A	2300	2.6E-06	2100	2.4E-05	2200	2.5E-06	1700	1.9E-07	2500	2.8E-08	520	5.9E-06	1200	1.4E-06	12520	3.7E-05	*
AB026G																	
AB027A	2200	2.5E-06	2300	2.6E-05	2600	3.0E-06	2000		2500	2.8E-08			1700	1.9E-06	13300	3.4E-05	*
AB027H																	
AB028A	590	6.7E-07	560	6.4E-06	620	7.1E-07	460	5.2E-08	650	7.4E-09			400	4.6E-07	3280	8.3E-06	
AB028G																	
AB029A	2400	2.7E-06	2400	2.7E-05	2600	3.0E-06	1900	2.2E-07	2800		650	7.4E-06	1800	2.0E-06	14550	4.3E-05	*
AB029H																	
AB030A	6900	7.9E-06	7400	8.4E-05	7200	8.2E-06	7200	8.2E-07	7800	8.9E-08	1000	1.1E-05	5200	5.9E-06	42700	1.2E-04	*
AB030G	150	1.7E-07	170	1.9E-06	180	2.0E-07	140	1.6E-08	170	1.9E-09			130	1.5E-07	940	2.5E-06	
AB030G DUP	400	4.6E-07	410	4.7E-06	460	5.2E-07	360	4.1E-08	440	5.0E-09			290	3.3E-07	2360	6.0E-06	
AB031A																	
AB031G																	
AB032A	43000	4.9E-05	41000	4.7E-04	46000	5.2E-05	29000	3.3E-06	43000	4.9E-07	7700	8.8E-05	28000	3.2E-05	237700	6.9E-04	*
AB032D			120	1.4E-06											120	1.4E-06	
AB033B																	
AB033H																	
AB034A	950	1.1E-06	1100	1.3E-05	1200	1.4E-06	980	1.1E-07	1200	1.4E-08			800	9.1E-07	6230	1.6E-05	*
AB034D			73	8.3E-07											73	8.3E-07	
AB035A																	
AB036A	860	9.8E-07	720	8.2E-06	690	7.9E-07	580	6.6E-08	850	9.7E-09			370	4.2E-07	4070	1.0E-05	*
AB036H																	
AB037A	1300	1.5E-06	1200	1.4E-05	1200	1.4E-06	1200	1.4E-07	1500	1.7E-08			830	9.5E-07	7230	1.8E-05	*
AB037D																	
AB038A	150	1.7E-07	190	2.2E-06	340	3.9E-07	230	2.6E-08	260	3.0E-09			200	2.3E-07	1370	3.0E-06	

AH CONCENTRATIONS ARE EXPRESSED IN UG/KG.

CARCINOGENIC PAH CONCENTRATIONS AND ASSOCIATED INGESTION RISK IN
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	BENZO(A) ANTHRACENE	RISK	BENZO(A) PYRENE	RISK	BENZO(B) FLUORANTHENE	RISK	BENZO(K) FLUORANTHENE	RISK	CHRYSENE	RISK	DIBENZ(A,H) ANTHRACENE	RISK	INDENO(123-CD) PYRENE	RISK	cPAH CONC	PAH RISK	ABOVE 1E-5 RISK
CSF:	0.73		7.3		0.73		0.073		0.0073		7.3		0.73				
AB038G																	
AB039A																	
AB039H																	
AB039H DUP																	
AB041A																	
AB041C																	
AB042A																	
AB042G																	
AB042G DUP																	
AB043D	2100	2.4E-06	1700	1.9E-05	1800	2.0E-06	1400	1.6E-07	2100	2.4E-08			1100	1.3E-06	10200	2.5E-05	*
AB043H																	
AB044D																	
AB044H																	
T001A	5700	6.5E-06	6600	7.5E-05	8200	9.3E-06	5400	6.1E-07	7300	8.3E-08			5100	5.8E-06	38300	9.7E-05	*
T001C																	
T002A	210	2.4E-07	170	1.9E-06	210	2.4E-07	210	2.4E-08	250	2.8E-09					1050	2.4E-06	
T002B																	
T002B DUP																	
T003A	890	1.0E-06	810	9.2E-06	1000	1.1E-06	800	9.1E-08	960	1.1E-08			240	2.7E-07	4700	1.2E-05	*
T003B																	
T004A	530	6.0E-07	480	5.5E-06	600	6.8E-07	340	3.9E-08	600	6.8E-09			290	3.3E-07	2840	7.1E-06	
T004B																	
T005A	130	1.5E-07			150	1.7E-07	100	1.1E-08	130	1.5E-09					510	3.3E-07	
T005C																	
T005C DUP																	
T006A	1100	1.3E-06	1100	1.3E-05	1200	1.4E-06	810	9.2E-08	1300	1.5E-08			600	6.8E-07	6110	1.6E-05	*
T006B																	
T007A																	
T007C																	

H CONCENTRATIONS ARE EXPRESSED IN UG/KG.

CARCINOGENIC PAH CONCENTRATIONS AND ASSOCIATED INGESTION RISK IN
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	BENZO(A) ANTHRACENE	RISK	BENZO(A) PYRENE	RISK	BENZO(B) FLUORANTHENE	RISK	BENZO(K) FLUORANTHENE	RISK	CHRYSENE	RISK	DIBENZ(A,H) ANTHRACENE	RISK	INDENO(123-CD) PYRENE	RISK	cPAH CONC	PAH RISK	ABOVE 1E-5 RISK
CSF:	0.73		7.3		0.73		0.073		0.0073		7.3		0.73				
AT008A																	
AT008D																	
AT008D DUP																	
AT009B1																	
AT009B1 DUP																	
AT009D1																	
AT009D2																	
AT009D3																	
AT009E1																	
AT009E2																	
BB001A	140	1.6E-07	120	1.4E-06	140	1.6E-07	98	1.1E-08	180	2.0E-09					678	1.7E-06	
BB001B																	
BB001C																	
BB002B	300	3.4E-07	270	3.1E-06	340	3.9E-07	240	2.7E-08	380	4.3E-09					1530	3.8E-06	
BB002G																	
BB002G DUP																	
BB003A																	
BB003D																	
BG001A																	
BG001D																	
BG002A																	
BG002D																	
BG003A																	
BG003D																	
BG004A																	
BG004D																	
BG005A																	
BG005D																	
BG005D DUP																	

AH CONCENTRATIONS ARE EXPRESSED IN UG/KG.

CARCINOGENIC PAH CONCENTRATIONS AND ASSOCIATED INGESTION RISK IN
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	BENZO(A) ANTHRACENE	RISK	BENZO(A) PYRENE	RISK	BENZO(B) FLUORANTHENE	RISK	BENZO(K) FLUORANTHENE	RISK	CHRYSENE	RISK	DIBENZ(A,H) ANTHRACENE	RISK	INDENO(123-CD) PYRENE	RISK	cPAH CONC	PAH RISK	ABOVE 1E-5 RISK
CSF:	0.73		7.3		0.73		0.073		0.0073		7.3		0.73				
BG006A																	
BG006D																	
BG007A																	
BG007D																	
BG008A																	
BG008D																	
BG009A																	
BG009D																	
BG009D DUP																	
BG010A																	
BG010D																	
BT001A	450	5.1E-07	450	5.1E-06	490	5.6E-07	380	4.3E-08	500	5.7E-09			310	3.5E-07	2580	6.6E-06	
BT001B																	
BT002A																	
BT002B																	
BT004A	64	7.3E-08			130	1.5E-07			68	7.7E-10					262	2.2E-07	
BT004D																	
BT004D DUP																	
B029A	520	5.9E-07	980	1.1E-05	1600	1.8E-06	760	8.7E-08	860	9.8E-09	310	3.5E-06	840	9.6E-07	5870	1.8E-05	*
B029E																	
B029E DUP																	
B030A																	
B030E																	
B031A																	
B031F																	
B032A																	
B032C																	
B033A																	
B033E																	

AH CONCENTRATIONS ARE EXPRESSED IN UG/KG.

CARCINOGENIC PAH CONCENTRATIONS AND ASSOCIATED INGESTION RISK IN
NIROP-FRIDLEY SOIL SAMPLES

SAMPLE ID	BENZO(A) ANTHRACENE	RISK	BENZO(A) PYRENE	RISK	BENZO(B) FLUORANTHENE	RISK	BENZO(K) FLUORANTHENE	RISK	CHRYSENE	RISK	DIBENZ(A,H) ANTHRACENE	RISK	INDENO(123-CD) PYRENE	RISK	cPAH CONC	PAH RISK	ABOVE 1E-5 RISK
CSF:	0.73		7.3		0.73		0.073		0.0073		7.3		0.73				
DB034A																	
DB034C																	
EB001A	1300	1.5E-06	1200	1.4E-05	1500	1.7E-06	900	1.0E-07	1500	1.7E-08			790	9.0E-07	7190	1.8E-05	*
EB001E																	
EB002A	460	5.2E-07	460	5.2E-06	510	5.8E-07	340	3.9E-08	530	6.0E-09			300	3.4E-07	2600	6.7E-06	
EB002D																	
EB003A																	
EB003F																	
EB004A	3300	3.8E-06	2900	3.3E-05	3400	3.9E-06	2000	2.3E-07	3400	3.9E-08			1800	2.0E-06	16800	4.3E-05	*
EB004D	100	1.1E-07	140	1.6E-06	170	1.9E-07	83	9.5E-09	140	1.6E-09					633	1.9E-06	
FB001A	200	2.3E-07	170	1.9E-06	240	2.7E-07	160	1.8E-08	230	2.6E-09					1000	2.5E-06	
FB001E																	
FB002A																	
FB002C																	
FB002H																	
FB003A																	
FB003E																	
FB004A																	
FB004G																	

AH CONCENTRATIONS ARE EXPRESSED IN UG/KG.

APPENDIX F

SOIL VAPOR EXTRACTION DESIGN INFORMATION

SVE Design Considerations

Table G-1 is a summary of the design considerations for the SVE system for removing VOCs and facilitating naturally occurring biodegradation of cPAHs in soils at NIROP. Design considerations for the SVE system include well configuration, the use of a surface seal or other types of airflow control, the depth and size of the screened interval in the extraction well, the blower types, instrumentation, and the need for emission controls.

Vertical wells are the most widely used SVE design method when contamination extends to groundwater and when the depth to groundwater is greater than 12 feet. During the Remedial Investigation (RMT, 1993), soil pore gas readings collected from many of the borings indicated that vapor concentrations are evenly distributed in soils from near the surface to groundwater (approximately 20 feet). Therefore, cost estimates, contained in Section 5 of this feasibility study, assume that vertical vapor extraction wells will be installed to a depth of 20 feet at NIROP.

To estimate the number and location of vapor extraction wells at NIROP, the common standard of practice was applied. According to Wilson (1982), extraction wells are typically spaced at two times the depth to which they are installed. Assuming vapor extraction wells at the NIROP are placed to a depth of 20 feet, the horizontal spacing for wells would be approximately 40 feet. Vapor extraction wells will be placed in areas A2, A3, A4, D, E1, and E2. Approximately 54 extraction wells will be required for soil remediation. Design calculations and equipment information are attached in Appendix G.

The size of the blower shown in Table G-2 was estimated from the number of extraction wells and assuming a target flow rate of 40 scfm at a vacuum of 10 to 20 inches of water in the sandy soils. Cost estimates for the soil vacuum system, presented in Section 5, are based on cost estimates for individual items, such as blowers, wells, trenching and piping, and the building. Prior to designing the system, pilot-scale vapor extraction tests will be required to determine the exact blower sizing and the total number of extraction wells needed for OU2.

TABLE G-1

SUMMARY OF DESIGN CONSIDERATIONS FOR SVE[a]

Item	Options/Description
Well type	Vertical or horizontal
Well configuration	Number and location of extraction wells required to remediate the site.
Extraction vents	Intended to induce air into the subsurface in fine-grained soils.
Surface seals	Prevent short circuiting of air from the surface, forcing air to be drawn from a greater distance, thereby contacting a greater volume of soil.
Blowers	Typically centrifugal blowers are used to create a vacuum in soils. Blower size depends on the vacuum necessary to create subsurface airflow.
Piping	Piping used to connect the blowers to the well head. Considerations include aboveground or below ground sloping, and materials for construction.
Vapor pretreatment	Normally, water knock-out tanks are installed before the blower to prevent moisture from entering electrical equipment.
Emission control	Normally, activated carbon or low-temperature catalytic oxidation is used when VOC concentrations in the vapor exceed state or federal guidelines.
Instrumentation/Controls	Normally, programmable logic controllers are used to automatically start and stop sections of the system when the rate of VOC removal becomes diffusion limited.

NOTES:

[a] USEPA. 1991. Soil Vapor Extraction Technology: Reference Handbook (EPA/540/2-91/003).

TABLE G-2

CONCEPTUAL DESIGN EQUIPMENT FOR THE SVE SYSTEM

Design Component	Description
Extraction well construction	
Casing	2-inch schedule 40 PVC
Screen	15-foot schedule 40 PVC
Total depth	20 feet
Number of extraction wells[a]	54
Piping form well head to building	2-inch schedule 40 PVC
Total distance of piping[b]	5,400 feet
Total depth of piping	2 feet
Gas flow rate per well	40 cfm
Total gas flow for affected area	2,160 cfm
Vapor phase activated carbon adsorber	2,500 SCFM capacity
Number of vapor phase activated carbon adsorber	2 1,600 lb units
Total number of blowers[c]	4
Blower size	10 hp
Blower type	Regenerative
Blower vacuum level	10 - 20 inches H_2O
Electrical requirements for blowers	460 volts, 3 phase
Water knockout pots	100 gallon
Number of knockout pots	4
Size of building	10 feet wide x 16 feet long
Number of buildings	1

NOTES:

[a] Number of extraction wells assume the radius of influence is equal to the well depth.
[b] Total piping distance calculated from Figure 4-4.
[c] Blower information provided by EG&G Rotron, Saugertise, NY.

Estimates for the cost of the piping and trenching needed to deliver vapor from the extraction wells through the off-gas control equipment assumed 4-inch-diameter, Schedule 40 PVC, trenched to a depth of 2 feet. The estimated length of piping and trenching is 5,400 feet, based on the conceptual design layout presented on Figure 4-4.

Attached calculations indicate that total VOC emissions from the SVE system will be less than 25 tons per year; therefore, off-gas control equipment has not been included in the conceptual design It is also assumed that a negligible amount of condensate water will be generated by the SVE system. Therefore, it was assumed that any condensate could be manually transported to the existing groundwater treatment system as part of routine maintenance of the SVE system

APPENDIX G

CALCULATIONS FOR BIOLOGICAL DEGRADATION OF PAHS IN SOILS

Biological Degradation of Carcinogenic PNAs in NIROP OU#2 Soils -							Sample AB032A From the Remedial Investigation (RMT, 1993)					
PNA Compound	Co	Ct	Ct	k	ln(Ct/Co)	ln(Ct/Co)	Td (1)	Td (1)	Td (0.5)	Td (0.5)	Reference	
	(mg/kg)	(mg/kg)	(mg/kg)	(1/day)			(days)	(Years)	(days)	(Years)		
Benz(a)anthracene	43	1	0.5	0.0026	-3.7612	-4.454347	1446.615	3.96333	1713.21	4.693727	A	
Chrysene	43	1	0.5	0.0019	-3.7612	-4.454347	1979.579	5.423504	2344.393	6.422995	A	
Benzo(a)pyrene	41	1	0.5	0.0022	-3.713572	-4.406719	1687.987	4.624623	2003.054	5.48782	A	
Benzo(k)fluoranthene	65	1	0.5	0.007	-4.174387	-4.867534	596.341	1.633811	695.3621	1.905102	B	
Indeno(1,2,3-cd)pyrene	28	1	0.5	0.0024	-3.332205	-4.025352	1388.419	3.803886	1677.23	4.59515	A	
Dibenz(a,h)anthracene	7.7	1	0.5	0.0019	-2.04122	-2.734368	1074.326	2.94336	1439.141	3.942851	A	
Benzo(j)fluoranthene	NA	1	0.5	0.001	NA	NA	NA	NA	NA	NA	B	
Benzo(b)flouranthene	46	1	0.5	0.0024	-3.828641	-4.521789	1595.267	4.370595	1884.079	5.161859	A	
	k = First order kinetic constant											
	Co = Concentration of PNA measured in soil sample AB032A											
	Ct = Target cleanup goal based on Risk Assessment											
	Td = Time for PNA to degrade to the target cleanup goal											
	NA = Not Analyzed											
Note: The list of carcinogenic PNAs provided by MPCA												
Reference A: K. Park. 1990. Transformation of PAHs in Soil Systems. Journal of Environmental Engineering												
Reference B: American Petroleum Institute - Publication 4379, Land Treatability of Appendix VIII Constituents - pg. 4-19												

Estimated Cleanup Times for Various Carcinogenic PNAs

Time (Weeks)	Benzo(a)pyrene (mg/Kg)	Benz(a)anthracene (mg/kg)
	41	43
1	40.6556	42.398
2	40.31409296	41.804428
3	39.97545458	41.21916601
4	39.63966076	40.64209768
5	39.30668761	40.07310832
6	38.97651143	38.5120848
7	38.64910874	38.95891561
8	38.32445622	38.41349079
9	38.00253079	37.87570192
10	37.68330953	37.3454421
11	37.36676973	36.82260591
12	37.05288887	36.30708942
13	36.7416446	35.79879017
14	36.43301479	35.29760711
15	36.12697746	34.80344061
16	35.82351085	34.31619244
17	35.52259336	33.83576575
18	35.22420358	33.36206503
19	34.92832027	32.89499612
20	34.63492238	32.43446617
21	34.34398903	31.98038364
22	34.05549952	31.53265827
23	33.76943332	31.09120106
24	33.48577008	30.65592424
25	33.20448962	30.2267413
26	32.9255719	29.80356693
27	32.6489971	29.38631699
28	32.37474552	28.97490855
29	32.10279766	28.56925983
30	31.83313416	28.16929019
31	31.56573583	27.77492013
32	31.30058365	27.38607125
33	31.03765875	27.00266625
34	30.77694242	26.62462892
35	30.5184161	26.25188412
36	30.26206141	25.88435774
37	30.00786009	25.52197673
38	29.75579406	25.16466906
39	29.50584539	24.81236369
40	29.25799629	24.4649906
41	29.01222912	24.12248073
42	28.7685264	23.784766
43	28.52687078	23.45177928
44	28.28724506	23.12345437
45	28.0496322	22.79972601
46	27.81401529	22.48052984
47	27.58037757	22.16580242
48	27.34870239	21.85548119
49	27.11897329	21.54950445
50	26.89117392	21.24781139
51	26.66528806	20.95034203
52	26.44129964	20.65703724
53	26.21919272	20.36783872
54	25.9989515	20.08268898
55	25.78056031	19.80153133
56	25.5640036	19.5243099
57	25.34926597	19.25096956
58	25.13633214	18.98145598
59	24.92518695	18.7157156
60	24.71581538	18.45369558
61	24.50820253	18.19534384
62	24.30233363	17.94060903
63	24.09819403	17.6894405
64	23.8957692	17.44178834
65	23.69504473	17.1976033
66	23.49600636	16.95683685
67	23.2986399	16.71944114
68	23.10293133	16.48536896
69	22.90886671	16.2545738
70	22.71643223	16.02700976
71	22.5256142	15.80263163
72	22.33639904	15.58139478
73	22.14877328	15.36325526
74	21.96272359	15.14816968
75	21.77823671	14.93609531
76	21.59529952	14.72698997
77	21.41389901	14.52081211
78	21.23402225	14.31752074
79	21.05565647	14.11707545
80	20.87878895	13.9194364
81	20.70340713	13.72456429
82	20.52949851	13.53242039
83	20.35705072	13.3429665
84	20.18605149	13.15816497
85	20.01648886	12.97197866
86	19.84835016	12.79037096
87	19.68162401	12.61130577
88	19.51629837	12.43474749
89	19.35236147	12.26066102
90	19.18980163	12.08901177
91	19.0286073	11.9197656
92	18.86878689	11.75288888
93	18.71026935	11.58834844
94	18.55310309	11.42611156
95	18.39725702	11.266146
96	18.24272006	11.10841995
97	18.08948122	10.95290208
98	17.93752957	10.79956145

Initial Concentrations in Sample AB032A (RMT, 1993 Remedial Investigation Report)

Biodegradation Rates: 0.84% per week (benzo(a)pyrene
1.4% per week (benz(a)anthracene)

Estimated Cleanup times:
Benzo(a)pyrene = 8.46 years to reach 1 ppm
Benz(a)anthracene = 5.1 years to reach 1 ppm

99	17.78685433	10.64836759							
100	17.63744475	10.49929044							
101	17.48929021	10.35230037							
102	17.34238018	10.20736817							
103	17.19670418	10.06446501							
104	17.05225187	9.923562504							
105	16.90901295	9.784832629							
106	16.76697724	9.647847772							
107	16.62613463	9.512580703							
108	16.4864751	9.379404574							
109	16.34798871	9.24809291							
110	16.21066561	9.118619609							
111	16.07449602	8.990958934							
112	15.93947025	8.865085509							
113	15.8055787	8.740974312							
114	15.67281184	8.618600672							
115	15.54116022	8.497940262							
116	15.41061447	8.378969098							
117	15.28116531	8.261663531							
118	15.15280352	8.146000242							
119	15.02551997	8.031956238							
120	14.8993056	7.919508851							
121	14.77415144	7.808635727							
122	14.65004857	7.699314827							
123	14.52698816	7.591524419							
124	14.40496146	7.485243078							
125	14.28395978	7.380449674							
126	14.16397452	7.277123379							
127	14.04499713	7.175243652							
128	13.92701916	7.074790241							
129	13.8100322	6.975743177							
130	13.69402793	6.878082773							
131	13.57899809	6.781789614							
132	13.46493451	6.686844559							
133	13.35182906	6.593228736							
134	13.23967369	6.500923533							
135	13.12846043	6.409910604							
136	13.01818137	6.320171855							
137	12.90882864	6.231689449							
138	12.80039448	6.144445797							
139	12.69287117	6.058423556							
140	12.58625105	5.973605626							
141	12.48052654	5.889975147							
142	12.37569012	5.807515495							
143	12.27173432	5.726210278							
144	12.16865175	5.646043334							
145	12.06643508	5.566998728							
146	11.96507702	5.489060746							
147	11.86457038	5.412213895							
148	11.76490799	5.336442901							
149	11.66608276	5.2617327							
150	11.56808788	5.188068442							
151	11.47091573	5.115435484							
152	11.37456004	5.043819387							
153	11.27901373	4.973205916							
154	11.18427002	4.903581033							
155	11.09032215	4.834930899							
156	10.99716344	4.767241866							
157	10.90478727	4.70050048							
158	10.81318706	4.634693473							
159	10.72235628	4.569807764							
160	10.63228849	4.505830456							
161	10.54297727	4.442748829							
162	10.45441626	4.380550346							
163	10.36659916	4.319222641							
164	10.27951873	4.258753524							
165	10.19317176	4.199130975							
166	10.10754912	4.140343141							
167	10.02264571	4.082378337							
168	9.938455485	4.02522504							
169	9.854972459	3.96887189							
170	9.77219069	3.913307683							
171	9.690104288	3.858521376							
172	9.608707412	3.804502076							
173	9.52799427	3.751239047							
174	9.447959118	3.698721701							
175	9.368596261	3.646939597							
176	9.289900053	3.595882443							
177	9.211864892	3.545540088							
178	9.134485227	3.495902527							
179	9.057755551	3.446959892							
180	8.981670405	3.398702453							
181	8.906224373	3.351120619							
182	8.831412089	3.30420493							
183	8.757228227	3.257946061							
184	8.68366751	3.212334816							
185	8.610724703	3.167362129							
186	8.538394615	3.123019059							
187	8.466672101	3.079296792							
188	8.395552055	3.036186637							
189	8.325029418	2.993680024							
190	8.255099171	2.951768504							
191	8.185756338	2.910443745							
192	8.116995984	2.869697532							
193	8.048813218	2.829521767							
194	7.981203187	2.789908462							
195	7.91416108	2.750849744							
196	7.847682127	2.712337847							
197	7.781761597	2.674365118							
198	7.7163948	2.636924006							
199	7.651577084	2.60000707							
200	7.587303836	2.563606971							
201	7.523570484	2.527716473							

202	7.460372492	2.492328443							
203	7.397705383	2.457435844							
204	7.335564638	2.423031743							
205	7.273945895	2.389109298							
206	7.212844749	2.355661768							
207	7.152256853	2.322682503							
208	7.092177896	2.290164948							
209	7.032603602	2.258102639							
210	6.973529731	2.226489202							
211	6.914952082	2.195318353							
212	6.856866484	2.164583896							
213	6.799268806	2.134279722							
214	6.742154948	2.104399806							
215	6.685520846	2.074938208							
216	6.629362471	2.045889073							
217	6.573675826	2.017246626							
218	6.518456949	1.989005174							
219	6.463701911	1.961159101							
220	6.409406815	1.933702874							
221	6.355567798	1.906631033							
222	6.302181028	1.879938199							
223	6.249242707	1.853619064							
224	6.196749069	1.827668397							
225	6.144696377	1.80208104							
226	6.093080927	1.776851905							
227	6.041899047	1.751975979							
228	5.991147095	1.727448315							
229	5.94082146	1.703264038							
230	5.890918559	1.679418342							
231	5.841434843	1.655906485							
232	5.792366791	1.632723794							
233	5.74371091	1.609865661							
234	5.695463738	1.587327542							
235	5.647821843	1.565104956							
236	5.600181819	1.543193487							
237	5.553140292	1.521588778							
238	5.506483913	1.500286535							
239	5.460239365	1.479282524							
240	5.414373354	1.458572568							
241	5.368882618	1.438152552							
242	5.32379392	1.418018417							
243	5.279074051	1.398166159							
244	5.234729829	1.378591833							
245	5.190758098	1.359291547							
246	5.14715573	1.340261465							
247	5.103919622	1.321497805							
248	5.061046697	1.302996836							
249	5.018533905	1.28475488							
250	4.97637822	1.266768312							
251	4.934576643	1.249033555							
252	4.893126199	1.231547085							
253	4.852023939	1.214305426							
254	4.811266938	1.19730515							
255	4.770852296	1.180542878							
256	4.730777137	1.164015278							
257	4.691038609	1.147719064							
258	4.651633884	1.131650997							
259	4.61256016	1.115807683							
260	4.573814654	1.100186573							
261	4.535394611	1.084783961							
262	4.497297297	1.069596985							
263	4.459519999	1.054622627							
264	4.422060031	1.039857911							
265	4.384914727	1.0252999							
266	4.348081443	1.010945701							
267	4.311557559	0.996792462							
268	4.275340476	0.982837367							
269	4.239427616	0.969077644							
270	4.203816424	0.955510557							
271	4.168504366	0.942133409							
272	4.133488929	0.928943541							
273	4.098767622	0.915938332							
274	4.064337974	0.903115195							
275	4.030197535	0.890471582							
276	3.996343876	0.87800498							
277	3.962774587	0.865712911							
278	3.929487281	0.85359293							
279	3.896479588	0.841642629							
280	3.863749159	0.829859832							
281	3.831293666	0.818241597							
282	3.799110799	0.806786215							
283	3.767198269	0.795491208							
284	3.735553803	0.784354331							
285	3.704175151	0.77337337							
286	3.67306008	0.762546143							
287	3.642208375	0.751870497							
288	3.611611842	0.74134431							
289	3.581274302	0.73096549							
290	3.551191598	0.720731973							
291	3.521361589	0.710641725							
292	3.491782151	0.700692741							
293	3.462451181	0.690883043							
294	3.433366591	0.68121068							
295	3.404526312	0.671673731							
296	3.375928291	0.662270298							
297	3.347570493	0.652998514							
298	3.319450901	0.643856535							
299	3.291567514	0.634842544							
300	3.263918346	0.625954748							
301	3.236501432	0.617191381							
302	3.20931482	0.608550702							
303	3.182358576	0.600030992							
304	3.155624781	0.591630558							

305	3.129117532	0.583347731
306	3.102832945	0.575180862
307	3.076789148	0.567128833
308	3.050924288	0.559188534
309	3.025296524	0.551359894
310	2.999884033	0.543640856
311	2.974685007	0.536029884
312	2.949697653	0.528525485
313	2.924920193	0.521126109
314	2.900350863	0.513830343
315	2.875987916	0.506636718
316	2.851829617	0.499543804
317	2.827874248	0.492550191
318	2.804120105	0.485654488
319	2.780565496	0.478855326
320	2.757208746	0.472151351
321	2.734048192	0.465541232
322	2.711082187	0.459023655
323	2.688309097	0.452597324
324	2.665727301	0.446260961
325	2.643335191	0.440013308
326	2.621131176	0.433853121
327	2.599113674	0.427779178
328	2.577281119	0.421790269
329	2.555631958	0.415885205
330	2.534164649	0.410062813
331	2.512877666	0.404321933
332	2.491769494	0.398661426
333	2.47063863	0.393080166
334	2.450083585	0.387577044
335	2.429502883	0.382150965
336	2.409095059	0.376800852
337	2.388858661	0.37152564
338	2.368792248	0.366324281
339	2.348894393	0.361195741
340	2.32916368	0.356139001
341	2.309598705	0.351153055
342	2.290198076	0.346236912
343	2.270960412	0.341389595
344	2.251884345	0.336610141
345	2.232968516	0.331897599
346	2.214211581	0.327251032
347	2.195612203	0.322669518
348	2.177169061	0.318152145
349	2.158880841	0.313698015
350	2.140746242	0.309306242
351	2.122763973	0.304975955
352	2.104932756	0.300706292
353	2.087251321	0.296496404
354	2.06971841	0.292345454
355	2.052332775	0.288252616
356	2.03509318	0.284217081
357	2.017998397	0.280238042
358	2.00104721	0.276314709
359	1.984238414	0.272446303
360	1.967570811	0.268632055
361	1.951043216	0.264871206
362	1.934654453	0.261163009
363	1.918403356	0.257506727
364	1.902288768	0.253901633
365	1.886309542	0.25034701
366	1.870464542	0.246842152
367	1.85475264	0.243386362
368	1.839172718	0.239978953
369	1.823723667	0.236619248
370	1.808404388	0.233306578
371	1.793213791	0.230040286
372	1.778150795	0.226819722
373	1.763214329	0.223644246
374	1.748403328	0.220513226
375	1.73371674	0.217426041
376	1.719155352	0.214382077
377	1.70471263	0.211380728
378	1.690393044	0.208421397
379	1.676193742	0.205503498
380	1.662113715	0.202626449
381	1.64815196	0.199789679
382	1.634307483	0.196992623
383	1.6205793	0.194234726
384	1.606966434	0.19151544
385	1.593467916	0.188834224
386	1.580082786	0.186190545
387	1.56681009	0.183583877
388	1.553648886	0.181013703
389	1.540598235	0.178479511
390	1.52765721	0.175980798
391	1.514824889	0.173517067
392	1.50210036	0.171087828
393	1.489482717	0.168692598
394	1.476971062	0.166330902
395	1.464564505	0.164002269
396	1.452262164	0.161706238
397	1.440063161	0.15944235
398	1.427966631	0.157210157
399	1.415971711	0.155009215
400	1.404077549	0.152839086
401	1.392283297	0.150699339
402	1.380588118	0.148589548
403	1.368991177	0.146509294
404	1.357491652	0.144458164
405	1.346088722	0.14243575
406	1.334781576	0.14044165
407	1.323569411	0.138475466

408	1.312451428	0.13653681
409	1.301428836	0.134625295
410	1.290494851	0.13274054
411	1.279654894	0.130882173
412	1.268905595	0.129049822
413	1.258246788	0.127243125
414	1.247677515	0.125461721
415	1.237197023	0.123705257
416	1.226804568	0.121973383
417	1.21649941	0.120265756
418	1.206280815	0.118582036
419	1.196148056	0.116921887
420	1.186100413	0.115284981
421	1.176137169	0.113670991
422	1.166257617	0.112079597
423	1.156461053	0.110510483
424	1.14674678	0.108963336
425	1.137114107	0.107437849
426	1.127562349	0.105933719
427	1.118090825	0.104450647
428	1.108698862	0.102988338
429	1.099385791	0.101546501
430	1.090150951	0.10012485
431	1.080993683	0.098723103
432	1.071913336	0.097340979
433	1.062909264	0.095978205
434	1.053980826	0.09463451
435	1.045127387	0.093309627
436	1.036348317	0.092003293
437	1.027642991	0.090715246
438	1.01901079	0.089445233
439	1.010451099	0.088193
440	1.00196331	0.086958298
441	0.993546818	0.085740882
442	0.985201025	0.084540509
443	0.976925337	0.083356942
444	0.968719164	0.082189945
445	0.960581923	0.081039286
446	0.952513035	0.079904736
447	0.944511925	0.078786069
448	0.936578025	0.077683064
449	0.928710769	0.076595502
450	0.920909599	0.075523165
451	0.913173958	0.07446584
452	0.905503297	0.073423318
453	0.897897069	0.072395392
454	0.890354734	0.071381856
455	0.882875754	0.070382511
456	0.875459598	0.069397155
457	0.868105737	0.068425595
458	0.860813649	0.067467637
459	0.853582814	0.06652309
460	0.846412719	0.065591767
461	0.839302852	0.064673482
462	0.832252708	0.063768053
463	0.825261785	0.0628753
464	0.818329586	0.061995046
465	0.811455618	
466	0.804639391	
467	0.79788042	
468	0.791178224	
469	0.784532327	
470	0.777942256	
471	0.771407541	
472	0.764927717	
473	0.758502324	
474	0.752130905	
475	0.745813005	
476	0.739548176	
477	0.733335971	
478	0.727175949	
479	0.721067671	
480	0.715010703	
481	0.709004613	
482	0.703048974	
483	0.697143363	
484	0.691287359	
485	0.685480545	
486	0.679722508	
487	0.674012839	
488	0.668351131	
489	0.662736982	
490	0.657169991	
491	0.651649763	
492	0.646175905	
493	0.640748028	
494	0.635365744	
495	0.630028672	
496	0.624736431	
497	0.619488645	
498	0.61428494	
499	0.609124947	
500	0.604008297	
501	0.598934628	
502	0.593903577	
503	0.588914787	
504	0.583967903	
505	0.579062572	
506	0.574198447	
507	0.58937518	
508	0.584592428	
509	0.559849852	
510	0.555147113	

511	0.550483877									
512	0.545859813									
513	0.54127459									
514	0.536727884									
515	0.532219369									
516	0.527748727									
517	0.523315637									

COMPUTATION SHEET

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SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
NIROP FS. - Biodegradation	MJB	3/13/95			

Biological Degradation of cPAH's in Soil

Literature: GENES and COSENTINI "Bioremediation of Polynuclear Aromatic Hydrocarbon Contaminated Soil at 3 Sites. In: Hydrocarbon Contaminated Soils, Volume III, Calabrese and Kostecki, ed. 1991.

Half Life Values For cPAH

1. 185 days
2. 56 days
3. 215 days

Assume the most conservative value of 215 days = 0.59 years

$$t_{1/2} = 215 \text{ days}$$

$$k = \frac{0.693}{T_{1/2}} = \frac{0.693}{0.59 \text{ years}} = 1.17$$

Equation (First order)

$$C_s = C_o e^{-kt}$$

$$C_s/C_o = e^{-kt}$$

$$\ln C_s/C_o = -kt$$

$$\ln 4/227 = -1.17(x)$$

$$-4.04 = -1.17(x)$$

$$x = 3.45 \text{ years}$$

where $C_s = 4$ mg/kg

$C_o = 227$ mg/kg

t = time (years)

$k = 1.17$

∴ Cleanup Time for O.V. #2 Total cPAHs = 3.45 years

APPENDIX H

THERMAL DESORPTION DESIGN INFORMATION

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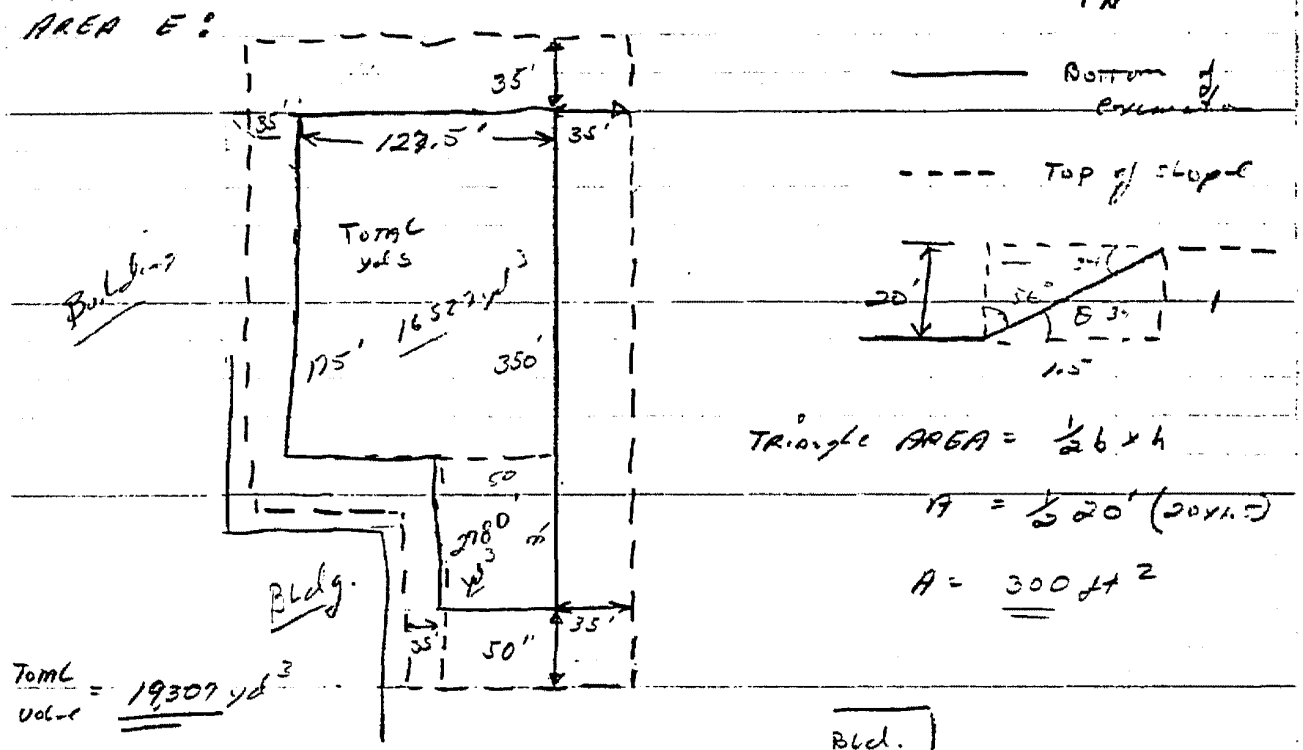
SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED By: MJB Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO
NIROP FS - AREAS of EXC.			

Assume slope stability of Type C soil

AREA E:



Because the area along the building (E) where the slope begins, is equal to the area on the west, the slope Δ is 0 and therefore sloping on the east and west do not add more soil. However note that sloping must be conducted in a manner which does not disturb the building foundation.

On the North and south the volume does become additional by the following:

North: [300 ft² x (127.5 + 35 + 35) ft] / 27 ft³/yd³ = 2194 yd³

South: [300 ft² x (120')] / 27 ft³/yd³ = 1330 yd³

Total E: 19307 + 2194 + 1330 = [illegible]

COMPUTATION SHEET

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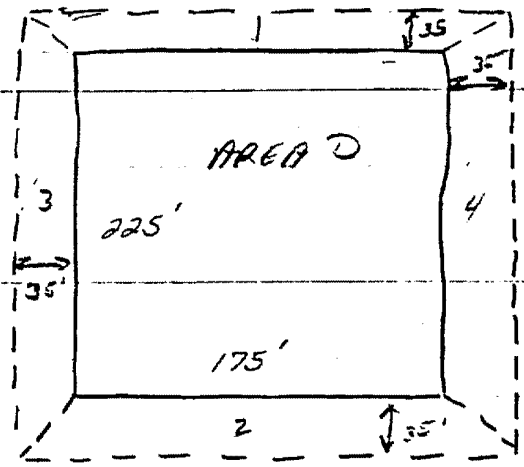
SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED By: MJB Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO
NIROP AREAS of Excavation			

AREA D :

TOTAL Depth = 20'

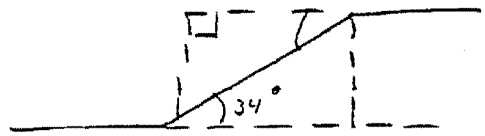


AREA of bottom

225' × 175' = 39375 ft²

volume of bottom

39375 ft² × 20'/27 = 29,170 yd³



TOTAL volume A+A'

A = 300 ft²

$V_{1,2} = 300\,ft^2 \times [(225 + 35 + 35)/27] \times 2$

$V_{1,2} = 6560\ yd^3$

$V_{3,4} = 300\,ft^2 \times [(175 + 35 + 35)/27] \times 2 = 5440\ yd^3$

TOTAL volume of AREA D

6560
5440
29170

41,170 yd³

Slope factors based on 29 CFR 1910 - Excavations through subpart P.

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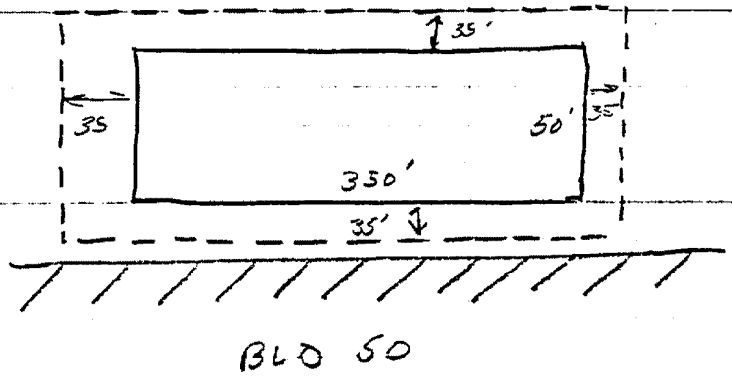
SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED	CHECKED	PROJECT / PROPOSAL NO
NIROP FS - AREAS of EXC	By: MTB Date:	By: Date:	

AREA A2 Assume 1 ft vertical to 1.5 ft horizontal



AREA of Bottom
350' x 50' = 17,500 ft²

Volume of Bottom
(17,500 ft² x 20 ft/27) = 12,963 yd³

Added volume from slope

1. [[300 ft² area x (350 + 35 + 35)] / 27] x 2 = 9330 yd³

2. [[300 ft² area x (50 + 35 + 35) / 27] x 2 = 2670 yd³

TOTAL volume from AREA A2 = 12,963 + 9330 + 2670 = 24,960

COMPUTATION SHEET

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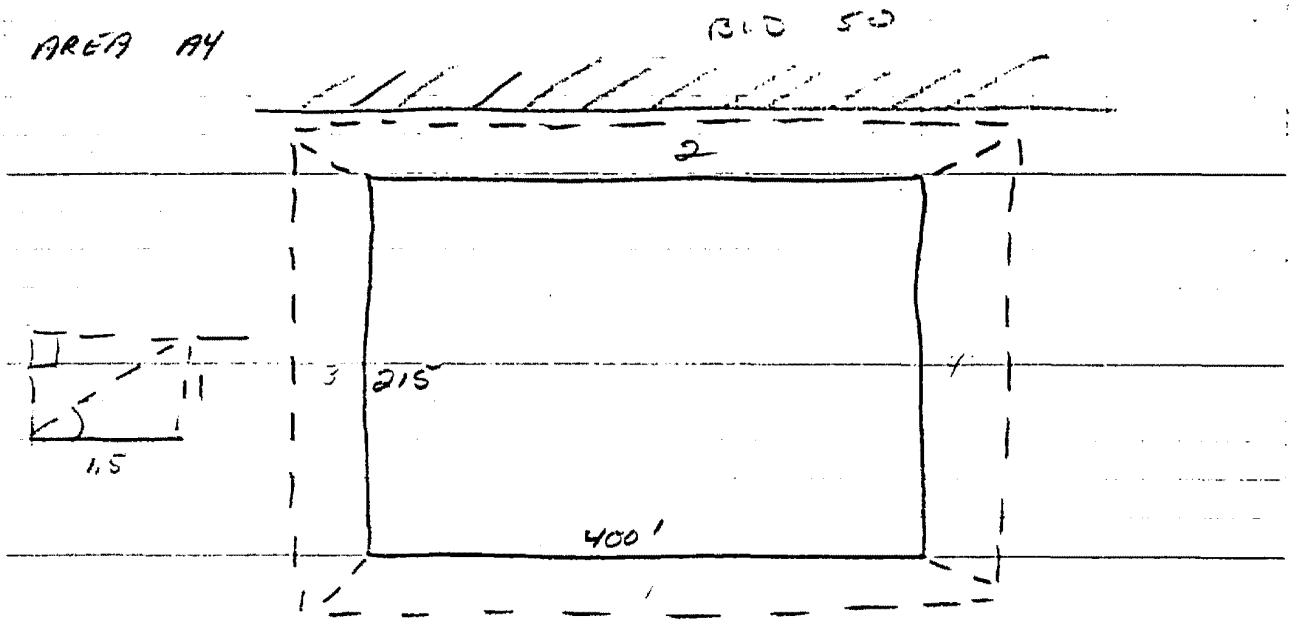
SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED By: MJR Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO.
NIROP Excavation AREA			

AREA A4



Inner volume = (400 x 215 x 20)/27 = 63,7

Volume$_{1,2}$ = [300 ft^2 x (400 + 35 + 35)/27] x 2 = 10,444

Volume$_{3,4}$ = [300 ft^2 x (215 + 35 + 35)/27] x 2 = 6330

Total soil volume from AREA A4 = 63703 yd^3
10,444 yd^3
6330 yd^3

80,477 yd^3

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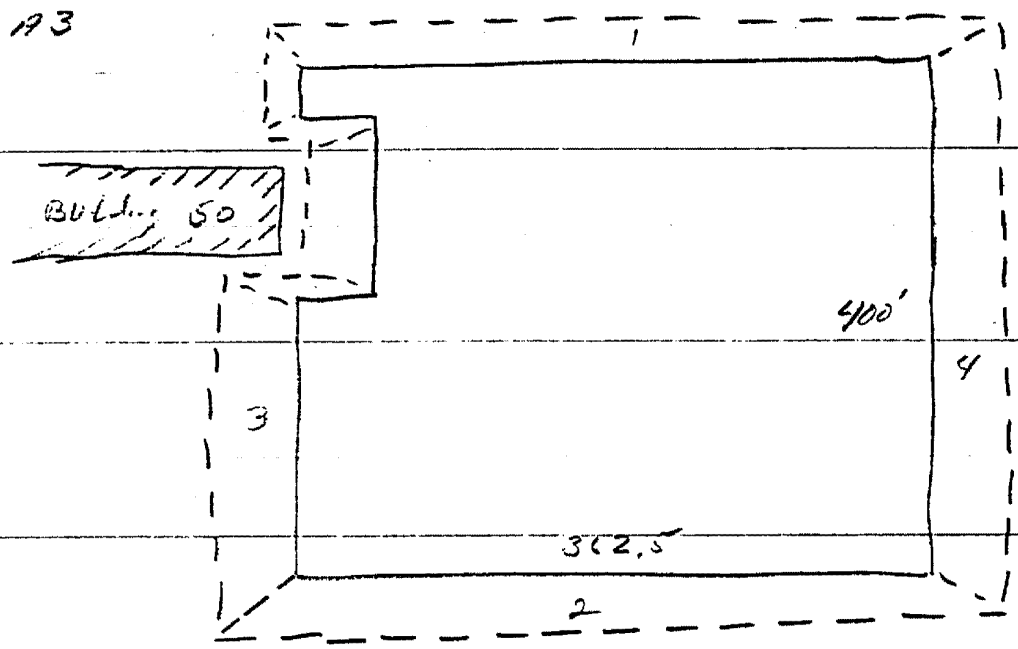
SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED By: Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO.
NIROP FS - AREAS of EXC.			

AREA A3



AREA of Basic excavation

$$\left[(362.5' \times 400' \times 20')/27 - (75 \times 35 \times 20)/27\right] = 105{,}500 \text{ yd}^3$$

AREA 1,2 : $\left[300 \text{ ft}^2 \times (362.5 + 35 + 35)/27\right] = 4800 \text{ yd}^3$

AREA 3,4 $\left[300 \text{ ft}^2 \times (400 + 35 + 35)/27\right] = 5200 \text{ yd}^3$

TOTAL volume $105{,}500 \text{ yd}^3 + 4800 + 5200 = \underline{115{,}500 \text{ yd}^3}$

COMPUTATION SHEET

RMT INC.

SHEET _____ OF _____

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PROJECT / PROPOSAL NAME	PREPARED By: MJB Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO
NIROP FS - AREAS of EXC			

TOTAL Estimated volume

AREA E : 22831 yd^3

AREA D : 41,170 yd^3

AREA A2 : 24,960 yd^3

AREA A4 : 80,477 yd^3

AREA A3 : 115,500 yd^3

TOTAL volume : 284,937 or 275,000 yds

Because of the degree of uncertainty in the actual areas that will be excavated (i.e. what areas are above the 1 ppm limit) we will round the total excavation volume to 300,000 yd^3. Actual soil volumes will be determined using field surveying techniques.

COMPUTATION SHEET

RMT INC.

SHEET _____ OF _____

20900 Swenson Drive Suite 100 Waukesha WI 53186-4050 (414) 798-9550 FAX: (414) 798-9551

PROJECT / PROPOSAL NAME	PREPARED By: MJB Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO
NIROP Feasibility Study			

Estimated Sheet Piling

Based on Figure 3-2, the estimated amount of sheet piling is:

AREA A2 (BLD 50): 375 feet

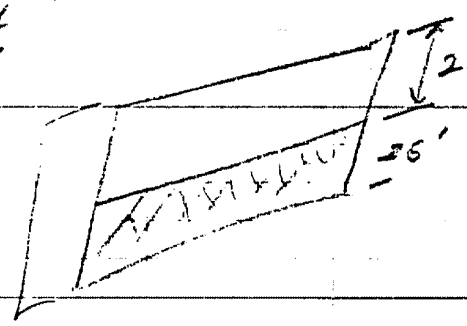
AREA A4 (BLD 50): 425 feet

AREA A3 (BLD 50): 75 feet

AREA E (main plant): 150 feet + 50 + 25 + 25 + 50 = 300 feet TOTAL

TOTAL length: 1175 feet

For an excavation of 20 feet, assume sheet piling driven to 20 feet below the excavation or 40 feet.



TOTAL Sheet Piling Area: 1175 feet x 40' = 47,000 ft^2

MEANS Construction Data Costs – 1993, pg 40, Item 1900
Assume 25' deep excavation, 38 psf, Drive, extract salvage

Estimated Cost: \$10.15/ft^2

TOTAL Cost: \$10.15/ft^2 x 47,000 ft^2 = \$477,000

SERVICES

Remedial Services:

- Provide all equipment and personnel to fully remediate contaminated soil to below governing cleanup objectives.

- With four thermal units in operation, MSR has the ability to respond quickly to your needs with the properly sized equipment.

    - 1- 12 load plant, capable of processing 120 tons per hour at 1200 F.

    - 1- 6 load plant, capable of processing 40 tons per hour at 900 F.

    - 2- 1 load plants capable of processing 15 tons per hour at 900 F.

- Soil processing costs are extremely competitive, often well below alternative technologies.

- Midwest Soil Remediation's thermal desorbtion plants are completely mobile, allowing rapid deployment to any site.

- The low temperature thermal treatment of contaminated soil effectively cleans the soil to below all cleanup objectives allowing the treated soil to be backfilled into the original excavation, with no future treatment or monitoring costs. This process also eliminates any future liability usually associated with the landfilling of contaminated soil.

- MSR has processed over 300,000 tons of contaminated soil to below state cleanup objectives. We guarantee all soil to meet these objectives, or you don't pay.

GENERAL DESCRIPTION OF SOIL PROCESSING

The Midwest Soil Remediation equipment fleet consists of both small and large mobile processing units. This wide range of process capability allows MSR to remediate contaminated sites ranging form 200 to 1,000,000 tons at consistently economic levels.

MSR systems meet and exceed all state and federal soil treatment and emissions levels for contaminants including; oil well crude, fuel oil, lubricating oil, jet fuel, diesel, gasoline, chlorinated hydrocarbons, and pesticides just to name a few.

The thermal remediation process begins with the placement of contaminated soil in the primary feed hopper by front end loader. All types of soil including; clay, sand, silty clay, gravel, and aggregate less than two inches in size can be treated. The soil passes through a six inch grizzly bar screen which rejects debris and large aggregate before entering the system.

After proceeding through additional screens to reduce soil to two inch diameter size for processing, the soil then passes over a dual idler in-motion weigh scale which has an electronic remote readout and recorder to log all soil tonnage entering the process. The recorder will log data for hourly, daily, and project totals for manifests and permanent records.

Soil less than two inches in size travels via a slinger conveyor feeding the systems rotary desorber.

The rotary thermal desorber can elevate soil temperature to a level necessary to convert all contaminants in the soil, liquid and solid, into a vapor state for removal by way of the exhaust gas stream. The rotary desorber is equipped with variable speed, slope, and temperature control to permit soil retention time to vary from eight to twenty minutes to assure the complete remediation of all contaminants regardless of weight and density.

The high temperature air stream containing the volitalized contaminates as well as any dust picked up from the rotary desorber then travels to the thermal dust conductor. The dust is thermally remediated by dwelling with the high temperature soil in a tumbling mode, using conductive heat transfer to vaporize any remaining contaminates in the dust before they exit the conductor. The vaporized contaminates are then ducted back into the combustion zone for elimination. The fabric filter baghouse is equipped with filter bags that trap dust as the 400 F gas stream is drawn inside by an exhaust fan. As dust is trapped on the outside of the bags the particulate free air exits the unit from inside the bags and is directed to the thermal oxidizer.

The thermal oxidizer receives the 400 F dust free air stream from the baghouse and the gasses enter the combustion zone of the thermal oxidizer. The combustion system will

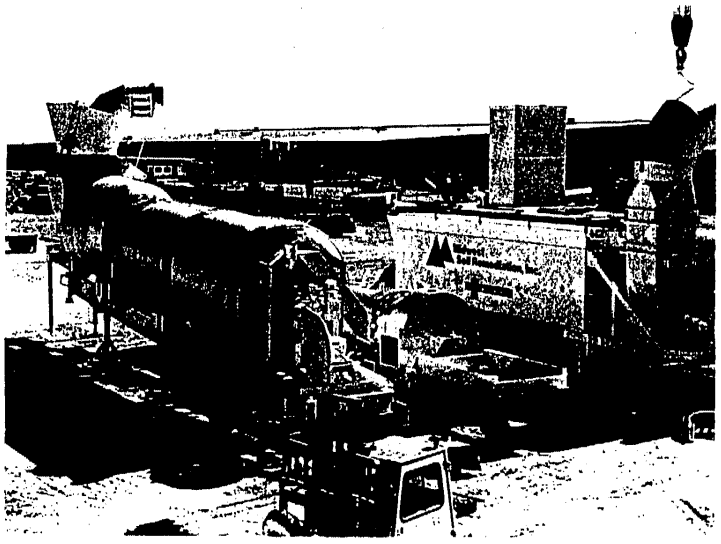
elevate the gas stream from 400 degrees to as high as 1800 F and retain the gasses for a period of one second within the destruct zone. This is the necessary retention time and temperature to destroy all organic compounds contained within the gas stream with an efficiency rate of 99.8%.

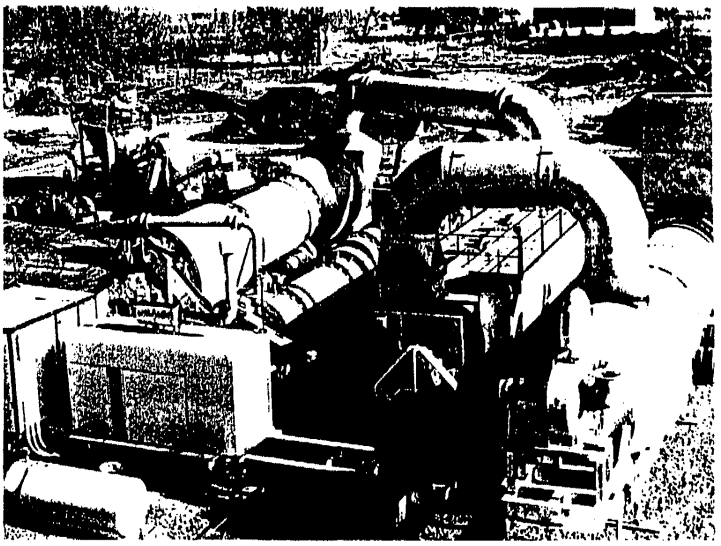
Soil exiting the rotary desorber enters a soil conditioner. The soil conditioner cools and rehydrates the soil with water sprayed from high pressure jets. The cool rehydrated soil exits the soil conditioner by gravity and is deposited on a stacking conveyor for stockpiling

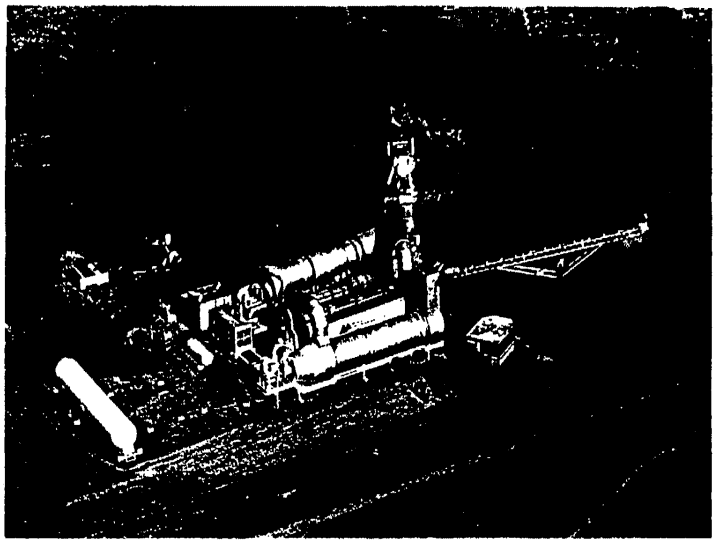
Upon completion of laboratory testing to confirm the removal of all VOC's to below the project cleanup objectives the soil is ready for use. Treated soil is commonly replaced to the original excavation to fulfill closure requirements. The treated soil can be compacted to above 95% with ease. Upon completion of backfilling and compaction the processed soil can be further treated with fertilizer, and seeded to fully restore the site to its original condition

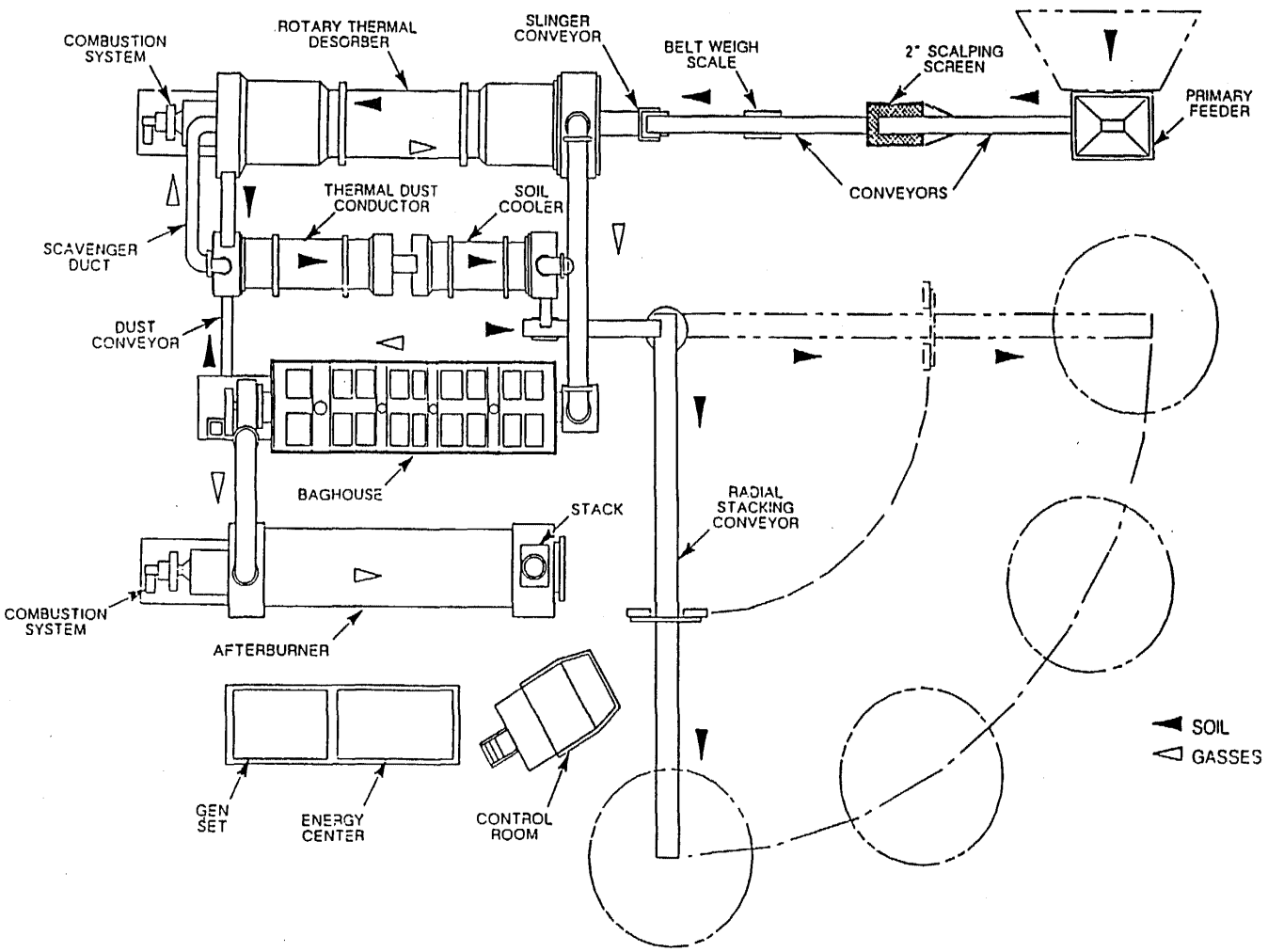
CMI 80-120

COMPONENT SPECIFICATIONS








COMBUSTION SYSTEM
ROTARY THERMAL DESORBER
SLINGER CONVEYOR
BELT WEIGH SCALE
2" SCALPING SCREEN
PRIMARY FEEDER
CONVEYORS
THERMAL DUST CONDUCTOR
SOIL COOLER
SCAVENGER DUCT
DUST CONVEYOR
BAGHOUSE
STACK
RADIAL STACKING CONVEYOR
COMBUSTION SYSTEM
AFTERBURNER
GEN SET
ENERGY CENTER
CONTROL ROOM
SOIL
GASSES

COMPONENT SPECIFCATIONS
ENVIRO-TECH
MODEL TMD-80/120 - ROTARY THERMAL DESORBER:

MAXIMUM PROCESS RATE ..... 120 T.P.H. (Max. Feed)

AVERAGE PROCESS RATE ..... 100 T.P.H. (Avg. Feed)

SOIL CONTENT OF TOTAL FEED (Net After Moisture Removal) ..... .90 T.P.H. (Net Feed)

SOIL MOISTURE CONTENT (Target) ..... 10% (16,000 lbs.)

SOIL CONTAMINANT PERCENTAGE (Process Target) ..... (5,000 PPM Avg.) - 10,000 PPM (1%)

DRYER/KILN SIZE ..... 9'-0" I.D. x 50'-0" Long

DRYER SHELL MATERIAL 800F (Skin Max.) (Drying Zone) (Heating Zone) ..... Carbon Steel (800F Soil)

DRYER SHELL MATERIAL 1,200F (Skin Max.) (Burn Zone) ..... Stainless Steel Alloy (1,200F Soil)

DRYER DRIVE-VARIABLE SPEED ..... .5 to 3 R.P.M.

DRYER ORIENTATION ..... Counterflow

SOIL DWELL TIME (Variable) (8 Min. TO 45 Min.) ..... (Avg.) 16 Minutes

SOIL DISCHARGE TEMPERATURE (Average) (450F Min. - 1200F Max.) ..... (Avg.) 850F

BURNER CAPACITY BTUH. (No Soil Fuel Considered) ..... 64.4 mm

BURNER CAPACITY BTUH. (With Soil Fuel Considered) @ (10,000 PPM)@ (60%) ..... 42.5 mm

FUEL VALUE IN SOIL (60%) (Destruction in Volatilizer) ..... 21.9 mm

BURNER COMBUSTION AIR REQUIRED (Primary) ..... 8,281 SCFM

SUPPLEMENTAL FUEL COMBUSTION AIR REQUIRED (Secondary) .....5,002 SCFM

TOTAL AIR REQUIRED (@ 100 TPH x 450 ACFM/ton) ..... 45,000 ACFM

DRYER VOLUME (Empty) ..... .3,181 Cu. Ft. Area (164 Tons)

SOIL VOLUME (@ 72 TPH @ 16 Min. Dwell) ..... 19.2 Tons In Transit

DRYER SLOPE VARIABLE (Avg.) (50) ..... .275 - .750" Per Foot

DRYER SPEED (Variable) (Avg.) ..... 3 R.P.M.

EXHAUST GAS EXIT TEMPERATURE 550F

EXHAUST GAS VOLUME AT 550F ..... 45,000 A.C.F.M.

EXHAUST GAS VELOCITY ..... 678 F.P.M.

Note: Rotary Dryer/Kiln has a process capacity range fo 25 T.P.H. to 120 T.P.H. depending upon temperature and dwell time. Throughput capacities will vary based upon contaminant content, moisture content and hydrocarbon structure. Fuel based on 137,500 BTU/GAL.

MODEL TOM-80/120 - THERMAL OXIDIZER:

OXIDIZER BURN ZONE TEMPERATURE RANGE ..... 1,600F to 1,800F (Avg.)

OXIDIZER GAS DWELL TIME ..... One (1) Second (Avg.)

BURNER BTUH CAPACITY (No Soil Fuel Considered) ..... 64.4 mm

BURNER BTUH CAPACITY (With Soil Fuel Considered) @ (10,000 PPM) (40%) ..... 49.8 mm

FUEL VALUE INCOMING GASSES (40%) ..... 14.6 mm

OXIDIZER SHELL MATERIAL ..... Carbon Steel

OXIDIZER OUTSIDE DIAMETER (O.D.) ..... 10'-0" O.D

OXIDIZER INSIDE DIAMETER (I.D. Refractory) ..... 8'-6" I.D

OXIDIZER LENGTH (Burn Zone) ..... 38'-0"

OXIDIZER LENGTH (Overall) ..... 53'-6"

OXIDIZER DESTRUCT ZONE SIZE (8'-6" I.D. x 38'-0" Long) ..... 2,156 Cu. Ft.

BURNER COMBUSTION AIR REQUIRED ..... 10,801 SCFM

EXHAUST GAS EXIT TEMPERATURE ..... 1,600F to 1,800F

EXHAUST GAS VOLUME (@ 1,800F) ..... 126,813 ACFM

EXIT GAS VELOCITY (@ 1,800F) ..... 2,234 FPM/37 FPS

OXIDIZER REFRACTORY TYPE (Light Weight) ..... 2,400F Rated/9" Wall Thickness

(FUEL BASED N 137,500 BTU/GAL.)

MODEL TDCM-80/120 - ROTARY THERMAL DUST CONDUCTOR:

THROUGHPUT (Maximum) ..... 120 T.P.H.
THROUGHPUT (Average) ..... 100 T.P.H.
DRUM SIZE ..... 6'-0" Dia. x 20'-0" Long
DRUM VOLUME (Max.) ..... 565 Cu. Ft. (29.31 Tons)
DRUM SOIL DISPLACEMENT (@ 8 Min. Dwell) (@ 72 T.P.H.) 32%
SOIL WEIGHT IN TRANSIT (@ 72 T.P.H.) ..... 9.6 Tons
SOIL DWELL TIME VARIABLE (4 TO 8 Min.) ..... (Avg.) 4 Minutes
DRUM INCLINE ..... 0-F Level
DRUM DRIVE (0-5) RPM ..... Variable Speed
DRUM DRIVE H.P. ..... 25 H.P.
SOIL INLET TEMPERATURE(Average) ..... 850F (Minimum)
SOIL AGGREGATE CONTENT ..... 123,840 Lbs/Hr. (Avg.)
DUST CONTENT (14%) ..... 20,160 Lbs/Hr (Avg.)

MODEL RSCM-80/120 - ROTARY SOIL COOLER:

THROUGHPUT (Max.)	120 T.P.H.
THROUGHPUT (Avg.)	100 T.P.H.
DRUM SIZE	6'-0" Dia. x 16'-0" Long
DRUM VOLUME	452 Cu. Ft. (23.4 Tons)
DRUM SOIL DISPLACEMENT (4 Min. Dwell) (@ 72 T.P.H.)	20%
SOIL WEIGHT IN TRANSIT (@ 72 T.P.H.)	4.8 Tons
SOIL DWELL TIME VARIABLE (4 TO 8 Min.)	(Avg.) 4.0 Minutes
WATER INJECTION RATE (Min.) (@ 100 TPH) (@ 850F)	48 G.P.M.
DRUM DRIVE VARIABLE SPEED (.5 TO 5 RPM)	Variable Speed
DRUM DRIVE H.P.	25 H.P.
SOIL INLET TEMPERATURE	(Avg.) 850F
SOIL OUTLET TEMPERATURE	120F
SOIL MOISTURE CONTENT (Processed Soil)	.8%

MODEL RA-220M-80/120 - ROTO-AIRE FABRIC FILTER BAGHOUSE:

BAGHOUSE SIZE (CFM)	48,000 ACFM (@500F)
NUMBER OF BAGS	720
SQUARE FEET CLOTH AREA	12,744 Sq. Ft.
AIR TO CLOTH RATIO	4 TO 1
OPERATING GAS INLET TEMPERATURE	500F
CONTINUOUS CLEANING	Roto-Step System
PRESSURE DROP (Avg.)	4" W.C.
OUTLET PARTICULATE LOADING	.016 TO .04 Grains/D.S.C.F.

ORGANIC COMPOUND EMISSIONS LEVEL

PROCESS MODEL **AVERAGE SOIL PROCESS RATE**

100	TONS/HR.
12	HOURS/DAY
7	DAYS/WEEK
30	WEEKS/YEAR
2,520	OPERATING HOURS PER YEAR
252,000	TONS/YEAR
5,000	PPM (0.5%) ORGANIC CONTAMINANTS
	BURNER FUEL:
	NATURAL GAS (1,000 BTU/CU. FT.)
	LIQUID PROPANE (92,000 BTU/GAL.)
	DIESEL FUEL (137,500 BTU/GAL.)
10 %	SOIL MOISTURE CONTENT
850 °	F. SOIL DISCHARGE TEMP.
500 °	F. DESORBER EXIT GAS TEMP.
12 %	ESTIMATED SOIL DUST CONTENT
1,600 °	F. THERMAL OXIDIZER EXIT TEMP.
1 %	SECOND GAS DWELL (OXIDIZER)
45,000	ACFM @ 500 ° F. GAS FLOW TEMP.

ORGANIC CONTAMINANT CONTENT IN SOIL

@ 5,000 PPM = 0.005 %

(200,000)(0.005)= 1,000 LBS.
LBS/SOIL ORG.C

(1,000)(18,835)= 18,835,000 ORGANIC COMPOUNDS
LBS/ORG BTU/LB BTU

NOTE: Estimating 60% organic compounds are oxidized within Thermal Desorber, with 40% non-oxidized organic compounds proceeding to destroy 99.4% of the total organic material entering oxidizer.

(400)(0.006)= 2.4 ORGANIC COMPOUNDS
LBS/HR/ORG EFF LBS/HR

(2.4)(2,520) 6,048 ÷ 2,000 = 3.02 ORGANIC COMPOUNDS
LBS/HR HRS/YR LBS/HR LBS/TON TONS/YR

THERMAL DESORBER
HEAT REQUIREMENTS

PROCESS MODEL — AVERAGE

100	TONS/HR.	SOIL PROCESS RATE
12	HOURS/DAY	
7	DAYS/WEEK	
30	WEEKS/YEAR	
2,520	OPERATING HOURS PER YEAR	
252,000	TONS/YEAR	
5,000	PPM (0.5%) ORGANIC CONTAMINANTS	
	BURNER FUEL:	
	NATURAL GAS (1,000 BTU/CU. FT.)	
	LIQUID PROPANE (92,000 BTU/GAL.)	
	DIESEL FUEL (137,500 BTU/GAL.)	
10 %	SOIL MOISTURE CONTENT	
850 °	F. SOIL DISCHARGE TEMP.	
70 °	F. ENTRY GAS TEMP.	
500	F. EXIT GAS TEMP.	
45,000 °	ACFM @ 70 ° F. GAS FLOW	

MAXIMUM FUEL CONSUMPTION /PER HR.
58,104 C.F.
632 GAL.
423 GAL.

HEAT REQUIRED TO ELEVATE SOIL TEMP

FROM: 70 ° F. INLET TO: 850 ° F. OUTLET

(100 TPH) 2,000 LBS/TON) 200,000 LBS

(200,000 LBS/HR) 0.10 WTR ; 20,000 LBS/HR

200,000 LBS - 20,000 LBS WTR = 180,000 LBS SOIL

(180,000 WEIGHT) 0.21 SH)(780 DELTA T) = 29,484,000 BTU

HEAT REQUIRED TO TDA.XLS

FROM: 70 ° F. INLET TO: 850 ° F. OUTLET

(20,000 LBS WTR) 1 SH)(142 DELTA T) = 2,840,000 BTUH

(20,000 LBS WTR) 1 SH)(970 VP FACTOR) = 19,400,000 BTUH

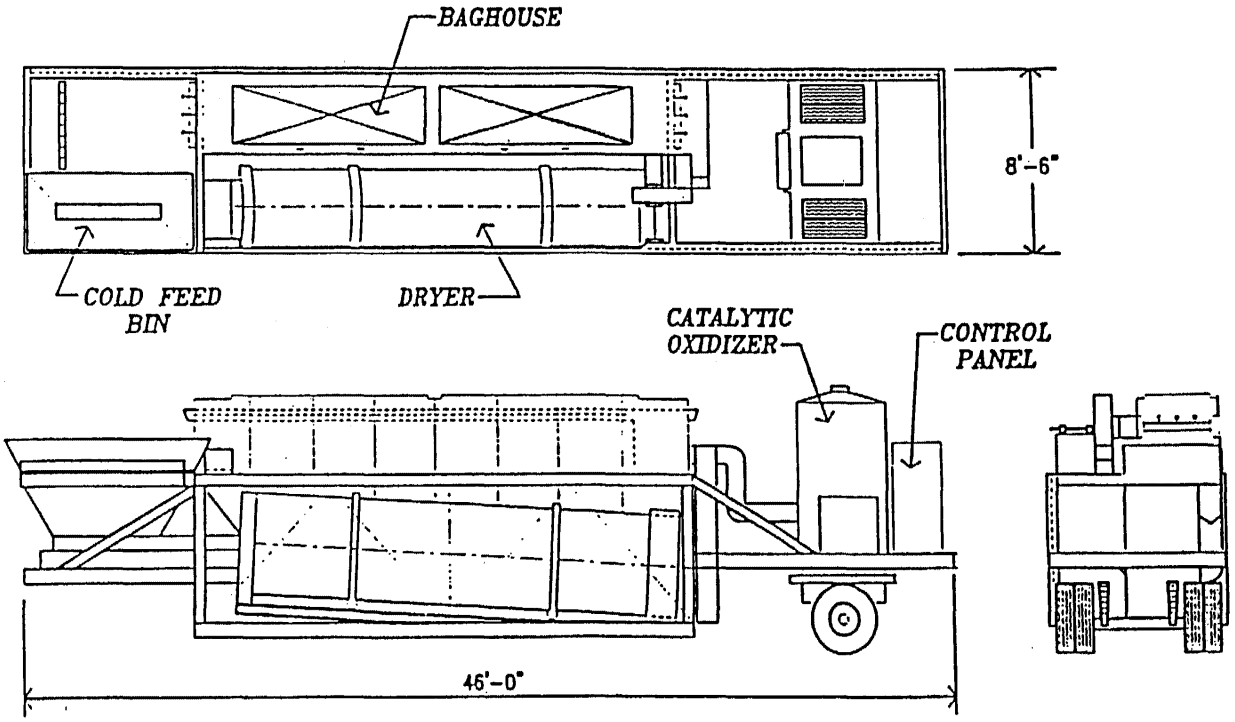
(20,000 LBS WTR) 0.5 SH)(638 VP FACTOR) = 6,380,000 BTUH

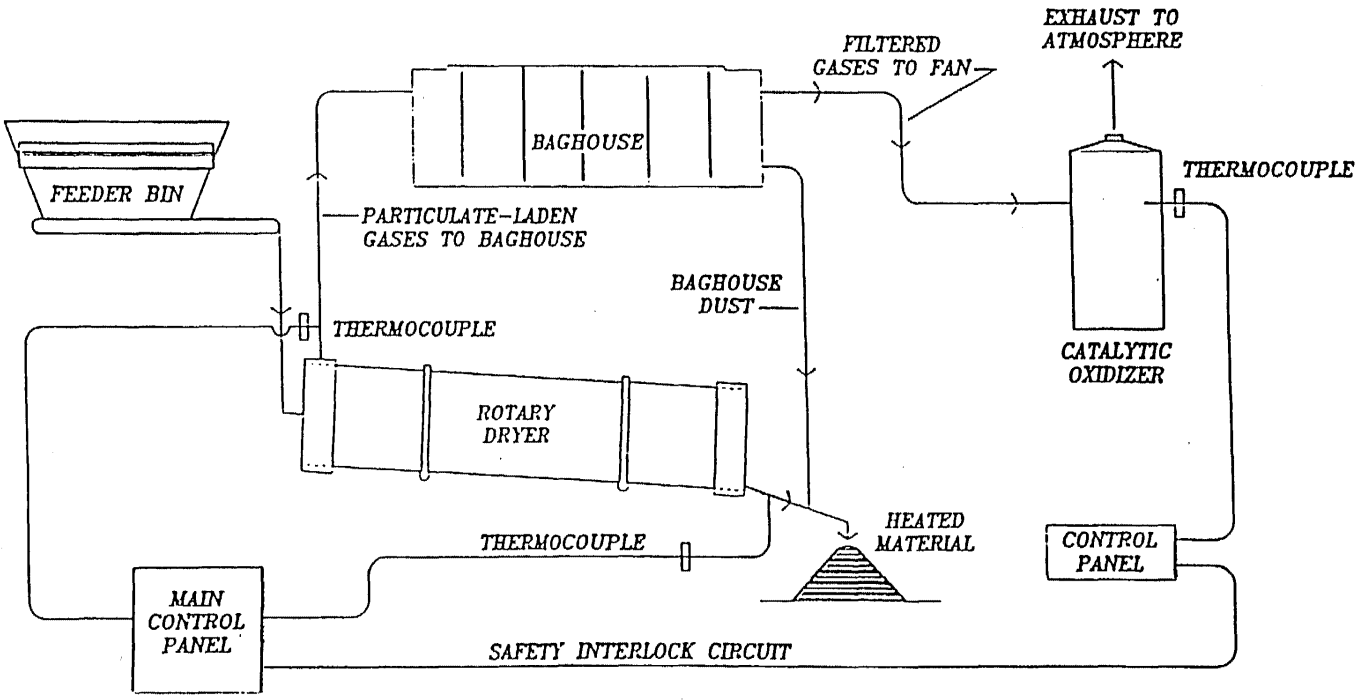
28,620,000 BTUH

TOTAL HEAT REQUIRED DESORBER 58,104,000 BTUH

GEM 1000

COMPONENT SPECIFICATIONS


BAGHOUSE
8'-6"
COLD FEED BIN
DRYER
CATALYTIC OXIDIZER
CONTROL PANEL
46'-0"


EXHAUST TO ATMOSPHERE
FILTERED GASES TO FAN
BAGHOUSE
FEEDER BIN
THERMOCOUPLE
PARTICULATE-LADEN GASES TO BAGHOUSE
BAGHOUSE DUST
THERMOCOUPLE
CATALYTIC OXIDIZER
ROTARY DRYER
HEATED MATERIAL
THERMOCOUPLE
CONTROL PANEL
MAIN CONTROL PANEL
SAFETY INTERLOCK CIRCUIT

BASIC EQUIPMENT INFORMATION

FEEDER BIN CAPACITY	3 cuyds.
ROTARY KILN SIZE	4' 0" x 20 ft.
ROTARY KILN SOIL TEMPERATURE	400 - 900 F
ROTARY KILN AIR TEMPERATURE	400 - 1200 F
ROTARY KILN RESIDENCE TIME	6 - 12 min.
VOLUMETRIC FLOW RATE	3,000 scfm
BAGHOUSE COVERAGE	900 sqft.
NUMBER OF BAGS	78
TEMPERATURE MAX CONTINUOUS OPERATION	370 F
CATALYTIC OXIDIZER TEMPERATURE	600 - 1200 F
CATALYTIC OXIDIZER PRESSURE DROP	6.8"
CATALYTIC VOLUME	4.9 cuft.
CATALYTIC DEPTH	10.5 ft.
GUARANTEED CONVERSION	95%
CATALYTIC BURNER	3,000,000 btu

REFERENCES

CLIENT /CONTACT	PROJECT
United States Air Force (AFCEE) Chanute AFB, Rantoul, IL Mr.Bijoy Gosh Engineering Science, Inc. 57 Executive Park South Atlanta, GA 30329 404-235-2484	40,000 tons of petroleum hydrocarbon contaminated soil thermally treated to below cleanup objectives.
Caterpillar, Inc. Joliet, IL Mr. Paul Sklar Woodward & Clyde 11270 W. Park Place Milwaukee, WI 53224	1,500 tons of RCRA hazardous waste contaminated soil thermally treated to below cleanup objectives, and backfilled to original location.
US Army Corps of Engineers Truax AFB, Madison, WI Mr. Bob Martin US Army Corps of Engineers 410 D East Stevenson Road Ottawa, IL 61350 815-434-7357	36,000 tons of soil contaminated with diesel and jet fuel thermally treated to below cleanup objectives, and backfilled to original location.
Rockwell International Darien, IL Mr. Tim Tracey Rust Remedial Services 7250 W. College Drive Palos Heights, IL 60463 708-361-8400	11,000 tons of chlorinated solvent and hazardous material contaminated soil processed to below cleanup objectives, and backfilled to original location.
United Airlines O'Hare Field, Chicago, IL Mr. Glenn Ernstmann 4800 E. 63rd Street Kansas City, Mo 64141 816-822-3222	10,000 tons of jet fuel contaminated soil treated to below cleanup objectives.

Shell Oil Co. Lombard, IL Mr. Dave Grotage Engineering Science, Inc. 1000 Jorie Blvd. Oakbrook, IL 60521 708-990-7200	5,400 tons of gasoline contaminated soil treated to below cleanup objectives. Soil backfilled to original location and compacted to 95%.
CSX Railroad Oak Park, IL Mr. Paul Kurzanski CSX Transportation 500 Water St. Jacksonville, FL 32202	600 tons of petroleum hydrocarbon contaminated soil treated to below cleanup objectives. Project completed in five days.
Unocal Oil Co. Glendale Heights, IL Mr. Rick Horn Unocal Oil Co. 1650 E. Golf Rd. Schaumburg, IL 60196 708-330-0076	5,500 tons of petroleum hydrocarbon contaminated soil treated to below cleanup objectives.
United States Army Ft. Hood, TX Mr. Joe Mathewson Foster Wheeler 11936 Altamar Pl. Santa Fe Springs, CA 90670 213-944-2985	7,100 tons of hazardous TCE and toluene contaminated soil processed to below cleanup objectives.
AT&T Springfield, IL Mr. Bruce Culbertson Becco Environmental 226 County Rd. 3300 N. Foosland, IL 61845 217-846-3115	Excavated, treated, backfilled, and compacted 4,000 tons of petroleum hydrocarbon contaminated soil.

STATE PERMITS

STATE OF MISSOURI

DEPARTMENT OF NATURAL RESOURCES

MISSOURI AIR CONSERVATION COMMISSION

PERMIT TO CONSTRUCT

Under the authority of RSMo 643 and the Federal Clean Air Act the applicant is authorized to construct the facility described below, in accordance with the laws, rules, and conditions as set forth herein:

Permit Number:	0592-007	Facility I.D. Number:	PORT-57-1
Owner:	Midwest Soil Remediation		
Owner's Address:	27W010 St. Charles Road, Wheaton, IL 60188		
Facility Name:	Midwest Soil Remediation		
Facility Address:	27W010 St. Charles Road, Wheaton, IL 60188		
Legal Description:	Portable Facility		

Application for Authority to Construct was made for:

**** a portable thermal soil remediation unit (GEM 1000). The equipment includes a feeder bin, a propane fired preheater, a propane fired rotary dryer, a baghouse, a catalytic combustor, and a 130 horsepower diesel generator. ****

AIR POLLUTION CONTROL DIVISION
MAIN OFFICE
640 Temple Street, Suite 700
Detroit, Michigan 48201
(313) 832-5000
FAX: (313) 832-5066
DOWNRIVER OFFICE
Eureka Road
231 Eureka Road
Wyandotte, Michigan 48192
(313) 281-8396
FAX: (313) 281- 6973

DEPARTMENT OF PUBLIC HEALTH
WAYNE COUNTY

EDWARD H. McNAMARA
County Executive
Bernard N. Kilpatrick
Assistant County Executive
Cynthia Taueg, MPH
Director-Health Officer
Donald Lawrenchuk, M.D., MPH
Medical Director

June 29, 1992

Mr. Tony Fetherling, President
Midwest Soil Remediation, Inc.
27W010 St. Charles Road
Wheaton, IL 60188

SUBJECT: TRANSMITTAL OF INSTALLATION PERMIT NUMBERS C-9731

State of Louisiana
Department of Environmental Quality

BUDDY ROEMER
Governor

PAUL TEMPLET
Secretary

Mr. Trevor Johansen, Secretary
Midwest Soil Remediation, Inc.
27W010 St. Charles Road
Carol Stream, Ill 60188

DEPARTMENT OF COMMERCE, LABOR & ENVIRONMENTAL RESOURCES
DIVISION OF ENVIRONMENTAL PROTECTION
1558 Washington Street, East
Charleston, WV 25311-2599

Gaston Caperton
Governor
John M. Ranson
Cabinet Secretary

David C. Callaghan
Director
Ann A. Spaner
Deputy Director

January 14, 1993

Mr. John Sweeney
Vice President
Midwest Soil Remediation
27W010 St. Charles Rd.

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
We make Indiana a cleaner, healthier place to live

Evan Bayh
Governor
Kathy Prosser
Commissioner

105 South Meridian Street
P.O. Box 6015
Indianapolis, Indiana 46206-6015
Telephone 317-232-8603
Environmental Helpline 1-800-451-6027

Midwest Soil Remediation, Inc.
27W010 St. Charles Road
Carol Stream, Illinois 60188

June 9, 1992

Attention: Tony Fetherling

State of Illinois
ENVIRONMENTAL PROTECTION AGENCY

Mary A. Gade, Director
217/782-2113

2200 Churchill Road, Springfield, IL 62794-9276

JOINT CONSTRUCTION AND OPERATING PERMIT

PERMITTEE

Midwest Soil Remediation, Inc.
Attn: John Sweeney
27W010 St. Charles Road
Wheaton, IL 60188

OhioEPA
State of Ohio Environmental Protection Agency

North Carolina Department of Environment, Health, and Natural Resources

Environmental Management Commission

AIR PERMIT APPLICATION

A

State of Kansas
Joan Finney, *Governor*

Department of Health and Environment
Robert C. Harder, *Secretary*

January 5, 1994

Permit# 7770324 PORTABLE
MIDWEST SOIL REMEDIATION, INC.
27 W. 101 ST. CHARLES RD.
WHEATON, IL 60188

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
9th Floor, L & C Annex
401 Church St.
Nashville, TN 37243-1531

OCT 02 1992

Mr. John Sweeney
Vice President Marketing and Sales
Midwest Soil Remediation, Inc.
Portable Thermal Treatment Units
27W010 St. Charles Road
Wheaton, IL 60188

RE: GEM 1000 Thermal Unit, TN Air National Guard Operation

Minnesota Pollution Control Agency
Air Quality Division
520 Lafayette Road, St. Paul, MN 55155-3898

For Agency Use Only

AQD File No. _____

JOHN ASHCROFT
Governor

G. TRACY MEHAN III
Director

STATE OF MISSOURI
DEPARTMENT OF NATURAL RESOURCES

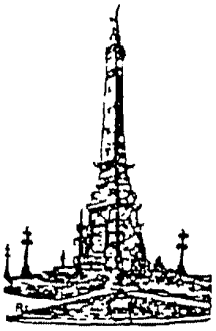
DIVISION OF ENVIRONMENTAL QUALITY
P.O. Box 176
Jefferson City, MO 65102

Division of Energy
Division of Environmental Quality
Division of Geology and Land Survey
Division of Management Services
Division of Parks, Recreation, and Historic Preservation

February 5, 1992

Tony Fetherling
Midwest Soil Remediation
27W010 St. Charles Rd.
Wheaton, IL 60188

CITY OF INDIANAPOLIS
DEPARTMENT OF PUBLIC WORKS
AIR POLLUTION CONTROL DIVISION



Certificate of Operation

FACILITY NUMBER: 777

ISSUED TO: Midwest Soil Remediation, Inc.

Valid Period:

February 26, 1992

WALLACE E. REED, CHAIRMAN
CHARLOTTESVILLE

TIMOTHY E. BARROW,
VICE CHAIRMAN
VIRGINIA BEACH

SAM C. BROWN, JR.
VIRGINIA BEACH

RICHARD L. COOK
RICHMOND

MANUEL DEESE
RICHMOND

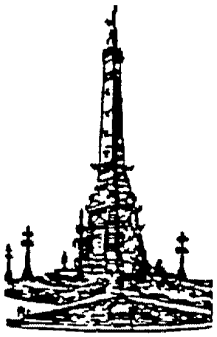
ALAN L. LAUBSCHER, P.E.
REGIONAL DIRECTOR

COMMONWEALTH of VIRGINIA

Department of Air Pollution Control

NORTHERN VIRGINIA REGIONAL OFFICE
SPRINGFIELD CORPORATE CENTER
6225 BRANDON AVENUE
SUITE 310
SPRINGFIELD, VIRGINIA 22150
(703) 644-0311
FAX # (703) 644-0296
TDD # (804) 371-8471

CITY OF INDIANAPOLIS
DEPARTMENT OF PUBLIC WORKS
AIR POLLUTION CONTROL DIVISION



Certificate of Operation

FACILITY NUMBER: 777

ISSUED TO: Midwest Soil Remediation, Inc.

DATE ISSUED: February 26, 1992

LOCATION: Portable, Marion County

Valid Period:

February 26, 1992

February 28, 1994

STATE OF IOWA

TERRY E. BRANSTAD, GOVERNOR

DEPARTMENT OF NATURAL RESOURCES
LARRY J. WILSON, DIRECTOR

August 3, 1992

CERTIFIED MAIL

Mr. Mike Sherer
Midwest Soil Remediation, Inc.
27W010 St. Charles Road
Wheaton, ILL 60188

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

DIVISION OF AIR AND HAZARDOUS MATERIALS
291 Promenade Street
Providence, R.I. 02908-5767

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

WISCONSIN
DEPT. OF NATURAL RESOURCES

George E. Meyer, Secretary
William R. Selbig, District Director

Lake Michigan District Headquarters
1125 N. Military Avenue
P.O. Box 10448
Green Bay, Wisconsin 54307-0448
Telephone #: (414)492-5800
Telefax #: (414)492-5913

April 21, 1994

IN REPLY REFER TO: 4530-1
FID No. 998 085 330
Construction Permit No. 93-DBY-107

Mr. John Sweeney
Midwest Soil Remediation, Inc.
27W010 St. Charles Road
Wheaton, IL 60188

STATE OF ARKANSAS
DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY
8001 NATIONAL DRIVE, P.O. BOX 8913
LITTLE ROCK, ARKANSAS 72219-8913
PHONE: (501) 562-7444
FAX: (501) 562-4632

December 31, 1991

Mr. Tony Fetherling, President
Midwest Soil Remediation, Inc.
27W010 St. Charles Road
Carol Stream, Illinois 60188

Georgia Department of Natural Resources

REPLY TO:

205 Butler Street, S.E., Floyd Towers East, Atlanta, Georgia 30334
Lonice C. Barrett, Commissioner
Harold F. Reheis, Assistant Director
Environmental Protection Division

UNDERGROUND STORAGE TANK MANAGEMENT PROGRAM
3420 NORMAN BERRY DRIVE
7TH FLOOR
HAPEVILLE, GEORGIA 30354
69-3927

APPENDIX I

INCINERATION VENDOR INFORMATION

COMPUTATION SHEET

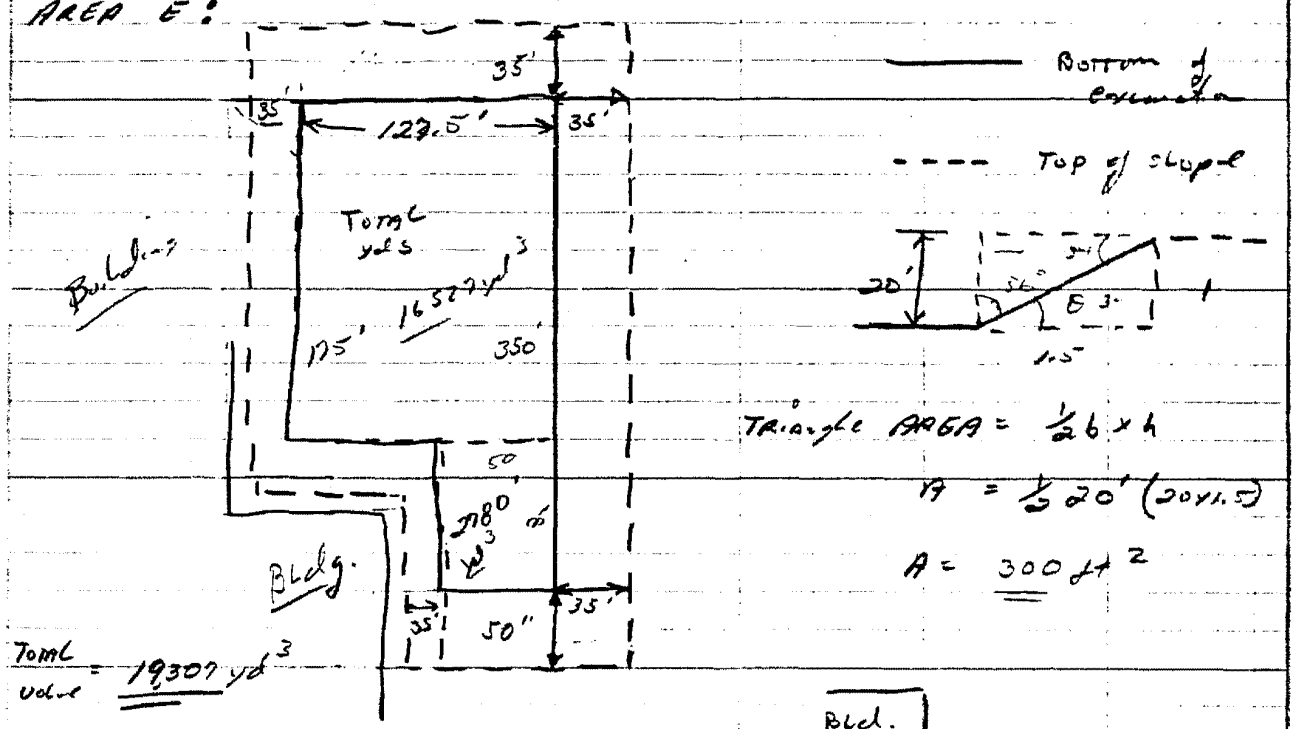
RMT INC.
20900 Swenson Drive Suite 100 Waukesha, WI 53186-4050 (414) 798-9550 FAX: (414) 798-9551

SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED	CHECKED	PROJECT / PROPOSAL NO
NIROP FS - AREAS of EXC.	By: MTB Date:	By: Date:	

Assume slope stability of Type C soil

AREA E:



Because the area along the building (E) where the slope begins, is equal to the area on the west, the slope Δ is 0 and therefore sloping on the east and west do not add more soil. However, note that sloping must be conducted in a manner which does not disturb the building foundation.

On the North and south the volume does become additional by the following:

North: [300 ft² x (127.5 + 35 + 35) ft] / 27 ft³/yd³ = 2194 yd³

South: [300 ft² x (120')] / 27 ft³/yd³ = 1330 yd³

Total E: 19307 + 2194 + 1330 = 22831 yd³

COMPUTATION SHEET

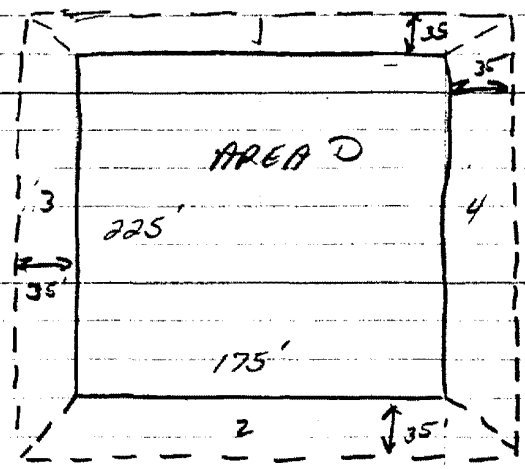
RMT INC.
20900 Swenson Drive Suite 100 Waukesha, WI 53186-4050 (414) 798-9550 FAX (414) 798-9551

SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED By: MJB Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO
NIROP AREAS of Excavation			

AREA D :

TOTAL Depth = 20'

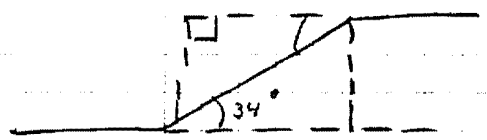


AREA of bottom

225' × 175' = 39375 ft²

volume of bottom

39375 ft² × 20'/27 = 29,170 yd³



TOTAL volume A+A'

A = 300 ft²

$V_{1,2} = 300\,ft^2 \times [(225+35+35)/27] \times 2$

$V_{1,2} = 6560\ yd^3$

$V_{3,4} = 300\,ft^2 \times [(175+35+35)/27] \times 2 = 5440\ yd^3$

TOTAL volume of AREA D

6560
5440
29170

41,170 yd³

Slope factors based on 29 CFR 1910 - Excavations through subpart P.

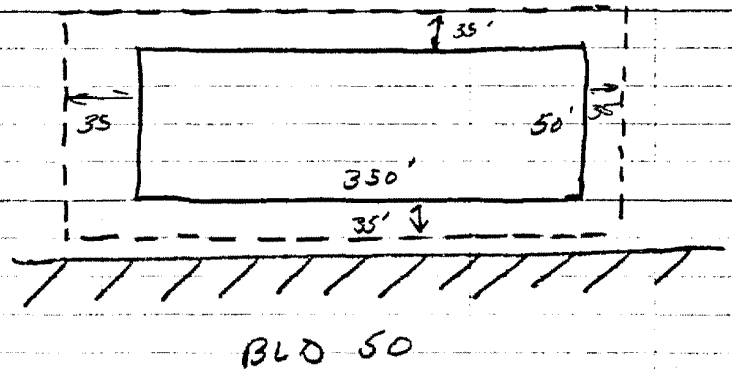
COMPUTATION SHEET

RMT INC.
20900 Swenson Drive Suite 100 Waukesha, WI 53186-4050 (414) 798-9550 FAX: (414) 798-9551

SHEET _____ OF _____

PROJECT / PROPOSAL NAME	PREPARED By: MJB Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO.
NIROP FS - AREAS of EXC.			

AREA A2 Assume 1 ft vertical to 1.5 ft horizontal



AREA of Bottom
350' x 50' = 17,500 ft^2

Volume of Bottom
(17,500 ft^2 x 20 ft/27) =
12,963 yd^3

Added volume from slope

1. [[300 ft^2 AREA x (350 + 35 + 35)] / 27] x 2 = 9330 yd^3

2. [[300 ft^2 area x (50 + 35 + 35) / 27] x 2 = 2670 yd^3

TOTAL volume from AREA A2 = 12,963 + 9330 + 2670 = 24,960 y

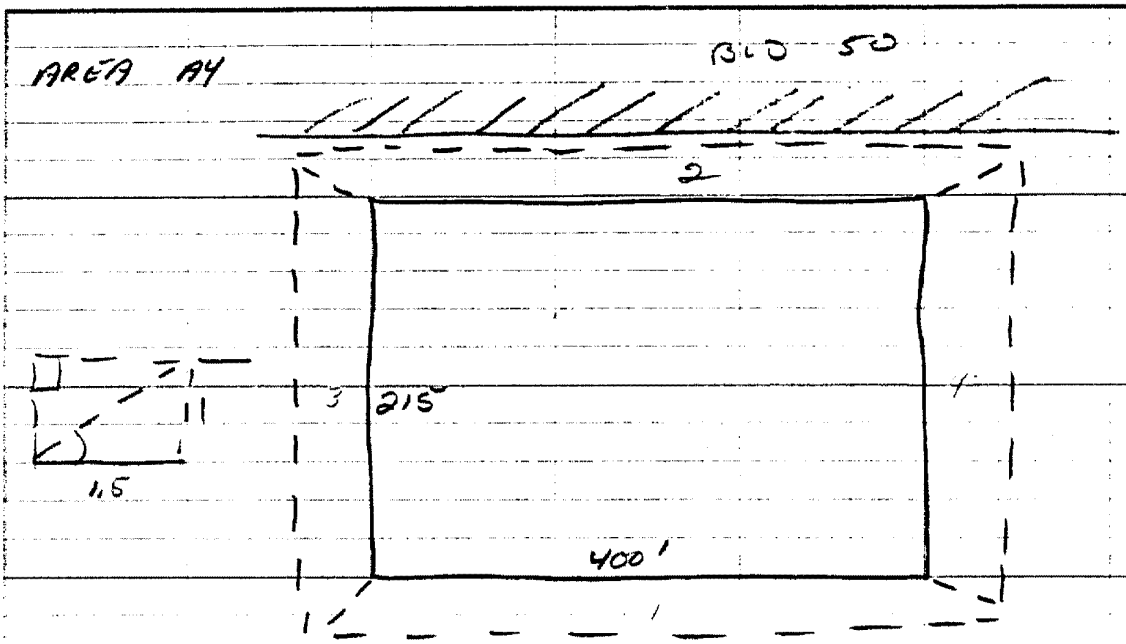
COMPUTATION SHEET

SHEET _____ OF _____

20900 Swenson Drive Suite 100 Waukesha, WI 53186-4050 (414) 798-9550 FAX: (414) 798-9551

PROJECT / PROPOSAL NAME	PREPARED By: Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO
NIROP Excavation AREA	MJB		

AREA A4



Inner volume = (400 x 215 x 20)/27 = 63,70 yd

Volume$_{1,2}$ = [300 ft^2 x (400 + 35 + 35)/27] x 2 = 10,444

Volume$_{3,4}$ = [300 ft^2 x (215 + 35 + 35)/27] x 2 = 6330

Total soil volume from AREA A4 = 63703 yd^3
10,444 yd^3
6330 yd^3

80,477 yd^3

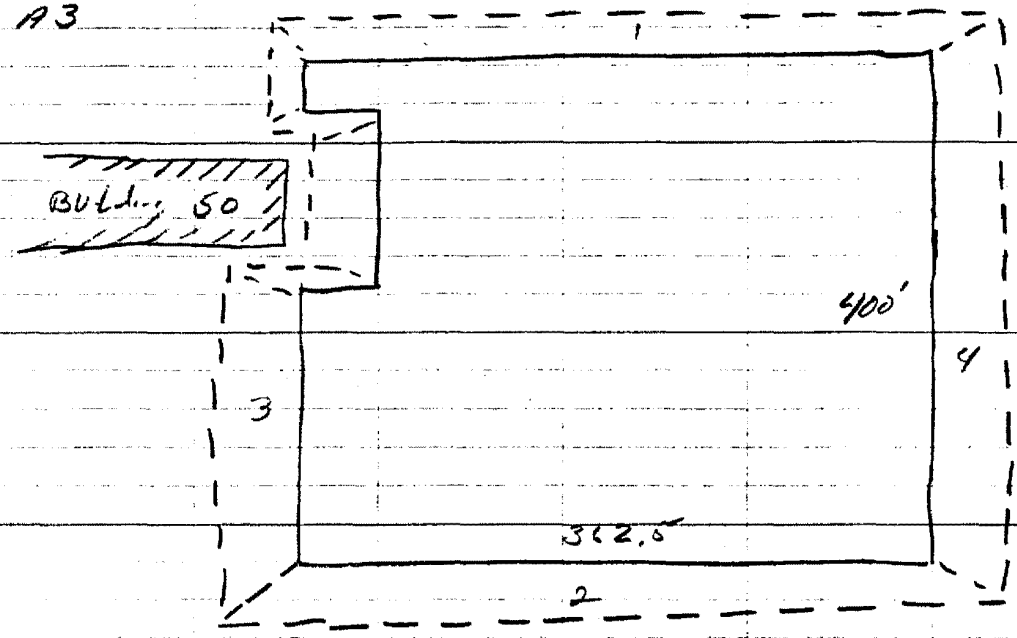
COMPUTATION SHEET

SHEET _____ OF _____

20900 Swenson Drive Suite 100 Waukesha, WI 53186-4050 (414) 798-9550 FAX: (414) 798-9551

PROJECT / PROPOSAL NAME	PREPARED By: Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO
NIROP FS - AREAS of EXC.			

AREA A3



AREA of Base excavation

$$\left[(362.5' \times 400' \times 20')/27 - (75 \times 35 \times 20)/27\right] = 105,500 \text{ yd}^3$$

AREA 1,2 : $\left[300 \text{ ft}^2 \times (362.5 + 35 + 35)/27\right] = 4800 \text{ yd}^3$

AREA 3,4 $\left[300 \text{ ft}^2 \times (400 + 35 + 35)/27\right] = 5200 \text{ yd}^3$

TOTAL volume $105,500 \text{ yd}^3 + 4800 + 5200 = \underline{115,500 \text{ yd}^3}$

COMPUTATION SHEET

RMT INC.

SHEET _____ OF _____

900 Swenson Drive Suite 100 Waukesha, WI 53186-4050 (414) 798-9550 FAX: (414) 798-9551

PROJECT / PROPOSAL NAME	PREPARED By: MJB Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO.
NIROP FS - AREAS of EXC			

TOTAL Estimated volume

AREA E : 22231 yd^3

AREA D : 41,170 yd^3

AREA A2 : 24,960 yd^3

AREA A4 : 80,477 yd^3

AREA A3 : 115,500 yd^3

TOTAL volume : 284,938 or 285,000 yds

Because of the degree of uncertainty in the actual areas that will be excavated (i.e. what areas are above the 1 ppm limit) we will round the total excavation volume to 300,000 yd^3. Actual soil volumes will be determined using field surveying techniques.

COMPUTATION SHEET

RMT INC.

SHEET _____ OF _____

20900 Swenson Drive Suite 100 Waukesha, WI 53186-4050 (414) 798-9550 FAX: (414) 798-9551

PROJECT / PROPOSAL NAME	PREPARED By: MJB Date:	CHECKED By: Date:	PROJECT / PROPOSAL NO
NIROP Feasibility Study			

Estimated Sheet Piling

Based on Figure 3-2, the estimated amount of sheet piling is:

AREA A2 (BLD 50): 375 feet

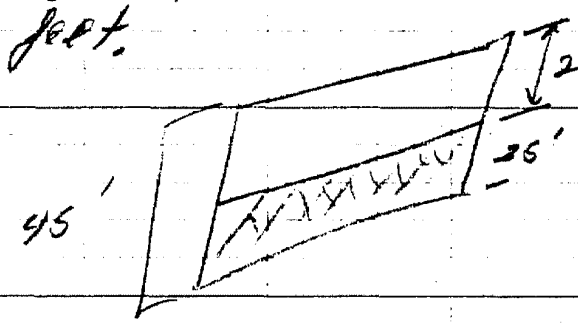
AREA A4 (BLD 50): 425 feet

AREA A3 (BLD 50): 75 feet

AREA E (main plant): 150 feet + 50 + 25 + 25 + 50 = 300 feet TOTAL

Total length: 1175 feet

For an excavation of 20 feet, assume sheet piling driven to 20 feet below the excavation or 40 feet.



Total Sheet Piling Area: 1175 feet × 40' = 47,000 ft²

Means Construction Data Costs – 1993, pg 40, from 1900 Assume 25' deep excavation, 38 psf, Drive, extract sheet pile

Estimated Cost: $10.15/ft²

Total Cost: $10.15/ft² × 47,000 ft² = $477,000

INTERNATIONAL TECHNOLOGY CORPORATION

December 5, 1994

Mr. Joseph Liello
RMT
20900 Swenson Drive
Suite 100
Waukesha, Wisconsin 53186-4050

Subject: IT's Thermal Treatment Capabilities

Dear Mr. Liello:

As we discussed last week, IT Corporation has developed two proprietary thermal treatment technologies to support the site remediation market. One of these technologies, our Hybrid Thermal Treatment System (HTTS), services the "incineration" market. This technology has been implemented on a number of projects, including:

Site Name	Size (Tons)	Client	Status
Cornhusker AAP	42,000	USACE - Omaha	Complete
Louisiana AAP	108,000	USACE - Omaha	Complete
Sikes Disposal Pits	500,000	TNRCC	Complete
Bayou Bonfouca	200,000	USACE - New Orleans	Ongoing
Times Beach	130,000	PRP	Ongoing
American Creosote	52,000	USACE - New Orleans	Ongoing

I have enclosed a document which describes this technology and several of these projects in some detail. This technology would be applicable for those sites which allow "destructive" back-ends (i.e. afterburners or secondary combustion chambers). I would anticipate a total project cost of $200-225 per ton if this technology is selected for your project.

We have also developed a "thermal desorption" technology in cooperation with Dow Environmental. This technology combines an indirectly-fired primary chamber with a "non-destructive" back-end to process contaminated materials. Since this technology doesn't destroy any of the organic contaminants, a second treatment step is required to destroy the contaminants. This typically involves the off-site incineration (@ $1,000-1,500 per ton) of a concentrated condensate stream. Because this second step is required, the total project cost with this technology will be significantly (i.e. 20-40%) higher than the cost achievable with the "incineration" option.

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If you have any questions after reviewing this information, please don't hesitate to give me a call. I look forward to discussing this project with you in the future.

Sincerely yours,

Kevin R. Smith
Director of Project Development
Remediation Projects

BEST AVAILABLE TECHNOLOGY (BAT) CRITERIA	HTTS UNIT ACHIEVEMENTS
Handle a wide range of applications and waste types	Five HTTS units have been designed, constructed, and successfully operated in full-scale applications involving a wide variety of waste types.
Provide economical incineration for a wide range of application	Proven to be economically competitive, as evidenced by IT's dominant market position.
Comply with regulatory criteria by controlling the quality of combustion gas emissions and ash and water discharges	HTTS units have repeatedly demonstrated full compliance with the highest U.S. regulatory standards. (See trail burn and operating data presented in Chapter 3.0.)

Of the various incineration technologies applied to hazardous waste, rotary kilns with secondary combustion chambers (SCC) are considered the most common and most versatile. The HTTS configuration is an innovative and patented version of these proven and demonstrated technologies. Patents issued (see Figure 4-1 at the end of this document) relate to reduced gas flow through the utilization of countercurrent controlled air operation; high turbulent mixing in the SCC to ensure high waste destruction efficiency; controlled ash quality by means of adjusting the treatment zones inside the kiln; and a crystallization process that eliminates aqueous purge from a wet gas cleaning system, even when incinerating highly halogenated wastes. All of these patented features have demonstrated their effectiveness in full-scale operating systems.

System Description

Five HTTS hazardous waste incineration systems have been designed, fabricated, and operated in the range of 60 to 150 million (MM) Btu/hr and an order for a sixth Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) application at Times Beach in Missouri was received in September 1992. The HTTS unit processes waste at a higher rate than other incineration technologies of equivalent thermal rating or physical size. A sketch of the basic HTTS process configuration is shown in Figure 1-2 and consists of the following major unit operations:

- Feed preparation systems to shred, crush, classify, mix, blend, filter, and heat the wastes to the desired consistency for consistent, controllable system feed.

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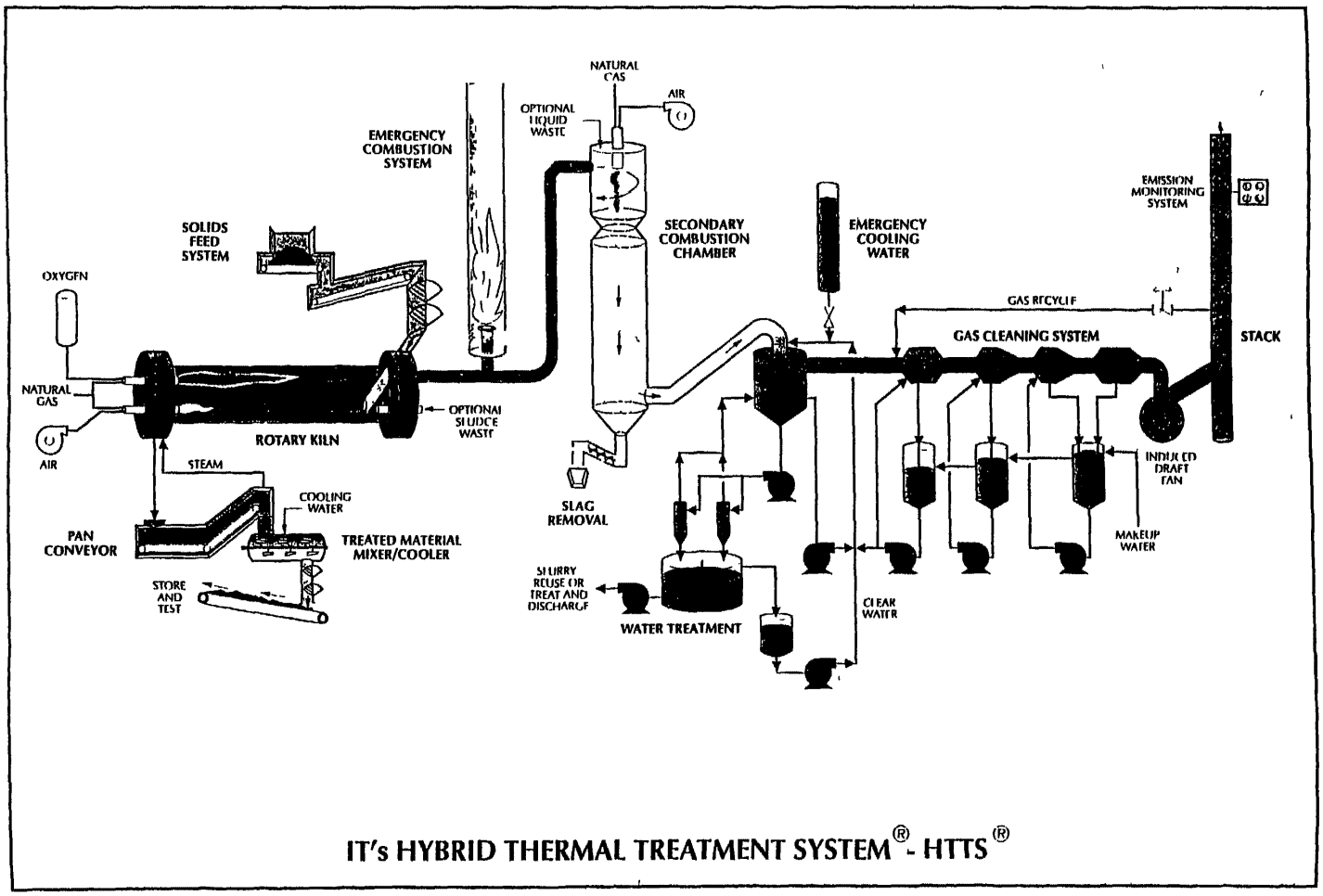

IT's HYBRID THERMAL TREATMENT SYSTEM® - HTTS®

Figure 1-2

- Belt and/or screw conveyor solid waste feed to the incinerator. Storage tanks with pumps, piping and control systems for sludge, organic liquid, and aqueous waste feed. Mass flow instrumentation and control.

  Pumpable organic and aqueous wastes are fed to rotary kiln and/or secondary combustion system; sludges and solids are treated in the kiln.

- A countercurrent flow, controlled air rotary kiln thermally treats solid and sludge wastes. Kiln off-gas flows to the SCC and the decontaminated kiln ash flows to the ash system. The refractory-lined kiln system includes a movable dual fuel burner (gas, oil, waste liquid), a variable speed drive system with emergency backup, combustion air delivery system, instrumentation, and controls. Figure 1-3 illustrates the patented HTTS rotary kiln's countercurrent controlled air concept with its distinct drying, pyrolysis, and oxidation zones.

- The ash handling system cools and remoisturizes rotary kiln ash. IT typically includes a high temperature pan conveyor and pug-mill type mixer to cool and moisturize the rotary kiln ash. Cooled ash is temporarily stored in specially designed bunkers until compliance with the ash quality requirements is verified.

- A vertically-oriented downfired secondary combustion system incinerates the off-gases from the rotary kiln, along with selected organic liquids, and aqueous waste. The system includes an SCC where the kiln off-gas and liquid waste materials are mixed under turbulent flow conditions with combustion air and auxiliary fuel and are thoroughly oxidized. The flue gases pass into a retention or postcombustion chamber where the gases are held at a high temperature for more than 2 seconds. The refractory-lined SCC includes a dual fuel burner (gas, oil, waste liquid), waste liquid injection nozzles, combustion air delivery system, instrumentation and controls, and a system for continuously removing ash and slag. Figure 1-4 illustrates the patented turbulent mixing and combustion in the patented SCC.

- The gas cleaning system treats combustion gas from the SCC. IT typically includes an evaporative water quench system, a two-stage free-jet venturiscrubber, an induced draft fan, and stack. The scrubber utilizes a pH controlled, recirculating scrubbing solution and provides high efficiency removal of acid gases, particulate matter, and heavy metals.

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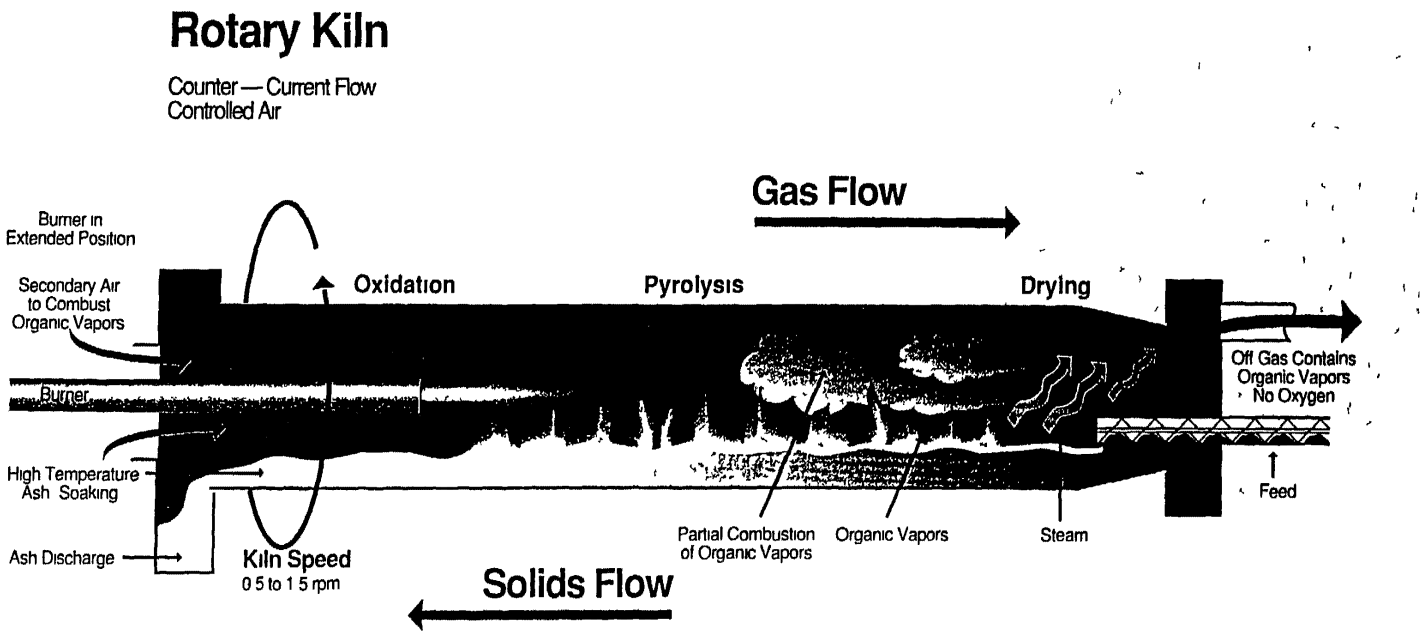

Figure 1-3 Illustration of the Treatment Zones in the Patented HTTS® Rotary Kiln

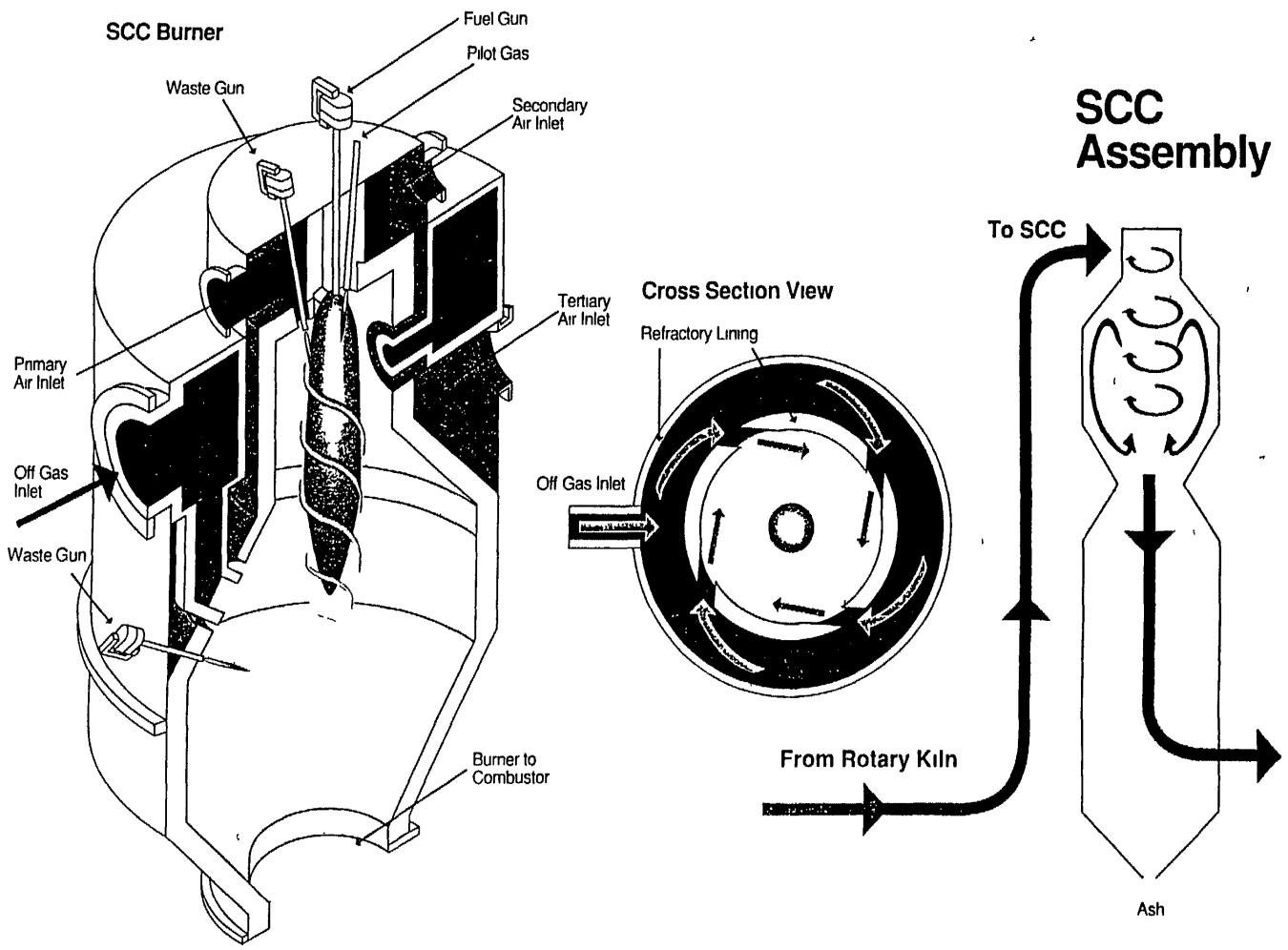

Figure 1-4 Illustration of the Turbulent Mixing and Combustion in the Patented HTTS® Secondary Combustion Chamber

A continuous emission monitoring (CEM) system samples and analyzes the stack emissions The stack emission data are collected and stored in the central control system The CEM is automatically interlocked via the central control system to shut off waste feeds before the stack gas quality falls below allowable regulatory criteria

The HTTS unit is controlled from a computerized central control system (CCS) to the system operation to achieve optimum performance The control system uses state-of the art technology and includes redundant components for high reliability and data integrity Alarms and automatic safety interlocks ensure safe environmentally compliant operation Data acquisition, trending and archiving are provided for process optimization and for diagnosing operational abnormalities

The HTTS process is part of an integrated facility that includes utilities fuels reagents maintenance facilities an analytical laboratory ash stabilization equipment decontamination facilities administration and engineering offices site security, etc

Skid mounted HTTS process modules are assembled piped wired and tested before they are shipped to the job site and can be customized for each site (by adding or substituting modules)

For each of the major process subsystems (feed storage preparation, rotary kiln secondary combustion system, gas cleaning system, and central control system) IT has custom designed alternative configurations to meet the requirements of specific projects For example rotary kilns have been supplied as shop-fabricated transportable units and as larger field fabricated "SuperKilns"

The SCC is particularly versatile in its ability to meet the project specific requirements The SCC has been designed in downfired (basic design shown in Figure 1-4) and uptired vertical configurations, and also in a horizontal configuration It has also been designed, built, and operated as a stand alone incinerator for polychlorinated biphenyl (PCB)-contaminated liquids Each configuration offers specific process capabilities while maintaining the overall HTTS technology driven performance

Similarly the gas cleaning system has been designed using free-jet venturi scrubbers (basic design) impaction venturi scrubbers, wet electrostatic precipitators and baghouses with packed column scrubbers, each fulfilling the needs of a specific application and maintaining the integrated functions of the HTTS plant

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Chapters 3.0 and 4.0 of this SOQ describe how the HTTS modules have been modified to suit the specific requirements of individual projects.

Range of Applications

HTTS technology has been applied to the complete spectrum of hazardous and toxic wastes. HTTS technology has successfully demonstrated incineration of the following types of feeds in full compliance with all applicable regulatory criteria: explosive-contaminated soils, high heat-of-combustion organic liquids and tars, organic sludges, PCB-contaminated liquids and sludges, organic-contaminated aqueous wastes, hydrocarbon saturated soils, and miscellaneous contaminated trash, debris, and drums. An HTTS unit has recently been designed and successfully pilot tested to incinerate a mixture of sewage treatment plant sludge and hazardous waste.

Chapters 3.0 and 4.0 present case histories of how the HTTS technology has been applied to these waste applications.

Test Facilities

Technology development is an ongoing program at IT to apply, improve, and develop thermal treatment and other hazardous waste treatment technologies. As the range of waste treatment applications has increased and the regulatory agencies around the world have tightened the performance requirements on systems that treat wastes, IT has remained a leader in the development and commercial application of technologies that meet the requirements. A separate SOQ on IT's Process and Technology Development capabilities is available upon request, and describes bench-, pilot-, and semicommercial-scale facilities where incineration of characteristics of wastes proposed for HTTS treatment can be fully evaluated. Interpretation of these evaluations allow feed preparation and blending systems to be designed to optimize HTTS feed consistency. Furthermore, the HTTS downstream equipment trains may be customized to suit the specific requirements of the wastes to be incinerated.

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2.0 Regulatory Framework

Background

The U.S. Environmental Protection Agency's (EPA) regulation of hazardous waste incineration utilizes three approaches: technology-based standards, performance-based standards, and health risk-based standards. The early regulatory framework utilized chiefly *performance-based* standards such as minimum destruction and removal efficiency for organic constituents, maximum particulate emissions, and minimum acid gas removal efficiency. Some *technology-based* standards were specified for operating conditions such as minimum temperature, minimum oxygen concentration, and minimum gas residence time. The EPA established the technology and performance standards based on good performance achieved using well-designed and -operated, commercially available technology.

Health risk-based standards evolved later, after the EPA began analyzing stack emissions of incinerators that were operating in compliance with these technology- and performance-based standards. Focusing specifically on emissions of combustion by-products, acid gases, and heavy metals, the EPA concluded that in some instances, meeting the performance- and technology-based standards did not necessarily achieve sufficiently low public health risks. The EPA then imposed health risk assessment based standards for these emissions and required site-specific evaluations of the risk consequences of these emissions.

Various legislation enacted by the U.S. Congress, such as Resource Conservation and Recovery Act (RCRA), Toxic Substance Control Act (TSCA), CERCLA, and the Clean Air Act (CAA) have resulted in a "patchwork" of regulations that are specific to certain situations, however, some duplication and overlap of regulatory jurisdiction does occur. A more detailed discussion of major regulations governing hazardous waste incineration follows. Chapter 3.0 describes how these regulations are applied to specific projects. (A separate SOQ describing IT's Permitting and Regulatory Services is available upon request.)

All HTTS plants have operated in full compliance with all applicable U.S. regulations.

RCRA

The RCRA was enacted by Congress in 1976 and amended in 1984 by the Hazardous and Solid Waste Amendment (HSWA). RCRA was the first federal level attempt at comprehensive solid/hazardous waste management and imposed "cradle to grave" management requirements on generation, transport, and treatment/storage/disposal (TSD) of hazardous waste.

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RCRA is the principal legislation governing the design and operation of incinerators used to treat or dispose of materials that are designated as hazardous wastes. Permitting an incinerator under RCRA requires the submittal of a permit application detailing the facility description, waste characterization, process description, trial burn (e.g., performance test) plan, procedures to prevent hazards, contingency plan, training plan, and facility closure plan. The permitting process culminates in an operating permit requiring adherence to performance criteria for gaseous emissions, liquid effluents, and solid residues. After permit approval is obtained, the incinerator may be constructed, commissioned, and started up prior to conducting the actual trial burn performance test. The trial burn is the mechanism required of owners and operators to demonstrate compliance with the RCRA performance standards.

RCRA specifies the following performance-based criteria that hazardous waste incinerators are required to meet:

- Destruction and removal efficiency (DRE) of each designated Principal Organic Hazardous Constituent (POHC) in the feed of at least 99.99 percent. (DRE for dioxin-contaminated waste is 99.9999 percent.)

- Particulate emissions of no greater than 0.08 grains per dry standard cubic foot (gr/dscf) of stack gas, corrected to 7 percent oxygen.

- 99 percent removal efficiency of hydrogen chloride (HCl) or 4 pounds per hour, whichever is greater.

Heavy metal limits are regulated using health risk-based criteria. Heavy metal stack emission limits are determined by methods found in the ***EPA Guidance on Metals and Hydrogen Chloride Controls for Hazardous Waste Incinerations***. These methods fall into three tier levels, of which Tier I is the most stringent and limits the metal concentrations in the feed to achieve a low risk level. Tier II is the second most stringent, and sets emission limits from the stack. Both of these tiers give specific quantitative limits and are based on very conservative air emission and atmospheric dispersion modeling for generic types of sites. The Tier III approach is the most accurate and site-specific method of establishing heavy metal emission limits and requires an extensive risk assessment of the incinerator operation. The Tier III method determines allowable metals emissions by calculating the metal partitioning between the ash and the combustion gas, the metal removal efficiency of the incinerator's specific gas cleaning technology, and by atmospheric dispersion modeling of the stack emission at a specific location. Actual topography and meteorological conditions are used along with established health risk

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criteria to calculate the maximum acceptable emission rates. These values are then used to back-calculate maximum allowable metal feed rates to the system. Allowable heavy metals emission rates calculated in this manner typically set the design basis for the air pollution control system. Since metals are present mainly as particulate matter, meeting the metal emission criteria typically imposes a more stringent particulate emission criteria than the nominal RCRA criteria.

The toxicity characteristic leaching procedure (TCLP) is a test required by the EPA and used to measure leachability of toxic organic and inorganic hazardous contaminants from solid waste materials before they are landfilled. Ash and other solid residuals from a hazardous waste incineration system must undergo this test and meet the established limits.

Following submittal of successful trial burn performance test results, the EPA sets the final permit conditions and issues the final permit. In addition to performance-based criteria, the RCRA permit establishes a number of required operating conditions that were demonstrated during the successful trial burn.

Operating permits typically specify the following operating conditions:

- Minimum temperature in each combustion chamber
- Maximum flue gas carbon monoxide concentration
- Maximum combustion gas velocity (e.g., SCC residence time)
- Maximum combustion chamber pressure
- Maximum feed rate for each waste type
- Thermal stability of hazardous constituents in the waste feed
- Maximum chlorine feed rate
- Maximum ash feed rate
- Maximum heavy metals feed rate
- Maximum container or feed batch size
- Maximum container or feed batch thermal release
- Minimum liquid waste heating value
- Maximum incinerator thermal duty
- Maximum liquid waste viscosity
- Minimum atomization media pressure for liquid wastes
- Maximum gas cleaning system inlet temperature
- Minimum liquid flow rates to wet gas cleaning system components
- Minimum gas cleaning system pressure differential
- Minimum scrubbing solution pH
- Minimum acid gas absorbent feed rate
- Minimum air pollution control system purge rate.

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TSCA

The TSCA was enacted by Congress in 1976 to specifically direct the EPA to regulate PCBs. Although other provisions of TSCA direct the EPA to regulate chemicals that present an "unreasonable risk of injury to health and environment," Section 6(e) is a provision of TSCA that directly bans the manufacture, processing, distribution, use of, and disposal of PCBs.

TSCA only applies to incinerators burning waste that contains PCBs. Like RCRA, TSCA regulations stipulate certain performance- and technology-based standards that must be met any time PCB waste is incinerated. TSCA specifies the following incineration criteria:

- Operation at 2200°F (1200°C) with $\geq$2 seconds residence time and $\geq$ 3 percent oxygen when burning PCB liquids.
- DRE of 99.9999 percent for PCB nonliquids.
- Combustion efficiency (based on the ratio of carbon dioxide to carbon monoxide) of 99.9 percent.

TSCA "authorizations" generally do not contain a wide range of operating conditions (like RCRA permits); however, certain operating conditions may be specified. TSCA requires a demonstration test that is very similar to the RCRA trial burn performance test.

CERCLA

The CERCLA was enacted by Congress in 1980 and amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA) primarily to address inactive/abandoned sites, but it also covers active sites. CERCLA requires stringent cleanup standards with a preference for permanent solutions that significantly reduce waste volume, toxicity, or mobility, encouraging an alternative to land disposal. CERCLA regulates incinerators via other existing regulations: hazardous substances handling and incineration under RCRA, wastewater discharges under the Clean Water Act (CWA), air emissions under the Clean Air Act (CAA), and any toxic chemicals under TSCA.

CERCLA differs from RCRA in the following areas:

- It involves environmental remediation and not management of ongoing waste generation
- A site can be remediated by EPA and then seek reimbursement from the principal responsible party (PRP)
- EPA can compel the liable party to clean up site
- No RCRA permits are issued; however, the substantive sections are typically required for submittal as a guideline.

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CAA

The CAA was first enacted by Congress in 1970 and was amended in 1977 and 1990. CAA provisions apply to the construction, modification, and operation of all incineration facilities. The CAA has established national standards for ambient air concentrations of carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter, ozone, and lead.

There are six major provisions of the CAA to consider when permitting a hazardous waste incinerator, including: National Ambient Air Quality Standards (NAAQS), Prevention of Significant Deterioration (PSD) (i.e., adding a new emission source in an area that currently meets NAAQS), Non-Attainment requirements (i.e., adding a new emission source in an area that does not meet NAAQS), national emission standards for Hazardous Air Pollutants (HAP) (regulating 189 specific organic compounds and heavy metals), New Source Performance Standards (NSPS), and any stack height requirements or limitations. These six provisions establish emission limits and influence the selection of gas cleaning technology for hazardous waste incineration systems.

CWA

In 1972, Congress laid the basic framework for federal water pollution control regulation by enacting the Federal Water Pollution Control Act (FWPCA). In 1977 Congress renamed the FWPCA the CWA and changed the regulatory framework to rigorous control of toxic water pollutants.

The CWA provisions apply to incinerators that discharge to a water source. Primarily the CWA, as it relates to incinerators, applies to the aqueous purge from wet gas cleaning systems and contaminated storm water runoff from the site. The effluent from an incinerator is treated, tested for compliance, and then discharged to a water body or sent to a publicly owned treatment works (POTW). The permit required for this discharge is through the National Pollutant Discharge Elimination System (NPDES) that identifies the maximum allowable concentration of specific organic and inorganic chemical constituents, defined on a case-by-case basis.

OSHA

The Occupational Safety and Health Administration (OSHA) was enacted by Congress in 1970. OSHA regulates the safety and health of employees involved in cleanup operations at RCRA-permitted facilities and CERCLA sites, and in any emergency response to incidents involving hazardous substances.

OSHA requires a written safety and health program that covers the safety and health organization and specific work practices to ensure employee safety and health. OSHA also requires a 40-hour classroom and 3-day on-the-job training for general site workers. An additional 8 hours of training is required for supervisors and managers. All employees must have annual refresher training to reemphasize the initial training and to update employees on any new policies or procedures.

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This chapter presents case summaries of remediation site cleanup projects involving the HTTS technology. Each case history describes the waste type and quantity, any project-specific features of the HTTS technology configuration, the regulatory requirements that apply to the project, and operating performance data for the HTTS unit. Correspondence with regulatory agencies and detailed information is available under the Freedom of Information Act. A combination of detail and narrative is presented in this chapter.

Cornhusker and Louisiana Army Ammunition Plants

Waste Characterization

Both Cornhusker Army Ammunition Plant (CAAP), located in Grand Island, Nebraska (EPA Region VII), and Louisiana Army Ammunition Plant (LAAP), located in Shreveport, Louisiana (EPA Region VI), were projects in which soils contaminated with explosives were thermally treated. The contamination resulted from the manufacture of explosives and the packaging of munitions. The waste characterizations for these two projects are summarized in Table 3-1.

Table 3-1. CAAP/LAAP Waste Characterization

Contaminants	Concentration Range in Blended Feed	
	CAAP	LAAP
Trinitrotoluene (TNT)	ND to 3.8%	0 to 14%
Cyclonite (RDX)	0 to 0.007%	3 to 10%
Trinitrobenzene (TNB)	0.0007 to 0.01%	0.067 to 1.5%

The CAAP site contained 45,000 tons of explosive-contaminated soil. The range of concentration of explosives in the soil ranged from a low of 0.1 percent to a high of 30 percent. The LAAP site contained 102,000 tons of explosive-contaminated soil and lagoon sediments with 0.19 percent (minimum) to 50 percent (maximum) explosive concentration. High concentration materials were blended with low concentration soils to achieve less than 10 percent feed concentration. The average feed concentration was less than 1 percent.

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APPENDIX J

COST DATA FOR SVE, THERMAL DESORPTION, AND INCINERATION

NIROP SOILS FS - ESTIMATED COSTS FOR SOIL VAPOR EXTRACTION						
ESTIMATED CAPITAL AND OPERATING COSTS						
	Quantity	Units	Cost ($)	Cost Units	Total Cost ($)	Cost Estimation Method
Capital Direct Costs						
Equipment Costs						
- Vapor Extraction Wells	54	wells	1080	$/well	58320	Quote - ML Furhman Company, Fond du Lac, WI
- Trenching and Piping from Wells to Building	5400	ft	25.34	$/ ft	136836	Quote - ML Furhman Company, Fond du Lac, WI
- Regenerative Blowers (10 hp each, 4" Hg Suction, explosion proof)	4	blowers	3000	each	12000	Cost Estimate from EG&G Rotron
- Water Knock-oput Pots (100 gallon carbon steel)	4	pot	600	each	2400	RMT Personal Experience
- Liquid Transfer Pumps	2	pump	1200	each	2400	
- Solonoid Valves (1.5 inch general purpose 2-way)	54	valve	230	each	12420	Grainger Industrial Equipment
- Flow gauges	54	gauge	120	each	6480	Erdco 3100 Series
- Vacuum gauges	54	gauge	50	each	2700	Dwayer Instruments
Subtotal Equipment Costs:					233556	
Building Costs (10' x 16' metal frame construction on a 6" reinforced concrete slab)	160	sq ft	75	$/sq ft	12000	1993 Means Building and Construciton Costs
- Markel baseboard heater - 8,530 Btu/hr - 240 volts	2	each	163	each	326	Grainger Industrual Equipment - item 3E222
- Motorized dampers (for 24 inch diameter fan)	1	each	292	each	292	Grainger Industrial Equipment - Dayton model
- Fan (24 inch diameter plus motor)	1	each	250	each	250	Grainger Industrial Equipment - Dayton model
Subtotal Building Costs:					12868	
Subtotal of SVE Equipment and the Building					246424	
Freight (2% of Equipment and Building)					4928.48	
Total Equipment Delivered Cost					251352.48	
Installation Costs						
- Mechanical Installation (assume 50% of equipment delivered costs)					125676.24	RMT Personnel Experience with Similar Type Systems
- Electrical Installation (assume 10% of equipment delived costs)					25135.248	RMT Personnel Experience with Similar Type Systems
- Instrumentation/Controls (assume 10% of equipment delived costs)					25135.248	RMT Personnel Experience with Similar Type Systems
Subtotal of Installation:					175946.736	
Total Direct Costs (Equipment plus Installation)					427299.216	
Capital Indirect Costs						
Pilot Scale Testing for Remedial Design Information						
- Pilot Scale Equipment Rental	7	days	800	$/day	5600	RCS Environmental Equipment
- Engineering and Field Support Labor (Assume 1 engineer planning for 10 days and 7 days in field)	136	hours	100	$/hour	13600	RMT Personal Experience
- Expenses (assume 5% of engineering and Field Support cost)	5	%	680	% of eng	680	RMT Personal Experience
- Analytical Testing of Off-gas	5	sample	200	$/sample	1000	RMT Analytical Laboroary Cost
- Pilot Testing Data Analysis and Design Report (assume 65 hours of engineering time)	65	hours	100	$/hour	6500	RMT Personal Experience
Subtotal of Pilot Scale Testing					26380	
SVE System Design with Plans and Specifications (15% of Total Direct Costs)					64094.8824	RMT Personnel Experience with Similar Type Systems
Licenses, Permits and Approvals (10% of Total Direct Costs)					42729.9216	RMT Personnel Experience with Similar Type Systems
Construction Supervision (15% of Total Direct Costs)					64094.8824	RMT Personnel Experience with Similar Type Systems
System Start-up Costs (10% of Total Direct Costs)					42729.9216	RMT Personnel Experience with Similar Type Systems
Total Indirect Costs (Pilot Testing, Engineering, Licenses, Construction Supervision, Startup)					240029.608	
Summary of Project Capital Costs						
Total Estimated Costs (Direct Costs plus Indirect Costs)					667328.824	
30% Contingency on Direct plus Indirect Costs					200198.6472	
Total Estimated Project Costs					867527.4712	

NIROP SOILS FS - ESTIMATED COSTS FOR THERMAL DESORPTION OF SOILS						
ESTIMATED CAPITAL COSTS						
Capital Direct Costs						
	Quantity	Units	Cost ($)	Cost Units	Total Cost ($)	Cost Estimation Method
Site Preparation						
- Vegitation Removal/Grubing	8	acers	2625	$/acer	21000	1993 Means Building and Construction - pg 37
- Decon Pad Removal (50 ft x 50 ft - 6" concrete or less)	2500	sq ft	1.96	$/sq ft	4900	1993 Means Building and Construction - pg 24
- Removal of Existing Railroad Tracks - distance from Fig. 4-3 (assume doser excavation)	9000	sq ft	1.96	$/sq ft	17640	1993 Means Building and Construction - pg 24
- Sheet Piling Around Buildings - assume 38 psf, (drive, extract, salvage)	47000	sq ft	10.15	$/sq ft	477050	1993 Means Building and Construction - pg 40
Subtotal Site Preparation:					520590	
Thermal Treatment (cost include thermal desorption, backfill and compaction, and permits)	450000	ton	48	$/ton	21600000	Cost estimate from Soil Remediation Services
- Excavation of Soil	450000	ton	2	$/ton	900000	Cost estimate from Soil Remediation Services
- Mobilization/Demobilizatio of the Treatment System	1	each	15000	$/event	15000	Cost estimate from Soil Remediation Services
Subtotal Thermal Soil Treatment:					22515000	
Site Closure						
- Grading and Backfill with a dozer and no compaction (assume 3" top soil over 8 acers)	3300	cu yd	1.1	$/cu yd	3630	1993 Means Building and Construction - pg 41
- Subsurface Drainage System						
8" diameter perforated aluminum subdrainage pipe	1600	ft	8.95	$/ft	14320	1993 Means Building and Construction - pg 65
Excavation and backfill of drain pipe trenches (assume 3' deep and 2' wide and 1600 feet in length)	355	cu yd	4.98	$/cu yd	1767.9	1993 Means Building and Construction - pg 45
2 Manholes in system (4' ID precast - total depth of 6 feet)	2	each	720	$/each	1440	1993 Means Building and Construction - pg 65
- Revegitation	8	acers	1450	$/acer	11600	1993 Means Building and Construction - pg 76
- Construction of a Roadway Through Area A (assume 129 yds long x 3 yds wide)						
Road Bedding (assume 6" Traffic Bond)	387	sq yd	9.45	$/sq yd	3657.15	Suburban Asphalt Inc. Milwaukee, WI
Ashphalt (assume course binder and 3" thick)	387	sq yd	21.6	$/sq yd	8359.2	Suburban Asphalt Inc. Milwaukee, WI
Subtotal Site Closure:					44774.25	
Total Direct Costs (Site Preparation + Thermal Treatment + Site Closure)					23080364.25	
Capital Indirect Costs						
Engineering and Procurement (assume 1% of Total Direct Costs)					230803.6425	RMT Experience with Similar Type Projects
Air Compliance Report Following Thermal Desorption Trial Test	1	each	15000	$/each	15000	Conversation with Don Smith (MPCA)
Licences, Permits, and Approvals (assume 1% of Total Direct Costs)					230803.6425	RMT Experience with Similar Type Projects
Construction Oversite (assume 5% of Total Direct Costs)					1154018.213	RMT Experience with Similar Type Projects
Total Indirect Costs (Engineering, Compliance Report, Licences, Construction Oversite)					1630625.498	
Summary of Project Capital Costs						
Total Estimated Costs (Direct plus Indirect Costs)					24710989.75	
30 % Contingency on Direct plus Indirect Costs					7413296.924	
Total Estimated Project Costs (Thermal Desorption Costs plus Contingency)					32124286.67	

Operating, Manintance and Monitoring Costs						
Electrical Costs (Assume four 10 hp blowers operating 24 hours /day and 365 days/year at a rate of $0.08/kwh					22000	
Monitoring Labor (Assume 16 hours/week at $30/hour for the entire year)					25000	
General Maintance Costs (Assume 10% of equipment costs)					25000	
Analytical Costs of Off-Gas Samples (assume 1 per week at $125/sample)					6500	
5-year Review Costs (assume 20 year life or 4 reviews)	4	reviews	50000	$/review	10000	
Subtotal of OM&M Costs					88500	
30% Contingency on OM&M Costs					26550	
Total Estimated Annual OM&M Costs					115050	
Equil Series Present Worth						
Present Worth OM&M Costs for SVE (assume a 20 year operational period and 5% interest rate)					1433776.11	
Total Present Worth Cost (OM&M Present Worth plus Capital Outlay)					2301303.581	

NIROP SOILS FS - ESTIMATED COSTS FOR THERMAL INCINERATION OF SOILS						
Capital Direct Costs						
	Quantity	Units	Cost ($)	Cost Units	Total Cost ($)	Cost Estimation Method
Site Preparation						
- Vegitation Removal/Grubing	8	acers	2625	$/acer	21000	1993 Means Building and Construction - pg 37
- Decon Pad Removal (50 ft x 50 ft - 6" concrete or less)	2500	sq ft	1.96	$/sq ft	4900	1993 Means Building and Construction - pg 24
- Removal of Existing Railroad Tracks - distance from Fig. 4-3 (assume doser excavation)	9000	sq ft	1.96	$/sq ft	17640	1993 Means Building and Construction - pg 24
- Sheet Piling Around Buildings - assume 38 psf, (drive, extract, salvage)	47000	sq ft	10.15	$/sq ft	477050	1993 Means Building and Construction - pg 40
Subtotal Site Preparation:					520590	
Thermal Treatment (cost include mobilization/demobilization, excavation, incineration, backfill, and permits)	450000	tons	212.5	$/ton	95625000	Cost estimate provided by IT Corporation
Subtotal Thermal Treatment Costs:					95625000	
Site Closure						
- Grading and Backfill with a dozer and no compaction (assume 3" top soil over 8 acers)	3300	cu yd	1.1	$/cu yd	3630	1993 Means Building and Construction - pg 41
- Subsurface Drainage System						
8" diameter perforated aluminum subdrainage pipe	1600	ft	8.95	$/ft	14320	1993 Means Building and Construction - pg 65
Excavation and backfill of drain pipe trenches (assume 3' deep and 2' wide and 1600 feet in length)	355	cu yd	4.98	$/cu yd	1767.9	1993 Means Building and Construction - pg 45
2 Manholes in system (4' ID precast - total depth of 6 feet)	2	each	720	$/each	1440	1993 Means Building and Construction - pg 65
- Revegitation	8	acers	1450	$/acer	11600	1993 Means Building and Construction - pg 76
- Construction of a Roadway Through Area A (assume 129 yds long x 3 yds wide)						
Road Bedding (Traffic Bond - 6 inch thick)	387	sq yd	9.45	$/sq yd	3657.15	Suburban Asphalt Inc. Milwaukee, WI
Ashphalt (assume course binder and 3" thick)	387	sq yd	21.6	$/sq yd	8359.2	Suburban Asphalt Inc. Milwaukee, WI
Subtotal Site Closure:					44774.25	
Total Direct Costs (Site Preparation, Soil Incineration, Site Closure)					96190364.25	
Capital Indirect Costs						
Engineering and Procurement (assume 0.1% of Total Direct Costs)					96190.36425	RMT Experience With Similar Type Projects
Air Compliance Report Following Incineration Trial Burn	1	each	20000	$/each	20000	Conversation with Don Smith (MPCA)
Licences, Permits and Approvals (assume 0.1% of Total Direct Cost)					96190.36425	RMT Experience With Similar Type Projects
Construction Oversite (assume 1% of Total Direct Costs)					961903.6425	RMT Experience With Similar Type Projects
Total Indirect Costs (Engineering, Air Compliance, Licences, Construction Oversite)					1174284.371	
Summary of Project Capital Costs						
Total Estimated Costs (Direct plus Indirect Costs)					97364648.62	
30 % Contingency on Direct plus Indirect Costs					29209394.59	
Total Estimated Project Costs (Total Incineration Costs plus Contingency)					126574043.2	
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