Feasibility Study Report

Penta Wood Products RI/FS
Town of Daniels, Wisconsin

WA No. 001-RICO-05WE
Contract No. 68-W6-0025

CH2MHILL

Final
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Prepared for

United States Environmental Protection Agency
Region V
Office of Superfund
77 West Jackson Boulevard
Chicago, Illinois 60604

Contents

Appendices

Table **Page**

Figure		Page

Acronyms and Abbreviations

ACZA	ammonia, copper II oxide, arsenate, and zinc
ARARs	Applicable or relevant and appropriate requirements
As	arsenic
AA	atomic abosrption
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminants of concern
COPC	contaminants of potential concern
Cu	copper
CAMU	Corrective Action Management Unit
cys	cubic yards
DO	dissolved oxygen
ERB	Emergency Removal Branch
ERT	Emergency Removal Team
ES	Enforcement Standard
EP	Extraction Procedure
GC/MS	gas chromatograph/mass spectrophotometer
GCL	geosynthetic clay liner
GAC	granular activated Carbon
G1	Groundwater Media Alternative 1
G2	Groundwater Media Alternative 2
G3	Groundwater Media Alternative 3
G4	Groundwater Media Alternative 4
G5	Groundwater Media Alternative 5
HI	hazard index
HDPE	high density polyethylene
HHRA	Human Health Risk Assessment
LDR	land disposal restriction
LNAPL	light non-aqueous phase liquid

MQC/MQA and CQC and CQA	manufacturer and construction quality construction and assurance
MCLs	maximum contaminant levels
µg/L	microgram/liter
mg/kg	milligram/kilogram
MG	million gallons
NCP	National Contingency Plan
ND	nondetect
OSHA	Occupational Safety and Health Administration
O&M	Operation and Maintenance
ppb	parts per billion
ppm	parts per million
PCP	pentachlorophenol
PWP	Penta Wood Products
PVC	polyvinyl chloride
PRGs	Preliminary Remediation Goals
PALs	Preventative Action Limits
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RAOs	Remedial Action Objectives
RI/FS	Remedial Investigation/Feasibility Study
RCL	Residual Contaminant Level
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
S1	Soil Media Alternative 1
S2	Soil Media Alternative 2
S4	Soil Media Alternative 4
S5	Soil Media Alternative 5
SVE	Soil Vapor Extraction
STP	standard temperature and pressure
SOW	Statement of Work
SACM	Superfund Accelerated Cleanup Model
TBC	to be considered

TPH	total petroleum hydrocarbons
TCLP	Toxicity Characteristic Leaching Procedure
TMV	toxicity, mobility, and volume
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
WAC	Wisconsin Administrative Code
WDNR	Wisconsin Department of Natural Resources
WDOT	Wisconsin Department of Transportation
WPDES	Wisconsin Pollutant Discharge Elimination System
XRF	X-ray Fluorescence

SECTION 1

Introduction

1.1. Purpose

This Feasibility Study (FS) report documents the development and evaluation of remedial action alternatives for the Penta Wood Products (PWP) site. The work was performed for the United States Environmental Protection Agency (USEPA) in accordance with the Work Assignment No. 001-RICO-05WE Statement of Work (SOW).

The USEPA, in consultation with the Wisconsin Department of Natural Resources (WDNR) and with input from the public, will use this information to select a remedial action alternative in its Record of Decision (ROD) in accordance with the National Contingency Plan (NCP) and the Wisconsin Administrative Code (WAC). The criteria for remedy selections under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) require that Superfund remedial actions satisfy the following requirements:

- Protect human health and the environment
- Comply with applicable or relevant and appropriate requirements (ARARs) of federal and state environmental laws within a reasonable time frame
- Be cost-effective
- Use permanent solutions and alternative treatment technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces contaminant toxicity, mobility, or volume

1.2. Organization

The progression and structure of this FS report is shown in Figure 1-1. This report consists of five sections. Section 1 includes the introduction and summarizes background information, such as site physical description, removal actions, site geology and hydrogeology, nature and extent of contamination, contaminant fate and transport, and summary of human health and ecological risks. The development of the Remedial Action Objectives (RAOs) and Preliminary Remediation Goals (PRGs) that are intended to provide adequate protection of human health and the environment are discussed in Section 2. Chemical-specific remedial goals were developed for soil, groundwater, sediments, surface water, and treated discharge water based on risk-associated with the various concentrations of contaminants in those media, ARARs, and background concentrations where applicable. Section 3 develops general response actions that address remedial action goals and introduces the identification and screening of the technology types and process options.

Remedial technologies were screened to reduce the number of technologies considered in the detailed alternatives. Section 4 assembles the remaining technologies into five soil, and five groundwater remedial action alternatives that achieve some or all of the remedial action goals, and provide a range of levels of remediation and a corresponding range of costs. A detailed analysis of these soil and groundwater alternatives is presented in Section 5. The detailed analysis addresses the NCP and WAC chapter NR 722 evaluation criteria listed previously. Two additional criteria to be used in the evaluation of alternatives and the selection of a remedy—state/federal agency acceptance and community acceptance—will be addressed following public comment on the FS.

1.3. Site Description

1.3.1. Site Physical Description

The PWP site is an inactive wood treating facility located on Daniels 70 (former State Route 70) in Burnett County, Wisconsin. It is approximately 78 miles northeast of Minneapolis, Minnesota, and 60 miles south of Duluth, Minnesota (Figure 1-2). The Village of Siren, Wisconsin, is approximately 2 miles east of the site and there are three residences within 200 feet of the site; one of which is currently a hobby farm with beef cattle. Siren has a population of approximately 863 people and there are 38 private wells within a 1-mile radius of the site (*Draft Report—Preliminary Hydrogeologic Investigation*, Weston, December, 1994).

The PWP property currently consists of approximately 82 acres which were actively used; 40 undeveloped acres consisting of forest were sold after the facility closed. The property is located in a rural agricultural and residential setting and is bordered to the east, west, and north by forested areas; some of these areas are classified by the State of Wisconsin as wetlands. With the exception of a small parcel, Daniels 70 forms the southern site boundary of the property. Approximately 8 acres of the PWP site is located south of Daniels 70 (Burnett County Plat Book 1997).

A number of surface water bodies are present north and east of the site. Doctor Lake and an unnamed lake are located 2,000 feet east and northeast of the site, respectively. Approximately 2,137 acres of lakes, 94 acres of bogs, and 7,500 acres of wetland are located within a 4-mile radius of the site. The Amsterdam Slough Public Hunting area covers 7,233 acres and is located 1 mile north of the site (USGS, 1982).

1.3.2. Site History

PWP operated from 1953 to 1992. Raw timber was cut into posts and telephone poles and treated with either a 5 to 7 percent pentachlorophenol (PCP) solution in a No. 2 fuel oil carrier, or with a water borne salt treatment called Chemonite consisting of ammonia, copper II oxide, arsenate, and zinc (ACZA). During its 39 years of operation, PWP discharged wastewater from an oil/water separator down a gully into a lagoon on the northeast corner of the property (Figure 1-3). Process wastes were also discharged onto the wood chip pile in the northwestern portion of the property. WDNR investigators noted

SECTION 1

INTRODUCTION

- Purpose of FS
- Summarize Site History
- Summarize Site Contamination/Health Risks

SECTION 2

REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIAL GOALS

- Evaluate ARARs
- Identify Site-Specific Objectives
- Identify Preliminary Remedial Goals
- Define Areas Exceeding Preliminary Remedial Goas

SECTION 3

REMEDIAL TECHNOLOGY DEVELOPMENT AND SCREENING

- Develop General Response Actions
- Technology Development and Screening

SECTION 4

ALTERNATIVE DEVELOPMENT AND DESCRIPTION

- Alternative Development
- Detailed Description of Alternatives

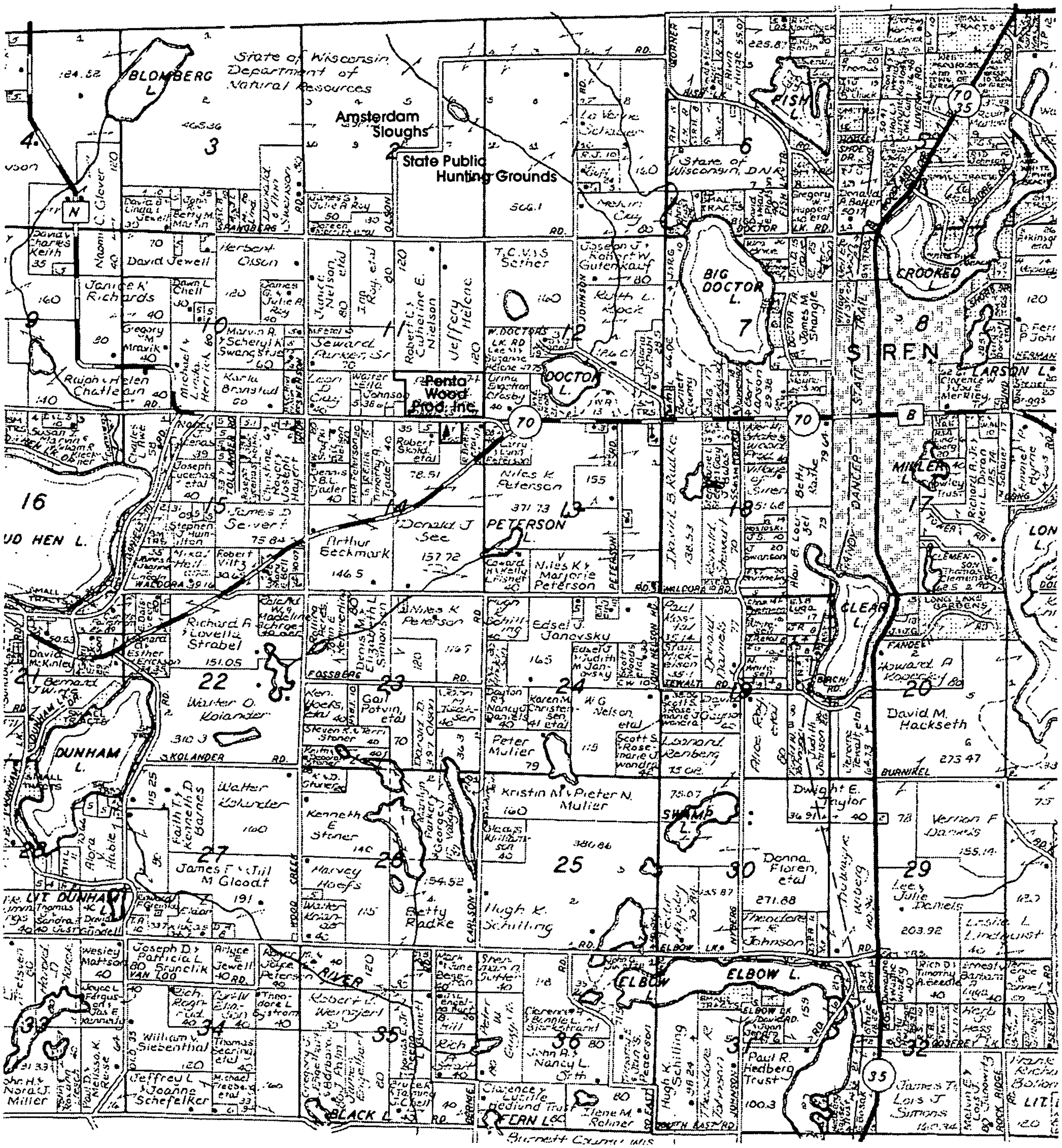
SECTION 5

DETAILED ANALYSIS OF ALTERNATIVES

Detailed Analysis of Alternatives in Terms of:

- Protection of Human Health and Environment
- Compliance with ARARs
- Long-Term and Short-Term Effectiveness
- Reduction of Toxicity, Mobility, and Volume
- Restoration Time Frame
- Implementability
- Estimated Cost

FIGURE 1-1
FS Report Flow Diagram
Penta Wood Products FS Report



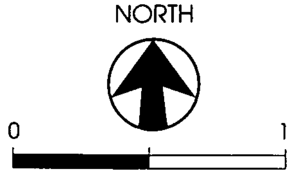


FIGURE 1-2
Site Location Map
Penta Wood Products FS Report

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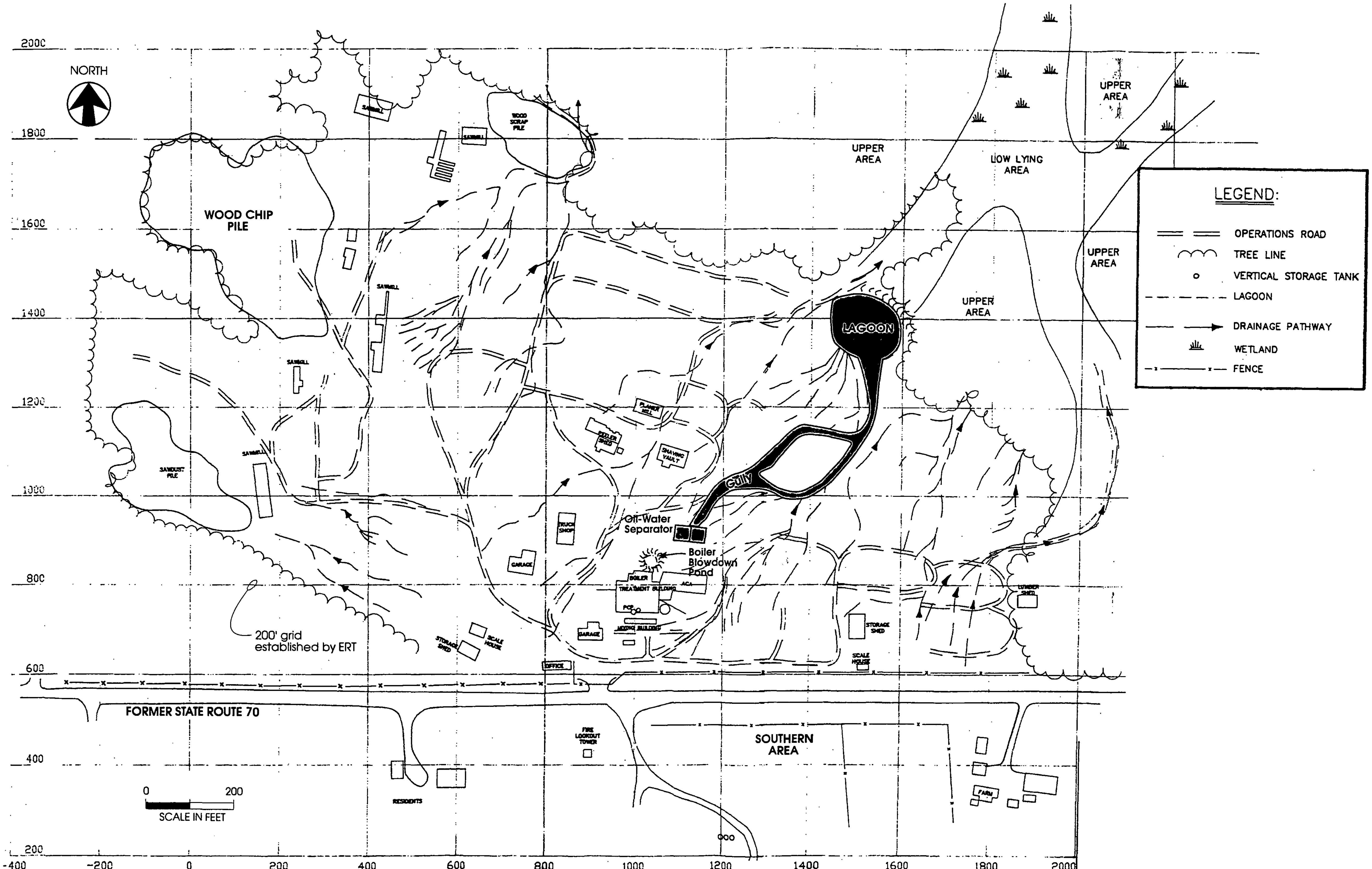


BASEMAP SOURCE: US EPA Analytical Contract #68-C4-0022, W.O.#03347-040-001-0026-01 Figure 4, May 1994

FIGURE 1-3
Site Features Map
Penta Wood Products FS Report

several large spills, stained soils, two fires, and poor operating practices during site inspections beginning in the 1970s. A large fire around 1979 destroyed the treatment building. Because the fire threatened to spread to the PCP/oil solution, PWP released 10,000 gallons of the PCP/oil solution to the oil/water separator, which then overflowed and discharged to the gully leading to the lagoon (White 1998). An 8-acre portion of the site, located south of old Highway 70, was used to transfer bulk PCP oil mix to buyers.

In 1988 the onsite production well was closed for potable use when it was found to contain 2,700 parts per billion (ppb) of PCP. From 1987 to 1992, PWP funded an investigation to characterize soil and groundwater contamination with 58 soil borings, test pits, and 10 monitoring wells (Conestoga-Rovers & Associates 1992). In 1989, the Wisconsin Department of Transportation (WDOT) detected 2,800 parts per million (ppm) of PCP in a surficial soil sample collected from the right-of-way on the south side of old Highway 70 (Aqua-Tech 1990).

In 1990, the Wisconsin Department of Justice (DOJ) filed a hazardous waste and spills law suit, which led to negotiations for a settlement. In 1991, DOJ required PWP to construct an approved drip track pad in compliance with the new Resource Conservation and Recovery Act (RCRA) drip track regulation. On the compliance date of May 1992, PWP closed for business due to lack of funds.

WDNR conducted a Screening Site Inspection in 1993 which detected 13 mg/kg of PCP, 190 mg/kg of copper, and 74 mg/kg of arsenic in a sediment sample collected from a wetland located downhill from the lagoon. Semi-volatile organic compounds (SVOCs) detected in surficial soil samples included PCP, pyrene, di-n-butylphthalate, and phenanthrene. Five residential wells were sampled and did not contain site contaminants (WDNR 1994).

In late 1992, the WDNR requested the USEPA to perform a site investigation to determine whether the site met federal removal action criteria. The site was put into the Superfund Accelerated Cleanup Model (SACM) pilot program. The USEPA Technical Assistance Team (TAT) contractor conducted a site assessment on April 2, 1993. Sixteen surficial soil samples, and one sludge sample from the oil/water separator tank were collected and analyzed for arsenic, copper, 2,3,7,8-TCDD (dioxin), and SVOCs. The SVOC list included 66 compounds, including the carcinogenic polyaromatic hydrocarbons (cPAHs). Besides elevated arsenic and PCP, several PAHs were detected; phenanthrene, acenaphthene, flourene, isosphorone, naphthalene, 2-methylnaphthalene, di-n-butylphthalate, and bis (2-ethylhexyl)phthalate. The highest concentrations were detected in the oily layer of the sludge sample. Dioxin was not detected, but the method detection limit was not reported (Ecology and Environment 1993).

Surficial soils and ash from the boiler where PCP sludges were burned were sampled at other times for dioxin. Sample results detected dioxin at less than 1 µg/kg toxicity equivalent using the 1987 United States Environmental Protection Agency (USEPA) toxicity equivalency factors (Weston, May 1995).

1.3.3. Removal Action

USEPA Region V Emergency Removal Branch (ERB) conducted a federally funded removal action between April 1994 and June 1996. About 28 storage tanks containing liquids and sludges were emptied, and 43,000 gallons of PCP oil and sludge were disposed of offsite for incineration. The ACZA treatment building was demolished, and the grossly contaminated soils from that area were excavated. Sitewide, about 1,600 cubic yards of soils contaminated with both PCP and arsenic were excavated and hauled offsite. About 4,000 cubic yards of ACZA-contaminated soil was excavated and mixed onsite with concrete to form a 580- by 260-foot, 1-foot-thick concrete pad (see Section 2 of this report for further discussion). The pad was intended to be used for ex situ bioremediation of PCP-contaminated soils. Because of its intended use, the concrete pad is herein referred to as the biopad.

In response to a June 1995 heavy rain that released water from the lagoon into the wetlands northeast of the site, the removal team stockpiled excavated soil across site gullies to reduce soil erosion.

1.3.4. Characterization and Treatability Studies

During the removal action, ERB requested site characterization support from the USEPA Emergency Response Team (ERT). ERT and its contractor conducted a hydrogeological and an onsite and offsite surficial soil investigation in 1994. The hydrogeological investigation included installation of 12 additional wells, three lysimeter nests, infiltration tests, and seismic studies (Weston, December 1994). Over 630 soil samples were collected during grid and biased surface soil sampling and soil boring installation. The samples were analyzed for PCP, arsenic, copper, and zinc. Some of the samples were also analyzed for Total Petroleum Hydrocarbons (TPH). The results of the seismic studies were not included in the report.

Treatability studies conducted by ERT to evaluate treatment technologies included soil washing, solidification, and bioremediation through landfarming, ex situ biopiles, anaerobic dechlorination, and white rot fungus. The soil washing bench-scale treatability study results indicated the oil/PCP residual is not flushed easily from soil pores. The solidification results were used in building the concrete Biopad. The bioremediation studies were relatively successful in degrading PCP, with the following results:

Landfarm Plots. PCP concentration declined from 46 to 6.6 mg/kg over nine months in the control sample. The sample augmented with Daramend declined from 49 mg/kg to 7.8 mg/kg over the same time period.

Biopile. PCP concentration declined from 460 to 50 mg/kg over 10 months. Similar or less percent reductions were achieved in piles amended with various combinations of wood chips and nutrients.

Anaerobic Dechlorination. PCP concentration declined from 28 to 9.4 mg/kg over nine months in the control sample. Samples amended with nutrients (phosphate, manure, blood meal) achieved slightly better results, with percent reductions of 84 percent, compared to 66 percent for the control sample.

White rot fungus pile. The test results were inconclusive, as the PCP concentrations increased during the 10 month test and then decreased with the end concentration matching the initial concentration of 7 mg/kg (Weston 1995).

1.3.5. Remedial Investigation

CH2M HILL conducted a Remedial Investigation (RI) in 1997 and early 1998 to fill remaining data gaps. RI field activities conducted in October 1997 included groundwater and residential well sampling, surface water and sediment sampling, surficial soil sampling, a subsurface soil investigation consisting of Cone Penetrometer Testing/Induced Fluorescence (CPT/IF) and test pit excavation, and a screening level ecological investigation. In January-February 1998 five new monitoring wells were installed and sampled, along with an extraction/bioventing well and nine soil gas wells for a bioventing treatability study.

1.4. Site Geology and Hydrogeology

1.4.1. Geologic Setting

The site stratigraphy can be divided into three stratigraphic layers: an upper sand, a glacial till, and a lower sand. The upper sand is fairly continuous across the site extending from the surface or beneath wood chip fill material to depths of 90 to 120 feet. The upper sand consists of well graded sand with some minor amounts (<10 percent) of silt and clay, well graded sand with silt, poorly graded sand, or poorly graded sand with gravel. Discontinuous lenses of till up to 25 feet in thickness were encountered within the upper sand between elevations of 975 and 1,002 feet msl (at depths of about 65 or 70 feet) at three locations (MW02, MW05 and MW15).

The glacial till at PWP is of variable lithology. It consists mainly of silts, silty sands to sandy silts with gravel. The unit is present beneath most of the site between elevations of 910 and 965 feet msl and ranges from 3 to 45 feet in thickness. The borehole data indicate that the tills are lenticular and vertically as well as laterally discontinuous.

The till is underlain by poorly sorted sand and gravel that is similar in composition, texture and depositional environment to the upper sand unit. The top of this lower sand unit was found at elevations ranging from 978 feet msl in IT01 (102.5 feet bgs) to elevation 910 feet msl in MW17 (215 feet bgs). The full thickness of the lower sand has not been determined during any of the subsurface investigations performed at the site. It extends to an elevation of at least 775 feet (300 feet bgs) to the bottom of the deepest boring (MW18D). The lower sand may be interbedded with glacial till layers at depths between 120 and 180 feet. The lower sand tends to fine upwards from poorly sorted gravel, medium- to coarse-grained sand to silty sand. Where the till unit is missing, the lower sand is usually indistinguishable from the upper sand and consequently, by convention, is described as part of the upper sand. Regional maps indicate the Pleistocene deposits overlay Cambrian sandstones and Precambrian basalt flows. Geotechnical analysis of the upper sands indicates the material has neutral to alkaline pH, low cation exchange capacity, and little organic carbon in noncontaminated areas.

1.4.2. Hydrogeologic Setting

Groundwater at the PWP site occurs both in a thin unconfined aquifer and within a multi-layered semiconfined aquifer system. In most areas of the site, the unconsolidated glacial deposits form a deep unsaturated zone. The continuity of the consolidated till deposits determines two distinct groundwater flow systems. Discontinuous consolidated till deposits of varying thickness have caused semiconfined conditions. Till is absent and glacial deposits function as a single water-bearing unit below the lagoon and near the PCP treatment area.

1.4.2.1. Unsaturated Zone

The site is situated in a groundwater recharge zone. Because of the high permeability of surficial soils, precipitation rapidly infiltrates the soil. The depth to groundwater ranges from 20 feet in the topographic low northeast of the lagoon (MW13) to greater than 150 feet south of Daniels 70 (MW15). Capillary moisture requirements are minimal in the unsaturated zone. Most of the soils were found to contain moisture near the saturation level (6 percent). Thus, water infiltrating from the surface will have to satisfy only minimal capillary requirements before downward percolation occurs. The unsaturated hydraulic conductivity probably approaches the saturated hydraulic conductivity (19.3 ft/d) during a rain event. During dry weather, the unsaturated hydraulic conductivity of sandy materials may be lower by three orders of magnitude (Hillel 1982).

Infiltration tests performed at two locations in the wastewater discharge gully found infiltration rates relatively consistent (3.6 to 5.3 ft/day) throughout the entire depth of the borings with the exception of IT01 (at 20 feet) which was found to have an infiltration rate of 200 ft/day. The later infiltration rate is considered high even for an extremely sandy material.

1.4.2.2. Unconfined Aquifer

The unconfined aquifer consists of a thin zone of groundwater, within the upper sand unit, perched upon the less permeable till. Beneath the lagoon and the PCP treatment area, the consolidated glacial till deposits are discontinuous. At these locations, the unconfined and the underlying semiconfined aquifers behave as a single unconfined system. The observed saturated thickness of the unconfined aquifer ranges from less than 5 feet in MW06S to greater than 25 feet in MW18.

Groundwater elevation data were collected on 33 different occasions between March 25, 1988, and February 7, 1998. Based on the water level data, the observed groundwater elevations ranged from a maximum of 994.5 feet msl at MW18 on September 8, 1994, to a minimum 979.83 feet msl in MW06S on March 31, 1994. The groundwater levels in the unconfined aquifer have generally increased over the monitoring period, with maximum elevations occurring in June 1997. The maximum water level fluctuation observed in a single well over the entire monitoring period was 10 feet in MW18. The fluctuations in the groundwater levels could not be correlated directly to precipitation events. The lack of correlation was expected because of the time required for percolation through the thick unsaturated zone and the frequency of measurements.

Average horizontal flow velocities were calculated using a range of horizontal hydraulic gradients and an average hydraulic conductivity (21 ft/day) and assuming an effective porosity for the aquifer matrix of 0.30. The horizontal velocities that were calculated based on these data range from 0.07 to 0.6 ft/d (25 to 219 ft/year). This compares well to estimation of groundwater velocity based on the distribution of chloride. Chloride is a conservative indicator parameter because it travels at the same rate as groundwater and does not undergo any degradation. Because chloride was discharged to a pond outside the treatment building beginning in 1953, the distance chloride has migrated can be used to estimate the groundwater velocity. Based on the chloride distribution, the groundwater velocity is estimated to be about 25 ft/yr.

1.4.2.3. Semiconfined Aquifer

The semiconfined aquifer system consists of the groundwater within the lower sand unit. Twelve wells and the production well (PW01) were installed in the uppermost portion of the semiconfined system. Groundwater elevation data were collected on 30 different occasions between May 8, 1990, and February 7, 1998. Groundwater elevations range from 980.80 feet msl in MW04 on March 28, 1994, to 987.22 feet msl in MW03 on October 10, 1997. The water levels in the semiconfined aquifer also increased over time, similar to the trend seen for the unconfined aquifer. The maximum water level fluctuation observed in a single well over the entire monitoring period was 5.85 feet in MW03. Consistent with the unconfined aquifer system, the fluctuations in the water levels could not be correlated to variations in precipitation.

Average horizontal flow velocities for the semiconfined aquifer were calculated using a range of horizontal hydraulic gradients and a geometric average hydraulic conductivity (7.6 ft/day), and assuming an effective porosity for the aquifer matrix of 0.30. The horizontal velocities calculated based on these data range from 0.01 to 0.1 ft/day (3.6 to 36 ft/year).

1.4.2.4. Groundwater Flow Unit Interconnection

The water levels in the unconfined aquifer are generally a foot higher than measured in the semiconfined aquifer. The data suggest that the till, where present, is acting as a confining layer.

Water elevation data collected from three monitoring well pairs in the unconfined and semiconfined aquifers (MW18/MW05, MW10S/MW10, MW16/MW12) were compared to assess the hydraulic connection between the two units. The limited data indicate strong downward vertical gradients exist between the shallow unconfined and semiconfined systems. The calculated vertical gradients ranged from 0.008 to 0.045 ft/ft. The vertical gradients between the well pairs are about an order of magnitude higher than the estimated horizontal gradients indicating a large vertical component to the groundwater flow. The strong downward vertical gradients suggest that the unconfined aquifer may be discharging to the semiconfined system in the area surrounding the lagoon.

1.5. Nature and Extent of Contamination

This section is based on previous investigation results and the information gathered during the RI activities. The contamination found at PWP primarily includes surficial soil PCP and metals contamination, subsurface soil PCP contamination, PCP and metal contamination in the surface water and sediments, a light non-aqueous phase fuel oil layer on top of the groundwater table, and groundwater contamination. Several PAHs were also detected during previous investigations in surface soils, as well as dioxins/furans that were below available health advisory levels. There is a limited amount of benzene and naphthalene in groundwater that exceeds WDNR Preventive Action Limits (PALs).

1.5.1. Source Areas

1.5.1.1. Gully to Lagoon

The vadose zone soils within the two prominent arms of the gully leading from the oil/water separator to the lagoon is contaminated with a PCP fuel oil residual as a result of spills and discharging contaminated wastewater from the oil water separator building down the gully to the lagoon. The average ratio of PCP to TPH is 5 percent, suggesting the PCP oil mixture is acting as a single compound in the environment. In general, PCP concentrations are highest in the first 20 feet bgs, then drop down until the water table where a residual LNAPL zone exists. A shallow (2 to 15 feet thick) wood debris layer is holding the PCP oil mixture much like a sponge. During test pit excavation oily liquid seeped into the pit from a semi-saturated wood debris layer.

1.5.1.2. Wood Chip Pile

The wood chip pile in the northwest corner of the PWP site contains both PCP oil and metals contamination. The contamination is present as a result of wastewater discharges. The wastewater discharge volumes were approximately 300 gallons at a discharge frequency of five to six times per week for 6 to 7 years (i.e., approximately 450,000 gallons).

PCP and TPH have been detected in the wood chips at elevated levels of 1,300 mg/kg PCP and 24,000 mg/kg TPH from a depth of 4 to 7.5 feet, and 1,300 mg/kg PCP and 14,000 mg/kg TPH at a depth of 16 to 17 feet. Elevated levels of PCP were detected from the 0- to 3-inch depth at the southern toe of the wood chip pile, with concentrations of 520 mg/kg PCP, and 25,000 mg/kg PCP. PCP was not detected in the center or northern portion of the pile. PCP concentrations detected in soil boring samples from the wood chip/sand interface were minimal, with the exception of 134 mg/kg at 14 to 15 feet bgs, located near the location which had a PCP concentration of 1,300 mg/kg at 4 to 7.5 feet bgs. A groundwater grab sample collected in this area contained 6.2 µg/L PCP. Monitoring well MW24 contains 4 µg/L PCP, while the subsurface soil sample collected during MW24 installation at the wood chip/sand interface (17 to 19 feet bgs) contained 189 mg/kg PCP.

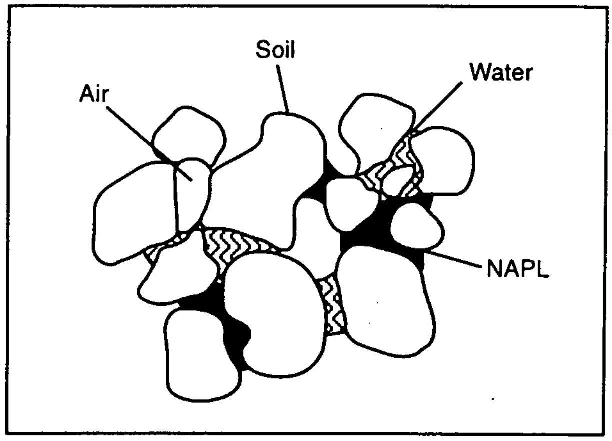
The PCP contamination is centered at the southern toe of the wood chip pile. Although significant levels of PCP and TPH were found in the wood chips, the soil interface beneath the wood chips appears minimally impacted. PCP in the wood chips ranged from 520 to 25,000 mg/kg, yet the soil beneath the pile contained a maximum of only 189 mg/kg. Groundwater samples collected at the water table in this area have minimal contamination.

1.5.1.3. LNAPL

As a result of the PCP/oil mixture draining from the surface to the water table, LNAPL is present within a smear zone (i.e., zone of water table elevation fluctuation) over an estimated 4-acre area beneath the site. The LNAPL area is larger than the area of contaminated unsaturated zone mid-level soils (10 feet bgs to the water table), which is estimated to be 2.4 acres. This is a result of lateral spreading of the LNAPL once it reaches the water table.

The LNAPL exists both as a free phase (i.e., floating on the water table) and as a residual phase (i.e., held immobile at residual saturation between particles in the soil). LNAPL distribution is significantly affected by water table fluctuations. As the water table rises, the mass of mobile LNAPL is reduced as LNAPL is entrapped at a residual saturation below the water table. After the water table drops, LNAPL saturation in the vadose zone will decline over time through drainage, with corresponding re-accumulation of the mobile LNAPL pool at the water table. The LNAPL does not completely drain from the vadose zone soil pore spaces, however, and soils throughout the smear zone will contain LNAPL (Drinkwater 1992). The LNAPL is a secondary source of groundwater and soil contamination at the site.

The volume of LNAPL is the sum of the free-phase LNAPL and the residual-phase LNAPL. In-well LNAPL thickness measurements from 1994 and 1997–1998 have shown measurable LNAPL in three wells (MW10S, MW19, and MW20) ranging from less than 1 inch to over 10 inches.



LNAPL thickness measured in monitoring wells overestimates the true thickness in the formation. In one study, a sample of sandy soil similar to that at PWP, the actual thickness of mobile free phase LNAPL was near zero for measured thickness up to 3 inches in observation wells. In a sandy soil with a measured LNAPL thickness of 6 inches in an observation well, the actual volume of free phase LNAPL was 0.4 inch. A similar sandy soil had less than 0.2 inch LNAPL at a measured observation well thickness of 9 inches (Farr et al. 1990). As a result, it is likely that very little free phase mobile LNAPL is present in the sandy soils at the site.

The residual-phase LNAPL in the smear zone extends both above and below the present water table. The smear zone is estimated to be an average thickness of about 4 feet based on water table fluctuations. Assuming a residual saturation of 30 percent of the pore space, the estimated volume of residual-phase LNAPL in the smear zone is 520,000 gallons.

1.5.2. Soils Outside of Source Areas

1.5.2.1. PCP

Additional onsite areas with PCP contamination besides the source areas already discussed include the area where the drain from the penta treatment area sump discharged (near LY01); hot spots located primarily west of the penta treatment building where treated lumber was pulled out of the retort chamber onto rail cars and allowed to drip; surficial soil collected along the fenceline adjacent to former State Route 70 east of the site entrance, and in the entrance to the parcel on the south side of the highway; and remaining PCP contamination in the ACZA treatment building area. Highly elevated concentrations of arsenic and PCP were detected within the ACZA treatment building in 1994 prior to removal activities. The upper 2 feet of soil within the ACZA treatment building, and directly north of it were excavated and shipped offsite in 1996. The maximum remaining detected PCP concentration in the vicinity of the ACZA building is 2,900 mg/kg at 3 feet bgs at the location where the ACZA pressure chamber door opened; additional soil may have been excavated from this location. The next highest detected concentration of remaining PCP is 500 mg/kg at 8 to 10 feet bgs.

Contaminants of concern were not detected along the south side of the pentachlorophenol treatment building, including samples collected from the vicinity of the structure that housed the PCP mixing tank, the laboratory, and other areas likely to receive spillage.

Two surficial soil samples were collected from the gully on the northern tree line that originates under the scrap wood pile and deposits material in a low spot offsite. PCP was not detected in either of these two samples. Historically PCP was detected at 200 mg/kg along the northern tree line where wastewater was discharged with a portable tank.

1.5.2.2. Arsenic

Arsenic has been found in soil above 50 mg/kg, the method detection limit of the analytical method used for the majority of the arsenic detection. Approximately 65 samples were analyzed with atomic absorption with a much lower detection limit. The soil arsenic contamination is largely limited to the eastern third of the site where the ACZA-treated wood was stored, and is limited to the upper 5 feet of soil due to its characteristic of being relatively immobile.

The maximum detected concentration of arsenic onsite was 150,000 mg/kg found under the hatch door of the ACZA pressure vessel, but the top 2 feet of grossly-contaminated arsenic soils in the ACZA treatment building and surrounding area were excavated and shipped offsite in 1996. An arsenic value of 150,000 mg/kg was detected at 3 feet bgs near the hatch door and may still remain onsite, however, it is feasible ERB may have removed additional soil from around the pressure chamber hatch.

Some of the ACZA-contaminated soil has been excavated and stabilized in the biopad. Areas where the upper 2 feet of soil were removed are shown in Figure 2-2 in the next section. Previous grid and biased soil sampling for PCP and arsenic show arsenic on the south side of old Highway 70, along the treeline on the northern boundary of the site (where wastewater was reportedly discharged with a portable tank), west of the treatment buildings, throughout the main treatment, gully and lagoon area and the area east of the gully and lagoon area.

Two composite samples of chipped concrete and loose sand found below flaking fragments were collected from the Biopad to determine if arsenic is leaching from the Biopad. The samples were analyzed for TCLP-arsenic and found not to be leaching arsenic above the characteristically hazardous criteria of 5 mg/L. Sample SS01 was 0.042 J mg/L, and SS02 was 0.072 J mg/L TCLP-arsenic. A surficial soil sample collected directly below the Biopad where runoff discharges contained 14.1 mg/kg arsenic.

1.5.2.3. Copper and Zinc

Elevated levels of copper and zinc are generally limited to the upper 2 feet of soil, and their horizontal distribution closely matches arsenic distribution.

Soil with the maximum levels of copper detected on site (290 mg/kg to 46,000 mg/kg) located in the ACZA treatment building was excavated and shipped offsite in 1996. The highest remaining level of copper is 2,200 mg/kg detected at the southern toe of the wood chip pile. Other hot spots include two samples collected from the eastern drainage area (570 mg/kg and 1,039 mg/kg).

The magnitude and extent of zinc contamination is less than the copper contamination. The maximum detected levels of zinc (210 mg/kg to 29,000 mg/kg) were from the same locations in the ACZA treatment building. The highest remaining level of zinc onsite is 320 mg/kg in the southern toe of the wood chip pile.

1.5.2.4. Dioxin/Furans

Dioxins and furans were detected in the soil samples collected from PCP/oil stain areas, from the area where the drain from the pentachlorophenol treatment sump discharged, and the ash pile, with total 1987 toxicity equivalents of 0.998, 0.756, and 0.035 µg/kg, respectively. The total 1989 toxicity equivalents were 11.52, 6.67, and 0.12 µg/kg, respectively. According to the OSWER Dioxin Disposal Advisory Group, if the total 1987 equivalent of a sample is above 1 µg/kg in a residential area or 20 µg/kg in a non-residential area, remedial action is necessary (des rosiers 1988). These threshold concentrations were upheld in a recent USEPA directive (USEPA 1998).

Based on the limited number of analyses performed, the results suggest the dioxin/furans are closely associated with PCP at the site. The highest concentrations of isomers and TEQs were detected in the stain area that had a PCP concentration of 4,500 mg/kg. Intermediate concentrations of isomers and TEQs were detected in the penta drain 1A sample, which had 500 mg/kg PCP. The lowest concentration of isomers and TEQs was found in the ash pile where no PCP was detected. This suggests the dioxin/furan found on site is a constituent of the PCP used at the site, rather than generated as an incomplete combustion product during the burning of PCP sludges in the boiler, or during fires that have occurred over the years.

1.5.2.5. PAHs

Historically surficial soils have been sampled on two occasions for polyaromatic hydrocarbons (PAHs). A sludge sample from the oil water separator tank was also analyzed for PAHs, including the carcinogenic PAHs which, if present, can be risk drivers at a site. Based on both sets of sample results, no carcinogenic PAHs were detected. The sludge sample contained the highest levels of PAHs, with 660 mg/kg phenanthrene, 3,000 mg/kg 2-methylnaphthalene, 750 mg/kg naphthalene, 740 mg/kg isosphorone, and 52 mg/kg flourene. The surficial soil sample collected next to the tank contained only two PAHs, at much lower concentrations, 110 mg/kg phenanthrene and 100 mg/kg 2-methylnaphthalene. Other surficial soil samples collected at scattered locations around the site contained even lower concentrations.

Groundwater at the site has been analyzed for naphthalene, but not for the entire CLP SVOC list. However, as carcinogenic PAHs were not detected in a sample of sludge (both the oil and water matrices were analyzed) , it is not likely the groundwater would contain contaminants not found in the source material.

1.5.3. Groundwater

Groundwater has been shown to contain elevated levels of PCP, chloride, TPH, and in one well, arsenic. Elevated levels of iron and manganese are also present in groundwater. As previously described, the source of the PCP and TPH is the LNAPL. Arsenic, iron, and manganese are present as a result of the reducing conditions. Chloride is elevated from the discharge of water softener salt and as a result of PCP degradation.

1.5.3.1. PCP

Table 1-1 presents the PCP concentrations in groundwater that have been collected over a 10-year period during eight sampling events by CRA, three sampling events by ERT, and the recent sampling event conducted by CH2M HILL. Concentrations are not available for every monitoring well over the time period, because additional wells were installed after well sampling began.

The unconfined wells that are grossly contaminated with PCP are MW10S, MW18, MW19, and MW20. These wells are within, or very near to, the LNAPL layer. A comparison of the PCP concentrations in the grossly contaminated wells between September 1994 and October 1997 shows that PCP decreased significantly in MW10S, from 110,000 to 30,000 µg/L. In both years, this is the maximum PCP concentration detected in groundwater. PCP concentrations in MW19 also decreased, from 83,000 to 19,000 µg/L. PCP concentrations in MW18 and MW20 increased, from 3,300 to 27,000 µg/L in MW18, and from 3,900 to 29,000 µg/L in MW20.

In the marginally contaminated unconfined wells, five of them went from low levels of PCP in 1994 to nondetect levels (or a J value below the detection limit for MW13) in 1997. One perimeter well increased in PCP concentration, MW01 on the eastern site border. The concentration increased from 0.3J µg/L in 1994 to 2 µg/L in 1997.

There are three known grossly contaminated wells in the semiconfined aquifer, and one well (MW06) that CH2M HILL was not able to sample in 1997 because it has been configured as an extraction well. A comparison of 1994 data to 1997 data shows that of the three wells, MW05 and MW12 increased in PCP concentration, from 26,000 µg/L to 28,000 µg/L in MW05, and 10,000 µg/L to 13,000 µg/L in MW12. PCP concentrations in MW05 have historically been variable, with one suspect value of 14 U µg/L in 1991. MW10 decreased in concentration from 17,000 µg/L in 1994 to 8,200 µg/L in 1997.

A significant finding was the apparent decrease of PCP contamination in MW17, distantly located from known source areas. The PCP concentration in 1994 was 2,000 µg/L, while it was not detected at 1 U µg/L in October, 1997. Because of the discrepancy, the well was

TABLE 1-1
Comparison of PCP Concentrations in Groundwater
Penta Wood Products FS Report

Sample Location	CRA 6/25/88	CRA 6/4/90	CRA 7/25/90	CRA 11/4/90	CRA 12/11/90	CRA 1/30/91	CRA 3/4/91	CRA 1/14/92	Weston 4/1/94	Weston 5/6/94	Weston 9/17/94	CH2M HILL 10/10/97	CH2M HILL 2/98
Unconfined Wells													
MW01	14 U		14 U	0.48	0.16	14 U	14 U	14 U	0.25 U	0.2 J	0.3 J	2	
MW02	14 U		0.3 U						0.25 U	0.25 U	0.7	1 U	
MW06S											7.3	1 U	
MW09							14 U	67	0.25 U	1.3	1.2	1 U	
MW10S											110000	30000	
MW13										1.2	3.5	0.7 J	
MW16										0.4 J	0.3 J	1 U	
MW18											3300	27000	
MW19											83000	19000	
MW20											3900	29000	
MW21													1 U
MW22													1 U
MW23													1 U
MW24													4
MW25													1 U
Semiconfined Wells													
MW03		1.1	14 U	0.57	1.7	14 U	14 U	14 U	0.3 J	0.3 J	2.6	1 U	
MW04		13 U	13	0.56	0.421	14 U	14 U	14 U	1.6	0.6	1.9	1 U	
MW05		18000	21000	14000	14000	2400	14 U	25000	24000	42000	26000	28000	
MW06		130	110	110	160	21	41	1800	2400	1800	4600		
MW07							14 U	14 U	0.1 J	2.4	0.4 J	1 U	
MW08							14 U	14 U	0.25 U	2	4.3	1 U	
MW10								12000	10000	23000	17000	8200	
MW11										7.7	1	1 U	
MW12										6000	10000	13000	
MW14										1.2	2.3	1 U	
MW15										6	1.3	1 U	
MW17											2000	1 U / 5	
PW01								2700	95	69	140	5	

All concentrations reported in µg/L.
U = Nondetected
J = Estimated, value below PCP quantitation limit

CRA Sampling Event 1 Sampled by Conestoga Rovers and Associates 6/25/88.
CRA Sampling Event 2 Sampled by Conestoga Rovers and Associates 6/4/90.
CRA Sampling Event 3 Sampled by Conestoga Rovers and Associates 7/25/90.
CRA Sampling Event 4 Sampled by Conestoga Rovers and Associates 11/4/90.
CRA Sampling Event 5 Sampled by Conestoga Rovers and Associates 12/11/90.
CRA Sampling Event 6 Sampled by Conestoga Rovers and Associates 1/30/91.
CRA Sampling Event 7 Sampled by Conestoga Rovers and Associates 3/4/91.
CRA Sampling Event 8 Sampled by Conestoga Rovers and Associates 1/14/92.

REAC Sampling Event 1 Sampled by WESTON/REAC 3/30/94–4/1/94.
REAC Sampling Event 2 Sampled by WESTON/REAC 5/2/94–5/6/94.
REAC Sampling Event 3 Sampled by WESTON/REAC 9/7/94–9/17/94.

CH2M HILL Sampling Event 1 Sampled by CH2M HILL 10/97, 2/98.

sampled twice in October, 1997 to confirm the nondetect value. The confirmation value was 5 µg/L PCP.

Another significant result was the decrease in the facility's production well PW01 from 140 µg/L in 1994 to 5 µg/L in 1997. The production well ceased functioning in May 1992 when the facility was closed. The remaining seven semiconfined wells were all nondetect for PCP, which was a decrease in concentration for five of them.

MW23 was installed 90 feet below the water table next to MW09 to determine if contaminated groundwater is migrating through the semiconfined zone to the wetland. As no PCP was detected in MW23, nor in MW09 or MW13, contaminated site groundwater is not reaching the wetland. Contaminants detected in the wetland are a result of overland transport of material from the collapsing lagoon wall, and perhaps from historic discharge of wastewater into the wetland.

Four residential wells were sampled only for PCP on October 9, 1997, and one residential well was sampled on October 15, 1997. One of the five wells had a positive detection of PCP, at 0.9J µg/L. A duplicate sample collected at this well contained 2.0 µg/L. The well, located south of the site at the Brethorst residence, was resampled on October 24, 1997, for PCP. The WDNR also collected a BTEX sample from the well. PCP was not detected in the confirmation sample. The WDNR reported BTEX was not detected in the well sample. The well was sampled again in April, 1998, by the WDNR and CH2M HILL, and neither PCP nor BTEX was detected.

1.5.3.2. Metals

Arsenic has also been found at concentrations exceeding the WDNR PAL in the groundwater, but more so in the 1994 data than the 1997 data. In 1994 arsenic was detected at 92 µg/L in MW06, and at 5.1 µg/L at MW05. The PAL for arsenic is 5 µg/L. In 1997, only one well contained arsenic exceeding the PAL; MW18 at 8.9 µg/L.

Iron and manganese also exceed criteria based on public welfare concerns of taste and odor aesthetics. The wells exceeding iron and manganese criteria in 1997 consist of MW05, MW10, MW10S, MW16, MW18, MW19, and PW01.

The presence of elevated concentrations of metals is due to high reducing conditions and low pH conditions found in the groundwater. The reducing conditions are caused by the utilization of oxygen by microbes degrading the TPH and PCP found in the groundwater. The pH is depressed also as a result of the production of carbon dioxide in microbial respiration. Soil arsenic found in the native aquifer soils is solubilized from the soil media under reducing and low pH conditions.

1.5.3.3. Fuel Components

Historic and recent groundwater sampling included analysis for fuel components. Compounds that have been detected above PALs and ESs are benzene and naphthalene. The 1997 sampling data shows PAL exceedances for benzene in MW04 (2 J µg/L), MW12 (1 J µg/L), and PW01 (1 µg/L). The PAL for benzene is 0.5 µg/L; the ES is 5 µg/L. The occurrence of benzene does not correlate with groundwater PCP concentrations.

For naphthalene, the 1994 sampling data shows four wells with exceedances above standards. All are above the ES of 40 µg/L. MW05 contained 90 µg/L, MW10 78 µg/L, MW10S 154 µg/L, and MW19 144 µg/L. Naphthalene was not analyzed for in 1997. MW10S and MW19 currently and historically have contained LNAPL. MW05 and MW10 also contain high levels of PCP, showing the naphthalene detections correlate well with elevated PCP concentrations.

1.5.4. Sediments and Surface Water

A series of five aerial photographs of the site show manmade influences to the hillside below the northern edge of the lagoon. It appears that wastewater may have been directed from the lagoon down through a terrace of levels built of wood chips to the base of the hill. At the base of the hill the terrain levels out, but still slopes down toward the wetland, and splits approximately 300 feet downgradient of the lagoon wall around a knob that creates a western and an eastern lobe of the tamarack sphagnum moss wetland. Drainage coming down this channel from the lagoon is primarily directed into the western lobe of the wetland, but wood butt end pieces and detection of contaminants in the eastern lobe show that when there is sufficient discharge volume some of it overcomes a slight rise in the terrain and reaches the eastern lobe.

The ERB On-Scene Pollution Control Report for June 1995 notes the lagoon wall collapsed in June 1995 after a heavy rainfall. During CH2M HILL's initial site visit in May 1997 the condition of the lagoon wall, downgradient channel and side gully, washout area below, and the perimeter of the western wetland lobe were noted. Based on the amount of sand and silt (about 6 inches) built up around a drum containing drill cuttings left by ERT next to MW13 and the presence of deposited wood butt ends all the way down to the wetland, it was apparent material from the lagoon wall has washed into the wetland. During the October 1997 field effort, the lagoon wall appearance had notably changed since May, and the amount of material deposited in the washout gully and into both lobes of the wetland was noticeably increased. Sections of the lagoon wall had slumped off, exposing over 12 feet of black stained soils. Exacerbating the undercutting of the lagoon wall is a side gully receiving drainage from the Biopad area. During the October visit an approximately 2-inch wide fissure was noted running parallel to the lagoon wall at 5 feet from the edge at the top of the lagoon. Test Pit TP01 was excavated close to the edge of the lagoon; oily, semi-saturated wood debris was noted from 1 to 3 feet deep. There was a distinct layer of wood butt ends from 8 to 9 feet, then visibly contaminated (though less so than the 1- to 8-foot interval) wood debris to 14 feet, which was the extent of the backhoe's capability. A soil sample collected from the 0- to 1-foot depth contained 935 mg/kg PCP as determined with the immunoassay kit, and a sample collected from the 9- to 14-foot interval contained 159 mg/kg.

It is evident that contaminated soils and PCP/oil residual is being transported to the wetland, particularly the western lobe, by overland mass transport. To determine the extent of contamination in the wetland lobes, a transect of four sediment samples and one surface water sample was collected through the middle of the western lobe, and three sediment samples and one surface water sample through the middle of the eastern lobe. Three additional sediment samples and two surface water samples were collected from the western lobe in April 1998, and one surface water sample was collected from the eastern lobe to define the extent of contamination. PCP, arsenic, and copper that exceed standards are discussed in Section 2.4.2.

1.6. Contaminant Fate and Transport

1.6.1. Metal Fate and Transport

Ammoniacal Copper Arsenate (ACA), or Chemonite, was developed in the mid-1920s. The original chemical constituency of ACA included $Cu(OH)_2$ and As_2O_3 meaning Cu(II) and As(III) were in reduced valence state. During the 1970s, a change was made to the more oxidated state of As(V), and copper was added as its oxide. Another change was promulgated in the early 1980s, when ZnO replaced half the AsO_5 active mass. Today, ammonium is added as the hydroxide salt into the formulation (Stoddard 1994). Upon application to wood materials, the ammonia volatilizes, leaving behind the insoluble salts of As and Cu which provide the necessary insecticide and fungicide properties.

The soils at the PWP site have been exposed to Chemonite since 1975 via accidental and intentional spills, and direct contact between the treated wood product and land surface. Knowledge of the reaction mechanisms involved with metals transformation is important in understanding the distribution of these chemicals in the environment. The environmental fate of metals differs radically from that of organic compounds; metals may undergo chemical transformations, but they do not degrade. Transformations include changes in oxidation state, precipitation with anions, adsorption, combination with organic ligands, or uptake by organisms. Some of these transformation processes result in immobilization of metals. Adsorption, the process whereby dissolved ions are removed from the aqueous phase by bonding to the surface of solid particles (positively charged metal cations are adsorped to balance the negative surface charges on soil and organic matter particles) is a reversible mechanism.

Unlike manmade organic molecules, transition metals are common to most soil materials and have associated background levels. In addition, transformation of a metal is not determined by standard analytical methods, which simply monitor for the bulk concentration of metals in soils. Generally, more advanced techniques such as differential extraction are needed to determine what reactions are prevalent to metals in a specific environment. The metals of interest at the PWP site are arsenic, copper, and zinc. Reactions with these specific chemicals are addressed below.

Arsenic compounds tend to adsorb to soils or sediments, and leaching usually results in transportation in soil only over short distances. Arsenic is most often introduced into the environment in one of two valence states: As(III) and As(V) (reduced versus oxidized). Conditions of soil redox and pH will determine if the metal will remain in its current valence state or be transformed to another. As(V) predominates in aerobic soils; As(III) in slightly reduced soils (i.e., temporarily flooded); and arsine, methylated arsenic, and elemental arsenic in very reduced conditions (i.e., swamps, landfills) (EPA 1982). The metal valence will influence sorption to soil constituents. As(III) is considered more mobile than As(V) with relative average distribution coefficients of 1.2 mL/g and 1.9 mL/g observed in soils, respectively (Dragun 1988). Sorption is also a function of soil type. Generally speaking, soils with high surface areas, organic matter content, or Fe- and Mn-oxides will retain greater amounts of metals.

Transport and partitioning of arsenic in water depends upon the chemical form (oxidation state and counter ion) of the arsenic and the interactions with the other materials present. Soluble forms move with the water, but arsenic may be absorbed from the water onto sediments or soils, especially clays, iron oxides, aluminum hydroxides, manganese compounds, and organic material (Callahan et al. 1979; EPA 1982; Welch et al. 1988). Arsenic in water can undergo a complex series of transformations, including oxidation-reduction reactions, ligand exchange, and biotransformation. The predominant form of arsenic in groundwater is usually arsenate, As(V), but under anaerobic conditions arsenate is reduced to arsenite, As(III). As(V) compounds are typically fixed to soil and are relatively immobile. As(III) compounds are 4 to 10 times more soluble than As(V) compounds.

In the aquatic environment, volatilization is important when biological activity or highly reducing conditions produce arsine or methylarsenics. Sorption by sediments is also important fate for the chemical.

Copper and zinc are compounds of interest at the PWP site. Previous investigations into the sorption and transformation of these metals are similar to those reported for arsenic. McLaren and Crawford (1973) developed a fractionation scheme for copper in soils. The separation components included water soluble fraction, weakly bound surface fraction, organics fraction, oxide material fraction, and residual fraction (i.e., copper incorporated into clay lattices). Although the results proved to be soil specific, on average over 50 percent of copper remained as soil residual. Another 30 percent was associated with the organic matter fraction and 15 percent with the oxide fraction. The soil solution and weakly held copper only accounted for 1 to 2 percent of the total copper mass, a small amount of leachable copper. The organic matter was said to behave as the source for water-soluble copper with decrease in system pH. Dragun (1988) provides a mean K_d for copper of 3.1 mL/g.

The distribution of zinc in the environment has been examined numerous times, due to contamination of soils by smelter stack effluent. Buchauer (1973) examined surface soils within 1 km of a zinc smelter and found levels of 50,000 to 80,000 mg/Kg zinc. These concentrations dropped dramatically with depth bgs in a stony loam soil. Most of the metal mass (85 to 95 percent) was retained in the top 15 cm of the soil. The high retention of zinc by the soil is thought to be a result of the insolubility of zinc oxide, and the fixation power of the soil. Dragun (1988) offers an average K_d for zinc of 2.8 mL/g.

The reported research indicates that water soluble transition metal concentrations will be limited in soils with high pH, or when sorptive materials such as organic matter, oxides, and clay minerals are present. System redox will also control the predominant oxidation state of each metal and its concomitant reactivity. Elevated concentrations of metals (arsenic, copper, and zinc) at the PWP site are contained within the top 5 feet of soil, as soil samples collected lower in the profile had metal concentrations within normal background limits for the region. Elevated copper or zinc concentrations were not detected in the groundwater.

1.6.2. PCP Fate and Transport

1.6.2.1. Contaminant Characteristics

The properties of both the constituent of concern and the environment are used to understand and predict chemical fate and transport. The important properties of the contaminant include molecular weight, water solubility, specific gravity, Henry's Law Constant, partitioning coefficients, and the biodegradation half-life. Because bioremediation is a presumptive remedy for wood treatment sites, and because the efficacy of bioremediation has already been demonstrated with site soils, biodegradation of PCP will be discussed in detail in Section 1.6.2.3.

The molecular weight of PCP is 262.34 grams/mole with the majority of the chemical mass due to the high degree of chlorination; chlorine atoms account for 67 percent of the compound mass. The density of pure PCP is 1.978 (Budavara 1989) making it heavier than water. Pure PCP is practically insoluble in water (5 mg/L at 5°C, 14 mg/L at 25°C, Vesala 1979) and must first be added into an organic solvent to provide efficient wood treatment. The solubility of PCP in #2 fuel oil often exceeds 5 percent. The effective density of PCP treatment mixtures are closely related to those of its carrier. A typical specific gravity for #2 fuel oil is 0.8654 at 15°C (Kirk-Othmer 1980), so PCP dissolved in fuel oil that reaches the groundwater would float.

Once in the environment, the solubility of PCP is further influenced by the pH of the soil solution or groundwater. PCP is considered a weak acid, meaning its addition to water at any pH will not necessarily lead to full dissociation of hydrogen ion from the parent molecule. Specifically, PCP has an acid dissociation constant (pK_a) ranging from 4.71 to 4.92 (Kirk-Othmer 1984) at 25°C. The pK_a indicates the pH at which 50 percent of a weak acid will be dissociated. As a rule of thumb, one may assume that systems with pH levels in excess of the pK_a by 2 S.U. provide complete dissociation of the compound of interest. For instance, an aqueous system with pH 6.8 would provide complete dissociation of PCP to its anion, pentachlorophenolate. This sodium salt of PCP has a solubility of 22,400 mg/L, a dramatic increase compared with the PCP molecule. Conversely, when the pH value is lower than the pK_a by 2 S.U. or more, the compound will be completely in its molecular form. Weston reported the system pH at PWP as 6.5 (Weston 1994). Based on the latest groundwater sampling, the average groundwater pH is 7.16, and the average groundwater pH in the wells with LNAPL is 7.89. At this pH, the PCP dissolved in the groundwater is pentachlorophenolate.

Solubility and sorption potential are strongly correlated (Chiou 1979). Sorption potential is a mechanism of solute removal to solid surfaces. Researchers have found that sorption of the PCP molecule is 50 times greater than sorption of the anion pentachlorophenolate. They also indicated that pentachlorophenolate can sorb appreciably to mineral surfaces, and that its sorption becomes predominant at pH values greater than 7.0 (Cjoi and Aomine 1973, Shimizu 1992). A relative index of sorption is provided by distribution coefficients (K_d). A site-specific K_d of 17.2 was developed for the PWP site from soil washing treatability studies (Weston 1994a) for unsaturated zone soils. Within the saturated zone a site-specific K_d of 0.6 L/Kg was estimated based on a 0.04% organic carbon.

Volatilization is the transfer of contaminant mass from soil, water, or separate phase to the air. Compounds that readily exhibit this mechanism are called volatile compounds. PCP is a semi-volatile compound, with a Henry's Law Constant of 1.3×10^{-6} atm-m^3/mol. This value is for the undissociated PCP. The relative rate of volatilization is lower for the phenochlorophenolate anion.

1.6.2.2. Migration Pathways

PCP was introduced to the environment through the discharge of wastewater containing the PCP No. 2 fuel oil mixture from the oil-water separator into the gully and lagoon areas, the wood chip pile area, and other isolated hot spots. From the surface, the PCP traveled as a single phase with the No. 2 fuel oil to the groundwater table, where it spread horizontally as a LNAPL layer until equilibrium with pore pressures was reached. Absent further LNAPL releases or changes in groundwater gradients, the LNAPL is not expected to continue spreading horizontally. The LNAPL acts as a continuous source of PCP to the groundwater.

Vertical migration of the LNAPL through the unsaturated zone is believed to have ceased. This is based on the lack of a substantial continuing source of pure phase LNAPL and the retention capacity of soils for fuel oil. The retention capacity of sands for light fuel oils is 4 percent of the soil volume (Dragun et al. 1991). TPH values in the contaminated soil of the unsaturated zone are much less than this value. Three samples from within the wood chips exceed 40, 000 mg/kg (4 percent) TPH, although wood chips would be expected to have a much higher retention capacity. Slow releases of LNAPL from the wood chips would be retained in the 80 feet of sand below that is not at retention capacity.

Dissolved phase PCP releases from the wood chips and soils beneath have occurred and are expected to continue. However the rate of downward transport is minimal for PCP because of its high adsorption capacity (K_d = 17.2). A more significant release mechanism for PCP is the dissociation of PCP from the LNAPL residual at the water table and its dissolution in the groundwater as phenochlorophenolate.

Migration pathways for the PCP in groundwater is generally expected to be in a radial pattern outward in all directions at a very slow rate. The flow directions are difficult to determine precisely from groundwater elevation data because the gradient is minimal. However based on the distribution of the chloride and PCP contamination it appears migration has occurred in all directions at roughly similar rates. It does appear that there will be less migration in the southwest direction as a result of the shut down of the water supply well PW-01 in May 1992. To the north, groundwater in the unconfined aquifer would be expected to eventually discharge to the wetland area.

Contamination in the unconfined groundwater will also migrate vertically down to the semiconfined aquifer. Once in the semiconfined aquifer further downward migration is not expected to be significant. Horizontal migration outward in all directions is expected. If the glacial till is continuous to the north, groundwater in the semiconfined aquifer may not discharge to the wetland but would migrate below it and eventually discharge to wetlands or lakes more distant.

Overland transport of contaminated soil and the PCP/oil mixture is another significant pathway, particularly in the northeast corner of the site. The northern wall of the lagoon is collapsing and wood debris from the site and fuel oil have been observed in the adjacent wetland.

1.6.2.3. Contaminant Fate

Contaminant fate processes for PCP in the subsurface include volatilization, dispersion, adsorption , and biodegradation. Surficial soil and surface water PCP contamination can also be degraded by photolysis, or photodegradation by sunlight.

PCP is considered a semivolatile, with a vapor pressure about four orders of magnitude less than that of volatile organic compounds (VOCs). As a result, volatilization of PCP is not a significant loss mechanism. Dispersion, the process by which concentrations are reduced as a result of horizontal and vertical spreading, will result in further reductions in PCP concentrations. Adsorption of PCP also occurs, which is dependent on its solubility and the soil organic carbon content. Solubility of PCP is dependent on the pH, though it is assumed to be very insoluble at most pH ranges. PCP is adsorbed on the organic portion of the soil. The ability of PCP to sorb to soil is expressed as the distribution coefficient K_d. High K_ds indicate high affinity to soil. For PCP, the site-specific measured K_d in soil is 17.2L/kg. The high K_d value indicates that adsorption is a significant mechanism for retardation of PCP migration. Within groundwater the fraction of organic matter is considerably less, resulting in a much lower K_d of 0.6 L/Kg, and much less adsorption. Because adsorption is considered a reversible process, it is not considered a removal mechanism.

The PCP K_d of 0.6 L/Kg in the saturated zone results in a retardation factor of 3.5. Given an average groundwater velocity of 25 ft/yr, PCP is expected to migrate at an average rate of 7 ft/yr. The estimated PCP migration velocity based on the travel distances from the perimeter of the LNAPL and assuming the presence of LNAPL in 1960, is 10 ft/yr (based on a distance of 400 feet in 38 yrs). The two estimates of migration velocity compare reasonably well.

Travel times for migration of PCP from the perimeter of the plume to the nearest residential wells, a distance of about 400 feet, is on the order of 40 years. Estimates of contaminant travel times are subject to a high degree of inaccuracy because of the many simplifying assumptions. Of particular importance is the estimate of hydraulic conductivity and the K_d, both of which can vary by an order of magnitude within short distances within the sand aquifer. Actual travel times may be considerably different than the estimated average values presented.

The estimated travel time does not include contaminant degradation. Given the long travel time for PCP to reach the groundwater and the relatively slow PCP migration velocities in groundwater, biodegradation can be a significant loss mechanism. Biodegradation is the process by which microorganisms consume the PCP, either as a primary substrate or as an electron acceptor. Biodegradation of PCP may occur anaerobically or aerobically with rates generally expected to be more rapid aerobically. Anaerobic biodegradation occurs by reductive dechlorination in which the chlorine atoms are sequentially replaced with hydrogen (PCP to tetra chlorophenol to trichlorophenol to dichlorophenol to chlorophenol to phenol). Abiotic reductive dechlorination may also occur as microorganisms can release organo metallic cofactors into the subsurface environment to catalyze the dechlorination reaction (Smith et al. 1994). Aerobic degradation pathways are less certain, although it appears that an initially hydroxyl group substitutes for a chlorine atom. Once the aromatic ring has two hydroxyl groups, the ring can be cleaved and then mineralized to carbon dioxide and water. Few intermediates other than chloride have been shown to accumulate (Rochkind, et al., 1986). Biodegradation rate constants vary considerably in the literature. Aerobic half lives range from 0.8 days to 51 days.

Anaerobic half lives are more pertinent to the unsaturated zone at PWP because the high TPH concentration has resulted in sufficient biological activity to utilize the available oxygen and produce anaerobic conditions. Anaerobic half lives are more limited in literature and range from 6.1 days to 266 days (Pelorus Environmental & Biotechnology Corporation, June, 1997). Site-specific aerobic half lives developed for treatability studies were generally on the order of 30 days (Weston, 1995a).

In summary, contaminant fate processes for PCP in the subsurface include volatilization, photolysis, dispersion, adsorption, and biodegradation. Because adsorption slows down migration, biodegradation has much longer time periods to degrade the PCP.

1.7. Summary of Human Health and Ecological Risks

1.7.1. Exposure Pathway Assessment

USEPA and WDNR had identified contaminants of potential concern (COPCs) at the site to be arsenic and PCP, and to a lesser extent, copper, zinc, and dioxins/furans. This was based on laboratory analyses of soil and groundwater data previously collected at the PWP site.

The significant routes of exposure are dermal contact and ingestion for onsite workers and excavation workers exposed to soils and residents exposed to groundwater. The significant routes of exposure for onsite residents exposed to soils were dermal contact, ingestion, and ingestion of produce.

1.7.2. Human Risk Characterization

The human risk evaluation is largely based on the results of the *Final Focused Human Health Risk Assessment*, Ecology and Environment, Inc., September 1997 (HHRA). The likelihood of adverse public health impacts associated with long-term exposure to COPCs at the PWP site was evaluated by estimating the potential excess lifetime cancer risks for carcinogens and by calculating hazard indices for noncarcinogens. Exposure and risk estimates were generated by using conservative (health-protective) reasonable maximum exposure (RME) and average exposure values. The average case represents exposure that is most likely to occur for most of the potentially exposed population, and is evaluated with the RME case to provide a range of risk estimates. The HHRA focused on the risks posed from potential future uses of the site in the absence of remediation. Exposure concentrations used in the HHRA were based on pre-removal action concentrations, and were not adjusted for the grossly contaminated soil that was removed from the site in 1996.

The HHRA found exceeding the "point of departure" risk of 1×10^{-6} or a hazard index (HI) of 1 for the RME are:

- Future onsite adult worker exposure to arsenic- and PCP-contaminated soils throughout the site (5.3×10^{-5}) and in the treatment area (2.4×10^{-3} and HI = 9.5)
- Future onsite excavation worker exposure to arsenic- and PCP-contaminated soils throughout the site (4.2×10^{-6})
- Future onsite adult resident exposure to arsenic- and PCP-contaminated soils throughout the site (3.4×10^{-4} and HI = 1.1) and in the treatment area (1.9×10^{-2} and HI = 81)
- Future onsite adult resident exposure to PCP-contaminated groundwater (1.1×10^{0} and HI = 1800)

In summary, cumulative cancer risks estimated for potential future onsite residential receptors in both areas were significantly greater than the range of "acceptable" risks defined in federal environmental laws and regulations (i.e., 1 × 10-6 to 1 × 10-4). Most of the RME residential cumulative cancer risk would be from domestic use (e.g., showering and ingestion) of groundwater contaminated with PCP, a Group B2 carcinogen. Significant potential risk also was associated with ingestion of arsenic (a Group A carcinogen) in soil, and ingestion of and dermal contact with PCP in soil. Cancer risks estimated for future workers were within the acceptable risk range for exposure to general site soils; however, risks from worker exposure to treatment area soils were above the acceptable range.

Noncancer hazard indices greater than 1 were estimated for future residents and for workers exposed to treatment area soils. An evaluation of chemical-specific hazard indices indicates that exposure to arsenic in soils, and PCP in soils and groundwater are the major factors driving the estimated noncancer risks. Hazard indices for PCP were above 1 for potential residential receptors because of dermal contact with PCP with groundwater. For workers in the treatment area, incidental ingestion of arsenic in soils accounted for more than 90 percent of the estimated noncancer risk. Background concentrations of arsenic in soil were not determined.

A greater-than-normal degree of uncertainty is associated with the arsenic risks because of the use of data obtained by field testing methods (X-ray fluorescence [XRF]). Laboratory confirmation sampling of the XRF data indicates that XRF may have significantly overestimated the true concentrations of metals in soil samples collected at the site. Additionally, the detection levels for arsenic were not low enough to adequately assess long-term residential exposure. For these reasons, the risks estimated for arsenic, copper, and zinc should be viewed as high-end estimates.

The risks estimated for the treatment area should also be viewed as high-end estimates since the grossly PCP- and arsenic-contaminated soil found under and adjacent to the ACZA treatment building was removed from the site.

1.7.3. Ecological Risk Characterization

A screening level ecological risk assessment was conducted and submitted as a separate document (CH2M HILL 1998). The objective of the assessment was to evaluate existing and future threats to the environment in the absence of any remedial action. Under the current ecological risk assessment guidance for Superfund, screening-level risk assessments are "simplified risk assessments that can be conducted with limited data by assuming values for parameters where data are lacking"(USEPA 1997). Risk is characterized in screening level assessments on the basis of several conservative exposure assumptions, utilizing maximum concentration data.

The PWP site is located in northwest Wisconsin in a region of extensive northern hardwood and coniferous forest, with numerous water bodies and associated wetlands. A large number of lakes and wetlands occur within 4 miles of the site. On and immediately adjacent to the site are four distinct community types that include upland mesic/dry-mesic forest, forested wetland, emergent wetland, and upland scrub/grassland. Although onsite habitat condition limits wildlife use, some species are expected to be found within the site boundaries. Wood upland and wetlands surrounding the site are considered relatively high quality habitat that may support a wide variety of wildlife species.

The most probable routes for exposure of terrestrial and semiaquatic ecological receptors at PWP include incidental ingestion and direct dermal contact with contaminated onsite and offsite soils, direct contact with contaminated wood chips, uptake and/or contact of contaminants through root systems resulting in phytotoxicity and ingestion and direct contact of offsite surface waters and sediments.

The hazard quotient (HQ) approach, which compares point estimates of exposures values with screening ecotoxicity values, was used as the primary approach for risk characterization. Risk estimates were calculated for four selected receptor species under four distinct exposure scenarios. Potential exposure estimates were calculated for the deer mouse, short-tailed shrew, American robin and raccoon. Exposure scenarios consisted of the previous treatment area, discharge areas, and hot spots such as the onsite general area, adjacent impacted wooded areas, and the offsite wetlands.

Calculations of exposure levels for each of the four receptors under each of the four exposure scenarios resulted in several HQ values which exceed one (unity). In particular, HQs calculated for receptors which may ingest contaminated soils and food items within the previous treatment area, discharge areas, and hot spots greatly exceed one and some cases exceed 1,000. Hazard quotient values for receptors onsite, but outside the previous treatment area, discharge areas, and hot spots ranged from 824 to 0.06, with the highest HQ value attributed to short-tailed shrew PCP exposure.

Offsite HQs also exceed one for most receptors and contaminants of concern. Within the wetland area, risk appears greatest from exposure to PCP and arsenic, with lesser risk levels associated with copper or zinc.

Additional potential routes of exposure besides ingestion include direct contact with soils and/or wood chips. At the PWP site, wood chips contain PCP above levels which have been found to result in reduced hatch and increased nestling mortality when nesting birds were exposed to PCP in nest material. Maximum concentrations of PCP and arsenic in soil also exceed levels associated with adverse effects on plant species.

The results of the screening-level ecological risk assessment indicate there is adequate information to conclude that current conditions at the PWP site present an ecological risk on and adjacent to the site.

For more detail on the subjects presented in Section 1 see the Remedial Investigation Report (CH2M HILL 1998).

SECTION 2

Development of RAOs and PRGs

2.1. Introduction

As described in the *Remedial Investigation/Feasibility Study* guidance document (USEPA, 1988) and in the USEPA 1990 *National Oil and Hazardous Substances Contingency Plan,* the FS consists of three phases: the development of remedial alternatives, the screening of alternatives, and the detailed analysis of selected alternatives. The following steps were used in developing the remedial alternatives for PWP.

- Identify applicable or relevant and appropriate requirements (ARARs)
- Develop RAOs
- Define remedial action goals, that include:
  - Developing quantitative PRGs using chemical-specific ARARs and human health- and ecological-based risk levels
  - Identifying areas of contamination exceeding PRGs
- Developing general response actions
- Identifying and screening technologies (including innovative technologies)
- Identifying and evaluating technology process options
- Assembling remaining process options into remedial alternatives

Section 2 presents the first three steps listed above: the identification of ARARs, the development of RAOs, and the identification of PRGs. Section 3 continues with the development of general response actions, and the identification and screening of remedial technologies and associated process options. Section 4 continues with the assembly of remaining technologies into remedial alternatives and the description of remedial alternatives.

2.2. Summary of ARARs

2.2.1. Definition of ARARs

Remedial actions must be protective of public health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental requirements, as well as to adequately protect public health and the environment.

Definitions of the ARARs and the "to be considered" (TBC) criteria are given below:

- Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, environmental action, location, or other circumstance at a CERCLA site.
- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law, which while not "applicable," address problems or situations sufficiently similar (relevant) to those encountered at a CERCLA site, that their use is well suited (appropriate) to the particular site.
- TBC criteria are nonpromulgated, non-enforceable guidelines or criteria that may be useful for developing an interim remedial action, or are necessary for evaluating what is protective to human health and/or the environment. Examples of TBC criteria include USEPA Drinking Water Health Advisories, Reference Doses, and Cancer Slope Factors.

Another factor in determining which requirements must be addressed is whether the requirement is substantive or administrative. "Onsite" CERCLA response actions must comply with the substantive requirements but not with the administrative requirements of environmental laws and regulations as specified in the NCP, 40 CFR 300.5, definitions of ARARs and as discussed in 55 FR 8756. Substantive requirements are those pertaining directly to actions or conditions in the environment. Administrative requirements are mechanisms that facilitate the implementation of the substantive requirements of an environmental law or regulation. In general, administrative requirements prescribe methods and procedures (e.g., fees, permitting, inspection, reporting requirements) by which substantive requirements are made effective for the purposes of a particular environmental or public health program.

ARARs are grouped into three types: chemical-specific, location-specific, and action-specific. ARARs for the PWP site have been identified and are further discussed in Appendix A. The most important aspects of the ARAR identification are summarized below.

2.2.2. Chemical-Specific ARARs

Chemical-specific ARARs include laws and requirements that establish health- or risk-based numerical values or methodologies for environmental contaminant concentrations or discharge. The chemical-specific ARARs can be classified into three categories: (1) residual concentrations of hazardous substances that can remain at the site without presenting a threat to human health and the environment; (2) land disposal restriction (LDR) concentrations that must be achieved if the contaminated media is excavated or extracted and later land disposed; and (3) effluent concentrations that must be achieved in treatment of the material so that air or water effluents do no exceed appropriate standards.

2.2.2.1. Residual Concentrations

ARARs for soil residual concentrations include Wisconsin soil standards (NR 720). For groundwater, Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) and the Wisconsin groundwater quality standards (NR140) are ARARs.

2.2.2.2. LDR Concentrations

The Resource Conservation and Recovery Act (RCRA) LDRs may apply to remedial actions performed at the site. For alternatives including ex situ soil treatment, it is assumed that soils containing PCP will be treated according to the following LDR treatment standards:

- F032-listed waste (wastewaters, process residuals, and preservative drippage from wood preservation with PCP)—LDR treatment standard of 7.4 mg/kg PCP or a treatability variance will be sought
- D037 TC waste—LDR treatment standard 7.4 mg/kg PCP and meet the universal treatment standards in 40 CFR 268.48 (e.g., 0.089 mg/L for PCP in Toxicity Characteristic Leaching Procedure [TCLP] extract) or a treatability variance will be sought

For alternatives including ex situ treatment of soils containing arsenic above background, it is assumed that soils will be treated according to the following LDR treatment standards:

- D004 TC waste—LDR treatment standard of 5 mg/L arsenic in Extraction Procedure (EP) or TCLP extract
- F035-listed waste (wastewaters, process residuals, and preservative drippage from wood preservation with arsenic)—LDR treatment standard of 5 mg/L arsenic in TCLP extract

If LDRs are achieved and if health-based residual contaminant levels (RCLs) are achieved in accordance with Wisconsin NR 720 Soil Cleanup Standards, WDNR may determine the soil to no longer contain the listed waste, in which case it could be replaced onsite, provided disposal complies with solid waste disposal requirements. If health-based concentrations are not achieved, disposal in an onsite Corrective Action Management Unit (CAMU) or offsite in a RCRA Subtitle C hazardous waste landfill would be necessary because the treated material would still be considered a hazardous waste. Soil that is a characteristic waste and is treated to below the TCLP limits, need only meet the solid waste disposal requirements (i.e., it does not have to be disposed in a RCRA hazardous waste landfill).

2.2.2.3. Effluent Limits

The substantive elements of the Wisconsin Pollutant Discharge Elimination System (WPDES) permit process will be used to establish the effluent limits for discharge of treated groundwater to surface water or groundwater. Discharge limits for treated groundwater to surface water will have to meet Wisconsin surface water quality standards. Discharge of treated groundwater to reinfiltration basins must meet Wisconsin NR 140 groundwater standards unless it can be demonstrated that capture of all reinfiltrating water is achieved.

2.2.3. Location-Specific ARARs

Location-specific ARARs are requirements that relate to the geographical position of the site. State and federal laws and regulations that apply to the protection of wetlands or construction in floodplains are examples of location-specific ARARs. The most important location-specific ARARs for the PWP site are the requirements for protection of wetlands (Executive Order 11990). This ARAR requires that actions at the site be conducted in ways that minimize the destruction, loss, or degradation of wetlands.

2.2.4. Action-Specific ARARs

Action-specific ARARs are requirements that define acceptable treatment and disposal procedures for nonhazardous and hazardous substances. These are triggered by the specific-control technology. One of the most important action-specific ARARs are the RCRA requirements for the management of hazardous waste. Other important action-specific ARARs are the potential to use the CAMU concept and the final cover requirements for wastes left in place. These are discussed in detail in Appendix A.4.3.1.5

The U*SEPA Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites* (USEPA, 1988a) and the NCP define RAOs as medium-specific or site-specific goals for protecting human health and the environment that are established on the basis of the nature and extent of the contamination, the resources that are currently and potentially threatened, and the potential for human and environmental exposure. Remediation goals are site-specific, quantitative goals that define the extent of cleanup required to achieve the RAOs. These goals are PRGs in the FS, and they will be finalized in the Record of Decision (ROD) for the site.

In this section, RAOs are developed for the media of concern at PWP. RAOs are based on the exposure pathways found to present unacceptable risks. They are largely based on the results of the *Final Focused Human Health Risk Assessment*, as summarized in Section 1.6. There are no currently exposed populations, so all risks are for potential future exposures. The HHRA found the following potential exposures exceeding the "point of departure" risk of 1×10^{-6} or a hazard index (HI) of 1 for the reasonable maximum exposure (RME):

- Future onsite adult worker exposure to arsenic- and PCP-contaminated soils throughout the site (5.3×10^{-5}) and in the treatment area (2.4×10^{-3} and HI = 9.5)
- Future onsite excavation worker exposure to arsenic- and PCP-contaminated soils throughout the site (4.2×10^{-6})
- Future onsite adult resident exposure to arsenic- and PCP-contaminated soils throughout the site (3.4×10^{-4} and HI = 1.1) and in the treatment area (1.9×10^{-2} and HI = 81)
- Future onsite adult resident exposure to PCP-contaminated groundwater (1.1 and HI = 1800)

The significant routes of exposure contributing to the risks were dermal contact and ingestion for onsite workers and excavation workers exposed to soils and residents exposed to groundwater. The significant routes of exposure contributing to the risks for onsite residents exposed to soils were dermal contact, ingestion and ingestion of produce.

In addition to human health threats, the contaminated soil and the LNAPL pose potential threats to groundwater. Consequently, the media of concern at PWP are:

- PCP- and arsenic-contaminated soil and sediment
- LNAPL
- PCP-contaminated groundwater

The contaminated soil media includes unsaturated geologic material occurring between the ground surface and the LNAPL smear zone. This includes soil eroded from the site and located north of the lagoon in the area referred to as the "wash out" area up to the edge of the wetlands. Also included in this media are the contaminated wood chips located in the northwest area of the site and the contaminated wood debris located in the shallow subsurface throughout the gully and lagoon areas. The biopad which is composed of solidified arsenic contaminated soil is also included in this media.

Wetland sediments, particularly those in the wetland north of the lagoon area, are included in the media posing unacceptable risk and requiring RAOs. Because only limited sediment sampling in the wetlands has been performed in the past, additional field investigations of sediments were performed. Visual and olfactory evidence of PCP oil contamination in the wetlands nearest the washout area has been observed. Wetland sediments will be addressed within the soil media.

LNAPL is a secondary source of groundwater and soil contamination at the PWP site, and exists both as a free phase (i.e., floating on the water table) and as a residual phase (i.e., held immobile at residual saturation between particles in the soil). The LNAPL is listed separately because remedial objectives, as well as remedial technologies to be developed later, are specific to LNAPL. The groundwater media includes contaminated groundwater in the unconfined and semi-confined zones throughout the site.

Surface water is not considered a media of concern because contaminants present in surface water are a result of either sediment contamination or runoff from contaminated soil. As a result, remediation of these media will in turn remediate surface water. Several ephemeral seeps with visible sheens have occurred in the gully area, apparently as a result of drainage from shallow low permeability wood debris. Because of their ephemeral nature and their unmeasurable flow (less than 0.1 gpm), these seeps will be addressed as part of the soil media in this area.

RAOs, remediation goals, and remediation strategies developed in this FS assume that the PWP site remains as an industrial site for the foreseeable future. The area to the north of the site where soils have been contaminated as a result of erosion is currently undeveloped woodland. It is unlikely this area will change in land use. However, because offsite, residential land use will be assumed, PRGs will be developed for both industrial and residential land uses.

2.2.5. RAOs for Soil

Results of the HHRA indicate that with future industrial land use there is potential for exposure of onsite receptors (adult workers and excavation workers) to contaminated soil that may present an unacceptable risk. In addition, contaminated soil at PWP is a source of contamination to groundwater onsite. Consequently, an additional objective for remediating the contaminated soil is to allow the goals for groundwater remediation to be met. Contaminated sediment may also pose an ecological risk.

The RAOs for soil and sediment at PWP include the following:

- Prevent human exposure through contact, ingestion, or inhalation to contaminated soil that presents an unacceptable risk (e.g., hazard index greater than 1 or excess cancer risk greater than $1x10^{-4}$ to $1x10^{-6}$)
- Prevent further erosion and offsite transport of soils contaminated in excess of PRGs
- Remediate contaminated soils as necessary to prevent further migration of contaminants in groundwater in excess of MCLs or HI greater than 1 or excess cancer risk greater than $1x10^{-4}$ to $1x10^{-6}$ to groundwater
- Prevent unacceptable risks to ecological receptors exposed to PCP- or metal-contaminated wetland sediment.

2.2.5.1. Prevent Human Exposure through Contact, Ingestion, or Inhalation

Exposure to contaminated soil or sediment through direct contact and ingestion is not likely to occur because the site is unoccupied and fenced. There is little potential for exposure to the offsite contaminated soil and sediment because of the site's remote location. This objective is intended to prevent unacceptable risks to potential future industrial or excavation workers as a result of exposure to onsite contaminated soils. Also, this RAO applies to prevention of unacceptable risks to residents as a result of exposure to offsite soil and sediment contamination.

2.2.5.2. Prevent Further Erosion and Offsite Transport of Contaminated Soils

Onsite soils have eroded as a result of the lack of vegetation and the relatively steep slopes across the site. Deep gullies caused by erosion are present immediately north and northwest of the lagoon. Further erosion of site soils should be prevented to minimize the offsite migration of site contaminants.

2.2.5.3. Remediate Contaminated Soils

Soil analytical data indicate that subsurface soil at PWP contains elevated concentrations of PCP. This contamination has leached to the groundwater and will likely continue to leach in the absence of site remediation. The amount of leaching should be controlled to the extent that it does not result in continued loadings to groundwater sufficient to cause further expansion of the groundwater PCP plume, or result in an unreasonable time to remediate the groundwater to MCLs.

2.2.5.4. Prevent Unacceptable Risks to Ecological Receptors Exposed to Wetland Sediment

Recent sampling of sediment downstream of the washout area found evidence of PCP oil in the wetlands. The remedial objective for the wetlands is to prevent unacceptable risks to ecological receptors exposed to arsenic, copper, zinc, or PCP in the sediment. Also, the pure phase oil itself may pose an ecological risk. Risks to human receptors exposed to sediment are addressed within the objectives above.

2.2.6. RAOs for LNAPL

LNAPL present at PWP contains significant concentrations of PCP and is a major secondary source of PCP to the groundwater. The RAOs for LNAPL at PWP are:

- Prevent human exposure to LNAPL through contact, ingestion, or inhalation
- Remove the pumpable LNAPL to the extent practicable
- Enable long-term attainment of groundwater RAOs

These objectives are discussed below.

2.2.6.1. Prevent Human Exposure to LNAPL through Contact, Ingestion, and Inhalation

LNAPL is a mixture of PCP and fuel oil. PCP is present at a concentration of several percent in the LNAPL. Although the HHRA for PWP did not quantify the risks associated with exposure to the LNAPL, the risk associated with any direct human exposure to LNAPL is expected to be well above acceptable levels. Consequently, the RAOs must continue to prevent exposure to LNAPL, including exposure during any activity involving excavation of soil containing LNAPL or use of groundwater containing LNAPL.

2.2.6.2. Remove the Pumpable LNAPL to the Extent Practicable

Action-specific ARARs require removal of LNAPL to the extent practicable. This ARAR is focused on the pumpable portion of the LNAPL and does not refer to the non-pumpable portion remaining as residual in the soil pore space.

2.2.6.3. Enable Long-term Attainment of Groundwater RAOs

LNAPL is a major secondary source of PCP to the groundwater at PWP. Based on field observations, it was determined that LNAPL is present in the soil, on the water table, and above and below the water table trapped as a residual phase in the aquifer matrix. Because LNAPL is in direct contact with soil and groundwater, the PCP in the LNAPL will continue to dissolve in groundwater and adsorb to soil particles.

2.2.7. RAOs for Groundwater

Remedial objectives for the contaminated groundwater at PWP are developed separately for the groundwater below the PCP-contaminated soil source areas and outside the source areas. This is because USEPA recognizes that the point of compliance in groundwater begins at the perimeter of waste management areas (see the preamble to the NCP, FR Vol. 55, No. 46 pg. 8753). Groundwater outside the waste management areas must be remediated to PRGs in a reasonable time frame given the particular circumstances of the site. Waste management areas are "sources of release" where waste is left in place. At PWP this is defined as the area of PCP-contaminated soil and LNAPL residuals within the main treatment, gully and lagoon area, and the area of contaminated wood chips in the northwest corner of the site. These are referred to as the source areas. Because of the large quantity of contaminated soil at PWP and the presence of difficult to remove LNAPL residuals, some remedial alternatives will include leaving portions of these wastes in place. The state of Wisconsin has a similar concept referred to as the Design Management Zone for landfills, where the compliance point is a vertical boundary outside the limits of the fill.

The RAOs for remediation of groundwater at PWP include the following:

- Minimize the potential for human exposure to contaminated groundwater both within and outside the source areas
- Remediate groundwater within the source area to the extent practicable and minimize further migration of contaminants to groundwater beyond the point of compliance
- Remediate contamination in groundwater outside the source areas to concentrations below MCLs and Wisconsin Preventative Action Limits (PALs), or HI 1 or excess cancer risk of $1x10^{-4}$ to $1x10^{-6}$ within a reasonable time frame

Each of these RAOs is discussed in the following sections.

2.2.7.1. Minimize Exposure to Contaminated Groundwater

There are currently no complete exposure pathways to contaminated groundwater beneath PWP because there are no known contaminated wells in use. If contaminated groundwater is used as drinking water or for showering in the future, significant health risks would exist. Thus, remedial actions must minimize the potential for human exposure to contaminated groundwater.

2.2.7.2. Remediate Groundwater within the Source Area tc the Extent Practicable and Minimize Further Migration

Groundwater below the source area must be remediated to the extent practicable. However, the presence of highly contaminated soils in the 100-foot-thick unsaturated zone and the LNAPL residuals in the zone of water table fluctuation, make it unlikely that groundwater below this area can be returned to MCLs or PALs in the foreseeable future, except with active remediation. Further migration of contaminants to groundwater outside the source areas should be minimized to allow remediation of this groundwater in a reasonable time frame.

2.2.7.3. Remediate Contamination in Groundwater outside the Source Areas to PRGs

Because the aquifer beneath PWP can be classified as a Class II aquifer (i.e., drinking water quality groundwater), it is necessary to reduce the mass of contaminants of concern to meet MCLs and PALS and an acceptable level of risk such as health risks of between 10^{-4} and 10^{-6} with a target risk of 10^{-6}, or HIs less than 1 outside the source areas. Controlling the source of contamination will also be part of the restoration.

2.3. Preliminary Remediation Goals

To meet these RAOs, PRGs were developed to define the extent of contaminated media requiring remedial action. This section presents the PRGs and defines the volumes of affected media exceeding the PRGs that will be addressed in this FS. In general, PRGs establish media-specific concentrations of contaminants of concern (COC) that will pose no unacceptable risk to human health and the environment, and are developed considering the following:

- PRGs representing concentration levels corresponding to an excess cancer risk between $1x10^{-4}$ and $1x10^{-6}$, a chronic health risk defined by a hazard quotient of 1, and/or a significant ecological risk
- Chemical-specific ARARs including Wisconsin NR 720 soil RCLs and Federal MCLs and Wisconsin NR 140 PALs for potential sources of drinking water
- Background concentrations of specific constituents
- Factors related to technical limitations, uncertainties, and other pertinent information

A number of the above factors have been discussed in the summary of site-related risks and RAO development in Sections 1.7. and 2.2. Chemical-specific ARARs are presented (in addition to potential location- and action-specific ARARs) in detail in Appendix A. Chemical-specific ARARs are health- or risk-based numerical values or methodologies derived from cleanup standards, standards of control, and other substantive environmental statutes or regulations. If these values are deemed "applicable" or "relevant and appropriate," they become a key element in developing PRGs when applied to the site-specific conditions.

As discussed below, the key chemical-specific ARARs for PWP are MCLs and PALs for the definition of PRGs for groundwater. Because a primary RAO for soil is to enable the achievement of groundwater RAOs, groundwater PRGs were used to estimate corresponding PRGs in soil protective of groundwater. This approach has significant limitations related to uncertainties in quantities used to model the transfer of contaminants from soil to groundwater and the resultant effect on contaminant concentrations in the groundwater; however, the resulting PRGs are expected to be conservative. Throughout the following development of media-specific PRGs, the likelihood of exposure pathways becoming complete in the future is a key factor in deriving achievable PRGs.

There are no chemical-specific ARARs that directly address LNAPL. Similar to soil, the groundwater protection RAO is the driving force behind LNAPL remediation. Unlike soil, a quantitative LNAPL remediation goal cannot be estimated because of the complex solute-solvent interactions of the constituents of LNAPL.

2.3.1. PRGs for Soil

Based on the potential future exposure risks and the RAOs presented in Section 2.2.5., soil PRGs were developed for onsite and offsite exposure. Onsite the human health exposure pathways were limited to industrial exposures because the site is expected to remain industrial for the foreseeable future. Onsite soil PRGs were developed for the following human health exposure pathways:

- Industrial site worker dermal, ingestion, and inhalation of particulates
- Industrial excavation worker dermal, ingestion, and inhalation of particulates
- Ingestion of groundwater contaminated from leached soil contamination

As discussed earlier, residential land use will be assumed for offsite areas. Offsite soil PRGs use the residential exposure scenario.

Soil PRGs for each of the site COCs, for each of the above pathways are presented in Table 2-1. Also listed is the Wisconsin NR 720.11 RCL for non-residential and residential land use direct contact. A soil concentration protective of groundwater was not developed for metals because they have limited mobility in the unsaturated zone. Site data confirms this as arsenic, copper, and zinc are limited to shallow soils throughout the site. PRGs developed for protection from direct contact ingestion and inhalation exposures are applied to shallow soils (< 10 feet depth), while the soil PRGs protective of groundwater apply to all soils. The lowest PRG for the relevant exposure pathways is used where more than one PRG has been developed.

Ecological soil PRGS were also developed for onsite and offsite (see Appendix E). A range of PRGs is presented because of the variation in PRGs among animal species. The upper range of the ecological PRGs were less than PRGs developed for human health protection, with the exception of copper and zinc. Mid-range ecological values for copper and zinc were chosen as the lowest PRG for both offsite and onsite contamination. Areas exceeding these values also exceed human health values for either PCP or arsenic.

For arsenic, the NR 720.11 direct contact PRG for non-residential exposure is the lowest PRG for onsite PRGs. Wisconsin regulations require use of the 10^{-6} cancer risk level. Because the PRG is below the natural background concentration of 5.2 mg/kg, the background concentration is used as the onsite soil PRG. This is also the case with the offsite PRG for residential exposure. A site specific background arsenic concentration will be developed as part of design investigatons. While the lowest PRGs are used to designate the areas requiring remediation, the remaining PRGs are useful in focusing on the type of remediation that may be necessary. For example, land use restrictions and engineering controls such as a soil cover may be a reasonable approach to soils exceeding the onsite background PRG for arsenic, while excavation and solidification may be the approach for soils exceeding the 10^{-4} cancer risk arsenic PRG of 106 mg/kg.

The PCP HHRA-based direct contact PRG for non-residential exposure is the lowest PRG for onsite PRGs. This value is applied to the shallow soil where direct contact exposure could occur. Below a depth of 10 feet, the PCP PRG for protection of groundwater of 4.6 mg/kg will be used. This value was developed based on the Summers Model, and was documented in the *Draft Report Preliminary Hydrogeologic Investigation Penta Wood Products Site (Weston, 1994)*. The Sommers Model assumes a mass balance between water infiltrating through contaminated soil (which leaches contaminants from the soil) and clean groundwater flowing beneath the contaminated soil. The model assumes that chemical equilibrium occurs between the infiltrating water and contaminants adsorbed to the soil and that complete mixing of infiltrating water and underlying groundwater occurs.

The PCP PRG protective of groundwater may be revised once ongoing biological degradation treatability studies are completed. A preliminary evaluation of unsaturated zone transport of PCP was performed using the SESOIL model to determine the validity of the simpler Sommer's model result. The one-dimensional, vertical transport SESOIL model simulates advection, dispersion, adsorption, volatilization, and degradation in the unsaturated zone. This evaluation (see Appendix B) showed that the transport of PCP in the unsaturated zone is very slow and the predicted concentration arriving at the water table is very sensitive to the degradation rate. Using existing site PCP concentrations and a literature PCP degradation rate of 0.00679/day (half life of 182 days) results in nondetectable concentrations arriving at the water table. This suggests a PRG protective of

TABLE 2-1
PRGs for Principal Contaminants of Concern in Soil
Penta Wood Products Site

	PRGs			Parameters Considered in Setting PRGs for Soil												
	Shallow Soil		Subsurface Soil	Industrial Site Worker[a]			Industrial Excavation Worker[a]		Residential Adult[a]			Wisconsin ARAR NR 720.11 RCL for Direct Contact[b]		Ecological PRGs		
Compound	Onsite PRG (mg/kg)	Offsite PRG (mg/kg)	Soil Concentration Protective of Groundwater (mg/kg)	Cancer Risks 10^{-6} (mg/kg)	Cancer Risks 10^{-4} (mg/kg)	Noncancer Risks HI=1 (mg/kg)	Cancer Risks 10-6 (mg/kg)	Noncancer Risks HI=1 (mg/kg)	Cancer Risks 10^{-6} (mg/kg)	Cancer Risks 10^{-4} (mg/kg)	Noncancer Risks HI=1 (mg/kg)	Nonresidential RCL (mg/kg)	Residential RCL (mg/kg)	Onsite (mg/kg)	Offsite (mg/kg)	Background[c] (mg/kg)
Arsenic	5.2[d]	5.2[d]	NA	1.1	106	171	14	87	0.414	41	80	1.9	0.425	0.25–17.4	0.25–52.2	5.2
Benzene	0.0055[e]	0.0055[e]	0.0055[f]	1.3	129	25	53	43	0.75	75	17.5	98.7	22	--	--	--
Copper	100	100	347	--	--	40,660	--	12,552	--	--	17,095	37,814	2,894	25–115	25–347	17
Ethylbenzene	2.9[e]	2.9[e]	2.9[f]	--	--	4,787	--	6,917	--	--	3,126	102,195	7,821	--	--	--
Fluorene	100[e]	100[e]	100[g]	--	--	8,517	--	7,799	--	--	4,294	40,880	3,129	--	--	--
Isophorone	628	264	--	628	62,754	42,583	14,367	38,996	264	26,367	21,471	3,012	672	--	--	--
Methylnaphthalene	--	--	--	--	--	--	--	--	--		--	--	--	--	--	--
Naphthalene	0.4[e]	0.4[e]	0.4[g]	--	--	8,517	--	7,799	--	--	4,294	40,880	3,129	--	--	--
Pentachlorophenol	2.1	0.9	4.6[h]	2.1	212	2,725	67	3,423	0.92	92	1,413	23.8	5.3	0.037–15.1	0.037–45.5	--
Phenanthrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Toluene	1.5[e]	1.5[e]	1.5[f]	--	--	2,656	--	4,367	--	--	1,849	204,346	15,643	--	--	--
Zinc	320	320	8,692	--	--	329,677	--	101,777	--	--	138,608	--	156,429	15–2,897	11–8,692	48
Xylene, Mixture	4.1[e]	4.1[e]	4.1[f]	--	--	425,833	--	389,957	--	--	214,706	306,600	23,464	--	--	--

NA = Not Applicable.

[a] PRGs for industrial workers, excavation workers and residential exposures are based on Region IX PRG approach assuming ingestion, inhalation and dermal exposure routes. See Appendix E, Tables E-1 to E-3.

[b] Wisconsin direct contact PRGs based on EPA RAGS Part B multiple pathway approach for soil ingestion and inhalation and default exposure assumptions presented in NR 720.19.
RCLs for PAHs based on WDNR Guidance Soil Cleanup Levels for PAHs Interim Guidance.

[c] Background not determined for site. Background value is based on the mean of concentrations in soils of the United States.
(Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. G. S. Professional Paper 1270, 1984). Background to be determined during pre-design investigations.

[d] Arsenic PRG is background because residential and industrial PRGs are below background. Site specific arsenic background will be determined as part of pre-design studies.

[e] Soil concentration protective of groundwater is the lowest of all the parameters considered.

[f] Soil concentrations protective of groundwater are Wisconsin NR 720.09 Table 1 values for the BTEXs.

[g] Soil concentrations protective of groundwater are based on Wisconsin DNR guidance *Soil Cleanup Levels for PAHs Interim Guidance, April 1997*.

[h] Based on Sommers Model methodology, as presented in the *Draft Report Preliminary Hydrogeologic Investigation Penta Wood Products Site December 1994*.
Value to be revised based on additional site investigation and treatability study data.

groundwater, at least two orders of magnitude greater than the 4.6 mg/kg estimate based on the Sommer's model. The anaerobic degradation rate used is being evaluated in a column treatability study using contaminated soil from the PWP site. Data were not available at the time of preparation of this FS. It is anticipated that data will be available to refine the PCP soil RCL for protection of groundwater. In the interim, the previously developed PRG of 4.6 mg/kg will continue to be used for soil. Shallow surficial soils must also meet the lower direct contact PRGs.

2.3.2. PRGs for Sediment

Based on the potential future risks to ecological receptors and the RAOs presented in Section 2.2.5., sediment PRGs were developed for protection of ecological receptors. Based on preliminary sediment sampling results, COCs include arsenic, copper, and PCP. Currently there are no Federal or Wisconsin sediment quality standards. Within the TBC category, the USEPA has published Ecotox Thresholds for sediment (USEPA Publication 9345.0 -12 FSI, January 1996). The publication does not include sediment quality benchmarks for either arsenic or PCP but does include an Effects Range Low concentrations for arsenic, copper, and zinc. The WDNR developed Sediment Quality Objectives for the site (WDNR 1998). Median sediment quality benchmark values for arsenic, copper, and zinc were calculated from four sources relating concentrations to effects on benthic organisms. The NOAA source cited by WDNR is the same source used by the USEPA Ecotox Threshold. WDNR also provided a TBC for DRO of 81 mg/kg for No Observed Effects, 150 mg/kg for Lowest Observed Effects, and 1,280 mg/kg for Severe Effect Threshold. These values were generated by toxicity testing for Newton Creek in Superior, Wisconsin.

USEPA does not include any criteria for PCP in sediment, however, the state of Washington does have a sediment criteria of 0.36 mg/kg for PCP. This value is considered a TBC and will be used as a PRG. Ecological PRGS based on the EPA toxicity reference values were developed for wetland sediment using a procedure similar to that used for ecological soil PRGs. The calculations are shown in Appendix E. The PRGs are presented in Table 2-2.

2.3.3. PRGs for Groundwater and Surface Water

PRGs were developed for groundwater based on the RAOs discussed earlier. In addition, PRGs are necessary for surface water because contaminated groundwater may eventually discharge to nearby surface water such as the wetlands or unnamed lake north of the site. The chemicals of concern for groundwater include:

- BTEXs and naphthalene - These are included because of the presence of fuel oil.
- Arsenic—Soil data indicates arsenic has not leached to groundwater. However, arsenic is solubilized from naturally occurring concentrations in soil under reducing conditions caused by the presence of organic contamination in groundwater. Dissolved arsenic has been found at one well, MW-6 (92 μg/L), exceeding the MCL of 50 μg/L.
- Chloride—Produced as a result of degradation of PCP and was also likely discharged to the pond north of the treatment building as a byproduct of boiler make-up water softening. Chloride exceeds the secondary MCL of 250 mg/L at one monitoring well (MW-06 at 430 mg/L).

- Ammonia —A component of the inorganic wood preservative ACZA used at the site and has been found in groundwater at one well, MW-06 (11 mg/L) at a concentration exceeding the NR 104.02 standard of 3 mg/L. Ammonia is included only for surface water because groundwater standards are not available.
- Iron—As is the case with arsenic, iron is solubilized under reducing conditions. Dissolved iron concentrations greater than the 300 µg/L secondary MCL occur at several monitoring wells.
- Manganese—Solubilized under reducing conditions, similar to arsenic and iron. Dissolved manganese has been found at concentrations greater than the 50 µg/L secondary MCL at several monitoring wells.
- Zinc—Zinc is included because it was used in the inorganic wood preservative. It is below the MCL and PAL in groundwater.
- PCP—PCP is the main COC in groundwater and is present in a wide area at concentrations exceeding the MCL and PAL.

Surface water PRGs for the COC are provided in Table 2-3. BTEXs and naphthalene were not included in the COC list because these have not been detected in surface water. The surface water PRGs include federal ambient water quality criteria, Wisconsin water quality criteria and the Great Lakes Water Quality Initiative chronic criteria. The lowest PRGs are either aquatic life chronic criteria or human cancer criteria. These PRGs are relevant in the development of WPDES surface water discharge limits or for groundwater discharges to surface water.

Chemical-specific ARARs (e.g., PALs) are the PRGs for the groundwater COCs at PWP. The PRGs for groundwater are listed in Table 2-4. USEPA considers MCLs as the relevant PRG for Superfund sites as required by the NCP. However Wisconsin considers PALs to be the relevant PRG for remediation of groundwater.

2.3.4. Areas Exceeding PRGs

2.3.4.1. Soil

The areas of unsaturated zone soil exceeding the arsenic background PRG and requiring remediation are shown in Figure 2-1. Figure 2-2 presents a larger scale map of the ACZA treatment area where soil was previously removed. The majority of the arsenic soil samples were analyzed with XRF and had a detection level of 49 mg/kg, well above the background PRG of 5.3 mg/kg. About 10 percent of the soil samples were analyzed with atomic absorption (AA) and had a detection limit of less than 1 mg/kg. A comparison of the samples analyzed by both XRF and AA showed that only 15 percent of the XRF nondetect (ND) results exceeded the background value based on AA results. As a result, the ND contour shown on Figure 2-1 is considered comparable to the extent of arsenic above background. Based on Figure 2-1, the area exceeding the background PRG for arsenic is 16 acres, of which about 2.3 acres is offsite in the lagoon wash out area. The depth of arsenic contamination within this area varies from less than 1 foot to 5 feet. Assuming an average depth of 2 feet, the in situ volume of soil contaminated at concentrations greater than the background PRG is 50,000 cubic yards (cys). This compares well with the estimated 55,000 cys of arsenic-contaminated soil shown on Table 36 of the *Final Report Site Characterization Extent of On- and Offsite Contamination Surficial and Near Surface Soil, Penta Wood Products Site. Weston, May, 1995.*

TABLE 2-2
PRGs for Principal Contaminants of Concern in Sediment
Penta Wood Products Site

Compound	Preliminary Remediation Goal (mg/kg)	Parameters Considered in Setting PRGs for Sediment					
		Summary of Concentrations Related to Effects to Benthic Organisms From Four Guidelines[a]		Ecological PRGs Based on Toxicity Reference Values[b]	Washington Sediment Quality Value[c] (mg/kg)	Site-Specific Background (mg/kg)	95% UCL of the Mean Regional Background[d] (mg/kg)
		Lowest Effect Level Median Value (mg/kg)	Severe Effects Level Median Value (mg/kg)				
Arsenic	9.6	9.6	40.5	0.25–52.1	--	1.8	1.77
Pentachlorophenol	0.4	--	--	0.037–1.6	0.36	--	--
Copper	31	31	154	25–347	--	9.6	15.5
Zinc	120	120	428	11.5–8,692	--	31	65

" -- " = No criteria.

[a] Sediment Quality Objectives provided by Tom Janisch/WDNR for Penta Wood Site. Guideline sources are Ontario Sediment Quality Guidelines, NOAA Potential for Biological Effects (Long and Morgan), Ingersoll et al. Calculation of Sediment Effect Concentrations, and Smith et al. Sediment Quality Assessment Values.

[b] Ecological PRGs prepared by CH2M HILL, see Appendix E.

[c] State of Washington criteria.

[d] "Statistical Summary for Stream Sediments of the Rice Lake Quadrangle", USDOE, 1978, National Uranium Resource Evaluation Program.

TABLE **2-3**
PRGs for Principal Contaminants of Concern in Surface Water
Penta Wood Products Site

Compound	Preliminary Remediation Goal (µg/L)	Parameters Considered in Setting PRGs for Surface Water						
		Federal Water Quality Criteria		Wisconsin Water Quality Criteria				Water Quality
		Acute Criteria (µg/L)	Chronic Criteria (µg/L)	Threshold Concentration for Taste and Odor (µg/L)	Acute Toxicity Criteria (µg/L)	Chronic Toxicity Criteria (µg/L)	Human Cancer Criteria[a] (µg/L)	
Arsenic	50	360	190	--	340	152	50	150
Iron	1,000	--	1,000	--	--	--	--	--
Manganese	--	--	--	--	--	--	--	--
Copper	43[b]	105[b]	57[b]	--	105[b]	57[b]	--	43[b]
Zinc	524[b]	579[b]	524[b]	--	579[b]	524[b]	--	580
Chloride	230,000	860,000	230,000	--	--	--	--	--
Pentachlorophenol	1.8[c]	--	1.8[c]	30	2.1[d]	2.1[e]	--	1.8[c]
Ammonia	--	--	--	--	[f]	--	--	--

" -- " = No criteria.

[a] Human threshold cancer criteria for nonpublic water supply.

[b] Hardness dependent, criterion based on 660 mg/L hardness.

[c] pH dependent, pH 5.68 assumed.

[d] PCP acute toxicity criteria = e (1.0054(pH)-4.877); at pH = 5.68, ATC= 2.1 µg/L (NR 105).

[e] PCP chronic toxicity criteria = e (1.0054(pH)-4.9617); at pH = 5.68, CTC= 2.1 µg/L (NR 105).

[f] Ammonia surface water quality criteria are set for specific discharges based on temperature and pH of the receiving water. NR 104.20 requires ammonia to be less than 3 mg/L in surface water.

TABLE 2-4

PRGs for Principal Contaminants of Concern in Groundwater

Penta Wood Products Site

Compound	Preliminary Remediation Goal (μg/L)	Parameters Considered in Setting PRGs for Groundwater: Federal MCLs: Primary MCL (μg/L)	Federal MCLs: Secondary MCL[b] (μg/L)	Residential Adult[a]: Cancer Risks 10^{-6} (μg/L)	Residential Adult[a]: Cancer Risks 10^{-4} (μg/L)	Residential Adult[a]: Noncancer Risks HI=1 (μg/L)	Wisconsin Groundwater Quality Standards: Enforcement Standard (μg/L)	Wisconsin Groundwater Quality Standards: Preventive Action Limit (μg/L)
Arsenic	5	50	--	0.045	4	11	50	5
Benzene	0.5	5	--	0.30	30	12.5	5	0.5
Chloride	125,000[b]	--	250,000	--	--	--	250,000[b]	125,000[b]
Copper	130	--	1,000	--	--	1,351	1,300	130
Ethylbenzene	140	700	--	--	--	1,327	700	140
Iron	150[b]	--	300	--	--	--	300[b]	150[b]
Manganese	25[b]	--	50	--	--	5,110	50[b]	25[b]
Naphthalene	8	--	--	--	--	1,460	40	8
Pentachlorophenol	0.1	1.0	--	0.56	56	1,095	1.0	0.1
Toluene	69	1,000	--	--	--	749	343	68.6
Xylene, mixture	124	10,000	--	--	--	73,000	620	124
Zinc	2,500[b]	--	5,000	--	--	10,950	5,000[b]	2,500[b]

" -- " = No criteria.

[a] PRGs for residential exposures are based on ingestion and inhaltion using U.S. EPA Region IX approach for tap water.

[b] Criteria is for public welfare concerns (taste or odor aesthetics).

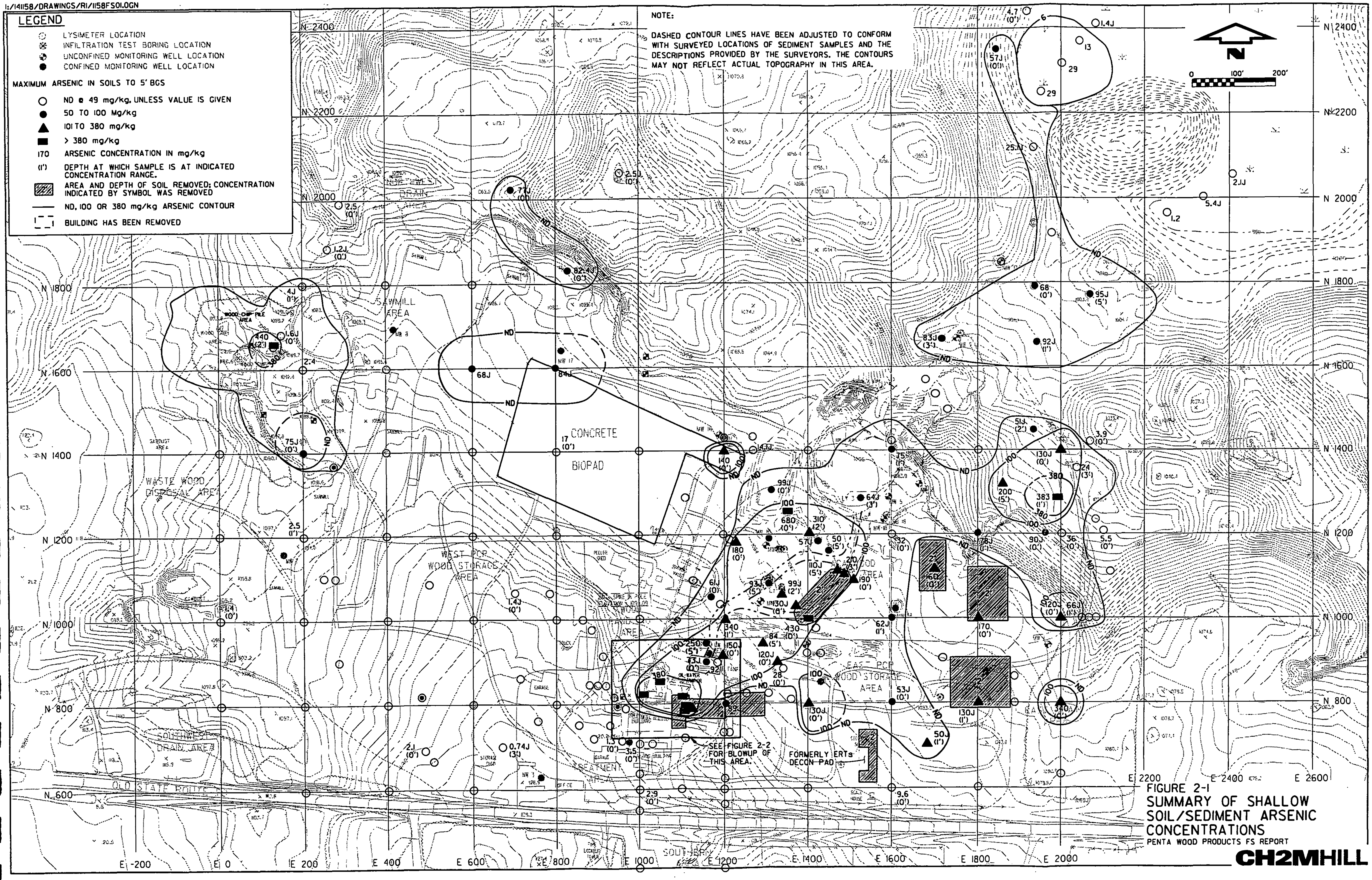
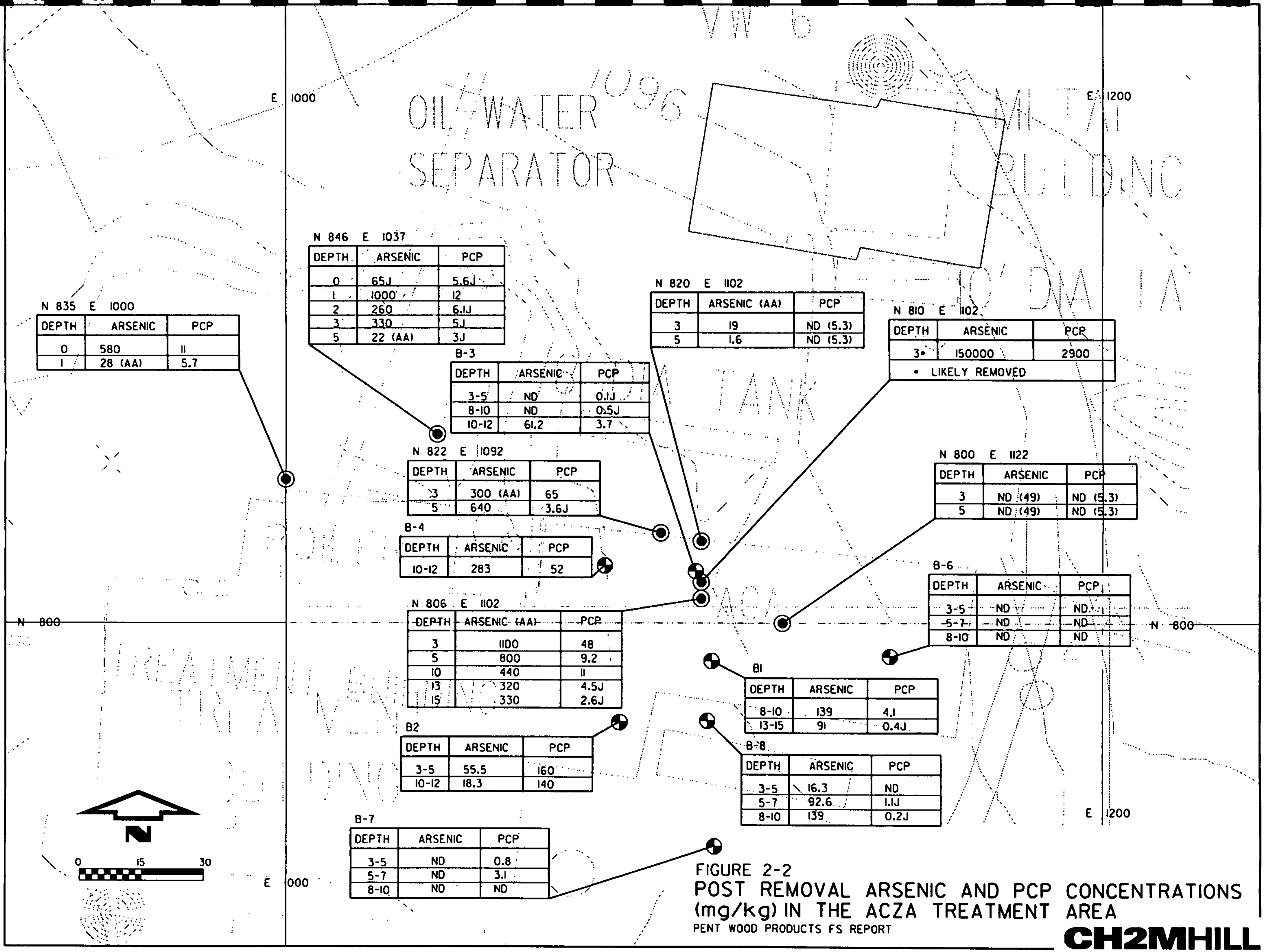


FIGURE 2-1
SUMMARY OF SHALLOW SOIL/SEDIMENT ARSENIC CONCENTRATIONS

14115[redacted]INGS [redacted]S02.D[redacted]



N 835 E 1000

DEPTH	ARSENIC	PCP
0	580	11
1	28 (AA)	5.7

N 846 E 1037

DEPTH	ARSENIC	PCP
0	65J	5.6J
1	1000	12
2	260	6.1J
3	330	5J
5	22 (AA)	3J

B-3

DEPTH	ARSENIC	PCP
3-5	ND	0.1J
8-10	ND	0.5J
10-12	61.2	3.7

N 820 E 1102

DEPTH	ARSENIC (AA)	PCP
3	19	ND (5.3)
5	1.6	ND (5.3)

N 810 E 1102

DEPTH	ARSENIC	PCP
3•	150000	2900

• LIKELY REMOVED

N 822 E 1092

DEPTH	ARSENIC	PCP
3	300 (AA)	65
5	640	3.6J

N 800 E 1122

DEPTH	ARSENIC	PCP
3	ND (49)	ND (5.3)
5	ND (49)	ND (5.3)

B-4

DEPTH	ARSENIC	PCP
10-12	283	52

B-6

DEPTH	ARSENIC	PCP
3-5	ND	ND
5-7	ND	ND
8-10	ND	ND

N 806 E 1102

DEPTH	ARSENIC (AA)	PCP
3	1100	48
5	800	9.2
10	440	11
13	320	4.5J
15	330	2.6J

B1

DEPTH	ARSENIC	PCP
8-10	139	4.1
13-15	91	0.4J

B2

DEPTH	ARSENIC	PCP
3-5	55.5	160
10-12	18.3	140

B-8

DEPTH	ARSENIC	PCP
3-5	16.3	ND
5-7	92.6	1.1J
8-10	139	0.2J

B-7

DEPTH	ARSENIC	PCP
3-5	ND	0.8
5-7	ND	3.1
8-10	ND	ND

FIGURE 2-2
POST REMOVAL ARSENIC AND PCP CONCENTRATIONS (mg/kg) IN THE ACZA TREATMENT AREA
PENT WOOD PRODUCTS FS REPORT

CH2MHILL

The onsite area of unsaturated zone soil exceeding the arsenic 10^{-4} industrial direct contact PRG of 106 mg/kg is 80,000 ft^2 and corresponds to an estimated 4,000 cys. Most of this contaminated soil is in the area of the former ACZA treatment building (see Figure 2-2).

The area of copper and zinc soil contamination exceeding PRGs is presented in Figure 2-3. This area is contained within the larger area of arsenic exceedances, or within the PCP hot spot areas, and so does not increase the total volume of soil exceeding PRGs.

The area of unsaturated zone shallow soil (0 to 10 ft. bgs) exceeding the PCP direct contact PRG of 2.1 mg/kg is shown in Figure 2-4. As with arsenic, the PCP onsite and offsite PRGs are below the detection level obtained for the majority of samples. The gas chromatograph mass spectrophotometer (GC/MS) detection level for PCP was typically about 5 mg/kg. PCP analysis was also performed using the Rapid Assay immunoassay field method on a subset of the samples. This method had a detection level of 0.1 mg/kg. About 60 percent of the GC/MS analyzed samples with ND were also found to be ND at 0.1 mg/kg detection level using the Rapid Assay test. As a result, the ND contour shown on Figure 2-4 is considered comparable to the extent of PCP above the PRG of 2.1 mg/kg. This area is also comparable to the PRG of 4.6 mg/kg for protection of groundwater. The area exceeding the PRG for PCP is 13 acres. About 3 acres of this is offsite in the lagoon washout area.

The area of unsaturated zone mid-level soil (10 feet bgs to the water table) and deep soil (LNAPL smear zone at water table) exceeding the PCP PRGs is shown in Figures 2-5 and 2-6. The areas of exceedance for the two depths are 2.4 acres and 4.3 acres, respectively. The larger area of exceedance for the LNAPL smear zone has occurred as a result of the lateral spreading of the LNAPL once it reaches the water table. The in situ volume of soil contaminated at concentrations greater than the direct contact and protection of groundwater PRGs is 400,000 cys. This compares well with the combination of the estimated 28,000 cys of PCP-contaminated shallow soil shown on Table 36 (*Final Report Site Characterization Extent of On- and Offsite Contamination Surficial and Near Surface Soil, Penta Wood Products Site. May, 1995*) and the estimated 360,000 cys of PCP-contaminated soil in the central treatment area presented in the *Draft Report Preliminary Hydrogeologic Investigation, Penta Wood Products Site, Weston, 1994.*

Estimates of areas and soil quantities were also prepared for exceedance of the 10^{-5} industrial direct contact PRG and the 500 mg/kg PCP limit. The later value is presented because it is representative of soil that may be toxic to microorganisms. Table 2-5 presents a summary of the areas and soil volumes exceeding PRGs. Because the arsenic and PCP-contaminated areas overlap, the total area and volumes of combined contamination is less than the sum of the areas and volumes for the individual contamination.

TABLE 2-5
Areas and Volumes of Soil
Contamination Exceeding PRGs

PRG	Area (acres)	Soil Volume (cys)
PCP > 2.9 mg/kg: 10^{-6} Industrial Direct Contact PRG ("ND" contour)	13	400,000
PCP > 29 mg/kg: 10^{-5} Industrial Direct Contact PRG	5.8	250,000
PCP > 500 mg/kg	2.3	60,000
Arsenic > 5.3 mg/kg: 10^{-6} Industrial Direct Contact PRG of 1.6 mg/kg (default to background or "ND" contour)	16	50,000
Arsenic > 100 mg/kg: 10^{-4} Industrial Direct Contact PRG	2	4,000
PCP > 2.9 mg/kg and Arsenic > 5.3 mg/kg	22	430,000

As shown in Table 2.2, sediment COCs consist of arsenic, copper, zinc, and PCP. A number of benchmarks and guidelines were considered for PRGs for the sediment. The driving PRG for the metals is a median value of the Lowest Effect Level determined from four sources (see Table 2.2 notes). Measured values of zinc do not exceed this level, so zinc is not considered a constituent of concern. Copper concentrations exceed the Lowest Effect Level to a distance of approximately 125 feet distance from the contaminant entrance point into the eastern wetland lobe, and arsenic concentrations exceed the Lowest Effect Level to 225 feet distance. These guidelines are not available for PCP; PCP exceeds a sediment quality value used in the State of Washington to a distance of 125 feet from contaminant entrance point into the eastern wetland lobe. Surface water concentrations exceed acute toxicity criteria for arsenic and PCP (see Table 2-3) at the entrance point to the wetland. Surface water PCP concentrations also exceed acute toxicity criteria in the eastern wetland lobe, but the sediment samples do not exceed any criteria.

The extent of sediment contamination in the wetland that exceeds acute ecological toxicity levels is estimated to be within about 200 feet of the toe of the western wetland lobe. The volume is estimated at 3,000 cys, assuming a depth of 2 feet.

2.3.4.2. LNAPL

The LNAPL area requiring remediation is defined as that area where free-phase LNAPL, including observations of sheens, has been detected in groundwater monitoring wells, and the area where observations made while drilling soil borings indicate that residual-phase LNAPL is present in the smear zone near the water table. The LNAPL occurs over about 4 acres, as shown in Figure 2-6. The volume of LNAPL is the sum of the free-phase LNAPL and the residual-phase LNAPL. In-well LNAPL thickness measurements have shown measurable LNAPL in three wells (MW 10S, MW 19, and MW20) ranging from less than 1 inch to about 10 inches. As discussed in the RI however, the free phase LNAPL depth in a monitoring well can be much greater than the actual thickness in the formation. Little free phase mobile LNAPL is believed to be present above the water table. The residual-phase LNAPL in the smear zone extends both above and below the present water table. At a recent boring south of MW 19, data indicate the smear zone may be up to 8 feet thick, although it is estimated to be an average thickness of about 4 feet based on water table fluctuations. Assuming a residual saturation of 30 percent of the pore space, the estimated volume of residual-phase LNAPL in the smear zone is 520,000 gallons.

2.3.4.3. Groundwater

The area exceeding PRGs is defined by the area over which concentrations of one or more contaminants in the shallow groundwater exceed the PRGs for groundwater. PCP is the most widespread groundwater contaminant exceeding PRGs. The 1 μg/L contour is used to define the area exceeding PRGs in both the unconfined and semi-confined groundwater as shown in Figure 2-7. The area exceeding PRGs for groundwater encompasses approximately 30 acres. The estimated volume of groundwater exceeding PRGs is approximately 77 million gallons (MG), assuming an effective porosity of 25 percent and an average saturated thickness of 15 and 25 feet for the unconfined and semi-confined zones, respectively.

I:/141158/DRAWINGS/FS/1158FS16.DGN

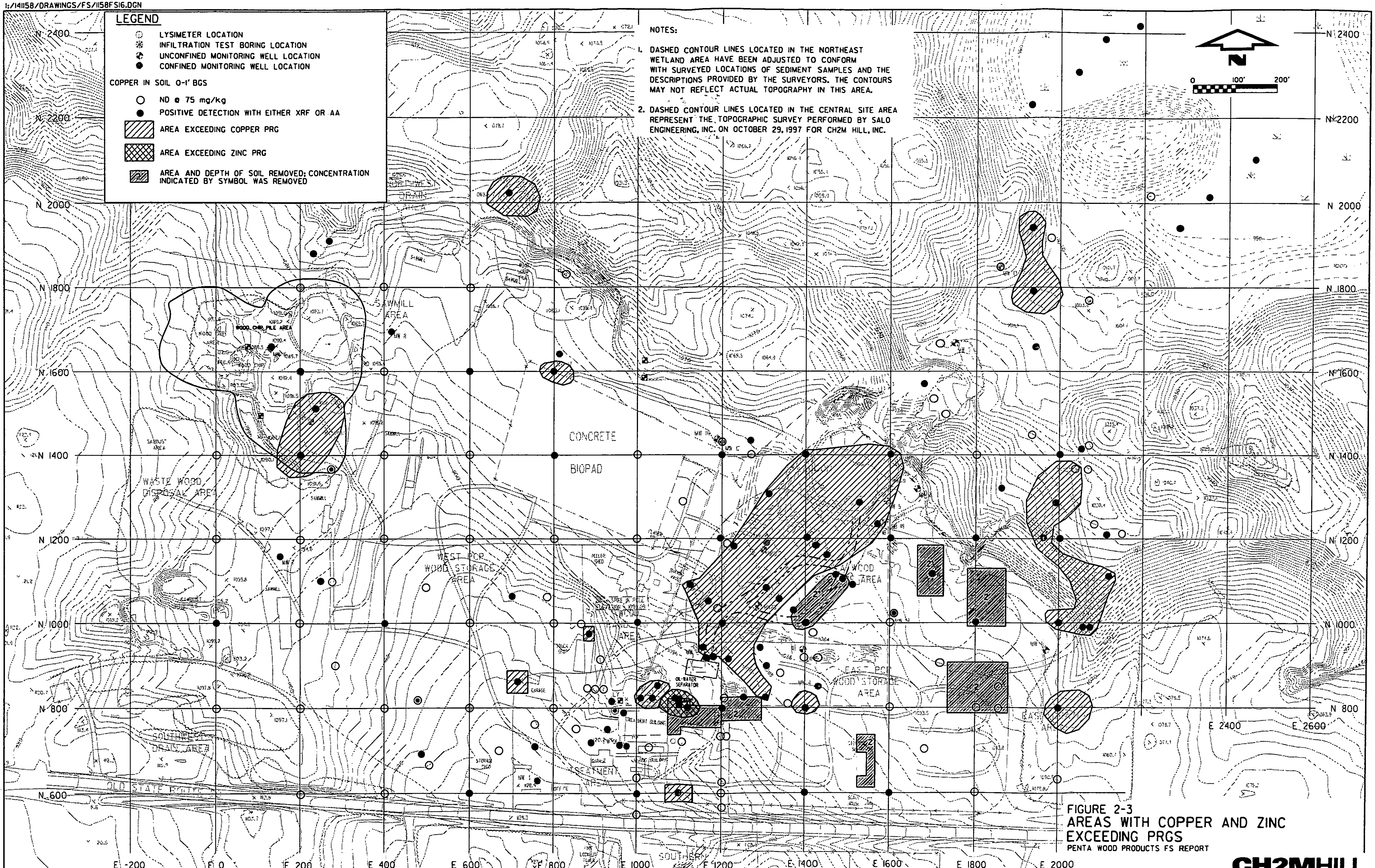


FIGURE 2-3
AREAS WITH COPPER AND ZINC EXCEEDING PRGS
PENTA WOOD PRODUCTS FS REPORT

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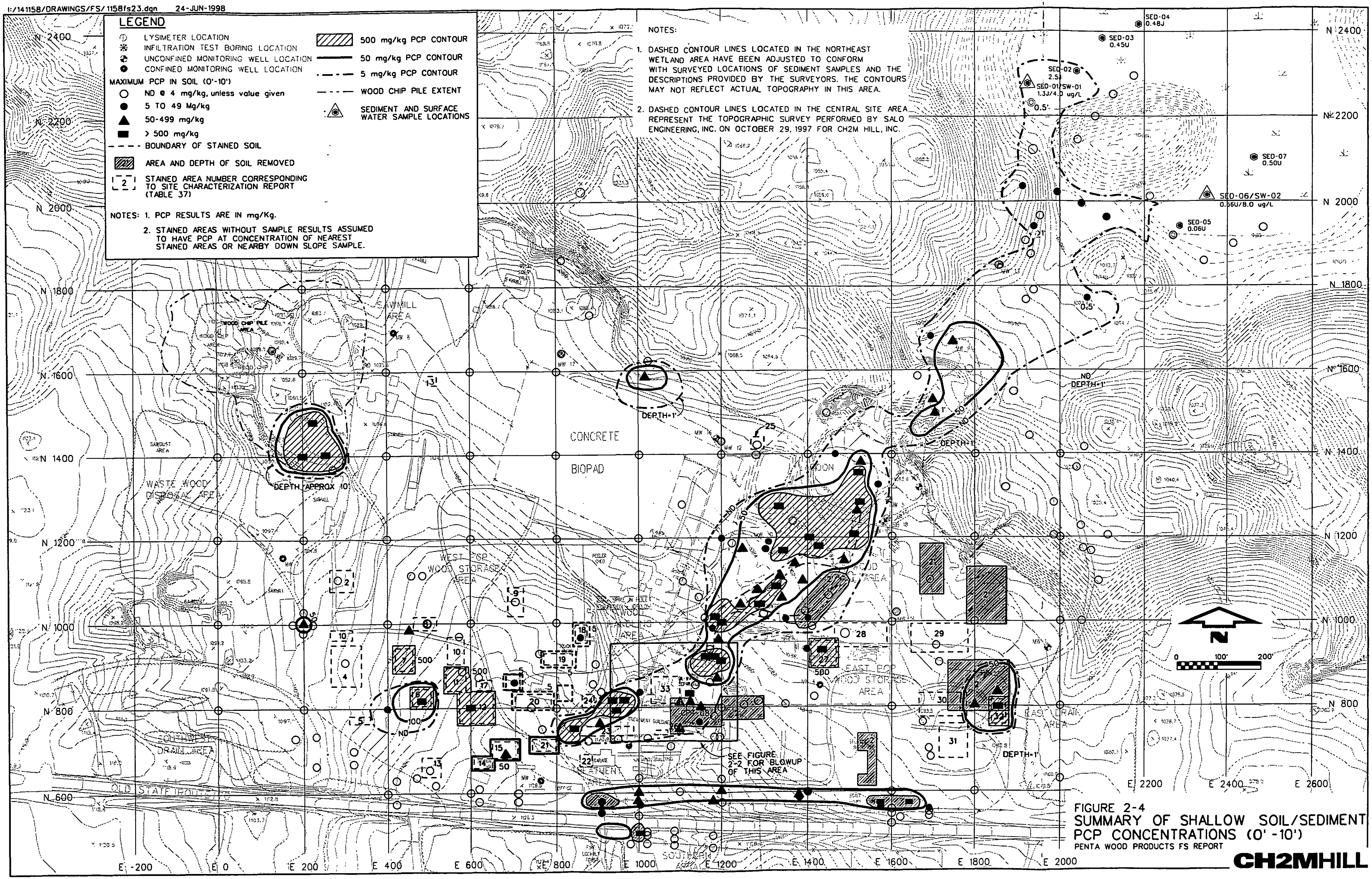

FIGURE 2-4
SUMMARY OF SHALLOW SOIL/SEDIMENT PCP CONCENTRATIONS (0' -10')
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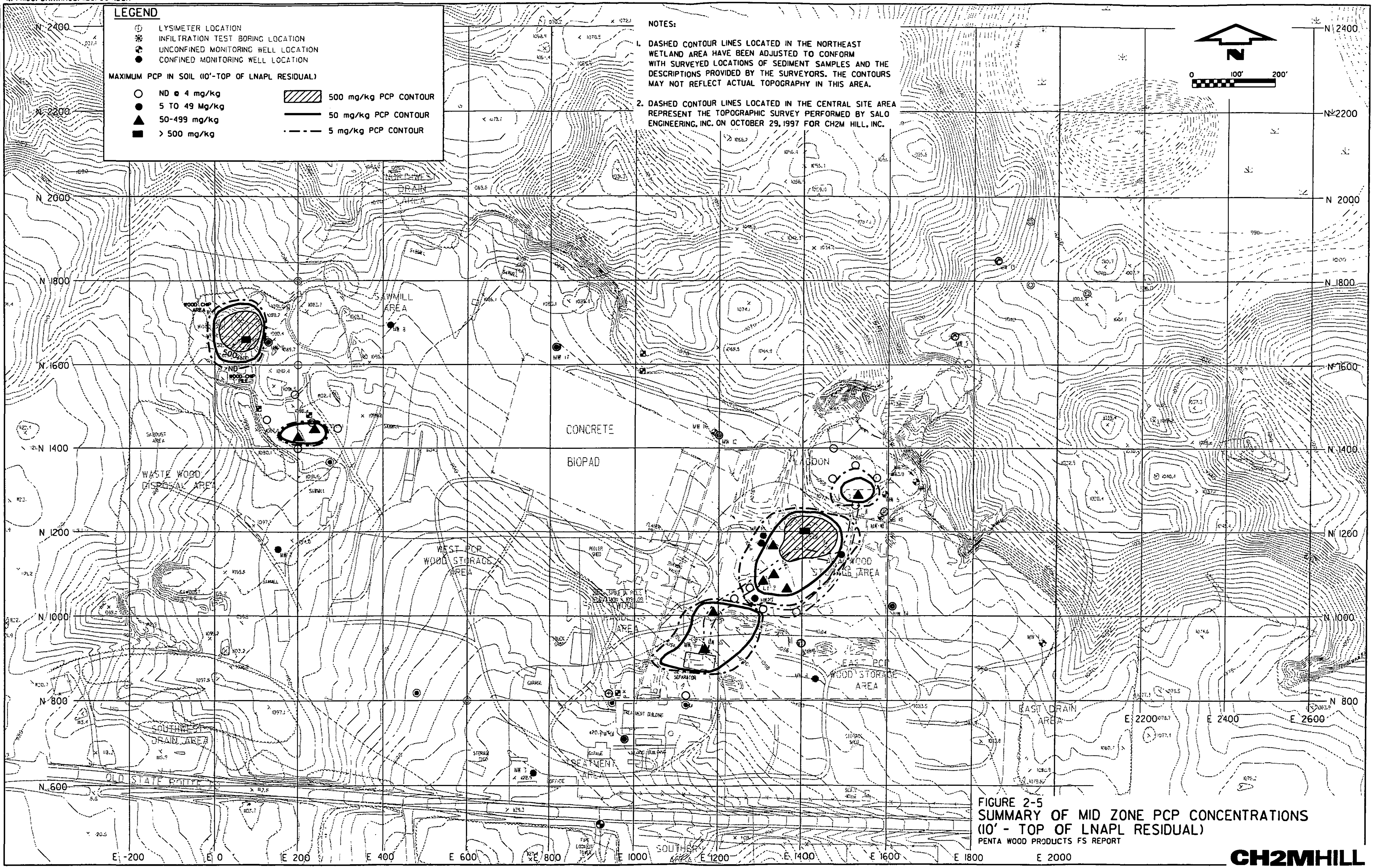

FIGURE 2-5
SUMMARY OF MID ZONE PCP CONCENTRATIONS
(10' - TOP OF LNAPL RESIDUAL)
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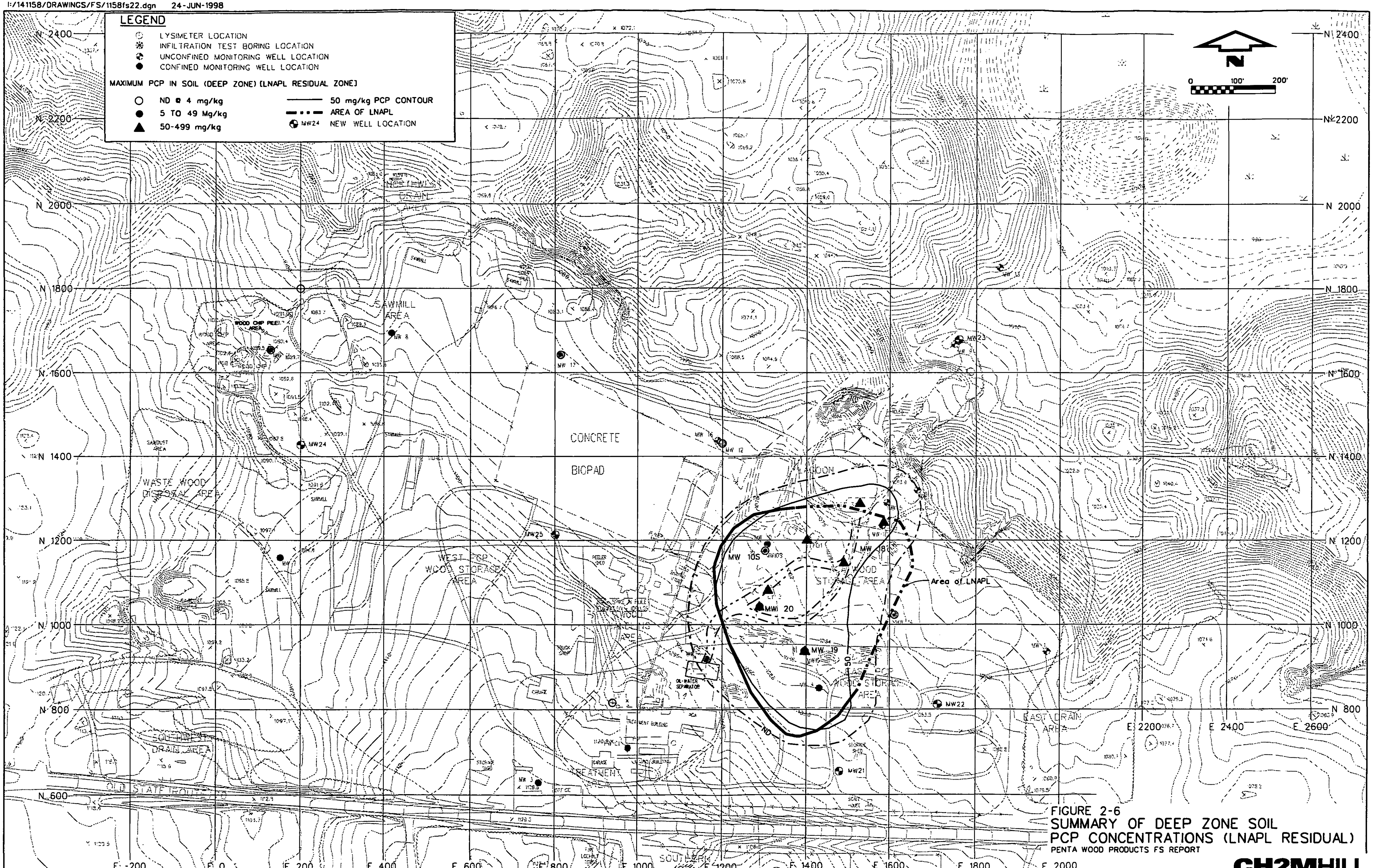

FIGURE 2-6
SUMMARY OF DEEP ZONE SOIL PCP CONCENTRATIONS (LNAPL RESIDUAL)
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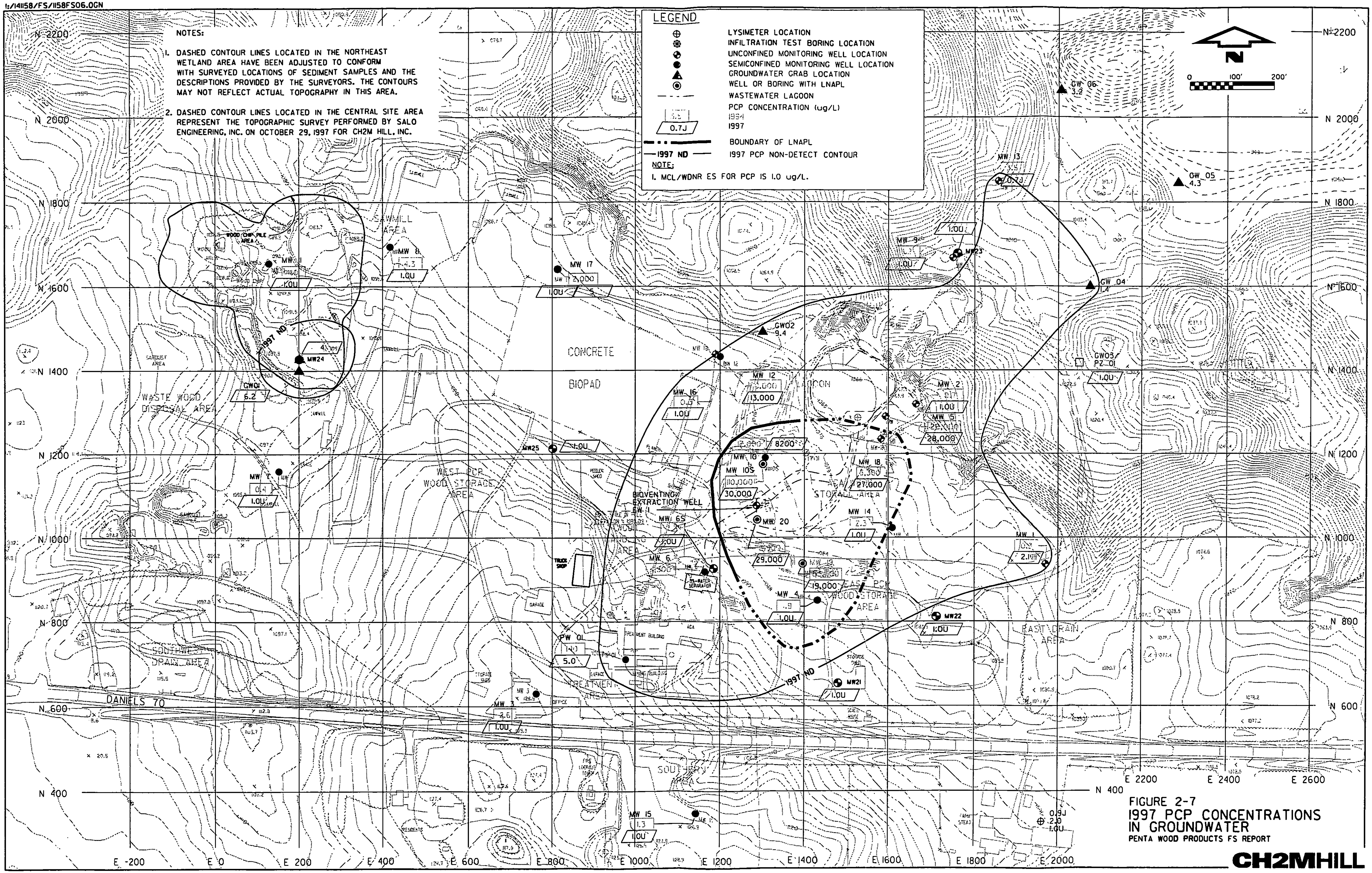

FIGURE 2-7
1997 PCP CONCENTRATIONS IN GROUNDWATER
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SECTION 3

Identification and Screening of Technologies

3.1. General Response Actions

Identifying general response actions is the first step in the FS alternatives analysis process; general response actions are basic actions that might be undertaken to remediate a site (e.g., no action, in situ treatment, or excavation and treatment). For each general response action, several possible remedial technologies may exist. They can be further broken down into a number of process options. These technologies and process options are then screened based on several criteria. Those technologies and process options remaining after screening are assembled into alternatives in Section 4. After the RAOs and PRGs were developed, general response actions consistent with these objectives were identified. The following sections present general response actions that may be applicable to PWP.

3.1.1. General Response Actions for Soil

The general response actions for soil at PWP include:

- No further action
- Institutional controls
- Containment
- In situ treatment
- Excavation/treatment/disposal

Each general response action is discussed in the following paragraphs along with an overview of some of the technologies that are representative of the response action. Wetland sediments are included in the soil media.

3.1.1.1. No Further Action

The no further action response includes no action for soil except for what has already been implemented (i.e., the solidification of a portion of the arsenic contaminated soil onsite and the removal of process chemicals and sludges). The no action response action would not satisfy the RAO of preventing erosion of contaminated soil; therefore, this action may not be feasible for PWP. The NCP requires that the no action alternative be retained through the FS process as a basis of comparison.

3.1.1.2. Institutional Controls

Institutional controls for soil consist of restricting access to contaminated soil through fencing or land use restrictions. At PWP, these measures would be used primarily for limiting human contact with the contaminated soil.

3.1.1.3. Containment

Containment is used to minimize the risk of contaminant migration as well as prevent direct contact exposures. Surface controls such as grading and revegetating can be used to reduce infiltration of precipitation through contaminated soil and prevent further erosion and offsite transport of contaminated soil. Capping and subsurface barriers are two applicable remedial technologies that could also be used at PWP to limit the infiltration of precipitation and to help prevent contaminant migration through source areas. These also apply to sediments, although excavation and consolidation of the sediment to a location above the water table would be done prior to capping.

3.1.1.4. In Situ Treatment

In situ treatment methods can be used to reduce contaminant concentrations in soil. In situ methods that may be applicable at PWP include physical/chemical, biological, and thermal technologies. A wide variety of technologies are considered in screening, including soil vapor extraction (SVE), bioventing, and surfactant flushing. SVE involves the volatilization and removal of contaminants in soil with an SVE system and may include heating of the soil to increase the volatility of PCP. Bioventing, which is related to SVE, involves stimulating aerobic biodegradation of PCP by introducing oxygen to contaminated subsurface soils. Surfactant flushing, which requires a groundwater extraction system, consists of desorbing and flushing contaminants from soil using a surfactant wash. In situ treatment technologies for sediments are either too difficult to apply or are more destructive of the ecosystem (e.g., in situ solidification) than protective.

3.1.1.5. Excavation/Treatment/Disposal

Physical, chemical, or thermal technologies are used once soil is excavated. Physical processes include excavating the contaminated soil and sediment and transferring it to an approved onsite or offsite disposal area. Based on the concentration of PCP and/or arsenic present in the soil most likely to be excavated, it is probable that the soil will require treatment to meet LDRs prior to disposal. Biological processes such as biological treatment on the already constructed biopad will be evaluated. Chemical processes such as washing/flushing or thermal processes such as incineration to treat the soil to meet soil disposal criteria will also be evaluated. Treatment residue would be disposed onsite if it no longer contained PCP or arsenic in concentrations posing a risk to human health or the environment, otherwise disposal in a licensed, permitted disposal facility would be necessary.

3.1.2. General Response Actions for LNAPL

LNAPL includes both the free-phase layer as measured as a separate phase in the monitoring wells and LNAPL residual, which is present as a result of smearing of soil in the zone of water table fluctuation. The general response actions for LNAPL include:

- No further action
- Institutional controls
- Containment
- In situ treatment
- Collection/treatment/disposal

3.1.2.1. No Further Action

The no further action response includes no action for LNAPL.

3.1.2.2. Institutional Controls

Institutional controls, such as access restrictions, may be used to prevent contact with LNAPL until RAOs are met. This action may include monitoring to track changes in LNAPL thickness and whether the LNAPL is migrating.

3.1.2.3. Containment

Containment refers to controlling the migration of the LNAPL plume through active or passive hydraulic gradient controls. Active gradient control can be accomplished with injection wells or trenches, while passive gradient control can be achieved using a slurry or sheet pile wall.

3.1.2.4. In Situ Treatment

In this response action, LNAPL would be treated in situ with surfactant or solvent washing/flushing, vapor extraction, steam injection in conjunction with SVE, oxidation, air sparging, or bioventing along with dewatering of the saturated zone.

3.1.2.5. Collection/Treatment/Disposal

In this response action, LNAPL would be extracted from the subsurface using wells. Enhancements for LNAPL extraction such as use of surfactants, cosolvents, depression of the water table, or vacuum assisted extraction are also possible. In addition, a SVE system could be installed to extract LNAPL present at residual saturation in soil. The collected LNAPL would then be disposed of by incineration.

3.1.3. General Response Actions for Groundwater

The general response actions for groundwater at PWP include:

- No further action
- Institutional controls
- Alternate water supply
- Natural attenuation
- Containment
- In situ treatment
- Collection/treatment/discharge

3.1.3.1. No Further Action

The no further action response includes no action for groundwater.

3.1.3.2. Institutional Controls

Institutional controls such as a restrictive covenant on the property deed of the PWP site limiting intrusive activities on the property may be necessary either as a stand alone action or in concert with other actions. Groundwater and surface water monitoring may also be necessary to track the direction and rate of movement of the groundwater contaminant plume.

3.1.3.3. Alternate Water Supply

An alternate water supply could be constructed if, in the future, the nearby residential wells become threatened with PCP or chloride contamination. Alternate water supplies could include bottled water, point-of-use water treatment, or construction of new water supply wells completed in a deeper aquifer.

3.1.3.4. Natural Attenuation

Natural attenuation is the process by which contaminant concentrations are reduced by various naturally occurring physical, chemical, and biological processes. The main processes include dilution, biodegradation, and retardation. Only unaugmented natural processes are relied upon under this general response action. Augmentation through addition of electron acceptors or nutrients is discussed under biological treatment technologies in the tables.

3.1.3.5. Containment

Containment refers to minimizing the spread of groundwater contaminants through active or passive hydraulic gradient controls. Active gradient control can be accomplished with pumping wells, while passive gradient control can be achieved using a slurry or sheet-pile wall. Containment of groundwater can be effective in preventing the release of contaminants from the source areas and their subsequent migration.

3.1.3.6. In Situ Treatment

In situ treatment of groundwater entails treating the groundwater while it is in the aquifer, which can be achieved by applying physical/chemical, biological, or thermal techniques. Examples of possible approaches to in situ treatment of PCP in groundwater include chemical oxidation, permeable treatment beds, air sparging, and biological treatment technologies.

3.1.3.7. Collection/Treatment/Discharge

In this response action, groundwater would be extracted from the shallow aquifer using pumping wells. The contaminants would then be removed from the water by physical, physical/chemical, chemical, or biological treatment. Disposal of groundwater can be accomplished by surface infiltration, subsurface injection, or discharge to surface water.

3.2. Identification and Screening of Technology Types and Process Options

In this section, the technology types and process options available for remediation of soil (including wood chips and sediment), LNAPL, and groundwater are presented and screened for suitability. The purpose of this step is to identify the technology that may be applicable for remediation of the media of concern at the site. An inventory of technology types and process options is presented based on professional experience, published sources, computer databases, and other available documentation for the general response actions identified in Section 3.1. Process options are also focused by following the presumptive remedy guidance for wood treator sites (USEPA 1995). This step may eliminate a general response action from the FS process if there are no feasible technologies identified. The objective, however, is to retain the best technology types and process options within each general response action and use them for developing remedial alternatives.

The evaluation and screening of technology types and process options are presented in Tables 3-1 through 3-3 for each of the media of concern to clarify and facilitate review. Each technology type and process option is either a demonstrated, proven process, or a potential process that has undergone laboratory trials or bench-scale testing. The initial screening of technology types and process options is presented in the first half of the tables based on technical implementability. The factors included in this evaluation include the following: the state of technology development, site conditions, waste characteristics, the nature and extent of contamination, and the presence of constituents that could limit the effectiveness of the technology. Entire technologies and individual process options are screened from further consideration based on technical implementability.

Process options that remain after the initial screening are further evaluated using a qualitative comparison based on effectiveness, implementability, and cost (presented in columns 6 through 9 of the tables). Following this qualitative screening, those remedial technology types and process options that are considered viable for remediating the media at the site are carried forward for incorporation into alternatives. Those technology types and process options that are not technically implementable are shown in italicized and bolded text in the first half of the table. Those that are not considered feasible based on effectiveness, implementability, and cost are shown in italicized and bolded text in the second half of the table.

As mentioned above, technology types and process options are screened in an evaluation process based on effectiveness, implementability, and cost. Effectiveness is considered the ability of the process option to perform as part of a comprehensive remedial plan to meet RAOs under the conditions and limitations present at the site. Additionally, the NCP defines effectiveness as the "degree to which an alternative reduces toxicity, mobility, or volume (TMV) through treatment, minimizes residual risk, affords long-term protection, complies with ARARs, minimizes short-term impacts, and how quickly it achieves protection." This is a relative measure for comparison of process options that perform the same or similar functions. Implementability refers to the relative degree of difficulty anticipated in implementing a particular process option under regulatory, technical, and schedule constraints posed by the PWP site. At this point, the cost criterion is comparative only, and similar to the effectiveness criterion, it is used to preclude further evaluation of process options that are very costly if there are other choices that perform similar functions with similar effectiveness. The cost criterion includes costs of construction and any long-term costs to operate and maintain technologies that are part of an alternative.

The NCP preference is for solutions that utilize treatment technologies to permanently reduce the TMV of hazardous substances. Available treatment processes are typically divided into three technology types: physical/chemical, biological, and thermal, which are applied in one or more general response actions with varying results.

The technology types and process options identified in the following sections are those offering at least theoretical applicability to remediation of the media of concern at the site.

This list of options should be considered dynamic, flexible, and subject to revision based on further investigation findings, results of treatability studies, or technological developments.

3.2.1. Technology and Process Option Screening for Soil Media

Table 3-1 presents a wide range of potentially applicable technology types and process options for soil remediation at the site. Screening comments are provided to highlight items of interest or concern for each option. This approach highlights differences within a remedial technology group to allow the best process within each group to be identified and selected.

Potentially feasible technologies and process options for each general response action for remediation of soil at the site are shown in plain text (i.e., not italicized or bolded) in Table 3-1. The response actions and associated technologies retained following screening include:

- No further action
- Institutional controls
- Containment by surface controls (grading, lagoon buttress, and revegetation) and capping over the source areas or biopad (clay, geosynthetic clay liner (GCL)/synthetic membrane, multimedia capping or pavement)
- In situ treatment by biological (natural attenuation and bioventing) treatment
- Excavation of the soil followed by physical/chemical treatment (fixation/stabilization), biological treatment (aerobic biological treatment such as biopile or white rot fungus treatment)
- Disposal onsite (backfill) or disposal offsite (RCRA Subtitle C or D landfills)

The rationale for selecting these process options is indicated in Table 3-1. The following sections highlight technologies where more detailed evaluation was necessary to distinguish between technologies or process options.

3.2.1.1. Containment

Under the containment response, surface controls such as grading and revegetation were selected because they are relatively inexpensive options and would effectively reduce infiltration through contaminated soil while preventing direct contact exposure and erosion. Additionally, clay, GCL/synthetic membrane and multimedia caps are retained for capping PCP-contaminated soil because they would reduce infiltration , thereby minimizing leaching of PCP from the soil into the shallow aquifer. Because of the dispersed areas of PCP contamination, consolidation of PCP contaminated soil to the treatment and gully area would be undertaken prior to capping. A CAMU would be designated for the entire site where contamination has been found to allow consolidation without triggering the LDR or disposal requirements for generated hazardous waste. Appendix A presents further discussion of the CAMU rule.

TABLE 3-1
Technology/Process Option Evaluation—Soil
Page (1 of 7)

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
No Further Action	None	None	No action.					Required for comparison by NCP; does not meet RAOs.
Institutional Controls	Access Restrictions	***Fencing***	***Restrict access to contaminated soils through fencing.***	***Technically implementable***	***Fair***	***Good***	***Low/Low***	***Does not meet RAOs; site is currently fenced along highway. Additional fencing not necessary because of remoteness of site. Not applicable to offsite contaminated soils and sediments.***
		Land Use Restrictions	Restrict access to contaminated soils through restrictive covenants on property deeds.	Technically implementable	Fair	Fair	Low/Low	Does not meet RAOs; may be applicable in conjunction with other technologies.
Containment	Surface Controls	Grading	Reshape topography to control infiltration, runoff, and erosion.	Technically implementable	Demonstrated	Good	Low/Low	Potentially feasible; typically used in conjunction with capping.
		Lagoon Buttress	Construct a buttress at the base of the lagoon to prevent further erosion of soils from lagoon.	Technically implementable	Good	Good	Moderate/ Low	Feasible.
		Revegetation	Add topsoil, seed and fertilize to establish vegetation (to control erosion and reduce infiltration).	Technically implementable	Demonstrated	Good	Low/Low	Potentially feasible.
	Capping	Clay	Place clay over contaminated soils. Includes a cover layer to protect clay.	Technically implementable	Demonstrated	Good	Moderate/ Moderate	Potentially feasible; clay source may not be close by; degradation of woodchips may cause settling and disruption of cap.
		GCL/ Synthetic Membrane	Place GCL or synthetic material over contaminated soils; includes a protective cover layer.	Technically implementable	Demonstrated	Good	Moderate/ High	Potentially feasible.
		Multimedia	Place clay and synthetic combination over contaminated soils.	Technically implementable	Demonstrated	Good	High/ High	Potentially feasible.

TABLE 3-1
Technology/Process Option Evaluation—Soil

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
		Pavement	Place asphalt or concrete over contaminated soils or biopad.	Technically implementable	Demonstrated	Fair	Low/ High	Potentially feasible for biopad. Not applicable to gully area soils or woodchip area because areas will settle as the wood debris and chips biodegrade, causing cracking of the pavement.
Containment	*Horizontal Subsurface Barriers*	*Block Displacement*	*Encapsulate block of soil with grout in conjunction with vertical barriers.*	*Not applicable to sands at site; typically used in hard rock environments*				
		Grout Injection	*Create barrier by pressure injection of grout.*	*Not applicable to the sands at site; typically used in hard rock environments*				
In situ Treatment	*Physical/ Chemical*	*Oxidation*	*Degrade contaminants by chemical (ozone or hydrogen peroxide), photo, or other oxidation techniques.*	*Difficult to distribute oxidants in wood chips or wood debris; difficult and expensive to determine effectiveness; unproven technology*				
		Washing/ Flushing	*Wash or flush soil with water or surfactant.*	*Technically implementable*	*Potential*	*Fair to Good*	*Moderate to High/ NA*	*High soil water partition coefficient (Kd =17.2) results in extremely long duration (estimated 10 years at 500 gpm flow rate) for soil washing to remove PCP; also oily phase on wood debris and sands would limit PCP desorption.*

TABLE 3-1
Technology/Process Option Evaluation—Soil
Page (3 of 7)

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
		Fixation/ Stabilization	Immobilize contaminants using solidification agents.	Technically implementable	Potential	Fair	Moderate/ NA	Arsenic contaminated soils are widely dispersed and contamination is shallow. In situ solidification would result in difficulties in monitoring the integrity of the solidified soil. Excavation prior to solidification is preferred; not applicable to PCP contaminated soils because of presence of fuel oil carrier; and potential for long-term weathering, resulting in PCP releases from solidified waste.
		Vitrification	Melt/solidify soil matrix using electric currents.	Technically implementable	Potential	Fair	High/NA	Limited commercial applications. Heating of soil may allow spreading of PCP to uncontaminated soil. Very costly technology relative to other technologies treating the PCP.
		Vapor Extraction	Extract contaminants by establishing a vacuum.	Technically implementable	Potential	Fair	Moderate/ NA	Not effective on PCP because of relatively low volatility.
In Situ Treatment	Biological	Natural Attenuation	Natural biological degradation of PCP by aerobic and anaerobic organisms in unsaturated zone.	Technically implementable	Potential	Fair	Low/Low	Potentially feasible.
		Bioventing	Biologically degrade organics through stimulation of aerobic organisms by the addition of oxygen in air.	Technically implementable	Potential	Fair	Low/Low	Potentially feasible.
	Thermal	Hot Air or Steam Stripping	Inject hot air or steam/ recover vapors (a variation of vapor extraction).	Technically implementable	Potential	Fair to Good	High/NA	Much more costly than other in situ technologies such as bioventing. Mixed soil and wood debris reduce effectiveness. May be applicable to LNAPL residual zone at water table.

TABLE 3-1
Technology/Process Option Evaluation—Soil

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
		Radio Frequency Stripping	*Use network of Radio Frequency Transmitters to heat soil; collect vaporized PCP with vapor extraction system.*	*Technically implementable*	*Potential*	*Fair to Good*	*High/NA*	*Much more costly than other in situ technologies such as bioventing. Mixed soil and wood debris reduce effectiveness.*
Excavation		Backhoe/Front-end Loader	Physically remove shallow soils/wood debris.	Technically implementable	Demonstrated	Good	Low/NA	Potentially feasible.
Ex Situ Treatment	Physical/ Chemical	*Washing/ Flushing*	*Wash or flush soil with water, steam, or surfactant.*	*Technically implementable*	*Demonstrated*	*Good*	*High/NA*	*Most often used to separate fine grained soils from coarse grained soils, thereby concentrating contaminants adsorbed to the fine fraction. May not remove all contaminants to low ppb PRGs in the coarse grain fraction. Multiple additional soil treatment processes such as bioremediation, solidification or incineration required for the fine soil fraction to remove PCP. Treatment of washing fluid is required and involves multiple treatment processes. The technical complexity, multiple unit processes and high cost make this poorly suited to ex situ soil remediation at the site.*
		Oxidation	*Degrade contaminants by chemical, photo, or other oxidation.*	*Technically implementable*	*Potential*	*Good*	*Moderate to High/ NA*	*Achieving soil PRGs for PCP with oxidation may increase costs substantially. Soil may require offsite disposal in a Subtitle C landfill following oxidation treatment. Treated soil containing elevated arsenic would require solidification prior to disposal. Treatability testing required. The technical complexity, multiple unit processes and potentially high cost make this poorly suited to soil remediation.*

TABLE 3-1
Technology/Process Option Evaluation—Soil
Page (5 of 7)

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
		Dechlorination	*Detoxify contaminants by chemical substitution.*	*Technically implementable*	*Demonstrated*	*Good*	*Moderate to High/ NA*	*The process is considered an effective technology for chlorinated SVOCs; treatability study required. Dechlorination treatment would have to be coupled with other treatment processes such as incineration. Dechlorination is not retained because of complexity of multiple treatment processes and poor cost effectiveness.*
		Fixation/ Stabilization	Immobilize contaminants.	Technically implementable	Potential	Fair	Moderate/ NA	Potentially feasible for arsenic contaminated soils; not applicable to PCP contaminated soils because of presence of fuel oil; potential for long-term weathering, may result in PCP releases from solidified waste.
		Vitrification	*Melt/solidify soil matrix.*	*Technically implementable*	*Potential*	*Poor*	*Very High/NA*	*Control of volatile emissions is necessary. Very high cost of treatment. Vitrified soil mass may require disposal in RCRA hazardous waste landfill adding to already high treatment cost. Technical implementability is poor because it is complex to operate, requiring specialized training and skills. Not retained because of poor implementability and very high cost.*
		Vapor Extraction	*Purge volatiles by forcing clean air through soil piles.*	*Technically implementable*	*Potential*	*Good*	*Moderate /NA*	*Not effective on PCP and arsenic.*
		Solvent Extraction	*Fractionates soil into three phases (soil, water, solvent).*	*Limited effectiveness on SVOCs, very complex, requires multiple processes*				
		Radio Frequency Waves	*Heat soil piles with radio frequency waves to volatilize contaminants.*	*Not effective on SVOCs; not a proven technology*				

TABLE 3-1
Technology/Process Option Evaluation—Soil

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
	Biological	Aerobic Biological Treatment	Excavated soils are placed on sealed biopad and aerated either by tilling or through a network of air lines. Soils amended with wood chips to improve aeration and provide substrate for biological growth.	Technically implementable	Demonstrated through onsite treatability studies	Fair	Moderate/ NA	Potentially feasible for PCP contaminated soil. Aerobic biological treatment could be operated as shallow soil depth with tilling providing aeration or in a biopile where air lines are installed to provide oxygen. Biodegradation using bacteria or fungus is possible.
	Thermal	***Low-Temp Desorption***	***Desorb contaminants/ treat offgas.***	***Technically implementable***	***Potential***	***Fair***	***High/NA***	***High wood content of soil complicates treatment and increases already high costs. Wood debris will combust in kiln necessitating additional air treatment and permitting requirements.***
		Onsite Incineration	***Combust soils at high temperature.***	***Technically implementable***	***Demonstrated***	***Fair***	***High/ NA***	***Not cost competitive. Extensive treatability testing required; air treatment and permitting requirements are substantial.***
		Plasma	***Expose soils to super-heated plasma.***	***Technically implementable***	***Potential***	***Poor***	***High/ NA***	***Extensive treatability testing required; costs similar to incineration; unproven technology.***
		Infrared	***Decompose contaminants with infrared radiation.***	***Unproven technology***				
		Wet Air Oxidation	***Use high temperature and pressure to thermally oxidize contaminants.***	***Technically implementable***	***Potential***	***Fair***	***High/ NA***	***Lengthy, extensive treatability testing required; energy consumptive, expensive.***
		Offsite Incineration	***Combust soils in offsite commercial incinerator.***	***Technically implementable***	***Demonstrated***	***Good***	***High/ NA***	
Disposal	Onsite	***RCRA Subtitle C Landfill***	***Construct onsite landfill to dispose excavated contaminated soils.***	***Technically implementable***	***Demonstrated***	***Poor***	***High/ NA***	***Difficult to obtain permit; unlikely to be necessary because soils will be treated to health based concentrations.***

TABLE 3-1
Technology/Process Option Evaluation—Soil
Page (7 of 7)

General Response Action	Remedial Technologies	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
		Backfill	Use treated soils to backfill excavations. May require an NR 504 cap.	Technically implementable	Demonstrated	Fair	Low/ NA	Potentially feasible; depends on TCLP results and the presence of hazardous waste constituents in the treated soil. Will require CAMU designation.
	Off site	***RCRA Subtitle C or D Landfill***	***Remove material for disposal in RCRA Subtitle C or D permitted landfill.***	***Technically implementable***	***Demonstrated***	***Fair***	***High/ NA***	***Soils are subject to land disposal restrictions; offsite disposal is least favored option for disposing contaminated soils at NPL sites; disposal in Subtitle C landfill may be applicable for small volumes of soil that still contain hazardous constituents at concentrations above health based levels.***

Effectiveness is the ability to perform as part of a comprehensive alternative that can meet RAOs under conditions and limitations that exist at the site.
Implementability is the likelihood that the process could be implemented as part of the remedial action plan under the regulatory, technical, and schedule constraints.
Cost is for comparative purposes only, relative to other processes/technologies that perform similar functions.
Process options that have been screened out are italicized and bolded.

GW Groundwater
HC Hydrocarbon
NCP National Contingency Plan
NPL National Priority List
NA Not applicable
RAOs Remedial Action Objectives
RCRA Resource Conservation and Recovery Act
SVOCs Semivolatile organic contaminants
SVE Soil vapor extraction
TCLP Toxicity Characteristic Leaching Procedure
VOCs Volatile Organic Contaminants

TABLE 3-2
Technology/Process Option Evaluation—LNAPL
(Page 1 of 2)

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
No Further Action	None	None	No action					Required for comparison by NCP; does not meet RAOs.
Institutional Controls	Monitoring		Monitor extent of LNAPL plume.	Technically implementable	Good	Good	Low/Low	Potentially feasible. Monitoring will allow the determination of whether the LNAPL plume is expanding and the amount of natural attenuation occurring.
	Restrict access	Restrictive Covenant	Add a restrictive covenant to property deed to prevent future groundwater use in area of LNAPL	Technically implementable	Demonstrated	Good	Low/Low	Potentially feasible in conjunction with other technologies; LNAPL will continue to act as source of contaminants to GW.
Containment	*Vertical Subsurface Barriers*	*Grout Curtain*	*Create subsurface barrier to horizontal flow of LNAPL by grout injection*	*Not feasible in fine grained soils/complex stratigraphy*				
		Slurry Walls	*Create subsurface barrier to horizontal flow of LNAPL by installing clay slurry wall*	*Not technically implementable at depths of over 140 feet that would be necessary*				
		Sealable Joint Sheet Piling	*Create subsurface barrier to horizontal flow of LNAPL by installing interlocking piles*	*Technically implementable*	*Good*	*Good*	*High/NA*	*Depth of installation, size of sheet piles and high cost limits applicability.*
	Hydraulic Controls (injection)	*Wells or Trenches*	*Inject GW to create hydraulic barrier to continued migration of LNAPL*	*Technically implementable*	*Potential*	*Fair*	*Moderate/ Low*	*Further expansion of LNAPL is unlikely. Hydraulic barrier is too difficult to control for marginal benefit in containment.*
Collection	LNAPL Recovery	Wells	Install vertical and/or horizontal wells equipped with pumps designed to extract LNAPL	Technically implementable	Demonstrated	Good	Moderate/ Low	Potentially feasible; dual phase (LNAPL and GW) pump may be required to recover LNAPL. Vacuum enhanced recovery may also be used. May not be feasible due to minimal LNAPL thickness in wells and relatively small volume of free-phase LNAPL as compared to total volume of LNAPL.

TABLE 3-2
Technology/Process Option Evaluation—LNAPL
(Page 2 of 2)

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Collection	LNAPL Recovery	***Injection and Extraction***	***Inject water around LNAPL plume (to create GW high) to force LNAPL to flow towards LNAPL extraction wells***	***Not feasible because of high flows required in the permeable sands to create sufficient hydraulic gradient***				
		Vacuum Enhanced Extraction	Create vacuum on LNAPL to attempt to concentrate it in the cone of depression of the LNAPL recovery well and enhance collection	Technically implementable	Potential	Fair to Good	Moderate/ High	Potentially feasible.
		GW Extraction	Extract GW from LNAPL recovery well to create a cone of depression to cause LNAPL to flow toward well	Technical implementable	Demonstrated	Good	Moderate/ Low	Potentially feasible.
In Situ Treatment	***Physical/ Chemical***	***Washing/ Flushing***	***Wash or flush soil with surfactant or solvent***	***Technically implementable***	***Potential***	***Fair to Good***	***Moderate to High/ NA***	***Difficult to measure effectiveness and to control surfactants and solvents in complex stratigraphy.***
		Vapor Extraction (in situ)	***Install vapor extraction system to extract LNAPL remaining as residual phase in soil matrix***	***Technically implementable***	***Poor***	***Good***	***Moderate/ NA***	***The #2 fuel oil carrier LNAPL is not sufficiently volatile. May be used in conjunction with steam air stripping.***
	Thermal	Hot Air or Steam Stripping	Inject hot air or steam/recover vapors (a variation of vapor extraction)	Technically implementable	Potential	Fair to Good	High/NA	Potentially feasible for LNAPL residual zone at water table.
Ex Situ Treatment	Physical	Incineration	Incinerate collected LNAPL	Technically implementable	Demonstrated	Good	High/NA	Potentially feasible; final disposition will be based on analytical results.

Effectiveness is the ability to perform as part of a comprehensive alternative that can meet RAOs under conditions and limitations that exist at the site.
Implementability is the likelihood that the process could be implemented as part of the remedial action plan under the regulatory, technical, and schedule constraints.
Cost is for comparative purposes only, relative to other processes/technologies that perform similar functions.
Process options that have been screened out are italicized and bolded.

LNAPL Light non-aqueous phase liquids
GW Groundwater
RAOs Remedial Action Objectives
NA Not Applicable

TABLE 3-3
Technology/Process Option Evaluation—Groundwater
(Page 1 of 5)

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
No Further Action	None	None	No action	Technically implementable	None	Good	None/Low	May expose future GW users; does not meet RAOs; required for comparison by NCP.
Institutional Controls	Access Restrictions	Close GW to Future Use	Property in the area impacted by contaminated groundwater would require restrictions on GW use	Technically implementable	Demonstrated	Good	Moderate/ Low	Potentially applicable in conjunction with other technologies.
		Monitoring	Continue sampling and analysis of groundwater	Technically implementable	None	Good	Low/Low	Potentially applicable in conjunction with other technologies.
Alternate Water Supply	**New Bedrock Water Supply Wells**		**Installation of new residential wells in the sandstone bedrock**	**Technically implementable**	**Demonstrated**	**Poor**	**Low/Low**	**Sandstone aquifer has low yield, and is in hydraulic communication with sand and gravel aquifer.**
	Point-of-Use Carbon Treatment		Installation of carbon treatment units	Technically implementable	Demonstrated	Good	Low/Low	Potentially applicable in conjunction with other technologies.
Natural—Attenuation			Use of naturally occurring physical, chemical and biological processes such as dispersion, biodegradation and retardation to reduce concentrations of contaminants	Technically implementable	Demonstrated	Good	Low/Low	Potentially feasible.
Containment	***Vertical Subsurface Barriers***	***Grout Curtain***	***Create subsurface barrier to horizontal GW flow by grout injection***	***Not feasible in fine grained soils/heterogeneous stratigraphy***	**Fair**	**Fair**	**High/NA**	**Not sufficiently effective or cost competitive for depths of 140 or more feet that would be required at PWP.**
		Slurry Walls	***Create subsurface barrier to horizontal GW flow by installing clay slurry wall***	***Not technically implementable at depths of over 140 feet that would be required at PWP; may not be nearby source of clay***				
		Sealable Joint Sheet Piling	***Create subsurface barrier to horizontal GW flow by installing interlocking piles***	***Technically implementable***	***Good***	***Good***	***High/NA***	***Depth, access, and slope stability near lagoon would limit implementability.***

TABLE 3-3
Technology/Process Option Evaluation—Groundwater
(Page 2 of 5)

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
	Horizontal Subsurface Barriers	*Block Displacement*	*Encapsulate block of soil with grout in conjunction with vertical barriers*	*Not applicable to heterogeneous stratigraphy at the site; typically used in hard rock environments*				
		Grout Injection	*Create barrier by pressure injection of grout*	*Not applicable to heterogeneous stratigraphy at the site; typically used in hard rock environments*				
	Hydraulic Controls	Wells/Drains (horizontal and/or vertical)	Extract GW to create hydraulic barrier to offsite migration of contaminants	Technically implementable	Demonstrated	Good	Moderate/ Low	Feasible.
In Situ Treatment	Physical-Chemical	*Oxidation*	*Inject/extract oxidants to degrade contaminants*	*Treatability testing required; transmissivity and aquifer hetero-geneity would limit effectiveness*				
		Permeable Treatment Beds	*Install downgradient treatment trenches to remove or degrade contaminants*	*Technically implementable*	*Potential*	*Fair*	*High/Low to High*	*Wall would have to be constructed to a depth in excess of 140 feet, making it not cost competitive with other technologies; also wall would need to encircle plume because of radial flow, greatly increasing costs; developing technology (e.g., reductive dehalogenation wall); not proven for PCP degradation; treatment media may clog because of precipitation of inorganics. Although controllable with pH adjustment system, the additional complexity, high installation costs and potential need to replace the media makes this a poor choice for in situ treatment.*

TABLE 3-3
Technology/Process Option Evaluation—Groundwater
(Page 3 of 5)

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
		Air Sparging	*inject air into groundwater*	*Technically implementable*	*Potential*	*Fair*	*Moderate/ Moderate*	*Not cost effective for PCP in LNAPL residual layer at water table; may be used in conjunction with bioventing to increase the humidity in the unsaturated zone while also increasing dissolved oxygen in the unconfined ground-water; would change redox of groundwater and reduce inorganic concentrations.*
	Biological	*Aerobic or Anaerobic*	*Enhance naturally-occurring degradation of contaminants with aerobic or anaerobic microbes*	*Technically implementable*	*Demonstrated*	*Poor*	*Moderate/ Moderate*	*Heterogeneity of aquifer, particularly the presence of silty sand glacial till layers within the sands, makes adequate distribu-tion of electron acceptors or organic substrates difficult.*
	Thermal	Steam Injection/SVE	Inject steam, collect/treat, gases/liquids	Technically implementable	Potential	Fair	Moderate/ High	Potentially feasible for the unconfined groundwater in the LNAPL smear zone. Not feasible for semiconfined groundwater because of hetero-geneity of aquifer, particularly the presence of silty sand glacial till layers within the sands, making adequate distribution of steam difficult.
Collection	Extraction and/or Drainage	Wells/Drains (horizontal and/or vertical)	Install vertical and/or horizontal wells and/or drains to extract contaminated GW	Technically implementable	Demonstrated	Good	Moderate/ Low	Potentially feasible.
		Trenches	*Extract GW from trenches*	*Trench depth would be in excess of 140 feet making this not technically feasible*				
Treatment	Physical-Chemical	*Air Stripping*	*Phase separation by forced air*	*Technically implementable*	*Not effective for semi-volatiles like PCP*	*Good*	*Low/Mod erate*	*Creates air emissions which may require treatment; not effective on PCP.*

TABLE 3-3
Technology/Process Option Evaluation—Groundwater
(Page 4 of 5)

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
		Steam Stripping	*Phase separation by steam and forced air*	*Technically implementable*	*Potential*	*Fair*	*High/High*	*Treatability testing required; more costly than GAC or UV oxidation.*
		Adsorption	Treat with GAC or other adsorptive media	Technically implementable	Demonstrated	Good	Moderate/ Low	PCP is very amenable to carbon; operation and maintenance requirements are lower than expected.
		Oxidation	*Chemical, photo, or other oxidation*	*Technically implementable*	*Demonstrated*	*Good*	*Moderate/ High*	*High iron content of groundwater would cause fouling of UV lamps. Photolysis by sunlight not as cost effective as GAC and may attract wildlife.*
		Ion Exchange	*Treat with selected resins*	*Technically implementable for organics and inorganics*	*Potential*	*Fair*	*High/High*	*Treatability testing required; more costly than GAC and precipitation. Removal of inorganics to very low concentrations not necessary.*
		Reverse Osmosis	*Remove contaminants by forcing water through high pressure membrane*	*Difficult operation, not effective for organics*				
		Liquid/Liquid Extraction	*Extract contaminants based on solubility*	*Very high concentrations required*				
		Precipitation with Sand Filtration	Precipitate contaminants and filter water with low pressure medium (sand)	Technically implementable for inorganics present	Demonstrated	Good	Moderate/ High	Pretreatment by precipitation may be necessary before treating iron and manganese prior to discharge to surface water.
		Ultrafiltration	*Treat water with high pressure membrane*	*Not effective for low molecular weight organics*				
		Micro-filtration	*Treat water with high pressure membrane*	*Not effective for low molecular weight organics*				
		Freeze Crystallization	*Inject refrigerant to separate contaminants*	*Very high concentrations of organics required; unproven technology*				

TABLE 3-3
Technology/Process Option Evaluation—Groundwater
(Page 5 of 5)

General Response Action	Remedial Technology	Process Options	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Treatment	***Biological***	***Aerobic***	***Degrade contaminants using aerobic microbes***	***Technically implementable***	***Potential***	***Good***	***High/High***	***Not cost effective compared to GAC alone.***
	Thermal	***Evaporation***	***Remove contaminants by evaporation***	***Not effective for SVOCs like PCP***				
		Rotary Kiln	***Combust GW in a heated horizontal rotary cylinder***	***Technically implementable***	***Potential***	***Fair***	***High/High***	***High cost, high energy requirements; treatability testing required.***
		Fluidized Bed	***Inject GW into hot bed of sand***	***Technically implementable***	***Potential***	***Fair***	***High/High***	***High cost, high energy requirements; treatability testing required.***
		Wet Air Oxidation	***High temperature/pressure thermal oxidation***	***Technically implementable***	***Potential***	***Fair***	***High/High***	***High cost, high energy requirements; treatability testing required.***
		RCRA TSDF	***Transport to RCRA treatment, storage, or disposal facility***	***Volume to be treated too high for effective transport offsite***				
Discharge	Surface	Doctor Lake	Discharge treated water to Doctor Lake	Technically implementable	Demonstrated	Fair to Good	Moderate/ Moderate	Potentially feasible. Would require WPDES permit.
	Subsurface	Injection Wells	Pump treated GW back into subsurface	Technically implementable	Demonstrated	Fair	Moderate/ High	Higher operational requirements than infiltration trenches.
		Infiltration	Discharge treated GW into infiltration galleries/trenches	Technically implementable	Demonstrated	Fair	Moderate/ High	Potentially feasible.

Effectiveness is the ability to perform as part of a comprehensive alternative that can meet RAOs under conditions and limitations that exist at the site.
Implementability is the likelihood that the process could be implemented as part of the remedial action plan under the regulatory, technical, and schedule constraints.
Cost is for comparative purposes only, relative to other processes/technologies that perform similar functions.
Process options that have been screened out are italicized and bolded.

GW	GAC	Granular activated carbon	RAOs	Remedial Action Objectives
POTW	GW	Groundwater	TSDF	Treatment storage or disposal facility
HDPE	RCRA	Resource and Conservation Recovery Act	NA	Not applicable
VOCs	VOCs	Volatile organic contaminants	SVOCs	Semivolatile organic contaminants

A low permeability asphalt pavement is retained exclusively for sealing the biopad to prevent further flaking and cracking of the concrete. (The biopad is currently cracked and peeling in thin layers in some areas.) The asphalt would act to seal the cracks while retaining its usefulness as a land treatment liner.

3.2.1.2. In Situ Treatment

Several in situ treatment processes required more detailed evaluation to determine whether they should be retained. These were soil oxidation, soil washing/flushing, hot air and steam SVE, and radio frequency heating. The in situ treatment process that was retained, bioventing, is discussed in detail in Section 4.2.4.

3.2.1.3. In Situ Soil Oxidation

The objective of in situ soil oxidation is to remediate PCP-contaminated soil in the unsaturated zone via the chemical oxidation of PCP to chloride, carbon dioxide, and water. Hydrogen peroxide, along with a catalyst to convert the hydrogen peroxide to free oxygen radicals, would be injected into the unsaturated zone in the area of PCP contamination. The hydrogen peroxide would result in the oxidation of other organics and reduced inorganics in addition to the PCP.

The advantages of in situ oxidation are rapid remediation and essentially complete destruction in the area targeted. Disadvantages are primarily associated with attaining adequate hydrogen peroxide distribution, costs, and delivery. Distribution may be difficult because of the presence of wood debris in the upper 10 feet of the unsaturated zone. Costs of hydrogen peroxide are high, particularly when the feed rate is elevated as a result of the organics associated with the residual fuel oil, wood debris and reduced inorganics in the unsaturated zone. In addition to the costs, hydrogen peroxide is difficult to handle and presents a safety risk. A relatively complex delivery system consisting of storage tanks, alarms, pumps, and delivery trains, in addition to the standard equipment necessary for air injection alone, would be required to be installed. This option for soil is not carried forward because of costs, safety concerns, and the difficulty in achieving adequate distribution of the oxidant in the soils.

3.2.1.4. In Situ Soil Washing/Flushing

Soil washing or flushing would involve construction of infiltration basins above the areas of PCP-contaminated soil. Prior to construction of the basins, the wood debris in the lagoon and gully areas (estimated at an average thickness of 10 feet), would have to be removed and treated by using an alternate technology because its permeability is too low to provide adequate infiltration rates. Water would be discharged to the basins and allowed to infiltrate through the unsaturated zone, flushing PCP to the groundwater. Extraction wells completed in the unconfined groundwater about 100 feet bgs would be used to collect the contaminated leachate. This water would be treated for PCP removal and returned to the infiltration basin. Although surfactants added to the water are sometimes used to improve desorption of contaminants from the soil, soil washing jar tests conducted at the PWP site showed that the surfactants tested did not improve desorption. The jar tests showed that three washes of the soil using a 6:1 liquids/solids ratio were necessary to reduce PCP concentrations by 85percent in non-oily soils. Essentially no removal was achieved in oily soils.

Based on the jar tests and a 2.75-acre area of contamination, it is estimated that a infiltration flow rate of 500 gpm would have to be maintained for 10 years to achieve the 85 percent reduction in non-oily soils. Water treatment costs for a 500-gpm flow rate would be very high. In addition, much of the non-oily soils and all the oily soils would still exceed the soil PRG. Soil washing/flushing was not retained because of the high costs, limited effectiveness, and the need for additional treatment technologies.

3.2.1.5. Hot Air or Steam Injection in Conjunction with SVE

Under the thermal remedial technology, hot air and steam injection were evaluated for removal of PCP. This technique is a variation of the vapor extraction process option and involves injection of hot air or steam combined with vapor extraction (SVE). The hot air or steam heats the soil matrix close to the boiling point of PCP, which is 590 °F (USEPA 1992). Based on the high boiling point of PCP, it appears that hot air would not produce enough heat capacity to sufficiently raise the temperature of the soil. Consequently, steam injection would be necessary.

In steam injection, the steam raises the soil temperature rapidly and creates a condensation front that migrates to the SVE extraction wells where the condensate and PCP/TPH vapors are recovered via distillation. The recovered condensate is treated and re-used as boiler make-up water.

Steam injection has been demonstrated to be effective at sites contaminated with VOCs and SVOCs. A full-scale demonstration for a PCP/DNAPL mixture is currently being conducted at a site in Visalia, California. No known full-scale demonstrations exist for PCP/LNAPL contamination. Therefore, an intensive lab scale and pilot scale study would be required if steam injection in conjunction with SVE is implemented at the PWP site.

This technology is primarily dependent on length of operation time (which effects O&M costs), steam requirements (which effect fuel costs), and number of injection and SVE wells (which effects capital costs). Based on vendor information, the length of time required for sufficient treatment of the PCP is about 3 months per treatment area.

Steam flows necessary to raise soil temperatures in a 100 X 100 X 10-foot thick cell sufficient to volatilize PCP range from 5,000 to 10,000 lb/hr. With respect to fuel, this corresponds to a requirement from 50 to 100 gallons/hour for #2 fuel oil. A more readily available fuel source for northern Wisconsin is propane. The equivalent propane requirement ranges from 75 to 150 gallons/hour, or 650,000 to 1,300,000 gallons/yr.

The number of injection and SVE wells is important to properly distribute the steam to the affected area. Previous information suggests that injection and extraction wells placed on 50-foot centers should be sufficient for capture. For the entire 7-acre contaminated area, approximately 130 wells are required.

The fuel flow requirement, the number of wells required, O&M labor hours, and the capital equipment (ie., boiler, catalytic oxidizer) were then used to calculate costs. For treatment time, only one 100 X 100 X 110-foot thick cell can be treated at one time because of the prohibitively high costs associated with purchasing larger equipment. The capital costs for treating all the subsurface PCP contaminated soil is about $8,000,000.The O&M cost per year is $10,000,000. The majority of this cost is for fuel. The present worth cost, calculated assuming a cleanup time of 8 years (assuming 3 months per 100 X 100-foot area), is over $65,000,000.

In summary, the advantage of this technology is that it more rapidly removes PCP than other non-thermal technologies (about 3 months per treatment area). Disadvantages include both high costs and unproven treatment effectiveness for sites contaminated with PCP/LNAPL mixtures. For these reasons, steam injection in conjunction with SVE for the unsaturated zone PCP contaminated soil will not be carried forward.

3.2.1.6. Radio Frequency Heating

Radio frequency heating utilizes the same removal mechanism of contaminants from the soil matrix as hot air injection—low temperature thermal stripping. Instead of using heated air to increase the soil and interstitial gas temperature, the technology utilizes radio frequency heating applicators or "antennas" arranged in a grid. Proponents of the technology believe that radio frequency heating has the added advantage over hot air stripping of creating agitation of the soil contaminant interface at the molecular level.

Radio frequency heating is a developing technology that has produced encouraging results at a number of Air Force sites with sandy soils (*Technical Evaluation Report for the Demonstration of Radio Frequency Soil Decontamination at Site S-1, Kelly AFB, Texas. April 1995*). Results in lower permeability soils at Kelly AFB in Texas were less encouraging. At the PWP site, the presence of wood debris in the shallow soils would make heating and vapor removal difficult because of the lower permeability of the wood debris.

Radio frequency heating is generally considered cost competitive with other in situ thermal treatment technologies, such as steam or hot air stripping. The capital costs include expenditures for the radio frequency transmitter, control unit, and installation of the antenna grid. Operational costs are high as a result of electrical costs and high amount of labor required to operate the system. The overall cost of the option, assuming only the most contaminated (those with PCP > 500 mg/kg) soils are (60,000 cys) treated, is conservatively estimated to be $5,000,000 plus the cost of an SVE system. As with other stripping technologies, an SVE system must be installed to enhance stripping and remove stripped PCP and TPH from the soil. The PCP and TPH in the SVE gas must then be treated using technologies such as vapor-phase carbon adsorption or catalytic oxidation. Assuming that 50 percent of the TPH is stripped and 100 percent of the PCP from the unsaturated soil, the carbon costs are roughly $5,000,000. Radio frequency heating is eliminated because the costs of this technology are high and the effectiveness is less than certain at the PWP site.

3.2.1.7. Ex Situ Treatment

Several ex situ aerobic treatment processes required more detailed evaluation to determine the best process option to carry forward. These were aerobic land treatment, biopile, white rot fungus, and low temperature thermal desorption (LTTD).

3.2.1.8. Aerobic Land Treatment

Land treatment is a process that encourages aerobic biological degradation in a relatively thin layer of contaminated soil. A soil thickness of 2 feet is typically used. The soil is periodically tilled to promote aeration of the soil and moisture distribution. Land treatment promotes uniform biological activity in the soil, thus, accelerating the biological degradation of the PCP.

The estimated volumes of shallow (< 10 ft) PCP-contaminated soil are 13,000 cys of soil and 12,000 cys of wood debris. From results of the treatability studies, a 4:1 ratio of wood debris to soil is required. Therefore, a total estimated volume to be treated is about 80,000 cubic yards. Assuming a land treatment cell depth of 2 feet on the existing concrete biopad, about 8,000 cys can be treated at one time. Assuming about 6 months is available for treatment each year in northern Wisconsin, the PCP could be reduced to the 10^{-5} risk level PRG of 29 mg/kg, based on a PCP degradation half life of 30 days from the PWP land treatment treatability study. A minimum of 10 years would be necessary to treat 80, 000 cubic yards. Given that treatability study results are often better than that achievable in full scale, the time required may exceed 10 years and could be as much as 20 years. Land treatment with tilling is not retained because of the long time required to achieve remediation goals.

3.2.1.9. Biopile

The biopile utilizes an aeration grid installed on the biopad to distribute air uniformly through soil piles about 8 feet high. The oxygen transfer through the air distribution system will promote aerobic biological activity, thus, accelerating the biological treatment of the PCP-contaminated soils.

Based on treatability results conducted at the PWP site, effective operation is assumed to be 6 months per year. In addition, details concerning operation, monitoring and handling, and treatment of biopad runoff must be investigated. This option was retained for further analysis because it has relatively low costs and is technically feasible. It is further described in Section 4 with respect to treatment ratio volumes, volume per treatment season, and operating details.

3.2.1.10. White Rot Fungus

White Rot Fungus (Phanerochaete Chrysosparim) produces chemical intermediates to chemically break down lignin in plant matter so the fungus can access the cellulose material in the plant matter (fungus' food source). These intermediates consist of reactive oxygen radicals which are used to oxidize PCP. One benefit of utilizing the fungus is its insensitivity to biological poisons such as arsenic that may be present in the soil. This technology would be applied to the same 25,000 cys of shallow soil and wood debris (<10 feet) that the land treatment and biopile technologies would remediate.

The PWP pilot test utilized a small amount of soil, inoculated with the fungus and wrapped in black plastic. A full-scale operation would incorporate large piles on the biopad, each pile being 6 to 8 feet deep. The pilot test results were encouraging, although sampling was limited and the initial PCP concentration was not well documented.

A follow-up treatability study was conducted on degradation of PCP with White Rot Fungus. Results are presented in Appendix F. The study found that the PCP contaminated sand required the addition of 40 percent by weight of an inoculated growth substrate such as a mix of alder wood chips and cotton seed hulls. The contaminated wood debris required addition of four parts sand to 1 parts wood debris to dilute the initial concentration of the wood chips. Based on the 4 to 1 ratio of sand to wood debris, treatment of the 12,000 cys of wood debris requires the addition of 48,000 cys of sand. It is assumed that the sand added to dilute the wood chip concentrations would include the 13,000 cys of contaminated sand to be treated. The total volume of contaminated media to be treated is therefore 60, 000 cys. The inoculated substrate adds an additional 100,000 cys (assuming addition at a 40 %

weight basis and a density of 25 pounds/cf). The total volume of substrate, wood debris and sand added for dilution is 160,000 cys. This is the volume necessary to treat the combined 25,000 cys of PCP contaminated wood debris and sand.

Effective operation is assumed to be 6 months per year. Based on the results of the most recent treatability study a minimum of 15 to 20 weeks would be required to reduce concentrations to the 10^{-5} risk level PRG of 29 mg/kg. Given that results for laboratory studies where only a small sample is treated (20 grams in this study) are typically much better than full scale, it is assumed that the entire 6 warm weather months available would be necessary for treatment.

The amount treated on the pad is limited by the need to inoculate the substrate and grow the fungus prior to mixing the substrate and contaminated media. The substrate is spread in rows about 10 feet wide and 1 foot in depth. The fungus is inoculated and allowed to grow for 4 weeks prior to mixing with the contaminated soil and wood debris. This substrate development period limits the amount of contaminated soil and wood chips that can be treated each year to about 2,800 cys of the 60,000 cys to be treated. A total of 21 years would be necessary to treat the shallow soil and wood debris. If treatment proceeds more rapidly (about 3 months per treatment pile) then two cycles can be accomplished per year and the duration would be 12 years. The technology was retained for further analysis because of its relative low cost and technical promise; however, additional laboratory testing would be needed to determine the optimal fungal species for locally available substrate. This would be followed by pilot scale testing to determine achievable degradation given the less than optimal conditions at near full scale operation.

3.2.1.11. Low Temperature Thermal Desorption

Low temperature thermal treatment uses heat to volatilize organic compounds and remove them from the soil. Heat is applied through natural gas or other fuel combustion with direct heat transfer to the soil media in a rotary or asphalt kiln. (Indirect methods are less common.) Excavated soil is processed and fed to the thermal treatment device and the treated soil is then stockpiled and eventually backfilled at the site.

The most significant issue concerning low temperature thermal desorption of the soils is related to the presence of the wood chips, wood debris, and the high heat capacity (British thermal unit [Btu] content) of the soils. The wood chips and wood debris materials will partially combust in the desorption process, creating inconsistent process temperatures and allowing partially combusted particulates to exit the kiln, potentially causing damage to the baghouse. Furthermore, there are more stringent regulatory requirements for a combustion process than if just a desorption process.

Significant air emission control would also be necessary. The system air emission controls would include a cyclone particulate removal device for emissions exiting the kiln to protect the baghouse used for fines removal. Following the baghouse, the air emissions would be treated in a natural-gas-fired incinerator (afterburner) to oxidize the desorbed organics. The expected high levels of PCP would likely make acid-gas (HCl) scrubbing necessary. The material collected in the baghouse and the processed soil would be rehydrated and combined in a pug mill.

Because of the stringent regulatory requirements and the issues related to emission control this technology will not be carried forward.

3.2.1.12. Disposal

The process option selected for disposal of untreated excavated arsenic-contaminated soils at the site is containment under the soil cover or cap onsite, under the CAMU concept. Grossly contaminated arsenic soils, defined as soil exceeding the 10^{-4} industrial direct contact PRG, will be treated onsite by solidification to meet TCLP limits before being replaced onsite.

Treated PCP soil will be disposed by backfilling onsite if it meets LDRs and no longer contains the listed waste. This is retained as the preferred disposal method because of the much lower costs and technical effectiveness. If PCP-treated soils do not meet the health-based concentrations considered necessary to designate the soil as no longer containing the listed waste, a treatability variance may be requested. Offsite disposal at a hazardous waste landfill involves excavation and transport of the soil to an out-of-state landfill; Wisconsin does not have a permitted RCRA hazardous waste landfill.

3.2.2. Technology and Process Option Screening for LNAPL

Using the same methodology described in the preceding sections, Table 3-2 presents the results of a qualitative comparison of technology types and process options available for remediation of LNAPL.

Potentially feasible technologies and process options for each general response action for remediation of LNAPL at the site are shown in Table 3-2. These technology types and process options will be used to develop potential remedial alternatives. The retained response actions and technologies for remediation of LNAPL include:

- No further action
- Institutional controls
- Collection by extraction in wells, collection with vacuum enhanced extraction, and collection with groundwater extraction enhanced recovery
- Treatment by incineration

The rationale for selecting these process options is indicated in Table 3-2. The following sections highlight technologies where more detailed evaluation was necessary to distinguish between technologies or process options. These include the LNAPL collection technology process options.

3.2.2.1. LNAPL Collection

The LNAPL collection response action, if implemented, would probably use all three process options. Extraction could be useful for collecting free floating, easily extractable LNAPL; and extraction with enhancements (e.g., groundwater extraction, vacuum enhanced extraction) could be applied to increase the gradient and LNAPL thickness at the recovery well.

Air sparging, steam injection in conjunction with SVE, and oxidation may be useful in reduction of the PCP and TPH in the area of LNAPL residual. These technologies are discussed within the Technology and Process Option Screening for Groundwater Media section that follows.

3.2.3. Technology and Process Option Screening for Groundwater Media

Using the same methodology described in the preceding section, Table 3-3 presents the results of a qualitative comparison of technology types and process options available for groundwater remediation.

Potentially feasible technologies and process options for each general response action for remediation of groundwater at the site are shown in Table 3-3. The response actions and associated process options that were retained after screening for remediation of groundwater at the site include:

- No further action
- Institutional controls
- Alternate water supply
- Natural attenuation
- Containment by hydraulic controls (groundwater collection)
- In situ treatment by dewatering and bioventing and steam injection in conjunction with vapor phase extraction
- Collection of groundwater by installing extraction wells
- Ex situ treatment of contaminated groundwater by adsorption (granular activated carbon [GAC])
- Discharge of treated water to Doctor Lake or infiltration trenches or wells

The rationale for selecting these process options is indicated in Table 3-3. The following sections highlight technologies where more detailed evaluation was necessary to distinguish between technologies or process options. These technologies include in situ treatment with air sparging, steam injection in conjunction with SVE, oxidation, ex situ groundwater treatment, and groundwater discharge.

3.2.3.1. Dewatering and Bioventing

In situ treatment of the LNAPL residual zone can be accomplished by dewatering the unconfined groundwater through a series of extraction wells and using the bioventing system discussed above for the soil media. Groundwater extraction of about 50 gpm is estimated to be needed to drop the water table to near the top of the semiconfining till. The groundwater would be treated as descibed later and reinjected in an area outside the capture zone of the dewatering system. The system would require about 10 years of operation to reduce the PCP soil concentration to PRG levels. There is some uncertainty on the ability of bioventing to treat soils at the high concentrations expected in this zone. Ongoing bioventing pilot scale testing and column testing will provide more information on the effectiveness of bioventing at these high concentration levels.

This option is the least expensive of the options for the LNAPL residual because it uses two technologies that are likely necessary for the soil and groundwater media irrespective of the LNAPL residual area; bioventing for the soil and collection and treatment for the groundwater. The added expense of this alternative is minimal and it will be retained for inclusion into remedial alternatives.

3.2.3.2. In Situ Air Sparging

Air sparging is the process in which air is introduced below the water table to enhance volatilization. The enhancement of aerobic biodegradation, through the increase of the oxygen content in the aquifer, also occurs, but this is a secondary objective of air sparging. Given that the PCP is relatively non-volatile, air sparging is limited to the enhancement of aerobic degradation at PWP. Air sparging at the PWP site would be applied only to the unconfined groundwater in the area of LNAPL residual. It cannot be applied to the semiconfined groundwater because of the presence of low permeability till lenses that would interfere with air distribution. The potential advantage of air sparging at the PWP sie is that it would add air to the LNAPL smear zone immediately above the water table as well as the saturated zone, thus increasing biological degradation of the PCP contained in the LNAPL residual.

Parameters required for design of air sparging include a number of injection wells for sufficient oxygen distribution, sufficient airflow rate, and length of operation to meet remedial objectives. These parameters were used to calculate capital and operating costs.

A high density of injection wells is necessary for sufficient oxygen distribution. Typical well spacings are 20 – 35 feet for air sparging (Boersma, et al.). Based on a conservative 25-foot spacing, this corresponds to about 260 wells.

Oxygen utilization rates are used to determine the airflow requirements. Observed oxygen utilization rates at the site range from 0.05 to 1 percent per hour for petroleum-based LNAPL. Given that there is approximately 21 percent oxygen in atmospheric air, one pore exchange per day in the affected zone would be adequate to provide enough oxygen for degradation to occur. The calculated airflow rate is thus 650 scfm based on a 4-acrea area, 10 feet thick LNAPL residual zone, and the one pore exchange per day.

Length of operation is important to calculate operating and maintenance and power costs. Based on similar degradation rates for sites contaminated with petroleum hydrocarbons (see Section 4 for details), a conservative degradation rate of the PCP would be on the order of 0.5 ppm/day. Based on the 0.5 ppm/day and an average PCP concentration of 1,500 ppm, time to meet remedial objectives for the PCP would be about 10years.

The 260 wells , the airflow rate requirement of 650 scfm, and the 10 year length of operation were used to calculate capital and operating costs. The calculated costs are about $2,000,000 for capital and about $160,000 per year for O&M, which correspond to a present worth cost of about $3,400,000.

In summary, while air sparging may be a viable treatment option for treatment of the PCP in the LNAPL residual zone below the water table, it is not cost competitive with the simpler dewatering and bioventing option. As a result it was not be carried forward.

3.2.3.3. In Situ Steam Injection in Conjunction with SVE

This technology is similar to that described for the soil media with the exception that only the LNAPL/residual zone will be targeted instead of the entire soil area. The resulting area is only about 4 acres instead of the entire 7-acres. The affected thickness of contaminated soil is only about 4 feet rather than the 100 feet for the soil alternative. This technology is thus carried forward into Section 4.0.

3.2.3.4. In Situ Oxidation

This technology is similar to that described for the Soil Media. only it would be focused on the 4-acre PCP/LNAPL residual zone area.

As previously described, the amount of hydrogen peroxide necessary for oxidation of the PCP is dependent on the amount of other organics present. For the PCP/LNAPL residual zone, there is approximately 500,000 gallons of PCP/LNAPL (Section 2). This LNAPL has an oxygen demand of approximately 3.5 lb oxygen/lb LNAPL, which will consume any hydrogen peroxide used to oxidize the PCP.

The 500,000 gallons LNAPL is equal to 3.3 million pounds, assuming the specific gravity of the LNAPL is 0.80. This corresponds to about 11.5 million pounds of required oxygen to oxidize just the LNAPL.

As described earlier, hydrogen peroxide in addition to a catalyst would be required to be delivered for oxidation of the PCP. Vendor-supplied costs for the hydrogen peroxide/catalyst mixture are on the order of $0.50/lb. In addition, the hydrogen peroxide is only assumed to be about 50 percent efficient. Therefore, the costs of chemicals alone would be over $10,000,000, not including injection and storage costs. Further, all of the safety and delivery concerns expressed previously are the same for the PCP/LNAPL residual zone.

This option is not carried forward as a result of costs, safety concerns, and the difficulty in achieving adequate distribution of the oxidant in the soils.

3.2.3.5. Ex Situ Treatment

PCP is the primary contaminant expected to be present in extracted groundwater that will require treatment to PALs prior to reinjection or discharge to surface water. Other organics that may be present in the extracted groundwater are benzene and napthalene. Iron and manganese may also be present in groundwater at concentrations exceeding PALs as a result of the reducing conditions in the aquifer. As previously discussed, the reducing conditions result in the reduction of iron and manganese naturally present in the aquifer soil to soluble forms. Once these inorganics are no longer under reducing conditions, they would be expected to become oxidized back to their immobile forms. For reinfiltration discharge options, this would be expected to occur within the 100 foot unsaturated zone. As a result, treatment to remove iron and manganese are not included in the groundwater treatment process evaluation for reinfiltration.

Removal of iron and manganese may be necessary prior to discharge to surface water. This would be accomplished using chemical precipitation with filtration or clarification followed by sludge thickening and dewatering and offsite disposal of sludge in a RCRA hazardous waste landfill. The sludge would have to managed as a hazardous waste per WDNRs identification of all media as containing F032 and F035 listed hazardous waste.

The most suitable process option identified for treatment of PCP is carbon adsorption (using GAC), based on vender studies. UV oxidation was evaluated but found to be costly and potentially ineffective as a result of the high iron content fouling the photoxidation lamps. An ex situ treatability study for treatment of groundwater via photolysis was recently conducted at the PWP site. This treatability study is further described below.

3.2.3.6. Ex Situ Groundwater Treatment via Photolysis

Extracted groundwater can potentially be treated using sunlight to photolytically degrade PCP. While this is not a typical treatment process used for treating PCP in water, the presence of the 3.5 acre concrete pad onsite makes this a potentially cost effective option by minimizing the initial construction costs of the ponds necessary to allow photolysis. The treatment would be operated during the warm weather months, about 6 months per year.

Photolytic degradation of dissolved PCP in water is initiated by the ultraviolet wavelengths in sunlight. Photolytic half lives for PCP in site groundwater collected from MW -18 were measured in an onsite treatability study. Pond depths of 1 inch, 3 inches and 6 inches were evaluated during cloudy and sunny conditions over the course of 2.5 days. A fourth treatment cell evaluated a 3-inch depth along with the addition of a sensitizer (methylene blue) to accelerate photolysis. The most rapid degradation was an 8-hour half life and occurred, as expected, in the 1 inch depth cell. The optimal photodegradation rate in a cell depth of 3 inches was achieved with methylene blue sensitizer, which resulted in a 13-hour half life (See Appendix F).

Based on a half life of 13 hours, a pond depth of 3 inches and a groundwater collection flow rate of 50 gpm, a 15 acre pond would be needed to photolytically degrade PCP to the PAL assuming one cycle of the water on the pad. The existing concrete pad is about 3 acres in size. The existing pad is large enough to provide about a 90 % removal of PCP. GAC treatment would still be necessary to remove the remainder of the PCP. Carbon usage rates, which primarily effect the annual O & M costs, would be reduced somewhat although they would still be substantial because many of the breakdown products of the PCP would be adsorbed as well as the remaining organic carbon in the groundwater. A present worth savings for reduced carbon useage on the order of $50,000 would be expected over an estimated 5 year duration. This cost is far less than the cost to upgrade and line the pad, provide rainfall storage capacity and possibly cover the pond with netting to prevent wildlife access to the pond. Because photolytic degradation does not offer cost advantages and is operationally more complex than GAC alone, it is not carried forward.

3.2.3.7. Discharge

Under the discharge response action, the process options of discharge of treated groundwater to infiltration trenches or Doctor Lake are retained. As discussed in Appendix A, discharge to groundwater via infiltration requires meeting Wisconsin PALs for any groundwater not subsequently recollected in the groundwater collection system. Treated groundwater discharged to the area captured by the collection system is allowed higher discharge limits. It is assumed that this water could be treated for PCP removal only using GAC. Discharge to a surface water such as Doctor Lake generally has more stringent discharge limits than PALs, particularly for the inorganics. It is assumed discharge to surface water would require chemical precipitation for inorganic removal in addition to PCP treatment processes.

SECTION 4

Alternative Descriptions

4.1. Introduction

The remedial technologies and process options that remain after screening for soil, LNAPL, and groundwater media were assembled into a range of alternatives. The remedial alternatives have been developed separately for the contaminated soil/sediment/wood chip media and the LNAPL/groundwater media to allow a wider range of alternatives and greater flexibility in selecting the recommended alternatives. LNAPL and groundwater media have been combined because the technologies used for each are similar and remediation of LNAPL typically includes groundwater remediation components. For simplicity, the media will be referred to as only soil, and groundwater.

The specific details of the remedial components discussed for each alternative are intended to serve as representative examples to allow order-of-magnitude cost estimates. Other viable options within the same remedial technology that achieve the same objectives may be evaluated during RD activities for the site. The following sections provide a detailed description of each alternative.

4.2. Soil Media Alternative Descriptions

Five soil media alternatives were developed to address a range of remedial actions and include all the remaining technologies into at least one alternative. Table 4-1 presents a matrix of technologies that survived screening and the alternatives into which they were incorporated.

4.2.1. Soil Media Alternative 1–No Further Action

The objective of Soil Media Alternative 1 (S1), the No Further Action Alternative, is to provide a baseline for evaluation of remedial alternatives, as required by the NCP. Under this alternative there would be no additional remedial actions conducted at the site to control the continued release of PCP and arsenic. It is anticipated that offsite erosional transport of arsenic- and PCP-contaminated soils would continue. In particular, the gully immediately downslope from the lagoon would likely continue to erode with large amounts of contaminated soil released to the "washout " area north of the lagoon. There would be a risk from direct contact with the soil if the site was developed in the future for industrial use.

4.2.2. Soil Media Alternative 2–Soil Cover and Monitored Natural Attenuation

The soil remedial objectives are met by the S2 alternative through prevention of direct contact to soils, preventing continued erosion of contaminated soils and allowing natural attenuation processes to reduce the PCP in soil to the PRGs. The main areas of contaminated soil would be covered with 1 foot of clean soil and revegetated. Smaller isolated areas of PCP- and arsenic-contaminated soil would be excavated and consolidated within the main soil cover in the source area. Figure 4-1 presents the layout of the soil cover. The main components of this alternative are:

- Institutional controls
- Consolidation and soil cover
- Erosion control measures
- Revegetation
- Biopad removal
- Environmental monitoring

These components are discussed below. Additional detail on existing conditions and the erosion control and revegetation components are provided in Appendix C.

4.2.2.1. Institutional Controls

Institutional controls would consist of land use restrictions for the areas below the soil covers. A restrictive covenant would be placed on the deed of the PWP property identifying the areas with the soil covers and specifying that: (1) the areas are contaminated with PCP and arsenic, (2) excavation within the areas must comply with Occupational Safety and Health Administration (OSHA) requirements for health and safety protection, (3) any excavated soils be managed as hazardous waste in accordance with applicable laws, (4) buildings are not permitted within the soil cover areas, and (5) activities that threaten the long-term integrity of the soil covers are not permitted.

4.2.2.2. Building Demolition

Demolition of existing buildings in the areas of high concentrations of PCP and arsenic contamination will be conducted as part of this alternative. This includes the former PCP treatment building and the oil/water separator building. Asbestos may be of concern in the former treatment building, which may increase demolition costs. Demolished buildings would be disposed of in a nearby solid waste landfill or salvaged. Debris such as concrete that may contain PCP or arsenic residuals would be tested for TCLP arsenic and PCP, and would be disposed of either in a special waste landfill or a hazardous waste landfill. Alternately, the demolition debris could be placed onsite below the cover areas or between the lagoon wall and the buttress if demolition debris is below TCLP arsenic and PCP.

4.2.2.3. Consolidation and Soil Cover

A soil cover would be placed over the treatment, gully, and lagoon source area, and the wood chip pile source area. Areas of metal and PCP soil and sediment contamination outside these source areas would be excavated to a depth of approximately one foot and consolidated within the main gully and lagoon source area prior to placement of the soil cover. The area of soil contamination would be designated as a CAMU to allow consolidation of soils containing listed hazardous waste without triggering the LDRs.

Removal of trees would be necessary in the area downstream of the lagoon and the area east of the source area prior to excavation. The source areas would initially be covered with 6 inches of clean soil from the uncontaminated areas west of the main source area onsite. Following installation of the erosion control measures and the lagoon and dam repair discussed below, an additional 6 inches of soil with sufficient organics to allow revegetation would be placed on the soil cover areas.

TABLE 4-1
Development of Soil Media
Remedial Alternatives
Penta Wood Products Site

Remedial Technologies / Process Options	Soil Media Remedial Alternatives				
	S1 No Further Action	S2 Soil Cover and Natural Attenuation	S3 Capping	S4 Bioventing	S5 Ex Situ Biological Treatment and Bioventing
No Further Action	X				
Land Use Restrictions		X	X	X	X
Grading, Lagoon Buttress, Revegetation		X	X	X	X
Capping—Clay			X		
Capping—Synthetic Membrane			X		
Capping—Pavement for Biopad		X	X	X	X
Monitored Natural Attenuation		X	X	X	X
In Situ Bioventing				X	X
Excavation and Consolidation		X	X	X	X
Excavation and Treatment				X	X
Fixation / Stabilization—Arsenic Contaminated Soil				X	X
Aerobic Biological Treatment—Biopile					X
Consolidation—PCP and Arsenic Soils		X	X	X	X
Onsite Disposal—Treated Soils				X (As)	X (PCP and As)

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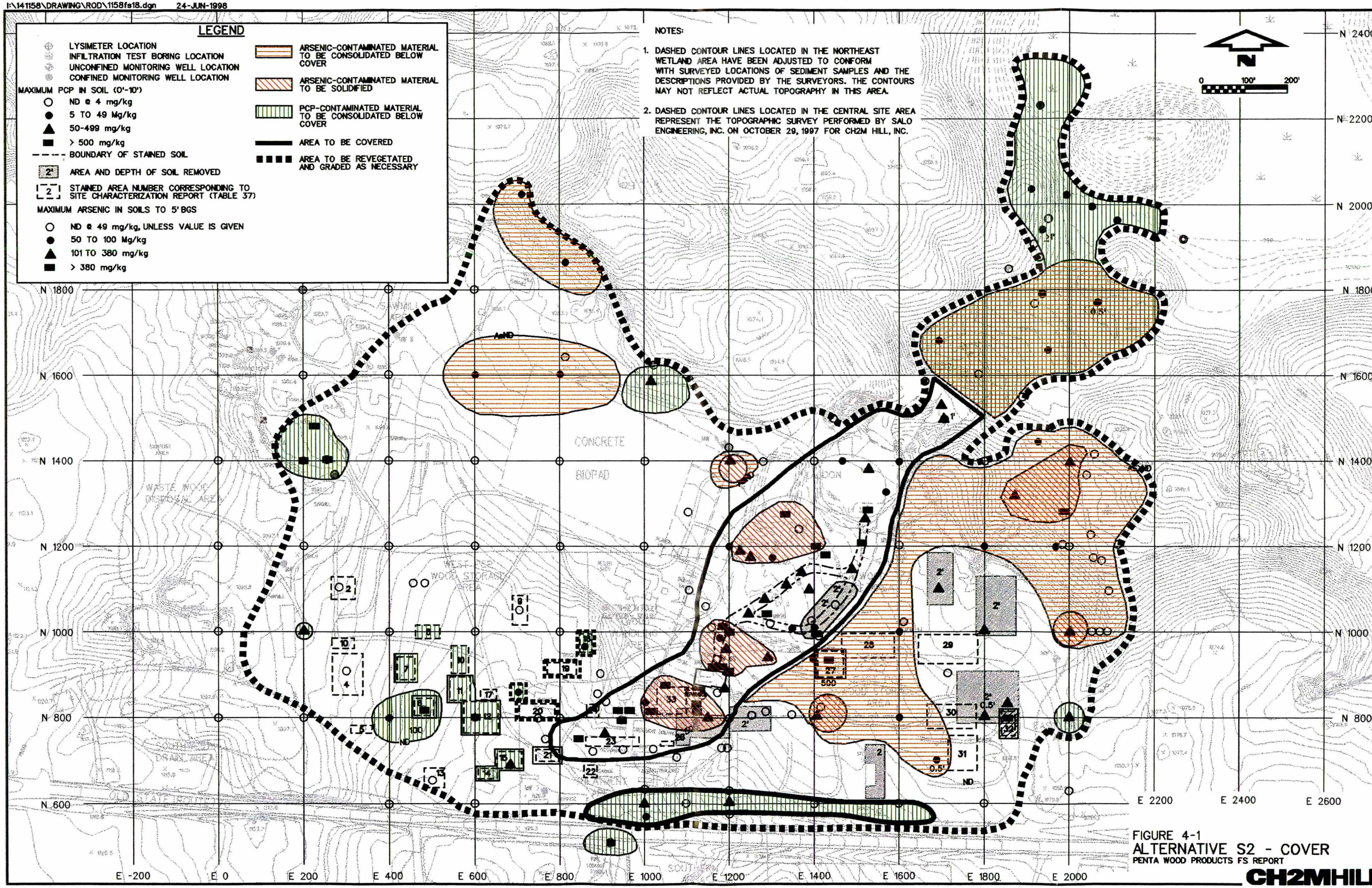

FIGURE 4-1
ALTERNATIVE S2 - COVER
PENTA WOOD PRODUCTS FS REPORT

4.2.2.4. Erosion Control Measures

Severe surface water erosion is occurring at the PWP site. The apparent cause of most of this erosion is rapid overland flow of water in the absence of vegetation and other natural flow barriers at the site. Evidence of this erosion is seen by the gullies and channels that have formed in areas where drainage paths have coalesced.

The erosion control plan for the PWP site will involve controlling surface water runoff such that the volume and velocity of overland flow is reduced to a level that will not result in erosion of surface soils. This goal will be achieved by constructing structures such as drainage ditches and water detention or infiltration basins at several locations on the site. The number and type of erosion control structures will be determined in the design phase, and will take into account the effect of interim surface control measures being implemented by the USEPA ERB in May 1998. The design of drainage ditches will likely involve use of geotextiles and rip rap to prevent erosion of the sandy material below and along the sides of the ditches during water flow. Check dams constructed of rip rap will likely be used in steeper areas to slow the velocity of water flow. The gullies on the north side of the PWP site may require some type of conveyance structures (e.g., corrugated metal culverts) to convey water from the PWP site to the bottom of the sloped area.

Serious erosion has occurred on the downstream face of the lagoon dam embankment. This erosion has resulted in the deposition of sand and wood debris that can be found 1000 feet downstream of the dam, and the formation of gullies on both sides of the dam. The gullies coalesce into a single gully 40 to 50 feet downstream of the crest of the dam. Cracks occur in several areas at the crest of the dam, suggesting that future failures are eminent.

The lagoon dam repair and recontouring plan will involve stabilizing the existing gully area and diverting some or all of the surface water that currently reaches the lagoon to detention or infiltration basins, or to other drainage areas. The goal of the lagoon dam repair effort will be to create a uniform slope of about 15 to 20 percent, consistent with the slopes on either side of the existing gully. The amount and type of material to achieve acceptable slope conditions downstream of the lagoon will be determined during design.

One possible concept for the dam repair/recontouring plan is to construct a 10- to 15-foot high rock containment berm approximately 50 feet downstream of the toe of the existing embankment. The gully between the rock containment berm and the embankment would be filled with the isolated areas of contaminated soil described earlier and debris from the site. The final cover layer on the slope would be an organic-rich soil that will support vegetation.

4.2.2.5. Revegetation

Much of the PWP site is currently devoid of or sparsely covered with vegetation. Soils exposed at the site are primarily sands and gravels with limited capacity to support plant growth. Following consolidation of contamination and excavation of areas in the western area of the site for cover soil, reestablishing vegetation will be necessary over much of the site.

The amount and type of revegetation will depend on the anticipated end-use of the site. Several options are presented in Appendix C. Alternative S2 includes the least expensive option that is consistent with future commercial or industrial use. Alternative S2 would involve importing 6 inches of organic rich soil to promote plant growth to allow rapid revegetation of the soil cover area. An option to importing topsoil would be to use biological solids from wastewater treatment plants (see Appendix C). In the excavated areas not provided with a soil cover, the regrading and erosion control measures would allow vegetation to reestablish. This plant growth would likely consist of grasses, thistles, and bushes within the central area of the PWP site, and pine and other trees around the perimeter of the site.

4.2.2.6. Biopad Removal

The biopad will be dismantled to prevent further spalling of the pad. Dismantling will consist of breaking up the pad into concrete blocks approximately 4 feet by 4 feet and using them as backfill between the lagoon wall and the buttress, or placing them in the soil cover area. Both of these areas will be designated as a CAMU.

4.2.2.7. Environmental Monitoring

Natural attenuation processes for PCP in the subsurface include volatilization, dispersion, adsorption , and biodegradation. Volatilization can be a significant loss mechanism from surficial soils, but is not significant in the subsurface where the majority of PCP is present. Lateral dispersion of PCP is not significant at the PWP site because the area of contamination is relatively wide in comparison to its depth. Vertical dispersion as the PCP leaches to lower depths occurs; however, because the vertical soil column is already entirely contaminated at relatively high PCP concentrations, dispersion alone is not a significant mechanism for contaminant reduction. PCP is strongly adsorbed on soil at the PWP site based on the results of soil washing jar tests and soil and pore water sampling in the unsaturated zone.

The K_d for PCP-based on the site-specific data ranged from 6.4 L/kg to 17.2 L/kg. These K_ds result in high retardation of PCP in the unsaturated zone and very long travel times to arrive at the water table. Based on SESOIL modeling of unsaturated zone (see Appendix B), PCP located at the surface requires hundreds of years to arrive at the water table. The current distribution of PCP and TPH throughout the entire soil column is most probably the result of the discharge of the pure phase diesel fuel PCP carrier and not the downward migration of PCP dissolved in infiltrating water. Continued downward migration of LNAPL is not expected because the LNAPL has had sufficient time to spread and reach a stable residual saturation concentration.

Given the long travel time for PCP to reach the groundwater, biodegradation can be a significant loss mechanism. Biodegradation of PCP may occur anaerobically or aerobically with rates generally expected to be more rapid aerobically. Anaerobic biodegradation occurs by reductive dechlorination in which the chlorine atoms are sequentially replaced with hydrogen (PCP to tetra chlorophenol to trichlorophenol to dichlorophenol to chlorophenol to phenol). Abiotic reductive dechlorination may also occur as microorganisms release organo metallic cofactors into the subsurface environment to catalyze the dechlorination reaction (Smith et al., 1994). Aerobic degradation pathways are less certain, although it appears that a hydroxl group initially substitutes for a chlorine atom. Once the aromatic ring has two hydroxyl groups, the ring can be cleaved and then mineralized to carbon dioxide and water. Few intermediates other than chloride have been shown to accumulate (Rochkind, et al., 1986).

Biodegradation rate constants vary considerably in the literature. Aerobic half lives range from 0.8 days to 51 days. The onsite treatability studies performed by WESTON generally found an aerobic half life on the order of 30 days.

Other data collected during in situ bioventing at sites contaminated with petroleum hydrocarbons suggest rates may be lower. Aerobic degradation rates of the TPH associated with the petroleum hydrocarbons ranged from 2 ppm/day to 15 ppm/day. Since the PCP associated with the petroleum hydrocarbons is on the order of 5 percent of the total mass of TPH, then the PCP would degrade at about 5 percent of the TPH degradation rates. Therefore, in areas with adequate TPH to sustain aerobic activity, PCP aerobic degradation rates would range from 0.1 to 0.75 ppm/day.

Anaerobic half lives are more limited in literature and range from 6.1 days to 266 days. Anaerobic half lives are more pertinent to the unsaturated zone and in the saturated zone in the area of LNAPL residual at PWP because the high TPH concentration has resulted in sufficient biological activity to utilize the available oxygen and produce anaerobic conditions. Soil gas measurements in the area of elevated PCP and TPH indicate anoxic conditions. SESOIL modeling using the slowest anaerobic degradation rate shows little PCP arrives at the water table. The site-specific anaerobic degradation rate will be further evaluated in the site treatability studies.

The mass of PCP present in the unsaturated zone is estimated at 120,000 lb based on the subsurface soil sampling results. The complete mineralization of this mass of PCP would produce about 80,000 lb of chloride. Because chloride does not adsorb to soil, it would be expected to be mobile and leach to groundwater. Evaluation of groundwater chloride results indicate a large plume of elevated chloride below the PCP contamination with an estimated mass of 190,000 lb However, based on the site history, chloride was also discharged to the cooling pond north of the treatment building during regeneration of the boiler make-up water softener. It is uncertain what proportion of the chloride mass is attributable to the degradation of PCP versus the discharge of water softener salt. The distribution of the chloride in groundwater is indicative of a wider source than just the cooling pond.

The objective of the Alternative S2 environmental monitoring program is to assess the degree of PCP natural attenuation and to determine whether the soil cover and erosion control measures are preventing transport of arsenic and PCP. Environmental monitoring for alternative S2 will include:

- Lysimeter sampling
- Groundwater sampling below source area
- Routine inspection of cover and sampling if necessary

The existing lysimeter nests LY02 and LY03 will be sampled on an annual basis for the first 5 years to determine whether observable trends in pore water PCP concentrations are evident, and to determine the amount of electron acceptors and donors and degradation byproducts. Subsequent sampling, if necessary will be based on these initial results. Analysis will include PCP, chloride, nitrate, sulfate, dissolved iron, hydrogen, oxidation/reduction potential, and pH.

Groundwater monitoring below the contaminated PCP soils is included in the groundwater alternatives to assess the amount of contaminant leaching.

4.2.3. Soil Media Alternative 3—Capping

Soil Media Alternative 3 (S3) objectives will be met by (1) consolidating isolated shallow contaminated soil areas (e.g., stained areas, wetland sediment, washout area) and wood waste with high PCP contamination to a central location, and (2) placing a cap on the contaminated soil and wood waste to reduce leaching of PCP to the groundwater. The purpose of the cap is to reduce infiltration.The cap will meet the criteria given in Paragraph NR 504.7 of WDNR's requirements for minimum design and construction of final cover systems for landfills. The volume of material to be relocated is estimated to be 40,000 yd^3; the area to be capped is estimated to be 5 acres.

The main components of alternative S3 include:

- Institutional controls
- Building demolition
- Consolidation and soil cover
- Site capping
- Erosion control measures
- Revegetation
- Biopad removal
- Environmental monitoring

The institutional controls, building demolition, consolidation of contaminated soils and sediments and soil cover, erosion control measures, revegetation, and biopad removal will be the same as described for alternative S2. The 5 acre cap will be located within the area of soil cover defined in Alternative S2. Details about the site capping component and environmental monitoring for the capped area follow below.

4.2.3.1. Cap over Gully and Lagoon Area

A 5-acre area shown on Figure 4-2 will be capped after PCP-contaminated soils are consolidated there. A soil cover in similar design to that described for alternative S2 will be constructed over the remaining area (about 2 acres).

The cap system will involve a sequence of earth and geosynthetic materials starting at the top: (1) a vegetation layer, (2) a drainage layer, (3) an impermeable geomembrane, (4) a geosynthetic clay liner (GCL), and (4) where appropriate, a bedding layer. The geomembrane will be a minimum of 40 mils thick and have a maximum hydraulic conductivity of 1×10^{-7} cm/sec; a GCL with a maximum hydraulic conductivity of 1×10^{-7} cm/sec will be used in place of 2 feet of clay; the drainage layer will be at least 12 inches thick with a minimum hydraulic conductivity of 1×10^{-3} cm/sec; and the vegetation layer will be at least 18inches thick.

The deep frost penetration depths at the site led to the selection of the GCL rather than 2 feet of compacted clay because of the better freeze-thaw performance of the GCL relative to the clay. However, this variation will have to be approved by WDNR. Climatic conditions will also necessitate special consideration of material properties for the geomembrane (i.e., use of polyvinyl chlorides and polypropylene versus high density polyethylene).

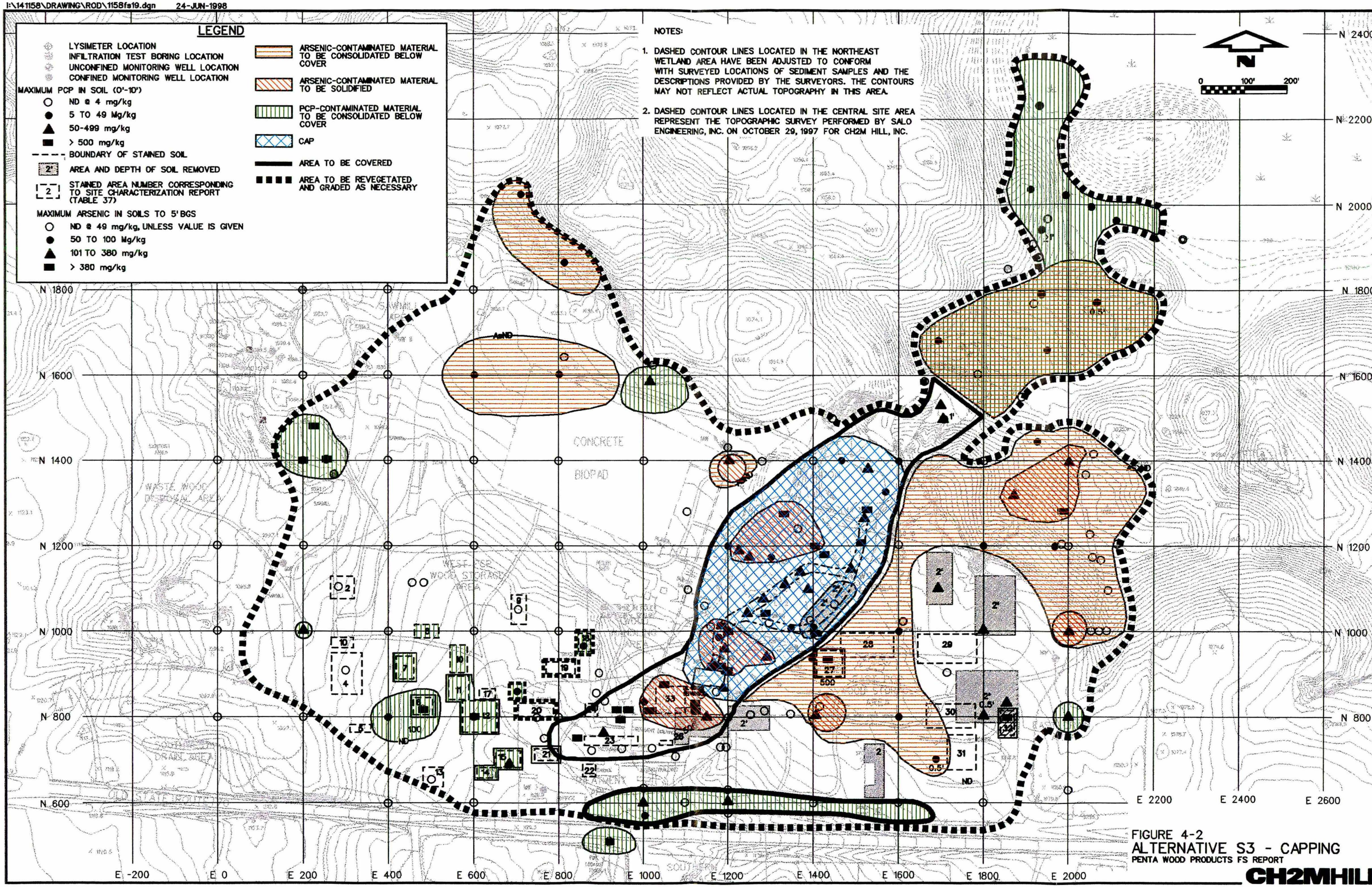

FIGURE 4-2
ALTERNATIVE S3 - CAPPING
PENTA WOOD PRODUCTS FS REPORT

Construction of the cap in the area north of the lagoon embankment will involve slopes that could range from 10 to 30 percent. In areas with slopes exceeding 10 to 15 percent, additional measures will be used to keep the drainage and vegetative layer from sliding on the geomembrane or the GCL. These measures could include the use of geotextiles or geogrids, in combination with anchor trenches. The need for matting or geosynthetic products, such as geo-cells, to control surface water erosion and soil creep during freeze-thaw cycles will also be evaluated.

Gas collection and venting systems for the areas to be capped will also be required because of the presence of the biodegradable wood waste. The gas collection and venting system will consist of trenches and vent wells. The trenches will be approximately 2 feet wide by 3 feet deep and will be located below the geomembrane at about 200 foot spacing. The vent wells will penetrate the membrane and will be located every couple of 100 feet.

The need to relocate material in the wood chip pile to the central area is still being considered. Another option is to cap the wood waste pile. The compressibility of the wood chip pile is such that a bedding layer and a heavy geotextile will likely be required to provide an adequate working surface and to accommodate localized settlement of the wood chips. Gas venting will also be provided for a cap over the wood chip pile.

4.2.3.2. Environmental Monitoring

Environmental monitoring for this alternative will be similar to that described for alternative S2. The effectiveness of the cap system will be assured by requiring detailed procedures for manufacturer and construction quality construction and assurance (MQC/MQA and CQC and CQA). Following construction, the condition of the cap system will be monitored visually on a regular basis as part of the Operation and Maintenance (O&M) plan. Excessive leakage through the cap system will be monitored through the existing groundwater monitoring wells. If excessive leakage is occurring, then modifications to the cap may be necessary.

4.2.4. Soil Media Alternative 4-Bioventing

The objectives of Soil Media Alternative 4 (S4) will be met by preventing direct contact to soils and enhancing aerobic degradation processes, via bioventing, to reduce the PCP in soil to the PRGs. S4 also includes consolidation of isolated shallow contaminated areas (e.g., stained areas, wetland sediment, washout area) into the gully and lagoon source area and bioventing the unsaturated zone in two areas: (1) the consolidated gully and lagoon source area and (2) the wood chip pile area. Alternatively, the contaminated areas from the wood chip pile could be excavated and consolidated in the gully and lagoon source area.

It may also be possible to address the LNAPL residual zone via bioventing. Recent well development data in a new well in the LNAPL residual zone suggests that the unconfined aquifer in the vicinity of the LNAPL residual zone could be dewatered. If so, then bioventing may be extended about 10 feet deeper into the currently saturated zone of the unconfined groundwater.

As previously discussed in Section 1, PCP was introduced to the subsurface soils at PWP as a 5 percent mixture with No. 2 fuel oil. Because of the high mass of TPH in relation to PCP in areas where high levels of TPH are measured, especially in the shallow soils (<10 feet bgs) and the deeper LNAPL residual zone soils (about 100 feet bgs), the degradation rate of

TPH will then control the overall degradation rate. Bioventing data collected at other sites contaminated with No. 2 fuel oil show that TPH degradation rates range from 5 to 15 ppm/day. However, since PCP only makes up about 5 percent of the TPH, then PCP would degrade slower. Assuming that PCP degrades along with the TPH at the same time, the resulting PCP degradation rate would then range from 0.1 to 0.75 ppm/day.

It was hoped that results from the ongoing in situ bioventing and lab-scale column treatability studies could be used to calculate site-specific in situ PCP degradation rates. Appendix F contains the initial bioventing treatability study memo that describes the study set-up, starting concentrations, and initial oxygen uptake study results. Contaminant concentration results recently collected after two months of operation are inconclusive, however. Therefore, the PCP degradation rates will remain in the range of 0.1 to 0.75 ppm/day for this FS Report.

Conversely, in areas with low TPH (specifically in the 10 - 100 feet bgs zone) PCP may also degrade slower than expected. Aerobic degradation, in addition to the dependence on oxygen, also requires sufficient substrate for adequate bacterial growth. For the PWP site, the No. 2 fuel oil (measured as TPH) acts as this substrate. Therefore, in these areas PCP degradation rates may be lower because ofthe low substrate conditions (TPH).

The major remedial components of Alternative S4 are the following:

- Institutional controls
- Building demolition
- Biopad capping and maintenance
- Consolidation and soil cover
- Arsenic contamination reduction
- Erosion control measures
- Revegetation
- Bioventing construction and operation
- Environmental monitoring
- Bioventing post-operation evaluation

The institutional controls, building demolition, erosion control measures, and revegetation for S4 are the same as that presented for soil media Alternative S2.

4.2.4.1. Biopad Removal

The existing concrete biopad will be dismantled and removed as described for soil media Alternative S2.

4.2.4.2. Consolidation and Soil Cover

Isolated shallow contaminated spots, sediments, and washout area soils will be consolidated and covered in the gully and lagoon source area to reduce the extent of contaminated areas across the PWP site and to reduce treatment costs by reducing the number of bioventing injection wells required. The consolidation procedure is similar to that presented for S2, with the following exceptions:

- Arsenic contaminated soil exceeding the background PRG and below the 10^{-4} industrial direct contact PRGs for arsenic will be excavated and placed directly in the consolidation area. As described in Section 4.2.4.3 below, arsenic-contaminated soil exceeding arsenic 10^{-4} industrial direct contact PRGs will be excavated for solidification and then placed in the consolidation area.

- The consolidation area will be covered with soil and revegetated for erosion control as described in Alternative S2.
- The estimated volumes of arsenic-contaminated soil and sediment that will be excavated and consolidated are 40,000 cy of soil and 3,000 cy of sediment. These estimated volumes take into account that both the wood chip pile area and gully and lagoon source area will be covered, therefore, no soil in these areas will be required to be removed for consolidation. Discrete confirmatory sampling will be performed to determine actual volumes.

4.2.4.3. Arsenic Contamination Reduction

The objective of this component is to excavate arsenic-contaminated soils, treat the grossly contaminated soils using solidification and to consolidate and dispose onsite. Arsenic contaminated soils exceeding background, but below the arsenic 10^{-4} industrial direct contact PRG and not already within areas to be covered will be consolidated as described in Section 4.2.2.3., arsenic-contaminated soil exceeding 10^{-4} industrial direct contact PRGs for arsenic will be solidified if necessary to meet TCLP limits and disposed onsite. The corresponding estimated volume of soil that may require solidification is 4,000 cubic yards. Discrete confirmatory sampling will be conducted to determine actual volumes.

The solidified soil may still be required to be treated as hazardous waste after solidification as previously discussed. The arsenic contaminated soil must be managed as a F035-listed waste by virtue of the contained-in rule (See Appendix A for a discussion of the-contained-in rule), in addition to potentially being a characteristic hazardous waste.Previous investigations at the site have shown that solidification will reduce the arsenic contaminated soil's leachability to below the TCLP limit for arsenic. (*Final Report, Phase I—Remedial Technology Evaluation*, REAC, December 1994). After solidification of arsenic contaminated soil it would be disposed onsite within the CAMU.

4.2.4.4. Bioventing Construction and Operation

The objective of bioventing is to enhance aerobic degradation of PCP-contaminated soil by injecting air into the unsaturated zone above the groundwater table. Bioventing will be conducted in the gully and lagoon source area. This section describes the construction and operation of the system.

Construction. The proposed layout of the bioventing system is shown on Figure 4-3. The bioventing system will consist of injection wells, connecting piping, blower, controls, treatment building, and piezometers. Approximately ten injection wells will be installed in the lagoon and gully area. The injection wells will be constructed with 4-inch ID PVC with approximately 125 feet of screen, 25 feet of which will be below the groundwater table. The wells will be connected to piping that will be located below the frost line. The piping will be valved for individual flow control and be run to a blower.

The blower will be capable of supplying an air flow of approximately 500 scfm with 10 pounds per square inch gage pressure per well. It will be housed in a treatment building with controls. The controls, at a minimum, will be programmed for automatic operation, emergency shutoff, on-off timer control, and remote sensing.

Piezometers at varying depths will be installed in discrete locations. The purpose of the piezometers is to allow for the monitoring of soil gas composition to assess effectiveness in delivering air to the affected subsurface regions.

Operation. Length of operation of the bioventing system is based on estimated time to reach 10^{-6} industrial direct contact PRGs for PCP. Based on discussions presented earlier, PCP aerobic degradation rates at PWP could range from 0.1 to 0.75 ppm/day. From Section 2, average PCP concentrations in the unsaturated soil and LNAPL residual zone are 150 mg/kg and 1,500 mg/kg respectively.

Based on the higher concentration and an average degradation rate of 0.5 mg/kg per day, the estimated time to reach the preliminary PRG for protection of groundwater of 4.6 mg/kg is approximately 10 years.

4.2.4.5. Environmental Monitoring

The objective of the Alternative S4 environmental program is to assess the degree and effectiveness of PCP removal and whether the soil cover and erosion control measures are preventing transport of arsenic and PCP. Environmental monitoring for Alternative S4 will include:

- Lysimeter sampling
- Soil gas analyses below bioventing treatment areas
- Soil sampling within bioventing treatment areas
- Routine inspection of cover and sampling if necessary

Lysimeter sampling will be performed as described in alternative S2. It is assumed that groundwater sampling will conducted as part of the groundwater media alternatives.

Soil gas analyses will be conducted semi-annually, at a minimum. Analyses for oxygen, carbon dioxide, methane, temperature, and moisture will be measured in the piezometers and the monitoring wells identified for groundwater sampling. If levels are out of acceptable ranges, process modifications may be proposed. For example, insufficient soil moisture may facilitate the installation of additional injection wells in the bioventing treatment areas to augment the insufficient moisture as well as provide additional oxygen to the more stagnant air near the water table.

Soil samples for PCP and other degradation indicators (i.e., chloride, pH) will be collected one to three times during the operational period. Samples will be collected at discrete locations and at various depths. The parameters sampled are similar to those described for Alternative S2. Based on the results, a decision to continue the bioventing operation and/or implement another treatment alternative will be made at that time.

4.2.4.6. Bioventing Post Operation Evaluation

The bioventing alternative effectiveness will be evaluated after 5 years. The evaluation will be based on analytical results collected from the groundwater and soil environmental monitoring. If the bioventing was unsuccessful in treating the areas highly contaminated with PCP, then either continued bioventing and/or implementation of other treatment alternatives, such as ex-situ biological treatment, may be considered. Ex Situ Biological treatment is further described in Section 4.2.5.

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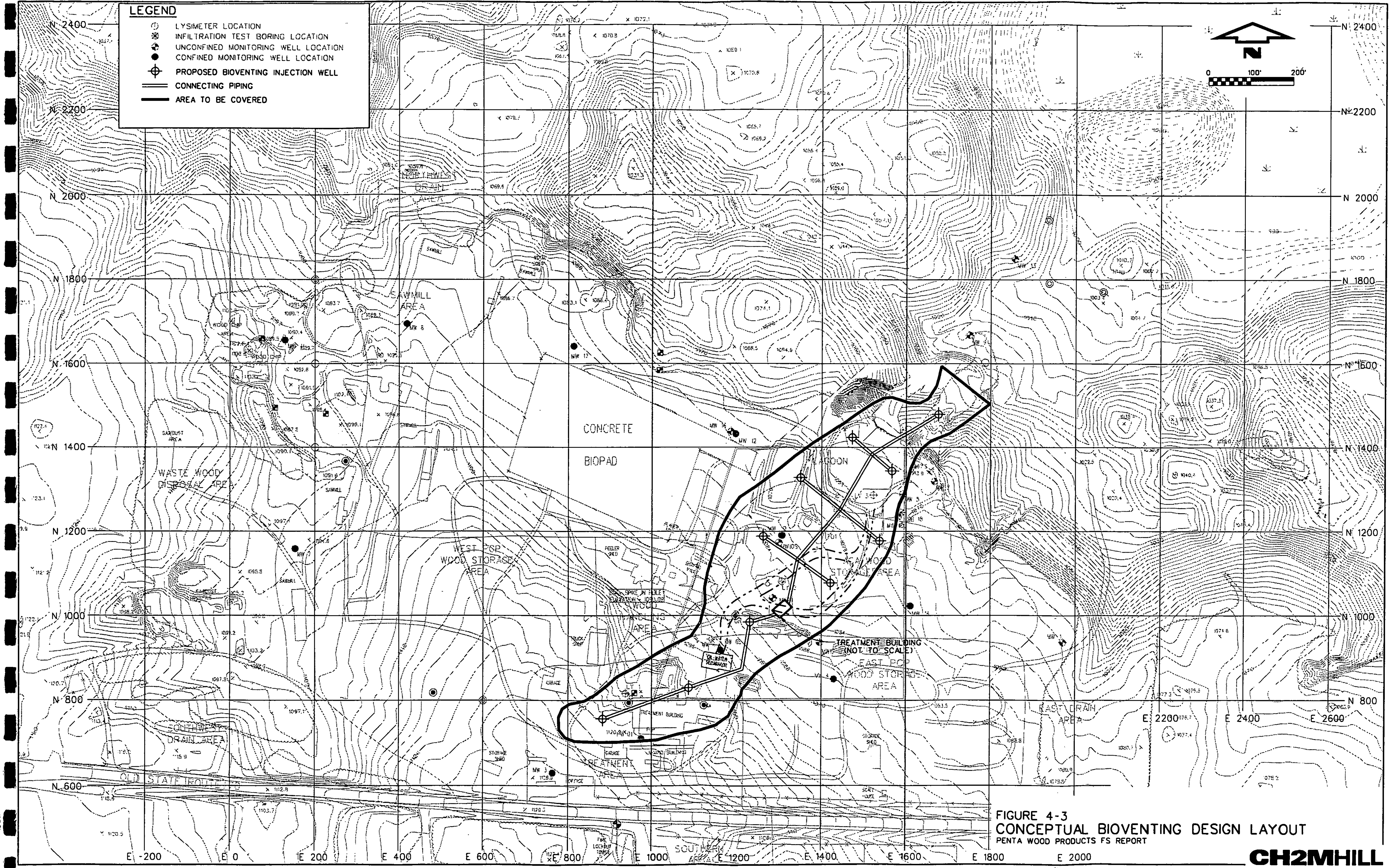

FIGURE 4-3
CONCEPTUAL BIOVENTING DESIGN LAYOUT
PENTA WOOD PRODUCTS FS REPORT

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4.2.5. Soil Media Alternative 5—Ex situ Biological Treatment and Bioventing

The objectives of Soil Media Alternative 5 (S5) will be met by: (1) excavating heavily contaminated arsenic soil, solidifying as necessary and disposing onsite, (2) consolidating and placing a soil cover over remaining arsenic contaminated soils, (3) treating the grossly contaminated PCP (exceeding 500 mg/kg) soil via ex situ biological treatment, and (4) bioventing the remaining in situ PCP soils and sediments contaminated above the soil PRG protective of groundwater. The soils to be treated with bioventing (Alternative S4) will be consolidated in the gully and lagoon source area (as will the arsenic soils) prior to treatment.

Ex situ biological treatment treatability studies for land treatment, anaerobic dechlorination, and biopiles have been previously conducted at the PWP site. White rot fungus, a fourth alternative, was previously evaluated (*Bioremediation Activity Summary Reports*, WESTON, May 31 and December 15, 1995) and more recently evaluated in a laboratory bench scale test (see Appendix F).

As discussed in Section 3, land treatment with manual soil tilling is not feasible due to the time required to achieve remediation goals. The estimated volumes to be treated via ex situ biological treatment of shallow (< 10 feet) contaminated soil are 13,000 yd^3 of soil and 12,000 yd^3 of wood debris. Based on maximum 2-foot-pile depths on the existing 2.5-acre biopad and a 4:1 ratio of wood chips to soil (as determined from the field treatability studies performed by ERT), the estimated time necessary to achieve remediation goals was calculated to be 10 to 15 years.

The treatability studies for anaerobic dechlorination of PCP-contaminated soils required the addition of amendments as substrate and caused unpleasant odors. Therefore, a full system design cost would include costs associated with substrate addition and the purchase, implementation, and operation of odor-control equipment. As discussed for Alternative S2, in situ conditions already simulate similar processes as would occur for ex situ anaerobic dechlorination.

Biopiles and white rot fungus may be viable options. From results of the treatability studies, a 4:1 ratio of soil to wood debris is required. Therefore, a total estimated volume to be treated is about 80,000 cubic yards. Assuming a biopile or white rot fungus treatment cell depth of 8 feet on the existing 2.5-acre concrete biopad, about 30,000 yd^3 can be treated at one time. About 6 months is necessary to treat the PCP-contaminated soil based on a PCP degradation half life of 30 days (see Alternative S2 for discussion). Given that 6 months are available each year for treatment in northern Wisconsin, about 3 years would be necessary to treat 80,000 yd^3.

White rot fungus also would require about 6 months to reduce PCP for each pile treated. Although the piles can be a similar depth as biopiles, the initial inoculation and growth of the fungus on the substrate requires the substrate to be spread in a lift of one foot and allowed to grow for 4 weeks prior to mixing with the contaminated soil and wood debris. This limits the amount of material that can be treated to about 5,000 yd^3 per year. Given that the soil and wood debris having high concentrations of PCP would require mixing with less contaminated soil or wood debris at a ratio of about 4 to 1, about 60,000 yd^3 would need to be treated. This would require about 12 years based on the size of the biopad. Further laboratory and pilot testing would be necessary to evaluate the particular substrate that would be used at PWP (likely including the sawdust and wood chips available onsite). Also the potential leachability and toxicity of the fumigant methyl bromide used to sterilize the substrate before innoculation to reduce competition for the fungus with bacteria would need to be evaluated.

In summary, ex situ biological treatment will consist of either biopiles or white rot fungus.

The major remedial components of alternative S5 are the following:

- Institutional controls
- Building demolition
- Arsenic contamination reduction
- Biopad upgrade
- Ex situ biological treatment construction and operation
- Consolidation and soil cover
- Erosion control measures
- Revegetation
- Environmental monitoring
- Pad removal
- Bioventing

The institutional controls, building demolition, arsenic contamination reduction, consolidation and soil cover, erosion control measures, revegetation, and bioventing components for S5 are the same as that presented for alternative S4.

4.2.5.1. Biopad Upgrade

The biopad consists of a relatively flat concrete pad that covers 2.5 acres. The pad is sloped to drain to the northeast; 6- to 12-inch curbs are located on all but one side of the pad to prevent water from flowing off the pad. Conditions of the pad are relatively good, although there is some evidence of normal tension cracking, as well as some spalling and flaking of concrete at the surface of the pad. The cracking could allow water flow through the pad; the spalling and flaking pose a potential hazard from either wind or water transport of the arsenic.

The concrete pad will be upgraded for biological treatment in the following manner:

- Existing curbs around the pad will be increased in height to provide more containment. Evaluations will be performed to determine whether cast-in-place concrete, jersey barriers, or some other method will provide the most cost-effective containment.

- A geomembrane will be placed over the existing concrete pad. The geomembrane will be sealed to prevent water from the treatment process from leaking through the geomembrane and then infiltrating into the underlying soil through cracks in the concrete. Consideration will also be given to technical and economic benefits of using asphalt sealant or layers in place of the geomembrane.

4.2.5.2. Ex situ Biological Treatment Construction and Operation

The objective of ex situ biological treatment is to treat excavated soils via aerobic degradation of PCP-contaminated soil. Shallow soils (< 10 feet) exceeding 500 mg/kg PCP in the oil-water separator, gully, lagoon areas, the wood chip area, and other isolated areas will be excavated and treated on the upgraded biopad. The 500 mg/kg concentration was chosen because it represents a concentration that is likely toxic to microorganisms under the in situ bioventing alternative. The concentration will be reduced for the ex situ treatment as a result of amending the soil with wood debris or less contaminated soil. The other areas below this risk level will be removed, consolidated, and biovented (see Alternative S4). This section describes the construction and operation of the ex situ biological treatment system.

Construction. The ex situ biological system components will depend on the type of ex situ biological treatment alternative chosen. From previous discussion, land treatment with soil tilling is not feasible given the limited amount of soil that can be treated on the pad in one season. More feasible options are either biopiles or white rot fungus.

Blowers, inlet and outlet piping, controls, spray heads for moisture addition and dust control, onsite mixer, excavator, and leachate collection equipment are required for biopiles. Blowers supplying approximately 500 scfm total will be connected to screened piping. The screened piping will be placed in a grid arrangement at the base of the pile. The onsite mixer will be used to mix the required amounts of wood debris, clean soil and contaminated soil as determined in the previous treatability studies. The excavator will be used for removal of in situ contaminated soil. Leachate collection equipment will consist of collection drains placed around the biopad and a collection system.

Inoculation of white rot fungus onto the substrate would be carried out in one foot lifts prior to mixing with the contaminated soil and wood debris. The contaminated soil, wood debris and substrate would be mixed and placed in 6 foot high piles on the biopad. The piles would include an air distribution and moisture addition system similar to the biopiles. The longer duration and need for substrate fungal growth would likely cause costs for the white rot fungus to be more than biopiles. For costing purposes it is assumed that biopiles would be used.

Operation. Operation of both the white rot fungus and biopile alternatives will be continuous during a 6-month operating season from April to October of each year for 3 years. Operations will include excavation, temporary storage (if necessary), and treatment. This section provides details for the biopile alternative.

The grossly contaminated shallow PCP-contaminated soil will be excavated and placed in the onsite mixer. The contaminated soil will be mixed with wood debris at a ratio of 4 parts soil to one part wood debris if native microorganisms are used, or 4 parts wood debris to one part soil if white rot fungus is used—the proportions determined in the treatability studies. After mixing, the mixture will be placed on top of the inlet screened piping grid for treatment. The gully and lagoon source area that will be used for consolidation and bioventing will be treated first.

Temporary storage of contaminated soil may be necessary so that the bioventing system can be installed as soon as possible. Storage will be in an uncontaminated area on sheeting. The storage piles will also be covered with sheeting for dust control and to prevent infiltration.

About 6 months (one season) is necessary to reduce the PCP concentrations in the PCP-contaminated soil by at least 75 percent. If possible within a treatment season, the Land Disposal Restriction treatment concentration of 7.4 mg/kg will be achieved. A treatability variance will be sought if the LDR concentration of 7.4 mg/kg cannot be achieved.

The treated soil will be sampled each 6-month season for confirmatory treatment reduction and then placed back onsite. For the first batch, the treatment time may be extended to a second 6-month season if treatment reduction objectives are not met.

4.2.5.3. Environmental Monitoring

The objective of the S5 environmental program is to assess the degree and effectiveness of PCP removal and to determine whether the soil cover and erosion control measures are preventing transport of arsenic and PCP. Environmental monitoring for alternative S5 will include:

- Confirmatory sampling
- Bioventing sampling

Confirmatory sampling will be performed to assess if the PCP is being degraded to below PRG levels. Groundwater sampling will be performed as described for the groundwater alternative. Bioventing sampling will be performed in a manner similar to alternative S4.

4.2.5.4. Pad Removal

At the conclusion of the treatment period, the pad will be broken up and disposed of onsite within the CAMU.

4.3. Groundwater Media Alternative Descriptions

Five groundwater media alternatives were developed to provide a range of remedial actions for groundwater contamination. They incorporate all the technologies that survived screening into at least one alternative. Table 4-2 presents a matrix of technologies that survived screening and the alternatives into which they were incorporated. The following sections detail each of these alternatives.

4.3.1. Groundwater Alternative 1—No Further Action

The objective of the groundwater media Alternative 1 (G1) is to provide a baseline for comparison to other alternatives, as required by the NCP. Alternative G1 does not include any further remedial action for groundwater. It does not include monitoring or institutional controls. Because it serves as a baseline, it is assumed that this alternative would be paired with the soil media Alternative 1—No Further Action.

4.3.2. Groundwater Alternative 2–LNAPL Collection and Monitored Natural Attenuation

The objective of Groundwater Alternative 2 (G2) is to remove the free phase LNAPL and rely on monitored natural attenuation for the PCP groundwater plume. Natural attenuation is the process by which contaminant concentrations are reduced by volatilization, dispersion, adsorption, and biodegradation. Volatilization of PCP is not significant in the groundwater as chloride is not volatile. Horizontal and vertical dispersion of PCP is significant and results in reduced concentrations as the plume disperses downgradient of the source area. Although PCP is strongly adsorbed on the unsaturated zone soils, it is less strongly adsorbed on the aquifer soils because of much lower organic carbon concentrations. Based on site-specific data, the K_d for PCP in groundwater is 0.6 L/kg.

TABLE 4-2
Development of Groundwater Media
Remedial Alternatives
Penta Wood Products Site

Remedial Technologies / Process Options	Groundwater Media Remedial Alternatives				
	G1 No Further Action	G2 LNAPL Collection and Monitored Natural Attenuation	G3 Groundwater Collection and Treatment	G4 Groundwater Collection and Treatment Throughout Plume	G5 Steam Injection With SVE
No Further Action	X				
Monitoring		X	X	X	X
Land Use Restrictions		X	X	X	X
Alternate Water Supply		X	if necessary	if necessary	if necessary
Groundwater Collection Wells			X	X	X
LNAPL Collection		X	X	X	X
Steam Injection with SVE Collection					X
GAC Adsorption			X	X	X
Precipitation and Filtration			[a]	[a]	[a]
Discharge to Doctor Lake			[b]	[b]	[b]
Discharge Via Infiltration Trenches			X	X	X
Recovered LNAPL Incineration		X	X	X	X

[a] Precipitation of iron and manganese may be necessary for discharge to Doctor Lake.

[b] Discharge to Doctor Lake will be considered if discharge limits result in more cost-effective treatment processes.

Biodegradation pathways and half lives for PCP were described earlier for the soil media Alternative S2. Based on the site groundwater data, anaerobic conditions are present in the groundwater below the source area and return to aerobic conditions at the plume perimeter. To provide a preliminary evaluation of the feasibility of the groundwater natural attenuation alternative, the BIOSCREEN groundwater transport and degradation model was run for the PWP site. This model was developed by the Air Force Center for Environmental Excellence as a screening tool to determine the feasibility of natural attenuation. It models groundwater contaminant dispersion, retardation, and biodegradation either based on first order decay rates or on the availability of electron acceptors (referred to as the instantaneous reaction model). Results are presented in Appendix D. Using first order degradation half lives of 30 to 266 days resulted in PCP migration from the source area a maximum distance of 100 to 200 feet. The relatively short migration distance is related to the slow groundwater velocity of 38 feet/year in combination with a PCP retardation factor of 3.5. PCP migrated up to about 600 feet from the source area after 60 years, based on the instantaneous reaction model. Sensitivity runs using the model indicate results are very sensitive to small changes in the PCP retardation factor and the amount of available electron acceptors (e.g., oxygen, nitrate, ferric iron, sulfate and carbon dioxide).

The main remedial components of Alternative G2 are:

- Institutional controls
- LNAPL removal
- Environmental monitoring
- Point-of-use carbon treatment, if necessary

4.3.2.1. Institutional Controls

Institutional controls include well drilling restrictions to prevent exposure to contaminated groundwater. Also, the existing production wells PW-1 and PW-2 would be abandoned under this alternative. A restrictive covenant would be placed on the PWP property deed that would specify that production wells not be installed within the plume or within areas in proximity to the plume that could affect plume migration.

4.3.2.2. LNAPL Removal

The objective of LNAPL removal is to remove LNAPL to the extent practicable to reduce a secondary source of PCP to the groundwater. Previous investigations have shown that measurable LNAPL is just north of the existing Oil-Water Separator treatment area.

LNAPL skimmer pumps will be installed in extraction wells where LNAPL has been previously been found (MW 10S, 19, and 20). The LNAPL recovery system will consist of LNAPL recovery pumps, LNAPL sensing probes, connecting pipes, controls, and storage tank. Operation of the LNAPL recovery system is continuous. Routine maintenance of the LNAPL sensing probes will be required. In addition, the contents of the storage tank will need to be pumped out periodically. The LNAPL is considered a listed F032 hazardous waste and will be incinerated at a RCRA Subtitle C TSD facility.

4.3.2.3. Environmental Monitoring

PCP concentrations in ground water have been monitored at the site since 1988, and some of the wells have 11 rounds of sampling data. PCP groundwater concentrations have shown consistent declines at the majority of monitoring wells over time, although many of the wells have only been monitored for three years. There is a general decrease in the size of the PCP plume, and the total contaminant mass of PCP in the saturated zone has declined from 1994. Contaminated ground water is not discharging to the wetland, or migrating below the wetland to surface water bodies.

Additional evidence that PCP is biodegrading in ground water is supported by the natural attenuation parameter data. The ground water is under anaerobic conditions in both the unconfined and semiconfined aquifer in the LNAPL plume area. The anaerobic plume is not expanding which is important since aerobic biodegradation has a faster decay rate than anaerobic biodegradation.

Environmental monitoring will be used to assess the degree of ongoing natural attenuation and allow estimates of the time necessary to reach remedial goals. If monitoring data indicate spreading of the plume above remedial goals, active restoration with one of the remaining alternatives (G3 or G4) will be implemented.

The objective of the monitoring program is to collect sufficient information to track the lateral and vertical extent of the PCP contaminant plume, monitor benzene and napthalene concentrations, and provide additional natural attenuation data to evaluate biodegradation of PCP. The program will also allow assessment of continued releases from the source area.

The groundwater monitoring network for Alternative G2 will include the following wells:

- Unconfined monitoring wells 1, 2, 6S, 9, 10S, 13, 16, and 19
- Semiconfined monitoring wells 3, 4, 5, 7, 8, 10, 11, 12, 14, 15, 17
- Two residential wells

The monitoring wells will be sampled annually and analyzed for PCP, benzene, napthalene, and TAL metals and for the following natural attenuation indicator parameters:

- DO
- pH, temperature, and specific conductance
- Oxidation/reduction potential
- Alkalinity
- Nitrate-and nitrite-nitrogen
- Sulfate-and sulfide-sulfur
- Total iron, ferrous iron, and ferric iron
- Manganese
- Carbon dioxide
- Chloride

A smaller subset of five monitoring wells (MW 3, 10, 10S, 13, 15) will be sampled and analyzed for the above parameters (excluding benzene and napthalene) on a quarterly basis.

The alternative includes development of a groundwater flow and solute transport model to allow prediction of contaminant transport and degradation. The model will be updated annually based on the monitoring results to reflect actual conditions.

4.3.2.4. Point-of-Use Carbon Treatment.

Point-of-use carbon treatment for the residential wells located south of the site may be necessary if PCP exceed groundwater quality standards. The carbon will consist of two canisters installed in series, the downstream one installed for redundancy. The upstream canister will be replaced when predicted breakthrough occurs. The time to breakthrough will be calculated using conservative carbon adsorption chemical-specific modeling.

4.3.3. Groundwater Alternative 3-Groundwater Collection and Treatment

The objective of Groundwater Media Alternative 3 (G3) is to remove the free phase LNAPL and treat the grossly PCP-contaminated groundwater plume (> 1,000 µg/L PCP). The remainder of the PCP plume will be allowed to naturally attenuate. Another objective of this alternative is to reduce the elevation of the water table to expose the LNAPL residual smear zone and allow bioventing of soil media Alternatives S4 and S5 to biodegrade PCP that would otherwise not be exposed to air.

LNAPL removal will consist of separately collecting the LNAPL and storing it in a designated storage tank for transport offsite for recycle and/or disposal. Groundwater treatment will consist of LNAPL removal and carbon adsorption before being discharged back onsite. From pore exchange modeling it is estimated that over 90 percent of the PCP found in the groundwater captured by this alternative would be removed after 5 years (see Appendix F).

The main remedial components of Alternative G3 are:

- Institutional controls
- LNAPL removal
- Grossly contaminated groundwater treatment
- Environmental monitoring
- Point-of-use carbon treatment, if necessary

The institutional controls and point-of-use carbon treatment components are as described for Alternative G2.

4.3.3.1. LNAPL Removal

The objective of LNAPL removal is to remove LNAPL to the extent practicable to reduce a secondary source of PCP to the groundwater. Previous investigations have shown that measurable LNAPL is just north of the existing Oil-Water Separator treatment area.

The LNAPL removal system will be part of the groundwater extraction and treatment system. Designated LNAPL recovery systems will be installed in extraction wells where LNAPL has been previously been found. Other groundwater extraction wells will be designed so that a LNAPL recovery system can be easily installed. In addition, all groundwater extraction systems will also include an oil-water separator to capture LNAPL not captured by the designated LNAPL recovery systems.

The system schematic is shown on Figure 4-3. The designated LNAPL recovery systems will consist of LNAPL recovery pumps, LNAPL sensing probes, connecting pipes, controls, and storage tank. The controls will be located within the groundwater treatment building and will include on-off operation, storage tank high-level shutoff, and remote sensing alarms.

The groundwater table would be dropped slowly initially to avoid further smearing of LNAPL. Once LNAPL has been removed and little is accumulating in the wells, the water table would be dropped to as close to the elevation of the till semi-confining lense as possible (about 10 feet below the current water table elevation).

Operation of the LNAPL recovery system is continuous. Routine maintenance of the LNAPL sensing probes will be required. In addition, the contents of the storage tank will need to be pumped out periodically. The LNAPL is considered a F032-listed hazardous waste and will therefore be incinerated at a RCRA Subtitle C TSD facility.

4.3.3.2. Grossly Contaminated Groundwater Treatment

The objective of this component is to collect and treat the most concentrated portions (exceeding 1,000 µg/L PCP) of the PCP groundwater plumes. The less contaminated portions of the PCP groundwater plumes will be allowed to naturally attenuate, as described in the Alternative G2. The groundwater extraction treatment system will consist of extraction wells, extraction pumps, connecting piping, oil-water separator, controls, treatment train, building, and infiltration basins.

Figure 4-4 shows a schematic of the Alternative G3. Based on a previous pump test in the deeper confined aquifer, an extraction flow of 10 gpm yields a radius of influence of approximately 200 feet (*Remedial Investigation and Corrective Action Plan*, Conestoga-Rovers & Associates, March 1992). Therefore, 5 extraction wells in the vicinity of the gully and lagoon source area are required. More recent well development data suggests that flows could be more on the order of 3 to 5 gpm in the unconfined aquifer. It is assumed that the combined flow rate from each well is 10 gpm, resulting in a total collection system flow rate of 50 gpm. The wells will be constructed with 6-inch PVC pipe with 40 feet of screen below the water table and 10 feet above—a total of approximately 140 feet well depth.

The extraction pumps will be submerged and capable of pumping 2 to 10 gpm against 200 feet of total head. Groundwater will be discharged to the oil-water separator, the GAC vessels, and then out to the infiltration areas. Controls will include on-off operation, high level alarms on the oil-water separator, and alarms should the infiltration areas become clogged. If this groundwater alternative is combined with the soil alternatives that include bioventing, the system would be operated for 10 years to remove the majority of the PCP contaminant mass and keep the water table lowered while the bioventing system is in operation.

The groundwater will be treated to Wisconsin PALs and discharged to infiltration basins. The infiltration basins will be located outside the zone of capture of the groundwater collection system and in an area that does not have soil contamination. Alternatively the water could be reinjected in wells that do not extend to the water table, allowing the reinjected water to travel through a soil layer before reaching the groundwater.

A third option would consist of locating the infiltration basins inside the zone of capture of the groundwater collection system. This would allow moisture levels to be kept at an optimum for the microorganisms.

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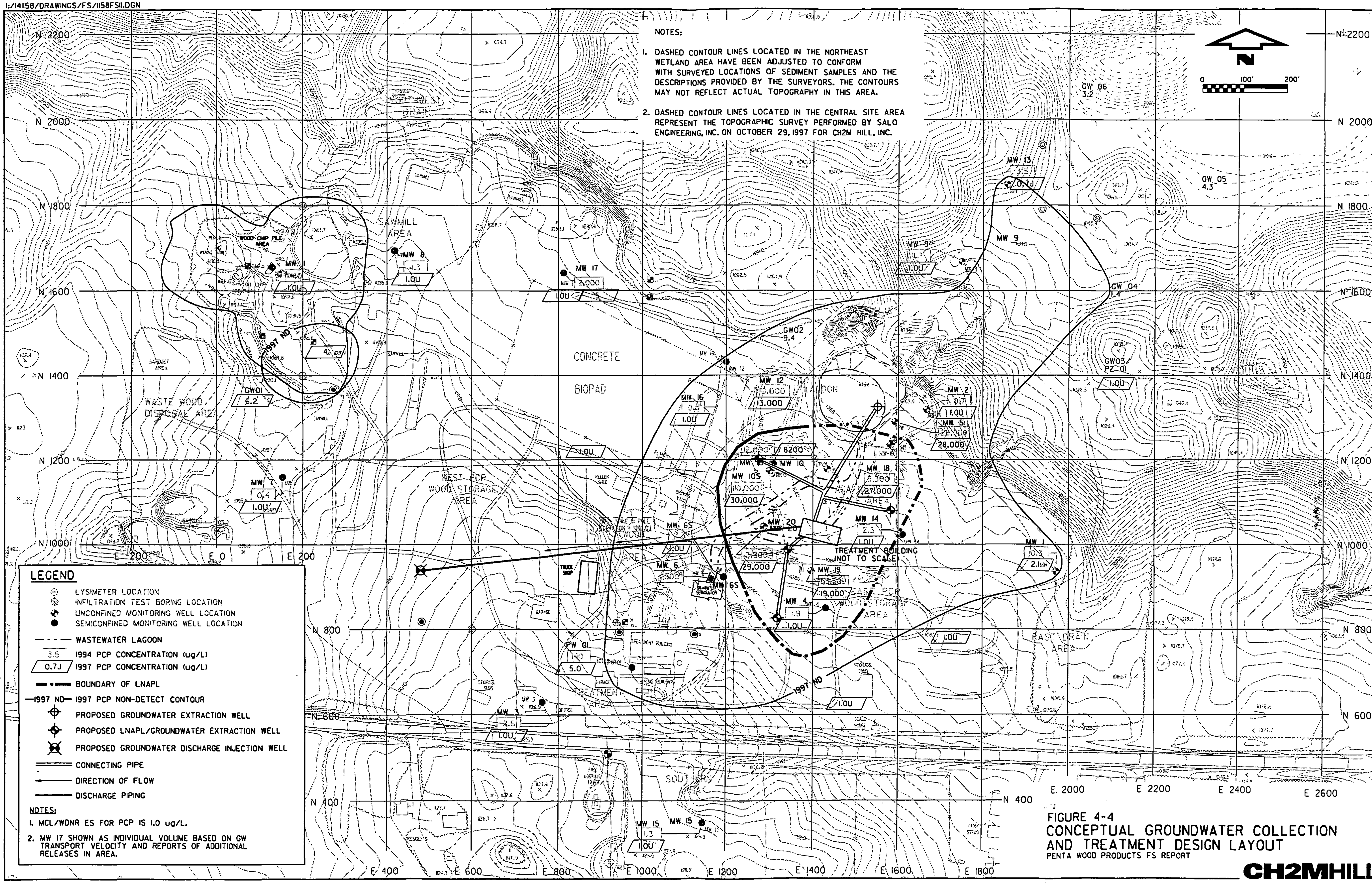

FIGURE 4-4
CONCEPTUAL GROUNDWATER COLLECTION AND TREATMENT DESIGN LAYOUT
PENTA WOOD PRODUCTS FS REPORT

4.3.3.3. Environmental Monitoring

Environmental monitoring will be used to assess the effectiveness of LNAPL removal and groundwater treatment and to assess the degree of natural attenuation. If monitoring data indicate further spreading of the plume above remedial goals, treatment process modifications, such as the installation of additional extraction wells, may be necessary.

The groundwater monitoring network for G3, the parameters to be measured, and the frequency is the same as that described for Alternative G2.

4.3.4. Groundwater Alternative 4—Groundwater Collection and Treatment Throughout Plume

The objective of Groundwater Media Alternative 4 (G4) is to remove the free phase LNAPL and to collect and treat the PCP-contaminated groundwater plume (> 1 µg/L PCP).

LNAPL removal will consist of separately collecting the LNAPL and storing it in a designated storage tank for transport offsite for incineration. Groundwater treatment will consist of LNAPL removal and carbon adsorption. The treated groundwater will be discharged to infiltration basins onsite.

Because this alternative could be paired with any of the Soil media alternatives, evaluation of this alternative will include estimates of contaminant transport under varying source loadings from the unsaturated zone. It is estimated that over 90 percent of the PCP found in the groundwater captured by this alternative would be removed after 10 years (see Appendix F) and over 99% would be removed after 30 years.

The main remedial components of Alternative G4 are:

- Institutional controls
- LNAPL removal
- Groundwater treatment
- Environmental monitoring
- Point-of-use carbon treatment, if necessary

The institutional controls, LNAPL removal, environmental monitoring, and residential point-of-use carbon treatment components are as described for Alternative G2.

4.3.4.1. Groundwater Treatment

The objective of this component is to treat PCP-contaminated groundwater plumes exceeding 1µg/L PCP. The groundwater extraction treatment system will consist of extraction wells, extraction pumps, connecting piping, oil-water separator, controls, treatment train, building, and infiltration basins.

Figure 4-5 shows a schematic of the S4 alternative. The description for the S4 is similar to that described for alternative S3 with the exception that a total of fourteen extraction wells will be used: thirteen in the vicinity of the gully and lagoon source area, and one in the vicinity of MW-8. The most recent RI data at MW 17 show this area to be below 1 ug/L, groundwater collection in the vicinity of MW-17 will not be necessary. The system is assumed to be operated for the entire 30 year present worth cost estimating period.

Groundwater would be treated using an oil- water separator followed by GAC adsorption. Treated groundwater would be discharged to infiltration basins outside the area of groundwater capture and in an area without soil contamination.

4.3.5. Groundwater Alternative 5—Steam Injection in Conjunction With SVE

The objective of Groundwater Media Alternative 5 (G5) is to target the PCP/LNAPL residual zone area using steam injection in conjunction with SVE. The remainder of the PCP plume will be allowed to naturally attenuate. It is estimated approximately 90 percent of the PCP in the LNAPL residual zone will be recovered with steam injection with SVE in 7.5 years time.

The main remedial components of G5 are:

- Institutional controls
- Steam Injection With SVE
- Environmental monitoring
- Point-of-use carbon treatment, if necessary

The institutional controls and point-of-use carbon treatment components are as described for Alternative G2.

4.3.5.1. Steam Injection in Conjunction with SVE

The objective of this component is to inject steam to recover the PCP/LNAPL mixture through subsurface volatilization. Steam is injected into injection wells that are screened in the zone of the PCP/LNAPL residual. The steam then moves in a thermal front out towards the SVE wells, first physically displacing the LNAPL towards the extraction wells. The LNAPL/PCP mixture is then volatilized when the removal process shifts from displacement to volatilization (USEPA 1998a). The steam-volatilized PCP/LNAPL mixture is withdrawn from these extraction wells and recovered at the surface. Groundwater is also pumped out of these wells to provide for a capture zone for the PCP/LNAPL mixture that may have re-solubilized. This section describes the construction and operation of the system.

Construction. The proposed layout of the system is shown on Figure 4-6. Treatment will be conducted in 100 X 100-foot cells given the high costs associated with the process equipment and fuel. The cells are shown as grids on Figure 4-6.

The steam injection system will consist of injection and extraction wells, connecting piping, boiler, blower, condensation/decant unit, catalytic oxidizer, and groundwater extraction pumps. Approximately 120 total wells will be installed in the 4-acre LNAPL residual zone area, half of which will be used to inject steam and the other half to extract the volatized PCP/LNAPL mixture. The injection and extraction wells will be 4-inch ID and constructed with approximately 10 feet of stainless steel screen and 100 feet of cast iron risers. The wells will be connected to piping that will serve as the conveyance system to and from the treatment system process equipment.

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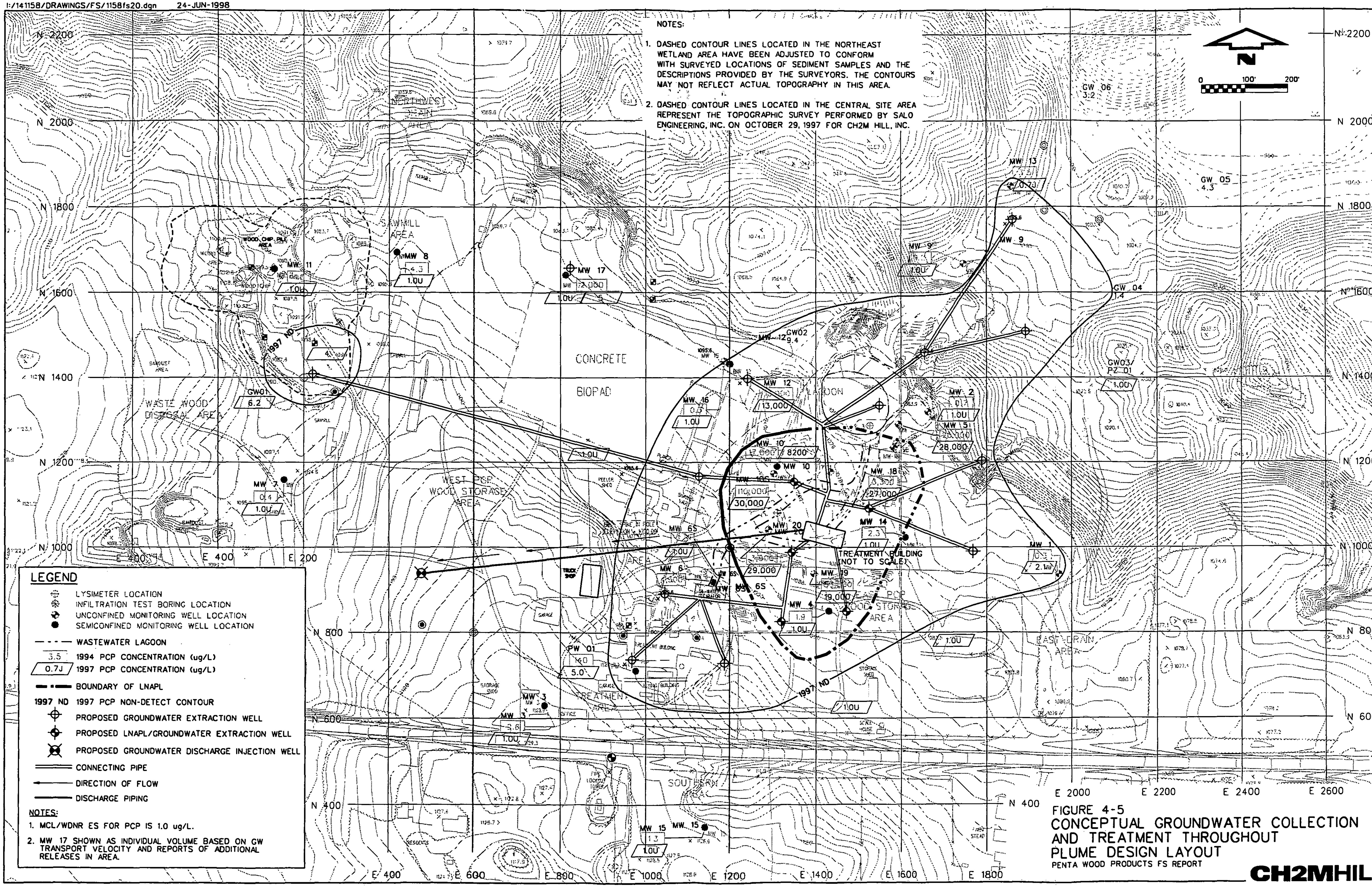

FIGURE 4-5
CONCEPTUAL GROUNDWATER COLLECTION AND TREATMENT THROUGHOUT PLUME DESIGN LAYOUT
PENTA WOOD PRODUCTS FS REPORT

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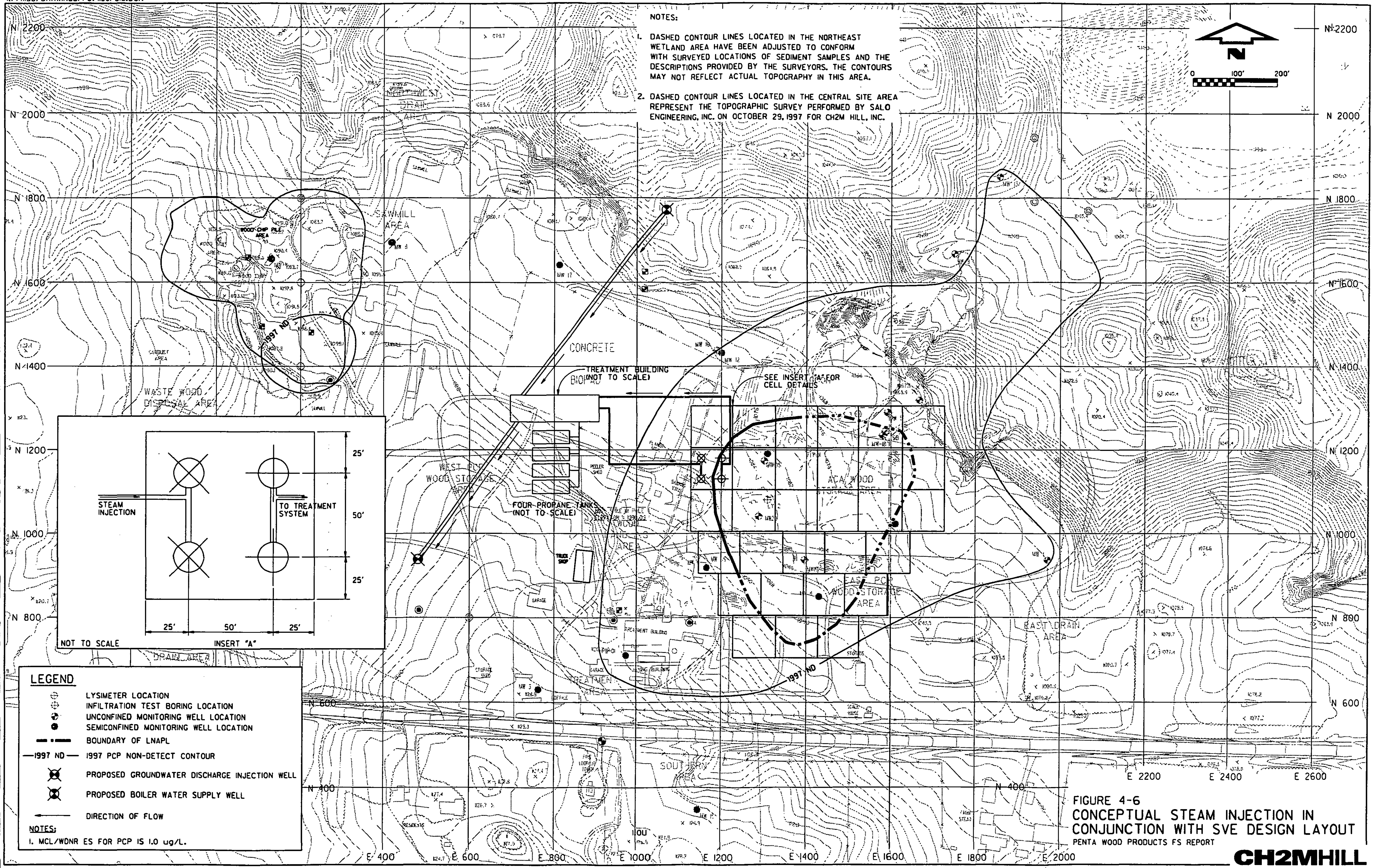

FIGURE 4-6
CONCEPTUAL STEAM INJECTION IN CONJUNCTION WITH SVE DESIGN LAYOUT
PENTA WOOD PRODUCTS FS REPORT

CH2MHILL

The boiler will be capable of producing 10,000 lb/hr of steam to the injection points. Water will be pumped from a separate groundwater supply well, which will be installed in an uncontaminated area in the western portion of the site. Before use, it will first be treated via a boiler make-up treatment system. Liquid propane will be used to heat the steam. Approximately 150 gallons/hour of liquid propane is required to produce 10,000 lb of steam per hour.

A condensed unit in conjunction with a decant tank will be utilized to recover the volatilized PCP/LNAPL/steam mixture. The volatized PCP/LNAPL/steam will be extracted via the blower, condensed and decanted. The LNAPL is considered a F032-listed hazardous waste and will therefore be incinerated at a RCRA Subtitle C TSD facility. The recovered water will be treated with GAC and recycled for re-use in the boiler. Air emissions from the distillation process will be treated using catalytic oxidation.

Groundwater recovery will also be necessary to control and capture PCP/LNAPL that may have mobilized. Approximately 8 wells will be used for groundwater recovery. The groundwater will be treated via carbon adsorption and either re-used as boiler make-up or discharged to infiltration trenches on-site. For costing purposes, it is assumed that treatment for both the condensate and the groundwater will total about 60 gpm.

Operation. Length of operation of the steam injection system is based on length of time that is required to reduce the PCP to the extent practical and within reasonable costs. Based on vendor-supplied information, a treatment time of 3 months in each cell should be sufficient in reducing PCP to the extent practical. This corresponds to a total treatment time of about 7.5 years based on the 30 cells.

4.3.5.2. Environmental Monitoring

Environmental monitoring will be used to assess the effectiveness of LNAPL removal and groundwater treatment and to assess the degree of natural attenuation. If monitoring data indicate further spreading of the plume above remedial goals, treatment process modifications, such as the installation of additional extraction wells, may be necessary. Environmental monitoring will be similar to that described for Alternative G2.

SECTION 5

Detailed Analysis of Alternatives

5.1. Introduction

The detailed analysis of alternatives presents the relevant information needed to compare the remedial alternatives assembled for the PWP site. The detailed analysis of alternatives follows the development and screening of alternatives, and precedes the selection of a final remedy. The extent to which alternatives are fully evaluated during the detailed analysis is influenced by the available data and the number and types of alternatives being analyzed.

Detailed analysis of alternatives consists of the following components:

- A detailed evaluation of each alternative against the seven evaluation criteria
- A comparative evaluation

5.1.1. Evaluation Criteria

In accordance with the National Contingency Plan (NCP) and Wisconsin Administrative Code NR722.07 (NR722.07), remedial actions must:

- Be protective of human health and the environment
- Attain applicable or relevant and appropriate requirements (ARARs) or provide grounds for invoking a waiver of ARARs that cannot be achieved
- Be cost-effective
- Utilize permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume (TMV) as a principal element

In addition, the NCP emphasizes long-term effectiveness and related considerations including:

- The long-term uncertainties associated with land disposal
- The goals, objectives, and requirements of the Solid Waste Disposal Act
- The persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bio-accumulate
- The short-and long-term potential for adverse health effects from human exposure
- Long-term maintenance costs
- The potential for future remedial action costs if the selected remedial action fails
- The potential threat to human health and the environment associated with excavation, transportation, redisposal, or containment

Provisions of the NCP require that each alternative be evaluated against nine criteria listed in 40 CFR 300.430(e)(9). These criteria were published in the March 8, 1990 *Federal Register* (55 FR 8666) to provide grounds for comparison of the relative performance of the alternatives and to identify their advantages and disadvantages. This approach is intended to provide sufficient information to adequately compare the alternatives and to select the most appropriate alternative for implementation at the site as a remedial action. The evaluation criteria are:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- Community Acceptance
- State Acceptance

NR722.07 identifies a tenth criteria that also needs to be met. The criteria is:

- Restoration Time Frame

The criteria are divided into three groups: threshold, balancing, and modifying criteria. Threshold criteria must be met by a particular alternative for it to be eligible for selection as a remedial action. There is little flexibility in meeting the threshold criteria—either they are met by a particular alternative, or that alternative is not considered acceptable. The two threshold criteria are overall protection of human health and the environment, and compliance with ARARs. If ARARs cannot be met, a waiver may be obtained when one of the six exceptions listed in the NCP occur (see 40 CFR 300.430 (f)(1)(ii)(C)(1 to 6).

Unlike the threshold criteria, the five balancing criteria weigh the trade-offs between alternatives. A low rating on one balancing criterion can be compensated by a high rating on another. The five balancing criteria include:

- Long-term effectiveness and permanence
- Reduction of TMV through treatment
- Short-term effectiveness
- Restoration Time Frame
- Implementability
- Cost

The modifying criteria are community and state acceptance. These are evaluated following public comment and are used to modify the selection of the recommended alternative. The remaining seven evaluation criteria are briefly described below.

5.1.1.1. Threshold Criteria

To be eligible for selection, an alternative must meet the two threshold criteria described below, or in the case of ARARs, must justify why a waiver is appropriate.

- **Overall Protection of Human Health and the Environment.** Protectiveness is the primary requirement that remedial actions must meet under Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). A remedy is protective if it adequately eliminates, reduces, or controls all current and potential risks posed by the site through each exposure pathway. The assessment against this criterion describes how the alternative achieves and maintains protection of human health and the environment.

- **Compliance with ARARs.** Compliance with ARARs is one of the statutory requirements of remedy selection. ARARs are cleanup standards, standards of control, and other substantive environmental statutes or regulations which are either "applicable" or "relevant and appropriate" to the CERCLA cleanup action (42 USC 9621 [d] [2]). Applicable requirements address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site. Relevant and appropriate requirements are those that while not applicable, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to environmental or technical factors at a particular site. The assessment against this criterion describes how the alternative complies with ARARs or presents the rationale for waiving an ARAR. ARARs can be grouped into three categories:

  - **Chemical-specific** ARARs are health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, establish the amount or concentration of a chemical that may remain in or be discharged to the environment.

  - **Location-specific** ARARs restrict the concentration of hazardous substances or the conduct of activities solely because they are in specific locations, such as flood plains, wetlands, historic places, and sensitive ecosystems or habitats.

  - **Action-specific** ARARs include technology- or activity-based requirements that set controls, limits, or restrictions on design performance of remedial actions or management of hazardous constituents.

5.1.1.2. Balancing Criteria

The five criteria listed below represent the criteria upon which the detailed evaluation and comparative analysis of alternatives is based.

- **Long-term Effectiveness and Permanence.** This criterion reflects CERCLA's emphasis on implementing remedies that will ensure protection of human health and the environment in the long term as well as in the short term. The assessment of alternatives against this criterion evaluates the residual risks at a site after completing a remedial action or enacting a no action alternative and includes evaluation of the adequacy and reliability of controls.

- **Reduction of TMV through Treatment.** This criterion addresses the statutory preference for remedies that employ treatment as a principal element. The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies an alternative may employ. The criteria is specific to evaluating only how treatment reduces TMV and does not address containment actions such as capping.
- **Short-term Effectiveness.** This criterion addresses short-term impacts of the alternatives. The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment (i.e., minimizing any risks associated with an alternative) during the construction and implementation of a remedy until the response objectives have been met.
- **Implementability.** The assessment against this criterion evaluates the technical and administrative feasibility of the alternative and the availability of the goods and services needed to implement it.
- **Cost.** Cost encompasses all engineering, construction, and operation and maintenance (O&M) costs incurred over the life of the project. The assessment against this criterion is based on the estimated present worth of these costs for each alternative. Present worth is a method of evaluating expenditures such as construction and O&M that occur over different lengths of time. This allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. The present worth of a project represents the amount of money, which if invested in the initial year of the remedy and disbursed as needed, would be sufficient to cover all costs associated with the remedial action. As stated in the Remedial Investigation (RI)/FS guidance (EPA, 1988a), these estimated costs are expected to provide an accuracy of plus 50 percent to minus 30 percent. Appendix G provides a breakdown of the cost estimate for each of the alternatives.

The level of detail required to analyze each alternative against these evaluation criteria depends on the nature and complexity of the site, the types of technologies and alternatives being considered, and other project-specific considerations. The analysis is conducted in sufficient detail to understand the significant aspects of each alternative and to identify the uncertainties associated with the evaluation.

5.2. Detailed Evaluation of Remedial Alternatives

5.2.1. Detailed Evaluation of Soil Media Alternatives

The following five alternatives for the soils were developed and described in Section 4:

- No Further Action
- Soil Cover and Natural Attenuation
- Capping
- Bioventing
- Ex Situ Biological Treatment and Bioventing

These five alternatives were evaluated in detail using the seven evaluation criteria described in Section 5.1. The detailed evaluations for the soil media alternatives are presented in Table 5-1.

TABLE 5-1
Detailed Evaluation of Soil Media Alternatives
Penta Wood, Feasibility Study Report

Alternative Description: Criterion	Alternative S1—No Further Action	Alternative S2—Soil Cover and Natural Attenuation	Alternative S3—Capping	Alternative S4—Soil Cover and Bioventing	Alternative S5—Ex Situ Biological Treatment and Bioventing
1. Overall protection of human health and the environment.	▪ Sesoil modeling of PCP leaching shows PCP is migrating downward at 005 ft/yr assuming no enhanced infiltration. Given even very slow natural degradation rates, only soils within a few feet of the water table will contribute PCP at concentrations sufficient to cause continued exceedance of EPA's Mass Concentration Limits (MCLs) or Wisconsin Administrative Code Prevention Action Limits (PALs). These soils are also heavily contaminated with LNAPL residual and will continue to leach for decades. ▪ Human exposure through contact, ingestion, or inhalation to shallow (<2 feet bgs) arsenic and PCP-contaminated soil in concentrations exceeding direct contact PRGs could still occur under this alternative. ▪ Erosion and off-site transport of soils containing PCP and metals in excess of PRGs would continue under this alternative. ▪ Unacceptable risks to ecological receptors exposed to PCP, arsenic, and copper contaminated wetland sediments and surface water will not be prevented under this alternative.	▪ Sesoil modeling of PCP leaching shows PCP is migrating downward at 005 ft/yr. Given even very slow natural degradation rates, only soils within a few feet of the water table will contribute PCP at concentrations sufficient to cause continued exceedance to MCLs or PALs. These soils are also heavily contaminated with LNAPL residual and will continue to leach. The soil cover will reduce infiltration by increasing runoff and thus further reduce PCP leaching. ▪ Human exposure through contact, ingestion, or inhalation to shallow (<2 feet bgs) arsenic and PCP-contaminated soil in concentrations exceeding direct contact PRGs would be eliminated through the construction of the soil cover and use restrictions. ▪ Erosion and off-site transport of soils containing PCP and metals in excess of PRGs would be eliminated because erosion control measures are part of this alternative. ▪ Unacceptable risks to ecological receptors exposed to PCP, arsenic, and copper contaminated wetland sediments will be prevented because wetland sediment consolidation is part of this alternative. ▪ The solidification of arsenic contaminated soil >10-4 cancer risk before placing it under the cover helps to further reduce its leachability, even though it is relatively immobile before solidification.	▪ The cap will essentially eliminate infiltration preventing any further leaching from unsaturated zone soils above the water table. However because of water table fluctuations and because of the LNAPL, continued contaminant loadings from the soils immediately above the water table may continue for decades. ▪ Human exposure through contact, ingestion, or inhalation to shallow (<2 feet bgs) arsenic and PCP-contaminated soil in concentrations exceeding direct contact PRGs would be eliminated through the construction of the cap. ▪ Erosion and off-site transport of soils containing PCP and metals in excess of PRGs would be eliminated because erosion control measures are part of this alternative. ▪ Unacceptable risks to ecological receptors exposed to PCP, arsenic, and copper contaminated wetland sediments will be prevented because wetland sediment consolidation is part of this alternative. ▪ Capping will also reducing infiltration to the point that may adversely affect the moisture content of the soil and thus, the rate of natural attenuation. ▪ The solidification of arsenic contaminated soil >10-4 cancer risk before placing it under the cover helps to further reduce its leachability, even though it is relatively immobile before solidification.	▪ Enhancing aerobic biodegradation of PCP in the unsaturated zone soils by blowing air into the subsurface will accelerate PCP concentration declines. The reduction of PCP to concentrations such it would not migrate to the groundwater in sufficient concentrations to cause an exceedance of MCLs or PALs may be achieved in 10 years. However, more time may be necessary because of substrate limiting or toxicity conditions. ▪ Human exposure through contact, ingestion, or inhalation to shallow (<2 feet bgs) arsenic and PCP-contaminated soil in concentrations exceeding direct contact PRGs would be eliminated through the construction of the soil cover. ▪ Erosion and off-site transport of soils containing PCP and metals in excess of PRGs would be eliminated because erosion control measures are part of this alternative. ▪ Unacceptable risks to ecological receptors exposed to PCP, arsenic, and copper contaminated wetland sediments will be prevented because wetland sediment consolidation is part of this alternative. ▪ The solidification of arsenic contaminated soil >10-4 cancer risk before placing it under the cover helps to further reduce its leachability, even though it is relatively immobile before solidification.	▪ Ex situ biological treatment of the top ten feet of contaminated soil/wood debris is likely to achieve substantial PCP degradation over the operational period. As previously described however, Sesoil modeling of PCP leaching shows PCP is migrating downward at 005 ft/yr. Given even very slow natural degradation rates, only soils within a few feet of the water table will contribute PCP at concentrations sufficient to cause continued exceedance to MCLs or PALs. ▪ Enhancing aerobic biodegradation of PCP in the unsaturated zone soils by blowing air into the subsurface will accelerate PCP concentration declines. The reduction of PCP to concentrations such it would not migrate to the groundwater in sufficient concentrations to cause an exceedance of MCLs or PALs may be achieved in 10 years. However, more time may be necessary because of substrate limiting or toxicity conditions. ▪ Human exposure through contact, ingestion, or inhalation to shallow (<2 feet bgs) arsenic and PCP-contaminated soil in concentrations exceeding direct contact PRGs would be eliminated through the construction of the soil cover and the active treatment of the shallow contaminated soil exceeding PRGs. ▪ Erosion and off-site transport of soils containing PCP and metals in excess of PRGs would be eliminated because erosion control measures are part of this alternative. ▪ Unacceptable risks to ecological receptors exposed to PCP, arsenic, and copper contaminated wetland sediments will be prevented because wetland sediment consolidation is part of this alternative. ▪ The solidification of arsenic contaminated soil >10-4 cancer risk before placing it under the cover helps to further reduce its leachability, even though it is relatively immobile before solidification.

Table 5-1 Contd.
Detailed Evaluation of Soil Media Alternatives
Penta Wood, Feasibility Study Report

Alternative Description: Criterion	Alternative S1—No Further Action	Alternative S2—Soil Cover and Natural Attenuation	Alternative S3—Capping	Alternative S4—Soil Cover and Bioventing	Alternative S5—Ex Situ Biological Treatment and Bioventing
2. Compliance with ARARs*	▪ Would meet ARARs when PCP migration into the groundwater does not result in concentrations that exceed groundwater MCLs or PALs. Under this alternative, this would take decades. ▪ Would not meet ARARs with respect to direct contact for soil because of exposure for shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs direct contact soil concentrations. ▪ Would not meet ARARs with respect to wetlands because erosion into the wetlands will continue under this alternative. The erosion of PCP/oil, arsenic, copper, and zinc into the wetlands will result in these concentrations to continually exceed surface water and sediment ARARs.	▪ Would meet NR 720 ARARs for protection of groundwater through the use of engineering controls and natural attenuation. PCP in soil near the water table would continue to cause exceedance of MCLs and PALs for decades. ▪ Would meet ARARs with respect to direct contact for soil because cover eliminates exposure to shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs direct contact soil concentrations. ▪ Would meet ARARs with respect to wetlands because this alternative includes wetland sediment consolidation and erosion control measures. The erosion control measures would eliminate erosion into the wetlands. ▪ May require Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers to meet ARARs associated with the classification, treatment, disposal, and/or placement of listed hazardous wastes.	▪ Would meet NR 720 ARARs for protection of groundwater through the use of engineering controls and natural attenuation. PCP in soil near the water table would continue to cause exceedance of MCLs and PALs for decades. ▪ Would meet ARARs with respect to direct contact for soil because capping eliminates exposure to shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs direct contact soil concentrations. ▪ Would meet ARARs with respect to wetlands because this alternative includes wetland sediment consolidation and erosion control measures. The erosion control measures would eliminate erosion into the wetlands. ▪ May require Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers to meet ARARs associated with the classification, treatment, disposal, and/or placement of listed hazardous wastes.	▪ NR 720 ARARs for protection of groundwater are met through use of engineering controls and contaminant reduction via bioventing. Soil ARARs for protection of soil may be met in 10 years. ▪ Would meet ARARs with respect to direct contact for soil because this alternative also includes a soil cover. The cover eliminates exposure to shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs direct contact soil concentrations. ▪ Would meet ARARs with respect to wetlands because this alternative includes wetland sediment consolidation and erosion control measures. The erosion control measures would eliminate erosion into the wetlands. ▪ May require Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers to meet ARARs associated with the classification, treatment, disposal, and/or placement of listed hazardous wastes.	▪ NR 720 ARARs for protection of groundwater are met through use of engineering controls and contaminant reduction via bioventing. Soil ARARs for protection of soil may be met in 10 years. ▪ Would meet ARARs with respect to direct contact for soil because this alternative includes active treatment of shallow (<10 feet bgs) PCP and arsenic contamination that exceed direct contact PRGs soil concentrations. This alternative also includes a soil cover. The cover eliminates exposure to shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs direct contact soil concentrations. ▪ Would meet ARARs with respect to wetlands because this alternative includes wetland sediment consolidation and erosion control measures. The erosion control measures would eliminate erosion into the wetlands. ▪ May require Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers to meet ARARs associated with the classification, treatment, disposal, and/or placement of listed hazardous wastes. ▪ Would meet ARARs with respect to the Clean Air Act because emissions from the treatment piles are expected to be minimal.

TABLE 5-1 CONTD.
Detailed Evaluation of Soil Media Alternatives
Penta Wood, Feasibility Study Report

Alternative Description: Criterion	Alternative S1—No Further Action	Alternative S2—Soil Cover and Natural Attenuation	Alternative S3—Capping	Alternative S4—Soil Cover and Bioventing	Alternative S5—Ex Situ Biological Treatment and Bioventing
3. Long-term effectiveness and permanence					
(a) Magnitude of residual risks	▪ No significant change in risk because no action taken. Reduction in risk relating to the PCP migration into the groundwater that may result in concentrations that exceed groundwater MCLs or Wisconsin Prevention Action Limits (PALs) would occur slowly over decades. ▪ Under this alternative, there would be no reduction in risk with respect to exposure for shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs for direct contact. Risk would continue to exceed 10^{-4} excess lifetime cancer risk and exceed the HI of 1. ▪ There would be no reduction in risk with respect to erosion because erosion into the wetlands will continue under this alternative.	▪ Once the soil cover is in place nearly all risks related to soil would be eliminated. Some minor leaching of PCP may occur near the water table that could continue to cause exceedance of MCLs and PALs, but this is greatly overshadowed by the leaching from the LNAPL in the smear zone and PCP desorption from soils under high water table fluctuations. ▪ The soil cover would eliminate the risk with respect to exposure for shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs for direct contact. ▪ Erosion of contaminated soil would essentially be eliminated under this alternative. ▪ Nearly all risk related to ecological receptors exposed to PCP or metal-contaminated wetland sediments would be eliminated because wetland sediment is removed and placed on-site under the soil cover.	▪ Once the cap is in place nearly all risks related to soil would be eliminated. Leaching from the LNAPL in the smear zone and PCP desorption from soils under high water table fluctuations would continue to contribute nearly all the PCP mass to the groundwater. ▪ The cap would eliminate the risk with respect to exposure for shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs for direct contact. ▪ Erosion of contaminated soil would essentially be eliminated under this alternative. ▪ Nearly all risk related to ecological receptors exposed to PCP or metal-contaminated wetland sediments would be eliminated because wetland sediment is removed and placed on-site under the cap.	▪ Once bioventing is completed nearly all risk related to soil would be eliminated. Leaching from the LNAPL in the smear zone and PCP desorption from soils under high water table fluctuations would continue to contribute nearly all the PCP mass to the groundwater. ▪ The soil cover would eliminate the risk with respect to exposure for shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs for direct contact. ▪ Erosion of contaminated soil would essentially be eliminated under this alternative. ▪ Nearly all risk related to ecological receptors exposed to PCP or metal-contaminated wetland sediments would be eliminated because wetland sediment is removed and placed on-site under the soil cover.	▪ Once ex situ biological treatment and bioventing are completed nearly all risk related to soil would be eliminated. Leaching from the LNAPL in the smear zone and PCP desorption from soils under high water table fluctuations would continue to contribute nearly all the PCP mass to the groundwater. ▪ The shallow soil treatment and soil cover would eliminate the risk with respect to exposure for shallow (<2 feet bgs) PCP and arsenic contamination that exceed PRGs direct contact soil concentrations. ▪ Erosion of contaminated soil would essentially be eliminated under this alternative. ▪ Nearly all risk related to ecological receptors exposed to PCP or metal-contaminated wetland sediments would be eliminated because wetland sediment is removed and placed on-site under the soil cover.
(b) Adequacy and reliability of controls	▪ Not applicable.	▪ Requires reliance on continued maintenance of soil cover. This reliance will be reduced when vegetation is allowed to grow and naturally sustain the soil cover. ▪ Deed restrictions are necessary to maintain the integrity of the soil cover and prevent direct contact. ▪ Ecological receptors that burrow to depths greater than 1 foot would contact contaminants may come in contact with the PCP and metals below the soil cover; regardless, quality of onsite habitat is poor.	▪ Requires reliance on for continued maintenance of cap. This reliance will be reduced when vegetation is allowed to grow and naturally sustain the cap. ▪ Deed restrictions are necessary to maintain the integrity of the cap and prevent direct contact.	▪ Requires reliance on maintenance of soil cover. This reliance will be reduced when vegetation is allowed to grow and naturally sustain the soil cover. ▪ There are no controls in place to address the continued migration of PCP to the groundwater. Bioventing will help reduce the PCP migration and thus minimize the need for such controls. ▪ Deed restrictions are necessary to maintain the integrity of the soil cover and prevent direct contact. ▪ Bioventing may not be able to achieve the low PRGs for direct contact and protection of groundwater if the substrate becomes limiting in areas of high PCP concentrations, or if toxicity inhibits biological growth. ▪ Ecological receptors that burrow to depths greater than 1 foot would contact contaminants may come in contact with the PCP and metals below the soil cover; regardless, quality of onsite habitat is poor.	▪ No institutional controls to reduce the risk with respect to exposure of shallow soil contamination exceeding concentrations of Wisconsin direct contact PRGs are necessary. This alternative actively treats this contamination. ▪ Deed restrictions are necessary to maintain the integrity of the soil cover and prevent direct contact. ▪ Placement of treated soil back on-site introduces some uncertainty in the long-term containment of contaminants. This uncertainty will be minimized by making sure the treated soil passes TCLP before being placed back on-site. ▪ Bioventing may not be able to achieve the low PRGs for direct contact and protection of groundwater if the substrate becomes limiting in areas of high PCP concentrations, or if toxicity inhibits biological growth. ▪ Ex situ biological treatment is expected to reliably treat the majority of PCP. However, given the limited time of 6 months for each treatment period, the low LDRs or soil PRGs may not be achievable. ▪ Ecological receptors that burrow to depths greater than 1 foot would contact contaminants may come in contact with the PCP and metals below the soil cover; regardless, quality of onsite habitat is poor.

TABLE 5-1 CONTD.
Detailed Evaluation of Soil Media Alternatives
Penta Wood, Feasibility Study Report

Alternative Description: Criterion	Alternative S1—No Further Action	Alternative S2—Soil Cover and Natural Attenuation	Alternative S3—Capping	Alternative S4—Soil Cover and Bioventing	Alternative S5—Ex Situ Biological Treatment and Bioventing
4. Reduction of toxicity, mobility, or volume through treatment					
(a) Treatment process used	• Not applicable.	• Natural attenuation. • Solidification of arsenic-contaminated soil >10-4 cancer risk.	• Solidification of arsenic-contaminated soil >10-4 cancer risk.	• Bioventing. • Solidification of arsenic-contaminated soil >10-4 cancer risk.	• Ex-situ biological treatment of shallow soil/wood debris (<10 feet bgs) via biopiles or white rot fungus in conjunction with bioventing. • Solidification of arsenic-contaminated soil >10-4 cancer risk.
(b) Degree and quantity of TMV reduction	• Not applicable	• Natural attenuation would take decades. • Solidification of the arsenic-contaminated soil increases the volume of soil by about 30 %. The mobility of the arsenic in the soil is greatly reduced, although the arsenic is relatively immobile prior to treatment.	• Solidification of the arsenic-contaminated soil increases the volume of soil by about 30 %. The mobility of the arsenic in the soil is greatly reduced, although the arsenic is relatively immobile prior to treatment.	• Previous data appear to show that PCP would be reduced in the unsaturated zone in about 10 years. The existing estimated PCP mass in the unsaturated zone of 120,000 pounds is expected to be reduced to below 1,000 pounds. • Solidification of the arsenic-contaminated soil increases the volume of soil by about 30 %. The mobility of the arsenic in the soil is greatly reduced, although the arsenic is relatively immobile prior to treatment.	• Previous data appear to show that PCP would be reduced in the unsaturated zone in about 10 years. The existing estimated PCP mass in the unsaturated zone of 120,000 pounds is expected to be reduced to below 1,000 pounds. • Solidification of the arsenic-contaminated soil increases the volume of soil by about 30 %. The mobility of the arsenic in the soil is greatly reduced, although the arsenic is relatively immobile prior to treatment. • Previous ex situ biological treatment treatability studies performed by ERT show that PCP could be reduced by at least 75% in about 2 operating seasons (one treatment per season) for the biopile alternative. The PCP mass of an estimated 52,000 lbs in the shallow soil would be reduced to less than 13,000 lbs.
(c) Irreversibility of TMV reduction	• Not applicable	• Natural degradation is irreversible. • Solidification is reversible although solidified arsenic soil will be below soil cover.	• Solidification is reversible although solidified arsenic soil will be below soil cap.	• Bioventing is irreversible. • Solidification is reversible although solidified arsenic soil will be below soil cover.	• Ex-situ biological treatment in conjunction with bioventing is irreversible. • Solidification is reversible although solidified arsenic soil will be below soil cover.
(d) Type and quantity of treatment residuals	• None, because no treatment included.	• The solidified arsenic-contaminated soil will be placed back on-site. An estimated 5,200 cubic yards will be replaced (4,000 cu. Yards X 1.3).	• The solidified arsenic-contaminated soil will be placed back on-site. An estimated 5,200 cubic yards will be replaced (4,000 cu. Yards X 1.3).	• No residuals associated with bioventing expected. • The solidified arsenic-contaminated soil will be placed back on-site. An estimated 5,200 cubic yards will be replaced (4,000 cu. Yards X 1.3).	• No residuals associated with bioventing expected. • The solidified arsenic-contaminated soil will be placed back on-site. An estimated 5,200 cubic yards will be replaced (4,000 cu. Yards X 1.3). • The treated PCP-contaminated soil will be placed back on-site.
(e) Statutory preference for treatment as a principal element	• Preference not met for PCP soil because no treatment included.	• Preference not met for PCP soil because natural attenuation is not considered treatment. • Preference met for solidified arsenic-contaminated soil because arsenic is one of the contaminants posing a principal threat in shallow soil (<2 feet bgs).	• Preference not met for PCP soil because treatment is not included. • Preference met for solidified arsenic-contaminated soil because arsenic is one of the contaminants posing a principal threat in shallow soil (<2 feet bgs).	• Preference met for soil because alternative includes treatment via bioventing, which treats PCP, the contaminant posing the principal threat in shallow and deeper soil (0 to 100 feet bgs). • Preference met for solidified arsenic-contaminated soil because arsenic is one of the contaminants posing a principal threat in shallow soil (<2 feet bgs).	• Preference met for soil because alternative includes biological treatment, which treats PCP, one of the contaminants posing the principal threat in the shallow soil (<10 feet bgs). • Preference met for soil because alternative includes treatment via bioventing, which treats PCP, the contaminant posing the principal threat in the deeper soil (>10 feet bgs). • Preference met for solidified arsenic-contaminated soil because arsenic is one of the contaminants posing a principal threat in shallow soil (<2 feet bgs).

TABLE 5-1 CONTD.
Detailed Evaluation of Soil Media Alternatives
Penta Wood, Feasibility Study Report

Alternative Description: Criterion	Alternative S1—No Further Action	Alternative S2—Soil Cover and Natural Attenuation	Alternative S3—Capping	Alternative S4—Soil Cover and Bioventing	Alternative S5—Ex Situ Biological Treatment and Bioventing
5. Short-term effectiveness					
(a) Protection of workers during remedial action	• No remedial construction, so no risks to workers.	• Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants, dermal absorption and inhalation of particulate. Environmental monitoring for dust and contaminant emissions is important to maintain the proper level of health and safety protection.	• Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants, dermal absorption and inhalation of particulate. Environmental monitoring for dust and contaminant emissions is important to maintain the proper level of health and safety protection.	• Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants, dermal absorption and inhalation of particulate. Environmental monitoring for dust and contaminant emissions is important to maintain the proper level of health and safety protection. • During remedial operations, risk to workers are limited to normal safety related risks related to construction accidents. Exposure to contaminants not expected because exposure risk eliminated during remedial construction.	• Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants, dermal absorption and inhalation of particulate. Environmental monitoring for dust and contaminant emissions is important to maintain the proper level of health and safety protection. • During remedial operations, risk to workers are increased due to the increased soil handling including mixing, placing, etc. Strict safety procedures will be followed to minimize these risks. Exposure to contaminants not expected because exposure risk eliminated during remedial construction.
(b) Protection of community during remedial action	• No remedial construction, so no short-term risks to community.	• Short-term health- related risks to community will be minimized through air monitoring and use of emission control techniques such as use of dust and contaminant emission suppressants. • Short-term safety-related risks to community may occur because about 400 truck loads of soil may be necessary to provide soil cover (the consolidation will all be on-site). Nuisance noise and dust will also occur.	• Short-term health- related risks to community will be minimized through air monitoring and use of emission control techniques such as use of dust and contaminant emission suppressants. • Short-term safety-related risks to community may occur because about 2,000 truck loads of soil may be necessary to import for cap construction (the consolidation will all be on-site). Nuisance noise and dust will also occur.	• Short-term health- related risks to community will be minimized through air monitoring and use of emission control techniques such as use of dust and contaminant emission suppressants. • Short-term safety-related risks to community may occur because about 400 truck loads of soil may be necessary to provide soil cover (the consolidation will all be on-site). Nuisance noise and dust will also occur. • During remedial operation, bioventing blowers will be designed to limit noise.	• Short-term health- related risks to community will be minimized through air monitoring and use of emission control techniques such as use of dust and contaminant emission suppressants. • Some odors are likely to occur as a result of the soil handling and mixing over the operational period of ex situ biological treatment. • Short-term safety-related risks to community may occur because about 400 truck loads of soil may be necessary to provide soil cover (the consolidation will all be on-site). Nuisance noise and dust will also occur. • During remedial operation, bioventing blowers will be designed to limit noise.
(c) Environmental impacts of remedial action	• No remedial construction, so no environmental impacts from remedial action.	• Environmental impacts will likely be limited to emissions of contaminants in dust and some migration via erosion. The impacts can be controlled through use of dust suppressants and implementation of an erosion control plan. Impacts are expected to be relatively minor. • With respect to wetland consolidation, environmental impacts will be minimized by following guidelines set forth by Army Corp of Engineers.	• Environmental impacts will likely be limited to emissions of contaminants in dust and some migration via erosion. The impacts can be controlled through use of dust suppressants and implementation of an erosion control plan. Impacts are expected to be relatively minor. • With respect to wetland consolidation, environmental impacts will be minimized by following guidelines set forth by Army Corp of Engineers.	• Environmental impacts will likely be limited to emissions of contaminants in dust and some migration via erosion. The impacts can be controlled through use of dust suppressants and implementation of an erosion control plan. Impacts are expected to be relatively minor. • With respect to wetland consolidation, environmental impacts will be minimized by following guidelines set forth by Army Corp of Engineers.	• Environmental impacts will likely be limited to emissions of contaminants in dust and some migration via erosion. The impacts can be controlled through use of dust suppressants and implementation of an erosion control plan. Impacts are expected to be relatively minor. • With respect to wetland consolidation, environmental impacts will be minimized by following guidelines set forth by Army Corp of Engineers. • Biopiles will be placed on lined and curbed pads to prevent erosion of soil.

TABLE 5-1 CONTD.
Detailed Evaluation of Soil Media Alternatives
Penta Wood, Feasibility Study Report

Alternative Description: Criterion	Alternative S1—No Further Action	Alternative S2—Soil Cover and Natural Attenuation	Alternative S3—Capping	Alternative S4—Soil Cover and Bioventing	Alternative S5—Ex Situ Biological Treatment and Bioventing
(d) Time until RAOs are achieved	▪ The RAO of remediating contaminated soil as necessary to prevent further PCP migration into the groundwater that results in concentrations that exceed groundwater MCLs or Wisconsin Prevention Action Limits (PALs would take decades. ▪ The other remaining RAOs are not met.	▪ Soil near the water table would continue to exceed PRGs protective of groudwater for decades. ▪ Remaining RAOs are met once soil cover is completed within one construction season.	▪ Soil near the water table would continue to exceed PRGs protective of groudwater for decades. ▪ Remaining RAOs are met once cap is completed within one construction season.	▪ Bioventing may achieve RAOs for preventing PCP migration to the groundwater within 10 years. ▪ Remaining RAOs are met once soil cover is completed within one construction season.	▪ Bioventing combined with ex situ biological treatment may achieve RAOs for preventing PCP migration to the groundwater within 10 years. ▪ Remaining RAOs are met once soil cover is completed within one construction season.
6. Implementability					
(a) Technical feasibility	• No impediments.	• No impediments.	• No impediments.	• No impediments.	• No impediments.
(b) Administrative feasibility	• No impediments.	• May require Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers associated with the classification, treatment, disposal, and/or placement of listed hazardous wastes.	• May require Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers associated with the classification, treatment, disposal, and/or placement of listed hazardous wastes.	• May require Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers associated with the classification, treatment, disposal, and/or placement of listed hazardous wastes.	• May require Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers associated with the classification, treatment, disposal, and/or placement of listed hazardous wastes.
(c) Availability of services and materials	• None needed.	• Necessary engineering services and materials readily available for soil consolidation and construction and maintenance of soil cover system.	• Necessary engineering services and materials readily available for soil consolidation and construction and maintenance of cap system.	• Necessary engineering services and materials readily available for soil consolidation and construction and maintenance of soil cover system. • Necessary engineering services and materials readily available for installation and operation of bioventing system. • Trenching machines are readily available for installation of bioventing system.	• Necessary engineering services and materials readily available for soil consolidation and construction and maintenance of soil cover system. • Necessary engineering services and materials readily available for installation and operation of bioventing system. • Trenching machines are readily available for installation of bioventing system. • Necessary engineering services and materials readily available for construction and operation of biopiles.
7. Total Cost	Direct Capital Cost $0 O&M Cost $0 Total Present Worth Cost $0	Direct Capital Cost $1,565,957 O&M Cost $164,194 Total Present Worth Cost $1,700,000	Direct Capital Cost $2,803,331 O&M Cost $334,835 Total Present Worth Cost $3,100,000	Direct Capital Cost $3,011,159 O&M Cost $1,700,000 Total Present Worth Cost $4,700,000	Direct Capital Cost $4,250,716 O&M Cost $3,500,000 Total Present Worth Cost $7,800,000

[a]For a detailed listing and analysis of key ARARs, see Appendix A.

5.2.2. Detailed Evaluation of Groundwater Media Alternatives

The following five alternatives for the groundwater were developed and described in Section 4:

- No Further Action
- LNAPL Collection and Natural Attenuation
- Groundwater Collection and Treatment
- Groundwater Collection and Treatment Throughout Plume
- Steam Injection in Conjunction with SVE

These five alternatives were evaluated in detail using the seven evaluation criteria described in Section 5.1. Table 5-2 includes the detailed evaluation for the groundwater media alternatives.

5.3. Comparative Analysis of Remedial Alternatives

The comparative analysis for the soil and groundwater is presented below.

5.3.1. Comparative Analysis of Soil Media Alternatives

5.3.1.1. Overall Protection of Human Health and the Environment

The no further action alternative is not protective as a result of continued erosion of surface contamination that poses unacceptable risks. Also, the current sand pile barriers to reduce erosion are resulting in the creation of infiltration basins, allowing much higher infiltration in localized areas and the potential for some flushing of PCP to occur.

The remaining alternatives are similar in their overall protectiveness because all meet the remaining remedial objectives. They consolidate the surficial contamination and cover it to prevent erosion and direct contact.

The capping alternative is similar in protectiveness to the soil cover and natural attenuation alternative. Although the cap reduces infiltration substantially, SESOIL modeling showed that even without a cap and assuming no runoff or degradation, PCP is migrating at about 0.05 ft/year. Even the slowest anaerobic decay rate results in concentrations of PCP in groundwater to be below PALs from the migration of the PCP in all unsaturated zone soils except for soils located a few feet above the water table. In addition, the capping alternative has the greatest potential for impacts on the community because of the large amount of truck traffic (about 2,000 trips) to construct the cap.

The treatment of soil included in the bioventing and ex situ biological treatment and bioventing alternatives reduces the residual risks if the site were ever developed and exposure to subsurface soil to occur. However, this is unlikely given the implementation of restrictive covenants and an issuance of a notice of contamination to the local governments. Bioventing also reduces PCP in the area near the water table that can continue to leach PCP to groundwater. However this area also has LNAPL residual above and below the water table. To be effective, the bioventing alternative should be coupled with dewatering of the LNAPL smear zone.

The ex situ biological treatment of shallow PCP contaminated sand and wood debris treats a substantial portion of the PCP mass in soil (about 33%) that otherwise may not be degraded with bioventing. However, as discussed earlier, this soil does not appear to be contributing PCP to the groundwater. Also the excavation, handling, and mixing of the heavily contaminated soil and wood debris will likely cause some releases of dust and odors, although some precaution will minimize the impacts on the workers, the community, and the environment.

5.3.1.2. Compliance with ARARs

Appendix A present a compilation of all the State and Federal chemical-specific, location-specific, and action-specific ARARs considered for PWP.

All alternatives with the exception of the no further action alternative would meet ARARs. Each of the alternatives rely on engineering controls to meet soil PRGs for direct contact and protection of groundwater. The bioventing and ex situ biological treatment (Alternative S5) and bioventing (Alternative S4) alternatives would meet PCP PRGs for protection of groundwater in less time than the other alternatives because they include active remediation of the unsaturated zone.

Wisconsin NR 680 exemptions and/or Wisconsin NR 500 waivers may be necessary to meet ARARs associated with classification, treatment, disposal, and/or placement of listed hazardous wastes. This would be necessary for all the remedial alternatives except for the no action alternative.

5.3.1.3. Long-term Effectiveness and Permanence

The long-term effectiveness and permanence of the ex situ biological treatment and bioventing alternative (Alternative S5) is better than the other alternatives because it includes the most PCP reduction and is more reliable in reducing PCP in the heavily contaminated shallow soil than bioventing (Alternative S4). The greater the PCP mass reduction in the shallow soil, the less the residual risk from direct contact in the event of exposure to subsurface soil in the future.

The bioventing alternative (Alternative S4) is the next best alternative in its long term effectiveness and permanence because it also treats the PCP contamination, thus reducing the residual risk. Both the ex situ biological treatment and bioventing and the bioventing alternatives are similar in effectiveness related to reducing the leaching of PCP from soils near the water table that may continue to cause exceedance of MCLs or PALs in the groundwater.

The soil cover and natural attenuation and the capping alternatives are similar in their long-term effectiveness and permanence because each is considered adequate and reliable in preventing further erosion and direct contact. As previously discussed, the slow rate of PCP migration in the unsaturated zone greatly diminishes the benefit of reducing infiltration provided by the cap in the capping alternative (Alternative S3).

TABLE 5-2
Detailed Evaluation of Groundwater Media Alternatives
Penta Wood, Feasibility Study Report

Alternative Description: Criterion	Alternative G1- No Further Action	Alternative G2- LNAPL Collection and Natural Attenuation	Alternative G3- Groundwater Collection and Treatment	Alternative G4- Groundwater Collection and Treatment Throughout Plume	Alternative G5 – Steam Injection in Conjunction with SVE
1. Overall protection of human health and the environment.	▪ LNAPL (both as residual and pumpable) will continue to act as a source for the PCP. The PCP in the LNAPL will continue to dissolve into the groundwater, resulting in concentrations outside source areas that would exceed groundwater EPA Maximum Concentration Limits (MCLs) or Wisconsin Prevention Action Limits (PALs). Under this alternative, this would occur for decades. ▪ There is a potential for human exposure to contaminated groundwater both within and outside the source areas under this alternative since no institutional controls are part of this alternative. ▪ Natural attenuation of the PCP may prevent further migration of the groundwater plume.	▪ This alternative does address the pumpable LNAPL to some extent, but since it is only skimming, most of the pumpable LNAPL will not be recovered. ▪ LNAPL (both as residual and as the remaining pumpable) will continue to act as a source for the PCP. The PCP will continue to dissolve into the groundwater, resulting in concentrations outside the source areas that would exceed groundwater MCLs or PALs. ▪ The potential for human exposure to contaminated groundwater both within and outside the source areas will be minimized through institutional controls. Under this alternative, the institutional controls will be required to be in effect for decades. ▪ Natural attenuation of the PCP may prevent further migration of the groundwater plume.	▪ This alternative removes more pumpable LNAPL because it includes groundwater table depression. Under this alternative, the recoverable pumpable LNAPL should be removed to the extent practicable in about 5 years. ▪ LNAPL (as residual) will continue to act as a source for the PCP. The PCP will continue to dissolve into the groundwater, resulting in concentrations outside the source areas that would exceed groundwater MCLs or PALs. Under this alternative, this would occur for decades. ▪ The potential for human exposure to contaminated groundwater both within and outside the source areas will be minimized through institutional contr[illegible] alternative, the institution[illegible] controls will be required to be in effect for decades, though less time than the LNAPL Collection and Natural Attenuation alternative. ▪ Although this alternative does not address the LNAPL residual zone by itself, it could be coupled with soil media alternatives 4 or 5 (bioventing). Then, this alternative would be operated to dewater the LNAPL residual zone and the bioventing would be used to address, through enhanced aerobic degradation, the dewatered zone. ▪ Natural attenuation of the PCP combined with groundwater collection and treatment of the high concentration portion of the unconfined and semi-confined PCP groundwater plume will minimize the potentialfor further migration of the groundwater plume.	▪ This alternative does address the pumpable LNAPL since this alternative includes groundwater table depression to further recover LNAPL. Under this alternative, the recoverable pumpable LNAPL should be removed to the extent practicable in about 5 years. ▪ LNAPL (as residual) will continue to act as a source for the PCP. The PCP will continue to dissolve into the groundwater, resulting in concentrations within the source areas that would exceed groundwater MCLs or PALs. Under this alternative, this would occur for decades. Outside the source areas, groundwater will be collected and treated until PRGs are met. ▪ The potential for human exposure to contaminated groundwater both within and outside the source areas will be minimized through institutional controls. Under this alternative, the institutional controls will be required to be in effect for decades, though in less time than Alternatives 2 and 3. ▪ Although this alternative does not address the LNAPL residual zone by itself, it could be coupled with one of the soil media alternatives (bioventing). Then, this alternative would be operated to actually dewater the LNAPL residual zone and the bioventing would be used to address, through enhanced aerobic degradation, the dewatered zone. ▪ This alternative prevents the further migration of the PCP groundwater plume through active groundwater collection until PRGs are met. Groundwater would be collected for decades.	▪ This alternative does address the pumpable LNAPL since this alternative includes steam injection. Under this alternative, the recoverable pumpable LNAPL should be removed to the extent practicable in about 5 years. ▪ This alternative addresses the LNAPL residual zone. Therefore, the PCP that would continue to dissolve into the groundwater, resulting in concentrations outside the source areas that would exceed groundwater MCLs or PALs would be minimized under this alternative. ▪ The potential for human exposure to contaminated groundwater both within and outside the source areas will be minimized through institutional controls. Under this alternative, the institutional controls will be required to be in effect for decades, though in less time than Alternativers 2, 3 and 4. ▪ Although this alternative does address the LNAPL residual zone, it may be just as effective to couple one of the groundwater collection and treatment alternatives with bioventing. The groundwater alternatives then could be operated to dewater the LNAPL residual zone and the bioventing would then be used to address this dewatered zone through enhanced aerobic degradation. ▪ This alternative minimizes the potential for further migration of the groundwater plume.

TABLE 5-2 CONTD.
Detailed Evaluation of Groundwater Media Alternatives
Penta Wood , Feasibility Study Report

Alternative Description: Criterion	Alternative G1- No Further Action	Alternative G2- LNAPL Collection and Natural Attenuation	Alternative G3- Groundwater Collection and Treatment	Alternative G4- Groundwater Collection and Treatment Throughout Plume	Alternative G5 – Steam Injection in Conjunction with SVE
2. Compliance with ARARs*	▪ Would meet ARARs when PCP contamination in groundwater outside the source areas does not result in concentrations that exceed groundwater MCLs or PALs. Under this alternative, this would take decades. ▪ Would not meet action-specific ARARs with respect to removing the pumpable LNAPL to the extent practicable because this is an alternative with no active treatment.	▪ Would meet ARARs when PCP contamination in groundwater outside the source areas does not result in concentrations that exceed groundwater MCLs or PALs. This alternative would meet these ARARs in less time than than the No Further Action alternative since this alternative also includes removing the pumpable LNAPL, one of the sources of groundwater PCP contamination. ▪ Would meet action-specific ARARs with respect to removing the pumpable LNAPL to the extent practicable.	▪ Would meet ARARs when PCP contamination in groundwater outside the source areas does not result in concentrations that exceed groundwater MCLs or PALs. This alternative also includes removing the pumpable LNAPL, one of the sources of groundwater PCP contamination, and groundwater remediation of grossly contaminated groundwater. Consequently, this alternative would meet ARARs in less time than the No Further Action and LNAPL Collection. ▪ Would meet action-specific ARARs with respect to removing the pumpable LNAPL to the extent practicable. ▪ Groundwater treatment would be necessary to meet ARARs with respect to groundwater discharge clean-up criteria. ▪ Collected LNAPL may be required to be specially handled to meet ARARS associated with treatment, storage, recycle, and/or disposal of solid/hazardous wastes.	▪ Would meet ARARs when PCP contamination in groundwater outside the source areas does not result in concentrations that exceed groundwater MCLs or PALs. This alternative also includes removing the pumpable LNAPL, one of the sources of groundwater PCP contamination, and groundwater remediation throughout plume. Consequently, this alternative would meet ARARs in less time than alternatives 1, 2 and 3. ▪ Would meet action-specific ARARs with respect to removing the pumpable LNAPL to the extent practicable. ▪ Groundwater treatment would be necessary to meet ARARs with respect to groundwater discharge clean-up criteria. ▪ Collected LNAPL may be required to be specially handled to meet ARARS associated with treatment, storage, recycle, and/or disposal of solid/hazardous wastes.	▪ Would meet ARARs when PCP contamination in groundwater outside the source areas does not result in concentrations that exceed groundwater MCLs or PALs. This alternative also includes removing the pumpable LNAPL and reducing the LNAPL residual, one of the primary sources of groundwater PCP contamination. Consequently, this alternative would meet ARARs in less time than alternatives 1, 2, 3 and 4. ▪ Would meet action-specific ARARs with respect to removing the pumpable LNAPL to the extent practicable. ▪ Groundwater treatment would be necessary to meet ARARs with respect to groundwater discharge clean-up criteria. ▪ Collected LNAPL may be required to be specially handled to meet ARARS associated with treatment, storage, recycle, and/or disposal of solid/hazardous wastes. ▪ Air treatment may be necessary to meet ARARs associated with the Clean Air Act.
3. Long-term effectiveness and permanence					
(a) Magnitude of residual risks	▪ No significant change in risk because no action taken. Reduction in risk relating to PCP contamination in groundwater outside the source areas that are in concentrations that exceed groundwater MCLs or PALs would occur slowly over decades.	▪ Reduction in risk relating to PCP contamination in groundwater outside the source areas that are in concentrations that exceed groundwater MCLs or PALs would occur slowly over decades. The reduction in risk would not be as slow as the No Further Action alternative because this alternative also includes LNAPL collection.	▪ PCP concentrations would be reduced substantially after 5 years of groundwater collection. A reduction in concentration of over 90 % may be achieved if this alternative is coupled with bioventing to remediate the LNAPL residual. If LNAPL residual is not remediated, PCP concentrations in groundwater will likely increase substantially following collection sytem shutdown in 5 years.	▪ Residual risks will be eliminated once the groundwater collection system remediates groundwater to below PRGs. However this will take decades.	▪ PCP concentrations would be reduced substantially after 5 years of steam injection and groundwater collection. A reduction in PCP concentration of over 90% may be achievable in the source area.
(b) Adequacy and reliability of controls	Not applicable.	▪ Requires reliance on institutional controls for the PWP site, and potentially surrounding properties, with respect to exposure to LNAPL and contaminated groundwater. These controls will be necessary for decades under this alternative.	▪ Requires reliance on institutional controls with respect to exposure to contaminated groundwater. These controls will not be necessary for as long a time period as the LNAPL Collection alternative. ▪ Institutional controls may not be necessary for exposure to LNAPL since this alternative includes LNAPL removal. ▪ Institutional controls may not be necessary for surrounding properties if this alternative effectively provides source control.	▪ Requires reliance on institutional controls with respect to exposure to contaminated groundwater. These controls will not be necessary for as long as the LNAPL Collection and Grossly Contaminated Groundwater alternatives. ▪ Institutional controls may not be necessary for exposure to LNAPL since this alternative includes LNAPL removal. ▪ Institutional controls may not be necessary for surrounding properties if this alternative effectively provides source control.	▪ Requires reliance on institutional controls with respect to exposure to contaminated groundwater. These controls will not be necessary for as long as the LNAPL Collection, Grossly Contaminated Groundwater, and Groundwater Treatment throughout Plume alternatives because this alternative addresses the LNAPL residual, one of the primary sources of PCP contamination in the groundwater. ▪ Institutional controls may not be necessary for exposure to LNAPL since this alternative includes LNAPL removal. ▪ Institutional controls may not be necessary for surrounding properties if this alternative effectively provides source control.

TABLE 5-2 CONTD.
Detailed Evaluation of Groundwater Media Alternatives
Penta Wood, Feasibility Study Report

Alternative Description: Criterion	Alternative G1- No Further Action	Alternative G2- LNAPL Collection and Natural Attenuation	Alternative G3- Groundwater Collection and Treatment	Alternative G4- Groundwater Collection and Treatment Throughout Plume	Alternative G5 – Steam Injection in Conjunction with SVE
4. Reduction of toxicity, mobility, or volume through treatment					
(a) Treatment process used	Not applicable.	▪ LNAPL Collection and Natural attenuation.	▪ LNAPL Collection and Grossly Contaminated Groundwater Treatment via carbon adsorption.	▪ LNAPL Collection and Contaminated Groundwater Treatment via carbon adsorption.	▪ Steam Injection in Conjunction with SVE and potential air emission treatment with catalytic oxidation. Also includes LNAPL Collection and Groundwater Treatment via carbon adsorption.
(b) Degree and quantity of TMV reduction	▪ Not applicable.	▪ Natural attenuation would take decades.	▪ LNAPL collection is expected to remove only a small fraction of the LNAPL present. ▪ Pore exchange modeling shows that groundwater treatment should reduce the average groundwater PCP concentration of 30 mg/l by over 90% in 5 years operation. ▪ The estimated 26,000 lbs of PCP in the saturated zone would be reduced by 23,000 lbs.	▪ LNAPL collection is expected to remove only a small fraction of the LNAPL present. ▪ Pore exchange modeling shows that groundwater treatment should reduce the average groundwater PCP concentration of 30 mg/l by over 99% in 15 years of operation if no further source loadings occur. However given the likelihood of further loadings from the LNAPL residual, groundwater collection to meet PRGs will continue for decades. ▪ The estimated 26,000 lbs of PCP presently in the saturated zone would be reduced by over 25,000 lbs. Only an estimated 1.5 lbs of PCP are present in the additional areas of the PCP plume that alternative 4 collects compared to the alternative 3 collection area.	▪ LNAPL collection is expected to remove only a small fraction of the LNAPL present. ▪ Steam injection should reduce the 500,000 gallons of total LNAPL (pumpable and residual) by over 90% in 5 years. The PCP should be reduced by the same percentage since the PCP is approximately 5% of the LNAPL. ▪ Catalytic oxidation, if necessary, will reduce air-phase contaminants by over 99% ▪ The estimated 26,000 lbs of PCP in the saturated zone would be reduced by 23,000 lbs.
(c) Irreversibility of TMV reduction	Not applicable.	▪ Natural degradation is irreversible.	▪ LNAPL Collection and Groundwater Treatment is irreversible. The contaminants adsorbed to the carbon would be removed irreversibly during the regeneration process. The LNAPL would be recycled in a process that is irreversible.	▪ LNAPL Collection and Groundwater Treatment is irreversible. The contaminants adsorbed to the carbon would be removed irreversibly during the regeneration process. The LNAPL would be recycled in a process that is irreversible.	▪ Steam Injection in Conjunction with SVE is an irreversible process. Catalytic oxidation is an irreversible process. ▪ LNAPL Collection and Groundwater Treatment is irreversible. The contaminants adsorbed to the carbon would be removed irreversibly during the regeneration process. The LNAPL would be recycled in a process that is irreversible.
(d) Type and quantity of treatment residuals	▪ None, because no treatment included.	▪ Recovered LNAPL will be recycled or incinerated.	▪ Residuals limited to liquid-phase carbon. At 50 gpm flowrate and 30 mg/l influent PCP concentration, approximately 15,000 lbs per year of carbon will be used. After use, this carbon will be regenerated. ▪ Recovered LNAPL will be recycled or incinerated.	▪ Residuals limited to liquid-phase carbon. At 140 gpm flowrate and 8 mg/l influent PCP concentration, approximately 15,000 lbs per year of carbon will be used. After use, this carbon will be regenerated. ▪ Recovered LNAPL will be recycled or incinerated.	▪ Residuals limited to liquid-phase carbon. At 50 gpm flowrate and 30 mg/l influent PCP concentration, approximately 15,000 lbs per year of carbon will be used. ▪ Recovered LNAPL will be recycled or incinerated. ▪ Catalysts used in the catalytic oxidation process, if air treatment is required, will be handled according to manufacturer's instructions.
(e) Statutory preference for treatment as a principal element	▪ Preference not met for groundwater because no treatment included.	▪ Preference partially met for groundwater because LNAPL collection removes some of the PCP, which is the contaminant posing the principal threat.	▪ Preference met for groundwater because LNAPL collection and groundwater treatment removes and treats the PCP, which is the contaminant posing the principal threat.	▪ Preference met for groundwater because LNAPL collection and groundwater treatment removes and treats the PCP, which is the contaminant posing the principal threat.	▪ Preference met for groundwater because steam injection in conjunction with SVE removes and treats the PCP, which is the contaminant posing the principal threat.

TABLE 5-2 CONTD.
Detailed Evaluation of Groundwater Media Alternatives
Penta Wood , Feasibility Study Report

Alternative Description: Criterion	Alternative G1- No Further Action	Alternative G2- LNAPL Collection and Natural Attenuation	Alternative G3- Groundwater Collection and Treatment	Alternative G4- Groundwater Collection and Treatment Throughout Plume	Alternative G5 – Steam Injection in Conjunction with SVE
5. Short-term effectiveness					
(a) Protection of workers during remedial action	▪ No remedial construction, so no risks to workers.	▪ Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil and LNAPL contaminants, dermal absorption and inhalation of particulate. ▪ During remedial operations, risk to workers are not expected because LNAPL will be contained and proper health and safety requirements will be followed.	▪ Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil and LNAPL contaminants, dermal absorption and inhalation of particulate. Environmental monitoring for dust and contaminant emissions during trenching is important to maintain the proper level of health and safety protection. ▪ During remedial operations, risk to workers are limited to normal safety related risks related to treatment operations.	▪ Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants, dermal absorption and inhalation of particulate. Environmental monitoring for dust and contaminant emissions is important to maintain the proper level of health and safety protection. ▪ During remedial operations, risk to workers are limited to normal safety related risks related to treatment operations.	▪ Risks to workers can be minimized if proper health and safety procedures are followed. During remedial construction, workers must adhere to the health and safety plan to minimize exposure to soil contaminants, dermal absorption and inhalation of particulate. Environmental monitoring for dust and contaminant emissions is important to maintain the proper level of health and safety protection. ▪ During remedial operations, risk to workers are limited to normal safety related risks related to treatment operations. ▪ Operation of steam injection system poses more safety and contaminant exposure risks than other alternatives but risks can be minimized through proper health and safety plan implementation.
(b) Protection of community during remedial action	▪ No remedial construction, so no short-term risks to community.	▪ Short-term health- related risks to community during remedial construction are minimal. ▪ During remedial operations, health- and safety-related risks to community are expected to be minimal. For noise, equipment will be designed to reduce noise levels.	▪ Short-term health-related risks to community during remedial construction will be minimized through air monitoring and use of emission control techniques such as use of dust and contaminant emission suppressants. ▪ During remedial operations, health- and safety-related risks to community are expected to be minimal. For noise, equipment will be designed to reduce noise levels.	▪ Short-term health-related risks to community during remedial construction will be minimized through air monitoring and use of emission control techniques such as use of dust and contaminant emission suppressants. ▪ During remedial operations, health- and safety-related risks to community are expected to be minimal. For noise, equipment will be designed to reduce noise levels.	▪ Short-term health-related risks to community during remedial construction will be minimized through air monitoring and use of emission control techniques such as use of dust and contaminant emission suppressants. ▪ During remedial operations, health- and safety-related risks to community are expected to be minimal. For noise, equipment will be designed to reduce noise levels. ▪ Short-term safety-related risks to community during remedial operations may occur because of some amount of truck traffic to transport and manage the collected LNAPL and carbon, and the delivery of fuel for the operation of the steam injection system.

TABLE 5-2 CONTD.
Detailed Evaluation of Groundwater Media Alternatives
Penta Wood , Feasibility Study Report

Alternative Description: Criterion	Alternative G1- No Further Action	Alternative G2- LNAPL Collection and Natural Attenuation	Alternative G3- Groundwater Collection and Treatment	Alternative G4- Groundwater Collection and Treatment Throughout Plume	Alternative G5 – Steam Injection in Conjunction with SVE
(c) Environmental impacts of remedial action	▪ No remedial construction, so no environmental impacts.	▪ Impacts are expected to be relatively minor. ▪ No environmental impacts are anticipated during remedial operations.	▪ Impacts are expected to be relatively minor. ▪ No environmental impacts are anticipated during remedial operations. ▪ If treated groundwater is discharged to Doctor Lake it will meet WPDES requirements.	▪ Impacts are expected to be relatively minor. ▪ No environmental impacts are anticipated during remedial operations. ▪ If treated groundwater is discharged to Doctor Lake it will meet WPDES requirements.	▪ Impacts are expected to be relatively minor. ▪ Environmental impacts during remedial operations are limited to the minor truck traffic and air emissions from steam system. This impact should be minimal. ▪ If treated groundwater is discharged to Doctor Lake it will meet WPDES requirements.
(d) Time until RAOs are achieved	▪ The RAO for LNAPL with respect to enabling long-term attainment of groundwater RAOs will take decades to meet under this alternative. ▪ Other remaining RAOs are not met.	▪ The RAOs for remediating groundwater within the source area to the extent practable, and remediating groundwater outside the source areas to PCP concentrations below groundwater MCLs or PALs would not be met under this alternative. ▪ Decades would be required to meet the remaining RAOs.	▪ The RAOs for remediating groundwater within the source area to the extent practable, and to PCP concentrations below groundwater MCLs or PALs would take decades under this alternative. PCP would continue to migrate to the groundwater from the LNAPL residual zone, which is not addressed by this alternative, unless it is coupled with dewatering and bioventing of LNAPL residual. ▪ The RAOs for remediating groundwater outside the LNAPL source area to PCP concentrations below groundwater MCLs or PALs may be met within 10 years under this alternative, provided groundwater collection within source area is effective. This assumes aerobic biodegradation rates on the order of 16 months. ▪ Decades would be required to meet the remaining RAOs.	▪ The RAO for removing the pumpable LNAPL to the extent practicable will be met under this alternative in less than 5 years. ▪ The RAOs for remediating groundwater outside the LNAPL source area to PCP concentrations below groundwater MCLs or PALs may be met within 10 years under this alternative, provided groundwater collection within source area is effective. ▪ Decades would be required to meet the remaining RAOs.	▪ The RAO for removing the pumpable LNAPL to the extent practicable will be met under this alternative in less than 5 years. ▪ The RAOs for remediating groundwater outside the LNAPL source area to PCP concentrations below groundwater MCLs or PALs may be met within 10 years under this alternative, provided groundwater collection within source area is effective. ▪ It is expected that the remaining RAOs would be met in less time than the other alternatives.
6. Implementability					
(a) Technical feasibility	▪ No impediments.	▪ No impediments.	▪ No impediments.	▪ No impediments.	▪ Few full-scale demonstrations for PCP/LNAPL-contaminated sites. Extensive lab-scale and pilot-scale tests necessary for pre-design activities.
(b) Administrative feasibility	▪ No impediments.	▪ No impediments.	▪ No impediments.	▪ No impediments.	▪ No impediments.
(c) Availability of services and materials	▪ None needed.	▪ Necessary engineering services and materials readily available for installation and operation of system.	▪ Necessary engineering services and materials readily available for installation and operation of system.	▪ Necessary engineering services and materials readily available for installation and operation of system.	▪ Necessary engineering services and materials readily available for installation and operation of system.
7. Total Cost	Direct Capital Cost $0 Annualized O&M Cost $0 Total Present Worth Cost $0	Direct Capital Cost $414,122 Annualized O&M Cost $2,500,000 Total Present Worth Cost $2,900,000	Direct Capital Cost $774,906 Annualized O&M Cost $2,700,000 Total Present Worth Cost $3,500,000	Direct Capital Cost $1,295,894 Annualized O&M Cost $2,900,000 Total Present Worth Cost $4,200,000	Direct Capital Cost $4,580,865 Annualized O&M Cost $9,300,000 Total Present Worth Cost $13,900,000

[a]For a detailed listing and analysis of key ARARS, see Appendix A.

5.3.1.4. Reduction of Toxicity, Mobility, and Volume (TMV) Through Treatment

Bioventing (Alternative S4) and ex situ biological treatment and bioventing (Alternative S5) offers the best TMV reduction. About 80 to 90 percent of the estimated 120,000 lbs of PCP is expected to be reduced in about 10 years. This treatment is irreversible. Ex situ biological treatment should be able to achieve a greater percentage of mass reduction than bioventing alone. In addition, both alternatives include solidification of arsenic-contaminated soil exceeding TCLP limits.

For Alternatives S1, S2, and S3, active treatment is not used. Reduction in TMV through natural biodegradation would occur for each of these alternatives, but the degradation rate is slow and could take decades. Natural degradation would be considerably slower under the capping alternative because moisture for biological growth would be minimal.

The biopad containing solidified arsenic-contaminated soil will be broken up into pieces and placed under the soil cover or cap. This will eliminate the threat of surface transport of arsenic as the pad cracks and spalls over time.

5.3.1.5. Short-term Effectiveness

All alternatives have minimal impacts with respect to the protection of workers during remedial construction, protection of community during remedial action, and environmental impacts of remedial action. The no further action alternative has no impact because the alternative involves no remedial construction. For the other alternatives with respect to environmental impacts, the primary impact is during wetland consolidation. This would be minimized through following guidance set forth by the Army Corp of Engineers. The capping alternative has a substantial amount of trucking that will cause moisture and dust nuisance. Ex situ biological treatment and bioventing alternative may result in odors because of the excavation and handling of the contaminated soil/wood debris.

For the other alternatives, risk to construction workers will be minimized through air monitoring and use of emission control techniques such as the use of dust suppressants. Short-term nuisance noise impacts and safety-related risks to the community caused by truck traffic will be minimal.

The short-term effectiveness with respect to time until the RAOs are achieved will not be met with the no further action alternative. Potential exposure to surface soil concentrations exceeding direct-contact PRGs will continue, and erosion of contaminated soil to the wetlands will continue. The remaining alternatives will achieve RAOs in about one year since erosion control, soil covering or capping, and wetland consolidation measures are included as part of the alternatives.

The time until the RAOs for remediating contaminated soil as necessary to prevent further PCP migration into the groundwater that results in concentrations that exceed groundwater MCLs or PALs differ between each alternative. The time to reach this RAO is longest for the no further action, soil cover and natural attenuation, and capping alternatives because they do not actively treat the soils near the water table. The time until RAOs protecting groundwater is met is similar for the bioventing and ex situ biological treatment and bioventing alternatives.

5.3.1.6. Implementability

Technical or administrative implementability problems are not expected to be significant for any of the alternatives. With respect to administrative implementability, exemptions and/or waivers with respect to classification, treatment, disposal, and/or placement of listed hazardous wastes may be necessary before one of the action alternatives are implemented.

5.3.1.7. Cost

A summary of the estimated costs for each of the soil media alternatives is presented in Table 5-3. The table breaks down the estimated capital, operations and maintenance, and present net worth cost. An overview of the cost analysis performed for this FS and the detailed breakdowns for each of the alternatives are presented in Appendix G.

TABLE 5-3
Soil Media Summary Cost Table
Penta Wood, Feasibility Study Report

Alternative	Description	Capital Costs ($)	O&M ($)	Alternative Life (years)	Total Project Present Worth Costs ($)
Alternative S1	No Further Action	0	0	30	0
Alternative S2	Soil Cover and Natural Attenuation	1,565,957	164,194	30	1,700,000
Alternative S3	Capping	2,803,331	334,835	30	3,100,000
Alternative S4	Bioventing	3,011,159	1,700,000	10	4,700,000
Alternative S5	Ex situ Biological Treatment and Bioventing	4,250,716	3,500,000	10	7,000,000

The no further action alternative has no cost, while the ex situ biological treatment and bioventing alternative has the highest cost. Of the active remediation alternatives, the bioventing alternative is (Alternative S4) less expensive than the ex situ biological treatment alternative (Alternative S5). Capping (Alternative S3) adds considerable cost of about $1,400,000 compared to the soil cover and monitored natural attenuation alternative (Alternative S2).

The cost estimates presented above have been developed strictly for comparing the five alternatives. The final costs of the project and the resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, the implementation schedule, the firm selected for final engineering design, and other variables. Therefore, final project costs will vary from the cost estimates. Because of these factors, project feasibility and funding needs must be reviewed carefully before specific financial decisions are made or project budgets are established to help ensure proper project evaluation and adequate funding.

The cost estimates are order-of-magnitude estimates having an intended accuracy range of +50 to -30 percent. The range applies only to the alternatives as they are defined in Section 4 and does not account for changes in the scope of the alternatives. Selection of specific technologies or processes to configure remedial alternatives is intended not to limit flexibility during remedial design, but to provide a basis for preparing cost estimates. The specific details of remedial actions and cost estimates would be refined during final design.

5.3.2. Comparative Analysis of Groundwater Media Alternatives

5.3.2.1. Overall Protection of Human Health and the Environment

The no further action alternative is not considered protective because it does not include groundwater monitoring or institutional controls to prevent access to contaminated groundwater. Future exposure to onsite groundwater would result in unacceptable risks.

The remaining alternatives are considered protective. The LNAPL collection and monitored natural attenuation alternative is considered protective because it includes restrictive covenants on the property deed to prevent groundwater use and it includes groundwater monitoring to verify natural attenuation and to provide an early warning if migration to receptors at concentrations exceeding PALs is occurring. The RI showed that PCP biodegradation is occurring. It is most rapid in the aerobic portion of the plume that surrounds the anaerobic central plume beneath the source areas. BIOSCREEN modeling showed natural attenuation is sufficient to prevent PCP migration to receptors. However, modeling of groundwater is imprecise and a sensitivity analysis showed that variation in input parameters (particularly the aquifer TOC) within reasonable ranges could result in migration of PCP to receptors. As a result, although natural attenuation is viable, groundwater monitoring is an important component. In addition, a contingency for active groundwater collection and treatment should be in place if monitoring at sentinel wells indicates increasing trends in PCP.

The groundwater collection and treatment alternative (Alternative G3) targets the main areas of PCP contamination and over 99% for the PCP mass in groundwater. Operation of the collection system for 10 years is expected to remove over 90% of the PCP mass from groundwater. It can also be operated to dewater the LNAPL smear zone to allow bioventing of the LNAPL residual. This alternative provides greater assurance that natural attenuation of the remaining untreated PCP in the groundwater will biodegrade because it removes the majority of the PCP. Also by treating the anaerobic area where PCP degradation is slowest, it will result in a much larger aerobic zone where more rapid biodegradation is possible.

The groundwater collection and treatment throughout plume alternative (Alternative G4) targets all areas where PCP exceeds MCLs, with active groundwater collection. It does not rely on natural attenuation. It has the greatest reliability in preventing offsite migration. However, it is likely that groundwater below the LNAPL smear zone will not meet MCLs or PALs for decades.

The steam injection in conjunction with SVE alternative (Alternative G5) remediates the LNAPL residual that is acting as a continuous source of PCP to the groundwater as well as actively collecting the most contaminated groundwater. It is considered the most reliable in preventing further migration of PCP. Impacts from operation of the steam injection in conjunction with SVE system on workers and the community have the potential to be greater for this alternative, although impacts can be minimized through proper adherence to a site health and safety plan.

5.3.2.2. Compliance with ARARs

Appendix A presents a compilation of all the State and Federal chemical-specific, location-specific, and action-specific ARARs considered for PWP.

With the exception of the no further action alternative, all would meet ARARs. The groundwater treatment and steam injection in conjunction with SVE alternatives would meet ARARs associated with MCLs or PALs in less time than the no further action or LNAPL collection and natural attenuation alternatives.

With respect to steam injection in conjunction with SVE, air treatment for the emissions may be required to meet Clean Air Act ARARs.

5.3.2.3. Long-term Effectiveness and Permanence

The long-term effectiveness and permanence of the groundwater collection and treatment (G3 and G4) and steam injection in conjunction with SVE (G5) alternatives are better than the other two alternatives because these involve active reduction in PCP concentrations.

The long-term effectiveness and permanence of the steam injection in conjunction with SVE alternative is better than the other alternatives because it actively removes the PCP mass causing the most loading to the groundwater. The groundwater collection and treatment Alternatives (G3 and G4) are similar in their long-term effectiveness and permanence because even though Alternative G4 captures a larger zone than Alternative G3, the corresponding extra PCP mass that is captured is minimal.

Neither groundwater collection and treatment alternatives address the PCP mass in the LNAPL residual zone causing the most loading to the groundwater. However, if Alternative G3 is focused to dewater this zone exposing the smear zone and is used in conjunction with bioventing, then bioventing may be effective in reducing the PCP mass.

The remaining alternatives, the no further action (G1) and LNAPL collection and natural attenuation (G2) alternatives, are similar in their long-term effectiveness and permanence. The LNAPL collection for the LNAPL collection and natural attenuation alternatives only removes a small fraction of the total PCP mass found in the LNAPL residual.

5.3.2.4. Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

Steam injection in conjunction with SVE offers the best TMV reduction because it is estimated to remove up to 90 percent of the 500,000 gallons of LNAPL and 26,000 lb of PCP in the saturated zone. If compared to the bioventing alternative (S4) coupled with one of the groundwater collection and treatment alternatives to dewater the LNAPL residual zone, the predicted TMV reduction of up to 90 percent for both alternatives is the same.

The other two groundwater collection and treatment alternatives are similar to each other in terms of percent TMV reduction. The groundwater collection and treatment throughout plume alternative affects a larger zone, but only removes marginally more PCP than alternative G3.

5.3.2.5. Short-term Effectiveness

All alternatives have minimal impacts with respect to the protection of workers during remedial construction, protection of community during remedial action, and environmental impacts of remedial action. The no further action alternative has no impacts because it does not involve handling extracted LNAPL or groundwater. The impacts of the steam injection in conjunction with SVE (Alternative G5) are greater because of potential emissions, odors, noise, and potential accidents, but measures will be implemented to minimize these.

The short-term effectiveness with respect to the time until the RAOs are achieved is shortest for the groundwater collection and treatment (G3, G4) and steam injection in conjunction with SVE (G5) alternatives because the three alternatives involve the active reduction of PCP in the groundwater. Time to meet RAOs is slowest is for the other two alternatives (G1, G2), which would take decades until RAOs are achieved.

The groundwater collection and treatment alternatives are similar relative to groundwater outside the LNAPL source area. The additional pumping wells as part of Alternative G4 may not result in much difference over the natural attenuation of Alternative G3 in the aerobic zone.

Both the groundwater collection and treatment alternatives, unless coupled with dewatering and bioventing, will take decades to reach groundwater RAOs because of continued PCP loading to groundwater from the LNAPL.

5.3.2.6. Implementability

No technical or administrative implementability problems are expected for all of the alternatives.

5.3.2.7. Cost

A summary of the estimated costs for each of the groundwater media alternatives is presented in Table 5-4. The table breaks down the estimated capital, operations and maintenance, and present net worth cost. An overview of the cost analysis performed for the FS and the detailed breakdowns for each of the alternatives are presented in Appendix G.

TABLE 5-4
Groundwater Media Summary Cost Table
Penta Wood, Feasibility Study Report

Alternative	Description	Capital Costs ($)	O&M ($)	Alternative Life (years)	Total Project Present Worth Costs ($)
Alternative G1	No Further Action	0	0	30	0
Alternative G2	LNAPL Collection and Natural Attenuation	414,122	2,500,000	30	2,900,000
Alternative G3	Groundwater Collection and Treatment	774,906	2,700,000	10	3,500,000
Alternative G4	Groundwater Collection and Treatment Throughout Plume	1,295,894	2,900,000	30	4,200,000
Alternative G5	Steam Injection in Conjunction with SVE	4,580,865	9,300,000	7.5	13,900,000

The no further action alternative has no cost, while the steam injection in conjunction with SVE alternative has the highest cost. Of the active remediation alternatives excluding steam injection in conjunction with SVE, the costs are within order-of-magnitude comparison.

SECTION 6

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Appendix A

Evaluation of ARARs

APPENDIX A

Evaluation of ARARs

Remedial actions must attain the standards defined by the applicable or relevant and appropriate requirements (ARARs) established by the USEPA and the WDNR for the site. Remedial actions must also take into account the "to be considered" criteria or guidelines if the ARARs do not address a particular situation. This appendix presents the definitions of ARARs, other criteria or guidelines to be considered, and the classification of ARARs and their determination.

A.1. Definition of ARARs

Remedial actions must be protective of public health and the environment. Section 121 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental requirements, as well as to adequately protect public health and the environment. The definitions of ARARs used in this document were developed from OSWER Directive No. 9234.1-01 CERCLA Compliance with Other Laws Manual.

Applicable requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, environmental action, location, or other circumstance at a CERCLA site. For a requirement to be applicable, the remedial action or the circumstance at the site must satisfy all the jurisdictional prerequisites of that requirement. For example, the minimum technology requirements for landfills under RCRA would apply only if a new hazardous waste landfill (or an expansion of an existing landfill) were to be built on a CERCLA site.

Relevant and appropriate requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, although not "applicable" to a hazardous substance, pollutant, contaminant, environmental action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar (relevant) to those encountered at the CERCLA site, that their use is well suited (appropriate) to the particular site. In some circumstances, a requirement may be relevant to the particular site-specific situation; however, it will not be appropriate because of differences in the purpose of the requirement, the duration of the regulated activity, or the physical size or characteristic of the situation it is intended to address. For example, National Ambient Air Quality Standards (NAAQS) developed under the Clean Air Act (CAA) may not be appropriate to use during the remedial activity because of the short duration of the activity.

The relevance and appropriateness of a requirement can be judged by comparing the factors addressed in the requirement with the features of the site. Those factors include the characteristic of the remedial action, the hazardous substances in question, and the physical circumstances of the site. For example, although RCRA capping regulations are not applicable to capping in-place hazardous waste that was disposed of before November 19, 1980 (effective date of the original RCRA regulations), and left undisturbed by the remedial action, the RCRA regulations for closure by capping may be deemed relevant and appropriate.

A requirement that is judged to be relevant and appropriate must be complied with to the same degree as if it were applicable. Relevant and appropriate requirements that are more stringent than applicable requirements take precedence. If, for example, a state standard is applicable while a more stringent federal standard is relevant and appropriate, the more stringent federal standard will prevail. There is more discretion in the determination of relevant and appropriate requirements than in the determination of applicable requirements. Therefore, it is possible for only a part of a requirement to be relevant and appropriate.

An additional factor in determining which requirements must be addressed is whether the requirement is substantive or administrative. Onsite CERCLA response actions must comply with substantive requirements but not with administrative requirements. Substantive requirements are those that pertain directly to actions or conditions in the environment. Examples of substantive requirements include quantitative health- or risk-based restrictions that limit exposure to types of hazardous substances and restrictions upon activities in certain special locations. Administrative requirements are mechanisms that facilitate the implementation of the substantive requirements of a statue or regulation. In general, administrative requirements prescribe methods and procedures (e.g., fees, permitting, inspection, documentation, reporting, and enforcement requirements) by which substantive requirements are made effective for purposes of a particular environmental or public health program (i.e., onsite CERCLA response action must meet the intent of the law but need not conform with all applicable administrative rules). This distinction applies only to onsite actions; offsite response actions are subject to the full requirements of applicable standards or regulations, including administrative requirements such as permits.

A.2. Other Criteria or Guidelines to Be Considered

In addition to laws and regulations, many state environmental and public health programs also develop unpromulgated and non-enforceable criteria, advisories, guidance, and proposed standards. These TBC criteria are not legally binding, but may provide useful information or recommend procedures when ARARs do not exist for a site condition or contaminant or when multiple contaminants or exposure pathways make ARARs insufficiently protective of human health and/or the environment. In such situations, the analysis of ARARs and TBCs serves to establish protective cleanup levels and to help identify preferred remedial action alternatives. Examples of criteria TBC include USEPA Drinking Water Health Advisories and reference doses (RfDs) and cancer potency factors for ingestion of noncarcinogenic and carcinogenic compounds used in risk assessments.

A.3. Classification of ARARs

The USEPA defines three types of ARARs:

- Chemical-specific
- Location-specific
- Action-specific

A.3.1. Chemical-Specific ARARs

Chemical-specific ARARs include laws and requirements that regulate the release to the environment of materials having certain chemical or physical characteristics or materials containing specified chemical compounds. These requirements generally establish health- or risk-based values or methodologies for environmental contaminant concentrations or discharge. If, in a specific situation, a chemical is subject to more than one discharge or exposure limit, the more stringent of the requirements should generally be applied.

A.3.2. Location-Specific ARARs

Location-specific ARARs are requirements that relate to the geographical or physical position of the site, rather than the nature of the contaminants or the proposed site remedial action. They may limit the type of remedial actions that can be implemented or may impose additional constraints on the remedial action. Examples of location-specific ARARs are state and federal laws and regulations that apply to the protection of wetlands or construction in floodplains.

A.3.3. Action-Specific ARARs

Action-specific ARARs are requirements that define acceptable treatment and disposal procedures for nonhazardous and hazardous substances. They generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to the management of hazardous substances or pollutants. These requirements are triggered by the remedial activities selected to accomplish a remedy. Since there are usually several alternative actions for any remedial site, different requirements can come into play. The action-specific requirements do not in themselves determine the remedial alternative; they indicate the type and level treatment or cleanup that will be achieved. Some of the most important action-specific ARARs are the RCRA requirements for the management of hazardous waste. Other important action-specific ARARs include the potential use of the corrective action management unit (CAMU) concept and the final cover requirements for wastes left in place.

A.4. Determination of ARARs

This evaluation mainly addresses State of Wisconsin ARARs. Several federal environmental programs have been delegated to the State of Wisconsin for implementation and enforcement. Thus, for those programs the state laws and rules constitute ARARs instead of the Federal laws and regulations. A comparison of the state and federal requirements is only necessary where there may be an instance of a federal requirement being more stringent than the state requirements in the delegated or authorized program. In Wisconsin the following programs are delegated to the WDNR:

- Resource Conservation and Recovery Act (RCRA) Subtitle C - Hazardous Waste (Authorized Program)
- Clean Water Act NPDES Discharges – WPDES/Wastewater Program (Authorized Program)
- Clean Air Act - Air Management Program (Delegated Program)

- Safe Drinking Water Act - Water Supply Program (Primacy Program)
- Underground Injection Control - Water Supply (Primacy Program)

Wisconsin also has cooperative agreements with USEPA to implement RCRA Subtitle I (LUST) program and State Lead Superfund projects. A basic requirement for these agreements is that the state laws and regulations must be equivalent to federal laws and regulations. The WDNR's Remediation and Redevelopment program's requirements under ch. 292 Wisconsin Statutes (Wis. Stats.) and the NR 700 rules series, Wisconsin Administrative Code (WAC), satisfies many of the federal equivalency requirements for these programs.

Federal and state ARARs are listed in Tables A-1 and A-2, but because the state ARARs were determined to comply with the following five criteria, the state ARARs are the focus of the following sections. The following are the five criteria that state ARARs must meet:

- Be promulgated standards
- Be more or as stringent as federal requirements
- Be identified to the USEPA in a timely manner
- Be applied consistently statewide
- Not result in a statewide prohibition on land disposal

It is USEPA's policy that state ARARs will be achieved to the greatest extent practicable.

The federal and state ARARS are listed in Tables A-1 and A-2, respectively. The tables are arranged in order of citation so that regulations cited elsewhere in this report may easily be located. Important ARAR-related considerations for the alternatives are discussed below.

A.4.1. Chemical-Specific ARARs

Chemical-specific ARARS include laws and requirements that regulate the release to the environment of specific substances having chemical or physical characteristics or materials containing specified chemical compounds. They are important in determining the extent of soil, sediment, and groundwater remediation and also residual levels of contaminants allowable after treatment. The chemical-specific ARARs can be classified into three categories: (1) residual concentrations of hazardous substances that can remain at the site without presenting a threat to human health and the environment; (2) land disposal restriction (LDR) concentrations that must be achieved if the contaminated media is excavated or extracted and later land disposed; and (3) effluent concentrations that must be achieved in treatment of the material so that water or air effluents do not exceed appropriate standards.

A.4.1.1. Residual Concentrations

The chemical-specific ARARs for residual soils are the Wisconsin soil cleanup levels as discussed in NR 720. NR 720 provides the procedures and risk assumptions for determining the soil cleanup standards and residual contaminant levels (RCLs) that are protective of public health, safety, welfare and the environment. The soil standard or site-specific RCL must be protective of the NR 140 groundwater standards for all contaminants of concern. The risk-based RCLs developed under NR 720 will be the basis for acceptance of any variances or exemptions under other regulatory authorities. The NR 720 procedures should be considered substantive requirements that are consistent with the NCP.Chemical-specific standards for groundwater include the Preventative Action Limits (PALs) and the Enforcement Standards (ES) listed in NR 140. Exemptions to the NR 140 Preventative Action Levels (PALs) are available under the terms of NR 140.28.

As previously mentioned, the State of Wisconsin administers the implementation of two major federal laws, the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) which contain chemical-specific standards and criteria that are often ARARs for groundwater remediation. NR 809 (formerly NR 112) establishes the drinking water standards, including the federal Maximum Contaminant Levels (MCLs).

A.4.1.2. LDR Concentrations

NR 675 describes the Land Disposal Restrictions as administered by the State of Wisconsin. Nearly all of the remaining contaminated soil attributed to the PWP site meets the definition in NR 605.09 of F032 for media containing PCP and F035 for media containing arsenic derived from ACZA formulations. The LDRs for F032 and F035 have not yet been promulgated into the Wisconsin rules. Thus, the federal LDRs may apply to remedial actions performed at the site. For alternatives including ex situ soil treatment, it is assumed that soils containing PCP will be treated according to the following LDR treatment standards:

- F032-listed waste (wastewater, process residuals, and preservative drippage from wood preservation with PCP)—LDR treatment standard of 7.4 mg/kg PCP or a treatability variance will be sought
- D037 TC waste—LDR treatment standard 7.4 mg/kg PCP and meet the universal treatment standards in 40 CFR 268.48 (e.g., 0.089 mg/L for PCP in Toxicity Characteristic Leaching Procedure [TCLP] extract) or a treatability variance will be sought

For alternatives including ex situ treatment of soils containing arsenic above background, it is assumed that soils will be treated according to the following LDR treatment standards:

- D004 TC waste—LDR treatment standard of 5 mg/L arsenic in Extraction Procedure (EP) or TCLP extract
- F035-listed waste (wastewater, process residuals, and preservative drippage from wood preservation with arsenic)—LDR treatment standard of 5 mg/L arsenic in TCLP extract

If the LDR treatment standard for a listed waste is more stringent than an RCL determined under NR 720 or NR 140 PAL, the LDR applies unless USEPA grants a variance in a ROD. WDNR would then recognize USEPA's decision under NR 675.24.

If LDRs are achieved and if health-based concentrations are achieved in accordance with the NR 140 PALs and the NR 720 RCLs, WDNR and USEPA may determine that the soil no longer contains the listed waste, in which case it could be replaced onsite. If health-based concentrations are not achieved, disposal in a RCRA Subtitle C hazardous waste landfill would be necessary because the treated material would still be considered a hazardous waste. Soil that is a characteristic waste and is treated to below the TCLP limits need only meet the solid waste disposal requirements (i.e., it does not have to be disposed in a RCRA hazardous waste landfill).

A.4.1.3. Effluent Limits

The substantive elements of the Wisconsin Pollutant Discharge Elimination System (WPDES) permit process will be used to establish the effluent limits for discharge of treated groundwater to surface water or groundwater (NR 102, NR 103, NR 104, NR 105, NR 106, NR 200, NR 207, and NR 220 and ch. 283, Wis. Stats.). Discharge limits for treated groundwater to surface water will need to meet Wisconsin surface water quality standards. Infiltration or reinjection of treated groundwater must meet Wisconsin NR 140 groundwater standards unless an exemption under NR 140.28(5) is obtained.

Any dust or emissions from treatment systems, grading or other earthwork must meet the ambient air standards for particulates in NR 404, fugitive dust standards in NR 415, control of organic compound emissions in NR 419, control of hazardous pollutant emissions in NR 445, and visible emissions standards in NR 431.

A.4.2. Location-Specific ARARs

Location-specific ARARs are requirements that relate to the geographical position of the site. The location-specific requirements identified as potential ARARs deal with environmentally sensitive areas (e.g., wetlands, floodplains, caves, fault zones, endangered species). The most important location-specific ARARs for the PWP site are the requirements for protection of wetlands (Executive Order 11990). This ARAR requires that actions at the site be conducted in ways that minimize the destruction, loss, or degradation of wetlands. The requirements evaluation of remediation impacts for wetland areas are included in NR 103 of the WAC.

A.4.3. Action-Specific ARARs

Action-specific ARARs are requirements that define acceptable treatment and disposal procedures for hazardous substances. Several of the more important action-specific ARARs that may affect the development and conceptual design of alternatives are discussed below.

A.4.3.1. Identification of Hazardous Waste and Land Disposal Restrictions

The most significant ARAR that affects alternatives involving excavation and treatment of soil is whether or not the contaminated soils to be managed are considered to be hazardous waste. The RCRA requirements, as established in the WDNR NR 600 rule series, are applicable if the waste is a hazardous waste and if the activity being considered as part of the remedial alternative constitutes treatment, storage, or disposal as defined by RCRA. The RCRA regulations may be relevant and appropriate to the site activities if the contaminated soils are not considered a hazardous waste, but are sufficiently similar in characteristic or composition to a RCRA hazardous waste. If the RCRA requirements are considered an ARAR, the excavation and disposal activities will require compliance with RCRA waste management standards including, accumulation, storage, transportation, and land disposal restrictions.

Alternatives for soil reconsolidation or redisposal units onsite must meet the ch. NR 600 land disposal minimum technology requirements (MTRs) for hazardous waste landfills, including a liner and a leachate collection system unless:

- Appropriate LDRs or NR 720 RCLs, whichever is more stringent are met prior to redisposal;

- An exemption is granted under NR 680.04;
- A CAMU is established and justified under ch. 636; or
- A CERCLA waiver is issued by USEPA.

These criteria are discussed below.

A.4.3.1.1. Classification of Wastes

The first part of the RCRA applicability determination is to determine whether or not the contaminated soil is a RCRA hazardous waste. The mixture rule within RCRA states that mixtures of hazardous waste and solid waste are to be considered hazardous waste. However, the mixture rule can not apply to contaminated media such as soil, because the media has not been "discarded" and is therefore not a solid waste. To clarify how the mixture rule applies to contaminated environmental media, EPA developed a "contained-in" policy which specifies that environmental media that "contains" a hazardous waste must be managed as a hazardous waste. This policy applies to contaminated environmental media that exhibits a characteristic of a hazardous waste, such as toxicity, and to environmental media contaminated with a listed hazardous waste, such as F-listed solvents. To determine whether a contaminated environmental media at a CERCLA site is a listed hazardous waste, the origin of the waste which contaminated the media must be known. If the origin of the waste is not known or there is no documentation on the waste, the media can be assumed not to contain a listed hazardous waste. To determine if a contaminated environmental media at a CERCLA site is a characteristic waste, the media can be tested or professional judgment can be used to determine whether testing is necessary. Under RCRA, a generator is not required to test their waste, but can use knowledge of the waste constituents to make a characteristic determination.

USEPA Region 5 requested WDNR to identify state ARARs for removal actions USEPA was conducting at the Penta Wood Products Company site in 1994. The removal actions included onsite solidification and placement of ammoniacal copper zinc arsenate (ACZA) containing soils, and offsite treatment and disposal of PCP and ACZA containing liquids, sludges and soils. WDNR responded in a letter dated July 12, 1994 (included as Attachment A). The following materials were identified as RCRA hazardous wastes:

- Materials contaminated by metals from the ACZA solutions could be toxicity characteristic hazardous waste if the metals exceed the TCLP limits. Soils contaminated with arsenic may be toxicity characteristic and should be managed as a D004 hazardous waste if the soil fails the TCLP limit of 5 mg/L for arsenic.
- Materials contaminated by pentachlorophenol (PCP) are F027 and F032 listed hazardous waste. F027 hazardous waste is defined as discarded unused formulations containing PCP. F032 waste are wastewater, process residuals, preservative drippage and spent formulations from wood preserving with PCP. These wastes have likely been spilled on the site and account for subsequent contamination of the soil.
- Any material classified as a wastewater sludge, regardless of the source of contamination is a K001 listed waste.

In an updated ARAR evaluation, WDNR indicated that the USEPA's removal activities at the site should have removed and disposed of any discarded PCP formulations and wastewater sludges (see Attachment A). Nearly all of the remaining contaminated soil and groundwater attributed to the PWP site meets the definition in NR 609.05 of F032 for media containing PCP and F035 for media containing arsenic derived from ACZA formulations. Thus, soil contaminated with PCP will be managed as if it were a hazardous waste (i.e., F032) in accordance with the "contained in" policy and as a D037 toxicity characteristic waste if it fails the TCLP limit of 0.089 mg/L for PCP. Soil contaminated with arsenic above background concentrations will be managed as if it were a hazardous waste (i.e., F035 and/or D004).

A.4.3.1.2. Land Disposal Requirements

The second part of the applicability determination for RCRA requirements is whether or not hazardous wastes activity at the site constitutes treatment, storage, or disposal. By excavating the hazardous waste contaminated soil and managing the soil for treatment and/or disposal, the second applicability criteria is met. Because several alternatives include land disposal either directly or as residuals from treatment, the major impact of the designation of the contaminated soils as hazardous waste is the restrictions placed on land disposal of those soils under 40 CFR 268. Difficulties that become apparent when trying to apply the LDR treatment standards to contaminated soils are, in many cases, that the LDR treatment standard is more stringent than the cleanup standards for the contaminated media, and the LDR treatment standards were developed and based on characteristics of "as generated" wastes, not on environmental media contaminated with hazardous wastes. The standards for the contaminated media were derived from risk-based considerations and other regulatory requirements. In some cases it may not be possible or appropriate to apply the LDR treatment standard to the contaminated soil. The January 9, 1992 preamble to the then proposed LDRs for newly listed wastes and contaminated debris contains the following language regarding the management of contaminated media:

> "Currently, media that are contaminated with hazardous waste must be managed *as if* they were hazardous wastes until they no longer "contain" the listed waste, exhibit a characteristic, or are delisted. The Agency has not issued any general rule as to when, or at what levels, environmental media or debris contaminated with hazardous wastes are no longer considered to "contain" those hazardous wastes. EPA believes that such levels for media are most appropriately determined on a site-specific basis by the EPA Region (or authorized State) overseeing the cleanup of such materials, such as Superfund or Corrective Action remediation. *Such levels for media are generally determined according to risk".* (emphasis added, 57 FR 986).

USEPA finalized LDR treatment standards for debris contaminated with hazardous waste on August 18, 1992 (57 FR 37194), including provisions which address when a debris no longer contains a hazardous waste. USEPA has not, however, finalized treatment standards for contaminated hazardous soil. EPA proposed Requirements for Management of Hazardous Contaminated Media (HWIR-media) on April 29, 1996 (61 FR 18780) which include modified LDR treatment standards for contaminated soil and interpretations of the application of the "contained-in" policy to contaminated media.

Based on discussions with WDNR, the point at which the media no longer contains a hazardous waste is when the contaminant is: 1) not detected, 2) below backgtound for naturally occurring compounds (e.g., arsenic) , or 3) below some other level determined to be acceptable. Consistent with their authority under the Chapter 160 Wis Statutes and their enforcement of the Hazardous Substance Spill Law (ss 292.11 Wis. Statutes), WDNR has been using the NR 140 PALs and the RCLs as determined in NR 720 as an "acceptable level." An exception to the use of NR 720 to meet the "contained in" interpretation is noted under NR 720.02(1)(b); in cases where USEPA has adopted a more stringent standard (such as an LDR treatment standard), then the more stringent standard applies.

For alternatives including ex situ soil treatment, it is assumed that soils containing PCP will be treated to the following LDR treatment standards:

- F032 listed waste—LDR treatment standard of 7.4 mg/kg for PCP or a treatability variance will be sought as discussed below
- D037 TC waste—LDR treatment standard 7.4 mg/kg PCP and meet the universal treatment standards in 40 CFR 268.43 (e.g. 0.089 mg/L of PCP in TCLP extract)

For alternatives including ex situ soil treatment of soils containing arsenic above background, it is assumed that soils will be treated to the following LDR treatment standards:

- D004 TC waste—LDR treatment standard of 5 mg/L for arsenic in EP or TCLP extract
- F035 listed waste—LDR treatment standard of 5 mg/L for arsenic in TCLP extract

Figure A-1 is a flow diagram that illustrates the ARARs that would apply for excavated PCP-contaminated soil.

If LDR treatment standards and background or acceptable levels are achieved in accordance with NR 720, WDNR no longer considers the soil to contain the listed waste, in which case it could be replaced onsite. Management of the material would still have to comply with the solid waste disposal requirements of NR 718.11(3). If background or the acceptable levels are not achieved, disposal in a RCRA Subtitle C hazardous waste landfill would be necessary because the treated material would still be considered a hazardous waste. Soil that is only a characteristic waste and is treated to below the TCLP limits, need only meet the solid waste disposal requirements of NR 718.11(3), (i.e., it does not have to be disposed in a RCRA hazardous waste landfill). NR 718 - Management of Solid Wastes Excavated During Response Actions sets minimum requirements for storage and disposal of excavated and/or treated soil.

Redisposal of contaminated media must meet the landfill technical requirements outlined in the NR 500 rule series, including a liner and a leachate collection system unless: an exemption is granted under s. NR 500.08(6); or a CERCLA waiver is issued by USEPA. Based on NR 500.08(6), an exemption from the solid waste rules (NR 500 to 538) may be obtained from WDNR for: (a) facilities for the treatment, storage, or disposal of solid waste which is excavated for the primary purpose of implementing a remedial action in compliance with the requirements of chs. NR 700 to 726 and which is returned to the same property from which it was excavated in compliance of ch. NR 718; and (b) facilities for the treatment, storage, or disposal of excavated contaminated soil which are operated in compliance with the requirements of ch. NR 718.

Another consideration for evaluating the impact of LDR requirements on alternatives including ex situ treatment is the possibility of obtaining a treatability variance. The applicability of treatability variances is stated in 40 CFR 268.44(a) as follows:

> "Where the treatment standard is expressed as a concentration in a waste or waste extract and a waste cannot be treated to the specified level, or where the treatment technology is not appropriate to a waste, the generator or treatment facility may petition the Administrator for a variance from the treatment standard. The petitioner must demonstrate that because the physical or chemical properties of the waste differs significantly from the wastes analyzed in developing the treatment standard, the waste cannot be treated to the specified level or by the specified methods."

USEPA has recognized that many of the LDR treatment standards may not be achievable in contaminated media and will grant treatability variances. This may be the case for soils containing F032 listed waste because the LDR treatment standard of 7.4 mg/kg may be difficult to achieve using the most feasible treatment technology—biological treatment. As a result, a treatability variance may be sought for soils containing F035 listed waste.

NR 675 describes the Land Disposal Restrictions as administered by the State of Wisconsin. However, the LDRs for F032 and F035 have not yet been promulgated into the Wisconsin rules. Thus, the LDRs are a Federal ARAR and the WDNR cannot issue a variance to the LDRs under the current law and codes. If a variance, such as a treatability variance, is necessary, NR 675.24 allows facilities to petition USEPA for a variance from the LDRs.

A.4.3.1.3. Phase IV Land Disposal Restrictions Final Rule

The USEPA recently promulgated the Phase IV Land Disposal Restrictions. The rule amends the LDR treatment standards for soil contaminated with hazardous waste. According to the rule's preamble, the purpose of the revision is to create standards which are more technically and environmentally appropriate to contaminated soils than those which currently apply. Generators of contaminated soil have the option of complying either with the existing treatment standards for industrial hazardous waste (i.e., the universal treatment standards) or the soil treatment standards. Soil-specific treatment standards require reduction in concentrations of hazardous constituents by 90% with treatment for any given constituent capped at ten times the universal treatment standard. This is commonly referred to as 90% capped at 10 times UTS. This rule relaxes the PCP LDR of 7.4 mg/kg to either 90% reduction of PCP (average PCP concentrations in the unsaturated soil is 150 mg/kg and in the LNAPL residual zone is 1,500 mg/kg), or 10 times the UTS of 7.4 mg/kg, if this value is higher. For the unsaturated soils if the average PCP value of 150 mg/kg is used, 90% reduction is 15 mg/kg, so the standard would be capped at 10 times the UST, at 74 mg/kg. For the LNAPL residuals if the average PCP concentration of 1,500 mg/kg is used, 90% reduction is 150 mg/kg, which would then be the standard.

If the chosen remedy for the site uses in situ treatment and the CAMU rule is applied to soils picked up and placed in the treatment area, the requirements for "generated" hazardous waste are not triggered and these LDRs do not apply to the site.

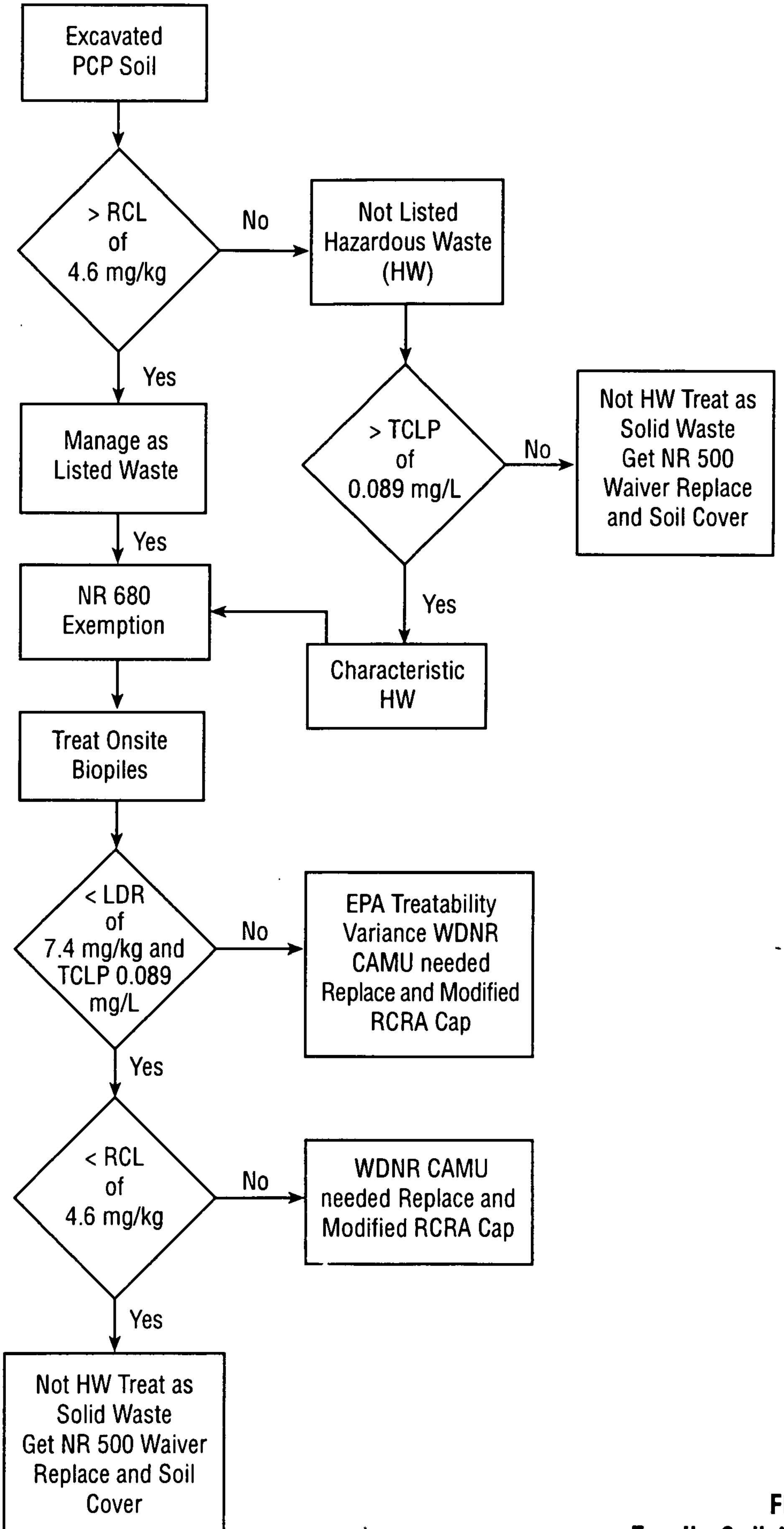

FIGURE A-1
Ex-situ Soil Alternative ARARs Flow Diagram
Penta Wood Products FS Report
CH2MHILL

E141158.FS.01 Org Chart 5-4-98 tll

A.4.3.1.4. NR 680.04 Exemption

Exemptions from the hazardous waste management requirements of chs. NR 600 to 685 in the WAC may be granted by WDNR for hazardous waste facilities in relation to location, engineering design and operation. The exemption may be justified provided the proposed alternative provides the same level of protection as the requirements of chs. NR 630 to 685. In addition, the proposed alternative must not pose an increased threat to human health or the environment and must take into consideration factors such as the quantity, composition, and degree of hazard of the waste to be managed, any potential degradation of the environment and potential nuisance conditions. The NR 680.04 exemption may be necessary for the construction of biopiles and for consolidation of contaminated soil under a cap.

A.4.3.1.5. Corrective Action Management Units

The corrective action management unit (CAMU) rule within RCRA (40 CFR 264 Subpart S [264.552]) allows movement of contaminated material within an area of contamination without triggering the requirements for "generated" hazardous waste. In essence it allows consolidation of contaminated soils and sediments containing listed or characteristic waste without triggering the land disposal restriction requirements. This concept is needed for alternatives involving consolidation followed by containment under a cap or otherwise the alternative would not comply with RCRA ARARs.

Wisconsin has adopted the corrective action management unit (CAMU) rule in NR 636. If a CAMU is established under NR 636, the LDRs do not apply. Criteria for establishing a CAMU in NR 636.40(3)(b) states that for waste management activities associated with the CAMU may not create unacceptable risk to humans and environment from exposure to the hazardous waste or hazardous constituents.

A.4.3.2. Capping Requirements

Several alternatives include capping for contaminated soils. The federal and state landfill capping requirements are not considered applicable because the soils are not being disposed under these alternatives. Given that the soils contain listed and potentially characteristic waste, the federal and state ARARs for closure of landfills may be considered relevant and appropriate. The specific requirements are presented below.

A.4.3.2.1. Hazardous Waste Landfill Closure ARARs

As mentioned previously, the USEPA has authorized the State of Wisconsin to implement and enforce the RCRA program. The Wisconsin regulations governing closure of a hazardous waste landfill are established in NR 660 (Landfill and Surface Impoundment Standards) and NR 685 (Closure, Long-term Care and Financial Responsibility). These requirements are not applicable because the remedial alternatives do not include disposal of hazardous waste. While not applicable, the requirements may be relevant and appropriate if they address problems or situations sufficiently similar and are well suited to the circumstances at the site.

The federal regulations governing landfill closure are RCRA Subpart G (Closure and Post-Closure) and Subpart N (Closure and Post-Closure for Landfills) and may also be considered relevant and appropriate. The state requirements are identical to the federal requirements.

NR 685.05 provides general closure requirements for hazardous waste facilities. The main requirements are to close the facility in a manner that: "(a) Minimizes the need for further maintenance;" and " (b) Controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post closure escape of wastes, hazardous leachate, contaminated runoff, or waste decomposition products to the ground or surface waters, or to the atmosphere."

Wisconsin ch. NR 660.20 requires at final closure any landfill, unit or cell be closed with a final cover designed and constructed to:

- Provide long-term minimization of migration of liquids through the closed landfill
- Function with minimum maintenance
- Promote drainage and minimize erosion or abrasion of the cover
- Accommodate settling and subsidence so that the cover's integrity is maintained
- Have a permeability of any bottom liner or natural subsoils present

A.4.3.2.2. Solid Waste Landfill Closure ARARs

In addition to requirements for closure of hazardous waste landfills, the closure requirements for solid waste landfills were also evaluated for more stringent requirements. Wisconsin Subtitle D landfill requirements are contained in NR 504 and 506. NR 506.08 sets the minimum requirements for closure of landfills and includes:

- Cover the area of disposal with a minimum of 2 feet of compacted earth of no more than 1×10^{-5} cm/sec
- Final slopes of at least 5 percent but not exceed 4 horizontal to 1 vertical
- Finished surface covered with 6 inches of topsoil
- Establish vegetation

NR 504.07 sets the minimum requirements for final cover systems for new or expanded solid waste landfills. The main requirements are:

- 6-inch grading layer over the wastes
- 2-foot clay capping layer of no more than 1×10^{-7} cm/sec
- 40-mil geomembrane layer for municipal solid waste landfills (not required for high volume industrial waste landfills)
- 2.5-foot drainage and root layer with at least 1 foot of sand or geosynthethic drain layer
- finished surface covered with 6 inches of topsoil and revegetated

The cap included in soil media containment alternative S3 meets these requirements with the one exception that a GCL replaces the 2-foot clay capping layer. This was done because the GCL has better self healing properties than clay if desiccation cracks occur as a result of the deep frost penetration in northern Wisconsin.

A.4.3.3. Groundwater Treatment Requirements

Extracting groundwater is a technology that will be considered to remediate the aquifer affected by PWP chemicals. Subsequent treatment and discharge of the extracted groundwater will be required. Options available for the treated water are discharged to a surface water body or reinjection.

In addition to discharge requirements, RCRA requirements may also be applicable if the groundwater treatment system yields residues to be disposed of offsite. The complexity of the disposal of groundwater treatment residues will be based on the determination of whether treatment residues are a characteristic hazardous waste.

A.4.3.4. WPDES Permit Requirements

The degree of treatment of groundwater is determined by the WPDES discharge requirements for discharge to surface water or groundwater of Wisconsin. Discharge limits for discharge of treated groundwater to surface water and discharge to infiltration basins will be obtained from WDNR prior to determining treatment requirements. Discharge to a surface water, seepage cell or infiltration gallery must meet effluent limits set by the WDNR. Infiltration galleries and injection wells must meet the terms of NR 140.28(5) and NR 812.05. An exemption by WDNR will be necessary for infiltration or reinjection of the treated groundwater. The following are the requirements for the exemption:

- The remedial action shall achieve the applicable response objectives within a reasonable time.
- The type, concentration and volume of substances or remedial material to be infiltrated or injected shall be minimized to the extent that is necessary for restoration of the contaminated soil or groundwater and be approved by the WDNR prior to use.
- Any infiltration or injection of contaminated water or remedial material will not significantly increase the threat to public health or welfare.
- No water, substance or remedial material will be infiltrated or injected into an area where a floating non-aqueous phase liquid is present.
- There will be no expansion of soil or groundwater contamination, or migration of any infiltrated or injected contaminated water or remedial material, beyond the edges of previously contaminated areas, unless the WDNR agrees that expansion into adjacent previously uncontaminated areas is necessary for the restoration of the contaminated soil or groundwater.

A.4.3.5. In Situ Soil Treatment ARARs

Alternative G5 includes in situ treatment of contaminated soils in the smear zone. Any technologies that include injection of chemicals into the soil would be prohibited under NR 112, and a variance would be required. For onsite Superfund action, only the substantive technical requirements for a variance would be required.

A.4.4. To Be Considered Criteria

The "to be considered criteria" are nonpromulgated, non-enforceable guidelines or criteria that may be useful for developing an interim remedial action, or are necessary for evaluating what is protective for human health and/or the environment. The following documents were identified as TBCs for the PWP site:

- *Sediment Quality Objectives for the Contaminants of Concern at the Penta Wood Products (PWP) Superfund Site, Town of Daniels* prepared by Tom Janisch (WDNR). This document was prepared according to applicable surface water criteria in NR 102, NR 105 along with NR 103.
- Chapter 245 Wisconsin Statutes establishes the authority of the State Department of Health and local health departments to assess human health hazards.
- *Interim Policy for Promoting the In-state and On-Site Management of Hazardous Waste in the State of Wisconsin* (March 14, 1991). This policy requires that several preferred management options are examined and utilized to the extent feasible. Out of state disposal of hazardous waste in a landfill is the least preferred option.
- *Understanding Wisconsin Standards for Cleanup of Contaminated Soil , An Overview of Wisconsin Administrative Code Chapter NR 700* (WDNR Publication RR-520-97, March 1997)
- *Interim Guidance on Soil Cleanup Levels for Polycyclic Aromatic Hydrocarbons (PAHs)* (WDNR Publication RR-519-97, April 1997)
- *Interim Guidance on Use of Leaching Tests for Unsaturated Contaminated Soils to Determine Groundwater Contamination Potential* (WDNR Publication RR-523-97, March 1997)
- *Interim Guidance on Soil Performance Standards* (WDNR Publication RR-528-97, March 1997)

TABLE A-1
Summary of Potential Federal ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
Executive Orders 11988 and 11990 40 CFR 6, Subpart A	Requires federal agencies to avoid whenever possible, adversely affecting flood plains or wetlands and to evaluate potential effects of actions in these designated areas.	S2, S3, S4, S5	Applicable to wetlands and Doctor Lake.
50 CFR 402–Interagency Cooperation—Endangered Species Act of 1973, as amended	Requires remedial agency to consult with Fish and Wildlife Service if action may affect endangered species or critical habitat.	S2, S3, S4, S5	Applicable if Fish and Wildlife Service deems area a critical habitat. Wetland and Doctor Lake are not designated to be critical habitat.
Air Regulations			
Clean Air Act Section 101	Calls for development and implementation of regional air pollution control programs	S5, G5	Section 101 of the Clean Air Act delegates primary responsibility for regional air quality management to the states. The rules for implementation of regional air quality plans are contained in 40 CFR 52. Regulations promulgated under the Clean Air Act may apply to possible actions at the site that generate air emissions, but are most applicable to stationary sources.
40 CFR 50–National Primary and Secondary Ambient Air Quality Standards	Establishes Ambient Air Quality Standards.	S2, S3, S4, S5 G5	Applicable to discharges of toxic substances to the atmosphere during waste handling or treatment.
40 CFR 51–Requirements for Preparation, Adoption, and Submittal of Implementation Plans	Requires excavation activities be controlled to minimize fugitive dust emissions.	S2, S3, S4, S5	Applicable to fugitive dust emissions from excavation and consolidation of contaminated soil.

TABLE A-1
Summary of Potential Federal ARARs
(Page 2 of 8)

Citation	Requirement/Purpose	Alternatives Affected	Applicability
40 CFR 52–Approval and Promulgation of Implementation Plans	Requires the filing of a notice with the state regarding intent to install a new stationary source of air pollution.	S5,G5	40 CFR 52 concerns the installation of stationary sources of air emissions. Provisions enforceable by the state follow the federal Prevention of Significant Deterioration (PSD) program with modifications to conform with regional and local ambient air quality standards. A CERCLA response action is not required to obtain permits under the PSD program, but must comply with the substantive requirements of a PSD review.
40 CFR 61–National Emission Standards for Hazardous Waste Pollutants	Requires limiting ambient hydrogen sulfide emissions to less than 0.10 ppm. The regulation also includes emission standards for PCP and inorganic arsenic–both of which are designated hazardous air pollutants.	S5, G5	Applicable to discharges of toxic substances to the atmosphere during waste handling or treatment.
40 CFR 264.AA–Air Emission Standards for Process Vents	Requires total organic emissions from air strippers or steam strippers to be reduced below 1.4 kg/hr and 2.8 Mg/yr or that total organic emissions be reduced by 95 percent by weight.	S5, G5	Applicable to discharges of toxic substances to the atmosphere during waste handling or treatment.
Water Regulations			
Federal Water Pollution Control Act as amended by the Clean Water Act of 1977, Section 208(b)	The proposed action must be consistent with regional water quality management plans as developed under Section 208 of Clean Water Act.	G3, G4, G5	Substantive requirements adopted by the state pursuant to Section 208 of the Clean Water Act would be applicable to direct discharge of treatment system effluent or other discharges to surface water.

TABLE A-1
Summary of Potential Federal ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
Federal Water Pollution Control Act as amended by the Clean Water Act of 1977, Section 304	Establishes water quality criteria for specific pollutants for the protection of human health and for the protection of aquatic life. These federal water quality criteria are non-enforceable guidelines used by the state to set water quality standards for surface water.	G2, G3, G4, G5	Water quality criteria may be relevant and appropriate to groundwater or treatment system effluent or other discharges to surface water.
40 CFR 122.21–Application for Permit	Permit application must include a detailed description of the proposed action, including a listing of all required environmental permits.	G3, G4, G5	Administrative requirement applicable only for discharges to offsite surface water (Doctor Lake).
40 CFR 122.44–Establishing Limitations, Standards, and Other Permit Conditions	Federally approved state water quality standards. These may be in addition to or more stringent than federal water quality standards under the CWA.	G3, G4,G5	All substantive requirements under the cited sections of 40 CFR 122 would be applicable to the direct discharge of effluent to an onsite or offsite surface water body. Administrative requirements, such as permitting and reporting procedures, would be applicable only for effluent discharged to an offsite location (such as a discharge into a stream flowing offsite). Therefore, at the PWP site these requirements would be applicable to proposed discharges to Doctor Lake.
40 CFR 122.44(a)–Technology-Based Effluent Limitations and Standards	Requires the use of the Best Available Technology (BAT) for toxic and nonconventional wastewaters or the Best Conventional Technology (BCT) for conventional pollutants. The nature of the wastewater and the technology-based limitations will be determined by the state on a case-by-case basis.	G3, G4, G5	

TABLE A-1
Summary of Potential Federal ARARs
(Page 4 of 8)

Citation	Requirement/Purpose	Alternatives Affected	Applicability
40 CFR 122.44(e)–Technology-Based Controls for Toxic Pollutants	Discharge limits must be established at concentrations exceeding levels achievable by the technology-based (BAT/BCT) standards. The discharge limitations would be evaluated on a case-by-case basis depending on the proposed treatment system and the receiving water.	G3, G4, G5	
40 CFR 122.44(i)–Monitoring Requirements	Requires monitoring of discharges to ensure compliance. Monitoring programs shall include data on the mass, volume, and frequency of all discharge events.	G3, G4, G5	Administrative requirement applicable only for discharges to offsite surface water (Doctor Lake).
40 CFR 125–U.S. EPA Regulations on Criteria and Standards for the NPDES (40 CFR 125.100)	The site operator shall develop a best management practice (BMP) program and shall incorporate it into the operations plan or the NPDES permit application if required.	G3, G4, G5	Substantive and administrative requirements of 40 CFR 125 would be applicable to the direct discharge of treatment system effluent to Doctor Lake or offsite surface water body.
40 CFR 125.104–Best Management Practices Program	The BMP program must establish procedures for managing potential spills, predict spill flow and ensure RCRA management of spilled waste.	G3, G4, G5	
40 CFR 131–Water Quality Standards	States are granted enforcement jurisdiction over direct discharges and may adopt reasonable standards to protect or enhance the uses and qualities of surface water bodies in the state.	G3, G4, G5	Applicable to direct discharge of treatment system effluent or other process waters. Such a discharge into Doctor Lake would activate the administrative requirements of this rule because it would affect offsite surface waters.
40 CFR 136–Guidelines Establishing Test Procedures for the Analysis of [Water] Pollutants (40 CFR 136.1 - 136.4)	These sections require adherence to sample preservation procedures including container materials and sample holding times.	G3, G4,G5	Applicable to direct discharge of treatment system effluent.

TABLE A-1
Summary of Potential Federal ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
40 CFR 141–National Primary Drinking Water Regulations	Establishes maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) for specific chemicals to protect drinking water quality.	G2, G3, G4, G5	MCLs and nonzero MCLGs may be applicable or relevant and appropriate as groundwater contaminant concentration goals depending on whether the water in question is to be used for drinking water supply. MCLs are applicable if the water is or will be used for drinking. MCLs are relevant and appropriate if the water could be used for drinking. MCLGs set above zero levels, are relevant and appropriate for current or potential sources of drinking water.
40 CFR 144– Underground Injection Control Program	Establishes the requirements for underground injection wells and for discharge of wastewaters and hazardous wastes. Reinjection is prohibited except for reinjection of contaminated groundwater into the same formation from which it was withdrawn pursuant to CERCLA actvities	G3, G4, G5	Applicable to reinjection of treatment system effluent.
40 CFR 146–Underground Injection Control Program: Criteria and Standards	Establishes the technical criteria for the UIC program, including the construction, operating, monitoring and reporting requirements.	G3, G4, G5	Applicable to injection of wastewater to aquifer.
40 CFR 147–Regulations on State UIC Programs	The proposed action is required to be in compliance with State underground injection requirements.	G3, G4, G5	Applicable to injection of wastewater to aquifer.
Solid and Hazardous Waste Regulations			
Subtitle D, 40 CFR 257–Criteria for Classification of Solid Waste Disposal Facility and Practices	Sets standards for land disposal facilities for nonhazardous waste.	S2, S3, S4, S5 G2, G3, G4, G5	Applicable to groundwater treatment residuals and to transport and disposal of any nonhazardous waste offsite.

TABLE A-1
Summary of Potential Federal ARARs
(Page 6 of 8)

Citation	Requirement/Purpose	Alternatives Affected	Applicability
Subtitle C, 40 CFR 260 through 264	Regulates the generation, transport, storage, treatment, and disposal of hazardous wastes generated in the course of a remedial action. Regulates the construction, design, monitoring, operation, and closure of hazardous waste facilities.	S2, S3, S4, S5 G2, G3, G4, G5	Requirements under these regulations may be relevant and appropriate to storage of certain non-hazardous wastes or treatment system residuals if the risk they present are similar to those associated with hazardous wastes. The criteria and limitations used to identify wastes as being hazardous or nonhazardous are applicable to groundwater treatment residuals.
40 CFR 261–Identification and Listing of Hazardous Waste	Identifies those wastes subject to regulation as hazardous wastes	S2, S3, S4, S5 G2, G3, G4, G5	The criteria and limitations used to identify wastes as being hazardous or nonhazardous in 40 CFR 261 are relevant and appropriate to all proposed cleanup actions at the PWP site. Determining whether wastes qualify as hazardous will often establish the applicability of other regulations.
40 CFR 264, Subpart F–Releases from Solid Waste Management Units (Groundwater Protection–40 CFR 264.90 - 264.101)	Establishes requirements for detecting, characterizing and responding to releases to the uppermost aquifer. Also establishes the groundwater protection standards for hazardous constituents in the upper-most aquifer underlying a waste management area beyond the point of compliance.	S2, S3, S4, S5	Requirements under these regulations may be relevant and appropriate if contaminated soils or treatment residuals qualifying as hazardous wastes are placed in a waste pile, landfill or miscellaneous unit onsite. The substantive requirements for permitting would also have to be met.
40 CFR 264, Subpart G–Closure and Post-Closure (40 CFR 264.110 to 264.120)	Provides technical and procedural closure requirements for hazardous waste facilities. Requires the facility be closed in a manner that controls, minimizes or eliminates to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground or surface water or to the atmosphere.	S2, S3, S4, S5	Consolidation of excavated material or soil treatment residuals that contains listed or characteristic waste may make these requirements applicable.

TABLE A-1
Summary of Potential Federal ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
40 CFR 264, Subpart N–Landfills (40 CFR 264.301 to 264.304)	Establishes the design and operating, monitoring and closure requirements for landfills. Requires that all landfills have a liner system, a leachate collection and removal system, and leak detection system to prevent any migration of wastes out of the landfill, to the adjacent subsurface soil or groundwater or surface water anytime during the active life of the landfill.	S2, S3, S4, S5	Consolidation of excavated material or soil treatment residuals that contains listed or characteristic waste may make these requirements applicable.
40 CFR 264.310–Closure and Post-Closure Care	Requires landfills to closed with a final cover designed and constructed to: provide long-term minimization of migration of liquids through the capped area; function with minimum maintenance; promote drainage and minimize erosion or abrasion of the cover; accommodate settling and subsistence so that the cover's integrity is maintained; and have a permeability less than or equal to the permeability of any bottom liner system or natural sub-soils present	S2, S3, S4, S5	Consolidation of excavated material or soil treatment residuals that contains listed or characteristic waste may make these requirements applicable.
40 CFR 264, Subpart S–Corrective Action for Solid Waste Management Units (Corrective Action Management Units–40 CFR 264.552)	Establishes the requirements for designating an area as a Corrective Action Management Unit (CAMU). (1) Placement of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes. (2) Consolidation or placement of remediation wastes into or within a CAMU does not constitute creation of a unit subject to minimum technology requirements.	S2, S3, S4, S5	Consolidation of excavated material or soil treatment residuals that contain listed or characteristic waste may require establishment of a CAMU.

TABLE A-1
Summary of Potential Federal ARARs
(Page 8 of 8)

Citation	Requirement/Purpose	Alternatives Affected	Applicability
40 CFR 241–Guidelines for Land Disposal of Solid Wastes	Offsite solid waste land disposal units must meet the federal guidelines for the land disposal of solid wastes.	S2, S3, S4, S5 G2, G3, G4, G5	Applicability depends on waste classification of soil, building debris, and groundwater treatment residuals.
40 CFR 268 Subpart C–Prohibitions on Land Disposal	The land disposal restriction under this subpart prohibits land-based disposal of certain solvent-containing wastes, dioxin-containing wastes, and listed wastes.	S2, S3, S4, S5	The rules in 40 CFR 268 restrict land disposal of several types of hazardous wastes and as such, may affect the implementation of several potential actions, including actions involving disposal of contaminated soils. The land disposal ban may be applicable or relevant and appropriate to the proposed cleanup of the PWP site because qualifying hazardous wastes might be present in onsite soils. The LDRs delegate primary responsibility to the states except to the extent that promulgated federal regulations are not yet incorporated.
40 CFR 268 Subpart D–Treatment Standards	Materials containing RCRA hazardous waste subject to land disposal restrictions. Some hazardous wastes restricted from land disposal in Subpart C may be land-disposed providing they attain levels achievable by best demonstrated available technologies (BDAT) for each hazardous constituent for each listed waste.	S2, S3, S4, S5	Movement of excavated materials to new location and placement in or on land will trigger land disposal restrictions for the excavated waste or closure requirements for the unit in which the waste is being placed.
U.S. EPA and DOT Regulations on Transport of Hazardous Waste			
40 CFR 262 and 263 49 CFR 100 through 199	Establishes responsibilities for transporters of hazardous waste in handling, transportation, and management of the waste. Sets requirements for manifesting, recordkeeping, and emergency response action in case of a spill.	G2, G3, G4, G5	Applicability depends on waste classification of groundwater treatment residuals.

TABLE A-2
Summary of Potential Wisconsin ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
NR 102–Water Quality Standards for Wisconsin Surface Water	Describes the designated use categories and water quality criteria to support uses.	G3, G4, G5	Actions involving treated discharge to Doctor Lake must meet water quality standards.
NR 103–Water Quality Standards for Wetlands	Establishes water quality standards for wetlands and implementation procedures for application of the wetland water quality standards.	S2, S3, S4, S5 G3, G4, G5	Relevant to treated discharge from groundwater source control and remediation of contaminated sediments in the wetlands. Also relevant for cover construction and groundwater withdrawal activities that have the potential to impact wetlands.
NR 104–Uses and Designated Standards and Secondary Values	Establishes surface water classifications and specifies effluent limitations for intrastate waters.	G3, G4, G5	Actions involving treated discharge to Doctor Lake must meet water quality standards
NR 105–Surface Water Quality Criteria for Toxic Substances	Establishes water quality criteria and methods for developing criteria and secondary values for toxic and organoleptic substances for the protection of human health and welfare, and propagation of fish, aquatic life and wildlife. Also requires that contaminated sediment be remediated to meet sediment quality criteria that are protective of surface water quality standards.	S2, S3, S4, S5 G3, G4, G5	Water quality criteria are used by WDNR in setting WPDES discharge limit for toxics and developing sediment quality criteria.
NR 106–Procedures for Calculating Water Quality Based Effluent Limitations for Toxic and Organoleptic Substances Discharged to Surface Waters	Specifies the procedures to calculate effluent limits for toxic and organoleptic substances and if and how these limits will be included in WPDES permits.	G3, G4, G5	Water quality criteria are used by WDNR in setting WPDES discharge limit for toxics and developing sediment quality criteria.
NR 140–Groundwater Quality	Establishes the remediation goals for groundwater which are to achieve the Preventive Action Limits (PALs) at the site. Also specifies actions required should a groundwater standard be exceeded at the point of standards application.	G1, G2, G3, G4, G5	Relevant to determine effectiveness of remedial alternatives considered.

TABLE A-2
Summary of Potential Wisconsin ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
NR 140.28(5)–Criteria for Granting a Temporary Exemption Where Infiltration or Injection is Utilized for a Remedial Action	Describes the criteria for requesting an exemption from WDNR to exceed the PALs or ES at a point of standard application for a remedial action including the infiltration or injection of contaminated groundwater.	G3, G4, G5	Contaminant concentrations in the effluent may require variance to discharge the treated groundwater.
NR 141–Groundwater Monitoring Well Requirements	Establishes minimum standards for the installation, construction and abandonment of monitoring wells	G2, G3, G4, G5	Construction and abandonment of monitoring wells must conform to standards specified.
NR 149–Laboratory Certification and Registration	Specifies requirements that all laboratories used for sample analysis are expected to meet. Also requires that the laboratory be certified under this chapter.	G2, G3, G4, G5	Applicable for environmental monitoring of groundwater subject to standardized procedures.
NR 200–Application for Discharge Permit	Specifies requirements for applying for permit for discharges to surface water and to land areas where water may percolate or seep to groundwater	G3, G4, G5	WPDES permit would be required for discharge to Doctor Lake but not required for onsite discharges. All the substantive requirements, however, must be met.
NR 207–Water Quality Antidegradation Policy	Establishes implementation procedures for the antidegradation policy in NR 102.	G3, G4, G5	Applicable for discharges to Doctor Lake. Establishes procedure to follow when proposing new or increased discharges to a surface water body.
NR 214–Land Treatment of Industrial Liquid Wastes, By-Product Solids and Sludges	Establishes the design for all land treatment systems that receive wastewater and require approval of plans and specifications by WDNR. Effluent limits, discharge permits and groundwater monitoring requirements are also specified. Use of injection wells of any sort is prohibited unless approved by WDNR.	G3, G4, G5	If groundwater is not considered a hazardous waste, NR 214 would be applicable to discharge of treated or untreated groundwater to infiltration basins.

TABLE A-2
Summary of Potential Wisconsin ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
NR 219–Analytical Test Methods and Procedures	Establishes analytical test methods, preservation procedures, requirements for laboratcries, and procedures applicable to effluent limits for discharges to surface waters.	G3, G4, G5	Procedures applicable to effluent limitations for discharges from point sources under 144 and 147 stats.
NR 220–Categories and Classes of Point Sources and Effluent Limits	Required WDNR to establish effluent limits for uncategorized point sources (i.e., not included in NR 221 to 299 inclusive) and to base those limits on best practicable control technology currently available or best available control technology economically achievable.	G3, G4, G5	The substantive requirements of obtaining a WPDES permit would be necessary.
NR 404–Ambient Air Quality	Establishes ambient air quality standards for particulate matter and specifies measurement methods.	S2, S3, S4, S5	Relevant to installation of soil cover or cap and reconsolidating soil.
NR 415–Control of Particulate Emissions	Establishes standards for fugitive dust emissions and specifies that precautions should be taken to prevent particulate matter from becoming air borne.	S2, S3, S4, S5	
NR 419–Control of Organic Compound Emissions	Describes the notification and approval requirements and emission limitations for remediation of soil or water contaminated organic compounds.	S4, S5	The requirements of NR 600 to 685 for the treatment, storage or disposal of hazardous waste must be followed if the contaminated soil or water is hazardous waste.
NR 445–Control of Hazardous Pollutants	Specifies emission limits and control requirements for air contaminant sources emitting hazardous pollutants.	S5, G5	Emissions for actions that may emit air pollutants must meet NR 445 requirements.
NR 445.04–Emission Limits for New or Modified Sources	Specifies air concentrations not to be exceeded in terms of 24-hour and 1-hour averages. Requires lowest achievable emission rates and best available technology for air contaminants without acceptable ambient concentrations.	S5, G5	Emissions for actions that may emit air pollutants must meet NR 445 requirements.

TABLE A-2
Summary of Potential Wisconsin ARARs
(Page 4 of 8)

Citation	Requirement/Purpose	Alternatives Affected	Applicability
NR 500 to NR 520–Solid Waste Management Requirements	Specifies design, operation, and maintenance requirements for new solid waste landfills.	S2, S3, S4, S5	Applies to actions involving consolidation of contaminated soil or disposal of treated soils and debris back onto the site.
NR 504–Landfill Location, Performance, Design, and Construction Criteria	Describes performance standards and the minimum design and construction requirements for landfills.	S2, S3, S4, S5	Applies to actions involving consolidation of contaminated soil or disposal of treated soils and debris back onto the site.
NR 504.07–Minimum Design and Construction Criteria for Final Cover Systems	Specifies minimum design requirements for final covers to minimize leachate generation and landfill maintenance.	S2, S3, S4, S5	Relevant to capping of areas not considered as a landfill unit.
NR 506.08–Closure Requirements	Specifies requirements and procedure for closure of a land disposal facility	S2, S3, S4, S5	Applies to actions involving consolidation of contaminated soil or disposal of treated soils and debris back onto the site.
NR 507–Environmental Monitoring for Landfills	Describes the environmental monitoring requirements at solid waste facilities and the application of groundwater standards.	S2, S3, S4, S5	Applies to actions involving consolidation of contaminated soil or disposal of treated soils and debris back onto the site.
NR 508–Responses When a Groundwater Standard is Attained or Exceeded	Establishes procedures for responding to a groundwater standard is attained or exceeded at a well monitoring a solid waste landfill.	S2, S3, S4, S5	Applies to actions involving consolidation of contaminated soil or disposal of treated soils and debris back onto the site.
NR 600 to NR 685–Hazardous Waste Management Requirements	Specifies minimum requirements for storage or treatment of hazardous wastes. Standards may also apply to CAMUs, unless determined otherwise under NR 636.	S2, S3, S4, S5	Applies to actions involving consolidation of contaminated soil or disposal of treated soils and debris back onto the site.
NR 600.04–Prohibited Activities	Prohibits underground injection of hazardous waste through a well, land treatment of hazardous waste, and use of hazardous waste in mixtures for dust suppression.	S2, S3, S4, S5	Relevant to actions including injection of untreated hazardous waste, and placement of hazardous waste on the soil surface or incorporated into the soil.

TABLE A-2
Summary of Potential Wisconsin ARARs
(Page 5 of 8)

Citation	Requirement/Purpose	Alternatives Affected	Applicability
NR 605–Hazardous Waste Classification	Establishes criteria for the classification of hazardous waste.	S2, S3, S4, S5	Contaminated soil may exceed TCLP toxicity characteristic levels and be considered a hazardous waste if recovered from ground.
NR 605.09–Lists of Hazardous Wastes	Lists hazardous wastes from nonspecific sources.	S2, S3, S4, S5	Contaminated soil and groundwater attributed to PWP meets the definition of F032 for media containing pentachlorophenol and F035 for media containing arsenic derived from ACZA formulations.
NR 610 to NR 615–Small and Large Quantity Generator Standards	Specifies transportation standards for hazardous waste based on RCRA standards	G2, G3, G4, G5	Relevant and appropriate for offsite management of hazardous substances. Would also apply to any treatment residuals from water treatment units, including LNAPL and spent activated carbon.
NR 630–Storage, Treatment and Disposal Facility General Requirements	Specifies the general requirements that apply to the storage, treatment, and disposal of hazardous waste.	S2, S3, S4, S5	Applies to the storage and treatment of contaminated soils or treatment residual that are considered hazardous waste.
NR 636–Corrective Action for Solid Waste Management Units	Specifies provisions for corrective action management units (CAMUs) to manage remediation wastes generated at a hazardous waste facility.	S2, S3, S4, S5	Consolidation of contaminated soils and sediments that contain listed or characteristic waste may require the establishment of a CAMU.
NR 655–Hazardous Waste Pile Standards	Describes the requirements for design and use of waste piles. Requires liner with a leachate collection and removal system. Also requires a runon/runoff design that will ensure the stability of waste piles in the event of a 25-year storm.	S5	Applicable for hazardous wastes or relevant and appropriate for nonhazardous wastes (based on risk) if onsite waste piles are to be managed. Requirements for waste piles may have wide application to removal of contaminated soil.
NR 660–Landfill and Surface Impoundment Standards	Specifies requirements and standards for hazardous waste landfills and surface impoundments.	S2, S3, S4, S5	Placement of treated or untreated soil that is classified as hazardous waste may make NR 660 applicable unless exemption under NR 680.04 is granted.

TABLE A-2
Summary of Potential Wisconsin ARARs
(Page 6 of 8)

Citation	Requirement/Purpose	Alternatives Affected	Applicability
NR 660.18–Minimum Design and Operational Requirements	Specifies minimum requirements for all landfill, and surface impoundments including liner, leachate collection, and drainage control systems.	S2, S3, S4, S5	Placement of treated or untreated soil that is classified as hazardous waste may make NR 660 applicable, unless exemption under NR 680.04 is granted.
NR 670–Miscellaneous Unit Standards	Establishes standards for environmental performance of miscellaneous treatment units.	S2, S3, S4, S5	Placement of treated or untreated soil that is classified as hazardous waste may make NR 660 applicable, unless exemption under NR 680.04 is granted.
NR 675–Land Disposal Restrictions	Identifies hazardous wastes that are restricted from land disposal and defines exceptions. Also contains specific numerical waste concentration numbers for pentachlorophenol.	S2, S3, S4, S5	Soils and debris exceeding TCLP level or considered to contain listed waste-type contamination may not be disposed in a landfill without treatment. After treatment, characteristic waste-type soils and debris may be disposed of in a Subtitle D landfill. Soils and debris with listed waste-type contamination after treatment must be disposed of in a Subtitle C landfill.
NR 675.24–Varience from a Treatment Standard	Allows facilities to petition U.S EPA for a variance, such as a treatbility variance from the LDRs if a waste cannot be treated to the specified level.	S2, S3, S4, S5	A treatability variance may be sought for soils containing F035 waste if the LDR treatment standard cannot be achieved using the most feasible treatment technology.
NR 680–Plan Review and Licensing	Establishes minimum standards for reports, submittals and the issuance of licenses and variances for facilities that recycle, treat, store, or dispose of hazardous waste.	S2, S3, S4, S5	Permitting would not be required for onsite actions. However, all substantive requirements must be met.

TABLE A-2
Summary of Potential Wisconsin ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
NR 680.04–Alternative Requirements	Exemptions from the requirements of chs. NR 600 to 685 may be grated by the WDNR if the proposed alternative requirement provides the same level of control and protection as the requirements of chs NR 630 to NR 685 (i.e., does not pose increased threat to human health or the environment).	S2, S3, S4, S5	Consolidation of excavated soil or sediment that contain listed or characteristic waste may require an exemption.
NR 685–Closure, Long-term Care Requirements	Specifies the requirements for closure and long-term care. Requires that subsequent use of the site on or which hazardous materials remains after closure may not disturb the integrity of the final cover, or any other containment system, or the monitoring system.	S2, S3, S4, S5	Consolidation of excavated soil or sediment or soil treatment residuals that contain listed or hazardous waste may make these requirements applicable.
NR 718–Management of Solid Wastes Excavated During Response Actions	Describes requirements for temporary storage, treatment, transportation, and disposal of contaminated soil and other non-hazardous solid wastes resulting from cleanup activities.	S2, S3, S4, S5	Applicable if excavated soil are not hazardous and relevant and appropriate for hazardous wastes (as defined by NR 600.03).
NR 720–Soil Cleanup Standards	Establishes the soil cleanup standards (residual contaminant levels, RCLs) for the remediation of soil contamination.	S2, S3, S4, S5	Applies to determining the effectiveness of soil remedial alternatives.
NR 722–Standards for Selecting Remedial Actions	Describes requirements for identifying and evaluating remedial action options and selecting remedial actions.	S2, S3, S4, S5	Requirements specified are consist with remedy selection in FS process.
NR 724–Remedial and Interim Action Design, Implementation, Operation, Maintainence, and Monitoring Requirements	Specifies the requirements for the design, implementation, operation, maintenance and monitoring of remedial actions	S2, S3, S4, S5	Design and implementation will conform to requirements specified.

TABLE A-2
Summary of Potential Wisconsin ARARs

Citation	Requirement/Purpose	Alternatives Affected	Applicability
NR 809–Safe Drinking Water (formerly NR 109)	Establishes drinking water standards for water supplies, including federal MCLs. Also specifies sampling and analysis requirements.	G2, G3, G4, G5	MCLs may be applicable or relevant and appropriate as groundwater contaminant concentrations goals depending on whether the water in question is to be used for drinking water supply. MCLs are applicable if the water is or will be used for drinking. MCLs are relevant and appropriate if the water could be used for drinking.
NR 812–Well Construction and Pump Installation (formerly NR 112)	Establishes the standards and methods for construction of new extraction wells and requirements for new pump installations.	G2, G3, G4, G5	Construction of extraction wells will conform to standards specified.
NR 812.05–Disposal of Pollutants; Injection Prohibition	Specifies that injection of any waste to surface or subsurface water is allowed if approved by WDNR.	G3, G4, G5	Injection of treated groundwater will require approval from WDNR.
NR 812.37–Water Treatment	Describes the requirements for installation of point of use or in-house water treatment systems and establishes the need for WDNR approval.	G2, G3, G4, G5	Applicable if alternate water consisting of point-of-use or in-house water treatment devices are needed.
Chapter 147 Statutes–Pollution Discharge Elimination	Requires point source discharges to obtain a permit from WDNR.	G3, G4, G5	Substantive requirements in obtaining a permit would have to be met for discharges to Doctor Lake or for land treatment. The actual permit, however, would not be obtained for onsite discharge.
ILHR 81 to 84–Uniform Plumbing Code	Requires that system plans for in-house units must by approved by the Wisconsin Department of Commerce. Establishes technical standards that system must conform to.	G2, G3, G4, G5	Applicable if alternate water consisting of point-of-use or in-house water treatment devices are needed.

Attachment A

1994 WDNR Identification of ARARs

1998 WDNR Identification of ARARs

WISCONSIN DEPT. OF NATURAL RESOURCES

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July 12, 1994

IN REPLY REFER TO:

Mr. Paul R. Steadman, OSC
U.S. EPA Region 5, HSE3-5J
77 W. Jackson Blvd.
Chicago, Ill 60604

SUBJECT: Identification of Applicable or Relevant and Appropriate Requirements (ARARs) for the Penta Wood Products Co. Site Removal, Town of Daniels, Burnett Co, WI

Dear Mr. Steadman:

Thank you for your letter of October 21, 1993 to Dave Kafura and Amy Parkinson requesting identification of ARARs for the above-referenced action. While we would normally respond more quickly to such requests, our office only recently received complete information on the scope of the removal actions planned at the site. We understand that you have been working closely with our staff as the action is being implemented, so the lack of a written response has not resulted in any delays or difficulties at this site.

Based on information provided to date, we understand the actions started and/or planned at the site include:

1. Building demolition, equipment and tank removal, decontamination (decon) and off-site management/disposal of contaminated debris, tanks, equipment, etc.

2. Off-site management/disposal of wood treating solutions found in equipment, tanks, etc. after on-site staging of drums (containers) containing these solution.

3. Tank storage of decon water prior to treatment.

4. Operation of an on-site contaminated water tank treatment unit utilizing aerobic fixed film biological treatment and/or activated carbon. This unit will treat decon water and water from groundwater extraction wells.

5. Discharge of treated water from the tank treatment unit to surface soils away from the contamination and/or to a constructed seepage gallery over contaminated soils. A discharge to a gallery is hoped to help flush contaminants from the vadoze zone to the saturated zone for collection in the groundwater extraction wells.

6. Storage (or staging) of impacted soils in waste piles.

7. Solidify metals impacted (ACZA) soils on-site in a tank unit and replace the solidified material on-site as treatment pads for the treatment of pentachlorophenol (penta) impacted soils and wood chips.

8. Construct treatment piles on-site for aerobic biological (or compositing) treatment of penta impacted soils and wood chips.

9. Redispose of biologically treated penta impacted soils on site.

We understand materials contaminated by metals (ACZA) could be a characteristic hazardous waste (if found to test hazardous for TCLP for metals) and the materials contaminated by penta are a listed hazardous waste (F027/F032). Any material classified as a wastewater sludge, regardless of the source of contamination is a listed waste (K001).

The following standards apply to the actions described above. Should the actions change or our understanding of what is planned be incorrect, then you should contact us for a revised determination. It may be necessary to provide a revised determination based on the results of recent sampling for dioxin.

A. Wastewater and Water Supply Standards

The discharge to a seepage pond or infiltration gallery must meet effluent discharge limits set by our Wastewater and Water Supply Programs. We understand that our District Solid Waste and Wastewater staff have begun the process of obtaining those limits. These limits will be set so the discharge does not cause an exceedance of ch. NR 140, Wis. Adm. Code, preventive action limits (PALs) in the groundwater directly beneath the discharge area.

Such discharges are also reviewed under the attached draft guidance (a TBC in this instance) prepared by our program. We expect that such a discharge would meet the hydraulic containment/control guidelines set out in the document. It may be necessary to perform groundwater modelling to show that the discharge will be controlled by the groundwater extraction system(s), unless an acceptable amount of treated water is discharged away from the extraction zone.

We strongly recommend the evaluation of the addition of nutrients to the discharge to facilitate in-situ biodegradation of organic contaminants in the vadoze zone. However, nutrients should not be added in concentrations that would cause an exceedance of ch. NR 140, Wis. Adm. Code, preventive action limits (PALs) in the groundwater directly beneath the discharge area, for compounds such as nitrate.

B. Hazardous Waste Management Standards

The hazardous waste generator requirements in ch. NR 615, Wis. Adm. Code, including transportation and manifesting requirements, would apply to any hazardous waste being accumulated for shipment off-site. These requirements also apply to any treatment residuals from the water treatment units, including sludge or residue from the biological portion of the units and spent activated carbon. Provided the staged drums are held at the site for less than 90 days, the generator accumulation standards for containers in ch. NR 615, Wis. Adm. Code, apply. If the drums are held for more than 90 days, the container storage requirements in ss. NR 640.08 through NR 640.16, Wis. Adm. Code, apply.

Treatment of waste in tanks is subject to the general facility standards in ss. NR 630.05 through NR 630.30, Wis. Adm. Code, and the tank system standards of ss. NR 645.08 through NR 645.15, Wis. Adm. Code.

Storage and treatment of waste in waste piles is subject to the general facility standards in ss. NR 630.05 through NR 630.30, Wis. Adm. Code, and the waste pile standards of ss. NR 655.05, NR 655.07, NR 655.08, NR 655.11 and NR 655.12, Wis. Adm. Code. If you construct and operate waste piles, we ask that you submit annual reports to us describing that operation in accordance with s. NR 630.40, Wis. Adm. Code.

Redisposal of waste in a disposal unit is subject to the general facility standards in ss. NR 630.05 through NR 630.30, Wis. Adm. Code, and the landfill standards of ss. NR 660.13, NR 660.14, NR 660.16, NR 660.17 and NR 660.20, Wis. Adm. Code. It is possible that a waste pile unit meeting the standards described in the previous paragraph, if properly designed and operated, could meet these disposal unit standards, if the waste is left in the unit after treatment is complete and the unit is closed in place.

Hazardous wastes intended to be subsequently managed in a land disposal facility are subject to the land disposal restriction certification and notification requirements outlined in ch. NR 675, Wis. Adm. Code. The chapter contains specific numeric TCLP extract standards for lead in K001 and dioxins and furans in F027 wastes (Table CCWE in s. NR 675.21, Wis. Adm. Code). The chapter also contains specific numeric waste concentration numbers for a number of compounds, including pentachlorophenol, xylene, toluene and lead, in K001 wastes (Table CCW in s. NR 675.23, Wis. Adm. Code). The chapter does not contain specific numeric land disposal standards for F032 wastes.

While we have not yet adopted the corrective action management unit (CAMU) rule, section NR 680.04, Wis. Adm. Code, provides the authority for exemptions from the design and operational requirements in the hazardous waste rules, provided that you can show the same level of control and protection. We understand that under § 40 CFR 300.415(i) of the NCP, you need only comply with ARAR's <u>to the extent practicable considering the exigencies.</u> We also understand that you only need to comply with the <u>substantive,</u> not the administrative requirements. Some of the standards outlined above may be considered administrative requirements. Viewing these authorities together, we recognize that you may determine which standards to comply with. Therefore, we are prepared to discuss the standards with you, and tailor them to this specific situation. Please contact us as soon as possible for this discussion.

As you intend to manage hazardous waste off-site, we ask that you meet our policy document "Interim Policy (Guidelines) for Promoting the In-State and On-Site Management of Hazardous Waste in the State of Wisconsin". This policy requires that you examine certain preferred management options and utilize them to the extent feasible. Out of state disposal of hazardous waste in a landfill is the least preferred option.

Solid Waste Management Standards

Solidified material that no longer displays the TCLP characteristic is still regulated as a solid waste. Replacement without further treatment as a pad falls under s. NR 718.11(3), Wis. Adm. Code, which allows for redisposal after prior department approval. This rule requires information on the volume and characteristics of the material to be disposed of. In this instance, we would be looking for the volume of material to be replaced, a complete analysis of the material, including water leach or TCLP tests, and an analysis, based on the test results, of the impacts on the soil and groundwater from the redisposal. Ch. NR 140, Wis. Adm. Code, groundwater standards must be met below the disposal area. TCLP test results showing no detection of the compounds of concern may be a basis for showing the standards will be met. The PALs must not be exceeded as a result of the redisposal. It may be necessary to perform modelling to determine if those standards would not be exceeded.

It may not be necessary to perform leach tests and show that PALs would not be exceeded through modelling if the material was replaced on top of an installed liner system. This could be a clay, geomembrane or composite liner system.

Air Management Standards

Any dust or emissions from treatment systems must meet the ambient air standards for particulates in ch. NR 404, Wis. Adm. Code, fugitive dust standards in ch. NR 415, Wis. Adm. Code, and visible emissions standards in ch. NR 431, Wis. Adm. Code.

Should you have any questions regarding this letter, please contact Amy Parkinson (608)267-5063 or Dave Kafura (715)635-4065 or Terry Koehn (715)635-4048 of our Northwest District Office.

Sincerely,

Jane M. Lemcke

Jane M. Lemcke, Unit Leader
Superfund Response Unit
Emergency & Remedial Response Section
Bureau of Solid & Hazardous Waste Management

GAE:JML

Attach.

cc: Walter Nied - U.S. EPA Region 5, HSE3-5J
Dave Kafura/Terry Koehn/Tom Kendzierski - NWD
Gary Edelstein - SW/3
Ed Lynch - SW/3
Amy Parkinson - SW/3

GUIDANCE ON REINFILTRATION AND REINJECTION OF GROUNDWATER FOR AQUIFER RESTORATION

INTRODUCTION

This guidance is intended to help ERR project managers when groundwater recirculation is proposed. The guidance is intended for use by Department staff, but may also be distributed to engineering consulting firms.

Issues to be considered when proposals for reinfiltration or reinjection of groundwater are received include the objectives of the remediation system, regulatory responsibilities, hydraulic containment and control of the contaminant plume, nutrient addition, allowable levels of contaminant in recirculated groundwater, and permit approvals. These issues are discussed in this guidance.

Authorities that allow reinfiltration and reinjection of groundwater for aquifer remediation include NR 214 (wastewater) and NR 112.05 (water supply) Wis. Adm. Codes.

DEFINITION OF TERMS

Reinfiltration of groundwater refers to the return of extracted groundwater to the aquifer through an above ground sprinkling system, a piping network, an in-ground trench system, or an infiltration pond or ditch. In short, it is intentional return of groundwater to an aquifer by any means except a well or soil borehole.

Reinjection of groundwater refers to the return of extracted groundwater through a well or soil boring.

Recirculation of groundwater refers to extraction and subsequent return of groundwater to the aquifer through any return method.

Aquifer Restoration refers to actions taken to improve the water quality of an aquifer such that groundwater can be used for human consumption. Reinfiltrating or recirculating groundwater for **disposal** purposes is **not** aquifer restoration.

OBJECTIVES OF THE REMEDIATION SYSTEM

Reinfiltration of groundwater is allowed for aquifer and/or soil remediation. Reinjection of groundwater is allowed only for aquifer remediation. Reinfiltrated/reinjected water is used as a carrier to transport beneficial chemicals, such as oxygen or nutrients to the soil and/or aquifer. (Reinfiltration is sometimes used to flush contaminants from in-situ soils and allow contaminants to be carried to the groundwater for extraction and above ground treatment.)

Infiltration/injection of groundwater to a contaminated soil or aquifer system is allowable only to enhance restoration of the contaminated media. Reinfiltration of groundwater as a disposal only mechanism is treated as a wastewater discharge and is subject to a WPDES permit. Reinjection of groundwater for disposal only is prohibited by NR 112.05.

[Systems for discharge and disposal of treated groundwater to a soil or aquifer system (such as seepage lagoons) can be permitted under a WPDES permit. This guidance does not cover this situation.]

Certain in-situ "soil flushing systems" recirculate groundwater to simply move contaminants off soil surfaces, but many environmental remediation techniques employing groundwater recirculation are used to achieve several goals:

a. Solubilize contaminants off soil surfaces and move them into the aqueous phase.

b. Deliver moisture, nutrients and oxygen (or other electron receptor) to encourage microbial metabolism of contaminants in the aqueous phase and on soil surfaces. (This management process is specifically known as in-situ bioremediation).

c. Control water movement so contaminant laden water from a soil/aquifer system is contained within a given spacial zone. Groundwater control often involves pumping, treating, and discharging water to a surface water or recirculating it to the aquifer. In almost every case, some form of above ground pollutant removal will be required prior to reinfiltration or reinjection.

Proposals for reinfiltration/reinjection of groundwater should clearly state the objectives of the remediation system and how the proposed engineering system will accomplish those goals.

SUMMARY OF REGULATORY RESPONSIBILITY

1. The Emergency & Remedial Response (ERR) Project Manager has responsibility for overseeing the remediation project (whether it be LUST, Superfund or the Environmental Repair Program). The Project Manager (PM) will review the proposed groundwater reinfiltration/reinjection plan and approve/conditionally approve or disapprove it. The PM has authority to determine the volume of reinfiltration allowed, the mass and/or concentration of nutrients to be introduced to the aquifer and the allowable concentration of contaminants that can be recirculated back to the aquifer. **When added, nutrients may not exceed the Enforcement Standard at any monitoring point.**

2. A Wisconsin Pollution Discharge Elimination Permit (WPDES) is required for all point source industrial discharges of pollutants to state waters, including groundwater. This permit is issued by the Bureau of Wastewater Management.

3. The Bureau of Wastewater Management also approves plans for all wastewater treatment equipment under s. 144.04, Stats.

3. If groundwater is being **injected through a well or borehole**, approval under NR 112.05 from the Bureau of Water Supply is also required. This approval authority may be delegated to the Bureau of Solid & Hazardous Waste through an MOU.

4. Depending on the groundwater contaminants and treatment method, an air discharge permit may also be necessary from the Bureau of Air Management.

5. Solid and Hazardous Waste Management requirements do not apply to solid or dissolved materials in industrial discharges which are point sources subject to WPDES permits. Management of extracted groundwater prior to the actual point source discharge may be subject to solid and hazardous waste management requirements, as well as management of any groundwater treatment residuals. Groundwater treatment devices may be exempt from hazardous waste licensing and other requirements (e.g., wastewater treatment unit exemption).

6. On-site actions at federal Superfund sites being managed by U.S. EPA need only meet the substantive requirements of the above permits/approvals, and do not need to obtain the actual permits/approvals.

HYDRAULIC CONTAINMENT/CONTROL OF THE RECIRCULATED GROUNDWATER

The primary concern in any groundwater recirculation system is hydraulic control of the recirculated groundwater. It is not necessary to hydraulically control the entire contaminant plume, but that portion designated as a bioremediation treatment zone must be controlled.

For the purposes of this guidance, hydraulic control of the plume is defined as controlling groundwater movement such that recirculated groundwater is restricted to the capture zone of the extraction well(s). A clearly identifiable groundwater divide must exist between the treatment zone and the downgradient portions of the aquifer.

Design of a hydraulic control system can be demonstrated several ways:

1. Through a three dimensional computer model that demonstrates groundwater pumping and recirculation leads to capture of all the recirculated water. The modelling must be verified through in-field sampling.

2. Through an empirical approach, using monitoring wells to determine the extent of the capture zone and demonstrate a downgradient groundwater divide. All groundwater would initially be treated and discharged off site, then groundwater would be recirculated in low volumes with incremental volume increases. Monitoring of water table elevation, piezometric head, and water quality would be used to determine the maximum extent of groundwater recirculation that could be allowed. Adequate stabilization time between volume increases would be necessary to determine the effect of the change of recirculation on the groundwater system. This approach may only be used with infiltration systems and water table aquifers.

3. Through a low, fixed rate of recirculation. The Department will allow up to 50% of groundwater removed from the aquifer to be recirculated back into the area affected by the cone of depression. This assumes that a flow model (2 or 3 dimentions) has been run for the site and the model indicates no unusual hydrogeologic effects from the recirculation. The model must indicate capture of the treatment zone. The modeling must be verified through in-field sampling.

All three options listed above assume the following:

1. Placement of extraction wells to control the plume has been designed according to accepted hydrogeologic and engineering principles and that computer modeling of plume capture has been performed.

2. An adequate monitoring well network is in place. The adequacy of the monitoring network should be evaluated by the extent of drawdown expected, the expected shape of the cone of depression, the groundwater flow directions, the sensitivity of plume location to nearby receptors, the depth of the plume and extraction well(s), the type of contaminants present and pertinent geologic and hydrogeologic information for the site.

3. The geology of the site is sufficiently characterized to fully understand the interaction of aquifers and aquatards that may be present at the site. A hydrogeologist (as defined by NR 500.03(64) or NR 600.03(98)) must prepare the boring logs. Soil and bedrock description must follow the requirements of NR 512.12.

4. Aquifer characterization must include a pumping test to accurately define transmissivity, storativity and the cone of depression.

5. If a fractured aquifer matrix is present at the site, a thorough evaluation of the containment system is necessary. In some fractured aquifers, reinfiltration and/or reinjection of waters that contain any substances above the PALs may not be allowed.

It is the Department's policy that, **in most instances, groundwater recirculation should not exceed more than 80% of the volume of groundwater pumped from the aquifer within a given groundwater control zone**. Groundwater recirculation above 50% must be justified through computer modeling or empirical data as described above. In some situations, additional in-situ remedial measures (such as air sparging wells at the periphery of the plume) may be necessary to ensure control of contaminant movement.

After installation of a reinfiltration/reinjection system, it must be demonstrated that hydraulic control/containment is achieved by the system. A good field monitoring system (with emphasis on groundwater monitoring wells surrounding the treatment area) must be in place to document hydraulic control. The system start-up monitoring program (including frequency and parameters to be monitored) must be able to document in the first 3 to 6 months that the system is controlling/containing the contaminants as predicted in the approved design.

APPROPRIATE LEVELS AND FORMS OF NUTRIENT AND OXYGEN ADDITION

The appropriate levels and forms of nutrient addition, including oxygen addition (or other electron receptor) must be determined. Groundwater concentrations of nutrients and electron receptors must be determined during the investigation phase of site remediation.

[The most common electron receptor other than oxygen is nitrate (NO_3). Systems not employing oxygen are called anaerobic or anoxic systems, and less information on control of these systems in-situ is available. Anaerobic systems tend to be managed above ground in bioreactors or containment vessels.]

Typically, oxygen (O_2) is the most important element that must be supplied to soil and groundwater microbes to stimulate degradation of organic contaminants. Biological oxygen demand by microbes is enormous. Approximately 3 lbs. of oxygen is required to degrade 1 lbs. of hydrocarbon. Systems to supply oxygen are one of the most important parts of engineering bioremediation clean-ups.

Because oxygen is not considered a contaminant, its control in the subsurface will be a matter of efficient engineering - the amount of oxygen supplied must be effective at enhancing biodegradation, must be balanced with precipitation of inorganic oxides and other oxygen sinks and must be cost effective. Common sources of oxygen include hydrogen peroxide (H_2O_2), compressed oxygen gas, an oxygen generator or air.

Delivering oxygen in a gaseous system (such as moving air through a dewatered portion of an aquifer) is much more effective in delivering large volumes of oxygen to the contaminant than dissolving oxygen in water to degrade contaminants below the water table. Therefore, remediation of aerobically degradable contaminants (such as petroleum hydrocarbons) is more efficient if groundwater pumping is coupled with a soil venting or bioventing system within the dewatered aquifer. [Note that an air discharge permit may be necessary for the soil venting system.]

The next most important nutrients in a bioremediation system are usually nitrogen (N) and phosphorus (P). The need for addition of nitrogen and phosphorus and the proper form of the chemical addition should be determined through microcosm studies. These can be run in the field or in the laboratory. [For example, microcosms studies can be run using VOC vials incubated in the monitoring well from which the water sample was withdrawn. The vials contain groundwater with premeasured amounts of O_2, N and

P. Concentration of the contaminant is measured after a 30 day incubation.] Because nitrate is a groundwater contaminant, it is important that N not be added in greater quantities than the microbes need. **Generally, nitrogen addition should be kept below 10 mg/l N-NO_3 (Enforcement Standard for nitrate) in the groundwater.**

When adding nutrients directly to groundwater, microcosm studies should always be conducted. In remediations where only oxygen addition is proposed, microcosm studies may not be necessary.

Appendix A of this guidance contains a list of groundwater and soil nutrient, trace element and field measured parameters that should be considered in assessing a site for bioremediation. All parameters listed do not have to be analyzed. The consultant, in consultation with a bioremediation specialist, should determine the basic testing program needed at the specific site in question. The ERR project manager should review the proposed testing program and comment on it, as appropriate.

Periodic nutrient and dissolved oxygen monitoring should be carried out prior to start up and during operation at all monitoring wells in the network. This will help determine the effectiveness of the system and indicate if nitrogen or other added compounds are "breaking through" the treatment zone. Routine monitoring of contaminant levels and, where applicable, contaminant transformation products, must also be conducted.

ALLOWABLE CONTAMINANT LEVELS IN RECIRCULATED GROUNDWATER

If some contaminants are to be present in the groundwater that is recirculated, the allowable levels of contaminant recirculation must be determined. This will, in part, determine the treatment methods and effluent concentration for the contaminated groundwater.

The Bureau of Wastewater Management will determine the appropriate discharge levels for contaminated water withdrawn from the aquifer, treated above ground and discharged to waters of the State. **All treated water containing pollutants that is discharged via a point source to waters of the State (including groundwater and surface water) will require a WPDES permit.** WPDES permits are not necessary if the treated groundwater is discharged to a POTW or a privately owned wastewater treatment facility. However, the effects of the contamination on the POTW or treatment system must be evaluated.[1] Most treated groundwater will be discharged to a surface water, a POTW or a groundwater seepage lagoon. Any groundwater discharge for purposes of disposal should be far enough away from the extraction system that the two do not interact hydraulically. If this is not the case, then the discharge must be fully considered in computer modeling studies to ensure the discharge will not adversely affect the operation of the extraction system.

In almost all cases, the Bureau of Wastewater Management requires that the entire volume of extracted groundwater be treated through a treatment system. The volume of groundwater to be reinfiltrated/reinjected should be taken from the treated water stream. Often, contaminated groundwater treated to surface water discharge standards will not meet NR 140 preventive action groundwater standards for the given contaminants. **At the discretion of the Project Manager and within the bounds of the WPDES permit, groundwater may be recirculated that contains contaminants above NR 140 ES and PAL standards. As long as the groundwater is hydraulically controlled and added nutrient levels meet NR 140 standards, the Project Manager can approve the recirculation.** Approval for recirculation of groundwater is given when the remediation plan for the site is approved.

Again, the monitoring program (frequency, analytical parameters, well placement, etc.) should be structured to detect any movement of contaminants away from the treatment area.

PERMIT APPROVALS FOR REINFILTRATION/REINJECTION OF GROUNDWATER

A. WASTEWATER

For a description of wastewater regulatory/approval issues, site characterization considerations for evaluation of treatment processes, general design concepts and many of the more established conventional and innovative treatment methods, please see the **Guidance for Treatment Systems for Ground Water and other Aqueous Streams**, expected to be available March 1, 1993.

In general, a permit application must be submitted to the District Wastewater Engineer. Groundwater that will be discharged from a treatment system (off-site or on-site), must be characterized for contaminants and expected flow must be defined. Best Available Treatment Economically Achievable (BAT) will be

[1]Extracted groundwater that is transported to a POTW or a privately owned wastewater treatment facility by a transport vehicle or vessel is subject to solid and hazardous waste management requirements.

required on all discharges to waters of the State. Above ground pollutant removal will be required where feasible and cost effective. Discharges to waters of the State <u>cannot</u> start until authorized by a WPDES permit.

The General Permit is intended for use specifically with petroleum contaminated groundwater cleanup operations or contamination incidents involving priority pollutant volatile organic compounds. It may be issued by District wastewater staff.

It should be noted that five or more people or corporations may petition for a site specific permit. In addition, the Department (Bureau of Wastewater Management) may determine that a general permit is not appropriate and that a specific permit should be issued. Site specific permits require a 30 day public notice and possibly a public hearing. A public hearing can take another month to notice, schedule and respond to comments. It usually takes an additional one to three months to draft a site specific permit. Regardless of the permit type, pollutant testing of the wastewater will be required.

The Industrial Wastewater program must receive and approve plans and specifications for any proposed treatment system, under s. 144.04, Stats. Basic packaged treatment systems (such as air strippers) may be approved by the District Wastewater engineer.

The ERR project manager is responsible for:

- approving the monitoring well network that will monitor hydrogeologic control of the plume.

- approving a groundwater monitoring program to ensure contaminants and added nutrients are not moving off-site.

- approving the split of treated effluent that is returned to the aquifer treatment zone or discharged off-site.

- monitor the project to ensure that the bioremediation project is working as designed. Wastewater staff will be involved in this through designation of the type and frequency of inflow monitoring of the above ground treatment system.

- approve nutrient addition to the groundwater and monitor project progress to ensure groundwater standards are met.

If treated groundwater is discharged to a POTW, requirements of the POTW must be met. This will involve pollutant testing and an analysis of the impacts the treated groundwater may have on the

POTW.

B. WATER SUPPLY

Bureau of Water Supply approval must be obtained prior to reinjecting groundwater by means of a well or borehole.[2] Where possible, infiltration galleries should be used in preference to injection wells.

NR 112.05 is being amended to read:

> "The use of a well, drillhole or water system for the underground placement of any substance, as defined in s. 160.01(8), Stats., is prohibited unless the placement is a Department-approved activity necessary for the construction, rehabilitation or operations of the well, drillhole, water system or aquifer."

Promulgation of the amendment is expected in Spring, 1993. The Bureau of Water Supply has authority to approve placement through a well or borehole any substance used to remediate an aquifer. This authority may be delegated to other programs through MOUs. Department staff involved in approving soil/aquifer remediations will receive copies of these MOUs[3].

All injection wells must be reported to EPA annually. All letters or documents approving injection wells must be copied to the following address:

Underground Injection Control Program
WDNR - Bureau of Water Supply
P.O. Box 7921
Madison, WI 53707

All requests for injection of substances to groundwater shall be in writing and must justify the need for injection wells verses use of a surface infiltration system. In situations where the Department determines that there is a need for an immediate response, a verbal approval may be granted for the injection well(s) and followed up with a written confirmation.

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[2]Reinjection of groundwater via a "land treatment system" as defined in s. NR 214.03(24) Wis. Adm. Code will require the approval of the Bureau of Wastewater Management.

[3]As of this time, 2 MOUs have been signed allowing the Solid & Hazardous Waste Program to review and approve the injection of air, oxygen and ozone to aquifers.

A well injection request must include the following information:

name and address of the property owner;
name and address of the owner's agent or contractor;
names and addresses of adjacent property owners;
a description of the reinjection project and all applicable data; and
a statement of the reasons why reinjection is being used instead of reinfiltration through a land treatment system.

The Department may also request additional information prior to making its decision to approve or deny the well injection request.

Upon receipt of a complete application for well injection, the Department shall complete its review and make a determination on the application within 65 days. An application will not be considered complete until the Department has received all information which it has requested from the owner or the owner's agents.

The Department may condition the issuance of a approval for well injection by requiring additional construction or installation features to safeguard groundwater quality and protect nearby public and private water supplies. Failure to comply with any condition of the well injection approval or the construction, reconstruction or operation of any well, drillhole or water system in violation of any statute, rule or Department order shall void the approval.

Approval by the Department does not relieve any person of any liability which may result from injury or damage suffered by any other person. In addition, approval for the operation of an injection well does not exempt the applicant from any other statutory or regulatory requirement. For example, if nitrate is approved for nutrient addition to groundwater and after injection exceeds NR 140 ES standards, the responsible party must address the nitrate plume as well as the original contaminants.

No application for reinjection of groundwater via a well will be approved if the applicant fails to obtain any of the following:

1) Wisconsin Pollution Discharge Elimination System (WPDES) Permit (if required);

2) Approval to construct the groundwater treatment and discharge system under s. 144.04, Stats.; and

3) Approval of the ERR Project Manager

C. EMERGENCY AND REMEDIAL RESPONSE

The Project Manager is usually the primary contact on the remediation project. The Project Manager will direct the responsible party in meeting the applicable regulatory requirements before groundwater recirculation can take place. Close oversight of the groundwater recirculation system must be maintained, especially in the early operating phases, until it is established that the system is operating as designed.

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State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

WISCONSIN
DEPT. OF NATURAL RESOURCES

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George E. Meyer, Secretary
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March 24, 1998

Mr. Kenneth Glatz, P.E.
U.S. EPA Region V, SR-6J
77 West Jackson Boulevard
Chicago, IL 60604-3590

Subject: Update and Identification of Applicable or Relevant and Appropriate Requirements (ARARs) for the Penta Wood Products Inc. Site RI/FS, Town of Daniels, Burnett, County, WI.

Dear Mr. Glatz:

I am writing to document and clarify issues raised in working discussions between you, staff at CH2M Hill, and WDNR staff regarding identification of ARARs and application of them at the above site. These issues were also highlighted in CH2M Hill's Remedial Alternatives Screening Technical (RAST) Memorandum prepared for the site.

Appendix A of the RAST document included a letter dated July 12, 1994, from Jane Lemcke (WDNR) to Paul Steadman (USEPA) regarding ARARs applicable during the removal phase of activities. This letter serves to update Ms. Lemcke's letter to include any Statutory and Administrative Code changes that occurred in the interim. Many of the ARARs discussed in Ms. Lemcke's letter still apply to activities at the Penta Wood site.

Areas and contaminants of concern to WDNR at the site include;

- Pentachlorophenol (PCP), its fuel oil carrier, and ACZA (ammonia, copper II oxide, arsenate and zinc) contamination in soil and waste wood debris.
- Wetland sediments and surface water contaminated with Fuel Oil, PCP, and ACZA components.
- LNAPL consisting of a mixture of Fuel Oil and PCP. This includes any free product and the LNAPL "smear zone" or soil residuals.
- Groundwater contaminated with PCP, fuel oil components, and ACZA components.
- Erosion, slope stability, and mass transport of contaminated soil and wood debris into the wetland and elsewhere.
- Occurrence and risk levels for Dioxin compounds.
- Actual and potential impacts to drinking water supplies.

ARARs

A comprehensive list of Wisconsin ARARs is updated and submitted to U.S. EPA on a regular basis. This comprehensive list should be consulted on any Superfund site in Wisconsin. A copy of the latest revision of this list is attached as part of this letter. The appendix to the list is not included. The document contains a contact list for information and obtaining any documents related to the list or the appendix.

Selected Wisconsin Administrative Codes, and guidance related to the site and the issues arising from the RAST document, were provided to CH2M Hill during our meeting with you on February 18, 1998. URLs and sources for Codes, Statutes and other references were also provided to Hill's staff.

General

Several federal environmental programs have been delegated to the State of Wisconsin for implementation and enforcement. For those programs, the state laws and rules constitute ARARs instead of the Federal laws and regulations. A comparison of the state and federal requirements is only necessary where there may be an instance of a federal requirement being more stringent than the state requirements in the delegated or authorized program. In Wisconsin, the following programs are delegated to the WDNR:

1. Resource Conservation and Recovery Act (RCRA) Subtitle C - Hazardous Waste (Authorized Program)
2. Clean Water Act NPDES Discharged - WPDES/Wastewater Program (Authorized Program)
3. Clean Air Act - Air Management Program (Delegated Program)
4. Safe Drinking Water Act - Water Supply Program (Primacy Program)
5. Underground Injection Control - Water Supply (Primacy Program)

Wisconsin also has cooperative agreements with U.S. EPA to implement RCRA Subtitle I (LUST) program and State Lead Superfund projects. A basic requirement for these agreements is that the state laws and regulations must be equivalent to federal laws and regulations. The WDNR's Remediation and Redevelopment program's requirements under ch. 292 Wis. Statutes and the NR 700 rule series, Wis. Admin. Code, satisfies many of the federal equivalency requirements for these programs.

<u>Investigations</u>

Site investigations, including Superfund Remedial Investigations (RIs) must meet the following requirements:

1. Chapter NR 700, Wis. Adm. Code, General Requirements, including the definitions that apply to the other applicable chapters, below and the general submittal and sampling and analysis requirements in ss. NR 700.11 and 700.13, Wis. Adm. Code, respectively.

2. Chapter NR 712, Wis. Adm. Code, Personnel Requirements. Environmental professionals conducting investigations in Wisconsin are expected to meet the qualifications of this chapter.

3. Chapter NR 716, Wis. Adm. Code, Site Investigations. This chapter contains the comprehensive requirements for all investigations. It should be noted that s. NR 716.11(6), Wis. Adm. Code, requires the proper management of investigation-derived wastes in accordance with wastewater, solid waste, and hazardous waste requirements.

4. Chapter NR 140, Wis. Adm. Code, groundwater quality standards, monitoring and data management requirements.

5. Chapter NR 141, Wis. Adm. Code, monitoring well requirements including abandonment.

6. Chapter NR 149, Wis. Adm. Code, requirements for laboratory certification. All laboratories used for sample analysis are expected to meet these requirements and to be certified under the chapter.

Feasibility Studies and Other Types of Remedial Action Option Reports

Superfund Remedial Feasibility Studies (FSs), Removal Engineering Evaluations/Cost Analysis (EECAs) and any other remedial action option type reports should meet the requirements outlined in ch. NR 722. This chapter outlines the procedures and criteria for selecting remedial actions.

It is recognized that the Superfund process for selecting remedial actions is similar to these procedures and criteria, but there are some differences between the state and federal requirements.

To Be Considered

A document titled "Sediment Quality Objectives for the Contaminants of Concern at the Penta wood Products (PWP) Superfund Site, Town of Daniels" prepared by Tom Janisch (WDNR) was submitted to you earlier. This document was prepared according to applicable surface water criteria in NR 102 and NR 105 along with NR 103.

Chapter 254 Wisconsin Statutes establishes the authority of the State Department of Health and local health departments to assess human health hazards.

WDNR has issued an interim policy document "Interim Policy for Promoting the In-State and On-Site Management of Hazardous Waste in the State of Wisconsin (March 14, 1991)". This policy requires that you examine several preferred management options and utilize them to the extent feasible. Out of state disposal of hazardous waste in a landfill is the least preferred option.

WDNR has published a series of guidance documents related to the NR 700 series to assist persons conducting cleanups work through the rules to achieve timely and cost effective closure. Most of these documents have been provided to CH2M Hill staff. These include;

- Understanding Wisconsin Standards for Cleanup of Contaminated Soil, An Overview of Wisconsin Administrative Code Chapter NR 700, Publication RR-520-97

- Interim Guidance on Soil Cleanup Levels for Polycyclic Aromatic Hydrocarbons (PAHs), Publication RR-519-97

- Interim Guidance on Use of Leaching Tests for Unsaturated Contaminated Soils to Determine Groundwater Contamination Potential, Publication RR-523-97

- Interim Guidance on Soil Performance Standards, Publication RR-528-97

Specific Requirements

The following discussion highlights the significant Wisconsin ARARs pertaining to the Penta Wood project.

On the whole, the RAST document did a good job of identifying ARARs for the site. This discussion serves to clarify and expand on the requirements identified in the RAST.

The RAST memorandum identifies Remedial Action Objectives (RAOs) based on Preliminary Remediation Goals (PRGs) for specific media and contaminants of concern. The RAST document also provides a matrix of assumptions for setting PRGs based on various exposure assumptions, migration pathways and regulatory concerns. The PRGs were used to estimate volumes of contaminated media for screening and evaluation of various remedial options.

The RAST assumptions for RAOs and PRGs should be modified to consider the ARARs identified in this letter and the following discussion. These ARARs should also be factored into the Feasibility Study of the Remedial Options for the site.

Wastewater, Water Supply and Wetland standards.

Wetlands and Sediments - NR 103 describes requirements for wetland water quality and evaluation of remediation impacts. NR 105 and NR 106 require that sediment must be remediated to sediment quality criteria that are protective of surface water quality standards.

Discharge to a surface water, seepage cell or infiltration galleries must meet effluent limits set by our Wastewater and Water Supply programs. Infiltration galleries and injection wells must meet the terms of NR140.28 (5) and NR812.05. The WDNR guidance cited in Appendix A of the RAST is no longer valid.

NR 102, NR 104, NR 105, NR 106, NR 108, NR 200, NR 207, NR 219 and NR 220 and Ch. 283, Wis. Stats., apply to discharge of wastewater to surface waters, effluent limits, treatment facility standards, discharge permits, and sampling/testing methods.

Any well withdrawing 70 gpm or more must meet the standards in NR 812.

NR140 and NR809 list groundwater quality standards and drinking water MCLs.

The NR140 Preventive Action Limits are the remediation goals for groundwater at the site.

Remedial actions evaluated under NR722 and any soil standards or site specific RCLs determined under NR720 must be protective of the NR140 groundwater standards for all contaminants of concern. These include Pentachlorophenol, it's daughter (breakdown) products and any accessory contaminants, volatile and semi-volatile petroleum constituents such as petroleum VOCs, naphthalene and polycyclic aromatic hydrocarbons (PAHs). Soluble inorganics including ammonia, nitrate and metals are also of concern.

Exemptions to the NR 140 PALs are available under the terms of NR 140.28(1). Please refer to the specific provisions of this section.

NR 140.28 (4) allows an exemption to the Enforcement Standard only if the background level for a substance of public health concern is above the ES.

The use of natural attenuation is allowed as a remedial option, under the terms of NR 140 Tables 5 and 6, provided this option will return groundwater quality to NR 140 standards in a reasonable period of time. An evaluation of the feasibility of using this option must follow the procedures in NR 722. A "reasonable period of time" must be determined using the criteria in NR 722.07 (4)(a)4.

The effectiveness of natural Attenuation must be demonstrated. Please refer to the WDNR guidance publication, "Interim Guidance for Selection of Natural Attenuation for Groundwater Restoration and Case Closure Under Section NR 726.05(2)(b).". A copy of this publication was furnished to CH2M Hill.

Point of Use or in-house water supply treatment devices must be approved by the Department. See NR 812.15 (5) and (6). Except where water treatment is proposed as a temporary measure, groundwater restoration is preferred. The Department will approve such systems as a permanent water supply replacement only as a method of last resort.

ILHR 81-84 (Uniform Plumbing Code) requires that system plans for in-house units must be approved by the Wisconsin Department of Commerce. Only treatment devices and products that have received a prior, separate, Commerce approval may be used in such systems.

Spent Carbon or other residuals from home treatment units may be considered household waste and may not be subject to the Hazardous Waste requirements.

We recommend evaluating the addition of nutrients to facilitate in-situ biodegradation of organic contaminants. However, nutrients should not be added in concentrations that would cause and exceedance of NR 140 preventive action limits.

Hazardous Waste Management Standards

Please refer to the Hazardous Waste Management Standards discussion in J. Lemcke's July 12, 1994, letter to Paul Steadman (Appendix A of the RAST, attached). The requirements described in this letter still apply to present site activities with the following clarifications;

EPA's removal activities at this site should have removed and disposed of any discarded Pentachlorophenol formulations and wastewater sludges. If there is any waste remaining on site meeting the definition in NR 605.09 of F027 or K001, it must be managed according to the requirements in Ms. Lemcke's letter (Appendix A).

Nearly all of the remaining contaminated soil and groundwater attributed to the Penta Wood site meets the definition in NR 605.09 of F032 for media containing Pentachlorophenol, and F035 for media containing arsenic derived from ACZA formulations.

NR 675 describes the Land Disposal Restrictions (LDRs). However, LDRs for F032 and F035 have not yet been promulgated into Wisconsin rules. They are a Federal ARAR.

Wisconsin can not issue a variance to the LDRs under our current laws and codes. However, NR675.24 allows facilities to petition U.S. EPA for a variance from the LDRs. Therefore, a variance, such as a treatability variance, could be considered in a ROD in accordance with the Federal criteria.

If an LDR treatment standard for a listed waste is more stringent than an RCL determined under NR 720 or an NR 140 PAL, the LDR applies unless EPA grants a variance in a ROD. WDNR would recognize EPA's decision under NR 675.24 unless the department clearly establishes that the variance would threaten human health and the environment.

We are consistent in practice with EPA's "Contained In" interpretation. In summary, if a media (soil, groundwater, sediments, debris, etc.) contains a listed hazardous waste, then it must be managed as a hazardous waste until it no longer contains that hazardous waste, or it's hazardous constituents.

The point at which it no longer contains a hazardous waste is: 1.) No Detect, 2.) Background for naturally occurring compounds, or 3.) Some other level determined to be acceptable.

Consistent with our authority under the Groundwater Law (Chapter 160 Wis. Statutes) and our enforcement of the Hazardous Substance Spill Law (ss 292.11 Wis. Statutes), the Department has been using the NR 140 Preventive Action Limits and Residual Contaminant Levels (RCLs) as determined in NR720 as "acceptable levels" under the third criteria of EPA's "contained in" interpretation.

Consistent with the second criteria, background levels of Arsenic and other naturally occurring contaminants of concern must be determined using local, in-field data. Published data generalized to the site is not appropriate.

An exception to the use of NR 720 to meet the "contained in" interpretation is noted under NR 720.02 (1) (b), where EPA has adopted a more stringent standard (such as an LDR treatment standard), then the more stringent standard applies.

NR 636 applies to Corrective Action Management Units.

Any hazardous waste associated with the Penta Wood site that is picked up and treated on site must meet the treatment unit standards for the appropriate type of management unit under the ch. NR 600 series.

If a CAMU is established under NR 636, the LDRs do not apply according to NR 636.40 (1)(a) and (b). Criteria for establishing a CAMU in NR 636.40 (3)(b) states that the waste management activities associated with the CAMU may not create unacceptable risk to humans and the environment from exposure to the hazardous waste or hazardous constituents.

The RAST document described several options for soil reconsolidation or redisposal units on site. These units must meet ch. NR 600 land disposal minimum technology requirements (MTRs) for hazardous waste landfills, including a liner and a leachate collection system unless:

Appropriate LDRs or NR 720 RCLs, whichever are more stringent, are met prior to redisposal (the contained in interpretation option);

An exemption is granted under s. NR 680.04;

A CAMU is established and justified under ch. NR 636; or

A CERCLA waiver is issued by U.S. EPA.

The actual design of redisposal elements of each option should be determined through discussions between the agencies and the appropriate authority to allow a variation from the MTRs determined after the actual design is agreed upon. If the first option is used (contained in interpretation), the material to be redisposed of would still be a solid waste and would have to meet requirements for the management of solid waste, as outlined in the next section.

Solid Waste Management Standards

Solid Waste as defined in ss. 289.01 Wis. Stats. includes "solid, liquid, semisolid, or contained gaseous materials". Management of contaminated soil, debris or other solid waste that is not a hazardous waste as defined in NR600.03 or federal law is regulated under the NR 500 series.

NR 718 provides exemptions from certain NR 500 licensing and approval requirements for non-hazardous solid wastes generated during cleanup activities conducted under NR 700 - 726.

NR 718 also describes requirements for temporary storage, treatment, transportation and disposal of non-hazardous solid wastes resulting from cleanup activities.

Redisposal of contaminated media must meet the landfill technical requirements outlined in the NR 500 rule series, including a liner and a leachate collection system unless:

An exemption is granted under s. NR 500.08(4); or

A CERCLA waiver is issued by U.S. EPA.

The actual design of redisposal elements of each option should be determined through the same discussions with the agencies outlined above for the hazardous waste MTRs.

Air Management Standards

Any dust or emissions from treatment systems, grading or other earthwork must meet the ambient air standards for particulates in NR 404, fugitive dust standards in NR 415, control of organic compound emissions in NR 419, control of hazardous pollutant emissions in NR 445, and visible emissions standards in NR 431.

Soil Standards

NR 720 provides procedures and risk assumptions for determining soil cleanup standards and residual contaminant levels that are protective of public health, safety, welfare and the environment. NR 720.05 discusses regulatory applicability including hazardous waste sites. NR 720.07 describes procedures for establishing soil standards and NR 720.09 through NR 720.19 describe procedures for each exposure or migration pathway of concern.

Note that NR 720.19 (6) mentions consideration of other pathways of concern that may exist at a site or facility. At the Penta Wood site, the surface water, aquatic and terrestrial ecosystems are pathways of concern.

Models used to evaluate pathways of concern and establish RCLs under NR 720 must be adequately documented and justified. The model chosen must be appropriate for the problem at hand and calibrated to on-site data.

Site specific RCLs determined under 720 must be based on data gathered in-field and on-site. Published data or comparables should only be used if they are appropriate and in-field data is impossible or impractical to obtain.

The RCLs for the Penta Wood site must be established and considered when assessing remedial options under NR 722.

Regardless of the media's regulatory status as a solid or hazardous waste or as a hazardous substance spill, establishing RCLs using the NR 720 procedures are critical to establishing concurrence and community acceptance of any proposed remedial action proposed for the Penta Wood site.

These risk based RCLs would be the basis for acceptance of any variances or exemptions under other regulatory authorities. The NR 720 procedures should be considered substantive requirements. They are consistent with the NCP.

Remedial Options

NR 722 describes requirements for the selection of remedial options. NR 722.07 (4) (a) 4 describes the criteria for evaluating the restoration time frame.

The RAST document suggests the use of various institutional and engineering controls and performance standards using "industrial standards" for establishing the PRGs for the site.

Institutional Controls;

Restrictions for "industrial uses" must be enforceable and appropriate for the site. Since there is no definition in NR 700 or NR 720 of the term "industrial", a dictionary definition applies. Webster's Ninth New Collegiate Dictionary (1991) defines "industrial" as "a company engaged in industrial production or service.".

NR 722.07 (4) (a) 4.g. states that the "effectiveness, reliability and enforceability of institutional controls" is a requirement for evaluating remedial options.

In order to apply an industrial soil cleanup standard, there must be a mechanism for ensuring that the property will only be used for industrial purposes. Since Penta Wood Products still holds title to the facility, the remaining officers or directors of the corporation must sign and record a deed restriction that will prohibit all non-industrial uses on the property as an institutional control.

However, since there are no current zoning requirements in the Town of Daniels, and future comprehensive zoning plans are not likely to designate the site or adjacent property as "industrial," according to the Burnett County zoning administrator, we question whether it is realistic to limit the site to industrial uses in the future.

Industrial soil cleanup standards, institutional controls and groundwater use restrictions may not be applicable, appropriate or available for off-site contamination.

Engineering Controls and Performance Standards;

There must be a reliable and effective mechanism or agreement in place to ensure that any engineering control or performance standard selected as a remedy for the Penta Wood Site is monitored and maintained.

Since the current owners of the site probably don't have the assets or reliability needed, some kind of long term maintenance agreement would be necessary as part of the ROD for any remedy employing engineering controls or performance standards. This could be an agreement with USEPA and the WDNR, or an acceptable third party consistent with federal and state law.

Other Comments on the RAST

Soil Cement Pad

During earlier cleanup activities conducted by U.S. EPA at the Penta Wood site, arsenic contaminated soil was incorporated into a soil cement pad. At the time, the F035 listing was in the process of being put into federal and state law. The timing of the promulgation of the listing into law produced some uncertainty. It is not clear whether or not the pad contained an F035 waste at the time it was constructed. This remains to be determined.

In the discussions at the time between the EPA Removals staff, REACT staff and WDNR, the pad was intended as an interim action to solidify ACZA contaminated soil and to act as a base for biotreatment of PCP contaminated media. Clearly, the pad was not intended as final placement of the ACZA contaminated soil.

If left in place, the pad must meet an appropriate performance standard consistent with the substantive standards applied to the ACZA contaminated soil for the rest of the site. Performance of the pad could be evaluated using an appropriate leachability test, analysis of runoff effluent, or other monitoring over time.

If the pad is picked up for redisposal, it should meet the same requirements as other soil contaminated with ACZA contamination. Please refer to the discussion in the earlier two sections on Hazardous Waste and Solid Waste management standards. There are a number of options for the final disposition of the pad that would benefit from further discussions between the agencies.

Fate and Transport of Arsenic

The discussion of Arsenic fate and transport in the RAST was rather simplistic. Our experience is that the behavior of Arsenic in the environment is more complex than portrayed in the RAST. This discussion should be expanded.

Pentachlorophenol

There are other ways that PCP could have been discharged besides spills. Several hypotheses for discharge by way of the on-site water supply wells are possible. The merit of these and any other possibilities in light of the site data should be discussed.

If there are circumstances that PCP could behave as a DNAPL once separated from the fuel oil carrier, the implications of this should be discussed.

Dioxin

Evidence of uncontrolled fires at the site on several occasions brings up the possibility of more widespread dioxin contamination. The occurrence and risk posed by Dioxin should be discussed in light of these fires and the previous surveys for Dioxin.

Technical Alternative Descriptions - RAST Section 4

Please refer to the previous discussion regarding the use of institutional and engineering controls.

In-situ chemical oxidation methods, in-situ biological methods and air sparging should be explored more fully. Some methods may have more merit once the LNAPL is addressed.

The RAST was unclear as to what criteria (PRG) would be used to determine which soil levels would be excavated and consolidated in the alternatives, and which would be left to naturally attenuate. The 10^{-4} industrial direct contact PRG for arsenic was mentioned. This PRG may or may not be protective of groundwater. How will any remaining soil left above a groundwater RCL be addressed, so that groundwater will be protected?

The TCLP limit is not appropriate for the arsenic contaminated soil. It is an F035 listed waste. Please refer to the earlier Hazardous Waste discussion regarding LDRs, the contained-in interpretation and the use of CAMUs.

Final treatment of the consolidation areas was mentioned. It was unclear how the remaining areas would be treated after excavation. Would this be part of the erosion control and revegetation option?

If natural attenuation is to be relied on as a remedy for soil and groundwater, it must be demonstrated that natural attenuation is working. Please refer to NR 720, NR722 and the WDNR guidance on natural attenuation mentioned earlier.

Models used to evaluate pathways of concern and establish RCLs under NR 720 must be adequately documented and justified. The model chosen must be appropriate for the problem at hand and calibrated to on-site data.

Bioventing in the wood chip piles and areas of high organic matter run the risk of fire without adequate design and safety controls.

Groundwater treatment to meet NR 140 PALs for dissolved petroleum (fuel oil) constituents, and any dissolved ACZA components, must be included along with PCP in any groundwater treatment plan.

Reinfiltration of treated groundwater must be in accordance with NR 140.28(5).

Erosion Control and Lagoon Dam Repair (Appendix C)

Erosion control, re-vegetation and lagoon dam stabilization and repair should proceed immediately. This should be implemented as an emergency or interim measure necessary to protect public safety and prevent off-site migration of contamination. This action should be taken immediately, regardless of future remedial actions.

Please contact me to discuss ways to accomplish this as early as possible this construction season.

Contingency ROD

It seems reasonable to build some contingencies into the ROD to account for uncertainties. Contingencies would allow for a phased or stepped approach. Options would be evaluated at designated decision points. This would enable a more flexible, cost effective remedy

I look forward to continued discussions toward development of the ROD. Please contact me if you have any questions or comments regarding this determination.

Sincerely,

Thomas J. Kendzierski P.G.

Thomas J. Kendzierski, P.G.

Attachments: July 12, 1994, DNR letter to Paul Steadman, USEPA (RAST Appendix A).

Legally Applicable or Relevant and Appropriate State Standards, Requirements, Criteria and Limitations for Superfund Projects in Wisconsin (6/96 Revision)

cc: Regina Bayer, CH2M Hill (w/attach.)
Gary Edelstein, WDNR RR/3
Linda Meyer, WDNR LS/5
Tom Janisch, WDNR WT/2
Dave Kafura, WDNR Spooner

Appendix B

Unsaturated Zone Modeling for the Development of PCP Soil PRG for Protection of Groundwater

APPENDIX B

Unsaturated Zone Modeling for the Development of PCP Soil PRG for Protection of Groundwater

B.1. Introduction

This appendix summarizes the approach and assumptions used to determine a site-specific residual contaminant level (RCL) based on the protection of groundwater quality for pentachlorophenol (PCP) at the Penta Wood site. Chemical transport modeling of the unsaturated zone was used to determine the RCL in soil that would cause groundwater concentrations to exceed the NR 140 Preventative Action Limit (PAL) of 0.1 μg/L or the Enforcement Standard (ES) of 1.0 μg/L.

B.2. Description of the Model

B.2.1. Conceptual Site Model

To implement the unsaturated zone model, a conceptual model that incorporates the onsite hydrogeology and chemical data was developed. The *Preliminary Hydrogeologic Investigation* report prepared by Weston for USEPA ERT in December 1994 was used as the base of the conceptual model. The unsaturated zone consists of approximately 100 feet of sand. The physical properties of the sand are presented in Table B-1.

TABLE B-1
Summary of Soil Properties

	Soil Properties[a]					
Depth	Bulk Density (g/cc)	Moisture Content (%)	Total Porosity	Hydraulic Conductivity (cm/s)	Total Organic Carbon (%)	pH
20 -60	1.52	6.10	0.407	6.8×10^{-3}	0.609	7.1
60 - 100	1.66	6.10	0.407	NR	0.609	8.3
>100	1.78	NR	0.407	0.02	0.609	7.1

NR = Not recorded
[a] Source: Preliminary Hydrogeologic Investigation Report (Weston 1994)

Based on the review of the conceptual model for this evaluation, the following additional site conditions and assumptions should be noted.

- The climate data used were from Duluth. It was also assumed that no infiltration occurs when the ground is frozen (i.e., November through March).
- The effective porosity, with respect to transport via water was assumed to be 0.30 percent for the sands(Bonazountas and Wagner, 984).
- A depth-weighted average value for the soil properties were used to represent the site conditions in the model.

The chemical data for PCP are presented in Table B-2.

TABLE B-2
Summary of Chemical Data for PCP

Parameter	Value	
Solubility in Water, S (mg/L)	22,400[a]	
Air Diffusion Coefficient, DA (cm^2/s)	0.056[b]	
Henry's Law Constant (atm-m^3/mol)	1.3×10^{-6}	
Soil Adsorption Coefficient, K (L/kg)	17.2[a]	
Molecular Weight (grams/mole)	262.34	
Distribution with Depth	0-10 feet bgs	1,000 mg/kg
	10-20 feet bgs	130 mg/kg
	20-50 feet bgs	240 mg/kg
	50-100 feet bgs	120 mg/kg

[a] As presented in the *Preliminary Hydrogeologic Investigation* report (Weston 1994)
[b] *Soil Screening Guidance: User's Guide* (EPA 1996)

B.2.2. Model Description

The model selected to evaluate the contaminant transport in the vadose zone was SESOIL. SESOIL is a one-dimensional vertical transport code for the unsaturated soil zone that was originally developed for the USEPA's Office of Water and the Office of Toxic Substances. It was also used by the state of Wisconsin in the development of NR 720 soil standards for BTEX. SESOIL can consider only one compound at a time and the model is based on mass balance and equilibrium partitioning of the chemical between different phases (dissolved, sorbed, vapor, and pure). The model uses theoretically derived equations to represent water transport, and chemical migration to the atmosphere and groundwater. Climate data, soil and chemical property data are the major components of the equations.

The processes modeled by SESOIL are categorized into three cycles: the hydrologic cycle, sediment cycle, and the pollutant fate. The hydrologic cycle deals with moisture movement or flow through the soil. The sediment cycle deals with runoff from the soil surface and is optional (i.e., can be turned off by the user). Based on site conditions, the sediment cycle was not modeled. The pollutant fate cycle focuses on the various chemical transport and transformation processes which may occur in soil. The various cycles and their associated processes are summarized in Table B-3.

TABLE B-3
SESOIL Cycles and Processes

Cycle	Processes	
Hydrologic Cycle	Rainfall Groundwater recharge Capillary rise Soil moisture retention (storage)	Infiltration Surface runoff Evapotranspiration
Pollutant Fate Cycle	Advection Diffusion (air phase) Sorption	Groundwater recharge Chemical degradation/decay Volatilization

Source: *The New SESOIL User's Guide* (Hetrick and Scott, 1993)

In SESOIL, the soil compartment (or column) is a cell extending from the surface through the unsaturated zone to the groundwater table. In the hydrologic cycle, the whole soil column is treated as a single homogeneous compartment extending from water surface to the water table. The pollutant cycle breaks the soil column into four layers. Each layer has a set volume and can receive or release chemicals to and from adjacent layers.

Detailed descriptions of the water or mass balance equations solved by the SESOIL model can be found in *The New SESOIL User's Guide* (Hetrick and Scott, 1993).

B.3. Model Results

Several model runs were conducted to simulate site conditions and to develop a soil PRG protective of groundwater. A summary of the model runs and the resulting leachate concentrations are presented in Table B-4. The model output have also been attached.

TABLE B-4
Summary of SESOIL Simulations

Simulation	Assumptions	Years to Reach Water Table	Maximum Concentration[a]
PCP01	Baseline with Soil Profile as follows Layer 1 = 0-10 ft, PCP concentration = 1,000 mg/kg Layer 2 = 10-20 ft, PCP concentration = 130 mg/kg Layer 3 = 20-50 ft, PCP concentration = 240 mg/kg Layer 4 = 50-100 ft, PCP concentration = 120 mg/kg No biodegradation	> 100 years	NC
PCP02	Revised Soil Profile Layer 1 = 0-10 ft, PCP concentration = 1,000 mg/kg Layer 2 = 10-20 ft, PCP concentration = 130 mg/kg **Layer 3 = 20-98 ft, PCP concentration = 165** mg/kg **Layer 4 = 98-100 ft, PCP concentration = 120** mg/kg No biodegradation	20	11.7 mg/L

TABLE **B-4**
Summary of SESOIL Simulations

Simulation	Assumptions	Years to Reach Water Table	Maximum Concentration[a]
PCP04	**Used revised soil profile in PCP02 and added an anaeobic biodegration decay rate (in liquid and solid phase) of 0.00679/day** [b]	20	8×10^{-10} mg/L

NC = Concentration not calculated
Assumptions in **bold** were revised from the baseline condition (in PCP01).
[a] Resulting concentration is the leachate concentration released from Layer 4 of the soil column to groundwater at end of 100 years. Concentration presented does not include any mixing into the groundwater.
[b] Anaerobic decay rate from (Harmsen, 1991. Onsite Bioreclamation Processes for Xenobiotic and Hydrocarbon Treatment, p255)

The results of the different scenarios were then used to calculate the RCL based on the protection of groundwater. The RCL was calculated by using a ratio as follows:

$$RCL = PAL\left(\frac{Concentration_{Layer4}}{Concentration_{Leachate}}\right)$$

The calculated RCLs are presented in Table B-5.

TABLE **B-5**
Calculation of RCL

Simulation	Layer 4 Concentration (mg/kg)	Leachate Concentration (mg/L)	RCL (mg/kg)[a]
PCP02	120	11.7	0.0012
PCP04	120	8×10^{-10} mg/L	3.8×10^{5} (b)

[a] Calculated using a PAL of 0.1 μg/L
[b] Calculated concentration in soil exceeds pure phase concentration. RCL based on Kd x 22,400 mg/l (solubility of PCP).

B.4. Results

The following observations can be made based on the SESOIL simulations conducted:

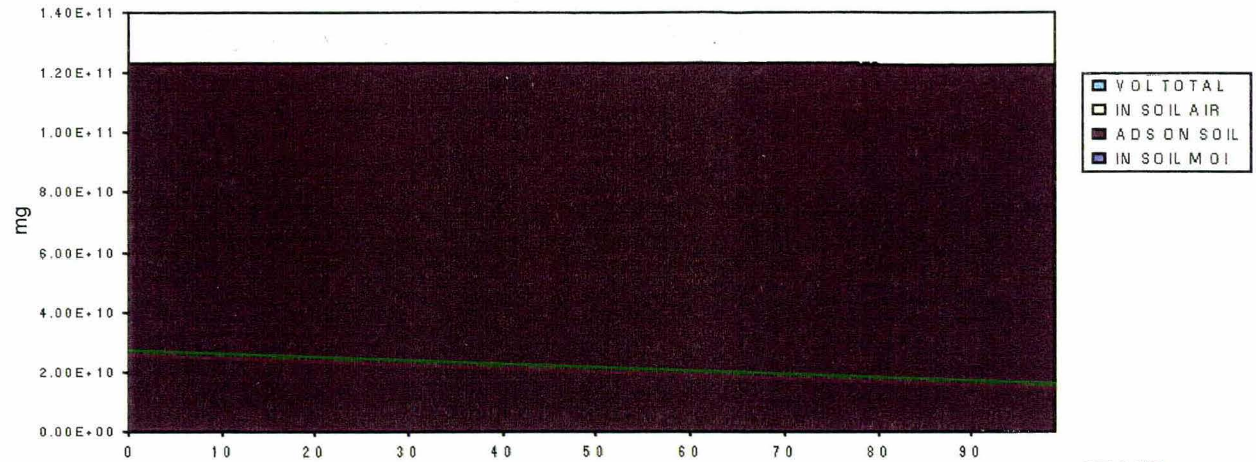
- The PCP contamination at depth cannot be attributed to migration resulting from infiltration. The concentrations at depth are likely the result of LNAPL migration through the vadose zone.
- Because of the high concentrations of PCP at depth, removal of the upper layers of contamination will not greatly impact the PCP loading to the groundwater.
- The biodegradation rate combined with the soil water distribution coefficient are critical factors in the estimation of PCP loading to the groundwater over time. The literature based anaerobic decay rate coupled with the high Kd, results in an unrealistically high PCP RCL.

Because the RCL is highly dependent on the degradation rate, the development of the RCL protective of groundwater should await the site-specific anaerobic decay rate developed based on the treatability studies being conducted as part of the site investigations. The previously developed PCP PRG for protection of groundwater of 4.6 mg/kg will be used in the interim. This value is based on the Summer's Model and was presented in the *Draft Report Preliminary Hydrogeologic Investigation, Weston, 1994*

SESOIL Pollutant Fate Cycle Report for PCP Baseline Values

PCP basline input data, 99 year run

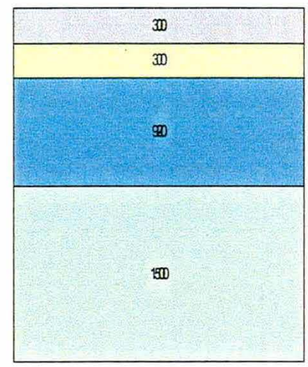
SESOIL Mass Fate



Leachate Concentration

A concentration plot can not be produced as the substance did not reach the water table.

SESOIL Profile (cm)



SESOIL Process	Pollutant Mass µg	Percent Input
Volatilized	1.027E+07	0.00
Soil Air	6.176E+04	0.00
Sur. Runoff	0.000E-01	0.00
In Washld	0.000E-01	0.00
Ads On Soil	1.226E+11	99.31
Hydrol Soil	0.000E-01	0.00
Degrad Soil	0.000E-01	0.00
Pure Phase	0.000E-01	0.00
Complexed	0.000E-01	0.00
Immobile CEC	0.000E-01	0.00
Hydrol CEC	0.000E-01	0.00
In Soil Moi	1.579E+08	0.12
Hydrol Mois	0.000E-01	0.00
Degrad Mois	0.000E-01	0.00
Other Trans	0.000E-01	0.00
Other Sinks	0.000E-01	0.00
Gwr. Runoff	0.000E-01	0.00
Total Output	1.228E+11	99.44
Total Input	1.235E+11	
Input - Output	6.816E+08	

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C:\PROJECTS\PENTA\PCP\PCP.INP
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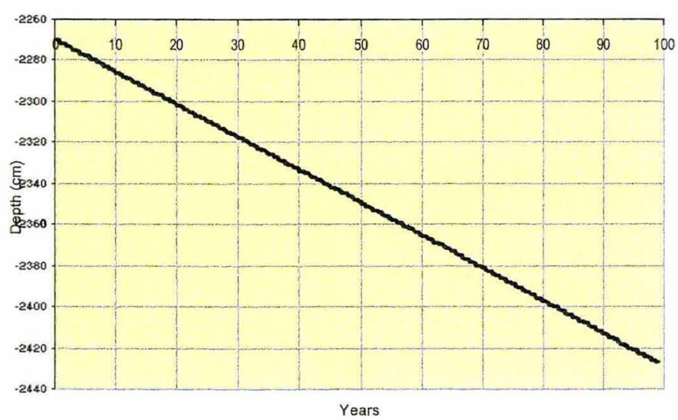
Maximum leachate concentration: 0.000E-01 mg/l

Climate: Spooner 0.0 cm Precip Nov - Mar
Chemical: PCP Baseline Values
Soil: Sand, Baseline values
Application: Generic Soil Profile

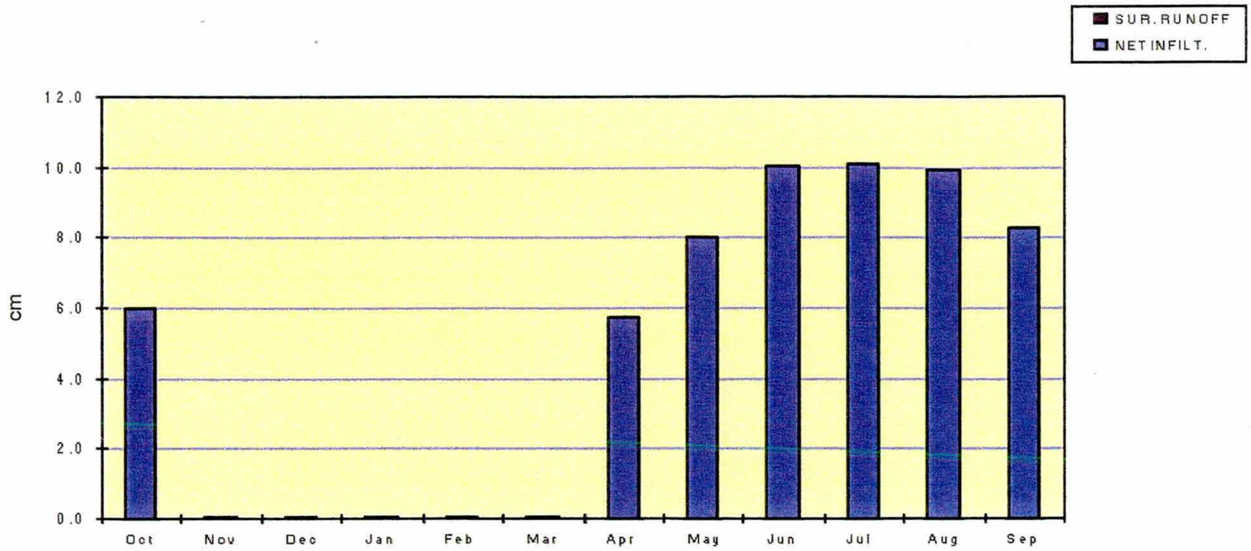
Starting Depth (cm): 2270.00 **Ending Depth (cm):** 2427.00
Total Depth (cm): 3020.00



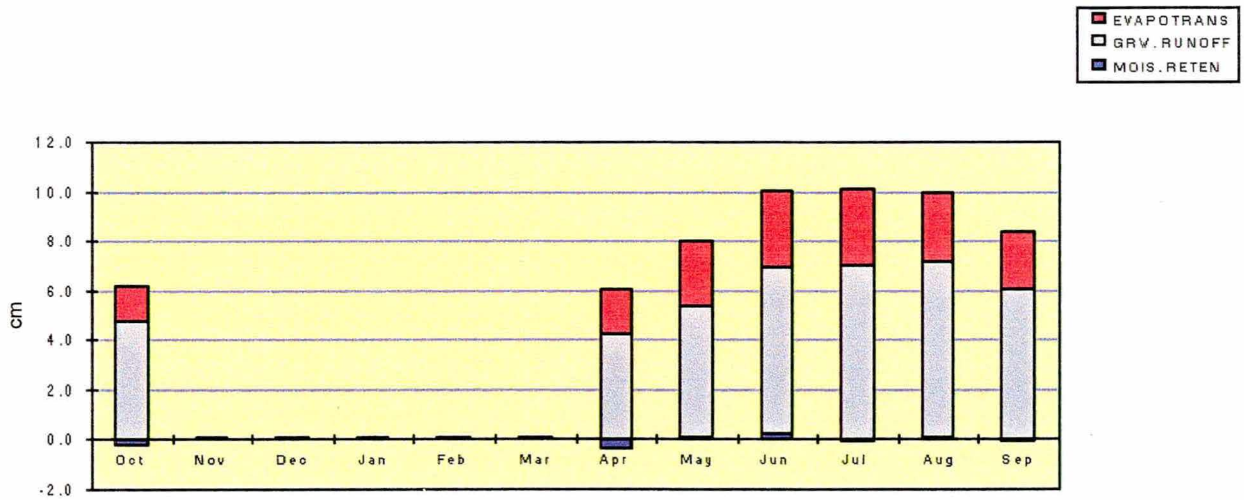
SESOIL Hydrologic Cycle Report

PCP basline input data, 99 year run

Monthly Precipitation



Monthly Water Balance



Monthly Hydrologic Cycle Components

	Surface Water Runoff (cm)	Net Infiltration (cm)	Evapotrans (cm)	Soil Moisture Retention (cm)	Groundwater Runoff (Recharge) (cm)
October	0.000	5.990	1.462	-0.226	4.755
November	0.000	0.076	0.000	0.076	0.000
December	0.000	0.076	0.000	0.076	0.000
January	0.000	0.076	0.000	0.076	0.000
February	0.000	0.076	0.000	0.076	0.000
March	0.000	0.076	0.000	0.076	0.000
April	0.000	5.710	1.803	-0.377	4.284
May	0.000	8.009	2.596	0.076	5.337
June	0.000	10.044	3.124	0.227	6.693
July	0.000	10.066	3.111	-0.075	7.031
August	0.000	9.952	2.753	0.076	7.123
September	0.000	8.276	2.307	-0.075	6.044
Annual Total	0.000	58.427	17.156	0.006	41.267

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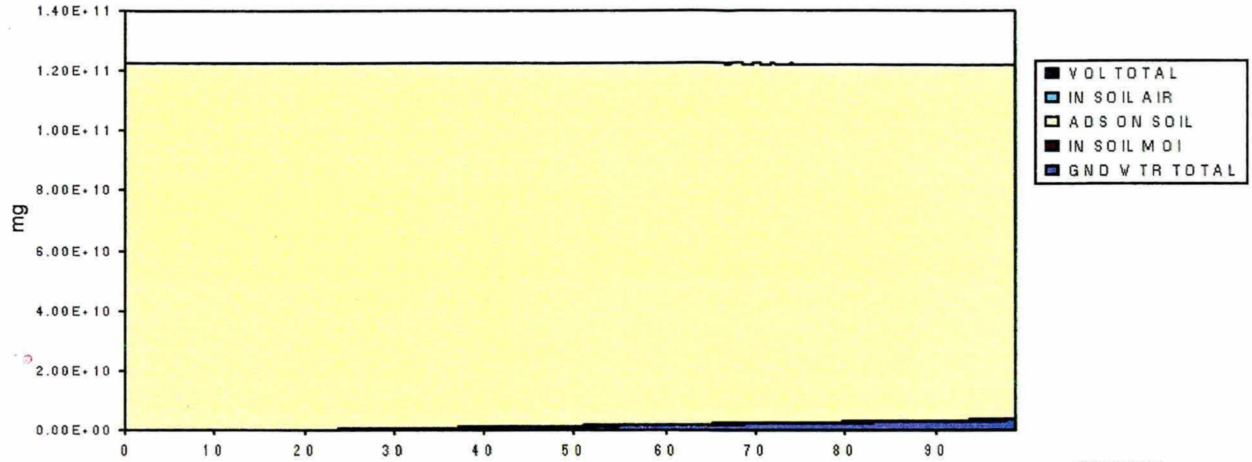
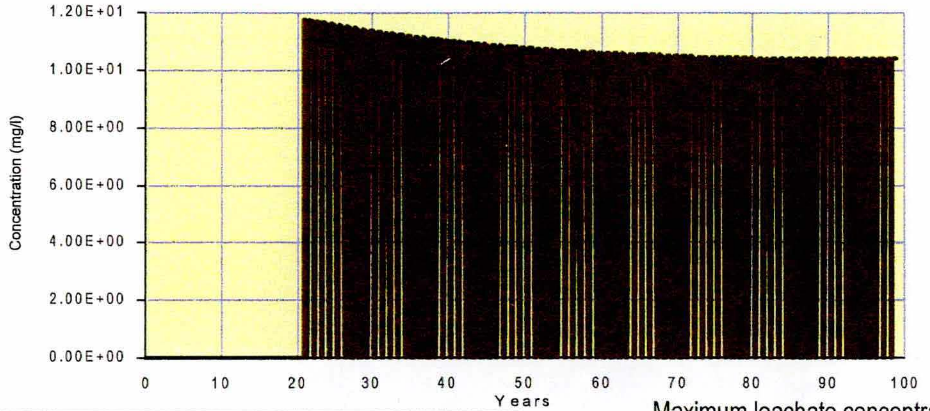
SESOIL Pollutant Fate Cycle Report for PCP Baseline Values

PCP, basline input, 2 foot bottom layer, 99 year run

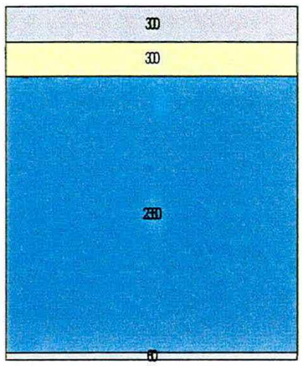
SESOIL Mass Fate



Leachate Concentration



SESOIL Profile (cm)

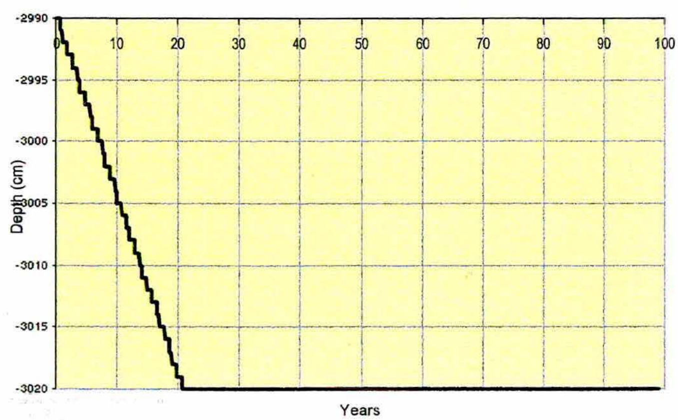


SESOIL Process	Pollutant Mass µg	Percent Input
Volatilized	1.027E+07	0.00
Soil Air	5.959E+04	0.00
Sur. Runoff	0.000E-01	0.00
In Washld	0.000E-01	0.00
Ads On Soil	1.183E+11	96.45
Hydrol Soil	0.000E-01	0.00
Degrad Soil	0.000E-01	0.00
Pure Phase	0.000E-01	0.00
Complexed	0.000E-01	0.00
Immobile CEC	0.000E-01	0.00
Hydrol CEC	0.000E-01	0.00
In Soil Moi	1.524E+08	0.12
Hydrol Mois	0.000E-01	0.00
Degrad Mois	0.000E-01	0.00
Other Trans	0.000E-01	0.00
Other Sinks	0.000E-01	0.00
Gwr. Runoff	3.486E+09	2.84
Total Output	1.220E+11	99.43
Total Input	1.227E+11	
Input - Output	6.968E+08	

Maximum leachate concentration: 1.178E+01 mg/l

Climate: Spooner 0.0 cm Precip Nov - Mar
Chemical: PCP Baseline Values
Soil: Sand, Baseline values
Application: Generic Soil Profile

Starting Depth (cm): 2990.00 **Ending Depth (cm):** 3020.00
Total Depth (cm): 3060.00



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C:\PROJECTS\PENTA\SAND.INP
C:\PROJECTS\PENTA\GENAPB.INP
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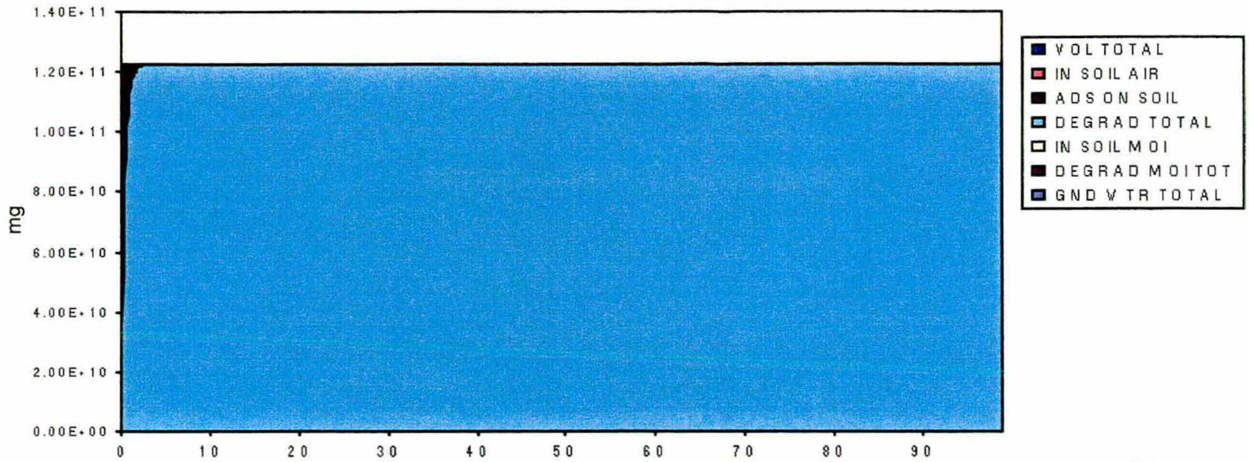
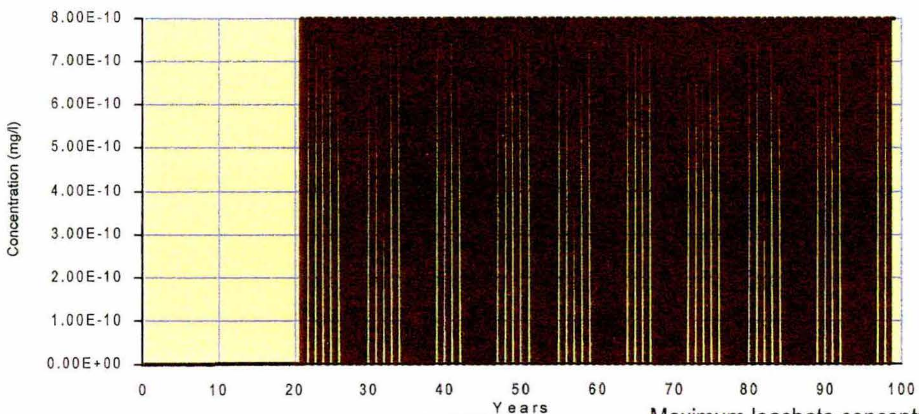
SESOIL Pollutant Fate Cycle Report for PCP Baseline Bio deg Values

PCP, basline input, Bio Deg, 2 foot bottom layer, 99 year run

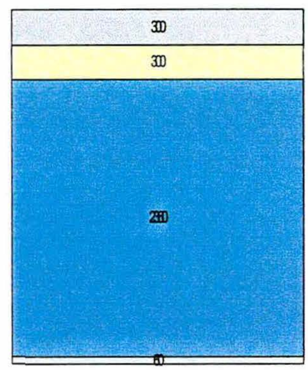
SESOIL Mass Fate



Leachate Concentration



SESOIL Profile (cm)

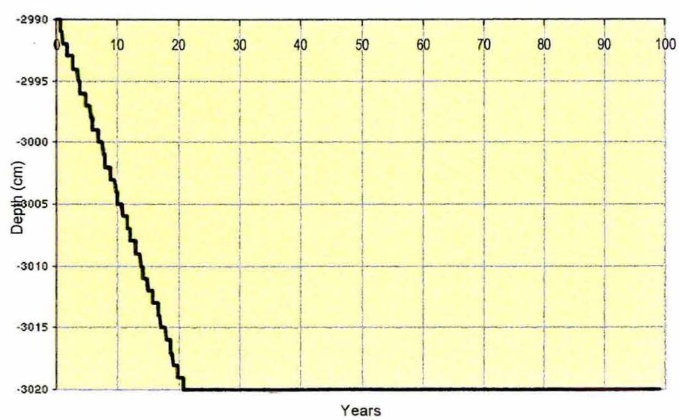


SESOIL Process	Pollutant Mass µg	Percent Input
Volatilized	4.360E+04	0.00
Soil Air	2.825E-07	0.00
Sur. Runoff	0.000E-01	0.00
In Washld	0.000E-01	0.00
Ads On Soil	5.611E-01	0.00
Hydrol Soil	0.000E-01	0.00
Degrad Soil	1.225E+11	99.87
Pure Phase	0.000E-01	0.00
Complexed	0.000E-01	0.00
Immobile CEC	0.000E-01	0.00
Hydrol CEC	0.000E-01	0.00
In Soil Moi	7.228E-04	0.00
Hydrol Mois	0.000E-01	0.00
Degrad Mois	1.529E+08	0.12
Other Trans	0.000E-01	0.00
Other Sinks	0.000E-01	0.00
Gwr. Runoff	2.588E-01	0.00
Total Output	1.226E+11	99.99
Total Input	1.227E+11	
Input - Output	3.104E+06	

Maximum leachate concentration: 8.000E-10 mg/l

Climate: Spooner 0.0 cm Precip Nov - Mar
Chemical: PCP Baseline Bio deg Values
Soil: Sand, Baseline values
Application: Generic Soil Profile

Starting Depth (cm): 2990.00 **Ending Depth (cm):** 3020.00
Total Depth (cm): 3060.00



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Appendix C

Erosion Control, Re-vegetation, Lagoon Dam Repair and Capping

APPENDIX C

Erosion Control, Revegetation, Lagoon Dam Repair and Capping

C.1. Erosion Control Measures

C.1.1. Existing Conditions

Severe surface water erosion is occurring at the PWP site. The apparent cause of most of this erosion is rapid overland flow of water in the absence of vegetation and other natural flow barriers at the site. Gullies and channels that have formed in areas where drainage paths have coalesced are evidence of this. Several particularly significant drainage gullies, with depths in excess of 10 feet, and in one case over 30 feet, have formed along drainage paths on the northern perimeter to channel surface water from the site. The characteristics of these channels indicate that active erosion is taking place. The fine to medium-sized sands found at or near the ground surface of the site are contributing factors to further erosion.

While most of the erosion can be attributed to normal overland flow, several site features appear to be exacerbating the surface water runoff. Of particular significance is the drainage from the biopad. The drainage currently flows from the east end of the pad, across several hundred feet of the PWP site into a major gully on the northwest end of the lagoon. This flow appears to be very concentrated and likely has led to additional failures within the gully. Active erosion also is occurring in the pole-butt area on the northwest side of the site and in another gully to the east of the lagoon area. At these locations, the large amount of surface water runoff appears to be causing rapid erosion of the sandy soils in the gullies.

C.1.2. Erosion Control Plan

The erosion control plan for the PWP site will involve controlling surface water runoff such that the volume and velocity of overland flow is reduced to a level that will not result in erosion of surface soils. This goal will be achieved by constructing drainage ditches, water detention or infiltration basins, and similar structures at several locations on the site.

Computer simulations will be performed to determine the amount and distribution of surface water during storm (rain) events. These analyses will account for anticipated end-use of the site, including plans for site grading and revegetation. Results of these analyses will be used to determine the location and size of drainage ditches and detention structures, as well as strategies for conveying surface water off the PWP site.

The design of drainage ditches will likely involve use of geotextiles and rip rap to prevent erosion of the sandy material below and along the sides of the ditches during water flow. Check dams constructed of rip rap and similar barriers will be used in steeper areas to slow the velocity of water flow. Use of alternatives to rip rap lining, such as geosynthetic cellular products and flexible concrete mats, will be considered at locations where rip rap is not suitable or where better economics can be realized through selection of one of these manufactured products.

Embankment slopes for detention basins will be designed to meet normal slope stability requirements. The detention basins will incorporate concrete- or rock-lined spillways to control overflow in the event that the storage capacity is exceeded.

Active erosion that is currently occurring in the three gullies on the north side of the PWP site will also be addressed during the design of the erosion control systems. These gullies will require some additional means of erosion protection in view of the hydraulic gradient that exists and the volume of water that must be handled. At these locations it may be necessary to use some type of conveyance structures, such as corrugated metal culverts, concrete pipes, or concrete-lined channels to convey water from the PWP site to the bottom of the sloped area.

C.2. Revegetation

C.2.1. Existing Conditions

Much of the PWP site is currently devoid of or sparsely covered with vegetation. This condition is the result of various mill-related activities during the nearly 40 years of operation. When the site was first developed, these activities included removal of the upper topsoil layer, as part of the usual process of clearing, grubbing, and recontouring necessary to provide adequate work and storage areas. Over the following years, further degradation of the topsoil layer resulted from the construction of mill facilities and log storage, as well as accidental and deliberate spreading of gravel surfacing, wood chips, sawdust, oils, and other materials normally associated with operations at a wood products facility. As a result of these activities, soils exposed at the site are primarily sands and gravel with limited capacity to support plant growth.

With the loss of vegetation and the recontouring of the site, surface water flow has become a significant factor in determining the condition of the topsoil layer. In the absence of vegetation, more rapid runoff of surface water occurs, and with the exposure of sands and gravels, erosion of surface materials has become a significant problem. While the PWP facility was in operation, normal maintenance methods provided some control of drainage and erosion. However, with closure of the facility and various interim cleanup efforts, runoff of surface water in sloped areas has resulted in numerous channels and gullies within the PWP site. In the flatter areas, materials carried by surface water erosion have formed alluvial fans that consist of inorganic sands and gravel.

C.?.2. Revegetation Plan

The revegetation plan for the PWP site will involve reestablishing vegetation over part or all of the PWP site. For costing purposes, it was assumed that Plan 1 (discussed below) will be implemented. The amount and type of revegetation will depend on the anticipated end-use of the site, restoration requirements imposed by the WDNR, and the percentage of the cleanup budget that can be allocated for revegetation.

In the absence of specific decisions on the end-use of the property and WDNR's restoration requirements, three levels of revegetation have been identified, and are discussed below.

1. **Minimal Revegetation Plan.** A minimal plan involves regrading and surface water control and revegetation of only those areas with special vegetation requirements, such as areas that have been capped. By regrading and providing surface water controls, the current erosion problem will be reduced, which will allow vegetation to reestablish with time.

   Revegetation of any capped areas, such as the wood waste pile and the drainage ditch/lagoon/gully area, will be required to meet Wisconsin requirements for protection of landfill cover systems. In those areas that revegetation is required, it will be necessary to import organic rich soil to promote plant growth, as onsite soils are primarily inorganic silts, sands, and gravels. Vegetation in capped areas will have to be limited to shallow-rooted grasses and brushes to avoid the potential for root penetration through the cover system.

   A minimal plan will be the least costly. This type of plan will be most appropriate if the end-use of the PWP site is commercial or industrial. In those areas that have not been revegetated, plant growth similar to that currently existing at the site is expected to develop with time. This growth would likely consist of grasses, thistles, and bushes within the central area of the PWP site, and pine and other trees around the perimeter of the site.

2. **Intermediate Revegetation Plan.** An intermediate plan would differ from the minimal plan only in so far as revegetation is concerned. This type of plan might be implemented if a 100- to 200-foot strip along old State Route 70 is left unvegetated for commercial or industrial development.

   Various amounts of revegetation could be introduced in the area north of the 100- to 200-foot strip, ranging from required vegetation over areas that are capped to little or no revegetation beyond the capped areas. As the area of revegetation increases, different species of plants could be considered, including native grasses, bushes, and trees. For many of these species it will be necessary to import organic material to support growth. The thickness and type of organic layer will depend on the selected plant species. Typically, the upper 6 to 12 inches of soil must be organic rich. In areas where clean sands are exposed and the amount of wood material (i.e., sawdust and chips) is minimal, organic materials could be blended with the sands to develop a layer that will support plant growth.

   While many types of vegetation will require import of organic materials, some species such as pine trees appear to be reestablishing naturally on the perimeter of the PWP site. This suggests that an economic revegetation plan in some areas might consist of planting pines with minimal improvement to existing soil conditions. Additional agronomic evaluations of the soil will be required to determine the likely success of this approach, given the range of surface soil conditions that exist.

   As with the minimal revegetation plan described previously, it will be critical to implement surface water control measures as part of the plan.

3. **Extensive Revegetation Plan:** An extensive revegetation plan would involve reestablishing the vegetative conditions at the site consistent with those that existed before the site was developed in the early 1950's. These conditions include deciduous and evergreen trees with native grasses and bushes.

   The cost of this plan would likely be prohibitive, as it would require import of significant amounts of topsoil and purchase of expensive native plant species. Similar to the other plans, implementation of this plan would require control of surface water flow at the site.

C.2.3. Biosolids Alternative to Topsoil

Revegetation of the PWP site will potentially require import of significant quantities of organic-rich material. The organic material is required to create a topsoil layer that will support plant growth. The amount of organic material required to cover even half of the site could be in access of 20,000 yd^3. Depending on the source of this material, the unit cost for purchasing, transporting, and spreading the topsoil could be significant, say from \$10 to \$15/yd^3, unless a local source is found.

An alternative being considered at other hazardous waste sites, where large quantities of topsoil are required, involves the use of biosolids. These organic-rich materials are the by-product of municipal sewage treatment plants. They can often be obtained for the cost of transportation. In some large metropolitan areas, such as Chicago and New York City, the amounts of biosolids produced on an annual basis have been so large that the biosolids have been trucked to sites over 100 miles away at no cost to the site receiving the biosolids.

Two concerns are often expressed about use of biosolids. One involves the odor associated with spreading of the materials. This odor typically decreases with time. The rate of odor reduction will depend on the amount of precomposting and the local climate. Typically, the odor issue has, however, restricted use to rural areas. The second more serious question deals with the potential for metals within the biosolids. This potential is determined by the waste stream that is being processed. The source of the biosolids has to be tested to determine the types and concentrations of the metals. If the metal content is high, it is possible to amend the biosolids with alkaline-rich materials, such as woodwaste ash, to increase the pH of the biosolids, which reduces the leachability of metals.

Biosolids have been used on a number of strip mine-restoration projects. They are also becoming more widely accepted as a soil enhancement for agricultural purposes. The U.S. Department of Agriculture also has an active research program on the use of biosolids for restoration projects. Given the potential cost benefits of using biosolids at the PWP site, some additional evaluation of this approach appears to be justified. This evaluation would include contacting possible sources of biosolids, such as the Cities of Minneapolis, St. Paul and Duluth, to determine the availability, cost, and metals contents of their biosolid production.

C.3. Lagoon and Dam Repair/Recontouring

C.3.1. Existing Conditions

Based on aerial photographs taken in 1978 and 1979, it appears that the large lagoon located on the north side of the PWP property was constructed in the late 1970's, presumably to provide temporary containment for surface water and other runoff from the site. The lagoon was previously located south of its current location, about midway between its current location and the treatment buildings, as shown in an aerial photograph taken in 1962.

No construction records for the existing lagoon have been found (if they ever existed); therefore, procedures used for constructing the existing lagoon can only be inferred from the aerial photographs taken in 1978 and 1979 and from inspection of the exposed sides of the gully below the lagoon. These photographs and observations suggest that the lagoon was created by constructing an embankment dam across a natural drainage feature. The dam was apparently constructed of local materials, including wood chips, sawdust, and other debris from PWP operations, The aerial photographs suggest that four to five similar embankments dams were constructed downslope of the main embankment dam. Only the main embankment can be seen at this time. Whether the other embankment dams were eroded away or the ground was regraded is unknown.

Serious erosion has occurred on the downstream face of the main dam embankment. This erosion has resulted in the formation of gullies that have formed on both sides of the dam. The gullies coalesce into a single gully 40 to 50 feet downstream of the crest of the dam. The more eastern gully is cut nearly vertically into the face of the embankment, resulting in 30 feet of drop from the crest of the dam embankment to the bottom of the gully. The exposed face of the gully reveals that at least the upper half of the embankment consists of wood chips and other debris. This material is located on sand, which could be the top of the native soil. The western gully involves a much less abrupt incision in the embankment. On one side of the western gully, the native soil is exposed; the other side consists of wood debris.

The downstream embankment for the dam is undergoing active erosion, as evidenced by sand and other debris that can be found several hundred feet downstream of the dam. Cracks occur in several areas at the crest of the dam, suggesting that future failures are eminent. It appears from debris located downstream of the dam, as well as erosion channels in both gullies, that the surface water that collects in the lagoon during heavy rainstorms is the primary cause of the active erosion, rather than instability of the embankment. It is believed that water that reaches the lagoon quickly flows into the wood waste, and once the embankment materials are saturated and after the hydraulic head within the embankment reaches a critical level, the material suddenly fails as a debris flow, carrying the woodwaste and nearby earth materials downstream.

C.3.2. Lagoon Dam Repair/Recontouring Plan

The lagoon dam repair/recontouring plan will involve stabilizing the existing gully area and diverting some or all of the surface water that currently reaches the lagoon to detention or infiltration basins or to other drainage areas. The goal of the repair/recontouring and surface water control effort will be to create a uniform slope consistent with the slopes on either side of the existing gully. The recontoured slope will need to be stable under gravity loading. It will also have support plant growth and resist tendencies for erosion of soils during rainfall.

Detailed design studies will be carried out to identify the amount and type of material to achieve acceptable slope conditions. One possible concept for the dam repair/recontouring plan is to construct a check dam at the toe of the embankment, as discussed below:

- A 10- to 15-foot high rock containment berm would be constructed approximately 50 feet downstream of the toe of the existing embankment. The intent of this containment berm is to provide a check dam to stabilize the existing embankment, which consist of significant quantities of wood debris.
- The gully between the rock containment berm and the embankment would be filled with earth materials and debris from the PWP site. This debris might include wood chips, sawdust, wood slash, broken concrete, and other building materials, as long as it is adequately compacted during placement.
- The upper 5 to 10 feet of fill located uphill from the containment berm would be filled with sand and gravels. It may be desirable to provide a thick geotextile between the debris and the sand and gravel to prevent migration of the finer earth material into the debris. The final 1 to 2 feet of the slope would be an organic-rich soil that will support vegetation. It may be necessary to use an erosion protection matting on the slopes to prevent erosion while vegetation is being reestablished.
- The area downstream of the containment berm would be graded to be consistent with the adjacent area. Material used to fill the gully would be clean sands and gravels. The top of the fill would be covered with a topsoil layer.

In the above concept, the regraded slopes would have an average slope of approximately 15 to 20 percent, similar to other natural slopes in the area. The existing lagoon in this concept would not be used for water storage. Any surface water reaching the north end of the lagoon would have to be conveyed through a pipe or lined ditch to the bottom of the recontoured area. If it becomes necessary to use the existing lagoon as a detention basin, then it would be necessary to line the bottom of the basin with a geomembrane. A lining would be required to prevent water from flowing through the highly permeable sand and wood debris that make up the bottom and north side of the existing lagoon.

As noted above, this concept involves construction of a rock containment berm within the existing gully to improve embankment stability. Additional studies may show that through appropriate material selection this containment berm may not be necessary. Alternatives to the rock containment berm, such as sheet pile walls and crib-type retaining structures, might prove to be a more economical approach, if the containment berm is determined to be necessary.

C.3.3. Cover and Vegetate Downstream of the Lagoon

C.3.3.1. Existing Conditions

The area downstream of the existing embankment consists of a relatively flat drainage basin. A nearly 200-foot long channel has been incised above the flat area within the existing hillslope. Wood chips, sand, and other debris eroded from the embankment and the channel have formed a large alluvial fan in the drainage basin. This alluvial fan is more than a foot deep in some areas. The base of small deciduous trees located throughout the fan area have been buried from the accumulation debris. Results of previous soil sampling programs suggest that at least a portion of the debris in the fan area will have elevated levels of PCP and other contaminants.

C.3.4. Recontouring Lagoon Area Alternative to Dam Repair

The simplest approach to repairing the gully located north of the lagoon appears to involve filling the existing gully with on-site materials, regrading the embankment face to be consistent with the surrounding topography, and then revegetating. This approach will involve a significant amount of earthwork that will only be possible if on-site woodwaste and PCP-contaminated soils can be disposed in the existing gully. The alternative of importing clean material appears to be cost prohibitive, as the quantity of fill is estimated to be greater than 40,000 yd^3, and the cost of purchase, transport, and placement of fill is expected to be on the order of $5 to $ 10/ yd^3.

Some type of remediation lagoon and embankment will be required. If the dam concept described previously is found to be too costly, another alternative would be to recontour the existing lagoon and gully area to eliminate the lagoon and embankment dam, restoring the original (i.e., pre-1950's) drainage feature for the area. This drainage feature might be more consistent with similar drainage features located to the east and west of the lagoon. Typically the existing drainage features involve more gradual slopes than exist currently in the gully. Various plant, bush, and tree species are located in the drainage feature.

If this approach were taken, it would be necessary to relocate the existing embankment materials. These materials include 15 feet or more of woodwaste and sawdust on the upstream side of the embankment dam at the north end of the lagoon. The upper layers of the waste are contaminated with PCP and would have to be relocated within the CAMU and capped The advantages and disadvantages of this alternative would be evaluated in future phases of the project.

C.4. Capping

The capping alternative involves constructing an impermeable cap over contaminated soils and wood waste. This impermeable cap will consists of a sequence of earth and synthetic materials, starting at the ground surface with a vegetation layer, followed by a drainage layer, an impermeable geomembrane, a clay layer, and then if required a bedding layer. The goal of installing a cap at the PWP site is to prevent surface water from percolating through the contaminated soils that cover or underlie the PWP site. By controlling surface water percolation in this manner, the potential for continued flushing of PCP into the groundwater will be significantly reduced.

C.4.1. Monitoring

The objective of the cap system is to intercept 100 percent of the water that percolates through the vegetation layer above the cap and to convey this water through a drainage layer to some off-cap location. In practice with proper design and construction of the cap system, all but a very small fraction of the water reaching the top of the geomembrane surface is conveyed to the off-cap location.

While much of the effectiveness of the cap system is determined through manufacturer and construction quality control and assurance programs (MQC/MQA and CQC/CQA), monitoring will be conducted on a regular basis to confirm that the objectives of the cap system, relative to infiltration of surface water, are being satisfied. The monitoring program will include, but not necessarily be limited to, the following:

- Regular visual monitoring of the surface of the capped area to confirm that no obvious signs of damage exist. Typical examples of damage include tears or cuts in the geomembrane caused by construction activities on the cap system, by vegetation and drainage layers sliding on the geomembrane cover in sloping areas, by excessive localized settlement that results in sinkholes or similar depressions, or by excessive surface water erosion. Approaches for identification and repair of these conditions will be fully documented in the Operations and Maintenance (O&M) Manual for the cap system.

- Monitoring of levels of contamination in the soil moisture in the unsaturated zone and in the groundwater below and around the area with the cap. Once the cap has been installed, the levels of PCP and TPH should diminish, since surface water will no longer be able to leach these materials from the soil into the groundwater.

Other methods of monitoring the integrity of the cap have been used on a limited basis, usually as a part of a research effort. These methods have included use of leak detection systems of one sort or another. By and large the use of these methods for a cap such as planned for the PWP site is not practical.

C.4.2. Consolidation of Contaminated Soil Below Cap

PCP- and arsenic-contaminated soils are located within 1 to 2 feet of the ground surface in several areas of the PWP site. The optimum approach to site remediation relative to these materials is to relocate these soils into a central area, and then place a cap over these soils.

With this approach it is estimated that approximately 40,000 cubic yards (yd^3) of PCP- and arsenic- contaminated soils will be relocated to the central area. The preferred central area for soil relocation and capping involves 6 to 7 acres located between the lagoon and the existing treatment building. If the 40,000 yd^3 of contaminated soil are placed in this 6- to 7-acre area, the ground surface will be raised about 3 feet.

The area between the treatment building and the lagoon was selected as the disposal area for contaminated soil because this area contains high concentrations of PCP and TPH between the ground surface and the groundwater. Therefore, the cap not only isolates the relocated soil from groundwater but also protects the deeper PCP- and TPH-contaminated soils from surface water infiltration. The contaminated soils are relocated and capped, rather than capped in their existing locations, to reduce the amount of capping required. Cost of constructing a cap system meeting WDNR requirements will be higher than the cost of relocating contaminated soils beneath a single cap; therefore, a more cost-efficient cleanup will result.

Relocation of the contaminated soils to a single area will require a number of well-defined protocols related to field screening of soils to confirm that soils exceeding the cleanup goals have been removed and that proper health and safety procedures are followed during excavation and haul of the materials. Placement of the contaminated soils is expected to involve the following tasks:

- A grading plan will be developed for fill placement to provide a uniform slope from the south end of the capped area to the lagoon. This grading plan will account for surface water control requirements. It will maintain a minimum slope of 2 to 3 percent to assure that water does not pond in any one area. The grading plan will be developed to include a waste-disposal cell for containment of the concrete biopad and building debris if it is decided to demolish these structures. The final decision to construct a waste disposal cell on site will be made in consideration of regulatory requirements and economics.

- Assuming that a waste-disposal cell is found to be economically justified, the cell will be constructed by excavating a pit with a depth of 15 to 20 feet and having horizontal dimensions sufficient to accommodate the anticipated amount of large contaminated debris. The cell will be located within the capped area. Its location will be such that it does not constrain future development in the area. [While the top of a normal cap system involves a vegetated layer, it is possible to substitute an low-permeability asphalt concrete (AC) pavement for the vegetation layer. This would allow future use in the event that the end-use if industrial or commercial.]

- Contaminated soils will be placed in 1- to 2-foot lifts and compacted to a soil density of 80 to 90 percent of the optimum density of the soil. Larger objects, such as timber logs and boards, will be separated from the soil during excavation, and disposed within the waste disposal cell. Debris placed in the waste disposal cell will also be compacted to the extent possible. If for regulatory or economic reasons the waste disposal cell is not used, then these larger objects will have to be hauled to a waste disposal facility or discarded in some other approved manner.

- The final surface of the relocated soil will be rolled with a smooth-drum roller ready for placement of the geomembrane. For the waste-disposal cell, the height of debris will be limited to a certain distance below the finished grade. A heavy geotextile will be placed over the debris, and then the final grade will be achieved by placing contaminated soils. This will result in the disposal cell having a final elevation consistent with the surrounding area (i.e., no mound) Depending on the contents of the disposal cell, this area could be more prone to settle than the surrounding soil, hence the need to locate the cell in an area that won't limit future end-use.

C.4.3. Revegetation of Excavated Areas and Erosion Control Measures

Areas that have been excavated to remove arsenic- or PCP-contaminated soils will be regraded in conformance with a grading plan that is prepared for the site. The grading plan will be developed to address the significant surface water erosion issues that currently exist, as well as the anticipated end-use. Once the site has been regraded, it will be revegetated.

Plans for surface water control and revegetation will be similar to those discussed earlier.

C.4.4. Cap Over Gully and Lagoon Area

A cap system will be placed over the 6- to 7-acre area located between the treatment building and the lagoon. It is also expected that the area north of the lagoon, referred to as the drainage gully area, will also have to be capped. The design and construction of this cap system will meet the intent of criteria given in Paragraph NR 504.07 of WDNR's requirements for minimum design and construction of final cover systems. Particular attention will be given to the climatic effects of freeze-thaw at the site. Information given by the Wisconsin Agricultural Reporting Services for the period of 1961 - 1977 suggests that the frost depth for the area could be 50 inches or more. This condition will influence the selection of materials used to construct the cap system.

For the area between the treatment building and the lagoon, the area is relatively flat, with average slopes (before regrading) ranging from approximately 3 to 4 percent. The cap system for this area is expected to include the following components, beginning at the top of the contaminated soil and working upwards:

- A GCL having a hydraulic conductivity of less than 1×10^{-7} cm/sec will be placed on the top of the contaminated soil. The GCL will be used rather than the 2-foot layer of compacted clay identified in the WDNR regulations because of its superior performance during freeze-thaw cycles. The advantage of the GCL is that it "heals" after freezing, in contrast to compacted clay which develops desiccation cracks. This healing process results in lower effective long-term permeability than the clay. Additional design studies will be required to determine whether GCLs bounded by geotextiles or glued to a geomembrane will be more suitable.

- A 40-mil minimum geomembrane will be placed directly on top of the GCL. The geomembrane is expected to be either a PVC or polypropylene material, rather than a high density polyethylene (HDPE) material, because of the better thermal characteristics of these materials. Polyethylene has a high thermal coefficient, which results in significant expansion and contraction during temperature changes. Under extreme conditions contraction could result in tears within the geomembrane cover, which would jeopardize the integrity of the geomembrane. Seams between geomembrane panels will be welded to provide a nearly impermeable condition.

- Drainage sand with a minimum thickness of 12 inches will be placed on the top of the geomembrane. The drainage layer will have a minimum hydraulic conductivity of 1×10^{-3} cm/sec, in accordance with WDNR requirements. On-site sands will be used to the extent possible to form the drainage layer. In the event that the hydraulic conductivity of the on-site sand either does not meet the minimum requirements or higher net hydraulic conductivity is desired to meet drainage requirements, consideration will be given to use of geosynthetic products (strip drains) to augment the flow characteristics of on-site materials. Alternatively, it may be necessary to import drainage materials if either flow requirements cannot be met or if off-site materials can be obtained more economically. Subsurface drainage collection pipes will be placed within and at the perimeter of the drainage layer to convey water from the drainage layer to drainage detention or infiltration basins.

- An 18-inch rooting zone layer will be placed on the top of the drainage sand. The upper 6 to 12 inches of the rooting zone will be an organic-rich soil to support vegetation. The type and thickness of the organic-rich material will be determined during future design studies, based on the type of vegetation planned for the site and the availability of local supplies of topsoil. As discussed in Section 4.1.2, the option of using biosolids, rather than natural topsoil, will also be considered. The drainage and rooting zone layer will not be separated by a geotextile, as has been suggested in the past. Recent studies have demonstrated that the extra expense of a geotextile is not justified, if it is being used strictly as a separation layer.

- The rooting zone will be revegetated in accordance with WDNR requirements. These revegetation requirements follow Wisconsin Department of Transportation standard specifications for road and bridge construction. As noted previously, it may be desirable from an end-use standpoint to replace the vegetation layer in some areas with a low-permeability AC pavement. This replacement would have to be approved by WDNR.

- A passive gas vent system may also be installed in the cap. The system would vent gas generated as a result of the degradation of wood debris.

The drainage gully area north of the lagoon will be filled and regraded to provide a more uniform topography. Objectives and requirements for regrading this area are discussed in greater detail in Section 4.1.2. Two special considerations for the cover in this area are summarized below:

- The slopes of the regraded area will likely be on the average of 6H:1V (horizontal to vertical), and could be as steep as 3H:1V in some areas. These slope conditions will require special evaluations to identify methods that will prevent the drainage and rooting zone layer from sliding on either the geomembrane or the GCL. In the event that stability of the cover layer is determined to be a problem, it will be necessary to use geotextiles or geogrids in combination with anchor trenches to augment the stability of the cover system.

- Of particular importance to the cover stability assessment in the area north of the lagoon will be the freeze-thaw effects on the rooting zone layer. As this layer freezes and thaws, there could be a tendency of the layer to creep downslope under the effects of gravity. If this is determined to be the case, it may be necessary to use a "geo-cell" product to prevent creep. These products are typically blankets of 4- to 8-inches thick cells formed of polyethylene or polyester. The cell is filled with soil. Various methods are used to anchor the blanket to the slope of the embankment.

C.4.5. Lagoon Dam Repair and Recontouring

Requirements for repair of the embankment dam forming the north side of the lagoon will be the same as those discussed in Section 4.1.2, Natural Attenuation.

C.4.6. Capping Wood Chip Pile

The wood chip pile involves approximately 1 to 2 acres of area on the west side of the PWP site. The pile, which is 10 to 15 feet above the surrounding topography, may have filled former depressions and drainage features, making its overall thickness in excess of 10 to 15 feet. Various types of wastewater, spent wood treating product, and treated wood are thought to have been disposed in this area.

The wood chip pile is relatively compressible and will settle as it breaks down with time. The amount of settlement is not expected to be uniform and not necessarily related to the thickness of the material, as is the normal case for soils. As a result, the cap for the wood chip pile will have to be designed to accommodate more differential settlement than will be necessary for the cap between the treatment area and the lagoon. Design will also have to consider the potential for local depressions, or cavities, forming beneath the geomembrane.

While most of the procedures described previously for capping the contaminated soils will be also be implemented during design and construction of the cap, starting with regrading to a more uniform condition, the following special provisions will be incorporated in the capping system.

- The minimum slopes for the regraded areas will be increased from 2 to 3 percent to 5 percent or more to allow for differential settlement within the wood waste pile. The objective of the steeper slopes is to assure drainage if localized settlement occurs.
- A heavy geotextile or geogrid will be placed on the top of the wood waste before placing the GCL. The objective of the geotextile or geogrid will be to provide additional support for the GCL and geomembrane, in the event that local cavities develop. It may also be necessary to provide a cushion layer between the wood waste and the GCL to add additional protection to the GCL and to provide a smoother working surface upon which the GCL is installed.
- O&M plans will have to specifically discuss actions to be taken if it becomes apparent that localized surface depressions are developing. These actions could include removing the cap system, filling in the depression, and then recapping

C.4.7. Demolition of Biopad

The biopad consists of a 580- by 260-foot concrete pad, with a thickness of approximately 1 foot, located on the north side of the PWP site. It may be desirable to demolish the pad and locate the concrete beneath the cap to provide long term disposal. The basis for this includes (1) the surface of the pad is deteriorating, which could lead to release of arsenic, (2) the pad is currently creating a significant surface water drainage problem, as all rain water collecting on the pad must be conveyed to some other drainage area, and (3) the location of the pad could affect future end-use.

If the pad is demolished, there will be the several special issues associated with demolition and hauling of metals-contaminated materials.

- Workers must be protected from fine materials that are created by breaking the concrete into pieces for hauling. It will also be necessary to prevent fine materials from either blowing to other areas on the site or being left at the biopad location, ready to be washed into drainage areas or leached into the groundwater during future rainfalls.

The concrete will have to be broken to a size that allows it to be efficiently placed and capped. If a waste-disposal cell concept is accepted, the pieces of concrete can be large in size. On the other hand, if the concrete is used to fill the gully or as general fill, it will be necessary to break the concrete into pieces that are probably no more than a foot in maximum size. If the concrete is processed to a small size, processing should be done in the area that will be capped to reduce the previously-discussed problems associated with water and wind transport of fine material.

Appendix D
Bioscreen Results

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence — *Version 1.3*

Penta Wood Products Site
Run Name

Data Input Instructions:

115	→ 1. Enter value directly....or
↑ or	2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
0.02	
Variable*	→ Data used directly in model.
20	→ Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	38.0	(ft/yr)
or		↑ or	
Hydraulic Conductivity	K	1.7E-02	(cm/sec)
Hydraulic Gradient	i	0.00086	(ft/ft)
Porosity	n	0.407	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	19.5	(ft)
Transverse Dispersivity*	alpha y	2.0	(ft)
Vertical Dispersivity*	alpha z	0.0	(ft)
or		↑ or	
Estimated Plume Length	Lp	600	(ft)

3. ADSORPTION

Retardation Factor*	R	3.5	(-)
or		↑ or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	1500	(L/kg)
FractionOrganicCarbon	foc	0.0004	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	8.4E+0	(per yr)
or		↑ or	
Solute Half-Life	t-half	0.08	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	6.3	(mg/L)
Delta Nitrate*	NO3	18	(mg/L)
Observed Ferrous Iron*	Fe2+	10	(mg/L)
Delta Sulfate*	SO4	45	(mg/L)
Observed Methane*	CH4	7.2	(mg/L)

5. GENERAL

Modeled Area Length*	1050	(ft)
Modeled Area Width*	400	(ft)
Simulation Time*	60	(yr)

L W

6. SOURCE DATA

Source Thickness in Sat.Zone* 45 (ft)

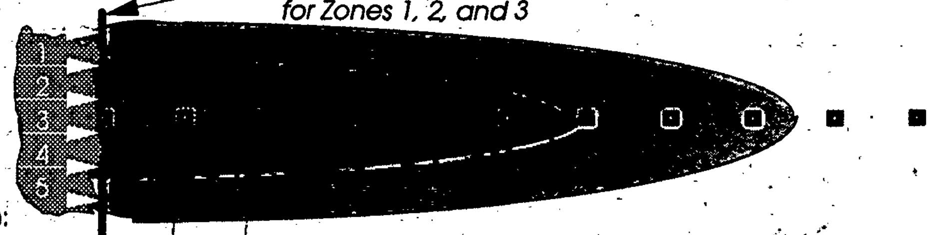
Source Zones:

Width* (ft)	Conc. (mg/L)*
0	
0	
400	83
0	0
0	0

Source Decay (see Help):

SourceHalflife*	20 - 50	(yr)
Soluble Mass	↑ or	
In NAPL, Soil	50000	(Kg)

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	83.0	4.6	8.0			.14	.003				
Dist. from Source (ft)	0	100	200	300	400	500	650	700	800	900	1050

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN CENTERLINE | **View Output**

RUN ARRAY | **View Output**

Help

Recalculate This Sheet

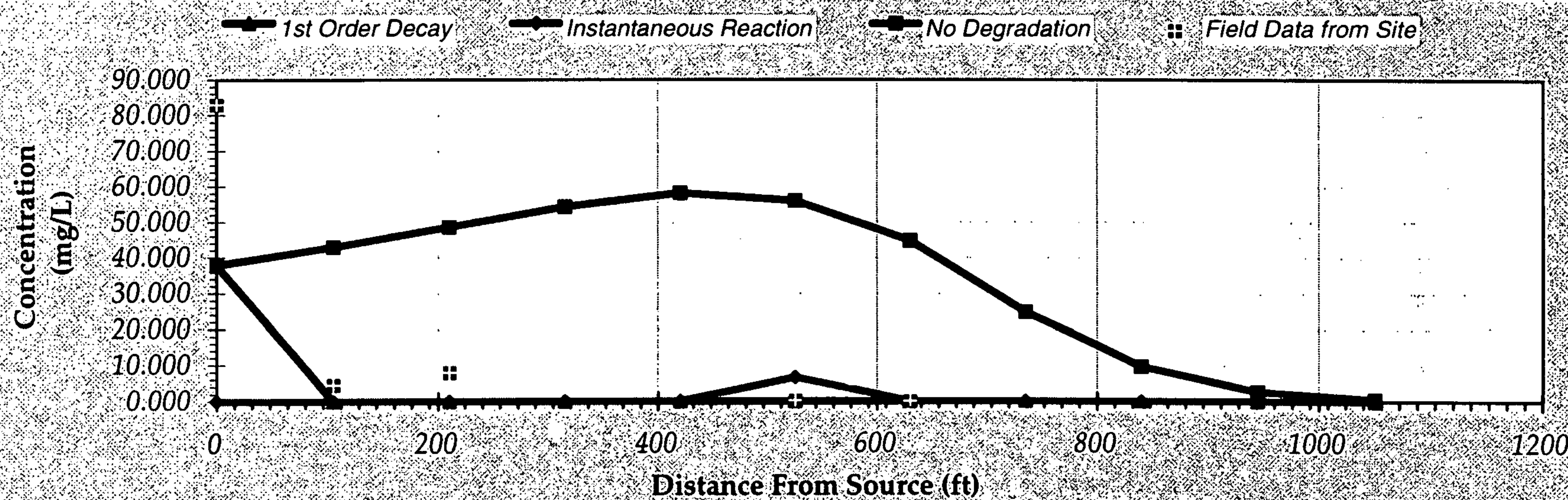
Paste Example Dataset

Restore Formulas for Vs, Dispersivities, R, lambda, other

Figure 1.
BIOSCREEN Input
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	105	210	315	420	525	630	735	840	945	1050
No Degradation	37.838	42.936	48.612	54.364	58.177	55.981	44.695	24.825	9.786	2.705	0.512
1st Order Decay	37.838	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	6.655	0.000	0.000	0.000	0.000	0.000
Field Data from Site	83.000	4.600	8.000			0.140	0.003				



Calculate Animation

Time:
60 Years

Return to Input

Recalculate This Sheet

Figure 2.
Centerline Output
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATIONS IN PLUME (mg/L at Z=0)

Transverse Distance (ft) / ***Distance from Source (ft)***

Transverse Distance (ft)	0	105	210	315	420	525	630	735	840	945	1050
200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100	0.000	0.000	0.000	0.000	0.000	5.289	0.000	0.000	0.000	0.000	0.000
0	0.000	0.000	0.000	0.000	0.000	6.655	0.000	0.000	0.000	0.000	0.000
-100	0.000	0.000	0.000	0.000	0.000	5.289	0.000	0.000	0.000	0.000	0.000
-200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Model to Display:

No Degradation Model

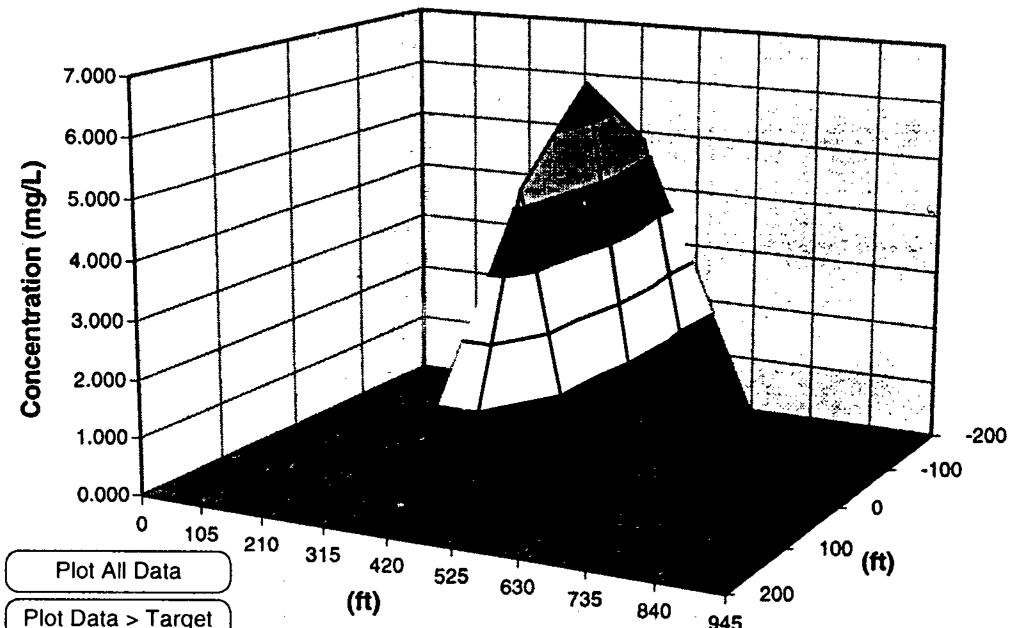
1st Order Decay Model

Instantaneous Reaction Model

Time: **60 Years**

Target Level: **0.005** mg/L

Displayed Model: **Inst. Reaction**



Plot All Data

Plot Data > Target

Plume and Source Masses (Order-of-Magnitude Accuracy)

Plume Mass if No Biodegradation	40613.7	*(Kg)*
- Actual Plume Mass	315.5	*(Kg)*
= Plume Mass Removed by Biodeg	**40298.2**	*(Kg)* (99 %)

Change in Electron Acceptor/Byproduct Masses:

Oxygen	*Nitrate*	*Iron II*	*Sulfate*	*Methane*	
-2708.1	-7737.4	+4298.5	-19343.4	+3094.9	*(Kg)*

Original Mass in Source (Time = 0 Years)	50000.0	*(Kg)*
Mass in Source Now (Time = 60Years)	9386.3	*(Kg)*
Current Volume of Groundwater in Plume	13.2	*(ac-ft)*
Flowrate of Water Through Source Zone	6.398	*(ac-ft/yr)*

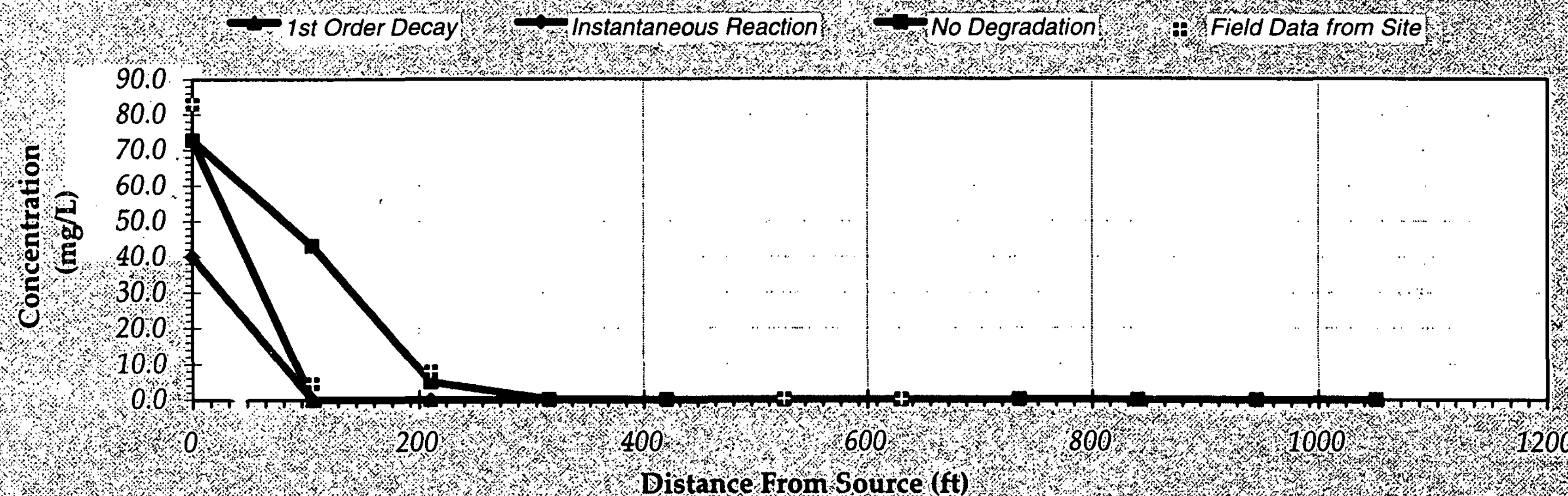
Mass HELP

Recalculate

Figure 3.
Centerline Output
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	105	210	315	420	525	630	735	840	945	1050
No Degradation	72.815	43.095	4.938	0.063	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1st Order Decay	72.815	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	39.996	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	83.000	4.600	8.000			0.140	0.003				



Replay Animation

Next Timestep

Prev Timestep

Time:

10 Years

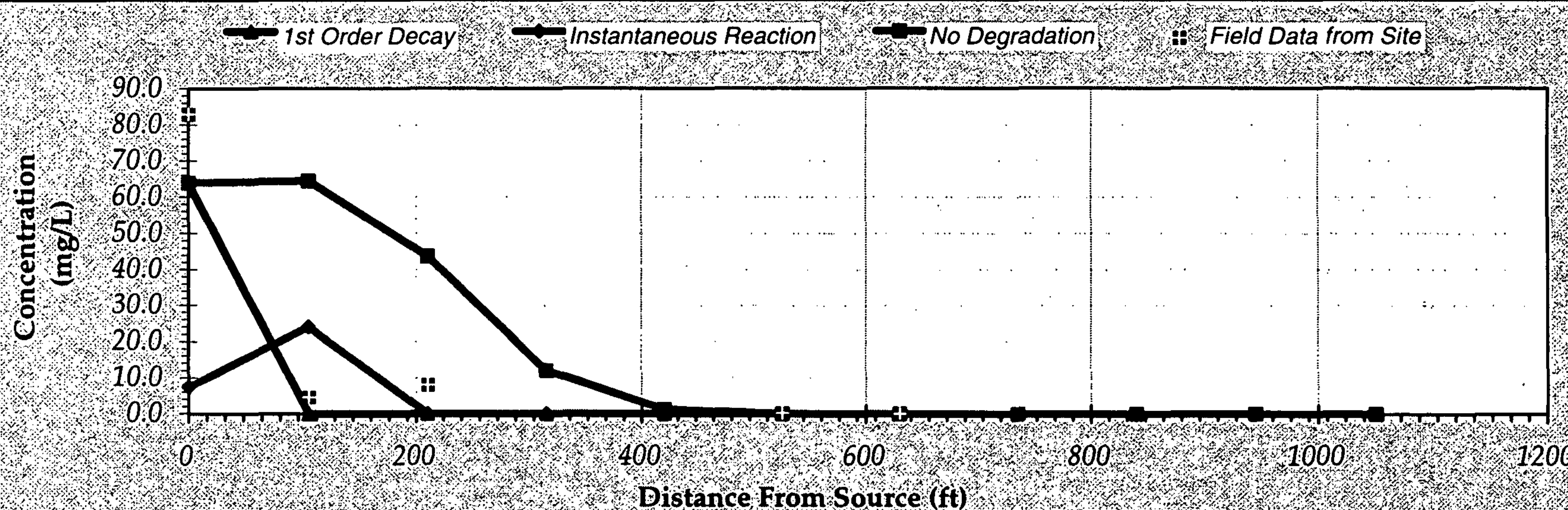
Return to Input

Recalculate This Sheet

Figure 4.
Centerline Output-10 years
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	105	210	315	420	525	630	735	840	945	1050
No Degradation	63.880	64.392	43.642	11.917	1.140	0.034	0.000	0.000	0.000	0.000	0.000
1st Order Decay	63.880	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	7.455	23.963	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	83.000	4.600	8.000			0.140	0.003				



Replay Animation | Next Timestep | Prev Timestep

Time: *20 Years*

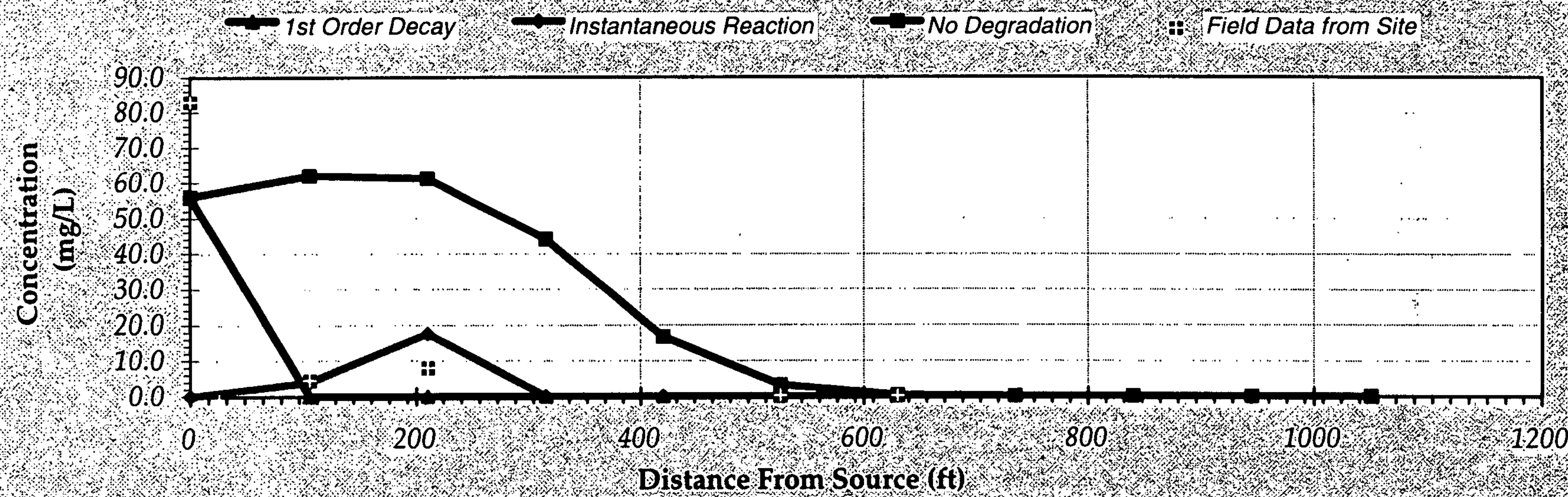
Return to Input | Recalculate This Sheet

Figure 5.
Centerline Output-20 years
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	105	210	315	420	525	630	735	840	945	1050
No Degradation	56.041	62.003	61.164	44.015	16.682	3.190	0.288	0.012	0.000	0.000	0.000
1st Order Decay	56.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	4.015	17.530	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	83.000	4.600	8.000			0.140	0.003				



Replay Animation

Next Timestep

Prev Timestep

Time: *30 Years*

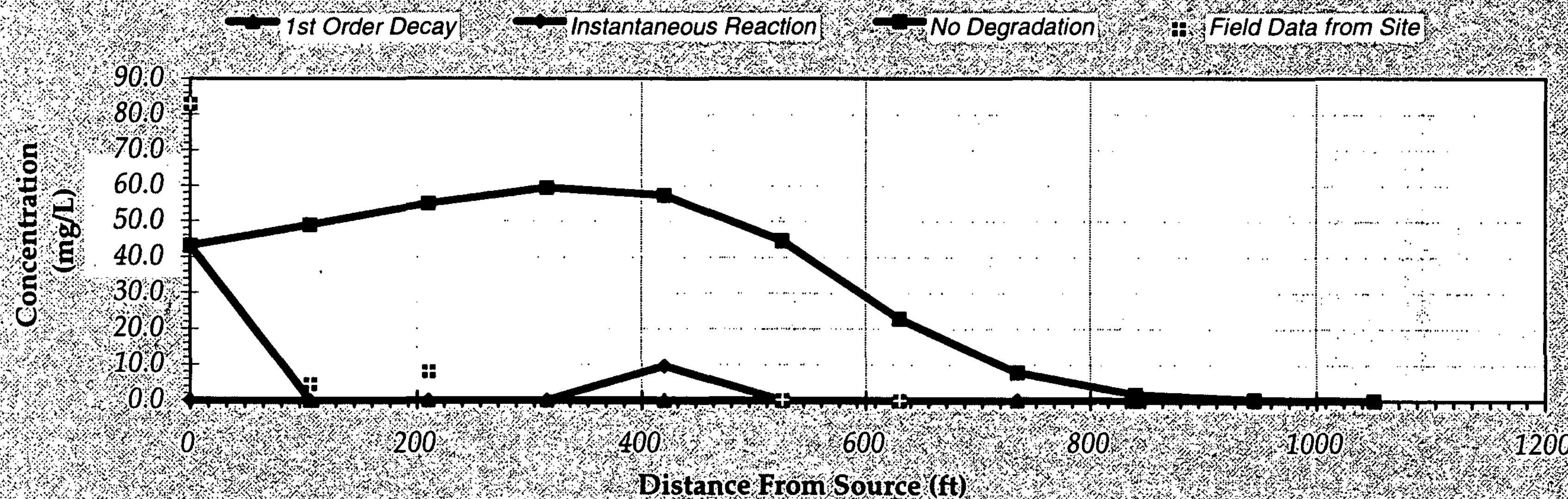
Return to Input

Recalculate This Sheet

Figure 6.
Centerline Output-30 years
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

	Distance from Source (ft)										
TYPE OF MODEL	0	105	210	315	420	525	630	735	840	945	1050
No Degradation	43.131	48.892	54.948	59.349	57.271	44.517	22.730	7.719	1.700	0.236	0.020
1st Order Decay	43.131	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	9.459	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	83.000	4.600	8.000			0.140	0.003				



Replay Animation

Next Timestep

Prev Timestep

Time:

50 Years

Return to Input

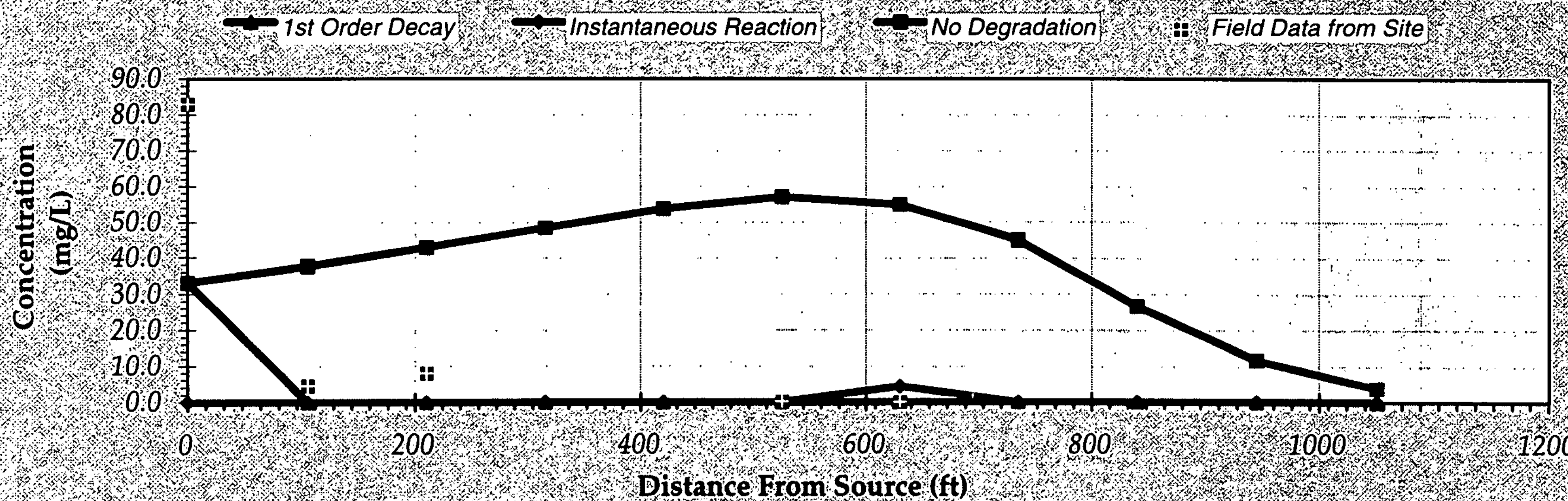
Recalculate This Sheet

Figure 7.
Centerline Output-50 years
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Distance from Source (ft)

TYPE OF MODEL	0	105	210	315	420	525	630	735	840	945	1050
No Degradation	33.195	37.676	42.738	48.306	53.760	57.121	54.937	44.836	26.554	11.670	3.798
1st Order Decay	33.195	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	4.314	0.000	0.000	0.000	0.000
Field Data from Site	83.000	4.600	8.000			0.140	0.003				



Replay Animation

Next Timestep

Prev Timestep

Time:

70 Years

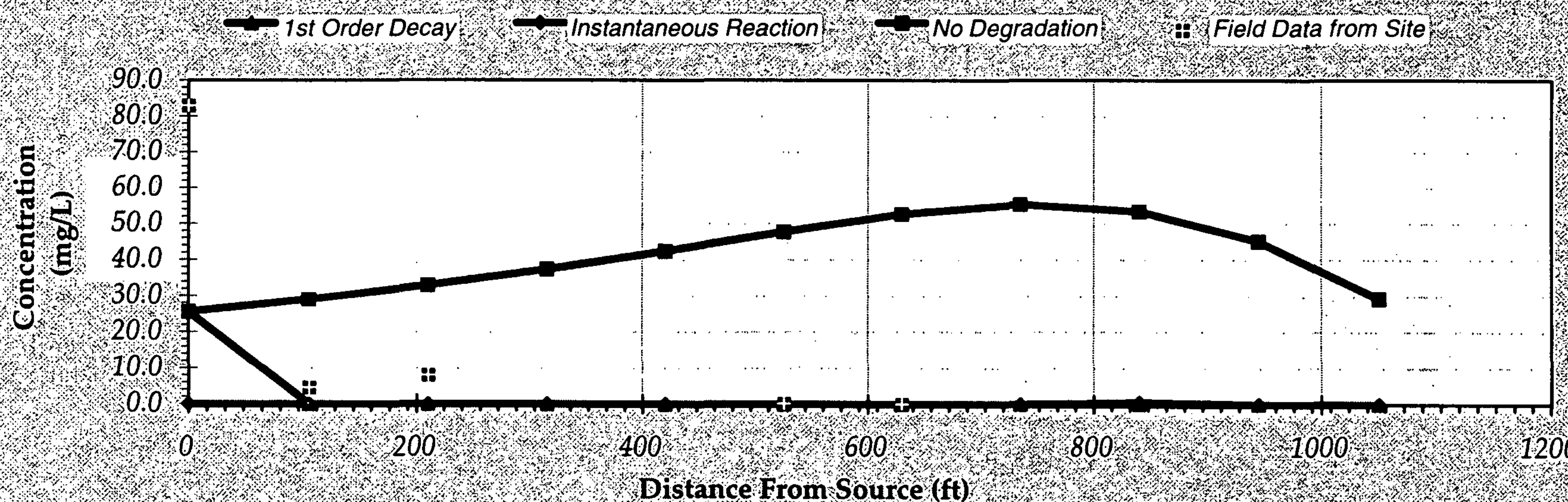
Return to Input

Recalculate This Sheet

Figure 8.
Centerline Output-70 years
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	*Distance from Source (ft)* 0	105	210	315	420	525	630	735	840	945	1050
No Degradation	25.548	28.999	32.915	37.349	42.316	47.636	52.558	55.300	53.310	45.022	29.270
1st Order Decay	25.548	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.507	0.000	0.000
Field Data from Site	83.000	4.600	8.000			0.140	0.003				



Replay Animation | Next Timestep | Prev Timestep

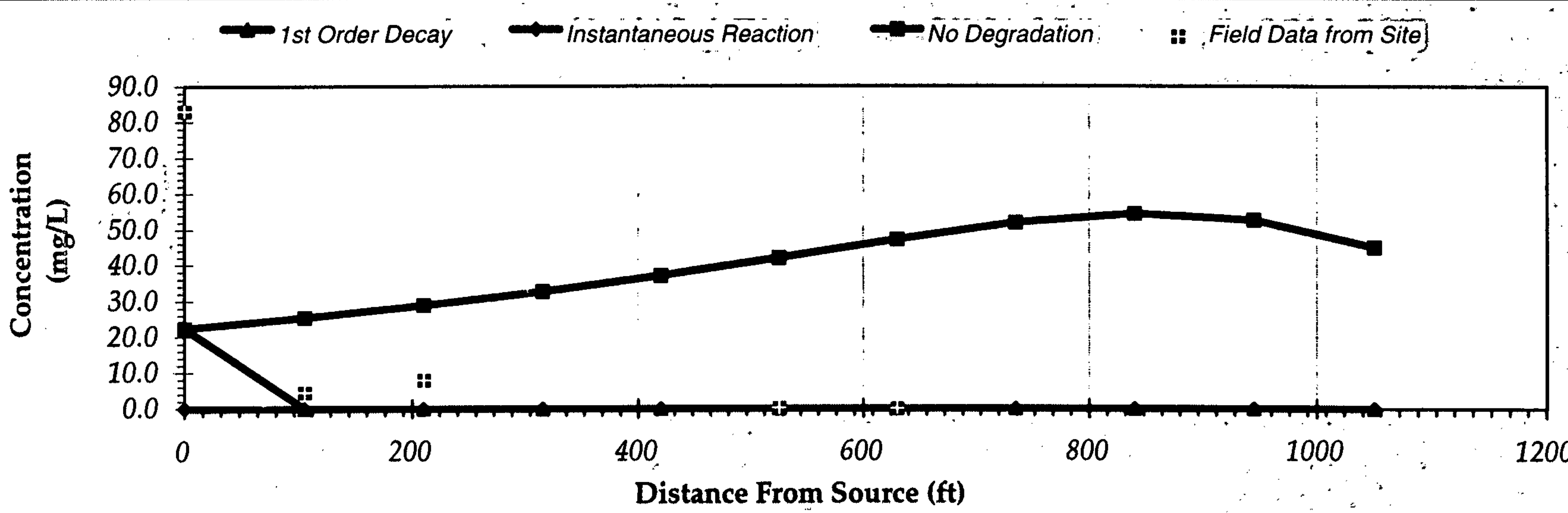
Time: *90 Years*

Return to Input | **Recalculate This Sheet**

Figure 9.
Centerline Output-90 years
Penta Wood Products Site

DISSOLVED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

TYPE OF MODEL	Distance from Source (ft) 0	105	210	315	420	525	630	735	840	945	1050
No Degradation	22.413	25.440	28.877	32.774	37.182	42.092	47.282	51.974	54.503	52.642	45.070
1st Order Decay	22.413	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Inst. Reaction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	83.000	4.600	8.000			0.140	0.003				



Replay Animation

Next Timestep

Prev Timestep

Time:

100 Years

Return to Input

Recalculate This Sheet

Figure 10.
Centerline Output-100 years
Penta Wood Products Site

Appendix E

Calculations for Human Health and Ecological Preliminary Remedial Goals

Penta Wood Products
Town of Daniels, Wisconsin
Media: Soil
Land Use: **Occupational**
Exposure Route: **Ingestion, Dermal Absorption, Inhalation**
Receptor: **Site Worker (adult)**
Region IX Occupational PRG Approach

TABLE E-1
RISK BASED PRGs—SOIL

Chemical	Risk Based PRGs 1E-06 Cancer Risk mg/kg	Risk Based PRGs 1.0 Non-cancer Hazard Index mg/kg	Oral Slope Factor (mg/kg/day)-1	Inh. Slope Factor (mg/kg/day)-1	Oral RfD (mg/kg/day)	Inh. RfD (mg/kg/day)	VF (a) (m3/kg)	DI-a (a) (cm2/sec)	Di-w (a) (cm2/sec)	DA (a) (cm2/sec)	H (a) (atm-m3/mol)	Kd (a) (cm3/g)	Koc (a) (cm^3/g)	Abs. (a)
ARSENIC	**1.06**	**171**	1.5	15.1	0.0003	--								3%
BENZENE	**1.29**	**24.5**	0.029	0.02905	--	0.00171	2.8E+03	0.0880	9.8E-06	2.0E-03	5.5E-03	3.9E-01	65.00	10%
COPPER	--	**40660**	--	--	0.037	--								1%
ETHYLBENZENE	--	**4787**	--	--	0.1	0.28571	4.2E+03	0.0750	7.8E-06	8.8E-04	7.9E-03	1.3E+00	220	10%
FLUORENE	--	**8517**	--	--	0.04	--								10%
ISOPHORONE	**628**	**42583**	0.00095	--	0.2	--								10%
METHYL NAPHTHALENE	--	**--**	--	--	--	--								
NAPHTHALENE	--	**8517**	--	--	0.04	--								10%
PENTACHLOROPHENOL	**2.12**	**2725**	0.12	--	0.03	--								25%
PHENANTHRENE	--	**--**	--	--	--	--								
TOLUENE	--	**2656**	--	--	0.2	0.11429	4.9E+03	0.0780	8.6E-06	6.7E-04	6.6E-03	1.5E+00	257	10%
ZINC	--	**329677**	--	--	0.3	--								1%
XYLENE, MIXTURE	--	**425833**	--	--	2	--								10%

Assumptions

Organic carbon content of soil (fraction)	0.006	Body Weight (kg)	70
Vegetative Cover - Fraction (unitless)	0.5	Averaging Time - Cancer risk (yr)	70
Equivalent Threshold Windspeed (m/s)	11.32	Averaging Time - Noncancer risk (yr)	25
Annual Wind Speed (m/sec)	4.69	Exposure Frequency (d/yr)	250
Skin Surface area exposed (cm2/event)	4300	Exposure Duration (yr)	25
Soil to skin adherence factor (mg/cm2)	1.0	Soil Ingestion Rate (mg/day)	50
		Inhalation Rate (m3/day)	20
		Particulate Emission Factor [PEF] (m3/kg)	1.3E+09

(a) Definition of Terms

VF: Soil to Air Volatilization Factor
Di-a: Molecular Diffusivity - Air
Di-w: Molecular Diffusivity - Water
DA: Apparent Diffusivity
H: Henry's Law Constant
Kd: Soil/water Partition Coefficient
KOC: Organic Carbon Coefficient
Abs.: Skin absorption factor (unitless)

MKE/Prg7gen3.xls

Penta Wood Products
Town of Daniels, Wisconsin
Media: Soil
Land Use: **Occupational**
Exposure Route: **Ingestion, Dermal Absorption, Inhalation**
Receptor: **Excavation Worker (adult)**
Region IX Occupational PRG Approach

TABLE E-2
RISK BASED PRGs—SOIL

Chemical	Risk Based PRGs 1E-06 Cancer mg/kg	1.0 Non-cancer mg/kg	Oral Slope Factor day)-1	Inh. Slope Factor day)-1	Oral RfD day)	Inh. RfD day)	VF (a) (m3/kg)	DI-a (a) sec)	Di-w (a) sec)	DA (a) sec)	H (a) mol)	Kd (a) (cm3/g)	Koc (a) (cm^3/g)	Abs. (a)
ARSENIC	**13.6**	**87.4**	1.5	15.1	0.0003	--								3%
BENZENE	**53.2**	**42.6**	0.029	0.02905	--	0.00171	2.8E+03	0.0880	9.8E-06	2.0E-03	5.5E-03	3.9E-01	65.00	10%
COPPER	--	**12552**	--	--	0.037	--								1%
ETHYLBENZENE	--	**6917**	--	--	0.1	0.28571	4.2E+03	0.0750	7.8E-06	8.8E-04	7.9E-03	1.3E+00	220	10%
FLUORENE	--	**7799**	--	--	0.04	--								10%
ISOPHORONE	**14367**	**38996**	0.00095	--	0.2	--								10%
METHYL NAPHTHALENE	--	**--**	--	--	--	--								
NAPHTHALENE	--	**7799**	--	--	0.04	--								10%
PENTACHLOROPHENOL	**66.6**	**3423**	0.12	--	0.03	--								25%
PHENANTHRENE	--	**--**	--	--	--	--								
TOLUENE	--	**4367**	--	--	0.2	0.11429	4.9E+03	0.0780	8.6E-06	6.7E-04	6.6E-03	1.5E+00	257	10%
ZINC	--	**101777**	--	--	0.3	--								1%
XYLENE, MIXTURE	--	**389957**	--	--	2	--								10%

Assumptions

Organic carbon content of soil (fraction)	0.006	Body Weight (kg)	70
Vegetative Cover - Fraction (unitless)	0.5	Averaging Time - Cancer risk (yr)	70
Equivalent Threshold Windspeed (m/s)	11.32	Averaging Time - Noncancer risk (yr)	1
Annual Wind Speed (m/sec)	4.69	Exposure Frequency (d/yr)	144
Skin Surface area exposed (cm2/event)	4300	Exposure Duration (yr)	1
Soil to skin adherence factor (mg/cm2)	1.0	Soil Ingestion Rate (mg/day)	480
		Inhalation Rate (m3/day)	20
		Particulate Emission Factor [PEF] (m3/kg)	1.3E+09

(a) Definition of Terms

VF: Soil to Air Volatilization Factor
Di-a: Molecular Diffusivity - Air
Di-w: Molecular Diffusivity - Water
DA: Apparent Diffusivity
H: Henry's Law Constant
Kd: Soil/water Partition Coefficient
KOC: Organic Carbon Coefficient
Abs.: Skin absorption factor (unitless)

MKE/Prg7gen3.xls

Penta Wood Products
Town of Daniels, Wisconsin
Media: Soil
Land Use: **Residential**
Exposure Route: **Ingestion, Dermal Absorption, Inhalation**
Receptor: Adult
Region IX Occupational PRG Approach (see note below)

TABLE E-3
RISK BASED PRGs—SOIL

Chemical	Risk Based PRGs: 1E-06 Cancer Risk mg/kg	Risk Based PRGs: 1.0 Non-cancer Hazard Index mg/kg	Oral Slope Factor (mg/kg/day)-1	Inh. Slope Factor (mg/kg/day)-1	Oral RfD (mg/kg/day)	Inh. RfD (mg/kg/day)	VF (a) (m3/kg)	DI-a (a) (cm2/sec)	Di-w (a) (cm2/sec)	DA (a) (cm2/sec)	H (a) (atm-m3/mol)	Kd (a) (cm3/g)	Koc (a) (cm^3/g)	Abs. (a)
ARSENIC	**0.414**	**79.9**	1.5	15.1	0.0003	--								3%
BENZENE	**0.75**	**17.5**	0.029	0.02905	--	0.00171	2.8E+03	0.0880	9.8E-06	2.0E-03	5.5E-03	3.9E-01	65.00	10%
COPPER	--	**17095**	--	--	0.037	--								1%
ETHYLBENZENE	--	**3126**	--	--	0.1	0.28571	4.2E+03	0.0750	7.8E-06	8.8E-04	7.9E-03	1.3E+00	220	10%
FLUORENE	--	**4294**	--	--	0.04	--								10%
ISOPHORONE	**264**	**21471**	0.00095	--	0.2	--								10%
METHYL NAPHTHALENE	--	**--**	--	--	--	--								
NAPHTHALENE	--	**4294**	--	--	0.04	--								10%
PENTACHLOROPHENOL	**0.92**	**1413**	0.12	--	0.03	--								25%
PHENANTHRENE	--	**--**	--	--	--	--								
TOLUENE	--	**1849**	--	--	0.2	0.11429	4.9E+03	0.0780	8.6E-06	6.7E-04	6.6E-03	1.5E+00	257	10%
ZINC	--	**138608**	--	--	0.3	--								1%
XYLENE, MIXTURE	--	**214706**	--	--	2	--								10%

Assumptions

Organic carbon content of soil (fraction)	0.006	Body Weight (kg)	70
Vegetative Cover - Fraction (unitless)	0.5	Averaging Time - Cancer risk (yr)	70
Equivalent Threshold Windspeed (m/s)	11.32	Averaging Time - Noncancer risk (yr)	30
Annual Wind Speed (m/sec)	4.69	Exposure Frequency (d/yr)	350
Skin Surface area exposed (cm2/event)	5800	Exposure Duration (yr)	30
Soil to skin adherence factor (mg/cm2)	1.0	Soil Ingestion Rate (mg/day)	100
		Inhalation Rate (m3/day)	20
		Particulate Emission Factor [PEF] (m3/kg)	1.3E+09

(a) Definition of Terms

VF: Soil to Air Volatilization Factor
Di-a: Molecular Diffusivity - Air
Di-w: Molecular Diffusivity - Water
DA: Apparent Diffusivity
H: Henry's Law Constant
Kd: Soil/water Partition Coefficient
KOC: Organic Carbon Coefficient
Abs.: Skin absorption factor (unitless)

(a) Occupational approach used because *age adjusted* intake factors used in the residential approach were not addressed in the original risk assessment.

MKE/Prg7gen3.xls

Penta Wood Products
Town of Daniels, Wisconsin
Media: Soil
Land Use: **Industrial**
Exposure Route: **Ingestion, Inhalation of Particulates**
Receptor: **Occupational Adult**
Wisconsin NR 729.19 Approach

TABLE E-4
RISK BASED PRGs—SOIL

Chemical	Risk Based PRGs: 1E-06 Cancer Risk mg/kg	Risk Based PRGs: 1.0 Non-cancer Hazard Index mg/kg	Oral Slope Factor (mg/kg/day)-1	Inhalation Slope Factor (mg/kg/day)-1	Oral RfD (mg/kg/day)	Inhalation RfD (mg/kg/day)
ARSENIC	**1.90**	**307**	1.5	15.1	0.0003	--
BENZENE	**98.7**	**--**	0.029	0.02905	--	0.0017
COPPER	--	**37814**	--	--	0.037	--
ETHYLBENZENE	--	**102195**	--	--	0.1	0.2857
FLUORENE	--	**40880**	--	--	0.04	--
ISOPHORONE	**3012**	**204400**	0.00095	--	0.2	--
METHYL NAPHTHALENE	--	--	--	--	--	--
NAPHTHALENE	--	**40880**	--	--	0.04	--
PENTACHLOROPHENOL	**23.8**	**30660**	0.12	--	0.03	--
PHENANTHRENE	--	--	--	--	--	--
TOLUENE	--	**204346**	--	--	0.2	0.1143
XYLENE, MIXTURE	--	--	--	--	2	--
ZINC	--	**306600**	--	--	0.3	--

Assumptions

Body Weight - Adult (kg)	70	Soil Ingestion Rate - Adult (mg/day)	100
Averaging Time - Cancer risk (days)	25550	Inhalation rate adult (m3/day)	20
Averaging Time - Noncancer risk (days)	9125	Particulate Emission Factor [PEF] (m3/kg)	1.3E+09
Exposure Frequency (d/yr)	250		
Exposure Duration - Industrial (years)	25		
Vegetative Cover - Fraction (unitless)	0.500	Soil Bulk density (g/cm3)	2.650
Equivalent Threshold Windspeed (m/s)	11.32	Fraction organic carbon in soil	0.006
Annual Wind Speed (m/sec)	4.69		

MKE/Prg7gen3.xls

Penta Wood Products
Town of Daniels, Wisconsin
Media: Soil
Land Use: **Residential**
Exposure Route: **Ingestion, Inhalation of Particulates**
Receptor: **Residential Child / Adult** [a]
Wisconsin NR 729.19 Approach

TABLE E-5
RISK BASED PRGs—SOIL

Chemical	Risk Based PRGs: 1E-06 Cancer Risk mg/kg	Risk Based PRGs: 1.0 Non-cancer Hazard Index mg/kg	Oral Slope Factor (mg/kg/day)-1	Inhalation Slope Factor (mg/kg/day)-1	Oral RfD (mg/kg/day)	Inhalation RfD (mg/kg/day)
ARSENIC	0.425	23.5	1.5	15.1	0.0003	--
BENZENE	22.0	--	0.029	0.02905	--	0.0017
COPPER	--	2894	--	--	0.037	--
ETHYLBENZENE	--	7821	--	--	0.1	0.2857
FLUORENE	--	3129	--	--	0.04	--
ISOPHORONE	672	15643	0.00095	--	0.2	--
METHYL NAPHTHALENE	--	--	--	--	--	--
NAPHTHALENE	--	3129	--	--	0.04	--
PENTACHLOROPHENOL	5.32	2346	0.12	--	0.03	--
PHENANTHRENE	--	--	--	--	--	--
TOLUENE	--	15643	--	--	0.2	0.1143
XYLENE, MIXTURE	--	156429	--	--	2	--
ZINC	--	23464	--	--	0.3	--

Assumptions

Body Weight - Child (kg)	15	Soil Ingestion Rate - Child (mg/day)	200
Body Weight - Adult (kg)	70	Soil Ingestion Rate - Adult (mg/day)	100
Averaging Time - Cancer risk (days)	25550	Combined Soil Ingestion ([mg/yr] / [kg day])	114
Averaging Time - Noncancer risk (days)	2190	Combined Inhalation ([mg/yr] / [kg day])	14.86
Exposure Frequency (d/yr)	350	Inhalation rate child (m3/day)	20
Exposure Duration - Child (years)	6	Inhalation rate adult (m3/day)	20
Exposure Duration - Residential (years) [b]	30	Particulate Emission Factor [PEF] (m3/kg)	1.3E+09
Vegetative Cover - Fraction (unitless)	0.500	Soil Bulk density (g/cm3)	2.650
Equivalent Threshold Windspeed (m/s)	11.32	Fraction organic carbon in soil	0.006
Annual Wind Speed (m/sec)	4.69		

[a] Exposure duration for noncarcinogens is assumed to be 6 years total. For carcinogens, exposures are combined for children (6 years) and adults (24 years) - Wisconsin NR 720.19.

[b] Calculation of combined intakes assumes an adult exposure duration of 24 years.

Penta Wood Products
Town of Daniels, Wisconsin
Media: Tap Water
Land Use: **Residential**
Exposure Route: **Ingestion, Inhalation of volatiles**
Receptor: **Residential Child / Adult** [a]
Region IX PRG Approach for Tap Water

TABLE E-6
RISK BASED PRGs—GROUNDWATER

Chemical	Risk Based PRGs 1E-06 Cancer Risk ug/L	Risk Based PRGs 1.0 Non-cancer Hazard Index ug/L	Oral Slope Factor (mg/kg/ day)-1	Inh. Slope Factor (mg/kg/ day)-1	Oral RfD (mg/kg/ day)	Inh. RfD (mg/kg/ day)
ARSENIC	0.045	11.0	1.5	15.1	0.0003	--
BENZENE	0.295	12.5	0.029	0.02905	--	0.0017
CHLORIDE	--	--	--	--	--	--
COPPER	--	1351	--	--	0.037	--
ETHYLBENZENE	--	1327	--	--	0.1	0.2857
IRON	--	--	--	--	--	--
MANGANESE	--	5110	--	--	0.14	--
NAPHTHALENE	--	1460	--	--	0.04	--
PENTACHLOROPHENOL	0.560	1095	0.12	--	0.03	--
TOLUENE	--	749	--	--	0.2	0.1143
XYLENE, MIXTURE	--	73000	--	--	2.0	--
ZINC	--	10950	--	--	0.3	--

Assumptions

Body Weight - Child (kg)	15	Water Ingestion Rate - Child (L/day)	1
Body Weight - Adult (kg)	70	Water Ingestion Rate - Adult (L/day)	2
Averaging Time - Cancer risk (yr)	70	Ingestion Factor - water, adj. [l/yr]/[kg/d]	1.09
Averaging Time - Noncancer risk (yr)	30	Inhalation Factor - water, adj. [m^3/yr]/[kg/d]	14.86
Exposure Frequency (d/yr)	350	Inhalation Rate-Child (m3/day)	20
Exposure Duration - Child (years)	6	Inhalation Rate-Adult (m3/day)	20
Exposure Duration - Residential (years) [b]	30	Volatilization Factor for water (L/m^3)	0.5

[a] Exposure duration for lifetime residents is assumed to be 30 years total. For carcinogens, exposures are combined for children (6 years) and adults (24 years) - per Region IX PRG approach

[b] Calculation of combined intakes assumes an adult exposure duration of 24 years.

Preliminary Remedial Goals Ecological Risk Assessment Penta Woods Product Site

PREPARED FOR: Gina Bayer/CH2M HILL/MKE

PREPARED BY: Jack Dingledine/CH2M HILL/MKE

DATE: April 27, 1998

A determination of preliminary remedial goals for ecological receptors at the Penta Woods Product site has been completed. These goals are based on several of the elements contained within the original ecological risk assessment conducted for the site (Feb., 1998). Soil remedial goals, expressed in mg/kg soil concentration of contaminant, have been calculated under three separate exposure scenarios. Determinations were made using originally proposed exposure assumptions as well as revised values. Clean-up values were calculated for areas on-site, as well as off-site wooded and off-site wetland areas.

Soil concentration values for each receptor, under each exposure scenario, were determined through the following formula:

$$Target Soil Concentration = \frac{Toxicity Refrence Value}{[(BCF \times FRc \times If) + (BAF \times Is)]HR}$$

Where:

BCF=Bioconcentration Factor

FRc=Fraction of diet comprised of contaminated food items

BAF=Bioavailability Factor

If=Ingestion rate of food

Is=Ingestion rate of soi'

HR=Home range fraction

Soil target values were calculated for each ecological receptor which may be exposed to soil contaminants within 3 areas in and around the site including on-site areas, off-site wooded areas, and off-site wetlands areas.

On-site Areas

Assumptions applied in the determination of preliminary remedial goals for ecological receptors within on-site areas included:

Bioconcentration Factors-Equivalent to baseline factors

Fraction of diet –Values for mouse, raccoon, and robin adjusted to reflect portions of diet comprised primarily of invertebrates and other potentially contaminated food items.

Bioavailability Factors- Although no site-specific data is available, bioavailability values for arsenic, copper and zinc were adjusted slightly to account for a more limited bioavailability.

Home Range Ratio- The ratio of home range size to the site was determined. Although the site is large enough to support the entire home range of the robin and a larger portion of the raccoon, limited habitat quality is expected to restrict use of the site.

Off-site Wooded Areas

Assumptions applied in the determination of preliminary remedial goals for ecological receptors within off-site wooded areas included:

Bioconcentration Factors-Equivalent to baseline factors

Fraction of diet –Values for mouse, raccoon, and robin adjusted to reflect portions of diet comprised primarily of invertebrates and other potentially contaminated food items.

Bioavailability Factors- Although no site-specific data is available, bioavailability values for arsenic, copper and zinc were adjusted slightly to account for a more limited bioavailability.

Home Range Ratio- The ratio of home range size to the area of contaminated soil within off-site wooded areas was determined.

Off-site Wetland Area

Assumptions applied in the determination of preliminary remedial goals for ecological receptors within off-site wetland areas included:

Bioconcentration Factors-Equivalent to baseline factors

Fraction of diet –Values for mouse, raccoon, and robin adjusted to reflect portions of diet comprised primarily of invertebrates and other potentially contaminated food items.

Bioavailability Factors- Although no site-specific data is available, bioavailability values for arsenic, copper and zinc were adjusted slightly to account for a more limited bioavailability.

Home Range Ratio- The ratio of home range size to contaminated off-site wetland area was determined

Penta Wood Products Site
Preliminary Remedial Goal Calculations
Baseline Ecological Values

Contaminant of Concern :Pentachlorophenol								
		Food Item Exposure			Incidental Soil Exposure		Ratio of HR	Target Soil Concentration
Receptor Species	Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	To Site	mg/kg
Deer Mouse	0.24	1	1	0.19	1	0.005	1	1.230769231
Short-tailed Shrew	0.24	13	1	0.49	1	0.012	1	0.037605766
Raccoon	1.5	13	1	0.05	1	0.0047	1	2.291125706
American Robin	5.04	13	1	1.52	1	0.152	1	0.2531137
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor If=ingestion rate of food, Is=Incidental ingestion rate of soil								

Contaminant of Concern :Arsenic								
		Food Item Exposure			Incidental Soil Exposure		Ratio of HR	Target Soil Concentration
Receptor Species	Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	To Site	mg/kg
Deer Mouse	0.126	1	1	0.19	1	0.005	1	0.646153846
Short-tailed Shrew	0.126	1	1	0.49	1	0.012	1	0.250996016
Raccoon	0.15	1	1	0.05	1	0.0047	1	2.742230347
American Robin	2.46	1	1	1.52	1	0.152	1	1.471291866
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor If=ingestion rate of food, Is=Incidental ingestion rate of soil								

Penta Wood Products Site
Preliminary Remedial Goal Calculations
Baseline Ecological Values

Contaminant of Concern :Copper								
		Food Item Exposure			Incidental Soil Exposure		Ratio of HR	Target Soil Concentration
Receptor Species	Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	To Site	mg/kg
Deer Mouse	12.5	1	1	0.19	1	0.005	1	64.1025641
Short-tailed Shrew	12.5	1	1	0.49	1	0.012	1	24.90039841
Raccoon	1	1	1	0.05	1	0.0047	1	18.28153565
American Robin	47	1	1	1.52	1	0.152	1	28.11004785
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor								
If=ingestion rate of food, Is=Incidental ingestion rate of soil								

Contaminant of Concern :Zinc								
		Food Item Exposure			Incidental Soil Exposure		Ratio of HR	Target Soil Concentration
Receptor Species	Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	To Site	mg/kg
Deer Mouse	160	1	1	0.19	1	0.005	1	820.5128205
Short-tailed Shrew	160	1	1	0.49	1	0.012	1	318.7250996
Raccoon	25	1	1	0.05	1	0.0047	1	457.0383912
American Robin	14.5	1	1	1.52	1	0.152	1	8.672248804
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor								
If=ingestion rate of food, Is=Incidental ingestion rate of soil								

Penta Wood Products Site
Preliminary Remedial Goals
Adjusted On-Site Values

Contaminant of Concern :Pentachlorophenol								
		Food Item Exposure			Incidental Soil Exposure		Ratio of HR	Target Soil Concentration
Receptor Species	Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	To Site	mg/kg
Deer Mouse	0.24	1	0.75	0.19	1	0.005	1	1.627118644
Short-tailed Shrew	0.24	13	1	0.49	1	0.012	1	0.037605766
Raccoon	1.5	13	0.5	0.05	1	0.0047	0.3	15.16530179
American Robin	5.04	13	0.75	1.52	1	0.152	0.75	0.448837831
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor								
If=ingestion rate of food, Is=Incidental ingestion rate of soil								

Contaminant of Concern :Arsenic								
		Food Item Exposure			Incidental Soil Exposure		Ratio of HR	Target Soil Concentration
Receptor Species	Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	To Site	mg/kg
Deer Mouse	0.126	1	0.75	0.19	0.8	0.005	1	0.860068259
Short-tailed Shrew	0.126	1	1	0.49	0.8	0.012	1	0.252201761
Raccoon	0.15	1	0.5	0.05	0.8	0.0047	0.3	17.3852573
American Robin	2.46	1	0.75	1.52	0.8	0.152	0.75	2.599873177
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor								
If=ingestion rate of food, Is=Incidental ingestion rate of soil								

Penta Wood Products Site
Preliminary Remedial Goals
Adjusted On-Site Values

Contaminant of Concern :Copper								
		Food Item Exposure			Incidental Soil Exposure		Ratio of HR	Target Soil Concentration
Receptor Species	Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	To Site	mg/kg
Deer Mouse	12.5	1	0.75	0.19	0.8	0.005	1	85.32423208
Short-tailed Shrew	12.5	1	1	0.49	0.8	0.012	1	25.02001601
Raccoon	1	1	0.5	0.05	0.8	0.0047	0.3	115.9017153
American Robin	47	1	0.75	1.52	0.8	0.152	0.75	49.67237371
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor If=ingestion rate of food, Is=Incidental ingestion rate of soil								

Contaminant of Concern :Zinc								
		Food Item Exposure			Incidental Soil Exposure		Ratio of HR	Target Soil Concentration
Receptor Species	Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	To Site	mg/kg
Deer Mouse	160	1	0.75	0.19	0.8	0.005	1	1092.150171
Short-tailed Shrew	160	1	1	0.49	0.8	0.012	1	320.256205
Raccoon	25	1	0.5	0.05	0.8	0.0047	0.3	2897.542884
American Robin	14.5	1	0.75	1.52	0.8	0.152	0.75	15.32445572
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor If=ingestion rate of food, Is=Incidental ingestion rate of soil								

Penta Wood Products Site
Preliminary Remedial Goals
Off-Site Woodland Values

Contaminant of Concern :Pentachlorophenol

Receptor Species	Toxicity Reference Value	Food Item Exposure BCF	FRc	If kg/kg-day	Incidental Soil Exposure BAF	Is kg/kg-day	Ratio of HR To Area	Target Soil Concentration mg/kg
Deer Mouse	0.24	1	0.75	0.19	1	0.005	1	1.627118644
Short-tailed Shrew	0.24	13	1	0.49	1	0.012	1	0.037605766
Raccoon	1.5	13	0.5	0.05	1	0.0047	0.1	45.49590537
American Robin	5.04	13	0.75	1.52	1	0.152	1	0.336628373

BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor
If=ingestion rate of food, Is=Incidental ingestion rate of soil

Contaminant of Concern :Arsenic

Receptor Species	Toxicity Reference Value	Food Item Exposure BCF	FRc	If kg/kg-day	Incidental Soil Exposure BAF	Is kg/kg-day	Ratio of HR To Area	Target Soil Concentration mg/kg
Deer Mouse	0.126	1	0.75	0.19	0.8	0.005	1	0.860068259
Short-tailed Shrew	0.126	1	1	0.49	0.8	0.012	1	0.252201761
Raccoon	0.15	1	0.5	0.05	0.8	0.0047	0.1	52.15577191
American Robin	2.46	1	0.75	1.52	0.8	0.152	1	1.949904883

BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor
If=ingestion rate of food, Is=Incidental ingestion rate of soil

Penta Wood Products Site
Preliminary Remedial Goals
Off-Site Woodland Values

Contaminant of Concern :Copper										
			Food Item Exposure			Incidental Soil Exposure			Target Soil Concentration
Receptor Species		Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	Ratio of HR To Area	mg/kg
Deer Mouse		12.5	1	0.75	0.19	0.8	0.005	1	85.32423208
Short-tailed Shrew		12.5	1	1	0.49	0.8	0.012	1	25.02001601
Raccoon		1	1	0.5	0.05	0.8	0.0047	0.1	347.705146
American Robin		47	1	0.75	1.52	0.8	0.152	1	37.25428028
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor If=ingestion rate of food, Is=Incidental ingestion rate of soil									

Contaminant of Concern :Zinc									
			Food Item Exposure			Incidental Soil Exposure			Target Soil Concentration
Receptor Species		Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	Ratio of HR To Area	mg/kg
Deer Mouse		160	1	0.75	0.19	0.8	0.005	1	1092.150171
Short-tailed Shrew		160	1	1	0.49	0.8	0.012	1	320.256205
Raccoon		25	1	0.5	0.05	0.8	0.0047	0.1	8692.628651
American Robin		14.5	1	0.75	1.52	0.8	0.152	1	11.49334179
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor If=ingestion rate of food, Is=Incidental ingestion rate of soil									

Preliminary Remedial Goals
Penta Woods Product Site
Ecological Values
Off-site Wetland Areas

Contaminant of Concern :Pentachlorophenol									
			Food Item Exposure			Incidental Soil Exposure			Target Soil Concentration
Receptor Species		Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	Ratio of HR To Area	mg/kg
Deer Mouse		0.24	1	0.75	0.19	1	0.005	1	1.627118644
Short-tailed Shrew		0.24	13	1	0.49	1	0.012	1	0.037605766
Raccoon		1.5	400	0.5	0.05	1	0.0047	0.1	1.499295331
American Robin		5.04	13	0.75	1.52	1	0.152	1	0.336628373
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor									
If=ingestion rate of food, Is=Incidental ingestion rate of soil									

Contaminant of Concern :Arsenic									
			Food Item Exposure			Incidental Soil Exposure			Target Soil Concentration
Receptor Species		Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	Ratio of HR To Area	mg/kg
Deer Mouse		0.126	1	0.75	0.19	0.8	0.005	1	0.860068259
Short-tailed Shrew		0.126	1	1	0.49	0.8	0.012	1	0.252201761
Raccoon		0.15	1	0.5	0.05	0.8	0.0047	0.1	52.15577191
American Robin		2.46	1	0.75	1.52	0.8	0.152	1	1.949904883
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor									
If=ingestion rate of food, Is=Incidental ingestion rate of soil									

Preliminary Remedial Goals
Penta Woods Product Site
Ecological Values
Off-site Wetland Areas

Contaminant of Concern :Copper									
			Food Item Exposure			Incidental Soil Exposure			Target Soil Concentration
Receptor Species		Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	Ratio of HR To Area	mg/kg
Deer Mouse		12.5	1	0.75	0.19	0.8	0.005	1	85.32423208
Short-tailed Shrew		12.5	1	1	0.49	0.8	0.012	1	25.02001601
Raccoon		1	1	0.5	0.05	0.8	0.0047	0.1	347.705146
American Robin		47	1	0.75	1.52	0.8	0.152	1	37.25428028
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor If=ingestion rate of food, Is=Incidental ingestion rate of soil									

Contaminant of Concern :Zinc									
			Food Item Exposure			Incidental Soil Exposure			Target Soil Concentration
Receptor Species		Toxicity Reference Value	BCF	FRc	If kg/kg-day	BAF	Is kg/kg-day	Ratio of HR To Area	mg/kg
Deer Mouse		160	1	0.75	0.19	0.8	0.005	1	1092.150171
Short-tailed Shrew		160	1	1	0.49	0.8	0.012	1	320.256205
Raccoon		25	1	0.5	0.05	0.8	0.0047	0.1	8692.628651
American Robin		14.5	1	0.75	1.52	0.8	0.152	1	11.49334179
BCF=bioconcentration factor, FRc=fraction of diet, BAF=bioavailability factor If=ingestion rate of food, Is=Incidental ingestion rate of soil									

Preliminary Remedial Goals Summary
Penta Woods Product Site
(mg/kg)

Contaminant of Concern	On-site Areas			Off-site Wooded Areas		
	Ecological Receptors (Range)	Phytoxicity Value	Human Health Value	Ecological Receptors (Range)	Phytoxicity Value	Human Health Value
Pentachlorophenol	0.037-15.1	3		0.037-45.5	3	
Arsenic	0.25-17.38	10		0.25-52.2	10	
Copper	25-115	100		25-347	100	
Zinc	15-2,897	50		11-8,692	50	

Contaminant of Concern	Off-site Wetland Areas		
	Ecological Receptors (Range)	Phytoxicity Value	Human Health Value
Pentachlorophenol	0.037-1.6	3	
Arsenic	0.25-52.1	10	
Copper	25-347	100	
Zinc	11.5-8,692	50	

Appendix F

Supporting Information for Alternative Development

Attachment F-1

White Rot Fungus Treatability Study Report

Preliminary Studies on White-Rot Fungal Remediation of Pentachlorophenol-Contaminated Materials from the Penta Wood Products Site

April, 1998

Prepared for:
CH2MHill

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State College, PA 16801

A Subsidiary of
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Summary

Preliminary bench-scale studies were conducted into the ability of white-rot fungi to remediate the PCP contamination in site materials from the Penta Wood Products site in Daniels, WI. Conditions were determined in which white-rot fungi were able to remove up to 53% (± 17%) of PCP from sand from the Penta site within 23 days; 32% (± 5%) removal of PCP was observed in mixtures containing both sand and material from the soil/wood chip layer at the site. Head-to-head comparisons within this study indicated that white-rot fungi significantly outperformed the indigenous microbial populations present at the site. Only very small amounts of pentachloroanisole (PCA) were detected in any of the cultures, indicating that degradation of PCP most likely includes formation of bound residues with soil organic matter. Comparison of these results with published reports of PCP degradation kinetics in longer-term field applications of white-rot fungi indicate that remediation of Penta site materials to Region 3 industrial-site guidelines should be possible in six months or less using white-rot fungi under the proper conditions.

Introduction

White-rot fungi (WRF) have been used, either commercially or as part of research projects (*i.e.* the USEPA SITE Program) for remediation of PCP contamination at over a half-dozen sites. These have ranged in size from small-scale field treatability studies, in which individual plot sizes were on the order of 1 yd^3, to a full-scale commercial field application at a former wood-preserving site in Southern Finland, at which 10,000 yd^3 of contaminated soils were treated. Performance data, as well as pertinent specifics on size, and other aspects of the various applications of WRF for PCP soil remediation are summarized below:

Project	Scale	Initial [PCP]	End [PCP]	Duration	Comments
Field Treatability Study - Oshkosh, WI 1989 (8)	1 yd^3 (per plot)	300-400 ppm	30-50 ppm	45 days	Small-scale landfarming
Field Treatability Study - Brookhaven, MS 1992 (10)	2-10 yd^3 (per plot)	670 ppm	74 ppm	8 weeks	Small-scale landfarming
Field Demonstration - Brookhaven, MS 1993 (7)	300 yd^3	1000 ppm	360 ppm	20 weeks	Larger-scale landfarming; performance was significantly hampered by poor inoculum and adverse weather.
Site Remediation - Finland 1992-3 (5)	10,000 yd^3	≤ 700 ppm	≤ 10 ppm	1 year	Performed by Intech licensee (Biotal Ltd.)
Site Remediation - Murphreesboro, NC 1996-8	750 yd^3	≤ 2300 ppm	9-36 ppm (Ave = 20 ppm)	30 days	*Ex-situ* biopile; Site also contaminated with lindane, benz[*a*]anthracene, PCDD/ PCDFs; Performed by Intech licensee (EarthFax Eng.) In collaboration with Intech/ Tienzyme
Site Remediation - Mountain View, CA 1997	40 yd^3	260 ppm	14 ppm	60 days	*Ex-situ* biopile; Performed by Intech/Tienzyme personnel under subcontract from OHM

Degradation of PCP by WRF, as with many other organic pollutants, occurs *via* a range of free-radical reactions, mediated (either directly (6) or indirectly (1, 4, 12)) by fungal peroxidase enzymes. In soils with large amount of organic matter (or in systems which receive large amounts of organic matter in the form of fungal growth substrate), these various free radicals frequently co-polymerize with soil organic matter and/or its precursor monomers, thereby yielding hybrid polymers (13). PCP transformation products thus become covalently bound into soil organic matter, and are rendered non-extractable (11). WRF growth on PCP-treated wood has also been shown to transform PCP to non-extractable products (9), presumably by similar processes. Fungi, including some WRF, are also capable of methylating PCP, producing pentachloroanisole (PCA). Although PCA is also a substrate for fungal peroxidases, and is therefore frequently degraded further, it has been seen in some cases (3, 8) to accumulate to significant levels in WRF-treated soils. Generally, we only observe this with members of the WRF genus *Phanerochaete*, none of which were used in the present work. Although PCA is considerably less toxic than PCP, this is not considered to be an optimal transformation, as simple ether cleavage reactions would regenerate PCP from PCA. In contrast, given the high stability and long turnover times (on the order of hundreds of years) associated with soil organic matter, the formation of the covalently-bound residues described above is generally viewed as a very significant risk reduction (2).

Procedures

Samples of PCP-contaminated sand and a PCP-contaminated soil/wood chip layer from the Penta Wood Products site were obtained from CH2MHill in January of 1998. Each sample was extensively mixed by manual stirring in an attempt to reach homogeneity. Moisture contents of each material were determined by weight loss upon overnight drying at *ca.* 60 °C. A total of five species of WRF were examined in the various stages of this work. All fungal inocula used herein were prepared by inoculating autoclaved growth substrates with a rye-based spawn (14) colonized with the WRF species of choice. Two substrate formulations were used; the first of these consisted of a supplemented mixture of alder wood chips with cottonseed hulls, whereas the second consisted of unsupplemented cotton gin trash.

Cultures were contained in 125-ml Erlenmeyer flasks, which were covered loosely with aluminum foil to permit air exchange. Each culture contained 20 grams (dry wt) of the material to be treated, either sand, soil/chips, or a mixture of 4 parts sand to 1 part soil/chips. This latter combination was included as a possible avenue towards diluting the highly-contaminated soil/chip layer with the relatively less-contaminated sand, thus allowing simultaneous treatment of all site materials in one system. Following colonization of the growth substrate, the fungal inoculum was transferred into the soil by manual mixing. Amendments and/or surfactants, if used, were added to the soil immediately prior to addition of the inoculum. Water was periodically added, as necessary, to maintain the moisture levels of the cultures.

Upon sampling, each culture to be sampled was first manually mixed to ensure collection of a representative sample. PCP extraction from samples was done by accelerated solvent extraction using a Dionex ASE system. The extract was analyzed by GC, and PCP concentrations were determined in all cases by comparison with a 5-point standard curve, which was linear over the entire relevant concentration range ($R^2 = 0.998$).

Results and Discussion

Initial PCP concentrations in the sand and soil/chip material were found to be 429 ± 93 and 7778 ± 1131 ppm, respectively. Thus, a 4:1 mixture of the two materials had a starting concentration of 1899 ± 300 ppm.

Two initial attempts at inoculating the various Penta site materials with fungal-colonized substrate at rates of 5%, 10%, and 20% (dry wt/dry wt) were unsuccessful. Very slight growth of some of the five fungi did occur (mostly confined to the 20% cultures); however, the extent of growth in all of these cases was deemed insufficient to have produced favorable results. The two fungi which showed some growth at the 20% inoculation level during these two trials were chosen for further attempts at higher inoculation rates; these fungi are hereafter referred to a "Species A" and "Species B".

In contrast to the 5-20% cultures, inoculation at the 40% rate yielded favorable growth. This was true in both the sand and the 4:1 mixture of sand and soil/chips. Unfortunately, however, due to the time consumed in the first two batches of cultures, it was only possible to run the third batch for slightly over three weeks (23 days), before it was necessary to harvest the cultures. Nonetheless, several WRF treatments were found to have resulted in significant PCP losses, as can be seen in Figures 1 and 2. All values displayed in the two figures represent those

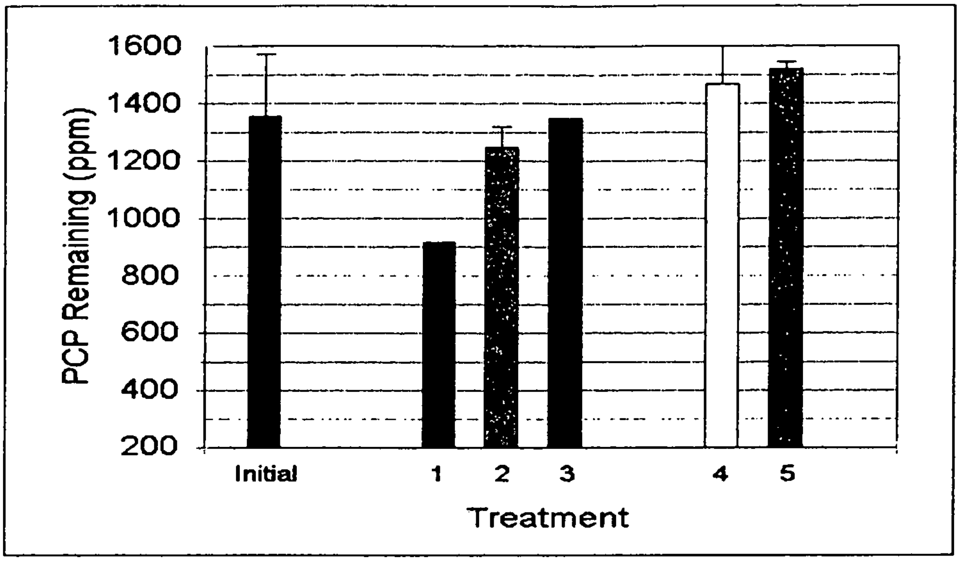


Figure 1 - Removal of PCP after 23 days from cultures containing a 4:1 mix of sand and soil/wood chips from the Penta site. All inoculation rates (including indigenous microbial controls which received sterilized substrate) were 40% (dry wt basis). Treatments are as follows:

(1) WRF Species A, alder/cottonseed hull substrate, no additional amendment
(2) WRF Species B, alder/cottonseed hull substrate, no additional amendment
(3) Site microbes, alder/cottonseed hull substrate, no additional amendment
(4) WRF Species A, cotton gin trash substrate, surfactant/nutrient
(5) WRF Species B, cotton gin trash substrate, surfactant/nutrient

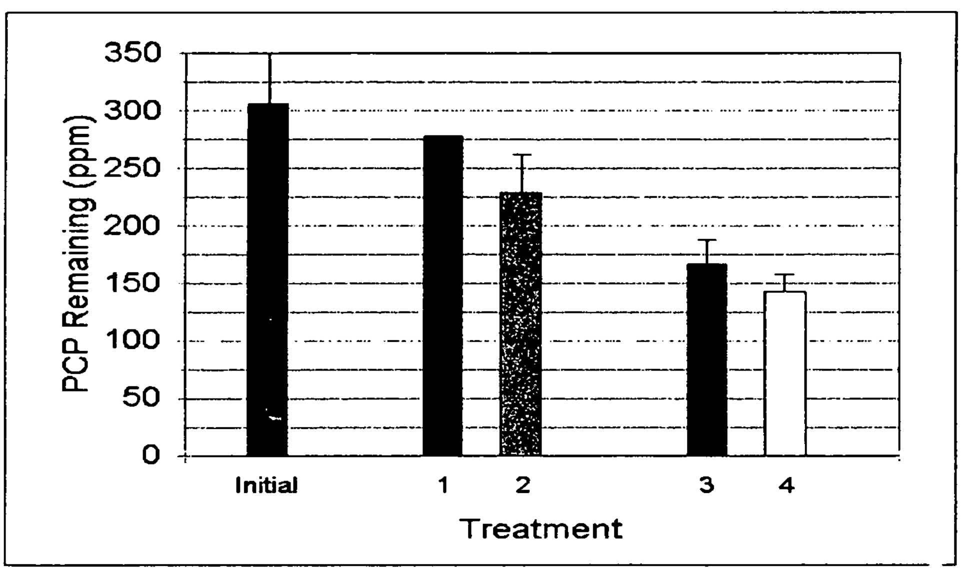


Figure 2 - Removal of PCP after 23 days from cultures containing sand from the Penta site. All inoculation rates were 40% (dry wt basis). Treatments are as follows:

(1) WRF Species A, alder/cottonseed hull substrate, surfactant/nutrient
(2) WRF Species B, alder/cottonseed hull substrate, surfactant/nutrient
(3) WRF Species A, cotton gin trash substrate, surfactant/nutrient
(4) WRF Species B, cotton gin trash substrate, surfactant/nutrient

for the combined site material/fungal growth substrate mixture; thus, the "initial" bars in Figures 1 and 2 are adjusted to reflect the 40% dilution of the original site materials with the growth substrate. This results in **true** initial sand-culture PCP concentrations of 306 (± 66) ppm and concentrations in the 4:1 mix of 1356 (± 215) ppm. In the case of cultures in the 4:1 mix, a 32% reduction in PCP (± 5%) was seen in the best-case scenario (inoculation with Species A, grown on alder/cottonseed hulls, with no surfactant or other amendment). In contrast, identical cultures containing Species B (growth of which was considerably inferior to that of Species A under these conditions) or sterile substrate removed only 8% (± 2%) or 0.7% (± 0.1%) of PCP, respectively. Thus, the performance of WRF Species A in the 4:1 mixture was significantly better than either WRF Species B or the combined indigenous microbial populations of the two site materials. Use of cotton gin trash as a growth substrate and inclusion of surfactants and other amendments, a strategy which led to better results with the sand alone (see below), did not improve results with the mixture of site materials; growth of both WRF species was reduced relative to the above cultures. Thus, it would appear possible that treatment of this material in this manner either **(A)** hinders growth of all microbes, perhaps by elevating the available concentration of PCP beyond a toxic threshold value, or **(B)** favors growth of one or more indigenous microbial species which, although tolerant of PCP, are much less capable of degrading it.

Sand-only cultures which were inoculated with either Species A or Species B on alder/cottonseed hulls, with no additional supplementation, showed weak growth. Inclusion of amendments and surfactants greatly increased growth of both species, but only supported 9% (± 2%) and 25% (± 10%) PCP removal for the two species, respectively. In contrast, when fungal-colonized cotton gin trash was used as an inoculum (with surfactant and additional amendment), PCP removal efficiencies were increased to 45% (± 15%) for Species A and 53% (± 17%) for Species B.

In no case were PCA levels greater than 12 ppm observed in any of the treatments (Figure 3). Thus, either PCP degradation in these cultures did not involve production of significant amounts of PCA, or any PCA which was produced was rapidly degraded. Again, this is not surprising, as *Phanerochaete* species, which we observe to be most prone to producing PCA, were, due to their poor growth in the site materials, not used in this study.

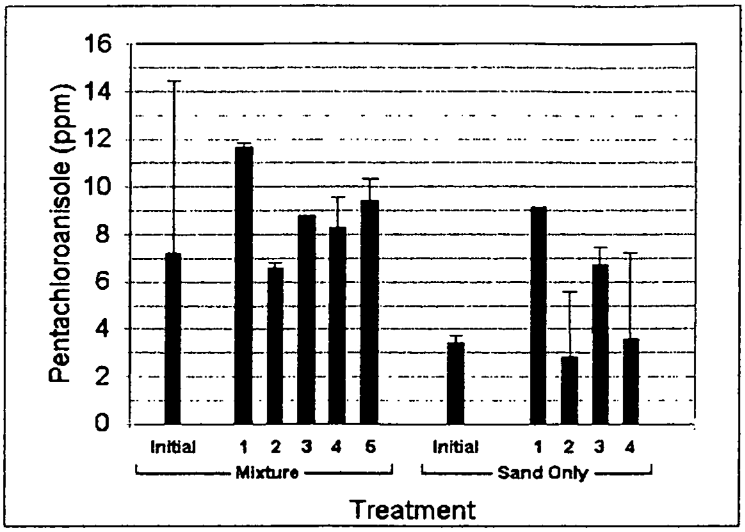
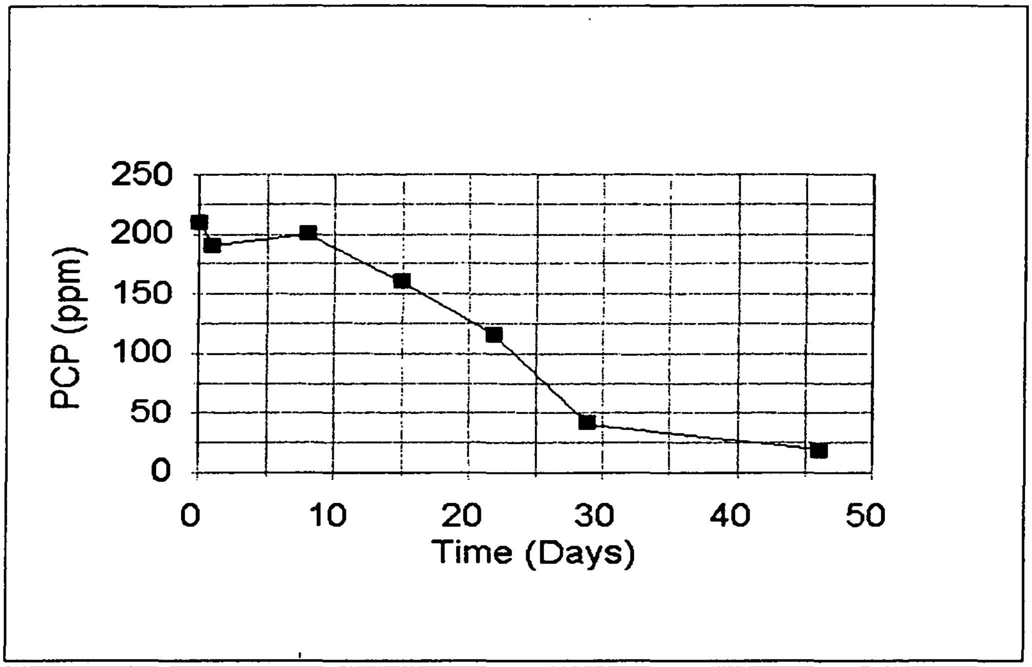


Figure 3 - Levels of pentachloroanisole (PCA) produced in cultures containing the mixture of sand and soil/chips. Treatment numbers correspond to those in Figures 1 (mixture cultures) and 2 (sand-only cultures).

Two published (8, 10) curves for the kinetics of PCP degradation during longer-term treatment with WRF are shown in Figure 4. Although much of the PCP removal in these cases did take place within the first 3 weeks, it is clear that removal continues, at very significant rates, for 8 weeks or longer. Indeed, both the Brookhaven field treatability study (10), and the Murphreesboro, NC site remediation by EarthFax Engineering demonstrated that measurable degradation of PCP continues for a year or more. WRF were recoverable by selective plating from Brookhaven soil 10-12 months after conclusion of the field treatability study. We would predict, based on the extents of PCP removal which we observed in 23-day cultures in this study, that WRF treatment of the materials at the Penta site could, for example, likely reach the EPA Region 3 industrial-site cleanup standards (48 ppm PCP) in approximately 15-20 weeks for the case of the 4:1 mix (assuming a uniform 1800 ppm PCP as a starting point), and 5-6 weeks in the case of the sand alone (again, assuming a uniform 400-500 ppm initial concentration). For example, it should be noted that the 143 ppm PCP remaining in the best sand-only cultures after 23 days ss very close to the level present in the soils in the Oshkosh, WI, field treatability study after a similar length of time, and the aforementioned cleanup standard was reached in just over 4 weeks in that project. Given that, particularly in the case of the soil/chip material, the samples used in this study were stated to have come from an unusually highly-contaminated "hotspot" within this layer, it is very possible that these time frames can be significantly reduced through judicious mixing of materials from various sections of the site prior to initiation of treatment.



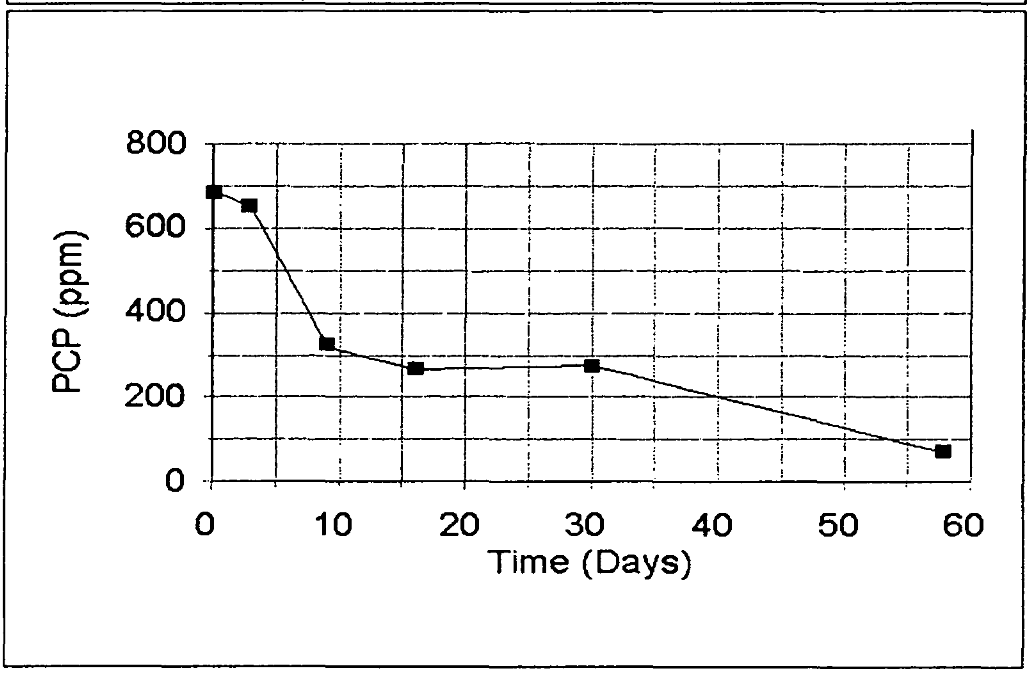


Figure 4 - Published time-courses of PCP degradation in field applications of WRF. Upper graph is from the Oshkosh, WI field treatability study (8), whereas the lower graph is from the field treatability study conducted at Brookhaven, MS (10).

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Attachment F-2

Bioventing Treatability Study Initial Memorandum

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April 3, 1998

Mr. Ken Glatz
Work Assignment Manager
U.S. Environmental Protection Agency
Remedial Response Branch (SR-6J)
77 West Jackson Boulevard
Chicago, IL 60604-3590

Dear Ken:

Subject: Bioventing Treatability Study Technical Memorandums
Penta Wood Products Site
Town of Daniels, Wisconsin
Work Assignment No. 001-RICO-05WE
Contract No. 68-W6-0025

Enclosed please find the Bioventing Column Study Technical Memorandum and the In Situ Field Bioventing Treatability Technical Memorandum that describe the setup and present the initial results of the two treatability studies. Please call me if you have any questions or concerns.

Sincerely,

CH2M HILL

Regina Bayer

Regina Bayer

Site Manager

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Bioventing Column Study Technical Memorandum

1 Introduction

This memorandum describes the implementation, start-up, initial operation, and the preliminary results of the bioventing column study. These activities are fully described in the Treatability Study Work Plan (TS Work Plan) dated September 10, 1997, for the Penta Wood Products Superfund Site in Town of Daniels, Wisconsin. This memorandum discusses the purpose and scope of the bioventing column study, the activities that occurred, the data collected and the preliminary results.

2 Purpose and Scope

As described in the TS Work Plan, the purpose of the bioventing column study is to investigate the feasibility for the degradation of pentachlorophenol (PCP) under simulated in situ soil bioventing conditions. The collected data will provide information to aid in the preparation of the Feasibility Study (FS).

According to the TS Work Plan the four bioventing columns were to be set up as follows:

1. Contaminated soil with PCP concentrations ranging from 100 - 200 mg/kg which will not be aerated (to simulate anaerobic conditions and serve as an experimental control column)
2. Contaminated soil with PCP concentrations ranging from 100 - 200 mg/kg which will be aerated
3. Contaminated soil with PCP concentrations ranging from 700 - 1000 mg/kg which will be aerated
4. Contaminated wood debris with PCP concentrations ranging from 700 - 1000 mg/kg which will be aerated

The scope of the column study consists of the implementation and operation of bioventing columns for six months. Implementation includes setting up the four soil columns, collecting initial soil/wood debris samples, starting the bioventing activities, and collecting initial air samples from the column off gas. Operation includes measurement of the in situ oxygen concentrations, measurement of the soil off gas oxygen concentrations, and measurement of the air flow rates. Soil sample collection occurs prior to start up, after 2 months of operation, and after 6 months of operation for direct measurement of PCP reduction.

3 Activities

3.1 Soil Sample Selection

Prior to set up of the bioventing columns, soil samples were collected from soil gas wells at the Penta Wood site to establish initial contaminant and soil parameter conditions. Results from these samples determined which soil samples would be used for the bioventing column study. The following table summarizes the samples selected for the column study and the initial PCP concentrations of those samples:

Sample Number	Sample Collection Date	Sample Interval (feet)	PCP Concentration (mg/kg)	Column Number
EW1CS	1/22/98	1-10	384	1 and 2
SG8CS	1/28/98	10-15	707	3
SG9CS	1/27/98	1-10	5,460	4

3.2 Column Set up

3.2.1 Column Preparation

Preparation of the columns included purchasing and modifying four clear acrylic columns. The 6 inch diameter by 16 inch high columns were purchased with the following features: two rubber gaskets to provide an air tight seal on the top and bottom ends, four 16 inch screws with washers and nuts used to tighten the top and bottom ends to the column, an air inlet at the center of the top end of the column, an air outlet halfway between the center and the side of the top end of the column, and a pressure release valve at the top end of the column.

The columns were modified as follows:

- one air inlet was installed in the center of the bottom ends of the three aerobic columns for aeration purposes
- one plug was installed in the air outlet in the top end of the anaerobic column to form an airtight seal
- one oxygen sensor was installed in an air inlet or outlet in the top end of each of the four columns to measure the in situ oxygen concentration

3.2.2 Initial Soil Sample Collection

Initial soil samples were collected after modifying the columns. Triplicate soil/wood debris samples were collected from the three 5 gallon buckets filled with the samples previously discussed in Section 3.1. The soil/wood debris from the 5 gallon buckets were mixed to homogenize the sample prior to sub-samples collection. Triplicate samples were collected to assess any variation in the PCP concentrations across the sample. The samples were collected with decontaminated equipment and analyzed for PCP, diesel-range organics (DRO), moisture, pH, and chloride. The samples were prepared and shipped following

EPA-approved guidelines and chain-of-custody procedures (Sampling and Analysis Plan, Revision 1, November 1997).

3.2.3 Column Set up

Column set up included the following steps:

- filling the columns with the contaminated soil/wood debris (as described in Section 3.1)
- adding an air diffuser system (pea gravel) at the base of the three aerated columns to distribute the air evenly throughout the column
- purging the anaerobic column with nitrogen to obtain anaerobic conditions
- sealing the anaerobic column to maintain anaerobic conditions
- connecting a humidified air source to the three aerobic columns
- setting up a compressed air cylinder to provide the air source to the aerobic columns

3.3 Start up of Bioventing System

Start-up of the bioventing columns included: turning the air on, measuring initial oxygen depletion, adjusting the air flow rate to each column to provide adequate in situ oxygen concentrations, and collecting two 7-day composite air samples from the soil off gas from columns 3 and 4.

The oxygen depletion was recorded by measuring the in situ oxygen concentration with the air on, turning the air off for 24 hours and measuring the resulting in situ oxygen concentration. This was done primarily to determine if oxygen depletion was occurring and to determine the relative oxygen use between each column. The column air flow rates were then adjusted accordingly, the greater the oxygen depletion the higher the required air flow rate to maintain aerobic conditions.

The air samples were collected to assess the potential for PCP volatilization (as opposed to biological degradation) and measure the rate of volatilization if it does occur. The air samples were collected in XAD tubes and were analyzed for PCP and DRO.

3.4 Summary of Activities

A summary of the activities are presented below.

Date	Activity
February 11, 1998	Initial soil samples collected. Bioventing column system started at 4:00 p.m.
February 11, 1998	Bioventing column system turned off at 5:25 p.m. to conduct first oxygen uptake study.
February 11 - 12, 1998	First oxygen uptake study conducted.
February 12, 1998	Bioventing column system turned on at 5:45 p.m.
February 16 -23, 1998	7-day composite off gas air samples collected.
February 12 - March, 1998	Operation of bioventing column system.

4 Preliminary Results

Preliminary results for the initial soil/wood debris samples, oxygen depletion and air flow measurements, and air samples from the bioventing column off gas are presented in the tables attached (Tables 1, 2, and 3). A discussion of the results follows.

4.1 Initial Soil/Wood Debris Sample Results

Table 1 presents analytical results for the initial soil/wood debris. The results present initial concentrations of PCP, DRO, moisture, pH, and chloride before the start of the bioventing system. Additional soil/wood debris samples will be collected from the four columns after 2- and 6-months to determine direct measurement of PCP and DRO reduction.

The other parameters (moisture, pH, and chloride) will be used to quantify aerobic degradation reduction. Moisture and pH are measured because optimum conditions for aerobic degradation to occur are dependent on pH and moisture. Chloride is measured because it is a degradation product of PCP.

The results of the triplicate samples show that there is some variability within each soil/wood debris sample used to fill the columns. The samples which will be collected at 2- and 6-months will be a composite from the entire column in an effort to provide a representative sample to compare degradation results. The 2- and 6-month results will be compared against the averages of the results obtained from the initial samples as shown in Table 1.

4.2 Oxygen Depletion and Air Flow Rates

The initial 24 hour oxygen depletion rate and air flow rates required to maintain aerobic conditions in Columns 2, 3 and 4 are shown in Table 2. Column 1 has maintained in situ oxygen concentrations of zero which reveals the column is completely sealed and maintaining anaerobic conditions.

4.3 Air Samples

The air sample results, shown on Table 3, indicate the petroleum products (as shown by the DRO measurements) appear to be volatilizing, but the PCP does not appear to be volatilizing at detectable levels.

Table 1

February 11, 1998 Soil/Wood Debris Analytical Data

Column	Sample	Sample Date	PCP (mg/kg)	DRO (mg/kg)	moisture (%)	pH	Chloride (mg/kg)
1 and 2	1	2/11/98	95	1,000	8.3	5.71	20.3
1 and 2	2	2/11/98	150	1,600	8.1	5.75	15.1
1 and 2	3	2/11/98	130	880	8.7	5.84	15.9
Average			125	1,160	8.4		17.1
3	1	2/11/98	450	12,000	5.5	4.63	8.85
3	2	2/11/98	450	12,000	6.2	4.63	8.52
3	3	2/11/98	560	8,400	5.5	4.70	8.35
Average			487	10,800	5.7		8.57
4	1	2/11/98	1,100	43,000	51.6	4.27	75
4	2	2/11/98	930	39,000	52.6	4.23	103
4	3	2/11/98	760	9,300	44.8	4.38	53.3
Average			930	30,433	49.7		77.1

Note: Columns 1 and 2 contain the same soil. Column 1 is set up to maintain anaerobic conditions and Column 2 is set up to maintain aerobic conditions.

Table 2

Initial Oxygen Depletion and Air Flow Rate Data

Column	Sample Dates	Initial (2/11) In Situ Oxygen Conc. (% O_2)	Depleted (2/12) In Situ Oxygen Conc. (%O_2)	(2/12) Air Flow Rate (ml/min)	(2/16) In Situ Oxygen Conc. (%O_2)	(2/16) Adjusted Air Flow Rate (ml/min)	(2/19) In Situ Oxygen Conc. (%O_2)
2	2/11-2/19	20.0	19.2	14.3	13.0	15.2	19.0
3	2/11-2/19	21.0	19.0	5.2	16.5	16.3	20.0
4	2/11-2/19	20.5	14.1	12.7	18.0	20.6	19.0

The air flow rate was adjusted on 2/16 to increase the in situ oxygen concentrations to between 19 and 20 % oxygen.

Table 3

Air Sample Data

Column	Sample Tube[1]	Sample Dates	Time (hrs)	Air Flow Rate (ml/min)	Total Air Flow (L)	Total PCP (µg)	PCP Concentration (ug/L)	Total DRO (µg)	DRO Concentration (µg/L)
3	1a	2/16-2/23				<2		21,700	
3	1b	2/16-2/23				<2		4,150	
3	2a	2/16-2/23				<2		4,140	
3	2b	2/16-2/23				<2		1,690	
Total			167	13.5	135	<2	NA	31,680	234
4	1a	2/16-2/23				<2		12,300	
4	1b	2/16-2/23				<2		1,830	
4	2a	2/16-2/23				<2		2,270	
4	2b	2/16-2/23				<2		663	
Total			167	16.6	166	<2	NA	17,063	103

[1] There were two XAD tubes placed in series on each of the two columns. Each tube has two portions (a and b).

In Situ Field Bioventing Treatability Study Technical Memorandum

1 Introduction

This memorandum describes the implementation, start-up, initial operation, and the preliminary results of the onsite in situ bioventing system, which is fully described in the Treatability Study Work Plan (TS Work Plan) dated September 10, 1997, at the Penta Wood Products Superfund Site in Town of Daniels, Wisconsin. This memorandum discusses the purpose and scope of the field bioventing study, the field activities that occurred, the data collected, and presents the preliminary results.

2 Purpose and Scope

As described in the TS Work Plan, the purpose of the in-situ bioventing study is to obtain site-specific data relating to the feasibility of using bioventing for the treatment of PCP-contaminated soils. The collected data will provide information to aid in the preparation of the Feasibility Study (FS).

The scope of the treatability study consists of the implementation and operation of the bioventing system for six months. Implementation included the installation of a new 6-inch extraction/bioventing well identified as EW-1, the installation of three nests of three soil gas wells each identified as SG-1 through SG-9, the placement of the bioventing building over EW-1, the connection of the blower to EW-1, and the hook-up of electrical power.

Operation includes the measurement of initial subsurface soil gas composition, start-up of the bioventing system, the conduction of an initial soil gas permeability test to provide data to determine the radius of influence, and the conduction of several oxygen uptake studies to provide data to determine degradation rates. In addition, soil from 6 of the nine soil gas wells were collected from the bottom of each well and analyzed for PCP, TPH, diesel-range organics (DRO), total organic carbon (TOC), moisture, pH, and chloride before system start-up. The soil will also be collected and analyzed after 3 months of operation and after 6 months for direct measurement of PCP reduction.

3 Field Activities

3.1 Personnel

The bioventing system was leased from Carbonair Environmental Services of New Hope, Minnesota. Electrical work was performed by ALDEN Electric of Siren, Wisconsin. The extraction/bioventing well EW-1 and the nine soil gas wells (SG-1 through SG-9) were installed by Boart Longyear of Minnesota. Implementation, start-up, and operation of the system was performed by Dave Shekoski and Erik White of CH2M HILL.

3.2 Location

EW-1 is located in the former gully area approximately 150 feet south of the oil-water separator building. SG-1 through SG-9 are located in three nests of three wells each at distances of 25, 50, and 100 feet away from EW-1. The depths of the soil gas wells in each nest are 5- 40-, and 80 feet below ground surface (bgs).

3.3 Installation

A 8-1/4-inch diameter hollow stem auger was used to drill the first 100 feet of EW-1. A rotosonic rig was used to complete EW-1 to a total depth of 125 feet bgs. A 6-inch diameter well screened the entire depth with stainless steel slotted screen was used for EW-1. A 4-1/4-inch hollow stem auger was used to drill the nine soil gas wells. They were completed with 2-inch diameter schedule 80 PVC with 2 feet of 10-slot screen. Additional boring and well construction detail log data are included in the Remedial Investigation (RI) report.

3.4 Soil Sampling

Soil samples were collected from the borings from soil gas wells SG-1, 2, 4, 5, 7, and 8 to establish initial contaminant and soil parameter conditions for the bioventing study. Soil from the cuttings were first placed in a 5-gallon bucket. After the soil in the bucket was thoroughly mixed, a sub-sample was collected from the bucket. After sampling, most of the contents of the bucket were poured back down the borehole immediately below the bottom of the well screen.

Samples were collected with decontaminated equipment. Samples were analyzed for PCP, TPH, DRO, TOC, moisture, pH, and chloride. Samples were prepared and shipped following EPA-approved guidelines and chain-of-custody procedures (Sampling and Analysis Plan, Revision 1, November 1997).

3.5 Summary of Activities

A summary of the activities are presented below.

Date	Activity
January 23 - 30, 1998	Extraction/bioventing well EW-1 installed.
February 4, 1998	Installation of soil gas wells SG-1 through SG-9 completed. Soil collected from SG-1, 2, 4, 5, 7, and 8 for initial concentrations.
February 4, 1998	Building housing bioventing system arrives on-site. Building placed over extraction/bioventing well EW-1.
February 5, 1998	Electrical power connected to bioventing system.
February 5 - 8, 1998	Blower system tested without connection to extraction/bioventing well EW-1.
February 7, 1998	Initial subsurface soil gas composition measured.
February 8, 1998	Blower connected to extraction/bioventing well EW-1. Bioventing system started at 10:00 a.m.
February 8 -9, 1998	Soil gas permeability test conducted.
February 10, 1998	Bioventing system turned off at 12:00 p.m. to conduct baseline oxygen uptake study.
February 10 - 11, 1998	Baseline oxygen uptake study conducted.
February 11, 1998	Bioventing system turned on at 12:40 p.m. for continuation of test.
February 11 - 24, 1998	Operation of bioventing system.
February 24, 1998	Bioventing system turned off at 9:30 a.m. to conduct first oxygen uptake study.
February 24 - 27, 1998	First oxygen uptake study conducted.
February 27, 1998	Bioventing system turned on at 9:30 a.m. for continuation of test.
February 27 - March, 1998	Operation of bioventing system.

4 Preliminary Results

Preliminary results for the initial subsurface soil gas composition conditions, soil gas permeability test, initial soil gas composition at the start of the oxygen uptake studies, two oxygen uptake studies (baseline and February test), and initial soil concentrations for PCP, TPH, DRO, TOC, moisture, pH, and chloride from the bottom of the six soil gas wells (SG-1, 2, 4, 5, 7, and 8) are presented in the tables attached (Tables 1, 2, 3, 4, 5, and 6). A discussion of the results follows.

4.1 Soil Gas Composition Initial Conditions

As shown on Table 1, most of the oxygen levels are below 5 percent oxygen while most of the carbon dioxide levels are above 10 percent. Initial low oxygen levels coupled with measurable carbon dioxide levels indicate that an oxygen limiting environment exists. Under such an environment, the enhancement of aerobic degradation may increase degradation rates.

4.2 System Influence

Data collected for the soil gas permeability test are shown on Table 2. All soil gas well points showed measurable levels of soil gas pressure. This data will be used to calculate the pressure radius of influence. The pressure radius of influence will be used to determine the spacing of the bioventing wells for the full-scale system.

4.3 Oxygen Uptake Studies

The object of bioventing is to induce air flow through the vadose-zone soil to promote aerobic degradation, a process whereby microbes use oxygen as an electron acceptor to degrade the PCP-TPH mixture.

To determine if oxygen is being inducted into the subsurface, methane, carbon dioxide, and oxygen are measured while the system is running. A decrease in both methane and carbon dioxide and an increase in oxygen versus time indicate that ambient air, which contains low carbon dioxide and no methane, is reaching the subsurface zone and air exchanges are occurring. The data collected at the start of the oxygen uptake studies show that this phenomenon is occurring in all of the soil gas points (Table 3).

Oxygen uptake study results which were measured with the system turned off, are shown in Tables 4 and 5. As shown, oxygen, carbon dioxide, methane, and VOCs were measured at each point during the study. The depletion of oxygen versus time in conjunction with the increase in carbon dioxide with the system turned off indicates that aerobic degradation is occurring. The microbes use oxygen as an electron acceptor, and respire carbon dioxide. As shown on Tables 4 and 5, oxygen is depleting at a slow rate while carbon dioxide is increasing.

Methane was measured because it is usually present in oxygen-limiting environments where there are high sources of carbon (PCP-TPH mixture). Oxygen is the preferred electron acceptor, but in its absence nitrate, iron (III), and sulfate (in that order) are used as electron acceptors for the anaerobic degradation of the PCP-TPH mixture. In the absence of the latter three, then anaerobic degradation via the conversion of carbon dioxide to methane would occur. As indicated on Tables 4 and 5, essentially no methane was measured in the soil gas wells.

Volatile organic carbon compounds, or VOCs, were also measured with a photo-ionization detector (PID). Measurable VOCs are the more volatile and readily degradable portions of the TPH in the soil. As indicated on Tables 4 and 5, detectable levels of VOCs were measured in several soil gas wells.

4.4 Soil Sampling

Table 6 presents analytical results for soil collected from the bottom of 6 of the 9 soil gas wells. The results present initial concentrations of PCP, TPH, DRO, TOC, moisture, pH, and chloride before the start of the bioventing system. Additional soil will be collected from the same 6 soil gas wells after 3- and 6-months to determine direct measurement of PCP and TPH reduction.

The other parameters (DRO, TOC, moisture, pH, and chloride) will be used to quantify aerobic degradation reduction. The results of DRO and TOC are used to determine how much of the shorter and more readily degradable portions of the TPH would be degraded. Moisture and pH are measured because optimum conditions for aerobic degradation to occur are dependent on pH and moisture. Finally, chloride is measured because it is a degradation product of PCP.

Table 1

Initial Subsurface Soil Gas Data

Well	$\%CO_2$	$\%O_2$	% Methane (CH_4)	VOCs (ppm)
SG-1	10.4	2.6	0.1	2
SG-2	12.0	4.6	0	0.0
SG-3	14.9	1.7	0	0.0
SG-4	5.4	13.3	0	0.0
SG-5	11.5	6.42	0	0.0
SG-6	15.7	1.1	0	0.0
SG-7	11.5	2.6	0.1	1.6
SG-8	12.6	4.2	0.1	See Note 3
SG-9	15.1	0.9	0.0	0.0

Notes:
1. $\%CO_2$, $\%O_2$, and $\%CH_4$ measured with Land-Tec GA-90 soil gas analyzer.
2. VOC's measured with Multi-Rae photoioniation dector (PID).
3. Multi-rae detector ceased to operate due to low battery.

Table 2

Soil Gas Permeability Data

Date	Time	Flow (1)		P Well (1)	Temp (1)	Soil Gas Pressure Measurements ("H_2O)								
		H_2O	Scfm	"H_2O	°F	SG-1 (5' bgs)	SG-2 (40' bgs)	SG-3 (80' bgs)	SG-4 (5' bgs)	SG-5 (40' bgs)	SG-6 (80' bgs)	SG-7 (5' bgs)	SG-8 (40' bgs)	SG-9 (80' bgs)
2/8/98	1335	0.5	158	1	100	.12	.47	.46	.15	.32	.36	.08	.21	.23
2/8/98	1505	1	224	2	100	.08	.54	.51	.10	.28	.31	.02	.13	.16
2/8/98	1700	1	224	2	100	.09	.54	.54	.09	.28	.29	.03	.10	.13
2/9/98	0740	1	227	0	85	.09	.62	.55	.10	.30	.32	.04	.12	.12
2/9/98	1225	3	397	5	80	.22	>1.0	>1.0	.26	.69	.72	.12	.35	.40
2/9/98	1750	3	397	4	80	.16	>1.0	>1.0	.16	.54	.55	.05	.20	.23
2/10/08	1200	5	522	7	64	.25	>1.0	>1.0	.30	.87	.88	.11	.37	.45
2/11/98	1420	5	517	6.5	73	.38	>1.0	>1.0	.36	.98	>1.0	.17	.45	.56
2/24/98	0850	4.9	506	1	77	.35	1.40	1.10	.14	.86	.87	.16	.38	.42
2/27/98	1115	9	511	1	79	.46	1.65	1.30	.32	1.0	1.0	.36	.55	.64

Notes:

1. Air flow, pressure, and temperature measured at inlet of bioventing well at point of injection.

Table 3

Soil Gas Data at Start of Oxygen Uptake Studies

Well	Date	Time	Hours	%C0$_2$	%0$_2$	% methane (CH$_4$)	VOCs (ppm)
February 10 - 11 Baseline Oxygen Uptake Study Data							
SG-2	2/10/98	1200	0	0.5	20.9	0.0	0.0
SG-3			0	0.0	21.1	0.0	0.0
SG-5			0	1.6	20.5	0.0	0.0
SG-6			0	0.4	21.0	0.0	0.0
SG-9			0	11.1	11.4	0.0	0.5
February 24 - 27 Oxygen Uptake Study Data							
SG-1	2/24/98	0915	0	1.9	15.8	0.0	2.9
SG-2	2/24/98	0916	0	0.1	20.6	0.0	0.0
SG-3	2/24/98	0919	0	0.0	20.5	0.0	0.1
SG-4	2/24/98	0922	0	3.9	16.5	0.0	0.5
SG-5	2/24/98	0924	0	0.1	20.5	0.0	0.1
SG-6	2/24/98	0927	0	0.0	20.5	0.0	0.0
SG-8	2/24/98	0934	0	0.6	20.1	0.0	1.8
SG-9	2/24/98	0937	0	0.2	20.4	0.0	1.5

Notes:

1. %C0$_2$, %0$_2$, and %CH$_4$ measured with Land-Tec GA-90 soil gas analyzer.
2. VOC's measured with Multi-Rae photoioniation dector (PID).
3. Oxygen uptake studies were not conducted in soil gas wells SG-1, 4, 7, and 8 for the baseline study and in SG-7 for the February 24 -27 study because intial oxygen levels were below testable levels.

Table 4

February 10 - 11
Baseline Oxygen Uptake Study Data

Well	Date	Time	Hours	%CO_2	%O_2	% methane (CH_4)	VOCs (ppm)
SG-2	2/10/98	1200	0	0.5	20.9	0.0	0.0
	2/10/98	1413	2	0.5	20.7	0.0	0.0
	2/10/98	1708	5	0.7	20.2	0.1	1.6
	2/10/98	2010	8	0.7	20.1	0.0	2.0
	2/11/98	0715	19	0.9	21.0	0.0	0.0
	2/11/98	1208	24	1.1	20.0	0.0	See Note 3
SG-3			0	0.0	21.1	0.0	0.0
	2/10/98	1420	2	0.0	20.9	0.0	0.0
	2/10/98	1713	5	0.0	20.6	0.0	2.2
	2/10/98	2015	8	0.1	20.2	0.0	2.5
	2/11/98	0721	19	0.0	21.4	0.0	0.0
	2/11/98	1217	24	0.1	20.5	0.1	See Note 3
SG-5			0	1.6	20.5	0.0	0.0
	2/10/98	1425	2	2.1	20.1	0.0	0.5
	2/10/98	1720	5	2.1	19.8	0.1	2.0
	2/10/98	2020	8	1.7	19.8	0.0	2.3
	2/11/98	0727	19	2.4	20.2	0.0	0.0
	2/11/98	1224	24	2.6	19.4	0.1	See Note 3
SG-6			0	0.4	21.0	0.0	0.0
	2/10/98	1435	2	0.5	20.8	0.0	0.0
	2/10/98	1728	5	0.6	20.4	0.0	2.5
	2/10/98	2025	8	0.5	20.3	0.1	2.1
	2/11/98	0732	19	0.9	21.0	0.0	0.0
	2/11/98	1230	24	1.0	20.2	0.1	See Note 3
SG-9			0	11.1	11.4	0.0	0.5
	2/10/98	1445	2	10.9	11.8	0.0	1.8
	2/10/98	1735	5	8.8	13.6	0.1	2.7
	2/10/98	2030	8	9.1	13.4	0.1	2.7
	2/11/98	0741	19	10.6	12.9	0.1	1.1
	2/11/98	1236	24	10.7	12.4	0.0	See Note 3

Notes:
1. %CO_2, %O_2, and %CH_4 measured with Land-Tec GA-90 soil gas analyzer.
2. VOC's measured with Multi-Rae photoioniation dector (PID).
3. Multi-rae meter not available because already shipped off-site before end of test.
4. Oxygen uptake studies were not conducted in soil gas wells SG-1, 4, 7, and 8 because intial oxygen levels were below testable levels.

Table 5

February 24 - 27
Oxygen Uptake Study Data

Well	Date	Time	Hours	$\%CO_2$	$\%O_2$	% methane (CH_4)	VOCs (ppm)
SG-1	2/24/98	0915	0	1.9	15.8	0.0	2.9
	2/25/98	0918	24	2.4	12.2	0.0	1.7
	2/26/98	0954	48	2.3	10.7	0.0	0.3
	2/27/98	0737	72	3.2	5.7	0.0	8.0
SG-2	2/24/98	0916	0	0.1	20.6	0.0	0.0
	2/25/98	0930	24	0.2	20.7	0.0	1.2
	2/26/98	1014	48	0.2	20.4	0.0	1.8
	2/27/98	0750	72	0.3	20.3	0.0	0.0
SG-3	2/24/98	0919	0	0.0	20.5	0.0	0.1
	2/25/98	0953	24	0.1	21.0	0.0	1.0
	2/26/98	1036	48	0.1	20.6	0.0	1.1
	2/27/98	0813	72	0.1	20.5	0.0	0.3
SG-4	2/24/98	0922	0	3.9	16.5	0.0	0.5
	2/25/98	1000	24	2.8	18.5	0.0	1.1
	2/26/98	1041	48	2.6	18.3	0.0	0.8
	2/27/98	0822	72	3.6	16.8	0.0	2.1
SG-5	2/24/98	0924	0	0.1	20.5	0.0	0.1
	2/25/98	1012	24	0.3	20.8	0.0	0.6
	2/26/98	1051	48	0.4	20.3	0.0	0.9
	2/27/98	0833	72	0.5	20.2	0.0	0.3
SG-6	2/24/98	0927	0	0.0	20.5	0.0	0.0
	2/25/98	1033	24	0.2	20.9	0.0	3.0
	2/26/98	1120	48	0.2	20.4	0.0	1.4
	2/27/98	0853	72	0.3	20.1	0.0	0.5
SG-8	2/24/98	0934	0	0.6	20.1	0.0	1.8
	2/25/98	1047	24	0.9	20.5	0.0	4.0*
	2/26/98	1136	48	0.8	20.1	0.0	2.5
	2/27/98	0903	72	1.0	19.9	0.0	0.9
SG-9	2/24/98	0937	0	0.2	20.4	0.0	1.5
	2/25/98	1107	24	0.3	20.9	0.0	7.7*
	2/26/98	1154	48	0.3	20.5-6	0.0	5.6*
	2/27/98	0924	72	0.4	20.4	0.0	4.1

Notes:
1. $\%CO_2$, $\%O_2$, and $\%CH_4$ measured with Land-Tec GA-90 soil gas analyzer.
2. VOC's measured with Multi-Rae photoioniation dector (PID).
3. Oxygen uptake study was not conducted in soil gas well SG-7 because intial oxygen levels were below testable levels.

Table 6

Initial Soil Data

Well	Depth (feet bgs)	PCP (ppm)	TPH (ppm)	DRO (ppm)	TOC (ppm)	moisture (%)	pH	Chloride (ppm)
SG-1	5	1,290	15,100	18,000	644	22.7	4.83	25.1
SG-2	40	179	3,430	1,000	107	7.4	6.57	<5.4
SG-4	5	157	3,670	1,100	299	7.6	5.31	8.1
SG-5	40	155	7,010	1,900	144	6.5	5.88	10.0
SG-7	5	973	11,800	19,000	644	41.1	4.94	18.6
SG-8	40	317	4,450	7,300	229	4.4	6.81	10.2

Attachment F-3

Pore Modeling

LNAPL Area
Contaminant Reduction Per Pore Volume Exchange
Pent Wood Products NPL Site

Aquifer Volume (gal)	15,000,000
Soil density(gr/cm3)- p	1.7
Effective Porosity- ne	0.407
TOC (1000ppm=.001)	0.0004

		PCP
Koc site-specific		1500
Kd (ml/gr.) = Koc * TOC		0.6
R=1+ p(Kd/ne)		3.51
Drinking Water MCL (ug/l)		1
Drinking Water PAL (ug/l)		0.1
Cw initial (ug/l)		30,000
Cw @ PV1		21,444
Cw @ PV2		15,328
Cw @ PV3		10,956
Cw @ PV4		7,831
Cw @ PV5		5,598
Cw @ PV6		4,001
Cw @ PV7		2,860
Cw @ PV8		2,044
Cw @ PV9		1,461
Cw @ PV10		1,044
Cw @ PV11		747
Cw @ PV12		534
Cw @ PV13		**381**
Cw @ PV35		0.90
Cw @ PV38		0.09
Time to Achieve PRGs-No Degradation & No Source Loading		
Pore Volumes to achieve MCL		31
Pore Volumes to achieve PAL		38
Alternative 1- No Action		
Aquifer flow rate (gpm)	3	
Years to achieve MCL-		295
Years to achieve PAL-		361
Alternative 3- Groundwater Collection and Treatment		
Aquifer flow rate (gpm)	75	
PVs after 5 Years		13
Concentration after 5 years- ug/l		381
Alternative 3b- Groundwater Collection and Treatment		
Groundwater extraction flow rate (gpm)	75	
Years to achieve MCL		12
Years to achieve PAL		14

Note:Cw=C(in previous PV)/((1/R-1))+1) or Cw=Co * exp((-LN(R/R-1))) * PV)

Attachment F-4

Groundwater Photolysis Treatability Study Results

Photo-Oxidation Study
Immunoassay PCP Results

	Cell #1 1"	Sample ID	Cell #2 3"	Sample ID	Cell #3 3" Methylene Blue	Sample ID	Cell #4 6"	Sample ID	Comments
4/7/98 0745	60.0	Photox 1	60.0	Photox 1	69.2	Photox 2	60.0	Photox 1	cloudy
4/7/98 1200	57.9	Photox 3	48.5	Photox 4	40.5	Photox 5	81.3	Photox 6	cloudy
4/7/98 1800	38.4	Photox 7	40.5	Photox 8	27.8	Photox 9	32.7	Photox 10	cloudy
4/8/98 0800	49.3	Photox 11	56.9	Photox 12	38.4	Photox 13	87.3	Photox 14	cloudy
4/8/98 1200	41.3	Photox 15	74.3	Photox 16	30.9	Photox 17	60.0/43.6	Photox 18/18DUP	cloudy
4/8/98 1800	11.1	Photox 19	24.5	Photox 20	16.3	Photox 21	36.6	Photox 22	cloudy
4/9/98 0800	13.4	Photox 23	24.5	Photox 24	15.6	Photox 25	31.2	Photox 26	sunny
4/9/98 1200	6.2	Photox 27	31.5	Photox 28	16.7	Photox 29	40.1	Photox 30	sunny
4/9/98 1400	8.0	Photox 31	28.1/31.9	Photox 32/32DUP	12.9	Photox 33	61.9	Photox 34	sunny

All Results in parts per million (ppm)

Appendix G
Cost Estimates

Penta Wood Products **Daniels, WI**
Remedial Alternatives Costing
Order of Magnitude Comparative Cost Estimate
Project No. 141158.RE.01 Jun-98

Remedial Alternative S2: Soil Cover and Natural Attenuation

Component Description	Quantity		Unit Price	Component Cost	Category Subtotal	NPV
			CAPITAL COSTS			
CONSTRUCTION COSTS						
Mobilization/Demobilization	1	LS	$10,000	$10,000	$10,000	
Building Demolition						
Former Treatment Building (corrugated metal with concrete floor)						
Asbestos Removal/Disposal	1	LS	$10,000	$10,000		
Remove Metal Building (100 ft x 80 ft x 15 ft)	1	LS	$20,000	$20,000		
Remove Steel Smokestack (100 ft high x 12" diameter)	1	LS	$7,500	$7,500		
Solid Waste Disposal	1000	TON	$30	$30,000		
Composite Sampling - Concrete Floor	5	EA	$200	$1,000		
Concrete Floor Removal/Recycling	600	TON	$21	$12,600		
Oil/Water Separator Building (corrugated metal with dirt floor)						
Remove Metal Building (30 ft x 40 ft x 10 ft)	1	LS	$10,000	$10,000		
Solid Waste Disposal	20	TON	$30	$600	$91,700	
Consolidate Soil/Sediment Contamination						
Clear, Grub, and Chip Trees	18	ACRE	$3,500	$63,000		
Excavate/Relocate Soil - Dry 1 ft deep	40000	CY	$3.50	$140,000		
Excavate/Relocate Soil - Wet 2 ft deep	3000	CY	$8.75	$26,250		
Perform Confirmation Sampling	175	EA	$220	$38,500	$267,750	
Construct Soil Cover - 7 acres						
Vegetation Layer (6-inches thick)	5680	CY	$12	$68,160		
Relocate Sand 6"	5680	CY	$3.50	$19,880	$88,040	
Restore Site						
Regrade using Onsite Sand	58	ACRE	$750	$43,500		
Seed	80	ACRE	$1,200	$96,000	$139,500	
Implement Erosion Control Measures						
Construct Drainage Ditches/Check Dams	1	LS	$75,000	$75,000		
Install Detention/Infiltration Basins	3	EA	$15,000	$45,000		
Repair Lagoon Dam	1	LS	$100,000	$100,000	$220,000	
Dismantle Biopad						
Decon/Breakup Biopad	1	LS	$50,000.00	$50,000		
Move Concrete to Cover Area	5585	CY	$3.50	$19,548	$69,548	
Construction Labor	880	HR	$32	$28,160	$28,160	
Construction Subtotal					$914,698	
Scope and Bid Contingency @ 25%					$228,674	
SUBTOTAL - CONSTRUCTION COSTS					**$1,143,372**	

Remedial Alternative S2: Soil Cover and Natural Attenuation

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
IMPLEMENTATION COSTS					
Bid/Performance Bonds				$57,169	
Permitting				$1,143	
Land Use Deed Restriction Document Development & Legal Fees				$25,000	
Services During Construction				$171,506	
Health and Safety				$3,430	
Report Preparation				$50,000	
Engineering Design Costs				$171,506	
SUBTOTAL - IMPLEMENTATION COSTS				**$422,585**	
TOTAL - CAPITAL COSTS					**$1,565,957**

OPERATION AND MAINTENANCE COSTS

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
GENERAL MAINTENANCE ACTIVITIES					
(Erosion Control, and Soil Cover)					
Annual Maintenance				$15,402	
Annual Soil Sampling - 6 samples in erosional areas					
Laboratory Analyticals	6 EA	$185	$1,110		
Sampling Equipment	1 LS	$200	$200	$1,310	
Subtotal				$16,712	
Other Costs					
PM & Administrative @ 10%			$131		
Contingency @ 20%			$262		
Subtotal - 1 year				$17,105	
SUBTOTAL - O&M, Erosion Control, and Soil Cover (every 5 years for 30 years)					**$51,885**
ENVIRONMENTAL MONITORING					
Lysimeter Sampling - annually for 5 years					
One Sampling Event - 6 locations					
Laboratory Analyticals	8 EA	$250	$2,000		
Sampling Equipment	1 LS	$200	$200		
Monitoring Equipment	2 EA	$100	$200	$2,400	
Other Costs					
PM & Administrative @ 10%			$240		
Contingency @ 20%			$480		
Subtotal - 1 year				$3,120	
SUBTOTAL - O&M, Lysimeter Sampling (annually for 5 years)					**$12,623**

Remedial Alternative S2: Soil Cover and Natural Attenuation

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
INSPECTION, MONITORING, AND REPORTING					
Years 1 through 5 - annual site visits					
2-person crew	40 HR	$140	$5,600		
Reporting	1 EA	$3,000	$3,000	$8,600	
Other Costs					
PM & administrative @ 10%			$860		
Contingency @ 20%			$1,720		
Subtotal - 1 year				$11,180	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (annually for 5 years)					**$45,233**
Years 5 through 30 - site visits every 5 years					
2-person crew	40 HR	$140	$5,600		
Reporting	5 EA	$3,000	$15,000	$20,600	
Other Costs					
PM & administrative @ 10%			$2,060		
Contingency @ 20%			$4,120		
Subtotal - 1 year				$26,780	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (every 5 years for 25 years)					**$54,453**
TOTAL - O&M COSTS (30 years)					**$164,194**
TOTAL - CAPITAL + O&M (Operational Life = 30 years)					**$1,700,000**

Remedial Alternative S2: Soil Cover and Natural Attenuation

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV

Primary Assumptions:

1) The former treatment building, smokestack, and oil/water separator building are recycled/salvaged.
2) Asbestos containing material is present in former treatment building but is of limited extent.
3) Composite sampling of the concrete floor within the former treatment building consists of TCLP-arsenic and TCLP-PCP analyses.
4) The concrete floor within the former treatment building is cleaned, recycled to concrete crusher or used as fill onsite.
5) Soil consolidated within main gulley and lagoon source area prior to placement of soil cover consists of isolated shallow contaminated spots (40000 CY metals-contaminated soil and PCP-contaminated soil and 3000 CY sediments).
6) Clearing and grubbing is required prior to excavation of contaminated shallow soils (1-foot) which cover 18 acres.
7) Trees will be chipped onsite and stay onsite for use as fill under cover or landscaping.
8) Confirmation sampling in conjunction with consolidation of soil and sediment contamination is conducted to confirm impacted solids have been successfully removed. Samples are collected approximately every 100 feet at the sidewals and base of the excavations and primarily analyzed for PCP and arsenic. Approximately 10 samples collected in biased locations will also be analyzed for copper, BTEX, and SVOCs.
9) Soil cover constructed over treatment gully and lagoon source area and wood chip pile source area comprise a total of 7 acres.
10) Drainage ditch costs include excavation and placement of geotextile and rip rap along ditch bottoms. A total of 2000 linear feet of ditches are located at the site and are 3 feet deep with 3:1 side slopes.
11) Three detention/infiltration basins are constructed at the site and are 50-feet by 50-feet in area and 10-foot deep with 3:1 side slopes.
12) Lagoon dam repair involves construction of a 50 foot wide, 15 feet above grade, 10 feet below grade 5300 cubic yard rock dam.
13) Biopad is constructed of arsenic contaminated soil and concrete and is 580 feet x 260 feet x 1 foot thick.
14) Services during construction consist of field oversight (10%) and office support (5%) as percentages of construction cost.
15) Design costs were estimated at 15% of construction costs and include development of plans and specifications for construction of soil cover, erosion control measures, biopad capping, restoration of site, and development of inspection, maintenance, and sampling plans.
16) Environmental monitoring is performed to assess the degree of PCP natural attenuation and to determine whether the soil cover and erosion control measures are preventing transport of arsenic and PCP. This monitoring consists of lysimeter sampling and groundwater monitoring.
17) Lysimeters (2 nests of 3, LY-02 and LY-03) are sampled annually for 5 years. Laboratory analyses consist of PCP, chloride, nitrate, sulfate, and dissolved iron. Field measurements include hydrogen, redox potential, and pH.
18) Net present value for O&M costs calculated using an interest rate of 7%.
19) Costs are in 1998 dollars.

Penta Wood Products Daniels, WI
Remedial Alternatives Costing
Order of Magnitude Comparative Cost Estimate
Project No. 141158.RE.01 Jun-98

Remedial Alternative S3: Capping

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
CAPITAL COSTS					
CONSTRUCTION COSTS					
Mobilization/Demobilization	1 LS	$15,000.00	$15,000	$15,000	
Building Demolition					
Former Treatment Building (corrugated metal with concrete floor)					
Asbestos Removal/Disposal	1 LS	$10,000.00	$10,000		
Remove Metal Building (100 ft x 80 ft x 15 ft)	1 LS	$20,000.00	$20,000		
Remove Steel Smokestack (100 ft high x 12" diameter)	1 LS	$7,500.00	$7,500		
Solid Waste Disposal	1000 TON	$30.00	$30,000		
Composite Sampling - Concrete Floor	5 EA	$200.00	$1,000		
Concrete Floor Removal/Recycling	600 TON	$21.00	$12,600		
Oil/Water Separator Building (corrugated metal with dirt floor)					
Remove Metal Building (30 ft x 40 ft x 10 ft)	1 LS	$10,000.00	$10,000		
Solid Waste Disposal	20 TON	$30.00	$600	$91,700	
Consolidate Soil/Sediment Contamination					
Clear, Grub, and Chip Trees	18 ACRE	$3,500.00	$63,000		
Excavate/Relocate Soil - Dry 1 ft deep	40000 CY	$3.50	$140,000		
Excavate/Relocate Soil - Wet 2 ft deep	3000 CY	$8.75	$26,250		
Perform Confirmation Sampling	175 EA	$158.00	$27,650	$256,900	
Construct Soil Cover - 2 acres					
Vegetation Layer (6-inches thick)	1570 CY	$12.00	$18,840		
Relocate Sand 6"	1570 CY	$3.50	$5,495	$24,335	
Construct Cap -5 acres					
Bedding Layer (1 foot thick)	8600 CY	$5.00	$43,000		
Impermeable Geomembrane (40-mils thick)	25000 SY	$4.00	$100,000		
Geosynthetic Clay Liner (10^{-7} cm/s)	25000 SY	$4.00	$100,000		
Geogrid	71000 SF	$3.00	$213,000		
Drainage Layer (12-inches thick)	8600 CY	$10.00	$86,000		
Vegetation Layer (18-inches thick)	13000 CY	$15.00	$195,000		
Gas Collection Trenches and Vent Wells	1 LS	$60,000.00	$60,000	$797,000	
Restore Site					
Regrade using Onsite Sand	58 ACRE	$750.00	$43,500		
Seed	80 ACRE	$1,200.00	$96,000	$139,500	
Implement Erosion Control Measures					
Construct Drainage Ditches/Check Dams	1 LS	$75,000.00	$75,000		
Install Detention/Infiltration Basins	3 EA	$15,000.00	$45,000		
Repair Lagoon Dam	1 LS	$100,000.00	$100,000	$220,000	
Dismantle Biopad					
Decon/Breakup Biopad	1 LS	$50,000.00	$50,000		
Move Concrete to Cover Area	5585 CY	$3.50	$19,548	$69,548	
Construction Labor	1870 HR	$32.00	$59,840	$59,840	
Construction Subtotal				$1,673,823	
Scope and Bid Contingency @ 25%				$418,456	
SUBTOTAL - CONSTRUCTION COSTS				**$2,092,278**	

Remedial Alternative S3: Capping

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
IMPLEMENTATION COSTS					
Bid/Performance Bonds				$104,614	
Permitting				$2,092	
Land Use Deed Restriction Document Development & Legal Fees				$25,000	
Services During Construction				$313,842	
Health and Safety				$6,277	
Report Preparation				$50,000	
Engineering Design Costs				$313,842	
SUBTOTAL - IMPLEMENTATION COSTS				**$711,053**	
TOTAL - CAPITAL COSTS					**$2,803,331**
OPERATION AND MAINTENANCE COSTS					
GENERAL MAINTENANCE ACTIVITIES					
(Erosion Control, Soil Cover, and Cap)					
Annual Maintenance				$50,850	
Annual Soil Sampling - 6 samples annually in erosional areas					
Laboratory Analyticals	6 EA	$185	$1,110		
Sampling Equipment	1 LS	$200	$200	$1,310	
Subtotal				$52,160	
Other Costs					
PM & Administrative @ 10%			$131		
Contingency @ 20%			$262		
Subtotal - 1 year				$52,553	
SUBTOTAL - O&M, Erosion Control, Soil Cover, and Cap (every 5 years for 30 years)					**$159,411**
ENVIRONMENTAL MONITORING					
Lysimeter Sampling - annually for 5 years					
One Sampling Event - 6 locations					
Laboratory Analyticals	8 EA	$250	$2,000		
Sampling Equipment	1 LS	$200	$200		
Monitoring Equipment	2 EA	$100	$200	$2,400	
Other Costs					
PM & Administrative @ 10%			$240		
Contingency @ 20%			$480		
Subtotal - Lysimeter Sampling, 1 year				$3,120	
SUBTOTAL - O&M, Lysimeter Sampling (annually for 5 years)					**$12,623**

Remedial Alternative S3: Capping

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
INSPECTION, MONITORING, AND REPORTING					
5 Years - annual site visits					
2-person crew	40 HR	$140	$5,600		
Reporting	5 EA	$3,000	$15,000	$20,600	
Other Costs					
PM & administrative @ 10%			$2,060		
Contingency @ 20%			$4,120		
Subtotal - 1 year				$26,780	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (annually for 5 years)					**$108,349**
Years 5 through 30 - site visits every 5 years					
2-person crew	40 HR	$140	$5,600		
Reporting	5 EA	$3,000	$15,000	$20,600	
Other Costs					
PM & administrative @ 10%			$2,060		
Contingency @ 20%			$4,120		
Subtotal - 1 year				$26,780	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (every 5 years for 25 years)					**$54,453**
TOTAL - O&M COSTS (30 years)					**$334,835**
TOTAL - CAPITAL + O&M (Operational Life = 30 years)					**$3,100,000**

Remedial Alternative S3: Capping

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV

Primary Assumptions:

1) The former treatment building, smokestack, and oil/water separator building are recycled/salvaged.
2) Asbestos containing material is present in former treatment building but is of limited extent.
3) Composite sampling of the concrete floor within the former treatment building consists of TCLP-arsenic and TCLP-PCP analyses.
4) The concrete floor within the former treatment building is cleaned, recycled to concrete crusher.
5) Soil consolidated within main gulley and lagoon source area prior to placement of soil cover consists of isolated shallow contaminated spots (40,000 CY metal-contaminated soil and PCP-contaminated soil and 3000 CY sediments).
6) Clearing and grubbing is required prior to excavation of contaminated shallow soils (1-foot) which cover 18 acres.
7) Trees will be chipped onsite and stay onsite for use as fill under cover or landscaping.
8) Confirmation sampling in conjunction with consolidation of soil and sediment contamination is conducted to confirm impacted solids have been successfully removed. Samples are collected approximately every 100 feet at the sidewals and base of the excavations and primarily analyzed for PCP and arsenic. Approximately 10 samples collected in biased locations will also be analyzed for copper, BTEX, and SVOCs.
9) Soil cover constructed over treatment gully and lagoon source area and wood chip pile source area comprise a total of 2 acres outside of cap.
10) Gas collection trenches and vent pipes will be constructed in conjunction with the cap. Gas collection trenches are located under the cap with vent pipes extending through the cap. Eight 2,500 foot long trenches are 550 cubic yards lined with geotextile and filled with drain rock. Perforated pipe in bottom of trenches are vented via two vent pipes per trench.
11) Drainage ditch costs include excavation and placement of geotextile and rip rap along ditch bottoms. A total of 2000 linear feet of ditches are located at the site and are 3 feet deep with 3:1 side slopes.
12) Three detention/infiltration basins are constructed at the site and are 50-feet by 50-feet in area and 10-foot deep with 3:1 side slopes.
13) Lagoon dam repair involves construction of a 50 foot wide, 15 feet above grade, 10 feet below grade 5300 cubic yard rock dam.
14) Biopad is constructed of arsenic contaminated soil and concrete and is 580 feet x 260 feet x 1 foot thick.
15) Services during construction consist of field oversight (10%) and office support (5%) as percentages of construction cost.
16) Design costs were estimated at 15% of construction costs and include development of plans and specifications for construction of soil cover, erosion control measures, biopad capping, restoration of site, and development of inspection, maintenance, and sampling plans.
17) Environmental monitoring is performed to assess the degree of PCP natural attenuation and to determine whether the soil cover and erosion control measures are preventing transport of arsenic and PCP. This monitoring consists of lysimeter sampling and groundwater monitoring.
18) Lysimeters (2 nests of 3, LY-02 and LY-03) are sampled annually for 5 years. Laboratory analyses consist of PCP, chloride, nitrate, sulfate, and dissolved iron. Field measurements include hydrogen, redox potential, and pH.
19) Net present value for O&M costs calculated using an interest rate of 7%.
20) Costs are in 1998 dollars.

Penta Wood Products Daniels, WI
Remedial Alternatives Costing
Order of Magnitude Comparative Cost Estimate
Project No. 141158.RE.01 Jun-98

Remedial Alternative S4: Bioventing

Component Description	Quantity		Unit Price	Component Cost	Category Subtotal	NPV
CAPITAL COSTS						
CONSTRUCTION COSTS						
Mobilization/Demobilization	1	LS	$20,000.00	$20,000	$20,000	
Building Demolition						
Former Treatment Building (corrugated metal with concrete floor)						
Asbestos Removal/Disposal	1	LS	$10,000.00	$10,000		
Remove Metal Building (100 ft x 80 ft x 15 ft)	1	LS	$20,000.00	$20,000		
Remove Steel Smokestack (100 ft high x 12" diameter)	1	LS	$7,500.00	$7,500		
Solid Waste Disposal	1000	TON	$30.00	$30,000		
Composite Sampling - Concrete Floor	5	EA	$200.00	$1,000		
Concrete Floor Removal/Recycling	600	TON	$21.00	$12,600		
Oil/Water Separator Building (corrugated metal with dirt floor)						
Remove Metal Building (30 ft x 40 ft x 10 ft)	1	LS	$10,000.00	$10,000		
Solid Waste Disposal	20	TON	$30.00	$600	$91,700	
Consolidate Soil/Sediment Contamination						
Clear, Grub, and Chip Trees	18	ACRE	$3,500.00	$63,000		
Excavate/Relocate Soil - Dry 1 ft deep	40000	CY	$3.50	$140,000		
Excavate/Relocate Soil - Wet 2 ft deep	3000	CY	$8.75	$26,250		
Perform Confirmation Sampling	175	EA	$158.00	$27,650	$256,900	
Construct Soil Cover - 7 acres						
Vegetation Layer (6-inches thick)	5680	CY	$12.00	$68,160		
Relocate Sand 6"	5680	CY	$3.50	$19,880	$88,040	
Restore Site						
Regrade using Onsite Sand	58	ACRE	$750.00	$43,500		
Seed	80	ACRE	$1,200.00	$96,000	$139,500	
Implement Erosion Control Measures						
Construct Drainage Ditches/Check Dams	1	LS	$75,000.00	$75,000		
Install Detention/Infiltration Basins	3	EA	$15,000.00	$45,000		
Repair Lagoon Dam	1	LS	$100,000.00	$100,000	$220,000	
Cap Biopad with Asphalt - 150,800 sq ft	150800	SF	$1.50	$226,200	$226,200	
Dismantle Biopad						
Decon/Breakup Biopad	1	LS	$50,000.00	$50,000		
Move Concrete to Cover Area	5585	CY	$3.50	$19,548	$69,548	
Excavate Arsenic Contaminated Soil						
Excavate Soil	4000	CY	$2.25	$9,000		
Solidify Onsite	4000	CY	$24.00	$96,000		
Perform Solidification Confirm. Sampling	20	EA	$60.00	$1,200	$106,200	
Pre-design Activities	1	LS	$125,000.00	$125,000	$125,000	
Construct Bioventing System						
Install 6-inch ID Injection Wells - 12 @ 120 ft bgs						
Drilling w/ sampling at residual zone	1440	FT	$150.00	$216,000		
Decontamination	10	HR	$125.00	$1,250		
PCP, TPH analysis of soils	12	EA	$250.00	$3,000		
Pipe Trenching (2' wide x 36" deep)	466	CY	$2.25	$1,049		

Remedial Alternative S4: Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
Piping/Pipe Fittings (2" polyethylene)	2100 FT	$3.00	$6,300		
Pipe Trench Backfill	466 CY	$2.25	$1,049		
Blower (5000 scfm/well x 10 wells)	1 EA	$40,000.00	$40,000		
Blower (1000 scfm/well x 2 wells)	1 EA	$12,000.00	$12,000		
Controls/Programming	1 LS	$20,000.00	$20,000		
Treatment Building	2 EA	$15,000.00	$30,000		
Electric	2 EA	$3,500.00	$7,000		
Install Piezometers - 10 nests of 3	1450 FT	$35.00	$50,750		
Survey Well and Piezometer Locations	5 Day	$1,000.00	$5,000		
Start-up	1 LS	$5,000.00	$5,000	$398,397	
Construction Labor	1870 HR	$32.00	$59,840	$59,840	
Construction Subtotal				**$1,801,325**	
Scope and Bid Contingency @ 25%				**$450,331**	
SUBTOTAL - CONSTRUCTION COSTS				**$2,251,656**	
IMPLEMENTATION COSTS					
Bid/Performance Bonds				$112,583	
Permitting				$2,252	
Land Use Deed Restriction Document Development & Legal Fees				$25,000	
Services During Construction				$337,748	
Health and Safety				$6,755	
Report Preparation				$50,000	
Engineering Design Costs				$337,748	
SUBTOTAL - IMPLEMENTATION COSTS				**$759,503**	
TOTAL - CAPITAL COSTS					**$3,011,159**

OPERATION AND MAINTENANCE COSTS

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
GENERAL MAINTENANCE ACTIVITIES					
(Erosion Control, and Soil Cover)					
Annual Maintenance				$26,712	
Annual Soil Sampling - 6 samples annually in erosional areas					
Laboratory Analyticals	6 EA	$185	$1,110		
Sampling Equipment	1 LS	$200	$200	$1,310	
Subtotal				$28,022	
Other Costs					
PM & Administrative @ 10%			$131		
Contingency @ 20%			$262		
Subtotal - 1 year				$28,415	
SUBTOTAL - O&M, Erosion Control, and Soil Cover (every 5 years for 30 years)					**$86,192**

Remedial Alternative S4: Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
BIOVENTING SYSTEM OPERATION					
Annual System Maintenance			$19,920		
Electrical	1 YR	$40,000	$40,000		
Semi-annual Soil Gas Analysis (Gas Meter)	2 EA	$100	$200	$60,120	
Other Costs					
PM & Administrative @ 10%			$6,012		
Contingency @ 20%			$12,024		
Subtotal - 1 year				$78,156	
SUBTOTAL - O&M, Bioventing System Operation (annually for 10 years)					**$576,703**
Bioventing Post Operation Evaluation (after 10 years)	1 LS	$15,000	$15,000	$15,000	**$10,448**
ENVIRONMENTAL MONITORING					
Lysimeter Sampling - annually for 10 years					
One Sampling Event - 6 locations					
Laboratory Analyticals	8 EA	$200	$1,600		
Sampling Equipment	1 LS	$200	$200		
Monitoring Equipment	2 EA	$100	$200	$2,000	
Other Costs					
PM & Administrative @ 10%			$200		
Contingency @ 20%			$400		
Subtotal - Lysimeter Sampling, 1 year				$2,600	
SUBTOTAL - O&M, Lysimeter Sampling (annually for 10 years)					**$19,185**
Soil Sampling - Within Bioventing Treatment Area after 5, and 10 years					
One Sampling Event - 9 samples/acre, 3 samples/location, 22 acres					
Drilling w/ sampling	8250 FT	$15	$123,750		
Laboratory Analyticals	220 EA	$360	$79,200		
Sampling Equipment	1 LS	$500	$500	$203,450	
Other Costs					
PM & administrative @ 10%			$20,345		
Contingency @ 15%			$30,518		
Subtotal - Soil Sampling, 1 year				$254,313	
SUBTOTAL - O&M, Soil Sampling (2 sampling events, 10 years)					**$300,534**

Remedial Alternative S4: Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
INSPECTION, MONITORING, AND REPORTING					
First 5 Years - annual site visits					
2-person crew	140 HR	$140	$19,600		
Reporting	20 EA	$3,000	$60,000	$79,600	
Other Costs					
PM & administrative @ 10%			$7,960		
Contingency @ 20%			$15,920		
Subtotal - 1 year				$103,480	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (semi-annual for 5 years)					**$450,068**
Years 5 through 30 - site visits every 5 years					
2-person crew	100 HR	$140	$14,000		
Reporting	25 EA	$3,000	$75,000	$89,000	
Other Costs					
PM & administrative @ 10%			$8,900		
Contingency @ 20%			$17,800		
Subtotal - 1 year				$115,700	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (every 5 years for 25 years)					**$235,256**
TOTAL - O&M (30 years)					**$1,700,000**
TOTAL - CAPITAL + O&M (Operational Life = 30 years)					**$4,700,000**

Remedial Alternative S4: Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV

Primary Assumptions:

1) The former treatment building, smokestack, and oil/water separator building are recycled/salvaged.
2) Asbestos containing material is present in former treatment building but is of limited extent.
3) Composite sampling of the concrete floor within the former treatment building consists of TCLP-arsenic and TCLP-PCP analyses.
4) The concrete floor within the former treatment building is cleaned, recycled to concrete crusher.
5) Soil consolidated within main gulley and lagoon source area prior to placement of soil cover consists of isolated shallow contaminated spots (40,000 CY arsenic-contaminated soil and PCP-contaminated soil and 3000 CY sediments).
6) Clearing and grubbing is required prior to excavation of contaminated shallow soils (1-foot) which cover 18 acres.
7) Trees will be chipped onsite and stay onsite for use as fill under cover or landscaping.
8) Confirmation sampling in conjunction with consolidation of soil and sediment contamination is conducted to confirm impacted solids have been successfully removed. Samples are collected approximately every 100 feet at the sidewals and base of the excavations and primarily analyzed for PCP and arsenic. Approximately 10 samples collected in biased locations will also be analyzed for copper, BTEX, and SVOCs.
9) Soil cover constructed over treatment gully and lagoon source area and wood chip pile source area comprise a total of 7 acres.
10) Drainage ditch costs include excavation and placement of geotextile and rip rap along ditch bottoms. A total of 2000 linear feet of ditches are located at the site and are 3 feet deep with 3:1 side slopes.
11) Three detention/infiltration basins are constructed at the site and are 50-feet by 50-feet in area and 10-foot deep with 3:1 side slopes.
12) Lagoon dam repair involves construction of a 50 foot wide, 15 feet above grade, 10 feet below grade 5300 cubic yard rock dam.
13) Biopad is constructed of arsenic contaminated soil and concrete and is 580 feet x 260 feet x 1 foot thick.
14) Confirmation sampling performed in conjunction with excavation of arsenic-contaminated soil consists of analysis of soil samples for arsenic to confirm impacted soil has been successfully removed. Samples will be collected approximately every 10' around the perimeter of the excavations.
15) Solidification samples are analyzed for TCLP-arsenic to confirm arsenic contaminated soil is contained prior to onsite disposal.
16) Pre-design activities may consist of activities such as pilot studies, pump testing, and/or laboratory studies.
17) Piezometers installed in conjunction with bioventing system consist of 10 nests of 3 installed to 5, 40, and 100 ft bgs.
18) Services during construction consist of field oversight (10%) and office support (5%) as percentages of construction cost.
19) Design costs were estimated at 15% of construction costs and include development of plans and specifications for construction of soil cover, erosion control measures, biopad capping, bioventing system, restoration of site, and development of inspection, operation, maintenance, and sampling plans.
20) Bioventing system is operated continuously for 10 years.
21) Environmental monitoring performed in conjunction with bioventing system operation to evaluate system performance consists of lysimeter sampling, soil gas analysis, soil sampling, and groundwater monitoring.
22) Lysimeters (2 nests of 3, LY-02 and LY-03) are sampled annually for a total of 10 years. Laboratory analyses consist of PCP, chloride, nitrate, sulfate, and dissolved iron. Field measurements include hydrogen, redox potential, and pH.
23) Soil gas is monitored in the field at the piezometers (10 nests of 3) and existing monitoring wells (3) semi-annually for 10 years. Parameters measured consist of oxygen, carbon dioxide, methane, temperature, and moisture.
24) Soil sampling within the bioventing treatment area occurs after 5, and 10 years of system operation. Soil analyses consist of PCP, chloride, pH, TOC, TPH, DRO, and moisture content.
25) Drilling includes costs associated with sampling at residual zone,well materials, aboveground completions, and well development.
26) Net present value for O&M costs calculated using an interest rate of 7%.
27) Costs are in 1998 dollars.

Remedial Alternative S5: Ex Situ Biological Treatment and Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
CAPITAL COSTS					
CONSTRUCTION COSTS					
Mobilization/Demobilization	1 LS	$40,000.00	$40,000	$40,000	
Building Demolition					
Former Treatment Building (corrugated metal with concrete floor)					
Asbestos Removal/Disposal	1 LS	$10,000.00	$10,000		
Remove Metal Building (100 ft x 80 ft x 15 ft)	1 LS	$20,000.00	$20,000		
Remove Steel Smokestack (100 ft high x 12" diameter)	1 LS	$7,500.00	$7,500		
Solid Waste Disposal	1000 TON	$30.00	$30,000		
Composite Sampling - Concrete Floor	5 EA	$200.00	$1,000		
Concrete Floor Removal/Recycling	600 TON	$21.00	$12,600		
Oil/Water Separator Building (corrugated metal with dirt floor)					
Remove Metal Building (30 ft x 40 ft x 10 ft)	1 LS	$10,000.00	$10,000		
Solid Waste Disposal	20 TON	$30.00	$600	$91,700	
Consolidate Soil/Sediment Contamination					
Clear, Grub, and Chip Trees	18 ACRE	$3,500.00	$63,000		
Excavate/Relocate Soil - Dry 1 ft deep	40000 CY	$3.50	$140,000		
Excavate/Relocate Soil - Wet 2 ft deep	3000 CY	$8.75	$26,250		
Perform Confirmation Sampling	175 EA	$220.00	$38,500	$267,750	
Construct Soil Cover - 7 acres					
Vegetation Layer (6-inches thick)	5680 CY	$12.00	$68,160		
Relocate Sand 6"	5680 CY	$3.50	$19,880	$88,040	
Restore Site					
Regrade using Onsite Sand	58 ACRE	$750.00	$43,500		
Seed	80 ACRE	$1,200.00	$96,000	$139,500	
Implement Erosion Control Measures					
Construct Drainage Ditches/Check Dams	1 LS	$75,000.00	$75,000		
Install Detention/Infiltration Basins	3 EA	$15,000.00	$45,000		
Repair Lagoon Dam	1 LS	$100,000.00	$100,000	$220,000	
Upgrade Biopad - 150,800 sq ft					
Increase Curbing Height			$30,000		
Seal Existing Concrete Pad	16800 SY	$4.00	$67,200	$97,200	
Construct Ex Situ Biological Treatment System					
Blowers (500 scfm total)	1 EA	$7,500.00	$7,500		
Screened Inlet/Outlet Piping	31000 LF	$18.00	$558,000		
Controls	1 LS	$4,000.00	$4,000		
Moisture Addition/Dust Control	1 LS	$10,000.00	$10,000		
Onsite Mixer	1 EA	$10,000.00	$10,000		
Excavate/Mix/Place Soil	60000 CY	$7.50	$450,000		
Leachate Collection System			$30,000	$1,069,500	

Remedial Alternative S5: Ex Situ Biological Treatment and Bioventing

Component Description	Quantity		Unit Price	Component Cost	Category Subtotal	NPV
Excavate Arsenic Contaminated Soil						
Excavate Soil	4000	CY	$2.25	$9,000		
Perform Confirmation Sampling	20	EA	$8.00	$160		
Solidify Onsite	4000	CY	$24.00	$96,000		
Perform Solidification Sampling	10	EA	$60.00	$600		
Pre-design Activities	1	LS	$125,000.00	$125,000	$125,000	
Construct Bioventing System						
Install 6-inch ID Injection Wells - 12 @ 10 ft bgs						
Drilling w/ sampling at residual zone	1200	FT	$150.00	$180,000		
Decontamination	10	HR	$125.00	$1,250		
PCP, TPH analysis of soils	12	EA	$250.00	$3,000		
Pipe Trenching (2' wide x 36" deep)	422	CY	$2.25	$950		
Piping/Pipe Fittings (2" polyethylene)	1900	FT	$3.00	$5,700		
Pipe Trench Backfill	422	CY	$2.25	$950		
Blower (5000 scfm/well x 10 wells)	1	EA	$40,000.00	$40,000		
Blower (1000 scfm/well x 2 wells)	1	EA	$12,000.00	$12,000		
Controls/Programming	1	LS	$20,000.00	$20,000		
Treatment Building	1	EA	$15,000.00	$15,000		
Electric	1	EA	$3,500.00	$3,500		
Install Piezometers - 10 nests of 3	1450	FT	$35.00	$50,750		
Survey Well and Piezometer Locations	5	Day	$1,000.00	$5,000		
Start-up	1	LS	$5,000.00	$5,000	$343,099	
Construction Labor	2500	HR	$32.00	$80,000	$80,000	
Construction Subtotal					**$2,561,789**	
Scope and Bid Contingency @ 25%					**$640,447**	
SUBTOTAL - CONSTRUCTION COSTS					**$3,202,236**	
IMPLEMENTATION COSTS						
Bid/Performance Bonds					$160,112	
Permitting					$3,202	
Land Use Deed Restriction Document Development & Legal Fees					$25,000	
Services During Construction					$480,335	
Health and Safety					$9,607	
Report Preparation					$50,000	
Engineering Design Costs					$480,335	
SUBTOTAL - IMPLEMENTATION COSTS					**$1,048,480**	
TOTAL - CAPITAL COSTS						**$4,250,716**

Remedial Alternative S5: Ex Situ Biological Treatment and Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
OPERATION AND MAINTENANCE COSTS					
GENERAL MAINTENANCE ACTIVITIES					
(Biopad, Erosion Control, and Soil Cover)					
Annual Maintenance				$15,402	
Annual Soil Sampling - 6 samples annually around biopad and erosional areas					
Laboratory Analyticals	6 EA	$185	$1,110		
Sampling Equipment	1 LS	$200	$200	$1,310	
Subtotal				$16,712	
Other Costs					
PM & Administrative @ 10%			$131		
Contingency @ 20%			$262		
Subtotal - 1 year				$17,105	
SUBTOTAL - O&M, Biopad, Erosion Control, and Soil Cover (every 5 years for 30 years)					**$51,885**
EX SITU BIOLOGICAL TREATMENT SYSTEM OPERATION					
Annual System Maintenance			$53,475		
Electrical	1 YR	$40,000.00	$40,000		
Annual Soil Confirmation Sampling	380 EA	$150.00	$57,000		
Excavation of Biopile and Redistribute Soil	60000 CY	$6.50	$390,000	$540,475	
Other Costs					
PM & Administrative @ 10%			$54,048		
Contingency @ 20%			$108,095		
Subtotal - 1 year				$702,618	
SUBTOTAL - O&M, Ex Situ Biological Treatment System Operation (3 years)					**$1,827,175**
BIOPAD DECON/CAPPING (after 3 years)					
System Dismantling/Decon/Breakup Biopad	1 LS	$60,000.00	$60,000		
Move Concrete to Cover Area	5585 CY	$3.50	$19,548	$79,548	**$64,033**
BIOVENTING SYSTEM OPERATION					
Annual System Maintenance			$17,155		
Electrical	1 YR	$40,000	$40,000		
Semi-annual Soil Gas Analysis (Gas Meter)	2 EA	$100	$500	$57,655	
Other Costs					
PM & Administrative @ 10%			$5,765		
Contingency @ 20%			$11,531		
Subtotal - 1 year				$74,951	
SUBTOTAL - O&M, Bioventing System Operation (10 years)					**$553,058**
Bioventing Post Operation Evaluation (after 10 years)	1 LS	$15,000	$15,000	$15,000	**$10,448**

Remedial Alternative S5: Ex Situ Biological Treatment and Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
ENVIRONMENTAL MONITORING					
Lysimeter Sampling - annually for 10 years					
One Sampling Event - 6 locations					
Laboratory Analyticals	8 EA	$200	$1,600		
Sampling Equipment	1 LS	$200	$200		
Monitoring Equipment	2 EA	$100	$200	$2,000	
Other Costs					
PM & Administrative @ 10%			$200		
Contingency @ 20%			$400		
Subtotal - Lysimeter Sampling, 1 year				$2,600	
SUBTOTAL - O&M, Lysimeter Sampling (10 years)					**$19,185**
Soil Sampling - Within Bioventing Treatment Area after 5 and 10 years					
One Sampling Event - 9 samples/acre, 3 samples/location, 22 acres					
Drilling w/ sampling	8250 FT	$15	$123,750		
Laboratory Analyticals	220 EA	$360	$79,200		
Sampling Equipment	1 LS	$500	$500	$203,450	
Other Costs					
PM & administrative @ 10%			$20,345		
Contingency @ 20%			$40,690		
Subtotal - Soil Sampling, 1 year				$264,485	
SUBTOTAL - O&M, Soil Sampling (2 sampling events, 10 years)					**$312,556**
INSPECTION, MONITORING, AND REPORTING					
First 5 Years - annual site visits					
2-person crew	140 HR	$140	$19,600		
Reporting	20 EA	$3,000	$60,000	$79,600	
Other Costs					
PM & administrative @ 10%			$7,960		
Contingency @ 20%			$15,920		
Subtotal - 1 year				$103,480	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (5 years)					**$450,068**

Remedial Alternative S5: Ex Situ Biological Treatment and Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
Years 5 through 30 - site visits every 5 years					
2-person crew	100 HR	$140	$14,000		
Reporting	25 EA	$3,000	$75,000	$89,000	
Other Costs					
PM & administrative @ 10%			$8,900		
Contingency @ 20%			$17,800		
Subtotal - 1 year				$115,700	

SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (every 5 years for 25 years)	$235,256
TOTAL - O&M (30 years)	$3,500,000
TOTAL - CAPITAL + O&M (Operational Life = 30 years)	**$7,800,000**

Remedial Alternative S5: Ex Situ Biological Treatment and Bioventing

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV

Primary Assumptions:

1) The former treatment building, smokestack, and oil/water separator building are recycled/salvaged.
2) Asbestos containing material is present in former treatment building but is of limited extent.
3) Composite sampling of the concrete floor within the former treatment building consists of TCLP-arsenic and TCLP-PCP analyses.
4) The concrete floor within the former treatment building is cleaned, recycled to concrete crusher.
5) Soil consolidated within main gulley and lagoon source area prior to placement of soil cover consists of isolated shallow contaminated spots (40,000 CY arsenic-contaminated soil and PCP-contaminated soil and 3000 CY sediments).
6) Clearing and grubbing is required prior to excavation of contaminated shallow soils (1-foot) which cover 18 acres.
7) Trees will be chipped onsite and stay onsite for use as fill under cover or landscaping.
8) Soil cover constructed over treatment gully and lagoon source area comprises a total of 7 acres.
9) Drainage ditch costs include excavation and placement of geotextile and rip rap along ditch bottoms. A total of 2000 linear feet of ditches are located at the site and are 3 feet deep with 3:1 side slopes.
10) Three detention/infiltration basins are constructed at the site and are 50-feet by 50-feet in area and 10-foot deep with 3:1 side slopes.
11) Lagoon dam repair involves construction of a 50 foot wide, 15 feet above grade, 10 feet below grade 5300 cubic yard rock dam.
12) Biopad is constructed of arsenic contaminated soil and concrete and is 580 feet x 260 feet x 1 foot thick. The upgrade will entail increasing the curbing height to 3 feet on all sides with cast-in-place concrete and sealing the surface with a 40-mil thick impermeable geomembrane.
13) The ex situ biological treatment system will treat 3 cycles of grossly contaminated PCP soil and wood debris from the wood chip pile source area (30,000 cubic yards per year). Inlet and outlet piping is installed in a 3-dimensional 20-foot grid with the inlet piping across the surface of the biopad and the outlet piping at a higher level. Moisture addition/dust control will be accomplished using a rented water truck. The leachate collection system consists of a concrete sump with a sump pump to transfer leachate to a collection tank prior to treatment at the onsite treatment system.
14) Confirmation sampling performed in conjunction with excavation of arsenic-contaminated soil consists of analysis of soil samples for arsenic to confirm impacted soil has been successfully removed.
15) Solidification samples are analyzed for TCLP-arsenic to confirm arsenic contaminated soil is contained prior to onsite disposal.
16) Bioventing system is installed and operated within the main gully and lagoon source area.
17) Piezometers installed in conjunction with bioventing system consist of 10 nests of 3 installed to 5, 40, and 100 ft bgs.
18) Services during construction consist of field oversight (10%) and office support (5%) as percentages of construction cost.
19) Design costs were estimated at 15% of construction costs and include development of plans and specifications for construction of soil cover, erosion control measures, ex situ biological treatment system, bioventing system, restoration of site, and development of inspection, operation, maintenance, and sampling plans.
20) Ex situ biological treatment system is operated in 3, 6 month cycles over the course of 3 years. Annual soil confirmation sampling is performed to confirm soil concentrations have been reduced to levels which can be placed back onsite. Samples will be collected manually from the middle of the biopile every 20 feet and analyzed for PCP.
21) After ex situ biological treatment is concluded, the biopad will be decontaminated, broken up, and placed under the soil cover.
22) Bioventing system is operated continuously for 10 years.
23) Environmental monitoring performed in conjunction with bioventing system operation to evaluate system performance consists of lysimeter sampling, soil gas analysis, soil sampling, and groundwater monitoring.
24) Lysimeters (2 nests of 3, LY-02 and LY-03) are sampled annually for a total of 7 years. Laboratory analyses consist of PCP, chloride, nitrate, sulfate, and dissolved iron. Field measurements include hydrogen, redox potential, and pH.
25) Soil gas is monitored in the field at the piezometers (10 nests of 3) and existing monitoring wells (3) semi-annually for 7 years. Parameters measured consist of oxygen, carbon dioxide, methane, temperature, and moisture.
26) Soil sampling within the bioventing treatment area occurs after 5, and 7 years of system operation. Soil analyses consist of PCP, chloride, pH, TOC, TPH, DRO, and moisture content.
27) Drilling includes costs associated with sampling at residual zone,well materials, aboveground completions, and well development.
28) Net present value for O&M costs calculated using an interest rate of 7%.
29) Costs are in 1998 dollars.

Penta Wood Products Daniels, WI
Remedial Alternatives Costing
Order of Magnitude Comparative Cost Estimate
Project No. 141158.RE.01 Jun-98

Remedial Alternative G2: LNAPL Collection/Natural Attenuation

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
CAPITAL COSTS					
CONSTRUCTION COSTS					
Mobilization/Demobilization	1 LS	$10,000.00	$10,000	$10,000	
Install LNAPL Recovery System					
Recovery Pumps (pneumatic)	3 EA	$5,000.00	$15,000		
Air Piping and Compressor	1 LS	$4,500.00	$4,500		
LNAPL Sensing Probes	3 EA	$1,000.00	$3,000		
Pipe Trenching (2' wide x 36" deep)	100 CY	$2.25	$225		
Connecting Piping (LNAPL and Water, same trench)	800 FT	$3.00	$2,400		
Pipe Trench Backfill	100 CY	$2.25	$225		
Controls/Programming	1 LS	$5,000.00	$5,000		
LNAPL Storage Tank (15K tank)	1 EA	$8,500.00	$8,500	$38,850	
Provide Onsite Groundwater Treatment					
Collection Tank	1 EA	$5,000.00	$5,000		
GAC Canisters	3 EA	$4,000.00	$12,000		
Install Re-injection Well - 1 @ 30 ft bgs	30 FT	$150.00	$4,500		
Pipe Trenching (2' wide x 36" deep)	3000 CY	$2.25	$6,750		
Connecting Piping	13500 FT	$3.00	$40,500		
Pipe Trench Backfill	3000 CY	$2.25	$6,750		
Re-injection Pumps	2 EA	$3,250.00	$6,500	$82,000	
Abandon Existing Production Wells (2 @ 170 ft bgs)	340 FT	$35.00	$11,900	$11,900	
Provide GW Treatment for Residents	1 LS	$2,500.00	$2,500	$2,500	
Develop Groundwater Flow and Solute Transport Model	500 HR	$100.00	$50,000	$50,000	
Construction Labor	400 HR	$32.00	$12,800	$12,800	
Construction Subtotal				**$208,050**	
Scope and Bid Contingency @ 25%				**$52,013**	
SUBTOTAL - CONSTRUCTION COSTS				**$260,063**	
IMPLEMENTATION COSTS					
Bid/Performance Bonds				$13,003	
Permitting				$260	
Land Use Deed Restriction Document Development & Legal Fees				$25,000	
Services During Construction				$39,009	
Health and Safety				$780	
Report Preparation				$50,000	
Engineering Design Costs				$39,009	
SUBTOTAL - IMPLEMENTATION COSTS				**$154,059**	
TOTAL - CAPITAL COSTS					**$414,122**

Remedial Alternative G2: LNAPL Collection/Natural Attenuation

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
OPERATION AND MAINTENANCE COSTS					
LNAPL RECOVERY AND GROUNDWATER TREATMENT SYSTEM OPERATION					
Annual System Maintenance			$1,943		
Load, transport, and incinerate LNAPL (1K gal)	750 LBS	$0.27	$203		
Sample Treated Water Prior to Reinjection	12 MO	$350	$4,200		
Part-time operator 16 hrs/week	832 HR	$30	$24,960	$29,363	
Other Costs					
PM & Administrative @ 10%			$2,936		
Contingency @ 20%			$5,873		
Subtotal - 1 year				$38,171	
SUBTOTAL - O&M, LNAPL Recovery System (10 years, LNAPL offloaded and incinerated 4 times)					**$281,661**
ENVIRONMENTAL MONITORING					
Monitoring Well Sampling - annually for 5 years and once every 5 years through year 30					
One Sampling Event - 21 samples					
Laboratory Analyticals	21 EA	$340	$7,140		
Monitoring Equipment	1 LS	$500	$500		
Sampling Equipment	1 LS	$200	$200	$7,840	
Other Costs					
PM & administrative @ 10%			$784		
Contingency @ 20%			$1,568		
Subtotal - Groundwater Sampling, 1 year				$10,192	
SUBTOTAL - O&M, Groundwater Sampling (10 sampling events, 30 years)					**$57,953**
Perimeter Monitoring Well Sampling - quarterly for 5 years, annually for 25 years					
One Sampling Event - 6 samples					
Laboratory Analyticals	8 EA	$340	$2,720		
Sampling Equipment	1 LS	$200	$200	$2,920	
Other Costs					
PM & administrative @ 10%			$292		
Contingency @ 20%			$584		
Subtotal - Groundwater Sampling, 1 event				$3,796	
Subtotal - Groundwater Sampling, 1 year				$15,184	
Update Solute Transport Model Annually	56 HR	$100	$5,600	$5,600	
Subtotal - 1 year				$20,784	
SUBTOTAL - O&M, Groundwater Sampling (20 sampling events, 5 years)					**$113,308**
SUBTOTAL - O&M, Groundwater Sampling (25 sampling events, 25 years)					**$147,588**

Remedial Alternative G2: LNAPL Collection/Natural Attenuation

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
INSPECTION, MONITORING, AND REPORTING					
First 5 Years - quarterly site visits					
2-person crew	140 HR	$140	$19,600		
Reporting	20 EA	$3,000	$60,000	$79,600	
Subtotal - 1 year				$318,400	
Other Costs					
PM & administrative @ 10%			$31,840		
Contingency @ 10%			$31,840		
Subtotal - 1 year				$382,080	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (5 years)					**$1,661,791**
Years 5 through 30 - every 5 years site visits					
2-person crew	100 HR	$140	$14,000		
Reporting	25 EA	$3,000	$75,000	$89,000	
Other Costs					
PM & administrative @ 10%			$8,900		
Contingency @ 10%			$8,900		
Subtotal - 1 year				$106,800	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (every 5 years for 25 years)					**$217,160**
TOTAL - O&M (30 years)					**$2,500,000**
TOTAL - CAPITAL + O&M (Operational Life = 30 years)					**$2,900,000**

Remedial Alternative G2: LNAPL Collection/Natural Attenuation

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV

Primary Assumptions:

1) LNAPL recovery pumps will installed in existing extraction wells where LNAPL was previously found (MW 10S, MW 19, and MW 20).
2) The LNAPL recovery system operates 50% of the time during a 10-year operating period and recovers 20% groundwater in addition to LNAPL.
3) Groundwater recovered in conjunction with LNAPL recovery and purge water generated during development of wells will be treated onsite and re-injected.
4) Services during construction consist of field oversight (10%) and office support (5%) as percentages of construction cost.
5) Design costs were estimated at 15% of construction costs and include development of plans and specifications for construction of LNAPL recovery system, onsite groundwater treatment system, residential groundwater treatment, abandonment of production wells, installation of injection well, and development of inspection, operation, maintenance, and sampling plans.
6) Recovered LNAPL is collected in a 15,000-gallon tank which is pumped out 4 times for transport and incineration at a Subtitle C TSD facility.
7) The onsite groundwater treatment system operates in conjunction with the LNAPL recovery system. Treated effluent is sampled monthly for TAL metals, chloride, and PCP prior to onsite re-injection.
8) The groundwater monitoring network consists of unconfined monitoring wells (1, 2, 6S, 9, 10S, 13, 16, and 19), semi-confined monitoring wells (3, 4, 5, 7, 8, 10, 12, 14, 15, 17, and 24), and two residential wells.
9) Perimeter monitoring wells are MW 1, 10, 10S, 13, 15, and 24.
10) The groundwater monitoring network will be sampled annually for 5 years and once every 5 years through year 30 while the perimeter monitoring wells will be sampled quarterly for 5 years and annually for years 5 through 30. Laboratory analyses for all groundwater monitoring will consist of PCP, arsenic, copper, zinc, chloride, and natural attenuation parameters (alkalinity, nitrate- and nitrite-nitrogen, sulfate- and sulfide-sulfur, total iron, ferrous and ferric iron, manganese, and chloride). Additional natural attenuation parameters (dissolved oxygen, pH, temperature, specific conductance, oxidation/reduction potential, and carbon dioxide) will be monitored in the field.
11) Net present value for O&M costs calculated using an interest rate of 7%.
12) Costs are in 1998 dollars.

Penta Wood Products Daniels, WI
Remedial Alternatives Costing
Order of Magnitude Comparative Cost Estimate
Project No. 141158.RE.01 Jun-98

Remedial Alternative G3: Groundwater Collection and Treatment

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
CAPITAL COSTS					
CONSTRUCTION COSTS					
Mobilization/Demobilization	1 LS	$15,000.00	$15,000	$15,000	
Construct LNAPL/Groundwater Recovery System					
Install Extraction Wells - 5 @ 140'					
Drilling	700 FT	$150.00	$105,000		
Decontamination	10 HR	$125.00	$1,250		
Recovery Pumps (pneumatic)	5 EA	$5,000.00	$25,000		
Air Piping and Compressor	1 LS	$4,500.00	$4,500		
LNAPL Sensing Probes	4 EA	$1,000.00	$4,000		
Pipe Trenching (2' wide x 36" deep) (LNAPL and Water, same trench)	180 CY	$2.25	$405		
LNAPL Piping	500 FT	$3.00	$1,500		
Groundwater Piping	800 FT	$3.00	$2,400		
Pipe Trench Backfill	180 CY	$2.25	$405		
Controls/Programming	1 LS	$5,000.00	$5,000		
LNAPL Storage Tank (15K tank)	1 EA	$8,500.00	$8,500		
Survey Well Locations	2 DAY	$1,000.00	$2,000		
Start-up	1 LS	$15,000.00	$15,000	$174,960	
Provide Onsite Groundwater Treatment					
Groundwater Treatment Building	1 LS	$54,100.00	$54,100		
Oil-Water Separator	1 LS	$3,900.00	$3,900		
Carbon Filtration	1 LS	$29,600.00	$29,600		
System Controls/Instrumentation	1 LS	$15,680.00	$15,680		
Install Re-injection Well - 1 @ 30 ft bgs	30 FT	$150.00	$4,500		
Pipe Trenching (2' wide x 36" deep)	2200 CY	$2.25	$4,950		
Connecting Piping	9500 FT	$3.00	$28,500		
Pipe Trench Backfill	2200 CY	$2.25	$4,950		
Re-injection Pump	1 EA	$3,250.00	$3,250	$149,430	
Abandon Existing Production Wells (2 @ 170 ft bgs)	340 FT	$35.00	$11,900	$11,900	
Provide GW Treatment for Residents	1 LS	$2,500.00	$2,500	$2,500	
Develop Groundwater Flow and Solute Transport Model	500 HR	$100.00	$50,000	$50,000	
Construction Labor	800 HR	$32.00	$25,600	$25,600	
Construction Subtotal				**$429,390**	
Scope and Bid Contingency @ 25%				**$107,348**	
SUBTOTAL - CONSTRUCTION COSTS				**$536,738**	

Remedial Alternative G3: Groundwater Collection and Treatment

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
IMPLEMENTATION COSTS					
Bid/Performance Bonds				$26,837	
Permitting				$537	
Land Use Deed Restriction Document Development & Legal Fees				$25,000	
Services During Construction				$80,511	
Health and Safety				$1,610	
Report Preparation				$50,000	
Engineering Design Costs				$80,511	
SUBTOTAL - IMPLEMENTATION COSTS				**$238,168**	
TOTAL - CAPITAL COSTS					**$774,906**

OPERATION AND MAINTENANCE COSTS

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
LNAPL/GROUNDWATER RECOVERY SYSTEM OPERATION					
Annual System Maintenance			$2,586		
Electric	1 LS	$5,000.00	$5,000		
Load, transport, and incinerate LNAPL (1k gal)	750 LBS	$0.27	$203		
Sample Treated Water Prior to Reinjection	12 MO	$350	$4,200		
Part-time operator 16 hrs/week	832 HR	$30	$24,960		
Carbon Exchange Service	1 YR	$19,600	$19,600	$56,548	
Other Costs					
PM & Administrative @ 10%			$5,655		
Contingency @ 10%			$5,655		
Subtotal - 1 year				$67,858	
SUBTOTAL - O&M, LNAPL Recovery System (10 years, LNAPL offloaded and incinerated 4 times)					**$465,780**
ENVIRONMENTAL MONITORING					
Monitoring Well Sampling - annually for 5 years and once every 5 years through year 30					
One Sampling Event - 21 samples					
Laboratory Analyticals	21 EA	$340	$7,140		
Monitoring Equipment	1 LS	$500	$500		
Sampling Equipment	1 LS	$200	$200	$7,840	
Other Costs					
PM & administrative @ 10%			$784		
Contingency @ 10%			$784		
Subtotal - Groundwater Sampling, 1 year				$9,408	
SUBTOTAL - O&M, Groundwater Sampling (10 sampling events, 30 years)					**$53,495**

Remedial Alternative G3: Groundwater Collection and Treatment

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
Perimeter Monitoring Well Sampling - quarterly for 5 years, annually for 25 years					
One Sampling Event - 6 samples					
Laboratory Analyticals	8 EA	$340	$2,720		
Sampling Equipment	1 LS	$200	$200	$2,920	
Other Costs					
PM & administrative @ 10%			$292		
Contingency @ 20%			$584		
Subtotal - Groundwater Sampling, 1 event				$3,796	
Subtotal - Groundwater Sampling, 1 year				$15,184	
Update Solute Transport Model Annually	56 HR	$100	$5,600	$5,600	
Subtotal - 1 year				$20,784	
SUBTOTAL - O&M, Groundwater Sampling (20 sampling events, 5 years)					**$113,308**
SUBTOTAL - O&M, Groundwater Sampling (25 sampling events, 25 years)					**$147,588**
INSPECTION, MONITORING, AND REPORTING					
First 5 Years - quarterly site visits					
2-person crew	140 HR	$140	$19,600		
Reporting	20 EA	$3,000	$60,000	$79,600	
Subtotal - 1 year				$318,400	
Other Costs					
PM & administrative @ 10%			$31,840		
Contingency @ 10%			$31,840		
Subtotal - 1 year				$382,080	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (5 years)					**$1,661,791**
Years 5 through 30 - every 5 years site visits					
2-person crew	100 HR	$140	$14,000		
Reporting	25 EA	$3,000	$75,000	$89,000	
Other Costs					
PM & administrative @ 10%			$8,900		
Contingency @ 10%			$8,900		
Subtotal - 1 year				$106,800	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (every 5 years for 25 years)					**$217,160**
TOTAL - O&M (30 years)					**$2,700,000**
TOTAL - CAPITAL + O&M (Operational Life = 30 years)					**$3,500,000**

Remedial Alternative G3: Groundwater Collection and Treatment

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV

Primary Assumptions:

2) LNAPL recovery pumps will be installed near existing extraction wells where LNAPL was previously found (MW 10S, MW 19, and MW 20).
3) The LNAPL recovery system operates 50% of the time during a 10-year operating period and recovers 20% groundwater in addition to LNAPL.
4) Purge water generated during development of wells will be treated onsite and re-injected.
5) Services during construction consist of field oversight (10%) and office support (5%) as percentages of construction cost.
6) Design costs were estimated at 15% of construction costs and include development of plans and specifications for construction of LNAPL/groundwater recovery system, onsite groundwater treatment system, residential groundwater treatment, abandonment of production wells, installation of injection well, and development of inspection, operation, maintenance, and sampling plans.
7) Recovered LNAPL is collected in a 15,000-gallon tank which is pumped out 4 times for transport and incineration at a Subtitle C TSD facility.
8) The onsite groundwater treatment system operates in conjunction with the LNAPL recovery system. Treated effluent is sampled monthly for arsenic, zinc, copper, iron, manganese, chloride, and PCP prior to onsite re-injection.
9) The groundwater monitoring network consists of unconfined monitoring wells (1, 2, 6S, 9, 10S, 13, 16, and 19), semi-confined monitoring wells (3, 4, 5, 7, 8, 10, 12, 14, 15, 17, and 24), and two residential wells.
10) Perimeter monitoring wells are MW 1, 10, 10S, 13, 15, and 24.
11) The groundwater monitoring network will be sampled annually for 5 years and once every 5 years through year 30 while the perimeter monitoring wells will be sampled quarterly for 5 years and annually for years 5 through 30. Laboratory analyses for all groundwater monitoring will consist of PCP, arsenic, copper, zinc, chloride, and natural attenuation parameters (alkalinity, nitrate- and nitrite-nitrogen, sulfate- and sulfide-sulfur, total iron, ferrous and ferric iron, manganese, and chloride). Additional natural attenuation parameters (dissolved oxygen, pH, temperature, specific conductance, oxidation/reduction potential, and carbon dioxide) will be monitored in the field.
12) Drilling includes costs associated with well materials, aboveground completions, and well development.
13) Net present value for O&M costs calculated using an interest rate of 7%.
14) Costs are in 1998 dollars.

Penta Wood Products Daniels, WI

Remedial Alternatives Costing

Order of Magnitude Comparative Cost Estimate

Project No. 141158.RE.01 Jun-98

Remedial Alternative G4: Groundwater Collection and Treatment Throughout Plume

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
		CAPITAL COSTS			
CONSTRUCTION COSTS					
Mobilization/Demobilization	1 LS	$15,000.00	$15,000	$15,000	
Pre-design Activities	1 LS	$30,000.00	$30,000	$30,000	
Construct LNAPL/Groundwater Recovery System					
Install Extraction Wells - 17 @ 140'					
Drilling w/o sampling	2380 FT	$150.00	$357,000		
Decontamination	30 HR	$125.00	$3,750		
Recovery Pumps (pneumatic)	17 EA	$5,000.00	$85,000		
Air Piping and Compressor	1 LS	$4,500.00	$4,500		
LNAPL Sensing Probes	4 EA	$1,000.00	$4,000		
Pipe Trenching (2' wide x 36" deep)	950 CY	$2.25	$2,138		
(LNAPL and Water, same trench)					
LNAPL Piping	500 FT	$3.00	$1,500		
Groundwater Piping	4100 FT	$3.00	$12,300		
Pipe Trench Backfill	950 CY	$2.25	$2,138		
Controls/Programming	1 LS	$5,000.00	$5,000		
LNAPL Storage Tank (15K tank)	1 EA	$8,500.00	$8,500		
Survey Well Locations	4 DAY	$1,000.00	$4,000		
Start-up	1 LS	$15,000.00	$15,000	$504,825	
Provide Onsite Groundwater Treatment					
Groundwater Treatment Building	1 LS	$162,300.00	$162,300		
Oil-Water Separator	1 LS	$11,700.00	$11,700		
Carbon Filtration	1 LS	$88,800.00	$88,800		
System Controls/Instrumentation	1 LS	$47,040.00	$47,040		
Install Re-injection Well - 1 @ 30 ft bgs	30 FT	$150.00	$4,500		
Pipe Trenching (2' wide x 36" deep)	2200 CY	$2.25	$4,950		
Connecting Piping	9500 FT	$3.00	$28,500		
Pipe Trench Backfill	2200 CY	$2.25	$4,950		
Re-injection Pump	1 EA	$3,250.00	$3,250	$93,190	
Abandon Existing Production Wells	340 FT	$35.00	$11,900	$11,900	
(2 @ 170 ft bgs)					
Provide GW Treatment for Residents	1 LS	$2,500.00	$2,500	$2,500	
Develop Groundwater Flow and Solute Transport Model	500 HR	$100.00	$50,000	$50,000	
Construction Labor	1300 HR	$32.00	$41,600	$41,600	
Construction Subtotal				**$749,015**	
Scope and Bid Contingency @25%				**$187,254**	
SUBTOTAL - CONSTRUCTION COSTS				**$936,269**	

Remedial Alternative G4: Groundwater Collection and Treatment Throughout Plume

Component Description	Quantity		Unit Price	Component Cost	Category Subtotal	NPV
IMPLEMENTATION COSTS						
Bid/Performance Bonds					$46,813	
Permitting					$936	
Land Use Deed Restriction Document Development & Legal Fees					$25,000	
Services During Construction					$140,440	
Health and Safety					$2,809	
Report Preparation					$50,000	
Engineering Design Costs					$140,440	
SUBTOTAL - IMPLEMENTATION COSTS					**$359,626**	
TOTAL - CAPITAL COSTS						**$1,295,894**
OPERATION AND MAINTENANCE COSTS						
LNAPL/GROUNDWATER RECOVERY SYSTEM OPERATION						
Annual System Maintenance				$6,254		
Electric	1	LS	$5,000.00	$5,000		
Load, transport, and incinerate LNAPL (1k gal)	750	LBS	$0.27	$203		
Sample Treated Water Prior to Reinjection	12	MO	$350	$4,200		
Carbon Exchange Service	1	YR	$19,600	$19,600	$35,256	
Part-time operator 16 hrs/week	832	HR	$30	$24,960	$48,760	
Other Costs						
PM & Administrative @ 10%				$3,526		
Contingency @ 20%				$7,051		
Subtotal - 1 year					$45,833	
SUBTOTAL - O&M, LNAPL/ Groundwater Recovery System (30 years)						**$541,307**
ENVIRONMENTAL MONITORING						
Monitoring Well Sampling - annually for 5 years and once every 5 years through year 30						
One Sampling Event - 21 samples						
Laboratory Analyticals	21	EA	$340	$7,140		
Monitoring Equipment	1	LS	$500	$500		
Sampling Equipment	1	LS	$200	$200	$7,840	
Other Costs						
PM & administrative @ 10%				$784		
Contingency @ 20%				$1,568		
Subtotal - Groundwater Sampling, 1 year					$10,192	
SUBTOTAL - O&M, Groundwater Sampling (10 sampling events, 30 years)						**$57,953**

Remedial Alternative G4: Groundwater Collection and Treatment Throughout Plume

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
Perimeter Monitoring Well Sampling - quarterly for 5 years, annually for 25 years					
One Sampling Event - 6 samples					
Laboratory Analyticals	8 EA	$340	$2,720		
Sampling Equipment	1 LS	$200	$200	$2,920	
Other Costs					
PM & administrative @ 10%			$292		
Contingency @ 20%			$584		
Subtotal - Groundwater Sampling, 1 event				$3,796	
Subtotal - Groundwater Sampling, 1 year				$15,184	
Update Solute Transport Model Annually	56 HR	$100	$5,600	$5,600	
Subtotal - 1 year				$20,784	
SUBTOTAL - O&M, Groundwater Sampling (20 sampling events, 5 years)					**$113,308**
SUBTOTAL - O&M, Groundwater Sampling (25 sampling events, 25 years)					**$147,588**
INSPECTION, MONITORING, AND REPORTING					
First 5 Years - quarterly site visits					
2-person crew	140 HR	$140	$19,600		
Reporting	20 EA	$3,000	$60,000	$79,600	
Subtotal - 1 year				$318,400	
Other Costs					
PM & administrative @ 10%			$31,840		
Contingency @ 20%			$63,680		
Subtotal - 1 year				$413,920	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (5 years)					**$1,800,273**
Years 5 through 30 - site visits every 5 years					
2-person crew	100 HR	$140	$14,000		
Reporting	25 EA	$3,000	$75,000	$89,000	
Other Costs					
PM & administrative @ 10%			$8,900		
Contingency @ 20%			$17,800		
Subtotal - 1 year				$115,700	
SUBTOTAL - O&M, Inspection, Monitoring, and Reporting (every 5 years for 25 years)					**$235,256**
TOTAL - O&M (30 years)					**$2,900,000**
TOTAL - CAPITAL + O&M (Operational Life = 30 years)					**$4,200,000**

Remedial Alternative G4: Groundwater Collection and Treatment Throughout Plume

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV

Primary Assumptions:

1) Pre-design activities may consist of activities such as pilot studies, pump testing, and/or laboratory studies.
2) LNAPL recovery pumps will installed in existing extraction wells where LNAPL was previously found (MW 10S, MW 19, and MW 20).
3) The LNAPL recovery system operates 50% of the time during a 10-year operating period and recovers 20% groundwater in addition to LNAPL.
4) Purge water generated during development of wells will be treated onsite and re-injected.
5) Services during construction consist of field oversight (10%) and office support (5%) as percentages of construction cost.
6) Design costs were estimated at 15% of construction costs and include development of plans and specifications for construction of LNAPL/groundwater recovery system, onsite groundwater treatment system, residential groundwater treatment, abandonment of production wells, installation of injection well, and development of inspection, operation, maintenance, and sampling plans.
7) Recovered LNAPL is collected in a 15,000-gallon tank which is pumped out 4 times for transport and incineration at a Subtitle C TSD facility.
8) Groundwater extraction occurs at an estimated rate of 10 gpm per well.
9) The onsite groundwater treatment system operates in conjunction with the LNAPL recovery system. Treated effluent is sampled monthly for arsenic, zinc, copper, iron, manganese, chloride, and PCP prior to onsite re-injection.
10) The groundwater monitoring network consists of unconfined monitoring wells (1, 2, 6S, 9, 10S, 13, 16, and 19), semi-confined monitoring wells (3, 4, 5, 7, 8, 10, 12, 14, 15, 17, and 24), and two residential wells.
11) Perimeter monitoring wells are MW 1, 10, 10S, 13, 15, and 24.
12) The groundwater monitoring network will be sampled annually for 5 years and once every 5 years through year 30 while the perimeter monitoring wells will be sampled quarterly for 5 years and annually for years 5 through 30. Laboratory analyses for all groundwater monitoring will consist of PCP, arsenic, copper, zinc, chloride, and natural attenuation parameters (alkalinity, nitrate- and nitrite-nitrogen, sulfate- and sulfide-sulfur, total iron, ferrous and ferric iron, manganese, and chloride). Additional natural attenuation parameters (dissolved oxygen, pH, temperature, specific conductance, oxidation/reduction potential, and carbon dioxide) will be monitored in the field.
13) Drilling includes costs associated with well materials, aboveground completions, and well development.
14) Net present value for O&M costs calculated using an interest rate of 7%.
15) Costs are in 1998 dollars.

Remedial Alternatives Costing
Order of Magnitude Comparative Cost Estimate
Project No. 141158.RE.01 Jun-98

Remedial Alternative G5:
Steam Injection With SVE for the LNAPL Residual Zone

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
CAPITAL COSTS					
CONSTRUCTION COSTS					
Mobilization/Demobilization	1 LS	$25,000	$25,000	$25,000	
Pre-design Activities	1 LS	$100,000	$100,000	$100,000	
Construct Steam Stripping Injection System					
Install Injection/Extraction Wells - 75 @ 110 ft bgs					
Drilling w/o sampling	13200 FT	$55.00	$726,000		
4" dia. Steel screen	1200 FT	$50.00	$60,000		
4" dia. Steel riser	12000 FT	$20.00	$240,000		
Decontamination	65 HR	$125.00	$8,125		
Blower for SVE	1 EA	$50,000.00	$50,000		
Boiler w/ water pre-treatment system	1 EA	$200,000.00	$200,000		
Condensate/decant system	1 EA	$300,000.00	$300,000		
Catalytic Oxidizer for Air Treatment	1 EA	$100,000.00	$100,000		
Propane tank - 30,000 gallon	4 EA	$100,000.00	$400,000	$2,084,125	
Install GW/LNAPL Recovery System					
--assuming treating one cell at a time and re-using same equipment for next cell					
Recovery Pumps (pneumatic)	8 EA	$5,000.00	$40,000		
Air Piping and Compressor	1 LS	$4,500.00	$4,500		
LNAPL Sensing Probes	8 EA	$1,000.00	$8,000		
Connecting Piping (LNAPL and Water, same trench)	500 FT	$3.00	$1,500		
LNAPL Storage Tank (15K tank)	1 EA	$8,500.00	$8,500		
Controls/Programming	1 LS	$5,000.00	$5,000	$67,500	
Provide Onsite Groundwater Treatment					
Groundwater Treatment Building	1 EA	$54,100.00	$54,100		
Oil-Water Separator	1 LS	$20,000.00	$20,000		
Carbon Filtration	1 LS	$50,000.00	$50,000		
System Controls/Instrumentation	10 EA	$4,000.00	$40,000		
Install Boiler Make-up and Re-injection Wells -	60 FT	$150.00	$9,000		
Pipe Trenching (2' wide x 36" deep)	4400 CY	$2.25	$9,900		
Connecting Piping	13500 FT	$3.00	$40,500		
Pipe Trench Backfill	4400 CY	$2.25	$9,900		
Pumps	4 EA	$3,250.00	$13,000	$246,400	
Abandon Existing Production Wells (2 @ 170 ft bgs)	340 FT	$35.00	$11,900	$11,900	
Provide GW Treatment for Residents	1 LS	$2,500.00	$2,500	$2,500	
Develop Groundwater Flow and Solute Transport Model	500 HR	$100.00	$50,000	$50,000	
Construction Labor	2800 HR	$32	$89,600	$89,600	
Construction Subtotal				$2,677,025	
Scope and Bid Contingency @ 25%				$669,256	
SUBTOTAL - CONSTRUCTION COSTS				$3,346,281	

Remedial Alternative G5:
Steam Injection With SVE for the LNAPL Residual Zone

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
IMPLEMENTATION COSTS					
Bid/Performance Bonds				$167,314	
Permitting				$3,346	
Services During Construction				$501,942	
Health and Safety				$10,039	
Report Preparation				$50,000	
Engineering Design Costs				$501,942	
SUBTOTAL - IMPLEMENTATION COSTS				**$1,234,584**	
TOTAL - CAPITAL COSTS					**$4,580,865**

OPERATION AND MAINTENANCE COSTS

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
STEAM INJECTION SYSTEM OPERATION					
Manpower to operate sytem for one year	4320 HR	$50	$216,000		
Electrical	1 YR	$61,320	$61,320		
Propane for steam generation	1320000 GAL	$0.50	$660,000		
Water treatment Costs ($100/month - Bo Stewart)	12 MTH	$100	$1,200		
Part-time operator (16 hr/week)	832 HR	$30	$24,960		
Carbon Replacement (Carbonair)	1 YR	$40,000	$40,000	$1,003,480	
Other Costs					
PM & Administrative @ 10%			$100,348		
Contingency @ 20%			$200,696		
Subtotal - 1year				$1,304,524	
SUBTOTAL - O&M, Steam Injection System Operation (7.5 years, NPV)					**$7,828,021**
GW/LNAPL RECOVERY SYSTEM OPERATION					
Annual System Maintenance			$3,375		
Load, transport, and incinerate LNAPL (65,000 gal/	20 LDS		$165,000		
Sample Treated Water Prior to Reinjection	12 MO	$350	$4,200	$172,575	
Other Costs					
PM & Administrative @ 10%			$17,258		
Contingency @ 20%			$34,515		
Subtotal - 1year				$224,348	
SUBTOTAL - O&M, GW/LNAPL Recovery System (7.5 years, LNAPL offloaded and incinerated 100 times)					**$1,346,236**

Remedial Alternative G5:
Steam Injection With SVE for the LNAPL Residual Zone

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV
ENVIRONMENTAL MONITORING					
Monitoring Well Sampling - annually for 5 years and once every 5 years through year 30					
One Sampling Event - 21 samples					
Laboratory Analyticals	21 EA	$340	$7,140		
Monitoring Equipment	1 LS	$500	$500		
Sampling Equipment	1 LS	$200	$200	$7,840	
Other Costs					
PM & administrative @ 10%			$784		
Contingency @ 20%			$1,568		
Subtotal - Groundwater Sampling, 1 year				$10,192	
SUBTOTAL - O&M, Groundwater Sampling (10 sampling events, 30 years)					$57,953
Perimeter Monitoring Well Sampling - quarterly for 5 years, annually for 25 years					
One Sampling Event - 6 samples					
Laboratory Analyticals	8 EA	$340	$2,720		
Sampling Equipment	1 LS	$200	$200	$2,920	
Other Costs					
PM & administrative @ 10%			$292		
Contingency @ 20%			$584		
Subtotal - Groundwater Sampling, 1 event				$3,796	
Subtotal - Groundwater Sampling, 1 year				$15,184	
Update Solute Transport Model Annually	56 HR	$100	$5,600	$5,600	
Subtotal - 1 year				$20,784	
SUBTOTAL - O&M, Groundwater Sampling (20 sampling events, 5 years)					$113,308
TOTAL - O&M (30 years)					$9,300,000
TOTAL - CAPITAL + O&M (Operational Life = 30 years)					$13,900,000

Remedial Alternative G5: Steam Injection With SVE for the LNAPL Residual Zone

Component Description	Quantity	Unit Price	Component Cost	Category Subtotal	NPV

Primary Assumptions:

1) Pre-design activities may consist of activities such as pilot studies, pump testing, and/or laboratory studies.
2) Purge water generated during development of wells will be treated onsite and re-injected.
3) Services during construction consist of field oversight (10%) and office support (5%) as percentages of construction cost.
4) Design costs were estimated at 15% of construction costs and include development of plans and specifications for construction of LNAPL/groundwater recovery system, onsite groundwater treatment system, residential groundwater treatment, abandonment of production wells, installation of injection well, and development of inspection, operation, maintenance, and sampling plans.
5) Recovered LNAPL is collected in a 15,000-gallon tank which is pumped out 20 times per year for five years for transport and incineration at a Subtitle C TSD facility.
6) The onsite groundwater treatment system operates in conjunction with the LNAPL recovery system. Treated effluent is sampled monthly for arsenic, zinc, copper, iron, manganese, chloride, and PCP prior to onsite re-injection.
7) The groundwater monitoring network consists of unconfined monitoring wells (1, 2, 6S, 9, 10S, 13, 16, and 19), semi-confined monitoring wells (3, 4, 5, 7, 8, 10, 12, 14, 15, 17, and 24), and two residential wells.
8) Perimeter monitoring wells are MW 1, 10, 10S, 13, 15, and 24.
9) The groundwater monitoring network will be sampled annually for 5 years and once every 5 years through year 30 while the perimeter monitoring wells will be sampled quarterly for 5 years and annually for years 5 through 30. Laboratory analyses for all groundwater monitoring will consist of PCP, arsenic, copper, zinc, chloride, and natural attenuation parameters (alkalinity, nitrate- and nitrite-nitrogen, sulfate- and sulfide-sulfur, total iron, ferrous and ferric iron, manganese, and chloride). Additional natural attenuation parameters (dissolved oxygen, pH, temperature, specific conductance, oxidation/reduction potential, and carbon dioxide) will be monitored in the field.
10) Net present value for O&M costs calculated using an interest rate of 7%.
11) Costs are in 1998 dollars.