PUBLIC COMMENT
PHASED FEASIBILITY STUDY REPORT

FOR THE

TAR LAKE SUPERFUND SITE

ANTRIM COUNTY, MICHIGAN

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1.0 INTRODUCTION

This Phased Feasibility Study (PFS) report for the Tar Lake Superfund Site in Antrim County, Michigan presents and evaluates the operable unit remedial alternatives to address environmental contamination and public health risks resulting from releases or potential releases from Tar Lake. The report provides the U.S. Environmental Protection Agency (U.S. EPA) with the information necessary for selection of a cost-effective remedial action alternative in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

The NCP is explicit in its stated support of the "bias for action" approach on Superfund Sites. The "operable unit" is an outgrowth of this concept and is defined in the NCP Section 300.5 as "...discrete action that comprises an incremental step toward comprehensively addressing site problems...". U.S. EPA decided that for proper management of the Tar Lake Site in an effort to expeditiously implement Site remedy for protection of public health and the environment, an operable unit was a prudent and appropriate measure to take. The Remedial Action objective is to eliminate and/or significantly reduce public health and environmental threats resulting from releases or potential releases from Tar Lake. To achieve the objective of this interim action, two components are examined. The first component is source control. The second component concerns an interim groundwater remedy. The objective of the second component is to prevent further migration of the contaminant plume.

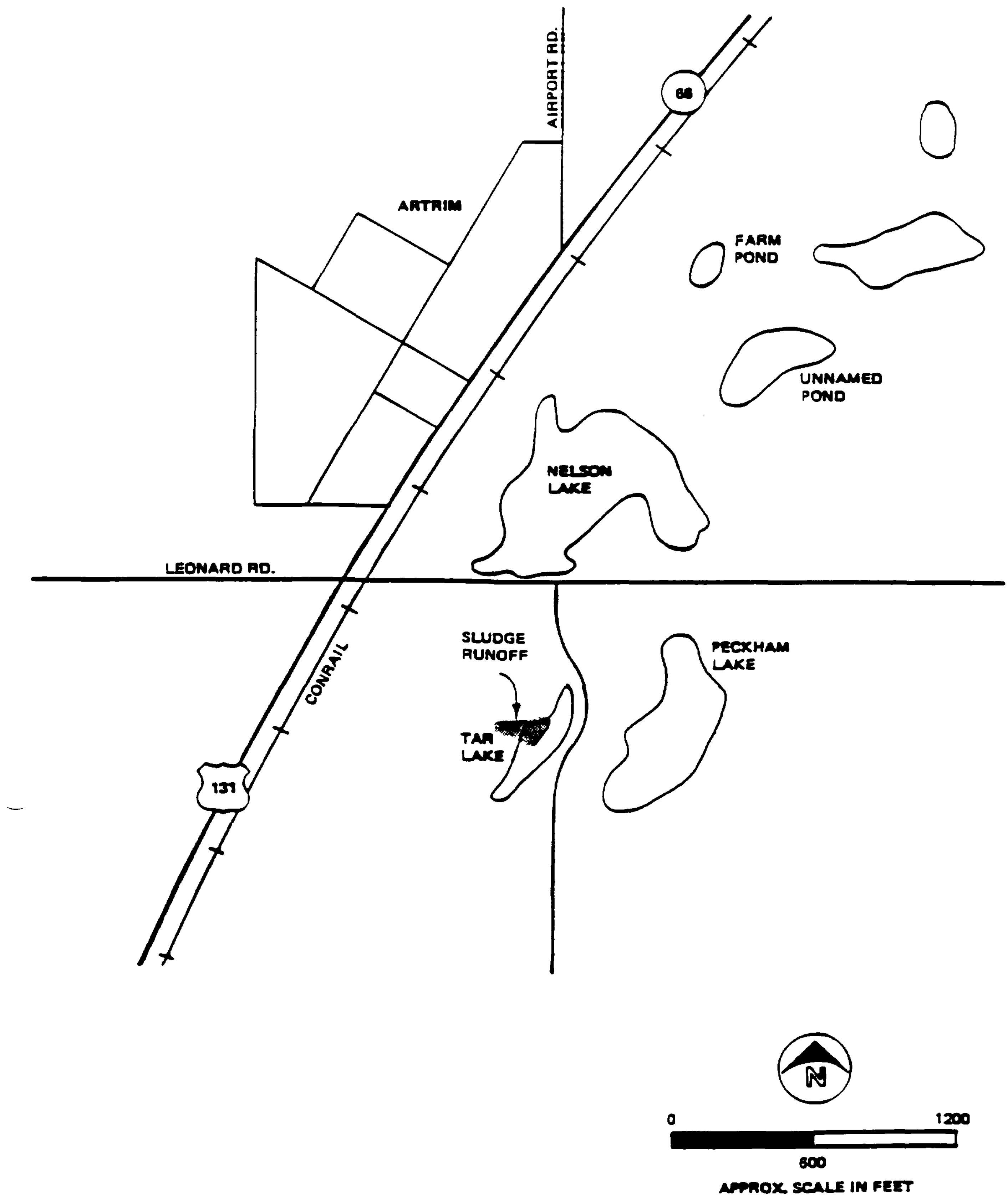
The PFS for Tar Lake is streamline in nature. No alternatives screening step is utilized. As allowed in the NCP, a few alternatives are evaluated in detail.

1.1 SITE DESCRIPTION

The Tar Lake Site is located in Antrim County, Michigan. The Site occupies over 200 acres just east of Highway 131, approximately one mile south of Mancelona, Michigan. It is situated in a rural area near the village of Antrim. The source area, essentially Tar Lake itself, covers over 4 acres areally and is up to 27 feet deep, containing tar and water. Some of the soil surrounding Tar Lake is also contaminated with residual tar material.

Figure 1 shows many of the relevant physical site features and surrounding land. The Site itself is characterized by severe topographic relief. No permanent or intermittent streams are present and there appears to be no surface run-off from the Site. Site features include Tar Lake, slag piles, limestone piles, one sludge pile on the west side of Tar Lake, and the remains of tank supports and cooling water ditches. Tar Lake, itself, is a large surface depression that was partially filled in with the disposal of tar-like residuals from a wood charcoal production operation, and as a result became known as "Tar Lake". There is no evidence

FIGURE 1 Physical Site Features



From Figure 2-3, Remedial Action Master Plan, Tar Lake Site, CH2M Hill/E&E, April 30, 1984 of containerized wastes present. The Site is characterized by a chemical odor. Tar Lake appears to have shrunk by more than 50% since the 1930's according to an evaluation of aerial photographs. It has been reported that Tar Lake caught fire in the 1960s and burned for an unspecified period before being extinguished by natural action. The fire may ultimately be responsible for some shrinkage considered to have occurred at Tar Lake.

1.2 BACKGROUND

From 1882 to 1945, the Site was the location of iron production by the charcoal method. In 1910, the Antrim Iron Works Company began producing charcoal in sealed retorts from which pyroligenous liquor was recovered. This liquor was further processed into calcium acetate, methanol, acetone, creosote oil, and wood tar. This secondary chemical manufacturing process produced a waste equivalent to still bottoms which was discharged into a natural depression on-site, i.e. Tar Lake. The chemical plant operated until 1944.

In 1985, Ensafe prepared a Remedial Investigation/Feasibility Study (RI/FS) work plan for 56th Century Antrim Iron Works Company (56th Century), a Potentially Responsible Party (PRP) at Tar Lake. The final work plan was completed on January 15, 1986. This final work plan was incorporated into a Consent Order between 56th Century and U.S. EPA which was effective on April 21, 1986. Under the Consent Order, 56th Century was to conduct an RI/FS at Tar Lake. The work plan had the RI being conducted in two phases. The first phase was the development of a preliminary endangerment assessment (PEA) which would include limited groundwater sampling. The second phase, yet to be conducted, would be a more detailed investigation based on the findings and results of the PEA.

During the Phase I RI work, deep and shallow monitoring wells were installed and a specialized analytical protocol for low level phenolics was developed. In January 1988, sampling and analysis of Tar Lake groundwater was performed using the special analytical protocol and Contract Laboratory Program (CLP) Routine Analytical Service (RAS) organic and inorganic parameters. The results, which became available in May 1988, confirmed the presence of classes of phenolic compounds, but did not identify specific constituents. Four of the groundwater samples that were collected and analyzed from on-site wells could not be properly quantified because of unexpectedly high concentrations. CLP RAS samples indicated concentrations near or below Contract Required Detection Limits for benzene, naphthalene, toluene, and ethylbenzene in three of eight wells. The PEA was submitted on October 4, 1988. The PEA concluded that based on available data, the phenols in the groundwater posed no endangerment at the concentrations found. U.S. EPA found the PEA to be deficient because U.S. EPA believed it inadequately and incompletely used data collected, and the Agency believed the conclusions drawn were not adequately supported; and consequently, U.S. EPA did not approve the PEA.

Additional work at the Site was performed to evaluate the nature and extent of contamination in the soil and groundwater underneath Tar Lake. The final soil boring and monitoring well installation work plan was submitted to U.S. EPA by 56th Century's consultant, Ensafe, on September 13, 1989. These recent investigations provide evidence that Tar Lake is a continuing source of contamination to the groundwater at the Site. The depth sounding survey has revealed that part of Tar Lake is actually 10 feet below the groundwater table and is over 26 feet deep in the western part of Tar Lake. The sampling and analyses have established a relationship between the tar and the groundwater underneath Tar Lake. Over 50 identified or tentatively identified compounds from Tar Lake are found in the groundwater. Two substances of note are benzene and styrene. Benzene was found in the tar at 1.2 parts per million (ppm) and in the groundwater at 0.43 ppm and 0.04 ppm. These groundwater concentrations of benzene are above the Safe Drinking Water Maximum Contaminant Level (MCL) of 0.005 ppm. It should be noted that benzene was found previously in a monitoring well sampled for the Preliminary Endangerment Assessment but it was attributed to possible gasoline contamination and was not addressed further in the PEA. U.S. EPA's position was that estimated positive values for benzene (as well as for napthalene, toluene, ethylbenzene, and xylenes) were found in other wells also. Thus, it was incorrect to dismiss the significance of the presence of this constituent. Styrene was also found in the groundwater at levels above its MCL of 0.005 ppm. The concentration of styrene found was 0.006 ppm and an estimated 0.063 ppm.

The contamination due to the Site extends approximately 3.5 miles down-gradient from the Site as evidenced by taste and odor observations in groundwater monitoring and residential wells made by Michigan Department of Natural Resources (MDNR) staff and the affected residences. Because the tar is a continuing source of contamination to the groundwater, which is a threat to the environment as well as a threat to public health, U.S. EPA has determined that the remediation of Tar Lake through a source control and groundwater containment operable unit is appropriate.

1.3 NATURE AND EXTENT OF CONTAMINATION

This PFS addresses an operable unit dealing with source control and interim groundwater containment. A Remedial Investigation/ Feasibility Study (RI/FS) is concurrently being conducted to study the final groundwater remedy.

Tar Lake is approximately 4 acres in size and is located in a topographical depression. Tar was apparently deposited on the property at the top of a hill and filled in low lying areas and gullies. Because of its age, exposure to air and water, and fire, the tar exists in various physical forms, ranging from viscous liquid to semi-solid. Depth of tar varies from 2 feet to 27 feet, with part of the tar actually 10 feet below the groundwater table as shown in Figures 2 - 4. The tar overlays a soil which is primarily sand and gravel.

The tar exhibits a strong chemical odor. Groundwater downgradient of the Site also exhibits odors which have been attributed to the low odor thresholds of site contaminants.

The Tar Lake site is underlain predominantly by brown medium sand. There are some thin lenses of silt and clay. The groundwater table in the unconfined, glacial outwash aquifer is about 15 to 50 feet below the ground surface. Groundwater flow is generally in a northwesterly direction with a more northerly component on the eastern side of the site as shown in Figure 5. Groundwater contamination extends approximately 3.5 miles down-gradient from the site as shown in Figure 6.

Organic Compound Analyses

The primary investigations of the identity and concentration of organic compounds associated with the Site are as follows:

1983 Colorimetric Analysis for Phenolic Compounds in Groundwater

Qualitative colorimetric tests detected total phenolic compound concentrations in on-site monitoring wells at concentrations ranging from 3 to 64 ug/l.

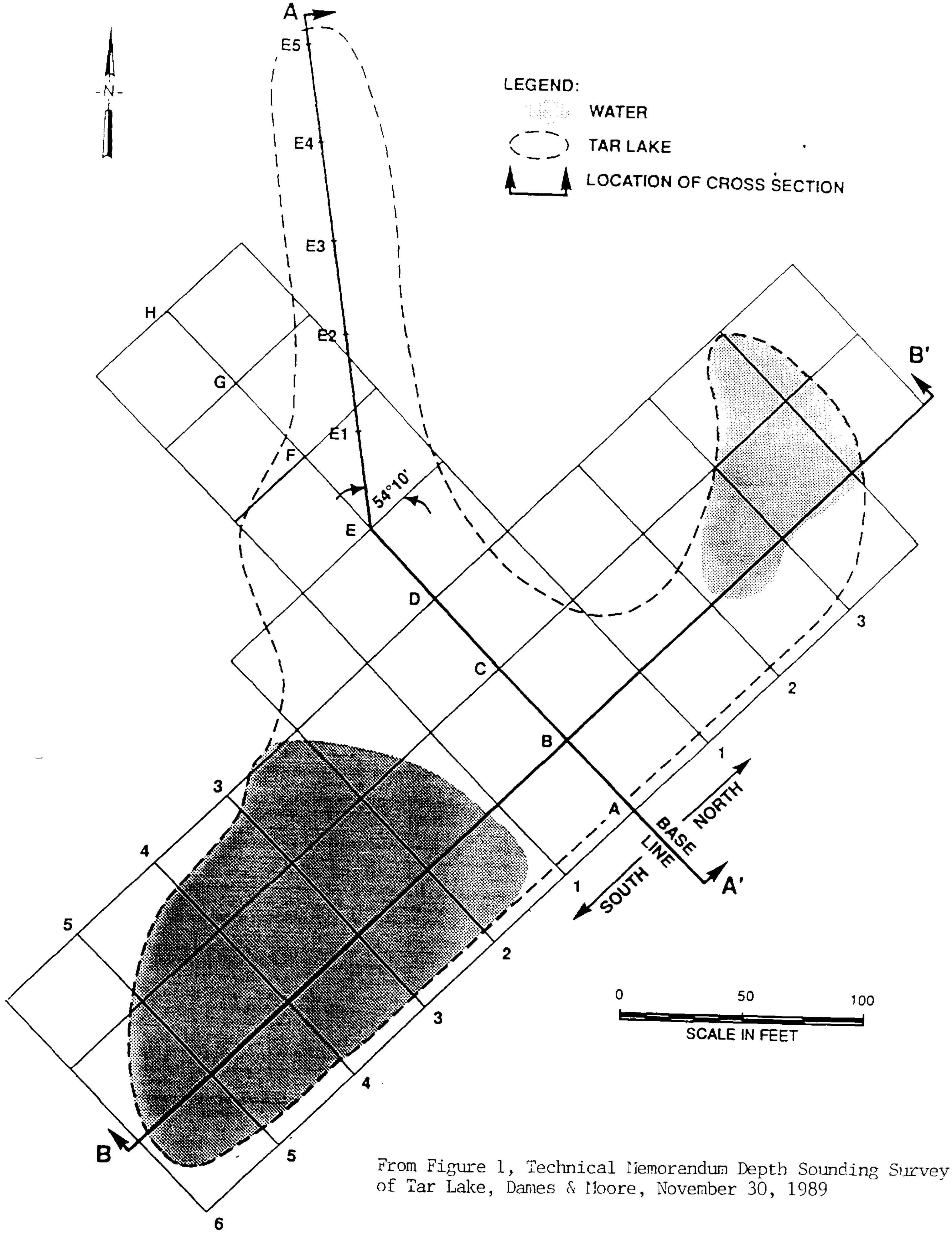
1988 Contract Laboratory Program (CLP) Analysis for Volatile and Semi-Volatile Compounds in Groundwater

Groundwater samples collected from on-site monitoring wells (MW-6, MW-7, MW-11, MW-12, MW-13, MW-14, MW-15, MW-16; Figure 7) were analyzed for volatile and semi-volatile compounds contained in the CLP Target Compound List. Results of these analyses indicated the presence in downgradient wells of three compounds at concentrations exceeding the Contract Required Quantitation Limits: 2,4-dimethylphenol (57-59 ug/l), ethylbenzene (7 ug/l), and total xylenes (7 ug/l). Other compounds tentatively identified in on-site wells included phenols, ketones, alcohols, and esters. Concentrations for the positively identified compounds are summarized in Table 1.

1988 Special Protocol Analysis for Phenols in Groundwater

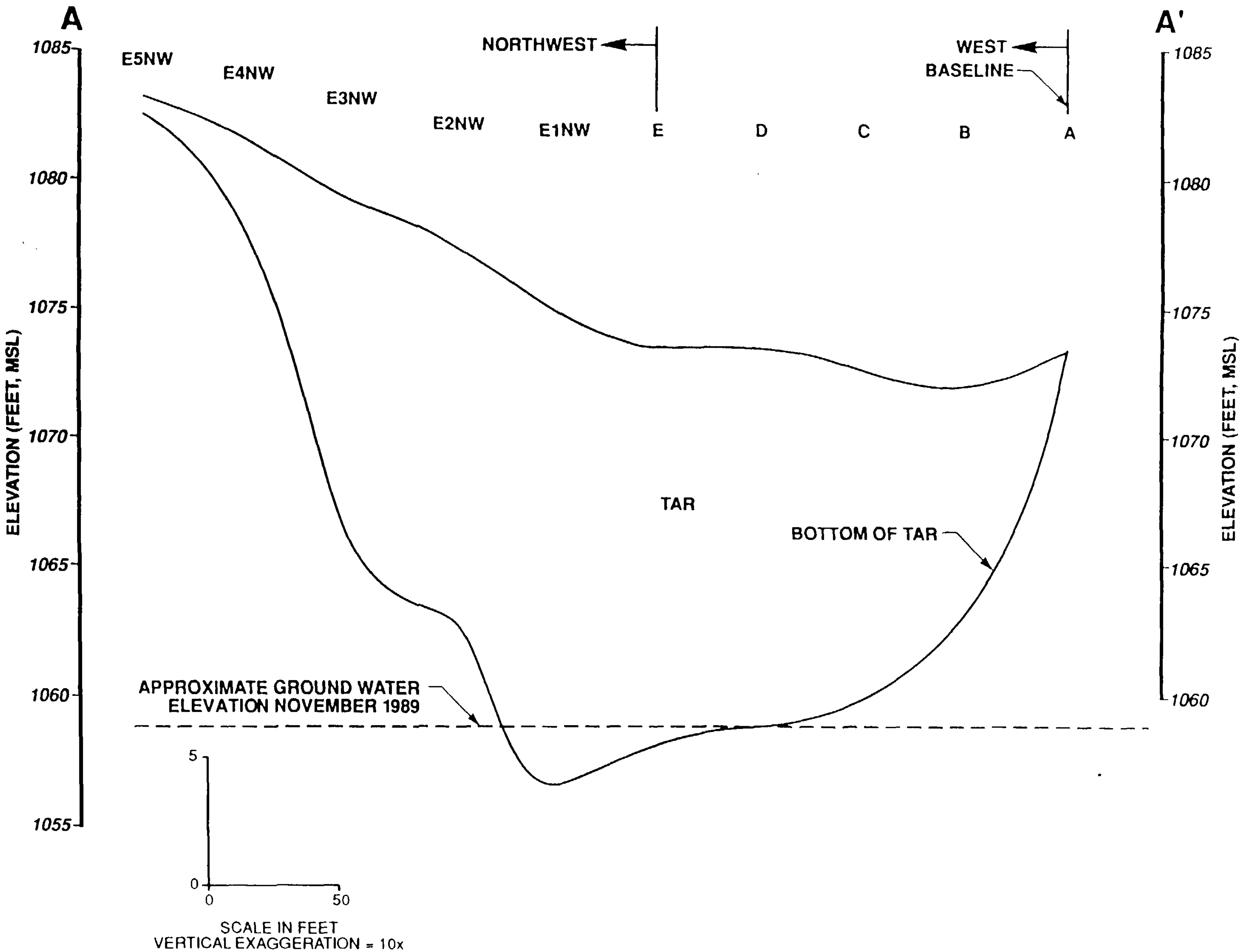
Sampling and special protocol analysis of 28 area wells, predominantly off-site (Figure 8) suggested the presence of a number of alkylphenols in downgradient groundwater. No given alkylphenol was present at concentrations exceeding the quantitation limit for the analysis, 0.8 ug/l.

FIGURE 2 Horizontal Extent of Tar



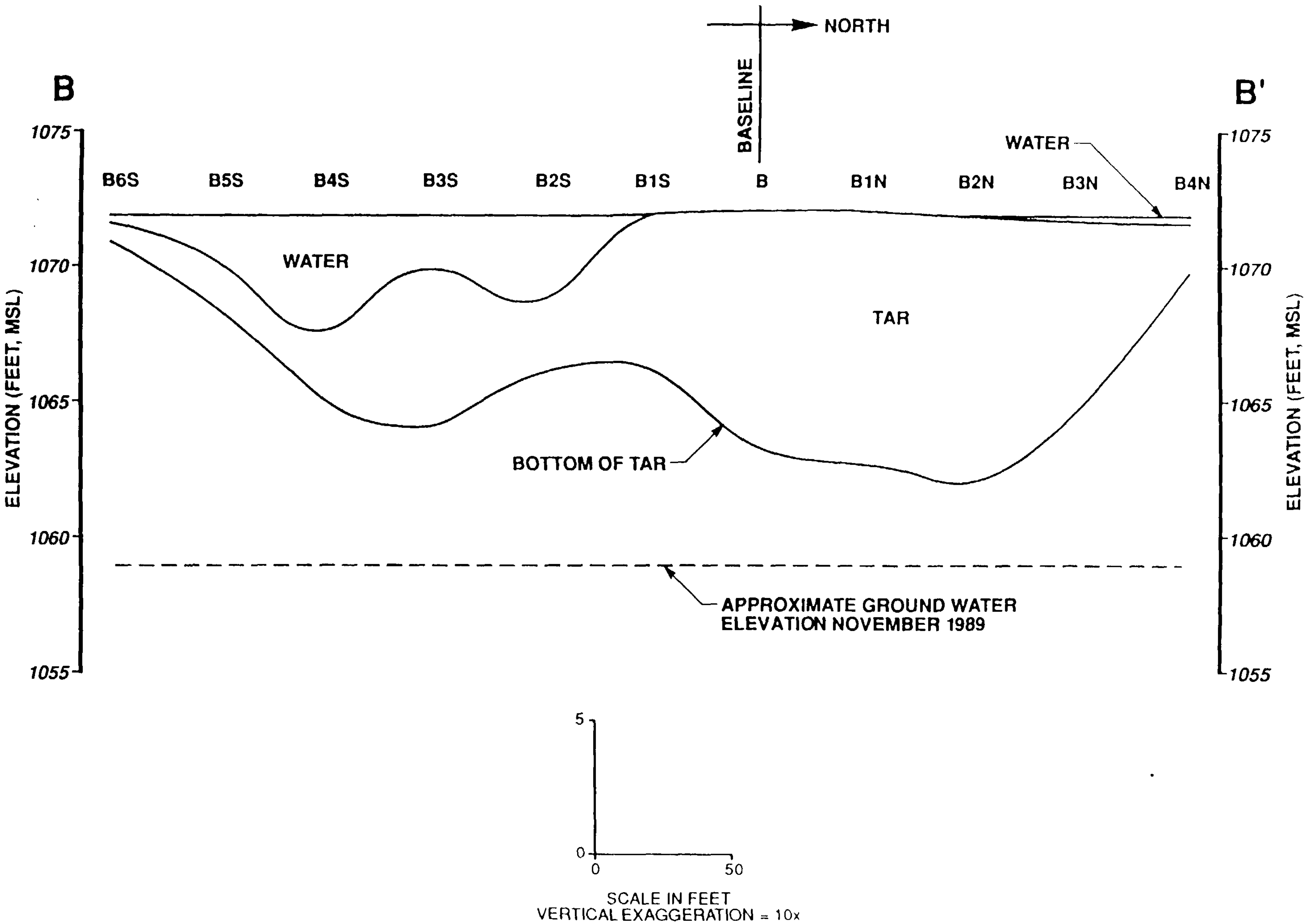
From Figure 1, Technical Memorandum Depth Sounding Survey of Tar Lake, Dames & Moore, November 30, 1989

FIGURE 3 Depth of Tar - A-A' Cross Section



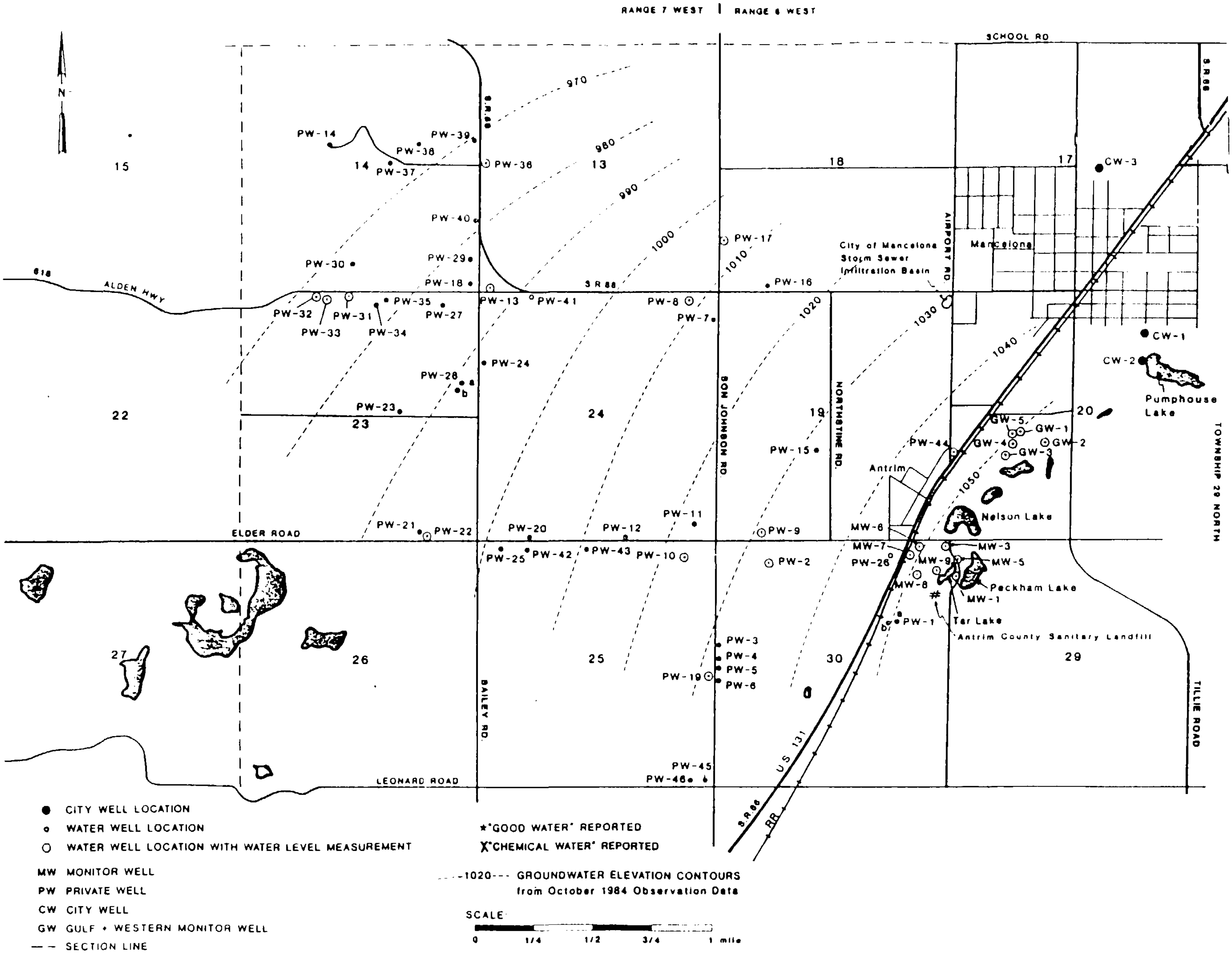
From Figure 6, Technical Memorandum Depth Sounding Survey of Tar Lak[illegible]

FIGURE 4 Depth of Tar - B-B' Cross Section



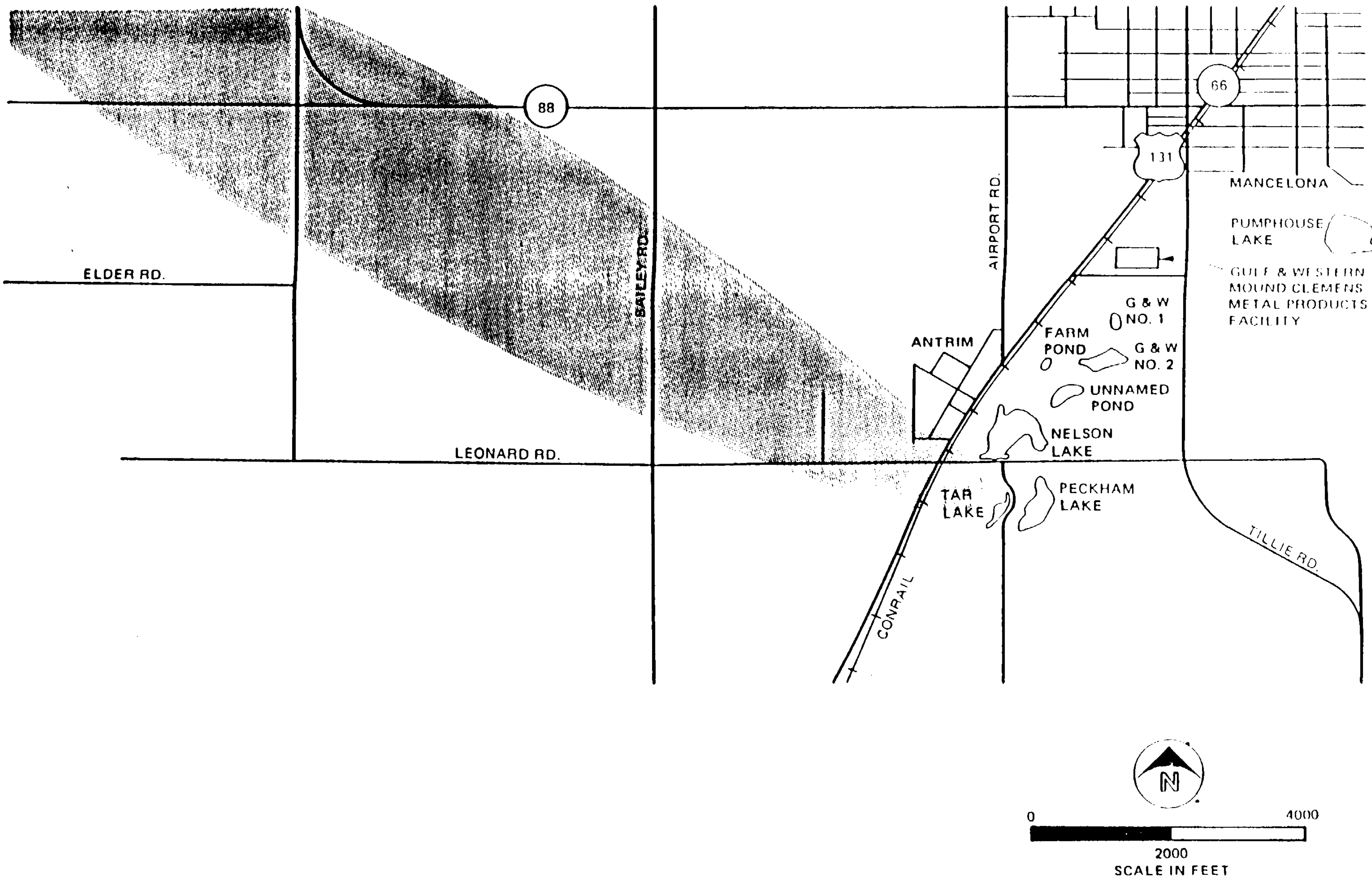
From Figure 7, Technical Memorandum Depth Sounding Survey of Tar Lake, Dames & Moore, November 30, 1989

FIGURE 5 Groundwater Flow



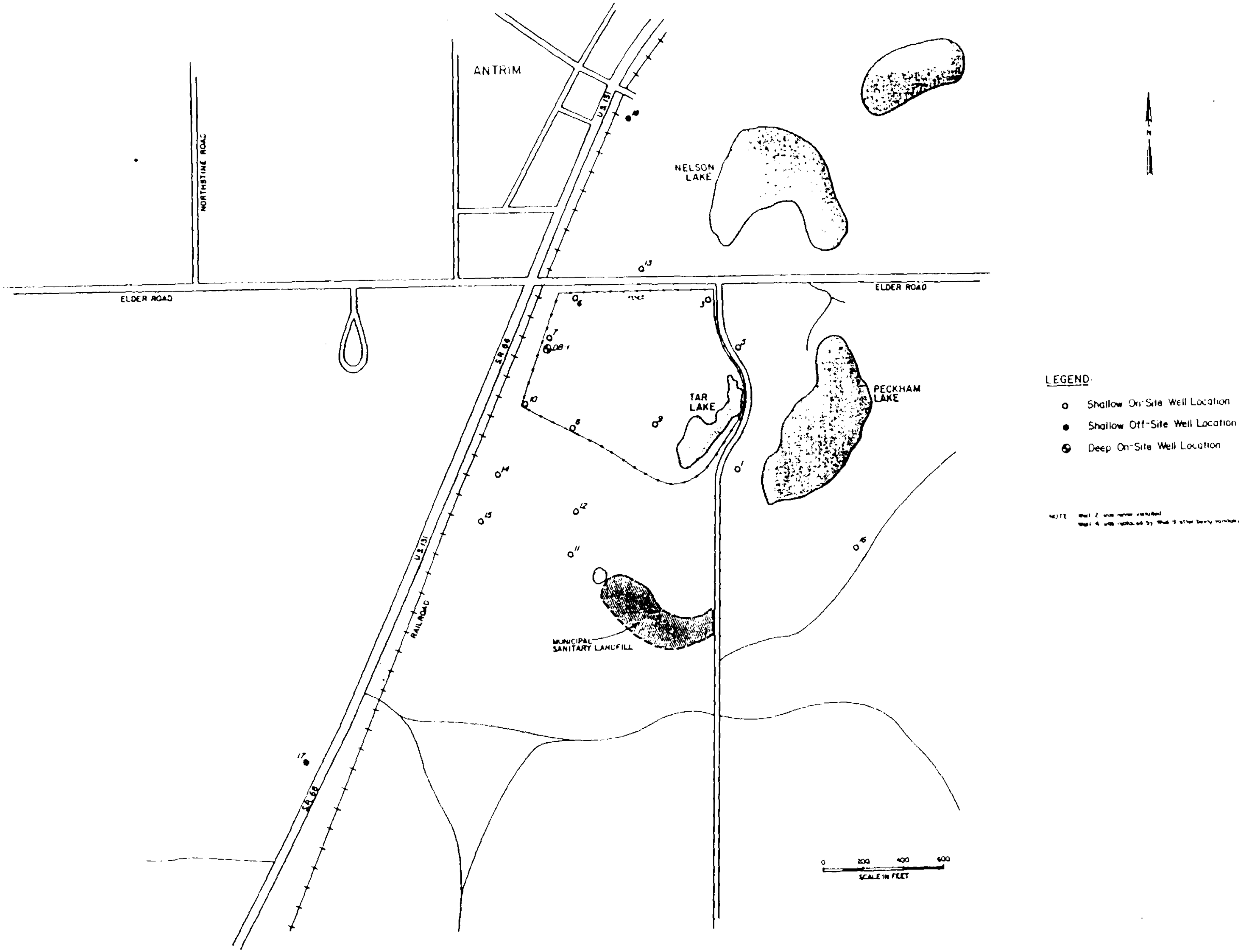
From Figure 3-2, RI and FS for the Antrim Iron Works Site (Tar Lake), Ensafe, Inc., January 15, 1986

FIGURE 6 Groundwater Contaminant lume



From Figure 2-5, Remedial Action Master Plan, Tar Lake Site, CH2M Hill/E&E, April 30, 1984

FIGURE 7 On-Site Monitorin, ell Locations



From Figure 2, unapproved Preliminary Endnagerment Assessment, Antrim Iron Works, Ensafe, Inc., October 3, 1988

TABLE 1 Positively Identified Compounds in Groundwater

Compound	CONCENTRATION (ug/l) MW-6	MW-7	MW-11(1)	MW-12	MW-13	MW-14(1)	MW-15	MW-16	Detect. Limit
VOLATILES:									
Chloroform									5
Benzene	4 J				3 J				5
Toluene	3 J								5
Ethylbenzene					7				5
Xylenes	7								5
SEMI-VOLATILES:									
4-methyl phenol	3 J								20
Nitrobenzene	5 J								20
2,4-dimethyl-phenol	57	59							20
Naphthalene	2 J	2 J			5 J				20

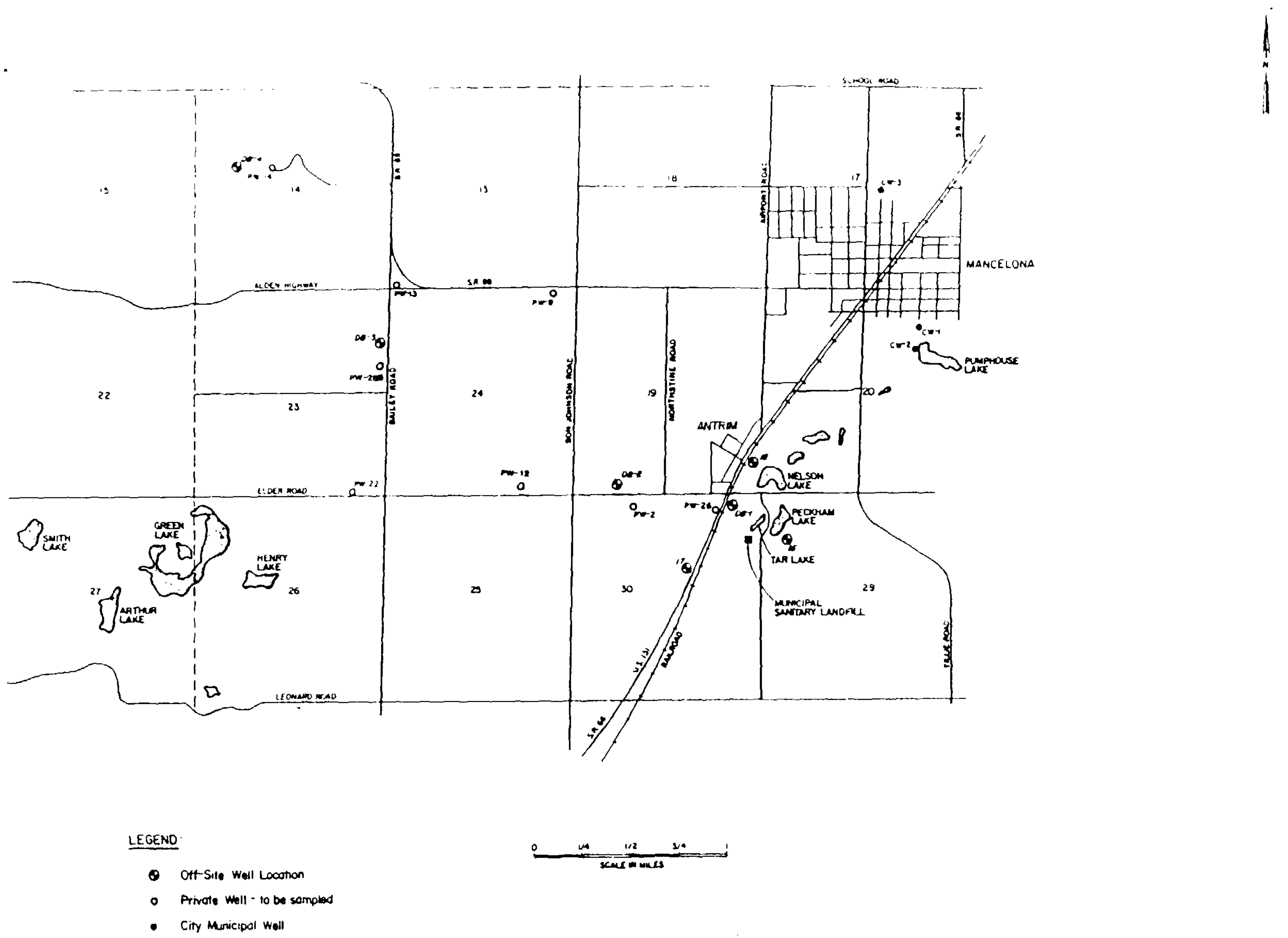
J - Compound was detected at a concentration below the quantitation limit reported concentrations are estimated values.

A blank indicates that the compound was tested for but not detected. Only those compounds detected in at least one sample are listed. Chloroform was detected in a field blank.

NOTES:
(1) Sample analyzed in duplicate. Values are averaged and all qualifiers are reported.

Adapted from Table 1-1, unapproved Phased Feasibility Study, Tar Lake Superfund Site, Gradient Corporation, February 12, 1991.

FIGURE 8 Off-Site Monitoring Well Locations



From Figure 3, unapproved Preliminary Endangerment Assessment, Antrim Iron Works Site, Ensafe, Inc., October 3, 1988

The exact structure of individual compounds detected using the special protocol analysis could not be determined, rather alkylphenols were identified by the number of carbon atoms in substituents on the aromatic ring. For example, a compound was identified generally as a C-2 alkylphenol (an alkylphenol bearing substituent(s) containing 2 carbon atoms) which might be either 2,3-, 2,4-, 2,5-, or 3,4-dimethylphenol or 2-, 3-, or 4-ethylphenol. C-2 through C-12 alkylphenols were detected. Given the nature of the available data from the special protocol analysis, a list of compounds that could conceivable be present in the groundwater was prepared by Environmental Safety & Designs, Inc. (Ensafe) using <u>CRC Handbook of Chemistry and Physics</u>, 68th edition, 1987, CRC Press, Boca Raton FL, to obtain a list of those known compounds meeting the criteria of C-2 through C-12 alkylphenols. These compounds are listed in Table 2.

<u>1989 CLP Analysis for Volatile and Semi-Volatile Compounds in Tar, Soil, and Groundwater</u>

Samples of tar from Tar Lake, soil immediately beneath the tar, and groundwater immediately beneath the tar were collected from the locations shown in Figure 9 and analyzed for volatile and semi-volatile compounds contained in the EPA CLP Target Compound List.

The highest concentration of organic compounds detected in tar from Tar Lake were alkylphenols (1,100 to 2,000 mg/kg). Other classes of organic compounds detected in the tar included: Benzene (1.2 mg/kg), Ethylbenzene (100 mg/kg), Toluene (100 mg/kg), Styrene (2.3 mg/kg), other polynuclear aromatic hydrocarbons (100 to 560 mg/kg), monoaromatic hydrocarbons (5 to 280 mg/kg) and ketones (1.2 to 15 mg/kg). A similar array of compounds was detected in soil samples collected immediately beneath Tar Lake at concentrations between 1 and 25% of the concentrations measured in the tar.

Groundwater samples contained the more water soluble of the organic constituents detected in the tar (i.e. alkylphenols, monoaromatic hydrocarbons, and ketones). Concentrations of these compounds were lower than the soil concentrations, roughly 0.01 to 1% of the concentration measured in the tar. Benzene (0.4-0.43 ppm) and styrene (0.006-0.063 ppm) were both present in the groundwater at concentrations which exceed the Safe Drinking Water Act Maximum Contaminant Levels (MCLs), 0.005 ppm for benzene and 0.006 ppm for styrene. Naphthalene (ranging between not detectable and 0.038 ppm) and 2-methylnaphthalene (0.017-0.38 ppm) were present in the groundwater.

Concentration data for all of the CLP Target Compound List chemicals detected during this analysis are summarized in Table 3.

The contamination due to the Site extends approximately 3.5 miles downgradient from the Site as evidenced by taste and odor observations in monitored wells by the Michigan Department of Natural Resources (MDNR) staff and the affected residences. The

TABLE 2 C-2 Through C-12 Alkylphenols

C-2 Alkylphenols
2,3-dimethyl phenol
2,4-dimethyl phenol
2,5-dimethyl phenol
2,6-dimethyl phenol
3,4-dimethyl phenol
3,5-dimethyl phenol
2-ethyl phenol
3-ethyl phenol
4-ethyl phenol

C-4 Alkylphenols
2,3,4,5-tetramethyl phenol
2,3,4,6-tetramethyl phenol
2,3,5,6-tetramethyl phenol
2-methyl,5-isopropyl phenol
4-tert-butyl phenol
4-sec-butyl phenol
4-butyl phenol
3-tert-butyl phenol
3-butyl phenol
2-tert-butyl phenol
2-sec-butyl phenol
2-butyl phenol

C-3 Alkylphenols
2-propyl phenol
3-propyl phenol
4-propyl phenol
2-isopropyl phenol
3-isopropyl phenol
4-isopropyl phenol
2,4,5-trimethyl phenol
2,4,6-trimethyl phenol

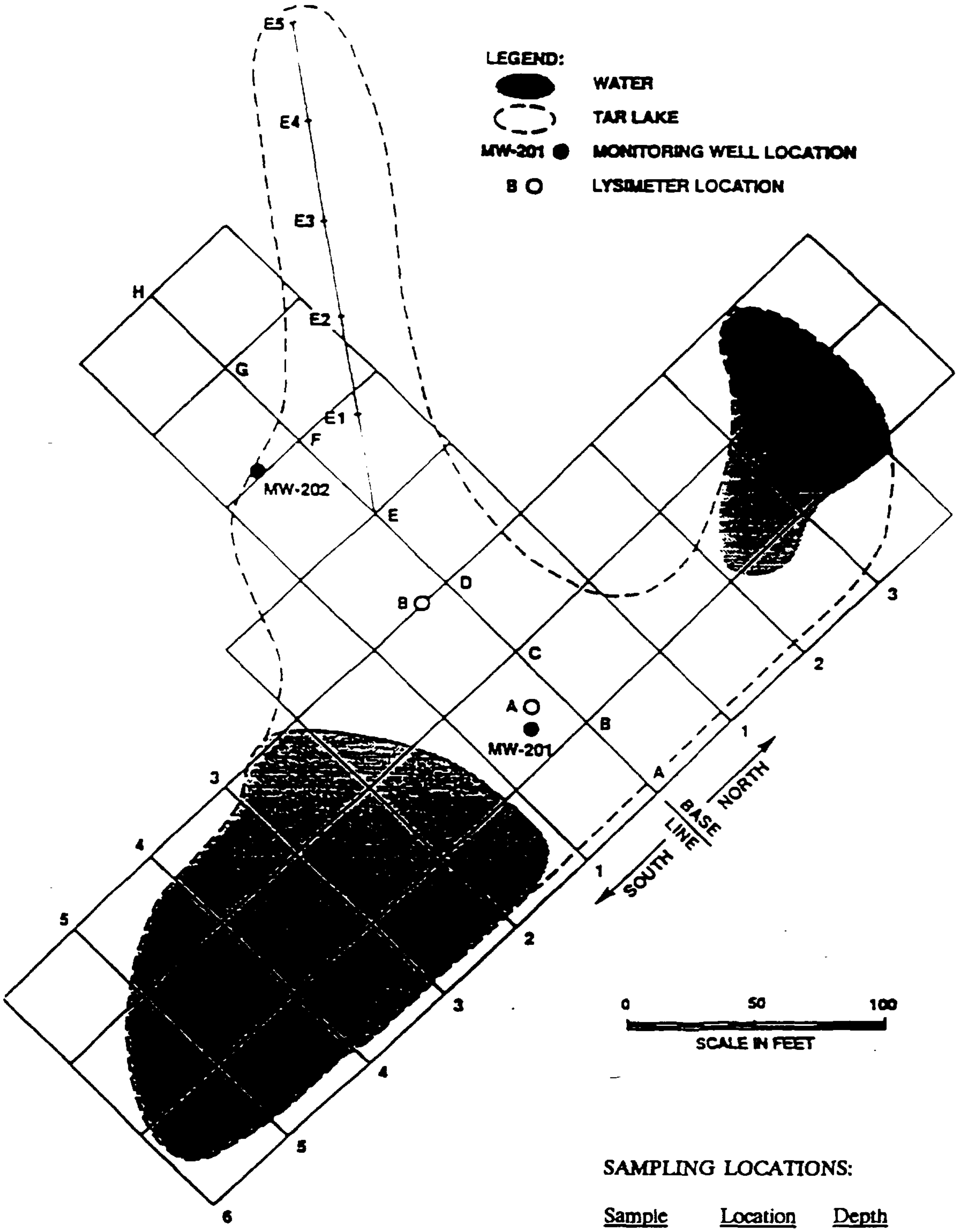
C-8 Alkylphenols
2,4-di-tert-butyl phenol
2,6-di-tert-butyl phenol
2,6-di-sec-butyl phenol
2-octyl phenol

C-9 Alkylphenols
2,4-di-tert-butyl-5-methyl phenol
2,4-di-tert-butyl-6-methyl phenol
2,6-di-tert-butyl-4-methyl phenol

C-10 - C-12 Alkylphenols
2,6-di-tert-butyl-4-ethyl phenol
2,6-(bis)(1,1-dimethyl propyl)-4-methyl phenol
2,4,6-tri-tert-butyl phenol

Adapted from Table 1-2, unapproved Phased Feasibility Study, Tar Lake Superfund Site, Gradient Corporation, February 12, 1991

FIGURE 9 Sampling Locations on Tar Lake



SAMPLING LOCATIONS:

Sample	Location	Depth
B202TAR	MW-202	10 ft below lake surface
B201A	MW-201	13 ft below lake surface; 4 ft below tar
B201B	MW-201	15 ft below lake surface; 6 ft below tar
201	MW-201	screened 16 ft below lake surface; 7 ft below tar
B202A	MW-202	15 ft below lake surface; <1 ft below tar
B202B	MW-202	17 ft below lake surface; 3 ft below tar
B202C	MW-202	19 ft below lake surface; 4 ft below tar
202	MW-202	screened 20 ft below lake surface; 5 ft below tar

From Figure 1, 1989 Antrim Iron Works (Tar Lake) Site Investigation, Vol. I, Gradient Corp., 3/90

TABLE 3 Compounds Detected in Tar, Soils, and Groundwater at Tar Lake

COMPOUND	TAR SAMPLE (mg/Kg)	SOIL SAMPLES (mg/Kg)					WATER SAMPLES (mg/L)	
	B202T [1]	B201A [1]	B201B [1]	B202A	B202B	B202C [1]	201 [1]	202 [1]
VOLATILES:								
Benzene	1.2	0.63 J	2.2				0.43	0.04
Ethylbenzene	100	3.1	7.4		0.012	0.001 J	0.12	0.045
Toluene	100	4.2	16	0.001 J	0.015	0.002 J	0.62	0.16
Styrene	2.3	1.3	2.8		0.003 J		0.063 J	0.006
2-Butanone	5 E	0.12	0.26	0.026	0.04	0.003 J	1.9	0.015
2-Hexanone	11 E	0.63 J	2.4	0.013	0.023		0.91	
4-Methyl-2-pentanone	1.2	0.017	0.071				0.091 J	
Xylenes (total)	280 E	9.5	21	0.002 J	0.054	0.007	0.39	0.14
SEMI-VOLATILES:								
Acenapthene		3.7 J			0.18 J			
Acenapthylene		4.2 J	11 J		0.14 J		0.049 J	
Anthracene		4.7 J	11 J		0.18 J			
Benzo(a)anthracene		2.3 J			0.063 J			
Benzo(b)fluoranthene		0.78 JX						
Benzo(k)fluoranthene		0.78 JX						
bis-(2-Ethylhexyl)phthalate				0.063 J	0.088 J	0.077 J		0.003 J
Chrysene		1.5 J			0.074 J			
Di-n-butyl phthalate					0.082 J	0.28 J		
Fluoranthene		3.6 J			0.23 J			
Fluorene	100 J		35 J	0.074 J	0.57	0.059 J		0.005 J
Napthalene	340	54	160	0.067 J	1.2	0.13 J		0.038
Phenanthrene		19	46 J	0.039 J	0.86			0.004 J
Pyrene		3.2 J	14 J		0.27 J			
Dibenzofuran	51 J	14	43 J		0.6	0.039 J		0.004 J
2-Methylnaphthalene	560	49	120	0.08 J	1.8	0.14 J	0.38 J	0.017
2,4-Dimethylphenol	2000	170	610	1.6	7.3	1.4	29	3.1
Phenol	330	44	120		1.3		14	0.29
2-Methylphenol	1100	120	400	0.052 J	2.4		28	0.78
4-Methylphenol	1400	170	690	6	12	0.51	49	4.9

Adapted from Table 1-3, unapproved Phased Feasibility Study, Tar Lake Superfund Site, Gradient Corp., Feb. 12, 1991 organic compound data collected to date indicates the existence of a steep concentration gradient with distance from Tar Lake. While there is a taste and odor problem in the downgradient wells, analyses of samples collected show that the contaminants are below the detection limits.

Inorganic Compound Analyses

The primary investigations of the identity and concentration of inorganic compounds associated with the Site are as follows:

1988 CLP Analysis for Metals in Groundwater

Groundwater samples collected from on-site monitoring wells (MW-5, MW-7, MW-11, MW-12, MW-13, MW-14, MW-15, and MW-16; Figure 7) were analyzed for metals contained in the CLP Target Compound List. Results of these analyses indicated that metal concentrations in groundwater downgradient of Tar Lake are comparable to background levels.

1989 CLP Analysis for Metals in Groundwater

Samples of tar from Tar Lake, soil immediately beneath the tar, and groundwater immediately beneath the tar were collected from the locations shown in Figure 9 and analyzed for metals contained in the EPA CLP Target Compound List. These results indicated that metal concentrations in groundwater are below MCLs and that metal levels in soil are comparable to background concentrations.

The inorganic data collected to date indicate a negligible impact of Tar Lake on local metal concentrations.

1.4 RISK ASSESSMENT

The baseline risk assessment performed by the Region V Office of Health and Environmental Assessment (See Appendix A) focuses on a few of the most critical potential exposure pathways for the Tar Lake operable unit. Exposure scenarios were chosen and evaluated in accordance with current U.S. EPA guidance, Risk Assessment Guidance for Superfund (RAGS). The risk assessment characterizes the most serious risks by assessing ingestion of groundwater and soil using a hypothetical future risk scenario which results in a cancer risk of 8×10^{-4} and a non-cancer hazard index of up to 24. The cancer risk at Tar Lake exceeds the 1×10^{-4} level which warrants remedial action under U.S. EPA policy, OSWER Directive 9355.0-30. It also exceeds the acceptable exposure levels for known or suspected carcinogens of 1×10^{-4} to 1×10^{-6} as presented in Section 300.430 (e)(2)(i)(A)(2) of the NCP. Risks for the Tar Lake site are presented in Table 4.

Because of these unacceptable risks from both carcinogens and non-carcinogens, U.S. EPA has decided that it is appropriate and warranted to conduct a source control and interim groundwater

TABLE 4 Cancer Risk and Non-cancer Hazard for Tar Lake

Future Residential Scenario (1)

EXPOSURE PATHWAY	CANCER RISK	HAZARD INDEX	ACUTE HAZARD
Ingestion of Groundwater (95% UCL)	4.8×10^{-5}	24	Not Assessed
Ingestion of Tar-Contaminated	8.0×10^{-4}	0.03	High (2)

(1) Values listed in this table were obtained from the output of the RISK ASSISTANT program.

(2) Potential for acute health effects from exposure to tar was judged to be high, based on high concentrations of phenols and cresols, reports of chemical burns and skin irritation and potentially lethal depth and viscosity of the tar.

containment operable unit at Tar Lake. The operable unit would expeditiously implement site remedy to protect human health and the environment.

Significant non-cancer risks exist at the site via the groundwater pathway, both when considering mean groundwater concentrations on-site and, more appropriately, when considering the 95% upper confidence limit on the arithmetic mean of the data (95% UCL). Hazard Indices calculated for the Site equal approximately 11 and 24. The cancer risk from ingestion of groundwater, as part of the same residential scenario, is 2.4×10^{-5} and 4.8×10^{-5} for mean and 95% UCL respectively.

The tar poses cancer risk primarily due to the presence of polycyclic aromatic hydrocarbons (PAHs). There are numerous sources of uncertainty due to the limited data available in the cancer analysis. The tar is described as being very heterogenous in viscosity and appearance. This risk assessment utilized the assumption that a number of PAHs were present in the tar at the limit of detection. This assumption is reasonable since the PAHs assumed to be present in the tar were detected in the soil beneath the tar. Use of surrogate values in a residential scenario results in a cancer risk driven by PAHs as high as 8×10^{-4}, assuming chronic exposure to soil containing contaminants at one tenth the detection limit in the tar.

A number of compounds present in the tar could present severe acute health risks if ingested or absorbed through the skin, especially phenol. The viscosity of the tar alone presents an extreme hazard. Adolescents or others who manage to trespass on the site could easily fall into the tar and die.

2.0 REMEDIAL ALTERNATIVES

This section presents the remedial action alternatives to address the source control and interim groundwater containment at the Tar Lake Site.

2.1 REMEDIAL ACTION GOAL

The remedial action goal for this Tar Lake operable unit is to eliminate and/or significantly reduce public health and environmental threats resulting from releases or potential releases from Tar Lake. The operable unit will minimize the potential for ingestion and direct contact with tar and associated contaminated soils having an excess cancer risk of greater than 1×10^{-6}. It will also prevent the migration of contaminants from the tar and soils that would result in further groundwater contamination.

2.2 REMEDIAL ACTION ALTERNATIVES

The following sections present a short discussion of each of the remedial action alternatives that will be evaluated in detail. There has not been a significant amount of work performed with respect to the exact extent of the tar and contaminated soils to date. The volumes of tar and contaminated soils as well as the additional concentration data will be gathered during the pre-design phase of the Remedial Design along with any treatability studies that need to be performed. Because of the areal extent and nature of the tar, probing the soils underneath is difficult. The exact extent of the contaminated soils may not be known until after the tar has been removed. The following assumptions are used for each of the alternatives:

- The volume of tar present is 30,000 cubic yards. A minimum quantity of 20,000 cubic yards of tar was calculated in a depth sounding survey performed by the consulting firm, Dames & Moore, for 56th Century. The 30,000 cubic yards includes a 50% uncertainty factor because it is believed that there is additional tar on the western and southern sides of Tar Lake.

- The volume of highly contaminated soils (excess cancer risk greater than or equal to 1×10^{-2}) is estimated to be 20,000 cubic yards.

- The volume of low level contaminated soils (excess cancer risk less than 1×10^{-2} and greater than 1×10^{-6}) is 20,000 cubic yards.

2.2.1 **ALTERNATIVE 1 - NO ACTION**
This is the no action alternative. The NCP requires that the no action alternative be considered at every site. Under this alternative, no further action would be taken at the Tar Lake site to reduce risks or to control the source and migration of contaminants. The no action alternative will not modify the site in any way.

2.2.2 **ALTERNATIVE 2 - REMOVAL AND INCINERATION OF TAR AND HIGHLY CONTAMINATED SOILS; BIO-REMEDIATION AND CONTAINMENT OF REMAINING SOILS; INTERIM GROUNDWATER CONTAINMENT**
This alternative involves the excavation and on-site incineration of the tar (approximately 30,000 yd^3) and the highly contaminated soils (soils with an excess cancer risk level greater than or equal to 1×10^{-2} which is approximately 20,000 yd^3) in and around Tar Lake extending to the adjacent landfill. Additional sampling will be conducted during the pre-design to define the limits of contamination. To facilitate the excavation of the tar and soils, a dewatering system will be constructed. The exact number and placement of extraction wells will depend on the areal extent and depth of contamination, and will be determined as part of the Remedial Design. The excavation will require the use of conventional equipment including drag-lines, conveyor loaders, backhoes, and bulldozers. The incineration technologies available and considered appropriate to incinerate the tar and soils include rotary kiln and infrared. The rotary kiln uses a primary combustion chamber heated by a natural gas or fuel oil burner. For material like the tar, the waste itself can sometimes be used to substitute for the natural gas or fuel oil. The infrared incinerators use infrared energy to heat the waste material in the presence of air until the auto-ignition temperature is reached. The tar and contaminated soils will be incinerated separately. Contaminated soil is not a waste, but only a media containing waste. This is so that the incinerated (treated) soil will be considered clean when the contamination is reduced below health based levels and no longer needs to be managed as a hazardous waste. It can be used as backfill at the Site. Ash and any residue resulting from the incineration of the tar remains a listed waste and will be treated and disposed of in a hazardous waste facility.

The remaining soil with an excess cancer risk level less than 1×10^{-2} and greater than 1×10^{-6} (approximately 20,000 yd^3) will be bio-remediated insitu to the maximum extent practicable with the goal being Michigan Act 307 Type B levels and contained on-site with the installation of hazardous waste cap that meets Michigan Act 64 requirements if it is determined that bio-remediation can not reach the desired cleanup goal. The bio-remediation involves the addition of nutrients and oxygen to the media to promote bio-degradation of contaminants by microorganisms. The exact amenability to this technology will be determined in pre-design treatability studies.

An interim groundwater containment system will be installed to prevent the contaminant plume from migrating further. This containment system will be constructed prior to any excavation work performed on the tar and contaminated soils so that any possible contaminant releases to the groundwater is captured and the dewatering system discharge can be treated. This includes:

- Installation of a groundwater pump and treat system for the containment of contaminated groundwater, the treatment of water ponded on Tar Lake, and discharge from the dewatering system

- Implementation of institutional controls including but not limited to, deed restrictions regulating the development of the Tar Lake property and groundwater usage restrictions within the areas of the existing or potential contaminant plume.

The groundwater pump and treat component will consist of: 1) a series of extraction wells at the down-gradient edge of the Tar Lake property to prevent further migration of the contaminant plume, and 2) an appropriate treatment system on-site, possibly carbon absorption, to treat the contaminated groundwater, water ponded on Tar Lake, and discharge from the dewatering system. Discharge from the treatment system shall be required to meet applicable effluent discharge limitations as determined by U.S. EPA and MDNR. Residues from the treatment system which contain constituents of K087 must be managed as hazardous waste. Because there is no surface water body or POTW nearby, the groundwater will be reinjected into to the ground and will meet the requirements under Michigan Act 245 Part 22. This can be used in conjunction with the bio-remediation of the lowly contaminated soils. The discharged water can be supplemented with the necessary nutrients for the bio-remediation process. Existing groundwater monitoring wells will be used to monitor the effectiveness of the groundwater containment system. Wells will be sampled on a monthly basis to ensure that exposure to contaminants does not occur. Final remedy for the groundwater, including clean-up standards, will be addressed in the second operable unit, through the final overall RI/FS for the Tar Lake project.

A site evaluation will be performed every five years for a 30 year period. The purpose of this evaluation is to determine if site conditions are changing, and if so, what actions may be necessary to address these changes.

2.2.3 ALTERNATIVE 3 - REMOVAL AND INCINERATION OF TAR AND HIGHLY CONTAMINATED SOILS; DISPOSAL OF THE REMAINING SOILS AT AN APPROVED HAZARDOUS WASTE LANDFILL; INTERIM GROUNDWATER CONTAINMENT

This alternative is similar to Alternative 2 except that the low level contaminated soils are disposed of off-site at an approved hazardous waste landfill rather than being bio-remediated on-site. Alternative 3 involves the excavation and on-site incineration of approximately 30,000 yd^3 of tar and approximately 20,000 yd^3 of highly contaminated soils (soils with an excess cancer risk level greater than or equal to 1×10^{-2}) in and around Tar Lake extending to the adjacent landfill. Additional sampling will be conducted during the pre-design to define the exact limits of contamination. Because a portion of the tar is sitting in the water table, in order to facilitate the excavation of the tar and soils, a dewatering system will be constructed. The exact number and placement of extraction wells will depend on the areal extent and depth of contamination, and will be determined as part of the Remedial Design. The excavation will require the use of conventional equipment including drag-lines, conveyor loaders, backhoes, and bulldozers. The incineration technologies available and considered appropriate to incinerate the tar and soils include rotary kiln and infrared. The rotary kiln uses a primary combustion chamber heated by a natural gas or fuel oil burner. For material like the tar, the waste itself can sometimes be used to substitute for the natural gas or fuel oil. The infrared incinerators use infrared energy to heat the waste material in the presence of air until the auto-ignition temperature is reached. The tar and contaminated soils will be incinerated separately. Contaminated soil is not a waste, but only a media containing waste. This is so that the incinerated (treated) soil will be considered clean when the contamination is reduced below health based levels and no longer needs to be managed as a hazardous waste. Ash and any residue resulting from the tar incineration remains a listed waste and will be treated and disposed of appropriately in a hazardous waste facility.

The remaining soil with an excess cancer risk level of less than 1×10^{-2} and greater than 1×10^{-6} (approximately 20,000 yd^3) will be excavated and disposed of at an approved hazardous waste landfill. The soils must first meet alternate treatment standards under a treatability variance from RCRA Land Disposal Restrictions (LDRs). This will be determined during pre-design. If the alternate treatment levels are above health based levels the soils will be loaded onto trucks and transported to a hazardous waste landfill. If the treatment levels are below health based levels, the soil can be backfilled at the Site. Of the licensed hazardous waste landfills in the State of Michigan, the Wayne Landfill in Wayne County, 250 miles from the site, has been determined by MDNR staff to be a good candidate, and is used for cost estimating purposes.

At the completion of the excavation, depressions caused by the excavations will be backfilled with clean soil to the original grade, covered with topsoil and revegetated to prevent erosion.

An interim groundwater containment system will be installed to keep the contaminant plume from migrating further. This containment system will be constructed prior to any excavation work performed on the tar and contaminated soils so that any possible contaminant releases to the groundwater is captured and the dewatering system discharge can be treated. This includes:

- Installation of a groundwater pump and treat system for the containment of contaminated groundwater, the treatment of water ponded on Tar Lake, and the discharge the dewatering system

- Implementation of institutional controls including but not limited to, deed restrictions to regulate the development of the Tar Lake property and groundwater usage restrictions within the areas of the existing or potential contaminant plume.

The groundwater pump and treat component will consist of: 1) a series of extraction wells at the down-gradient edge of the Tar Lake property to prevent further migration of the contaminant plume, and 2) an appropriate treatment system on-site, possibly carbon adsorption, to treat the contaminated groundwater, water ponded on Tar Lake, and the discharge from the dewatering system. Discharge from the treatment system shall be required to meet applicable effluent discharge limitations as determined by U.S. EPA and MDNR. Because there is no surface water body or POTW nearby, the groundwater will be reinjected into to the ground and will meet the requirements under Michigan Act 245 Part 22. Residues from the treatment system which contain constituents of K087 must be managed as hazardous waste. Existing groundwater monitoring wells will be used to monitor the effectiveness of the groundwater containment system. Wells will be sampled on a monthly basis to ensure that exposure to contaminants does not occur. Final remedy for the groundwater, including clean-up standards, will be addressed in the second operable unit, through the final overall RI/FS for the Tar Lake project.

2.2.4 <u>ALTERNATIVE 4 - REMOVAL AND INCINERATION OF TAR AND HIGHLY CONTAMINATED SOILS; THERMALLY TREAT REMAINING SOILS; INTERIM GROUNDWATER CONTAINMENT</u>

This alternative differs from the previous two alternatives in the manner the low level contaminated soils are treated, i.e., through thermal desorption. Like the other two alternatives, this alternative involves the excavation and incineration on-site of approximately 30,000 yd^3 of tar and approximately 20,000 yd^3 of highly contaminated soils (soils with an excess cancer risk level greater than or equal to 1 x 10^{-2}) in and around Tar Lake extending to the adjacent landfill. Additional sampling will be conducted during the pre-design to define the limits of contamination. To facilitate the excavation of the tar and soils, a dewatering system will be constructed. The exact number and placement of extraction wells will depend on the areal extent and depth of contamination, and will be determined as part of the Remedial Design. The excavation will require the use of conventional equipment including drag-lines, conveyor loaders, backhoes, and bulldozers. The incineration technologies available and considered appropriate to incinerate the tar and soils include rotary kiln and infrared. The rotary kiln uses a primary combustion chamber heated by a natural gas or fuel oil burner. For material like the tar, the waste itself can sometimes be used to substitute for the natural gas or fuel oil. The infrared incinerators use infrared energy to heat the waste material in the presence of air until the auto-ignition temperature is reached. The tar and contaminated soils will be incinerated separately. Contaminated soil is not a waste, but only a media containing waste. This is so that the incinerated (treated) soil will be considered clean when the contamination is reduced below health based levels and no longer needs to be managed as a hazardous waste. It can be used as backfill at the Site. Ash and any residue resulting from the incineration remains a listed waste and will be treated and disposed of appropriately in a hazardous waste facility.

The remaining soil with an excess cancer risk level of less than 1 x 10^{-2} (approximately 20,000 yd^3) will be treated through the use of thermal desorption, with the cleanup goal being Michigan Act 307 Type B levels. Treatability studies will be performed during the pre-design to determine the effectiveness of this treatment technology to the site media and contaminants. This process physically separates volatile and some semi-volatile contaminants from soil by heating the contaminated media between 200 - 1000 degrees F. Offgases may be burned in an afterburner, condensed to reduce the volume to be disposed, or captured by carbon adsorption beds. Gaseous discharges will meet the applicable air discharge limitations as determined by the appropriate regulating authority. Any ash and residue resulting from the process will be treated and disposed of appropriately in a permitted facility. If the soils can be treated below health based levels through thermal desorption, the soils no longer contains a hazardous waste and no longer needs to be managed as such. If health based levels are not attained by low temperature thermal desorption, then RCRA treatment standards must be met and the treatment residue must be disposed in a Subtitle C unit.

At the completion of the excavation and treatment, depressions caused by the excavations will be backfilled with clean soil to the original grade, covered with topsoil and revegetated to prevent erosion.

An interim groundwater containment system will be installed to keep the contaminant plume from migrating further. This containment system will be constructed prior to any excavation work performed on the tar and contaminated soils so that any possible contaminant releases to the groundwater is captured and the dewatering system discharge can be treated. This includes:

- Installation of a groundwater pump and treat system for the containment of contaminated groundwater, the treatment of water ponded on Tar Lake, and the discharge from the dewatering system

- Implementation of institutional controls including but not limited to, deed restrictions to regulate the development of the Tar Lake property and groundwater usage restrictions within the areas of the existing or potential contaminant plume.

The groundwater pump and treat component will consist of: 1) a series of extraction wells at the down-gradient edge of the Tar Lake property to prevent further migration of the contaminant plume, and 2) an appropriate treatment system on-site, possibly carbon adsorption, to treat the contaminated groundwater, water ponded on Tar Lake, and discharge from the dewatering system. Discharge from the treatment system shall be required to meet applicable effluent discharge limitations as determined by U.S. EPA and MDNR. Because there is no surface water body or POTW nearby, the groundwater will be reinjected into to the ground and will meet the requirements under Michigan Act 245 Part 22. Residues from the treatment system which contain constituents of K087 must be managed as a hazardous waste. Existing groundwater monitoring wells will be used to monitor the effectiveness of the groundwater containment system. Wells will be sampled on a monthly basis to ensure that exposure to contaminants does not occur. Final remedy for the groundwater, including clean-up standards, will be addressed in the second operable unit, through the final overall RI/FS for the Tar Lake project.

2.2.5 ALTERNATIVE 5 - REMOVAL AND DISPOSAL OF TAR AND CONTAMINATED SOILS IN A HAZARDOUS WASTE LANDFILL; INTERIM GROUNDWATER CONTAINMENT

This Alternative involves the excavation and disposal of the tar and all of the contaminated soils in and around Tar Lake extending to the adjacent landfill at an approved hazardous waste landfill. Additional sampling will be conducted during the pre-design to define the limits of contamination. To facilitate the excavation of the tar and soils, a dewatering system will be constructed. The exact number and placement of extraction wells will depend on the areal extent and depth of contamination, and will be determined as part of the Remedial Design. The excavation will require the use of conventional equipment including drag-lines, conveyor loaders, backhoes, and bulldozers.

Once excavated the tar and contaminated soils will be treated in order to meet the treatment standards for K087 because the tar waste is very similar to K087 waste, i.e., decanter tank tar sludge from coking operations, and contains many of the same hazardous constituents. Since the treatment standards for K087 are based on incineration, incineration may be required to meet these standards. The treatment method will be determined during the pre-design phase. The tars and the contaminated soils will be sampled and treated separately to the maximum extent possible to avoid diluting the tar in the process. For the soil, alternate treatment levels can be based on data from actual treatment of the soil under a treatability variance. This will be established during the pre-design with the most appropriate treatment technology.

Once treated the tar residue will be loaded onto trucks for transportation to a secure, CERCLA off-site policy compliant, RCRA hazardous waste landfill for disposal. If the treated soil is below health based levels, it will be considered clean. Contaminated soil is not a waste, but only a media containing waste. When the contaminants have been removed below health based levels, the soil no longer contains the waste and no longer needs to be treated as a hazardous waste. Thus, clean soil can be used as backfill at the Site.

At the completion of the excavation, depressions caused by the excavations will be backfilled with clean soil to the original grade, covered with topsoil and revegetated to prevent erosion.

An interim groundwater containment system will be installed to keep the contaminant plume from migrating further. This containment system will be constructed prior to any excavation work performed on the tar and contaminated soils so that any possible contaminant releases to the groundwater is captured and the dewatering system discharge can be treated. This includes:

- Installation of a groundwater pump and treat system for the containment of contaminated groundwater, the treatment of water ponded on Tar Lake, and the discharge the dewatering system

- Implementation of institutional controls including but not limited to, deed restrictions to regulate the development of the Tar Lake property and groundwater usage restrictions within the areas of the existing or potential contaminant plume.

The groundwater pump and treat component will consist of: 1) a series of extraction wells on the down-gradient edge of the Tar Lake property to prevent further migration of the contaminant plume, and 2) an appropriate treatment system on-site, possibly carbon adsorption, to treat the contaminated groundwater, water ponded on Tar Lake, and the discharge from the dewatering system. Discharge from the treatment system shall be required to meet applicable effluent discharge limitations as determined by the appropriate regulating authority. Because there is no surface water body or POTW nearby, the groundwater will be reinjected into to the ground and will meet the requirements under Michigan Act 245 Part 22. Residues from the treatment system which contain constituents of K087 must be managed as hazardous waste. Existing groundwater monitoring wells will be used to monitor the effectiveness of the groundwater containment system. Wells will be sampled on a monthly basis to ensure that exposure to contaminants does not occur. Final remedy for the groundwater, including clean-up standards, will be addressed in the second operable unit, through the final overall RI/FS for the Tar Lake project.

2.2.6 ALTERNATIVE 6 - REMOVAL AND DISPOSAL OF TAR AND CONTAMINATED SOILS IN ON-SITE RCRA CELL; INTERIM GROUNDWATER CONTAINMENT

This Alternative involves excavating the tar and the contaminated soils in and around Tar Lake extending to the adjacent landfill. Additional sampling will be conducted during the pre-design to define the limits of contamination. To facilitate the excavation of the tar and soils, a dewatering system will be constructed. The exact number and placement of extraction wells will depend on the areal extent and depth of contamination, and will be determined as part of the Remedial Design. The excavation will require the use of conventional equipment including drag-lines and bulldozers.

The tar and contaminated soils will be contained (untreated) on-site in two adjoining RCRA containment cells that will be constructed within the area of contamination. With the construction of the containment cells within the AOC and transferring the tar and contaminated soil into the cells without moving it outside of the AOC or placing it into a separate unit, placement as defined by RCRA will not occur and RCRA Land Disposal Restriction (LDR) treatment standards will not be triggered. This avoids the necessity of having to incinerate the tar and soils in order to meet the K087 treatment standards. The RCRA cells must meet minimum technology requirements, i.e. double liners, two leachate collection systems, and groundwater monitoring. The first RCRA cell will be sized to hold the 30,000 yd^3 of tar and some of the contaminated soils, the amount to be determined in the Remedial Design, to help physically stabilize the tar. The second RCRA cell will be sized to hold the remainder of the contaminated soils. Initial design of the cells will be based on the estimate of 40,000 yd^3 of contaminated soils. The two cells will be constructed sequentially. First, the RCRA cell for the tar and some of the soils will be constructed so that the tar excavated and additional sampling can be performed on the soils underneath to better determine the extent of contaminated soils. Once the volume of contaminated soils is known, final sizing and construction of the second RCRA cell will be completed.

An interim groundwater containment system will be installed to keep the contaminant plume from migrating further. This containment system will be constructed prior to any excavation work performed on the tar and contaminated soils so that any possible contaminant releases to the groundwater is captured and the dewatering system discharge can be treated. This includes:

- Installation of a groundwater pump and treat system for the containment of contaminated groundwater, the treatment of water ponded on Tar Lake, and the discharge the dewatering system

- Implementation of institutional controls including but not limited to, deed restrictions to regulate the development of the Tar Lake property and groundwater usage restrictions within the areas of the existing or potential contaminant plume.

The groundwater pump and treat component will consist of: 1) a series of extraction wells on the down-gradient edge of the Tar Lake property to prevent further migration of the contaminant plume, and 2) an appropriate treatment system on-site, possibly carbon adsorption, to treat the contaminated groundwater, water ponded on Tar Lake, and the discharge from the dewatering system. Discharge from the treatment system shall be required to meet applicable effluent discharge limitations as determined by the appropriate regulating authority. Because there is no surface water body or POTW nearby, the groundwater will be reinjected into to the ground and will meet the requirements under Michigan Act 245 Part 22. Residue from the treatment system which contain constituents of K087 must be managed as hazardous waste. Existing groundwater monitoring wells will be used to monitor the effectiveness of the groundwater containment system. Wells will be sampled on a monthly basis to ensure that exposure to contaminants does not occur. Final remedy for the groundwater, including clean-up standards, will be addressed in the second operable unit, through the final overall RI/FS for the Tar Lake project.

2.2.7 ALTERNATIVE 7 - REMOVAL AND DISPOSAL OF TAR AND HIGHLY CONTAMINATED SOILS IN AN OFF-SITE HAZARDOUS WASTE LANDFILL; BIO-REMEDIATION OF LOW LEVEL SOILS AND CONTAINMENT; INTERIM GROUNDWATER CONTAINMENT

This Alternative involves excavating the tar and the contaminated soils in and around Tar Lake extending to the adjacent landfill. Additional sampling will be conducted during the pre-design phase to define the limits of contamination. To facilitate the excavation of the tar and soils, a dewatering system will be constructed. The exact number and placement of extraction wells will depend on the areal extent and depth of contamination, and will be determined as a part of the Remedial Design. The excavation will require the use of conventional equipment including drag-lines, conveyor loaders, backhoes, and bulldozers.

Once excavated the tar and contaminated soils will be treated in order to meet the treatment standards for K087 because the tar waste is very similar to K087 waste, i.e., decanter tank tar sludge from coking operations, and contains many of the same hazardous constituents. Since the treatment standards for K087 are based on incineration, incineration may be required to meet these standards. The treatment method will be determined during the pre-design phase. The tars and the contaminated soils will be sampled and treated separately to the maximum extent possible to avoid diluting the tar in the process. For the soil, alternate treatment levels can be based on data from actual treatment of the soil under a treatability variance. This will be established during the pre-design with the most appropriate treatment technology.

Once treated the tar residue will be loaded onto trucks for transportation to a secure, CERCLA off-site policy compliant, RCRA hazardous waste landfill for disposal. If the treated soil is below health based levels, it will be considered clean. Contaminated soil is not a waste, but only a media containing waste. When the contaminants have been removed below health based levels, the soil no longer contains the waste and no longer needs to be treated as a hazardous waste. Thus, clean soil can be used as backfill at the Site.

The remaining soil with an excess cancer risk level less than 1×10^{-2} and greater than 1×10^{-6} will be bio-remediated insitu to the maximum extent practicable with the goal being Michigan Act 307 Type B levels and contained on-site with the installation of a hazardous waste cap if it is determined that bio-remediation can not reach the desired cleanup goal. The bio-remediation involves the addition of nutrients and oxygen to the media to promote bio-degradation of contaminants by microorganisms. The exact amenability and effectiveness to this technology will be determined in pre-design treatability studies.

An interim groundwater containment system will be installed to keep the contaminant plume from migrating further. This containment system will be constructed prior to any excavation work performed on the tar and contaminated soils so that any possible contaminant releases to the groundwater is captured and the dewatering system discharge can be treated. This includes:

- Installation of a groundwater pump and treat system for the containment of contaminated groundwater, the treatment of water ponded on Tar Lake, and discharge from the dewatering system

- Implementation of institutional controls including but not limited to, deed restrictions to regulate the development of the Tar Lake property and groundwater usage restrictions within the areas of the existing or potential contaminant plume.

The groundwater pump and treat component will consist of: 1) a series of extraction wells at the down-gradient edge of the Tar Lake property to prevent further migration of the contaminant plume, and 2) an appropriate treatment system on-site, possibly carbon absorption, to treat the contaminated groundwater, water ponded on Tar Lake, and discharge from the dewatering system. Discharge from the treatment system shall be required to meet applicable effluent discharge limitations as determined by the appropriate regulating authority. Residues from the treatment system which contain constituents of K087 must be managed as hazardous waste. Because there is no surface water body or POTW nearby, the groundwater will be reinjected into to the ground and will meet the requirements of Michigan Act 245 Part 22. This can be used in conjunction with the bio-remediation of the lowly contaminated soils. The discharged water can be supplemented with the necessary nutrients for the bio-remediation process. Existing groundwater monitoring wells will be used to monitor the effectiveness of the groundwater containment system. Wells will be sampled on a monthly basis to ensure that exposure to contaminants does not occur. Final remedy for the groundwater, including clean-up standards, will be addressed in the second operable unit, through the final overall RI/FS for the Tar Lake project.

A site evaluation will be performed every five years for a 30 year period. The purpose of this evaluation is to determine if site conditions are changing, and if so, what actions may be necessary to address these changes.

3.0 DETAILED ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives is the analysis and presentation of relevant information upon which the site remedy is selected. An individual analysis of each alternative against a set of nine evaluation criteria and a comparative analysis using the same evaluation criteria with respect to each other.

The evaluation criteria are as follows:

Overall Protection of Human Health and the Environment - This addresses whether or not a remedy provides adequate protection of human health and the environment and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

Compliance with ARARs - This addresses whether or not a remedy will meet all of the applicable or relevant and appropriate requirements of Federal and State environmental statutes and/or provide grounds for invoking a waiver.

Long-Term Effectiveness and Permanence - This refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met.

Reduction of Toxicity, Mobility, or Volume Through Treatment - This is the anticipated performance of the treatment technologies a remedy may employ. The 1986 Superfund Amendments and Reauthorization Act (SARA) emphasizes that, whenever possible, U.S. EPA should select a remedy that will permanently reduce the level of toxicity of the contaminants at the site, the spread of contaminants away from the site, and the volume, or amount of contaminants at the site.

Short-Term Effectiveness - This addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

Implementability - This is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular remedy.

Cost - This includes estimated capital and operation and maintenance costs, and net present worth costs.

State Acceptance - This addresses the technical or administrative issues and concerns the State may have regarding each alternative.

Community Acceptance - This addresses the issues and concerns the public may have to each of the alternatives.

3.1 INDIVIDUAL DETAILED ANALYSIS

The following is the detailed analysis of each individual alternative against the nine criteria.

3.1.1 Alternative 1 - No Action

Overall Protection of Human Health and the Environment - This alternative is not protective of human health and the environment as nothing is done to address the hazardous substances at the site. The public would still be exposed to unacceptable risks as described in the risk assessment.

Compliance with ARARs - This alternative does not comply with ARARs. Resource Conservation and Recovery Act (RCRA) closure requirements for hazardous waste facilities would not be met with this alternative. Also, the requirements of the Michigan Act 307 Rules would not be met.

Long-Term Effectiveness and Permanence - This alternative does not provide long-term effectiveness nor permanence as there is nothing done to reduce risk at the site. The unacceptable risks at the site will remain at the completion of this no action alternative.

Reduction of Toxicity, Mobility, or Volume Through Treatment - This alternative does not reduce the toxicity, mobility, nor volume through treatment as no action is taken at the site.

Short-Term Effectiveness - There is no additional risk to the local residents or workers due to the implementation of the no action alternative. This alternative would not take any time to implement consequent to no construction or monitoring necessary under this alternative.

Implementability - There is nothing to construct or operate with the no action alternative.

Cost - There is no cost associated with the no action alternative.

State Acceptance - State acceptance of this remedy will be evaluated through discussions with the State of Michigan.

Community Acceptance - Community acceptance of this remedy will have to be evaluated during the public comment period.

3.1.2 Alternative 2 - Removal and Incineration of Tar and Highly Contaminated Soils; Bio-Remediation and Containment of Remaining Soils; Interim Groundwater Containment

Overall Protection of Human Health and the Environment - This alternative is protective of human health and the environment as the present and potential risks posed by the site are mitigated. The risks from ingestion of soil and from contact with the tar will be reduced as: (1) the tar and highly contaminated soils will be excavated and incinerated; and (2) the remaining contaminated soil will be bio-remediated to the maximum extent possible and contained on-site. These actions will result in an acceptable risk level at the site. This alternative provides a high level of effectiveness and permanence as there is minimal residual risk remaining from the treatment of the tar and contaminated soil. As the overall RI/FS will address the clean-up of contaminated groundwater, the interim groundwater containment installed as part of this operable unit will keep the contaminant plume from spreading further. Residential wells have taste and odor problems but have not as yet been found to contain quantifiable levels of the Site contaminants. However, excedences of MCLs have occurred on the Tar Lake property and this groundwater containment measure is to protect the public in the interim from contaminants migrating from the Site.

Compliance with ARARs - This alternative complies with all ARARs. The excavation will meet the requirements of the Clean Air Act standards for total suspended particulates and Michigan's Soil Erosion and Sedimentation Control Act (Act 347) standards. The National Ambient Air Quality Standard for PM-10 (particulate matter with a diameter of 10 micrometers or less) 40 CFR 50.6 will be met.

Because the tar waste is very similar to K087 waste, i.e., decanter tank tar sludge from coking operations, and contains many of the same hazardous constituents, RCRA ARARs are relevant and appropriate. RCRA requirements for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264, will be met. This includes but is not limited to closure and post-closure requirements; waste pile design, monitoring, and closure; and incineration controls and closure (40 CFR Part 264 Subpart O).

The Michigan Hazardous Waste Management Act (Act 64) and the Michigan Solid Waste Management Act (Act 641) requirements will be met with respect to the installation, operation, and closure of the incinerator.

All effluent stack gases from the incineration process will meet the requirements of the Clean Air Act and Michigan's Air Pollution Control Act (Act 348).

The ash from the tar remains a listed waste and must be disposed of in a Subtitle C landfill. Before final disposal, the tar ash will meet the LDR treatment standards for K087 waste in 40 CFR Part 268 Subpart D. If the contaminated soils is incinerated separately from the tar, then the ash from the soil may not require disposal in a Subtitle C landfill if it no longer contains constituents of hazardous waste above health based levels.

Michigan Rules for Act 307 Part 7, which address cleanup type will be met. For bio-remediation of the low level contaminated soils, Type B cleanup criteria for soils are proposed and are presented in Table 5.

If the bio-remediation is technically unable to reach cleanup standards, and the remaining low level contaminated soils are contained with a hazardous waste cap, RCRA, Subpart C, 40 CFR Part 260, will be met by this alternative.

Given that the groundwater remedy is an interim measure, ARARs concerning groundwater cleanup standards will be waived in the Record of Decision as provided for in the NCP, Section 300.430 (f)(1)(ii)(c)(1). The objective of the groundwater component of the operable unit is to prevent further migration of the contaminant plume. The second groundwater operable unit (through the final overall RI/FS) will address ARARs concerning groundwater cleanup standards. The discharge of the captured water will meet the requirements for reinjection into the ground, i.e., Michigan Water Resources Commission Act 245, Part 22 - Ground Water Quality, which will be determined during the pre-design phase when more specific groundwater contaminant information is available. Part 22 provides groundwater quality rules, including nondegredation of usable aquifers. Treatment residues, such as spent carbon, which contain K087 constituents, are subject to and will comply with RCRA requirements.

<u>Long-Term Effectiveness and Permanence</u> - This alternative is effective in the long-term as risks from human exposures associated with the tar and soils will be significantly reduced. The residual risk remaining from the treatment of the tar and contaminated soil are minimal. The tar and highly contaminated soils will be removed and incinerated. The remaining low level contaminated soils will be treated through bio-remediation to the maximum extent practicable. If the desired cleanup levels can not be met with bio-remediation, the soils will be capped to prevent exposure to contaminants, either by direct contact with the groundwater or by leaching into the groundwater. If the soils are contained, the cap will require long-term maintenance and long-term monitoring will be required. This alternative also provides permanence as the tar and contaminated soils will be removed and/or treated to minimize risks.

<u>Reduction of Toxicity, Mobility, or Volume Through Treatment</u> - This alternative reduces the toxicity, mobility, and volume through treatment. The tar and highly contaminated soil are removed and

TABLE 5 Type B Soil Cleanup Levels

Chemical	Soil Criteria (ppb)
CARCINOGENS	
Benzene	0.4 *
Styrene	20
Benzo(a)anthracene	100
Benzo(b)fluoranthene	100
Benzo(k)fluoranthene	100
Chrysene	100
NON-CARCINOGENS	
Ethylbenzene	1,400
Toluene	16,000
2-Butanone	7,000
4-Methyl-2-Pentanone	7,000
Xylenes	6,000
Acenapthene	2,000
Anthracene	40,000
Di-n-butyl phthalate	14,000
Fluoranthene	6,000
Fluorene	6,000
Naphthalene	800
Pyrene	4,000
2,4-Dimethylphenol	8,000
Phenol	6,000
2-Methylphenol	8,000
4-Methylphenol	8,000

* If local background is greater than these health-based criteria, the average local background can be used as a final cleanup goal.

treated through thermal destruction. The remaining soil is also treated until cleanup standards are met or if this is found to be technically impracticable, the toxicity and volume of lowly contaminated soil will be reduced to the maximum extent practicable and then capped. This alternative satisfies the statutory preference for treatment as a principal element through its incineration of the most highly contaminated material.

Short-Term Effectiveness - This alternative will be effective in the short-term. Even though this alternative could introduce risks to workers and residents through the possible release of volatile chemicals through the excavation of the tar and contaminated soils, these risks can be controlled by safe working practices and by following the health and safety plan that will be developed for the Remedial Design/Remedial Action. Air monitoring will be set up to indicate if volatiles are emitted into the air and at what concentrations. If it is determined that volatiles emitted pose a threat to residents, appropriate actions will be taken immediately to mitigate the threat and protect the public. The health and safety plan for the site will at a minimum include the different levels of respiratory protection for the workers and at what detected levels of contaminants they are required to be used. The implementation of this alternative may cause the release of additional contaminants to the groundwater through the excavation of the tar and soils. This is offset by the interim groundwater containment system, which will capture the contaminated groundwater and prevent its migration. The time to implement this remedy is estimated to be a minimum of 3 years.

Implementability - This alternative will be technically and administratively feasible. Excavation and incineration are established technologies. Because the tar is in the water table, dewatering to be performed during the excavation, which is not an unusual practice. The proximity of the site to major highways makes the site accessible for transporting an on-site incinerator. The bio-remediation of the low level contaminated soils is an innovative technology and will have to be ultimately evaluated with a treatability study. However, it has been shown that soils contaminated with wood tars are amenable to bio-remediation at other sites. For the interim groundwater containment portion of the alternative, pump and treat is an established technology.
There should not be any major problems administratively with this alternative. The appropriate requirements for the incineration, bio-remediation, and groundwater discharge will be established and met. Potential areas of administrative concern are access and institutional controls. Access to the Tar Lake property will have to be acquired from the two PRPs, 56th Century and the Township of Mancelona, which own parcels of land at the Site. Institutional controls must be implemented by the Tar Lake property owners and the local government, including but not limited to: deed restrictions regulating the development of the Tar Lake property

and groundwater useage restrictions in the affected or potentially affected areas.

Cost - The cost of this alternative, which was derived from the cost estimates included in Appendix B, is estimated as follows:

Excavation:

Mobilization/Demobilization = **$5,000**

Material Handling:
Excavate Tar and Heavily Contaminated Soil
($30,000\ yd^3 + 20,000\ yd^3$)($\$50/yd^3$) = **$2.5 million**
Health and Safety Equipment = **$10,000**
Confirmation Sampling
(25 events)($350/event) = **$8,750**

Decontamination Station = **$50,000**

Dewatering:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
12 inch Well Boring and Installation = **$67,375**
Geophysical and Analytical Testing = **$5,000**
Well Development
(44 hr)($100/hr) = **$4,400**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Wastes = **$11,440**

Extraction Piping, Pumps, Well Vaults
Vaults
(11 vaults)($5,000/vault) = **$55,000**
Pumps
(11 pumps)($8,750/pump) = **$96,250**
Piping = **$291,000**

Operation and Maintenance
Extraction Well Pumps = **$144,000**

Sub-total Capital Cost for Excavation.......**$3.1 million**

Incineration:

Mobilization/Demobilization = **$800,000**

Thermal Destruction
Tar: (30,375 ton)($600/ton) = **$18.2 million**

Soil: (27,000 ton)($300/ton) = **$ 8.1 million**

Disposal of Residue
Transportation
($3,000\ yd^3$)($37/$yd^3$) = **$111,000**
Disposal
($3,000\ yd^3$)($160/$yd^3$) = **$480,000**

Site Restoration = **$351,000**

Sub-total Capital Cost for Incineration....**$28.0 million**

Bio-remediation of Low Level Contaminated Soils:

Mobilization/Demobilization = **$5,000**

Health and Safety Equipment = **$5,000**

Injection Wells
(8 wells)($10,000/well) = **$80,000**

Trenching and Piping = **$20,000**

Oxygen and Nutrient:
Delivery System = **$35,000**
Pilot Study = **$30,000**

Operation and Maintenance:
Injection Well Labor
(125 Man Days)($600/MD) = **$75,000**
Analytical Costs = **$2,000**
Nutrients/O_2 = **$3,000**
Delivery System = **$3,000**

Sub-total Capital Cost for Bio-remediation....**$175,000**

Groundwater Containment System:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
6 inch Well Boring and Installation = **$22,500**
Geophysical and Analytical Testing = **$5,000**
Well Development
(20 hr)($100/hr) = **$2,000**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Waste = **$5,200**

Extraction Piping, Pumps, Well Vaults
Vaults
(10 vaults)($5000/vault) = **$50,000**
Pumps
(10 pumps)($3375/pump) = **$33,750**
Piping = **$195,000**

Treatment System
Influent Holding Tank = **$34,100**
Feed Pump = **$8,600**
Carbon Adsorption System = **$556,000**
Effluent Tank = **$22,800**
Effluent Pump = **$8,600**
Effluent Piping = **$78,000**

Operation and Maintenance
Extraction Well Pumps = **$32,700**
Carbon Adsorption System
(2 lb carbon/1000 gal) = **$574,300**
Feed Pump = **$20,400**
Effluent Pump = **$20,400**

Sub-total Capital Cost for Groundwater....**$1 million**

Sub-Total Capital Cost.............$32.3 million

Bid Contingencies (15%).......$ 4.8 million
Scope Contingencies (15%).....$ 4.8 million

Construction Total.................$41.9 million

Permitting and Legal (3%).....$ 1.3 million
Construction Services (5%)....$ 2.1 million

Total Implementation Cost..........$45.3 million

Engineering Design Costs (5%).$ 2.3 million

Total Capital Cost.................$47.6 million

Total Annual Cost (O&M)............$ 874,800
Present Worth of Annual Costs
(5 years, 5% discount rate).....$3.8 million

Total Present Worth................$51.4 million

Note: It is assumed that the containment system is an interim action and that the RI/FS for the groundwater operable unit will be completed within the 5 year period for the sake of the present worth analysis.

If bio-remediation is determined not to be technically feasible to reach the cleanup standards for the low level contaminated soils, a cap will be installed at an estimated cost of $1.5 million.

State Acceptance - State acceptance of this alternative will be determined through discussions with the State.

Community Acceptance - Community acceptance of this remedy will have to be evaluated during the public comment period.

3.1.3 Alternative 3 - Removal and Incineration of Tar and Highly Contaminated Soils; Disposal of the Remaining Soils at an Approved Hazardous Waste Landfill; Interim Groundwater Containment

Overall Protection of Human Health and the Environment - This alternative will be protective of human health and the environment. The risks posed by the tar and soils will be mitigated by: (1) the excavation and incineration of the tar and the highly contaminated soils; and (2) the excavation and disposal of the remaining contaminated soils at an approved hazardous waste landfill. This alternative provides a high level of effectiveness and permanence as the residual risk is minimized with proper disposal of the ash and any residual from the incineration process. The second operable unit (through the overall RI/FS) will address the groundwater clean-up but implementation of interim groundwater containment as part of this operable unit will keep the contaminant plume from spreading further. Residential wells have taste and odor problems but have not as yet been detected with quantifiable levels of the Site contaminants. The groundwater containment will protect the public in the interim.

Compliance with ARARs - This alternative complies with all ARARs. The excavation will meet the requirements of the Clean Air Act standards for total suspended particulates and Michigan's Soil Erosion and Sedimentation Control Act (Act 347) standards. The National Ambient Air Quality Standard for PM-10 (particulate matter with a diameter of 10 micrometers or less) 40 CFR 50.6 will be met.

Because the tar waste is very similar to K087 waste, i.e., decanter tank tar sludge from coking operations, and contains many of the same hazardous constituents, RCRA ARARs are relevant and appropriate. RCRA requirements for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264, will also be met. This includes but is not limited to closure and post-closure requirements; waste pile design, monitoring, and closure; and incineration controls and closure (40 CFR Part 264 Subpart O). The off-site transport of contaminated materials is regulated by 40 CFR Part 263 which will be met.

Regulations for Hazardous Waste Generators, 40 CFR 262, is relevant and appropriate for classifying the site as a generator of hazardous waste in relation to the off-site shipment of the tar and soils. Land Disposal Restrictions under 40 CFR Part 268 will also be met with respect to the disposal of the low level contaminated soil at an off-site hazardous waste landfill. The soil will meet alternate treatment standards under a treatability variance from LDR treatment standards.

The U.S. EPA off-site policy is a "To Be Considered" (TBC) requirement and will be followed to ensure that wastes are sent to a CERCLA off-site compliant RCRA permitted landfill.

The Michigan Hazardous Waste Management Act (Act 64) and the Michigan Solid Waste Management Act (Act 641) requirements will be met with respect to the installation, operation, and closure of the incinerator.

All effluent stack gases from the incineration process will meet the requirements of the Clean Air Act and Michigan's Air Pollution Control Act (Act 348).

The ash from the tar remains a listed waste and must be disposed of in a Subtitle C landfill. Before final disposal of the tar ash, it will meet the LDR treatment standards in 40 CFR Part 268 Subpart D. If the contaminated soils is incinerated separately from the tar, then the ash from the soil may not require disposal in a Subtitle C landfill if it no longer contains constituents of hazardous waste above health based levels.

Michigan Rules for Act 307 Part 7, which addresses cleanup type will be met. For the removal and disposal of the low level contaminated soil, Type B criteria are proposed as the cleanup level for the soils and are listed in Table 5.

Given that the groundwater remedy is an interim measure, ARARs concerning groundwater cleanup standards will be waived in the Record of Decision as provided for in the NCP, Section 300.430 (f)(1)(ii)(c)(1). The objective of the groundwater component of the operable unit is to prevent further migration of the contaminant plume. The second groundwater operable unit (through the overall RI/FS) will address ARARs concerning groundwater cleanup standards. The discharge of the captured water will meet the requirements for reinjection into the ground, i.e., Michigan Water Resources Commission Act 245, Part 22 - Ground Water Quality, which will be determined during the pre-design phase when more specific groundwater contaminant information is available. Part 22 provides groundwater quality rules, including nondegredation of usable aquifers. Treatment residues, such as spent carbon, which contain K087 constituents, are subject to and will comply with RCRA requirements.

Long-Term Effectiveness and Permanence - This alternative provides long-term effectiveness and permanence as the risks due to exposure to site contaminants will be minimized through treatment of the principal threat through thermal destruction of the tar and highly contaminated soils and removal of the low level contamination to an off-site facility. The proper disposal of the ash and any residue from the incineration process will minimize the residual risk at the Site.

Reduction of Toxicity, Mobility, or Volume Through Treatment - This alternative partially reduces toxicity, mobility, and volume through the thermal treatment of the tar and the highly contaminated soils. The toxicity, mobility, and volume of low level contamination is also be reduced through treatment, as it is treated prior to disposal at an off-site facility. Through the use of incineration for the highly contaminated materials at the Site, the statutory preference for treatment as a principal element is satisfied.

Short-Term Effectiveness - This alternative will be effective in the short-term. Even though this alternative could introduce risks to workers and residents through the possible release of volatile chemicals through the excavation of the tar and contaminated soils, these risks can be controlled by safe working practices and by following the health and safety plan that will be developed for the Remedial Design/Remedial Action. Air monitoring will be set up to indicate if volatiles are emitted into the air and at what concentrations. If it is determined that volatiles emitted pose a threat to residents, appropriate actions will be taken immediately to mitigate the threat and protect the public. The health and safety plan for the site will at a minimum include the different levels of respiratory protection for the workers and at what detected levels of contaminants they are required to be used. The implementation of this alternative may cause the release of additional contaminants to the groundwater through the excavation of the tar and soils. This is offset by the interim groundwater containment system, which will capture the contaminated groundwater and prevent its migration. The time to implement this remedy is estimated to be a minimum of 3 years.

Implementability - This alternative will be technically and administratively feasible. Excavation and incineration are established technologies. Because the tar is in the water table, dewatering to be performed during the excavation, which is not an unusual practice. The proximity of the site to major highways makes the site accessible for transporting an on-site incinerator. For the interim groundwater containment portion of the alternative, pump and treat is an established technology. There should not be any major problems administratively with this alternative. The appropriate requirements for the incineration and groundwater discharge will be established and met. Potential areas of concern administratively are: (1) an off-site landfill's acceptance of the waste, (2) gaining access to the Tar Lake property, and (3) implementation of institutional controls. (1) Even though there are licensed solid waste landfills that could accept the low level contaminated soil, getting the facility to accept the waste may be a problem. Facilities may be reluctant to accept waste from a Superfund site and there are county solid waste management plans which prohibit the receipt of waste from outside of the county. (2) Access to the Tar Lake property will have to be acquired from the two PRPs, 56th Century and the Township of Mancelona, which own parcels of land at the Site. (3) Institutional controls must be implemented by the Tar Lake property owners and the local government, including but not limited to: deed restrictions regulating the development of the Tar Lake property and groundwater useage restrictions in the affected or potentially affected areas.

Cost - The cost of this alternative, which are derived from the cost estimates in Appendix B, is estimated as follows:

Excavation:

Mobilization/Demobilization = **$5,000**

Material Handling:
Excavate Tar and Heavily Contaminated Soil
(30,000 yd^3 + 20,000 yd^3)($50/$yd^3$) = **$2.5 million**
Health and Safety Equipment = **$10,000**
Confirmation Sampling
(25 events)($350/event) = **$8,750**

Decontamination Station = **$50,000**

Dewatering:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
12 inch Well Boring and Installation = **$67,375**
Geophysical and Analytical Testing = **$5,000**
Well Development
(44 hr)($100/hr) = **$4,400**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Wastes = **$11,440**

Extraction Piping, Pumps, Well Vaults
Vaults
(11 vaults)($5,000/vault) = **$55,000**
Pumps
(11 pumps)($8,750/pump) = **$96,250**
Piping = **$291,000**

Operation and Maintenance
Extraction Well Pumps = **$144,000**

Sub-total Capital Cost for Excavation.......**$3.1 million**

Incineration:

Mobilization/Demobilization = **$800,000**

Thermal Destruction
Tar: (30,375 ton)($600/ton) = **$18.2 million**
Soil: (27,000 ton)($300/ton) = **$ 8.1 million**

Disposal of Residue
Transportation
(3,000 yd^3)($37/$yd^3$) = **$111,000**
Disposal
(3,000 yd^3)($160/$yd^3$) = **$480,000**

Site Restoration = **$351,000**

Sub-total Capital Cost for Incineration....**$28.0 million**

Off-Site Disposal of Low Level Contaminated Soils:

Material Handling
Excavate Low Level Contaminated Soil
(20,000 yd^3)($50/$yd^3$) = **$1 million**

Material Loading
Equipment Rental (2 Loaders)
(4 months)($3625/month) = **$14,500**
Hourly Operation
(1,000 hr)($13/hr) = **$13,000**
Labor (7 people)
(650 hr)($140/hr) = **$91,000**
Health and Safety Equipment = **$10,000**

Additional Site Restoration = **$240,000**

Transportation/Disposal
Transportation
(20,000 yd^3)($37.50/$yd^3$) = **$750,000**
Disposal
(20,000 yd^3)($160/$yd^3$) = **$3.2 million**

Sub-total Capital Cost for Off-Site Disposal....**$5.3 million**

Groundwater Containment System:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
6 inch Well Boring and Installation = **$22,500**
Geophysical and Analytical Testing = **$5,000**
Well Development
(20 hr)($100/hr) = **$2,000**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Waste = **$5,200**

Extraction Piping, Pumps, Well Vaults
Vaults
(10 vaults)($5000/vault) = **$50,000**
Pumps
(10 pumps)($3375/pump) = **$33,750**
Piping = **$195,000**

Treatment System
Influent Holding Tank = **$34,100**
Feed Pump = **$8,600**
Carbon Adsorption System = **$556,000**
Effluent Tank = **$22,800**
Effluent Pump = **$8,600**
Effluent Piping = **$78,000**

Operation and Maintenance
Extraction Well Pumps = **$32,700**
Carbon Adsorption System
(2 lb carbon/1000 gal) = **$574,300**
Feed Pump = **$20,400**
Effluent Pump = **$20,400**

Sub-total Capital Cost for Groundwater....**$1 million**

Sub-Total Capital Cost.............$37.4 million

Bid Contingencies (15%).......$ 5.6 million
Scope Contingencies (15%).....$ 5.6 million

Construction Total.................$48.6 million

Permitting and Legal (3%).....$ 1.5 million
Construction Services (5%)....$ 2.4 million

Total Implementation Cost..........$52.5 million

Engineering Design Costs (5%).$ 2.6 million

Total Capital Cost.................$55.1 million

Total Annual Cost (O&M)............$ 791,800
Present Worth of Annual Costs
(5 years, 5% discount rate).....$3.4 million

Total Present Worth................$58.5 million

Note: It is assumed that the containment system is an interim action and that the RI/FS for the groundwater operable unit will be completed within the 5 year period for the sake of the present worth analysis.

State Acceptance - State acceptance of this alternative will be determined through discussions with the State.

Community Acceptance - Community acceptance of this remedy will have to be evaluated during the public comment period.

3.1.4 Alternative 4 - Removal and Incineration of Tar and Highly Contaminated Soils; Thermally Treat Remaining Soils; Interim Groundwater Containment

Overall Protection of Human Health and the Environment - This alternative is protective of human health and the environment. The risks posed by the tar and the soils are mitigated by: (1) the excavation and incineration of the tar and highly contaminated soils; and (2) the treatment of the remaining soil so residual contaminants are at or below health-based acceptable levels. This alternative provides a high level of effectiveness and permanence as the residual risk remaining from treatment processes is minimal with the proper disposal of residuals and there are no untreated wastes left at the Site. The second operable unit (through the overall RI/FS) will address the groundwater clean-up but the implementation of interim groundwater containment in this operable unit will keep the contaminant plume from spreading. Residential wells have taste and odor problems but have not yet been found to contain quantifiable levels of Site contaminants. This groundwater containment measure will protect the public from the migration of Site contaminants, some of which have been found to exceed MCLs on the Tar Lake property.

Compliance with ARARs - This alternative complies with all ARARs. The excavation will meet the requirements of the Clean Air Act standards for total suspended particulates and Michigan's Soil Erosion and Sedimentation Control Act (Act 347) standards. The National Ambient Air Quality Standard for PM-10 (particulate matter with a diameter of 10 micrometers or less) 40 CFR 50.6 will be met.

Because the tar waste is very similar to K087 waste, i.e., decanter tank tar sludge from coking operations, and contains many of the same hazardous constituents, RCRA ARARs are relevant and appropriate. RCRA requirements for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264, will also be met. This includes but is not limited to closure and post-closure requirements; waste pile design, monitoring, and closure; and incineration controls and closure (40 CFR Part 264 Subpart O).

The Michigan Hazardous Waste Management Act (Act 64) and the Michigan Solid Waste Management Act (Act 641) requirements will be met with respect to the installation, operation, and closure of the incinerator.

All effluent stack gases from the incineration process will meet the requirements of the Clean Air Act and Michigan's Air Pollution Control Act (Act 248).

The ash from the tar remains a listed waste and must be disposed of in a Subtitle C landfill. Before final disposal of the tar ash, it will meet the treatment standards in 40 CFR Part 268 Subpart D. If the contaminated soils is incinerated separately from the tar, then the ash from the soil may not require disposal in a Subtitle C landfill if it no longer contains constituents of hazardous waste above health based levels.

Michigan Rules for Act 307 Part 7, which addresses cleanup types, will be met. For the low temperature thermal desorption, Type B criteria for the soils are proposed and are listed in Table 5.

Treatment of soils by low temperature thermal desorption will be done in a unit which is in compliance with RCRA regulations for miscellaneous units, as set forth in 40 CRF Part 264 Subpart X. As with incinerated soils, if the soil is treated to below health based levels, it is not subject to RCRA ARARs for final land disposal. If health based levels are not attained by low temperature desorption, then RCRA treatment standards must be met and the treatment residue must be disposed in a Subtitle C unit.

Given that the groundwater remedy is an interim measure, ARARs concerning groundwater cleanup standards will be waived in the Record of Decision as provided for in the NCP, Section 300.430 (f)(1)(ii)(c)(1). The objective of the groundwater component of the operable unit is to prevent further migration of the contaminant plume. The second groundwater operable unit (through the overall RI/FS) will address ARARs concerning groundwater cleanup standards. The discharge of the captured water will meet the requirements for reinjection into the ground, i.e., Michigan Water Resources Commission Act 245, Part 22 - Ground Water Quality, which will be determined during the pre-design phase when more specific groundwater contaminant information is available. Part 22 provides groundwater quality rules, including nondegredation of usable aquifers. Treatment residue, such as spent carbon, which contains K087 constituents, are subject to and will comply with RCRA requirements.

Long-Term Effectiveness and Permanence - This alternative is effective in the long-term as risks from human exposures associated with the tar and soils will be minimized. The tar and highly contaminated soils are removed and incinerated. The low level contaminated soils are removed and treated until health-based levels are met. Permanence is provided as the tar and contaminated soils will be removed and/or treated to minimize risks. The residual risk resulting from the treatment of the tar and contaminated soil is minimized through the proper disposal of any ash and residuals from the treatment processes.

Reduction of Toxicity, Mobility, or Volume Through Treatment - This alternative reduces the toxicity, mobility, and volume through treatment. The tar and highly contaminated soil are removed and treated through thermal destruction. The remaining soil is thermally desorbed so that cleanup standards are met. This alternative utilizes treatment as a principal element through the incineration of the tar and highly contaminated soil and the low temperature desorption of the low level contaminated soil.

Short-Term Effectiveness - This alternative will be effective in the short-term. Even though this alternative could introduce risks to workers and residents through the possible release of volatile chemicals through the excavation of the tar and contaminated soils, these risks can be controlled by safe working practices and by following the health and safety plan that will be developed for the Remedial Design/Remedial Action. Air monitoring will be set up to indicate if volatiles are emitted into the air and at what concentrations. If it is determined that volatiles emitted pose a threat to residents, appropriate actions will be taken immediately to mitigate the threat and protect the public. The health and safety plan for the site will at a minimum include the different levels of respiratory protection for the workers and at what detected levels of contaminants they are required to be used. The implementation of this alternative may cause the release of additional contaminants to the groundwater through the excavation of the tar and soils. This is offset by the interim groundwater containment system, which will capture the contaminated groundwater and prevent its migration. The time to implement this remedy is estimated to be a minimum of 3 years.

Implementability - This alternative will be technically and administratively feasible. Excavation and incineration are established technologies. Because the tar is in the water table, dewatering to be performed during the excavation, which is not an unusual practice. The proximity of the site to major highways makes the site accessible for transporting an on-site incinerator. Thermal desorption of the low level contaminated soils is an innovative technology and will have to be ultimately evaluated with a treatability study. However, commercial-scale units exist and are in operation. Thermal desorption has been shown in pilot tests to be effective for creosote and coal tar contaminated media. For the interim groundwater containment portion of the alternative, pump and treat is an established technology. There should not be any major problems administratively with this alternative. The appropriate requirements for the incineration, thermal desorption, and groundwater discharge will be established and met. Potential areas of administrative concern are access, institutional controls, and acceptance of Superfund waste at off-site landfills. Access to the Tar Lake property will have to be acquired from the two PRPs, 56th Century and the Township of Mancelona, which own parcels of land at the Site. Institutional controls must be implemented by the Tar Lake property owners and the local government, including but not limited to: deed restrictions regulating the development of the Tar Lake property and groundwater useage restrictions in the affected or potentially affected areas. Even though a facility is permitted to accept hazardous waste, some operators have been known to be reluctant about accepting Superfund waste. Locating a facility that will accept the waste may require some effort.

Cost - The cost of this alternative, which are derived from the cost estimates in Appendix B, is estimated as follows:

Excavation:

Mobilization/Demobilization = **$5,000**

Material Handling:
Excavate Tar and Heavily Contaminated Soil
(30,000 yd^3 + 20,000 yd^3)($50/$yd^3$) = **$2.5 million**
Health and Safety Equipment = **$10,000**
Confirmation Sampling
(25 events)($350/event) = **$8,750**

Decontamination Station = **$50,000**

Dewatering:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
12 inch Well Boring and Installation = **$67,375**
Geophysical and Analytical Testing = **$5,000**
Well Development
(44 hr)($100/hr) = **$4,400**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Wastes = **$11,440**

Extraction Piping, Pumps, Well Vaults
Vaults
(11 vaults)($5,000/vault) = **$55,000**
Pumps
(11 pumps)($8,750/pump) = **$96,250**
Piping = **$291,000**

Operation and Maintenance
Extraction Well Pumps = **$144,000**

Sub-total Capital Cost for Excavation.......**$3.1 million**

Incineration:

Mobilization/Demobilization = **$800,000**

Thermal Destruction
Tar: (30,375 ton)($600/ton) = **$18.2 million**
Soil: (27,000 ton)($300/ton) = **$ 8.1 million**

Disposal of Residue
Transportation
(3,000 yd^3)($37/$yd^3$) = **$111,000**
Disposal
(3,000 yd^3)($160/$yd^3$) = **$480,000**

Site Restoration = **$351,000**

Sub-total Capital Cost for Incineration....**$28.0 million**

Thermal Desorption of Low Level Contaminated Soils:

Material Handling
Excavate Low Level Contaminated Soil
(20,000 yd^3)($50/$yd^3$) = **$1 million**

Thermal desorption of low level contaminated soils

The cost ranges from $80 - $350 per ton of feed. $300/ton is used to account for the higher energy needed because of the high moisture content anticipated in the soil.

(27,000 ton)($300/ton) = **$8.1 million**

Sub-total Capital Cost for Thermal Desorption....**$9.1 million**

<u>Groundwater Containment System</u>:

Extraction Wells
- Surveying/Staking = **$1,000**
- Permitting/Utility Checks = **$500**
- Mobilization/Demobilization = **$2,500**
- 6 inch Well Boring and Installation = **$22,500**
- Geophysical and Analytical Testing = **$5,000**
- Well Development
  - (20 hr)($100/hr) = **$2,000**
- Equipment Decontamination
  - (15 hr)($100/hr) = **$1,500**
- Drum and Dispose of Waste = **$5,200**

Extraction Piping, Pumps, Well Vaults
- Vaults
  - (10 vaults)($5000/vault) = **$50,000**
- Pumps
  - (10 pumps)($3375/pump) = **$33,750**
- Piping = **$195,000**

Treatment System
- Influent Holding Tank = **$34,100**
- Feed Pump = **$8,600**
- Carbon Adsorption System = **$556,000**
- Effluent Tank = **$22,800**
- Effluent Pump = **$8,600**
- Effluent Piping = **$78,000**

Operation and Maintenance
- Extraction Well Pumps = **$32,700**
- Carbon Adsorption System
  - (2 lb carbon/1000 gal) = **$574,300**
- Feed Pump = **$20,400**
- Effluent Pump = **$20,400**

Sub-total Capital Cost for Groundwater....**$1 million**

Sub-Total Capital Cost.............$41.2 million

Bid Contingencies (15%).......$ 6.2 million
Scope Contingencies (15%).....$ 6.2 million

Construction Total.................$53.6 million

Permitting and Legal (3%).....$ 1.6 million
Construction Services (5%)....$ 2.7 million

Total Implementation Cost..........$57.9 million

Engineering Design Costs (5%).$ 2.9 million

Total Capital Cost.................$60.8 million

Total Annual Cost (O&M)............$ 791,800
Present Worth of Annual Costs
(5 years, 5% discount rate).....$3.4 million

Total Present Worth................$64.2 million

Note: It is assumed that the containment system is an interim action and that the RI/FS for the groundwater operable unit will be completed within the 5 year period for the sake of the present worth analysis.

State Acceptance - State acceptance of this alternative will be determined through discussions with the State.

Community Acceptance - Community acceptance of this remedy will have to be evaluated during the public comment period.

3.1.5 Alternative 5 - Removal and Disposal of Tar and Contaminated Soils in a Hazardous Waste Landfill; Interim Groundwater Containment

Overall Protection of Human Health and the Environment - This alternative will be protective of human health and the environment. The risks posed by the tar and contaminated soils will be mitigated by the excavation and disposal at an approved hazardous waste landfill. This alternative provides a high level of effectiveness and permanence as the tar and contaminated soil are removed from the Site and no untreated materials or residue remain. The second operable unit (through the overall RI/FS) will address the groundwater clean-up but implementation of interim groundwater containment as part of this operable unit will keep the contaminant plume from spreading. The residential wells have taste and odor problems but quantifiable levels of contaminants have yet to be detected in them. The groundwater containment protects the public from the contaminants at the Site, some of which have exceeded MCLs on the Tar Lake property.

Compliance with ARARs - This alternative complies with all ARARs. The excavation will meet the requirements of the Clean Air Act standards for total suspended particulates and Michigan's Soil Erosion and Sedimentation Control Act (Act 347) standards. The National Ambient Air Quality Standard for PM-10 (particulate matter with a diameter of 10 micrometers or less) 40 CFR 50.6 will be met.

Because the tar waste is very similar to K087 waste, i.e., decanter tank tar sludge from coking operations, and contains many of the same hazardous constituents, RCRA ARARs are relevant and appropriate. RCRA requirements for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264, will also be met. This includes but is not limited to closure and post-closure requirements; waste pile design, monitoring, and closure. Other RCRA requirements that will be met include 40 CFR Part 263, Standards Applicable to Transporters of Hazardous Waste; 40 CFR 262, Regulations for Hazardous Waste Generators (classification of the site as a generator of hazardous waste with respect to the removal and off-site transportation of contaminated materials); and, 40 CFR Part 268, Land Disposal Restrictions. The tar will meet the LDR treatment standards for K087 waste, prior to disposal at the off-site hazardous waste landfill, in 40 CFR Part 268 Subpart D. Since the treatment standard for K087 waste are based on incineration, this alternative may require incineration of the tar prior to land disposal. The soils will meet alternate treatment standards under a treatability variance from LDR treatment standards.

The U.S. EPA off-site policy is a "To Be Considered" (TBC) requirement and will be followed to ensure that wastes are sent to a CERCLA off-site compliant RCRA permitted landfill.

Michigan Rules for Act 307 Part 7, which addresses cleanup type, will be met. For the removal of the contaminated soil, Type B cleanup criteria are proposed and are listed in Table 5.

Given that the groundwater remedy is an interim measure, ARARs concerning groundwater cleanup standards will be waived in the Record of Decision as provided for in the NCP, Section 300.430 (f)(1)(ii)(c)(1). The objective of the groundwater component of the operable unit is to prevent further migration of the contaminant plume. The second groundwater operable unit (through the overall RI/FS) will address ARARs concerning groundwater cleanup standards. The discharge of the captured water will meet the requirements for reinjection into the ground, i.e., Michigan Water Resources Commission Act 245, Part 22 - Ground Water Quality, which will be determined during the pre-design phase when more specific groundwater contaminant information is available. Part 22 provides groundwater quality rules, including nondegredation of usable aquifers. Treatment residues, such as spent carbon, which contain K087 constituents, are subject to and will comply with RCRA requirements.

<u>Long-Term Effectiveness and Permanence</u> - This alternative provides long-term effectiveness and permanence as the risks due to exposure to site contaminants will be minimized through removal of the tar and contaminated soils and disposal at an approved off-site hazardous waste facility. There are no untreated waste or residual material left at the Site with this alternative.

<u>Reduction of Toxicity, Mobility, or Volume Through Treatment</u> - This alternative does reduce toxicity, mobility, or volume through treatment. The toxicity, mobility, and volume of the tar and the contaminated soils will be reduced due to the treatment required by LDRs prior to disposal at an approved off-site hazardous waste facility. This satisfies the statutory preference for treatment is a principal element of this alternative.

<u>Short-Term Effectiveness</u> - This alternative will be effective in the short-term. Even though this alternative could introduce risks to workers and residents through the possible release of volatile chemicals through the excavation of the tar and contaminated soils, these risks can be controlled by safe working practices and by following the health and safety plan that will be developed for the Remedial Design/Remedial Action. Air monitoring will be set up to indicate if volatiles are emitted into the air and at what concentrations. If it is determined that volatiles emitted pose a threat to residents, appropriate actions will be taken immediately to mitigate the threat and protect the public. The health and safety plan for the site will at a minimum include the different levels of respiratory protection for the workers and at what detected levels of contaminants they are required to be used. The implementation of this alternative may cause the release of additional contaminants to the groundwater through the excavation of the tar and soils. This is offset by the interim groundwater containment system, which will capture the contaminated groundwater and prevent its migration. The time to implement this remedy is estimated to be a minimum of 3 years.

<u>Implementability</u> - This alternative will be technically and administratively feasible. Excavation and incineration are established technologies. Because the tar is in the water table, dewatering to be performed during the excavation, which is not an unusual practice. The proximity of the site to major highways makes the site accessible for transporting the tar ash and residue to an approved off-site hazardous waste facility. For the interim groundwater containment portion of the alternative, pump and treat is an established technology. There should not be any major problems administratively with this alternative. The appropriate

requirements for the groundwater discharge will be established and met. Potential areas of administrative concern are access, institutional controls, and acceptance of Superfund waste by an off-site landfill. Access to the Tar Lake property will have to be acquired from the two PRPs, 56th Century and the Township of Mancelona, which own parcels of land at the Site. Institutional controls must be implemented by the Tar Lake property owners and the local government, including but not limited to: deed restrictions regulating the development of the Tar Lake property and groundwater useage restrictions in the affected or potentially affected areas. Locating an approved hazardous waste landfill to accept Superfund waste may require some effort. Some operators have been reluctant to take in Superfund waste.

Cost - The cost of this alternative, which is derived from the cost estimates in Appendix B, is estimated as follows:

Excavation:

Mobilization/Demobilization = **$5,000**

Material Handling:
- Excavate Tar and Contaminated Soil
  - (30,000 yd^3 + 40,000 yd^3)($50/$yd^3$) = **$3.5 million**
- Health and Safety Equipment = **$10,000**
- Confirmation Sampling
  - (25 events)($350/event) = **$8,750**

Dewatering:

- Extraction Wells
  - Surveying/Staking = **$1,000**
  - Permitting/Utility Checks = **$500**
  - Mobilization/Demobilization = **$2,500**
  - 12 inch Well Boring and Installation = **$67,375**
  - Geophysical and Analytical Testing = **$5,000**
  - Well Development
    - (44 hr)($100/hr) = **$4,400**
  - Equipment Decontamination
    - (15 hr)($100/hr) = **$1,500**
  - Drum and Dispose of Wastes = **$11,440**

- Extraction Piping, Pumps, Well Vaults
  - Vaults
    - (11 vaults)($5,000/vault) = **$55,000**
  - Pumps
    - (11 pumps)($8,750/pump) = **$96,250**
  - Piping = **$291,000**

Operation and Maintenance
Extraction Well Pumps = **$144,000**

Sub-total Capital Cost for Excavation.......**$4.1 million**

<u>Off-Site Disposal of Tar and Contaminated Soils</u>:

Incineration: (To meet LDR treatment standards)

Mobilization/Demobilization = **$800,000**

Thermal Destruction
Tar: (30,375 ton)($600/ton) = **$18.2 million**
Soil: (27,000 ton)($300/ton) = **$ 8.1 million**

Off-Site Disposal of Tar Residue
Transportation
(3,000 yd^3)($37/$yd^3$) = **$111,000**
Disposal
(3,000 yd^3)($160/$yd^3$) = **$480,000**

Site Restoration = **$351,000**

Sub-total Capital Cost for Treatment and Off-Site Disposal of Tar Residue................................**$28.0 million**

<u>Groundwater Containment System</u>:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
6 inch Well Boring and Installation = **$22,500**
Geophysical and Analytical Testing = **$5,000**
Well Development
(20 hr)($100/hr) = **$2,000**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Waste = **$5,200**

Extraction Piping, Pumps, Well Vaults
Vaults
(10 vaults)($5000/vault) = **$50,000**
Pumps
(10 pumps)($3375/pump) = **$33,750**
Piping = **$195,000**

Treatment System
Influent Holding Tank = **$34,100**
Feed Pump = **$8,600**

Carbon Adsorption System = **$556,000**
Effluent Tank = **$22,800**
Effluent Pump = **$8,600**
Effluent Piping = **$78,000**

Operation and Maintenance
Extraction Well Pumps = **$32,700**
Carbon Adsorption System
(2 lb carbon/1000 gal) = **$574,300**
Feed Pump = **$20,400**
Effluent Pump = **$20,400**

Sub-total Capital Cost for Groundwater....**$1 million**

Sub-Total Capital Cost.............$33.1 million

Bid Contingencies (15%).......$ 5.0 million
Scope Contingencies (15%).....$ 5.0 million

Construction Total.................$43.1 million

Permitting and Legal (3%).....$ 1.3 million
Construction Services (5%)....$ 2.2 million

Total Implementation Cost..........$46.6 million

Engineering Design Costs (5%).$ 2.3 million

Total Capital Cost.................$48.9 million

Total Annual Cost (O&M)............$ 791,800
Present Worth of Annual Costs
(5 years, 5% discount rate).....$3.4 million

Total Present Worth................$52.3 million

Note: It is assumed that the containment system is an interim action and that the RI/FS for the groundwater operable unit will be completed within the 5 year period for the sake of the present worth analysis.

State Acceptance - State acceptance of this alternative will be determined through discussions with the State.

Community Acceptance - Community acceptance of this remedy will have to be evaluated during the public comment period.

3.1.6 Alternative 6 - Removal and Disposal of Tar and Contaminated Soils in an On-site RCRA Cell; Interim Groundwater Containment

Overall Protection of Human Health and the Environment - This alternative will be protective of human health and the environment. The risks posed by the tar and the contaminated soils will be mitigated by the excavation and containment in a RCRA compliant containment cell. With its double liner, leachate collection system and monitoring, exposure to the contaminants in the tar and soils will be eliminated. This alternative provides a high level of effectiveness and permanence as the engineered controls are adequate and reliable with its many backup components. The residual risk remaining from the untreated waste at the conclusion of the operable unit remedial action is minimal because of this reliability. The second operable unit (through the overall RI/FS) will address the groundwater clean-up, however implementation of the interim groundwater containment as part of this operable unit will keep the contaminant plume from spreading further. The residential wells have taste and odor problems but have not as yet been found to contain quantifiable levels of Site contaminants. This groundwater containment measure is to protect the public from contaminants which have been found to exceed MCLs on the Tar Lake property.

Compliance with ARARs - This alternative complies with all ARARs. The excavation will meet the requirements of the Clean Air Act standards for total suspended particulates and Michigan's Soil Erosion and Sedimentation Control Act (Act 347) standards. The National Ambient Air Quality Standard for PM-10 (particulate matter with a diameter of 10 micrometers or less) 40 CFR 50.6 will be met.

Because the tar waste is very similar to K087 waste, i.e., decanter tank tar sludge from coking operations, and contains many of the same hazardous constituents, RCRA ARARs are relevant and appropriate. RCRA requirements for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264, will be met. This includes but is not limited to closure and post-closure requirements; waste pile design, monitoring, and closure. Minimum technology requirements for the containment cells are set forth in 40 CFR Part 264.301(c).

Requirements for Hazardous Waste Landfill Design, Construction, and Closure EPA/625/4-89/002, August 1989, and Final Covers on Hazardous Waste Landfills and Surface Impoundments EPA/530-SW-89-047, July 1989 are "To Be Considered" (TBC) with respect to the design and construction of the containment cells.

Michigan Rules for Act 307 Part 7, which addresses cleanup type, will be met. For the excavation and containment of the contaminated soil, Type B criteria are proposed and are listed in Table 5.

Given that the groundwater remedy is an interim measure, ARARs concerning groundwater cleanup standards will be waived in the Record of Decision as provided for in the NCP, Section 300.430 (f)(1)(ii)(c)(1). The objective of the groundwater component of the operable unit is to prevent further migration of the contaminant plume. The second groundwater operable unit (through the overall RI/FS) will address ARARs concerning groundwater cleanup standards. The discharge of the captured water will meet the requirements for reinjection into the ground, i.e., Michigan Water Resources Commission Act 245, Part 22 - Ground Water Quality, which will be determined during the pre-design phase when more specific groundwater contaminant information is available. Part 22 provides groundwater quality rules, including nondegredation of usable aquifers. Treatment residues, such as spent carbon, which contain K087 constituents, are subject to and will comply with RCRA requirements.

Long-Term Effectiveness and Permanence - This alternative provides long-term effectiveness and permanence as the risks due to exposure to site contaminants will be minimized through the removal of the tar and contaminated soils and disposal in RCRA compliant containment cells. The protective measures of the containment cell, i.e. the double liners, leachate collection systems, and groundwater monitoring, will provide reliability to ensure that any exposures to untreated waste will be minimized. The containment cell cap would require long-term maintenance and long-term monitoring will be required to ensure that the cell remains protective.

Reduction of Toxicity, Mobility, or Volume Through Treatment - This alternative does not reduce toxicity, mobility, or volume through treatment. The ability of the tar and contaminated soils to migrate will be reduced by placing them in a containment cell, however, this reduction in mobility is not the result of treatment of the contaminated media. Treatment is not a principal element of this alternative, which uses engineering controls to reduce risk at the Site.

Short-Term Effectiveness - This alternative will be effective in the short-term. The excavation of the tar and contaminated soils could possibly result in the release of volatile chemicals into the groundwater and the air, which would introduce risks to residents and workers. However, the possible releases can easily be mitigated. Any releases into the groundwater would be captured by the interim groundwater containment system to prevent migration. With respect to possible air releases, air monitoring will be set up to indicate if volatiles are emitted into the air and at what concentrations. If it is determined that an unacceptable risk exists, appropriate actions will be taken immediately to mitigate the threat and protect the public. For the workers who could be more directly exposed to volatiles released and with contact with the contaminated media, their risks can be controlled by following safe working practices and the health and safety plan that will be set up for the site. The health and safety plan for the site will at a minimum include the different levels of respiratory protection for the workers and the levels of contaminants they are required to be used. The time to implement this alternative is estimated to be a minimum of 3 years.

Implementability - This alternative will be technically and administratively feasible. Excavation is an established technology. Because the tar and contaminated soils are in the water table, dewatering will be performed during the excavation, which is not an unusual practice. The RCRA compliant containment cell and groundwater pump and treat are also established technologies. There should not be any major problems administratively with this alternative as no permits need to be obtained. Potential areas of administrative concern are access and institutional controls. Access to the Tar Lake property will have to be acquired from the two PRPs, 56th Century and the Township of Mancelona, which own parcels of land at the Site. Institutional controls must be implemented by the Tar Lake property owners and the local government, including but not limited to: deed restrictions regulating the development of the Tar Lake property and groundwater useage restrictions in the affected or potentially affected areas.

Cost - The cost of this alternative, which is derived from the cost estimates in Appendix B, is estimated as follows:

Excavation:

Mobilization/Demobilization = **$5,000**

Material Handling:
Excavate Tar
(30,000 yd^3)($50/$yd^3$) = **$1.5 million**
Protective Clothing (Health & Safety Equipment)
(400 sets)($33/set) = **$13,200**
Confirmation Sampling
(25 events)($350/event) = **$8,750**

Excavate Contaminated Soils
(40,000 yd^3)($50/$yd^3$) = **$2 million**
Protective Clothing (Health & Safety Equipment)
(400 sets)($33/set) = **$13,200**
Confirmation Sampling
(25 events)($350/event) = **$8,750**

Decontamination Station = **$50,000**

Dewatering:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
12 inch Well Boring and Installation = **$67,375**
Geophysical and Analytical Testing = **$5,000**
Well Development
(44 hr)($100/hr) = **$4,400**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Wastes = **$11,440**

Extraction Piping, Pumps, Well Vaults
Vaults
(11 vaults)($5,000/vault) = **$55,000**
Pumps
(11 pumps)($8,750/pump) = **$96,250**
Piping = **$291,000**

Operation and Maintenance
Extraction Well Pumps = **$144,000**

Sub-total Capital Cost for Excavation.......**$4.1 million**

Disposal of Tar and Contaminated Soils in RCRA Cells:

Cell One for Tar

Mobilization/Demobilization = **$2,200**

Cell One Construction:
Excavation Cell Area
(53,556 yd^3)($4.21/$yd^3$) = **$225,500**
Clay, Liner, and Cap
(29,000 yd^3)($22/$yd^3$) = **$638,000**
Sand, Leak Detection, and Cap
(14,000 yd^3)($16.50/$yd^3$) = **$231,000**
Top Soil
(4,800 yd^3)($19.80/$yd^3$) = **$95,000**
Synthetic Liners (Base and Cap, 40 ml)
(388,200 ft^2)($0.44/$ft^2$) = **$170,800**
Geotextile Filter Fabric
(242,000 ft^2)($0.22/$ft^2$) = **$53,200**
Collector Pipe, 6 in. PVC
(3,600 ft)($5.50/ft) = **$19,800**
Manhole
(2)($2,200) = **$4,400**
Sump

(1)($2,200) = **$2,200**

Revegitation

($14,833\ yd^2$)($0.66/$yd^2$) = **$9,800**

Drainage Channel

(1,450 ft)($4.95/ft) = **$7,200**

Monitoring Wells (3)

(180 ft)($126.50/ft) = **$22,800**

Waste Placement and Compaction

($30,000\ yd^3$)($4.40/$yd^3$) = **$132,000**

Protective Clothing

(100 sets)($33/set) = **$3,300**

Sub-total Capital Cost for Cell One........**$1.62 million**

<u>Cell Two for Contaminated Soils</u>

Mobilization/Demobilization = **$2,200**

Cell Two Construction:

Excavation Cell Area

($70,852\ yd^3$)($4.21/$yd^3$) = **$298,300**

Clay, Liner, and Cap

($37,377\ yd^3$)($22/$yd^3$) = **$822,300**

Sand, Leak Detection, and Cap

($18,014\ yd^3$)($16.50/$yd^3$) = **$297,000**

Top Soil

($6,135\ yd^3$)($19.80/$yd^3$) = **$121,500**

Synthetic Liners (Base and Cap, 40 ml)

($502,991\ ft^2$)($0.44/$ft^2$) = **$221,300**

Geotextile Filter Fabric

($315,220\ ft^2$)($0.22/$ft^2$) = **$69,400**

Collector Pipe, 6 in. PVC

(4,836 ft)($5.50/ft) = **$26,600**

Manhole

(2)($2,200) = **$4,400**

Sump

(1)($2,200) = **$2,200**

Revegitation

($18,405\ yd^2$)($0.66/$yd^2$) = **$12,100**

Drainage Channel

(1,650 ft)($4.95/ft) = **$8,200**

Monitoring Wells (3)

(180 ft)($126.50/ft) = **$22,800**

Waste Placement and Compaction

($40,000\ yd^3$)($4.40/$yd^3$) = **$176,000**

Protective Clothing

(100 sets)($33/set) = **$3,300**

Sub-total Capital Cost for Cell Two........**$2.1 million**

<u>Groundwater Containment System</u>:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
6 inch Well Boring and Installation = **$22,500**
Geophysical and Analytical Testing = **$5,000**
Well Development
(20 hr)($100/hr) = **$2,000**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Waste = **$5,200**

Extraction Piping, Pumps, Well Vaults
Vaults
(10 vaults)($5000/vault) = **$50,000**
Pumps
(10 pumps)($3375/pump) = **$33,750**
Piping = **$195,000**

Treatment System
Influent Holding Tank = **$34,100**
Feed Pump = **$8,600**
Carbon Adsorption System = **$556,000**
Effluent Tank = **$22,800**
Effluent Pump = **$8,600**
Effluent Piping = **$78,000**

Operation and Maintenance
Extraction Well Pumps = **$32,700**
Carbon Adsorption System
(2 lb carbon/1000 gal) = **$574,300**
Feed Pump = **$20,400**
Effluent Pump = **$20,400**

Sub-total Capital Cost for Groundwater....**$1 million**

Sub-Total Capital Cost.............	$ 8.8 million
Bid Contingencies (15%).......	$ 1.3 million
Scope Contingencies (15%).....	$ 1.3 million
Construction Total.................	$11.4 million
Permitting and Legal (3%).....	$ 0.3 million
Construction Services (5%)....	$ 0.6 million
Total Implementation Cost..........	$12.3 million
Engineering Design Costs (5%).	$ 0.6 million
Total Capital Cost.................	**$12.9 million**
Total Annual Cost (O&M)............	$ 791,800
Present Worth of Annual Costs (5 years, 5% discount rate).....	$3.4 million
Total Present Worth................	**$16.3 million**

Note: It is assumed that the containment system is an interim action and that the RI/FS for the groundwater operable unit will be completed within the 5 year period for the sake of the present worth analysis.

State Acceptance - State acceptance of this alternative will be determined through discussions with the State of Michigan.

Community Acceptance - Community acceptance of this remedy will have to be evaluated during the public comment period.

3.1.7 Alternative 7 - Removal and Disposal of Tar and Highly Contaminated Soils in an Off-Site Hazardous Waste Landfill; Bio-Remediation of Low Level Soils and Containment; Interim Groundwater Containment

Overall Protection of Human Health and the Environment - This alternative will be protective of human health and the environment. The risks posed by the tar and highly contaminated soils will be eliminated through excavation and disposal off-site at an approved hazardous waste landfill. The risks posed by the low level contaminated soils will be mitigated by through bio-remediation. If cleanup levels can not be attained, the low level contaminated soils will be capped, minimizing any further risk. This alternative provides a high level of effectiveness and permanence as the residual risk from untreated waste or treatment residuals are minimal. The tar and contaminated soil are taken off-site for disposal and the low level contaminated soil are bio-remediated to health based levels or are capped if these levels can not be attained. The second operable unit (through the overall RI/FS) will address the groundwater clean-up, however implementation of the interim groundwater containment as part of this operable unit will keep the contaminant plume from spreading further. Residential well have taste and odor problems but have not as yet been detected with quantifiable levels of Site contaminants. This groundwater containment measure is to protect the public from the migration of contaminants which were found to exceed MCLs on the Tar Lake property.

<u>Compliance with ARARs</u> - This alternative complies with all State and Federal ARARs. The excavation will meet the requirements of the Clean Air Act standards for total suspended particulates and Michigan's Soil Erosion and Sedimentation Control Act (Act 347) standards. The National Ambient Air Quality Standard for PM-10 (particulate matter with a diameter of 10 micrometers or less) 40 CFR 50.6 will be met.

Because the tar waste is very similar to K087 waste, i.e., decanter tank tar sludge from coking operations, and contains many of the same hazardous constituents, RCRA ARARs are relevant and appropriate. RCRA requirements for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264, will also be met. This includes but is not limited to closure and post-closure requirements; waste pile design, monitoring, and closure. Other RCRA requirements that will be met include 40 CFR Part 263, Standards Applicable to Transporters of Hazardous Waste, and 40 CFR Part 268, Land Disposal Restrictions. The tar will meet the LDR treatment standards for K087 waste, prior to disposal at the off-site hazardous waste landfill, in 40 CFR Part 268 Subpart D. Since the treatment standard for K087 waste are based on incineration, this alternative may require incineration of the tar prior to land disposal. The soils will meet alternate treatment standards under a treatability variance from LDR treatment standards.

The U.S. EPA off-site policy is a "To Be Considered" (TBC) requirement and will be followed to ensure that wastes are sent to a CERCLA off-site compliant RCRA permitted landfill.

Michigan Rules for Act 307 Part 7, which addresses cleanup type, will be met. For the bio-remediation of the low level containated soil, Type B cleanup criteria are proposed and are listed in Table 5.

If the bio-remediation is technically unable to reach cleanup standards, and the remaining low level contaminated soils are contained with a hazardous waste cap, the Resource Conservation and Recovery Act (RCRA), Subpart C, 40 CFR Part 260, will be met by this alternative.

Given that the groundwater remedy is an interim measure, ARARs concerning groundwater cleanup standards will be waived in the Record of Decision as provided for in the NCP, Section 300.430 (f)(1)(ii)(c)(1). The objective of the groundwater component of the operable unit is to prevent further migration of the contaminant plume. The second groundwater operable unit (through the overall RI/FS) will address ARARs concerning groundwater cleanup standards. The discharge of the captured water will meet the requirements for reinjection into the ground, i.e., Michigan Water Resources Commission Act 245, Part 22 - Ground Water Quality, which will be determined during the pre-design phase when more specific groundwater contaminant information is available. Part 22 provides groundwater quality rules, including nondegredation of usable aquifers. Treatment residues, such as spent carbon, which contain K087 constituents, are subject to and will comply with RCRA requirements.

Long-Term Effectiveness and Permanence - This alternative provides long-term effectiveness and permanence. The tar and highly contaminated soils will be taken off-site to an approved hazardous waste landfill, which eliminates the risk of exposure to contaminants in these media. The risks from the low level contamination will be minimized through bio-remediation of the remaining soil to acceptable cleanup levels. If these levels can not be reached, the soils will be contained, mitigating exposure risks. If the soils are contained, the cap will require long-term maintenance and long-term monitoring will be required.

Reduction of Toxicity, Mobility, or Volume Through Treatment - This alternative reduces toxicity, mobility, or volume through treatment. The toxicity, mobility, and volume of the tar and the highly contaminated soils are reduced through the treatment required by LDRs prior to disposal in an off-site landfill. The toxicity and volume of the low level contaminated soils will also be reduced through bio-remediation. This alternative satisies the statutory preference for treatment as a principal element.

Short-Term Effectiveness - This alternative will be effective in the short-term. The excavation of the tar and contaminated soils could possibly result in the release of volatile chemicals into the groundwater and the air, which would introduce risks to residents and workers. However, the possible releases can easily be mitigated. Any releases into the groundwater would be captured by the interim groundwater containment system to prevent migration. With respect to possible air releases, air monitoring will be set up to indicate if volatiles are emitted into the air and at what concentrations. If it is determined that an unacceptable risk exists, appropriate actions will be taken immediately to mitigate the threat and protect the public. For the workers who could be more directly exposed to volatiles released and with contact with the contaminated media, their risks can be controlled by following safe working practices and the health and safety plan that will be set up for the site. The health and safety plan for the site will at a minimum include the different levels of respiratory protection for the workers and the levels of contaminants they are required to be used. The time to implement this alternative is estimated to be a minimum of 3 years.

Implementability - This alternative will be technically and administratively feasible. Excavation and incineration are established technologies. Because the tar is in the water table, dewatering will be performed during the excavation, which is not an unusual practice. The proximity of the site to major highways makes the site accessible for transporting the tar ash and residue to an approved off-site hazardous waste landfill. For the interim groundwater containment portion of this alternative, pump and treat is a established technology. There should not be any major problems administratively with this alternative. Potential areas of administrative concern are acceptance of the waste by an off-site landfill, access, and institutional controls. First, it should be noted that finding a hazardous waste landfill that will accept waste from a Superfund sites may require some effort. Second, access to the Tar Lake property will have to be acquired from the two PRPs, 56th Century and the Township of Mancelona, which own parcels of land at the Site. Third, institutional controls must be implemented by the Tar Lake property owners and the local government, including but not limited to: deed restrictions regulating the development of the Tar Lake property and groundwater useage restrictions in the affected or potentially affected areas.

Cost - The cost of this alternative, which is derived from the cost estimates in Appendix B, is estimated as follows:

Excavation:

Mobilization/Demobilization = **$5,000**

Material Handling:
Excavate Tar and Heavily Contaminated Soil
($30,000\ yd^3 + 20,000\ yd^3)(\$50/yd^3)$ = **$2.5 million**
Health and Safety Equipment = **$10,000**
Confirmation Sampling
(25 events)($350/event) = **$8,750**

Decontamination Station = **$50,000**

Dewatering:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**

12 inch Well Boring and Installation = **$67,375**
Geophysical and Analytical Testing = **$5,000**
Well Development
(44 hr)($100/hr) = **$4,400**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Wastes = **$11,440**

Extraction Piping, Pumps, Well Vaults
Vaults
(11 vaults)($5,000/vault) = **$55,000**
Pumps
(11 pumps)($8,750/pump) = **$96,250**
Piping = **$291,000**

Operation and Maintenance
Extraction Well Pumps = **$144,000**

Sub-total Capital Cost for Excavation.......**$3.1 million**

<u>Off-Site Disposal of Tar and Contaminated Soils</u>:

Incineration: (To meet LDR treatment standards)

Mobilization/Demobilization = **$800,000**

Thermal Destruction
Tar: (30,375 ton)($600/ton) = **$18.2 million**
Soil: (27,000 ton)($300/ton) = **$ 8.1 million**

Off-Site Disposal of Tar Residue
Transportation
(3,000 yd^3)($37/$yd^3$) = **$111,000**
Disposal
(3,000 yd^3)($160/$yd^3$) = **$480,000**

Site Restoration = **$351,000**

Sub-total Capital Cost for Treatment and Off-Site Disposal of Tar Residue................................**$28.0 million**

<u>Bio-remediation of Low Level Contaminated Soils</u>:

Mobilization/Demobilization = **$5,000**

Health and Safety Equipment = **$5,000**

Injection Wells
(8 wells)($10,000/well) = **$80,000**
Trenching and Piping = **$20,000**

Oxygen and Nutrient:
Delivery System = **$35,000**
Pilot Study = **$30,000**

Operation and Maintenance:
Injection Well Labor
(125 Man Days)($600/MD) = **$75,000**
Analytical Costs = **$2,000**
Nutrients/O_2 = **$3,000**
Delivery System = **$3,000**

Sub-total Capital Cost for Bio-remediation....**$175,000**

Groundwater Containment System:

Extraction Wells
Surveying/Staking = **$1,000**
Permitting/Utility Checks = **$500**
Mobilization/Demobilization = **$2,500**
6 inch Well Boring and Installation = **$22,500**
Geophysical and Analytical Testing = **$5,000**
Well Development
(20 hr)($100/hr) = **$2,000**
Equipment Decontamination
(15 hr)($100/hr) = **$1,500**
Drum and Dispose of Waste = **$5,200**

Extraction Piping, Pumps, Well Vaults
Vaults
(10 vaults)($5000/vault) = **$50,000**
Pumps
(10 pumps)($3375/pump) = **$33,750**
Piping = **$195,000**

Treatment System
Influent Holding Tank = **$34,100**
Feed Pump = **$8,600**
Carbon Adsorption System = **$556,000**
Effluent Tank = **$22,800**
Effluent Pump = **$8,600**
Effluent Piping = **$78,000**

Operation and Maintenance
Extraction Well Pumps = **$32,700**
Carbon Adsorption System
(2 lb carbon/1000 gal) = **$574,300**
Feed Pump = **$20,400**
Effluent Pump = **$20,400**

Sub-total Capital Cost for Groundwater....**$1 million**

Sub-Total Capital Cost.............$32.3 million

Bid Contingencies (15%).......$ 4.8 million
Scope Contingencies (15%).....$ 4.8 million

Construction Total.................$41.9 million

Permitting and Legal (3%).....$ 1.3 million
Construction Services (5%)....$ 2.1 million

Total Implementation Cost..........$45.3 million

Engineering Design Costs (5%).$ 2.3 million

Total Capital Cost.................$47.6 million

Total Annual Cost (O&M)............$ 874,800
Present Worth of Annual Costs
(5 years, 5% discount rate).....$3.8 million

Total Present Worth................$51.4 million

Note: It is assumed that the containment system is an interim action and that the RI/FS for the groundwater operable unit will be completed within the 5 year period for the sake of the present worth analysis.

State Acceptance - State acceptance of this alternative will be determined through discussions with the State of Michigan.

Community Acceptance - Community acceptance of this remedy will have to be evaluated during the public comment period.

3.2 COMPARATIVE ANALYSIS

The following is a comparison of each of the four alternative's strength and weakness with respect to the nine evaluation criteria.

Overall Protection of Public Health and the Environment

Evaluation of the overall protectiveness of each alternative focuses on how the alternative achieves protection over time and how the risks are eliminated, reduced, and controlled through treatment, engineering controls or institutional controls. Alternatives 2, 3, 4, 5, 6, and 7 are all protective of public health and the environment as the risks due to the tar and the contaminated soils are minimized by removal, treatment, or containment of the media.

Alternatives 2, 3, and 4 are similar in that each involve removing and incinerating the tar and the highly contaminated soils. The low level contaminated soils are treated differently by these alternatives. Alternative 2 bio-remediates the low level contaminated soils. Alternative 3 excavates, treats, and disposes these soils off-site. Alternative 4 thermally desorbs the soils. The actions taken in Alternatives 2 through 4 will result in an acceptable risk level at the site by minimizing or eliminating potential exposure, i.e. direct contact and ingestion of contaminated groundwater, by treating the contaminated wastes.

Alternative 5 minimizes risk by removal and treatment of the tar and all of the contaminated soils and disposal in an off-site hazardous waste landfill. Alternative 6 minimizes the risk at the Site by eliminating the exposure pathways. Direct contact threats and continuing contamination of the groundwater are mitigated through the removal of the tar and all of the contaminated soils and disposal on-site in two adjoining RCRA containment cells. Alternative 7 reduces risk by removing, treating, and then disposing the tar and highly contaminated soils in an off-site hazardous waste landfill and bio-remediating the low level contaminated soils.

Alternatives 2 - 7 also each include the interim groundwater containment system to prevent further migration of the contaminant groundwater plume. This measure is to protect the public from the potential migration of Site contaminants, some of which have been found to exceed MCLs on the Tar Lake property.

Alternative 1 is not protective of public health and the environment because nothing is done to the contaminated media.

Compliance with ARARs

Each alternative is evaluated for compliance with ARARs. These ARARs are presented in Table 6. All of the alternatives, except for the no action alternative, will meet their ARARs. Some of the major ARARs that will be met include:

- Compliance with the Clean Air Act standard for total suspended particulates (National Ambient Air Quality Standard for PM-10) and Michigan's Soil Erosion and Sedimentation Control Act (Act 347) standards during the excavation in Alternatives 2 - 7.

- Compliance with requirements for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264, by Alternatives 2 - 7 because of the similarity of the tar to K087 waste, i.e., decanter tank tar

TABLE 6 ARARs for Tar Lake

Federal: Resource Conservation and Recovery Act (RCRA), Subtitle C, 40 CFR Part 260
RCRA, Regulations for Hazardous Waste Generators, 40 CFR 262
RCRA, Standards Applicable to Transporters of Hazardous Waste, 40 CFR 263
RCRA, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, 40 CFR Part 264
(including Subpart O - Incinerators)
(including Subpart X - Miscellaneous Units)
RCRA, Land Disposal Restrictions, 40 CFR Part 268
(including Subpart D - Treatment Standards)
(including 40 CFR 268.44 - Variance from a treatment standard)
Clean Air Act (CAA), 40 CFR 50
(including National Ambient Air Quality Standards for PM-10, 40 CFR 50.6)

State: Michigan Hazardous Waste Management Act, Public Act 64 of 1979, as amended
Michigan Solid Waste Management Act, Public Act 641 of 1978
Michigan Water Resources Act, Public Act 245 of 1929, to the extent held to be applicable or relevant and appropriate
Michigan Air Pollution Control Act, Public Act 348 of 1965
Michigan Rules for Act 307 of 1982, as amended
Michigan Soil Erosion and Sedimentation Control Act, Public Act 347 of 1972

To Be Considered are as follows:

Federal: CERCLA Off-Site Policy, OSWER Dir.9834.11

Requirements for Hazardous Waste Landfill Design, Construction, and Closure EPA/625/4-89/002, August 1989

Final Covers on Hazardous Waste Landfills and Surface Impoundments EPA/530-SW-89-047, July 1989 sludge from coking operations. This includes 40 CFR Part 264 Subpart O, incinerator controls and closure for Alternatives 2 - 5, and 7.

- Compliance with the Michigan Hazardous Waste Management Act (Act 64) and the Michigan Solid Waste Management Act (Act 641) requirements for installation, operation, and closure of incinerators by Alternatives 2 - 5, and 7.

- Compliance with the Clean Air Act and Michigan's Air Pollution Control Act (Act 348) for the incinerator effluent stack gases by Alternatives 2 - 5, and 7.

- Compliance with 40 CFR 262, Regulations for Hazardous Waste Generators for the classification of the site as a generator of hazardous waste with respect to the removal and off-site transportation of contaminated material by Alternatives 3, 5, and 7.

- Compliance with 40 CFR Part 263, Standards Applicable to Transporters of Hazardous Waste, by Alternatives 3, 5, and 7 which involve off-site transportation of wastes.

- Compliance with 40 CFR Part 268, Land Disposal Restrictions, by Alternatives 3, 5, and 7 which involve the placement of wastes in an off-site landfill and Alternatives 2 and 4 which involve the placement of incinerator ash.

- Compliance with 40 CFR Part 268.44, Variance from a treatment standard, for the treatment of contaminated soil in Alternatives 2 - 5, and 7.

- Compliance with Michigan Rules for Act 307 Part 7 concerning the type of clean up by all of the alternatives.

- Compliance with Michigan Water Resources Act (Act 245) Part 22 which addresses groundwater quality by all of the alternatives for the reinjection of groundwater from the containment system.

- U.S. EPA's off-site policy is a "To Be Considered" requirement which will be met by Alternatives 3, 5, and 7 which involve disposal at off-site hazardous waste landfills.

- Requirements for Hazardous Waste Landfill Design, Construction, and Closure EPA/625/4-89/002, August 1989, and Final Covers on Hazardous Waste Landfills and Surface Impoundments EPA/530-SW-89-047, July 1989 are "To Be Considered" (TBC) with respect to the design and construction of the containment cells.

ARARs for groundwater cleanup standards will be waived in the Record of Decision since the groundwater containment is an interim measure in Alternatives 2 - 7.

Long-Term Effectiveness and Permanence

This evaluation focuses on the results of a remedial action in terms of the risk remaining at the site after the alternative has been implemented.

Alternative 1 will not mitigate any of the risks presently at the site. Alternatives 2 through 4 minimize the risks associated with the tar and the highly contaminated soils permanently through excavation and incineration. They also address the low level contaminated soils but through different methods. Alternative 2 bio-remediates the soils. Alternative 3 excavates, treats, and disposes the soils off-site. Alternative 4 thermally desorbs the soils. Thus, Alternatives 2 through 4 provide high levels of effectiveness and permanence as there are minimal residual risks because there are no untreated waste left on the Site once the alternatives are implemented.

Alternative 5 eliminates risks by excavating and treating the tar and all of the contaminated soils and disposing the hazardous treatment residue off-site in a permitted landfill. No untreated wastes are left on the Site. Alternative 6 mitigates the risks at the site by excavating the tar and all of the contaminated soils and containing them on-site in two adjoining RCRA cells. The protective measures of the containment cells will provide reliability to ensure that any exposures will be minimized. Alternative 7 mitigates the risk from the tar and highly contaminated soils by treating them and disposing the hazardous residuals off-site in a permitted landfill. The low level contaminated soils are treated through bio-remediation. There are no untreated wastes left on Site with Alternative 7. Thus, Alternatives 5 - 7 also provide high levels of effectiveness and permanence.

Reduction of Toxicity, Mobility, and Volume Through Treatment

This evaluation addresses the statutory preference for selecting remedial actions that employ treatment technologies which permanently and significantly reduce toxicity, mobility, or volume of the hazardous substance as thier principle element. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

Alternative 1 provides no treatment and thus does nothing to affect toxicity, mobility, or volume. Alternatives 2 though 4 reduce the toxicity, mobility, and volume of the principal threat, i.e., the tar and the highly contaminated soils, through incineration. This satisfies the statutory preference for the use of treatment as a principal element. Each of the alternatives addresses the low level contamination differently. Alternative 2 reduces the toxicity, mobility, and volume through treatment of the low level contaminated soils through bio-remediation. Alternative 3 does not treat the low level contaminated soils but removes and disposes of it off-site. Alternative 4 reduces toxicity, mobility, and volume of the low level contaminated soils through thermal desorption.

Alternative 5 reduces the mobility of the contaminants by removal, treatment, and off-site disposal in a permitted landfill. This satisfies the statutory preference for the use of treatment as a principal element. Alternative 6 reduces the ability of the contaminants to migrate through excavation and disposal on-site in two adjoining RCRA cells, but this is not through treatment. Alternative 7 reduces toxicity, mobility, and volume by treating the tar and highly contaminated soils prior to disposal and by bio-remediation of the low level contaminated soils. Treatment is a principal element in Alternative 7.

Short-Term Effectiveness

This evaluation focuses on the effects on human health and the environment which may occur while the alternative is being implemented. The factors used to evaluate the short-term effectiveness of each alternative were: protection of the community during remedial actions, protection of workers during remedial actions, environmental impacts from implementation of alternatives, and time to implement remedial actions.

With respect to protection of the community, Alternative 1 dose not pose any additional risk to the community as nothing is done. Alternatives 2 through 7 could introduce risks to residents through the possible release of volatile chemicals through the excavation of the tar and contaminated soils. These risks will be minimal and can be controlled through air monitoring. If it is determined that volatiles are being emitted into the air and pose a threat to the residents, immediate action will be taken to mitigate the threat.

There are no risks to workers with Alternative 1 as there is no work being performed. Alternatives 2 through 7 could introduce risks through the possible release of volatile chemicals through the excavation. These risks can be controlled by safe working practices and by following the health and safety plan that will be developed for the Remedial Design/Remedial Action. This health and safety plan will indicate the different levels of protection, including but not limited to respiratory protection, and when these protective devices are to be used to ensure worker safety.

With respect to environmental impacts, Alternative 1 will have continued migration of contamination from the tar to the groundwater as the source remains partially immersed in the groundwater. Alternatives 2 through 7 could release some contaminants from the tar into the groundwater during the excavation process. However, the interim groundwater containment remedy will capture the contaminated groundwater and prevent its migration.

Evaluation of the time to implement the alternatives reveals the following estimates: Alternative 1 will not take any time to implement. Alternatives 2 through 7 will take 3 years at a minimum to implement.

Implementability

This evaluation addresses the technical and administrative feasibility of implementing the alternatives.

Alternative 1 has nothing to implement. Alternatives 2 through 4 are technically and administratively feasible. The excavation and incineration used in each alternative are established technologies. The pump and treat system in each alternative for interim groundwater containment is also an established technology. With respect to low level contaminated soils, Alternatives 2 and 4 use innovative technologies, bio-remediation and thermal desorption, respectively. However, with both of these technologies, they are currently being used at other sites and have had successful pilot tests performed for similar contaminants to those at the site. Alternative 3 excavates and disposes the low level contaminated soils at an off-site facility. It should be noted that even though there are licensed hazardous waste landfills that could accept the low level contaminated soils, facilities may be reluctant to accept the waste, which could be a problem.

Alternatives 5 through 7 are also technically and administratively feasible. They each involve some excavation, which is an established technology. Alterative 5 includes incineration which is also an established technology. Alternative 6 includes the construction of RCRA cells, which is a task that has much experience behind it. Alternative 7 includes incineration and bio-remediation, which as mentioned above, are established technologies. Administratively there should not be any major problems. It should be noted that as with Alternative 3, Alternatives 5 and 7 may run into licensed hazardous waste landfills reluctant in accepting Superfund waste.

Cost

This evaluation examines the estimated costs for implementing the remedial alternatives. It should be noted that these costs are estimates and will have to be refined during the pre-design as more information is gathered and treatability studies are performed.

The cost breakdown for each alternative are as follows:

Alternative	Capital Cost	Annual O&M Cost	Present Worth
1	$0	$0	$0
2	$47,600,000	$874,800	$51,400,000
3	$55,100,000	$791,800	$58,500,000
4	$60,800,000	$791,800	$64,200,000
5	$48,900,000	$791,800	$52,300,000
6	$12,900,000	$791,800	$16,300,000
7	$47,600,000	$874,800	$51,400,000

Present worth was calculated for 5 years at 5%.

All of the Alternatives, except for Alternatives 1 and 6, include incineration of the tar and at least part of the contaminated soils. Alternatives 2 - 4 include incineration as the primary treatment element. Alternatives 5 and 7 examine off-site landfilling but because RCRA Land Disposal Restrictions are triggered, treatment standards must be met prior to disposal. Incineration is also used in these two alternatives as a means to meet the treatment standards because the tar is similar to K087 waste and K087 treatment standards are based on incineration. With the large volume of materials and the high unit cost of the treatment, the $28 million incineration cost represents approximately 50% of the capital costs for each of these alternatives. When the other parts of the alternatives are included, these remedies are in the $40 - $60 million range, which brings into question the cost effectiveness.

Alternative 6 is not subject to the RCRA Land Disposal Restrictions. The RCRA containment cells would be constructed within the area of contamination (AOC) and the tar and contaminated soils transferred into these cells without moving it outside the AOC or placing it into a separate unit. Because placement, as defined by RCRA, does not occur, LDR treatment standards are not triggered and incineration is avoided.

State Acceptance

The MDNR's acceptance of the alternatives will be determined through discussions held with the State.

Community Acceptance

The community's acceptance of the alternatives will be determined during the public comment period.

APPENDIX A

INTERIM BASELINE RISK ASSESSMENT

TAR LAKE SUPERFUND SITE

Prepared by:

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Region V Office of Health and Environmental Assessment

April 3, 1991

BASELINE RISK ASSESSMENT

TAR LAKE

INTRODUCTION

The remedial investigation/feasibility study (RI/FS) site for this baseline risk assessment is located at the Antrim Iron Works Site, just east of Highway 131, approximately one mile south of Mancelona, Michigan in Antrim County. Tar Lake covers approximately four acres located in a topographic depression, and contains wood tar waste produced on site between 1910 and 1944. The tar exists in various physical forms, from viscous liquid to caky solid, and ranges in depth from 2 to 27 feet. Soils surrounding Tar Lake are also contaminated with tar. Depending on the season and weather conditions, a fluctuating amount of water sits on the surface of the tar.

Strong odors have been reported to emanate from the tar especially in areas not previously exposed to air. Groundwater as far as 3-4 miles downgradient of the site also has been reported to exhibit odors. The tar is in direct contact with the groundwater at one point and otherwise overlays a sand and gravel soil. A number of volatile and semi-volatile organic compounds have been demonstrated to be associated with the site.

Region V's Office of Health and Environmental Assessment was asked to prepare an interim risk assessment for this site due to the repeated failure of the potentially responsible parties to produce and deliver a risk assessment prepared in accordance with EPA guidance.

All data used in this risk assessment was taken from the report entitled "Phased Feasibility Study Tar Lake Superfund Site Antrim County Michigan" prepared by Gradient Corporation, dated February 12, 1991.

CHEMICALS OF CONCERN

On-site groundwater sampling was conducted in 1988 and 1989 and contaminant concentration values presented in the 1991 Gradient document (mean and 95% upper confidence limit) were utilized in this document for assessing risk from groundwater. A number of chemicals of concern were detected including phenol, o-cresol, p-cresol and benzene. The list of groundwater chemicals and concentrations is found in Table 1.

Despite the volume and heterogeneous nature of Tar Lake only one tar sample was collected. Certain polycyclic aromatic hydrocarbons (PAHs) detected in the underlying soil were assumed to be present in the tar at the detection limit (280 mg/kg). This is a reasonable assumption since these compounds were detected in the soil beneath the tar. A number of other compounds were detected including phenols, o-cresol, p-cresol and 2,4 dimethylphenol. A list of chemicals detected or presumed to be present in the tar is listed in Table 2, along with their concentrations.

EXPOSURE PATHWAYS

Exposure calculations were performed using "RISK ASSISTANT", a software system for risk assessment developed under an EPA grant. Concentrations of contaminants listed in the Gradient document dated February 1991 provided the input to the model for exposure calculations.

Two hypothetical future residential exposure pathways were evaluated. In the first, it was assumed that future residents might be exposed chronically exposed to groundwater through ingestion of drinking water. Standard EPA exposure assumptions for Superfund were utilized (2 liters of water ingested per day for 30 years by a 70 kg individual). In the second, exposure of future residents through a soil pathway was assessed. This assumed the placement of a house adjacent to Tar Lake such that soil concentrations of contaminants equals one-tenth the concentrations present in the tar itself. In accordance with current Superfund guidance, individuals were assumed to ingest 0.100 grams of soil per day in the form of some combination of soil and dust. This exposure was presumed to take place 350 days per year for 30 years. This exposure analysis did not include a separate assessment for exposure to children, due to the uncertainty in the data. If children were included in the analysis, the overall exposure and risks would be greater than those discused in this document. The exposure assumptions and calculations for the two pathways are listed in the exposure calculation printouts at the end of the document.
Please note that the omission of a conversion factor requires soil concentrations to be entered in terms of mg/kg instead of the ug/kg that the program requests.

In addressing soil and groundwater ingestion for future residents, the document characterizes two of the most significant pathways. However, these are only two of many exposure pathways which are pertinent at this site. Other potentially significant exposure routes include soil and groundwater ingestion for workers, soil ingestion for trespassers, dermal contact for residents, workers and trespassers, and ingestion of contaminated game.

TOXICITY ASSESSMENT

Current EPA guidance on risk assessment recognizes and differentiates between two broad classes of contaminants, carcinogens and non-carcinogens. Compounds which are known or suspected human carcinogens are considered to have no threshold; any amount of exposure results in some finite risk that the exposed individual will develop cancer. Risk from carcinogens is assessed through the use of a Cancer Potency Factor calculated by EPA, based on experimental or epidemiologic evidence.

Compounds causing systemic non-cancer effects are generally considered to have a threshold below which no adverse effect will be seen. For these compounds EPA calculates a lifetime dose which can be considered safe. An individual or population is considered to be at risk for non-cancer effects from a particular compound if the ratio of exposure (mg/kg-day) to the reference dose (mg/kg-day) exceeds unity. This ratio is known as the hazard quotient.

Both cancer risk and non-cancer types of risk are additive. For persons exposed to more than one compound and/or exposed via more than one pathway, it is necessary to sum cancer risks from multiple compounds and pathways to obtain one overall risk number for each exposure scenario. For example, residents at a site may be exposed to contaminants not only through their drinking water but through their yards, garden produce, and indoor air as well. Non-cancer risks are summed as well, the sum of appropriate hazard quotients is called the hazard index.

For this risk assessment, Cancer Potency Factors and Reference Doses (RfD) from EPA's Health Effects Summary Tables (HEAST) and Integrated Risk Information System (IRIS) database were utilized by the "RISK ASSISTANT" software. Some adjustments, as described below, were necessary to comply with more recent guidance on PAHs.

EPA's Environmental Criteria and Assessment Office (ECAO) currently recommends use of the cancer potency factor for benzo(a)pyrene for all carcinogenic PAHs. This includes chrysene, benzo(a)anthracene, benzo(b)fluoranthene and benzo(k)fluoranthene which are relevant to the Tar Lake site (Memo from Pei-Fung Hurst to C. Braverman, 1990). ECAO has developed RfD values for 6 PAHs. For those compounds without assigned RfDs, surrogate values were assigned on the basis of structural similarity to those PAHs for which RfDs exist. Specifically, based on structure activity relationships, the RfD for fluorene was used for acenaphthylene and phenanthrene, the RfD for pyrene was used for chrysene, benzo(a)anthracene, benzo(b)fluoroanthene and benzo(k)fluoroanthene, and the RfD for naphthalene was used for methyl naphthalene. These assignments have been made previously for risk assessment purposes in the Region (CERCLA Draft RI Reilly Industries). Since methyl naphthalene was not among the files contained in the software, the concentrations of methyl naphthalene and naphthalene were summed and entered under the naphthalene listing.

The RfD for naphthalene was changed to the current value of 4.0e-03 mg/kg-day. The reference dose for 2-4 dimethylphenol was not found in the software files, so the value listed in HEAST was used. All changes to Cancer Potency Factors and RfDs are amended onto the printouts along with the revised calculations.

RISK CHARACTERIZATION

Risk calculations based on the previously discussed exposure calculations were performed using the "RISK ASSISTANT" software.

Cancer risk for the residential groundwater ingestion pathway was calculated to be 2.4e-05 and 4.8e-05 for mean and 95%UCL concentrations of on-site groundwater contaminants respectively. These values exceed EPA's point of departure value for cancer risk of 1e-06. Benzene, a known human carcinogen, (EPA weight-of-evidence "A" classification) is the driving contaminant, responsible for about 85% of the cancer risk from this pathway. The risk calculations and the IRIS printout for benzene are attached.

The non-cancer hazard indices for the groundwater ingestion pathways were calculated to be 10.54 and 24.1 for mean and 95% UCL for on-site groundwater contaminant concentrations, respectively. Both these values exceed unity, the value at which non-cancer health risk begins to be a matter of concern.

Cancer risk for the residential soil ingestion pathway was calculated to be 8e-04. This value greatly exceeds EPA's point of departure value for cancer risk of 1e-06. As previously discussed, the risks calculated in this assessment would be higher still if children were assessed separately. The carcinogenic PAHs chrysene, benzo(a)anthracene, benzo(b)fluoranthene, and benzo(k)fluoranthene (EPA weight-of-evidence "B2" classification) were the driving contaminants, together resulting in almost 100% of the risk from this pathway. There is an high degree of uncertainty in the conclusions of this pathway given that only one sample of tar was analyzed, and that none the carcinogenic PAHs were actually measured in the tar. However since the four carcinogenic PAHs were present in soil sample taken from beneath the tar, logic dictates their presence in the tar. The detection limit was used as a surrogate value for the carcinogenic PAHs. The cresols, o-methylphenol and p-methylphenol, present in the tar together at 2500 mg/kg are possible human carcinogens (EPA weight-of -evidence "C" classification). As no Cancer Potency Factor is available yet for these compounds, quantification of cancer risk from cresols is not possible.

Non-cancer risks for this pathway were calculated to be 2.9e-02. This value is below unity. This would normally indicate non-cancer health risks not to be a problem, however, a number of acutely toxic compounds and skin irritants are present in the tar at very high concentrations (cresols at 2500 mg/kg, phenol at 330 mg/kg, naphthalene/methyl naphthalene at 900 mg/kg). Phenol, for example, has been lethal to humans at a dose as low as 1 gram. Lethal doses may be absorbed through the skin or inhaled (IRIS-phenol). See attached excerpts from IRIS and Sax discussing acute toxicity hazards associated with some of the compounds.

The tar itself presents a substantial source of endangerment because of the high viscosity of the tar and the depth of the pit (up to 27 feet). Anyone gaining access to the site and falling into the pit would probably not be able to extricate themselves without assistance and could be easily drowned.

In summary, future residents at the site would be exposed through both groundwater and soil pathways, resulting in a cancer risk of 8e-04 and a non-cancer hazard index of up to 24. Acute hazards from the site can be qualitatively described as very serious.

ECOLOGICAL ASSESSMENT

An ecological assessment was not included in any prior documents, and to date this issue remains unaddressed. Preliminary ecological assessment is required for all Superfund sites and is especially important at a rural site like Tar Lake. For the reasons of viscosity and depth mentioned above, the tar poses a serious hazard to wildlife in the area. Waterfowl will be attracted to the liquid surface and will either become stuck in the tar and perish there, or may escape covered with the oily mixture, itself lethal. Small animals in the area are vulnerable to the same threat of sinking in the tar.

REFERENCES

1. Phased Feasibility Study, Tar Lake Superfund Site, Antrim County Michigan, Gradient Corporation, February 12, 1991.

2. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), U.S. EPA December 1989.

3. Integrated Risk Information System. U.S.EPA 1991

4. Health Effects Assessment Summary Tables. U.S.EPA Fourth Quarter 1990.

5. RISK ASSISTANT. Hampshire Research Institute 1990.

6. Dangerous Properties of Industrial Materials, Sixth Edition. N. Irving Sax. Van Nostrand Reinhold Co. New York, 1984.

7. CERCLA Draft RI Report for Reilly Industries, ENSR Consulting and Engineering. December 1990.

8. Toxicity Information for PAHs. Memo from Pei Fung Hurst to Carole T. Braverman. 1990.

TABLE 1

Compounds Detected in On-Site Groundwater

MEAN CONCENTRATIONS 95th PERCENTILE OF THE MEAN CONCENTRATIONS

Compounds Detected in On-Site Groundwater	Mean concentration (ug/l)	95th percentile of the mean concentration (ug/l)
benzene	49.2	115.7
ethylbenzene	18.95	37.7
toluene	80.05	177.1
styrene	8.9	18.3
2-butanone	195.5	492
2-hexanone	95.5	237.2
4-methyl-2-pentanone	13.6	27.1
xylenes	55.45	117.4
acenaphthylene	13.9	20
bis(2-ethylhexyl)phthalate	7.9	9.6
fluorene	9.5	10.3
naphthalene	10.7	15.7
phenanthrene	9.4	10.3
dibenzofuran	9.4	10.3
2-methylnaphthalene	47.7	105.5
2,4-dimethylphenol	3228	7736
phenol	1437	3622.5
2-methylphenol	2886	7255.6
4-methylphenol	5397	13019
nitrobenzene	9.5	10.3

Adapted from Table B2a, Phased Feasibility Study, Tar Lake Superfund Site Gradient Corporation, Febuary 12, 1991.

TABLE 2

Compounds Known or Presumed to be Present in Tar

Compound	Tar Concentration (mg/kg)
benzene	12
ethylbenzene	100
toluene	100
styrene	23
2-butanone	5
2-hexanone	11
4-methyl-2-pentanone	12
xylenes (total)	280
acenaphthene	280
acenapththylene	280
anthracene	280
benzo(a)anthracene	280
benzo(b)fluoranthene	280
benzo(k)fluoranthene	280
bis(2-ethylhexyl)phthalate	280
chrysene	280
di-n-butyl phthalate	280
fluoranthene	280
fluorene	100
naphthalene	340
phenanthrene	280
pyrene	280
dibenzofuran	51
2-methylnaphthalene	560
2,4-dimethylphenol	2000
phenol	330
2-methylphenol	1100
4-methylphenol	1400

Adapted from: Table B4a, Phased Feasiblity Study for Tar Lake
Gradient Corporation, Febuary 12, 1991.

TABLE 3

CANCER RISK AND NON-CANCER HAZARD FOR TAR LAKE

FUTURE RESIDENTIAL SCENARIO (1)

EXPOSURE PATHWAY	CANCER RISK	HAZARD INDEX	ACUTE HAZARD
INGESTION OF GROUNDWATER (95% UCL)	4.8e-05	24	Not Assessed
INGESTION OF TAR-CONTAMINATED SOIL	8.0e-04	0.03	HIGH (2)

1. Values listed in this table were obtained from the output of the RISK ASSISTANT program. Please see text and printouts for details.

2. Potential for acute health effects from exposure to tar was judged to be high, based on high concentrations of phenols and cresols, reports of chemical burns and skin irritation and potentially lethal depth and viscosity of the tar.

Status of Polyaromatic Hydrocarbons

I. RfD

A. Oral

Only 6 PAHs have interim oral RfDs. Table 1 lists the chemicals with oral RfDs along with the critical study, species, critical effect and reference dose. For the verified chemicals, the date of verification is listed; these chemicals are not currently loaded onto IRIS.

B. Inhalation

Inhalation RfDs were not found for any of the PAHs.

II. Carcinogenic Assessment

A. IRIS Status

Benzo(a)pyrene has been classified as a B2 carcinogen on IRIS, but a CRAVE-verified carcinogenic slope factor is not available because of lack of adequate data.

B. Interim Guidance

An oral slope factor of 11.5 $(mg/kg/day)^{-1}$ and an inhalation slope factor of 6.1 $(mg/kg/day)^{-1}$, calculated for benzo(a)pyrene in the Health Effects Assessment for PAHs (EPA, 1984), can be adopted as interim numbers pending verification by the Work Group.

The classification for twelve PAHs were discussed and verified at the February 1990 CRAVE Work Group Meeting. Interim carcinogenic classifications are listed below:

Acenaphthylene - D
Anthracene - D
Benz(a)anthracene - B2
Benzo(b)fluoranthene - B2
Benzo(k)fluoranthene - B2
Benzo(g,h,i)perylene - D
Chrysene - B2
Dibenz(a,h)anthracene - B2
Fluoranthene (scheduled for 4/89 CRAVE meeting)
Fluorene - D
Indeno(1,2,3-c,d)pyrene - B2
Naphthalene - D
Phenanthrene (scheduled for 4/89 CRAVE meeting)
Pyrene - D

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL CRITERIA AND ASSESSMENT OFFICE
CINCINNATI, OHIO 45268

SUBJECT: Toxicity information for PAHs (Old City Landfill/ Columbus, IN)

FROM: for Pei-Fung Hurst W. Bruce Peirano
Biologist
Chemical Mixtures Assessment Branch

TO: Carol Braverman
U.S. EPA
Region V

THRU: W. Bruce Peirano W. Bruce Peirano
Acting Chief
Chemical Mixtures Assessment Branch

This memo is a draft response to your request regarding toxicity information on PAHs. Outlined on the attached pages is a brief summary of the available EPA toxicity assessments for chemicals of this group.

Please note that ECAO is seeking further review of these assessments. We will furnish you with any additional information as soon as it becomes available. Should you require any additional information regarding this draft response, feel free to contact me at FTS 684-7300 or (513)-569-7300.

Attachments

cc: C. DeRosa (ECAO-Cin)
B. Means (OS-230)
T. O'Bryan (OS-230)
P. Van Leeuwen (Region V)

5.0 Combining Risks Across Chemicals and Routes

In general, RISK*ASSISTANT reports present risks that are specific to a particular chemical and route of exposure. Risks are not combined across chemicals, or across routes of exposure. This is because one can not assume that a given chemical will produce the same toxic effects by all routes of exposure, and different chemicals produce different ranges of toxic effects.

In some situations, it is appropriate for the user to calculate such combined risks. Many chemicals will produce the same toxic effect, regardless of the exposure route. For chemicals that cause cancer by several routes of exposure, the COMBINED RISK FROM ALL ROUTES may be more informative than route-specific risk estimates, unless there is evidence that carcinogenic risks from different routes reflect different mechanisms of action.
Similarly, for non-cancer toxic effects, differences between routes may only affect toxic potency, which will be reflected in the use of route-specific Reference Doses. A COMBINED HAZARD INDEX for all routes of exposure may be more informative than route-specific hazard indices in such cases.

V‾ ›n there is evidence that doing so would be toxicologically appropriate, you s‿ould consider calculating an estimate of TOTAL carcinogenic risk for all carcinogenic chemicals to which your population is exposed. Similarly, a GLOBAL HAZARD INDEX is appropriate for a set of chemicals that have overlapping patterns of toxicity. RISK*ASSISTANT does not automatically make such calculations, which should be preceded by careful consideration of the specific chemicals covered by the assessment.

In generating estimates of the combined toxic and carcinogenic risks of different chemicals, it is also important to bear in mind that the risks of exposure to multiple chemicals are not necessarily additive. Risks may be less than additive, or SYNERGISM may lead to risks that are greater than would be predicted by an additive model. Unfortunately, only very limited data are available on the risks of exposure to multiple chemicals.

In addition to considering the potential combined risks of the chemicals at a site, it is also important to identify those chemicals, routes of exposure, e ›sure scenarios, and media that are associated with the highest cancer risk a‿ the greatest hazard indices. Such information will help in the selection of the most effective strategies for alleviating those risks.

THESE ARE THE NOTES, IF ANY, ENTERED BY THE USER DURING THIS ANALYSIS

None

6.0 References

.IRIS: Integrated Risk Information System.

.HEAST: Health Effects Assessment Summary Tables.

.Konz, J.; K. Lisi and E. Friebele. 1989. Exposure Factors Handbook. Us EPA, Office of Health and Environmental Assessment. Washington, D.C.

.EXPOSURE NAME:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>END OF REPORT<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

RISK CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

Exposure is defined as the CONTACT of an organism (humans in the case of health risk assessment) with a chemical or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of an agent available for absorption at the lungs, gut, or skin, not the amount absorbed.

Two different methods are used to calculate exposure. Average Daily Exposure (ADE) is an average exposure computed for the period over which exposure occurs, and is used to calculate risks for non-cancer toxic effects. Lifetime Average Daily Exposure (LADE), used to calculate carcinogenic risks, takes into account the fact that while carcinogenic hazard values are determined with an assumption of lifetime exposure, actual exposure may be over a shorter period.

ADE = (Contaminant Concentration x Contact Rate) / Body weight

LADE = ADE x (Exposure Period in Years / Lifetime)

Contact Rate is the amount of the contaminated medium (water, air, food) with which a person comes into contact (generally a daily average) for the period of exposure (e.g. liters per day of water ingested, kilograms per day of food ingested, cubic meters per day of air inhaled). Both ADE and LADE are generally expressed in units of milligrams of the contaminant available for absorption, per kilogram of body weight, per day.

The risk values calculated by RISK*ASSISTANT reflect both the uncertainties associated with the estimation of toxic hazard information for each chemical and the uncertainties associated with the exposure estimates you have calculated. To understand the influence of the quantitative exposure estimates on the corresponding calculations of risk, it is necessary to consider the key assumptions used in deriving them, and the uncertainties associated with those assumptions:

- A key assumption is that the concentrations specified for various environmental media represent the true concentrations to which people will be exposed during the period of exposure. Actual contaminant concentrations will likely vary across both time and space.
- The selection of exposure scenarios will also have a significant influence on predicted exposures. Actual exposures to members of any specified population will vary in accordance with the degree to which they participate in the activities described by the exposure scenarios.
- Similarly, the numerical parameter values applied to each exposure scenario will have a marked effect on exposure. The default values provided are estimates for the entire U.S. population. Various demographic factors (including geographic region, rural or urban setting, socioeconomic status and ethnic heritage) may call for significant alterations in these values.

The uncertainty analyses provided as an option by RISK*ASSISTANT can illustrate the differences between the risk estimates that you have calculated and risks calculated using alternative assumptions.

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Where available, cancer potencies and reference doses have been obtained from the Integrated Risk Information System (IRIS). All values in IRIS have been reviewed and accepted for Agency-wide use by EPA. For chemicals not included in IRIS, toxicity data were extracted from the Health Effects Assessment Summary Tables (HEAST), distributed quarterly by the Office of Emergency and Remedial Response. These values, and risk estimates derived from them, are marked by an asterisk(*).

For a very limited set of chemicals, carcinogenic slope factors and/or reference doses may be estimated from epidemiologic data collected in humans. Most slope factors and RfDs, however, are derived from experimental studies in animals. Such extrapolations are based on the assumptions that 1) the physiological and biochemical responses of exposed persons will be qualitatively (but not necessarily quantitatively) the same as that seen in the experimental animals, 2) effects seen at high doses in a limited number of animals over a comparatively brief period of observation are predictive of toxicity at lower doses, if a sufficiently large group is exposed for a sufficiently long period. For some chemicals, hazard values may also have been extrapolated across differing routes of exposure. This introduces additional uncertainty to these estimates.
The slope (potency) factors for cancer risks are estimated as the 95th percentile confidence limits using the linearized multistage model. As such, they are conservative estimates of toxic hazard. Risks estimated by combining these hazard values with exposure estimates are commonly referred to as upper-bound risks, but because exposure estimates may not represent upper-bound estimates, risk estimates are not true upper-bound risks.
The exposure estimates used to calculate the risks presented in this assessment refer ONLY to the specific exposure pathways enumerated in the assessment, and depend upon the specific exposure parameters used for calculation. An exposure pathway combines contamination in an environmental medium, a scenario describing how a person contacts that medium, and a route of exposure (oral, inhalation, or dermal). An assessment that incorporates other pathways of exposure, or that does not incorporate all of the pathways described in this analysis, will yield different exposure values. Further, exposure and risk TOTALS for each medium involve the assumption that the same individual experiences ALL SCENARIOS corresponding to that medium.

Soil :

Ingestion of Soil (Oral)
Children are assumed to consume a significant amount of soil, relative to adults, as a result of outdoor play. When children have access to areas of contaminated soil, soil ingestion may represent a significant source of exposure to contaminants.

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

IRIS DATABASE Update: 03/15/90
HEAST DATABASE Update: 03/15/90
EXPOSURE NAME:

LADE		= Lifetime Average Daily Exposure
ADE		= Average Daily Exposure (during exposure period)
SLOPE FACTOR		= Cancer Potency (Slope of the Dose-Response Function)
W.O.E. CLASS		= Weight of evidence for HUMAN carcinogenicity
	A	= Known human carcinogen.
	B1	= Probable human carcinogen, limited human data.
	B2	= Probable human carcinogen, inadequate or no human data.
	C	= Possible human carcinogen.
	D	= Not classifiable as human carcinogen.
	E	= Evidence that not carcinogenic in humans.
RISK		= Lifetime probability of getting cancer from this exposure.
RfD		= Reference Dose (daily exposure NOT causing toxicity)
H.I.		= HAZARD INDEX (Ratio of ADE to RfD (ADE/RfD))

4.0 Uncertainties

Because risk values incorporate all of the estimates, default values, and assumptions used throughout risk assessment, the values presented in these tables must be understood in terms of key uncertainties regarding both the toxic hazard and the exposure estimates used to derive them.

The potency (slope factor) of a known or suspected human carcinogen is generally derived from a linearized multistage model of carcinogenesis. Such a model assumes that any non-zero exposure to a carcinogen is associated with a finite probability of cancer, and that at low doses, the relationship between exposure and probability of cancer can be approximated by a straight line. Accordingly, the potency of a carcinogen can be expressed as the slope of this straight line. Slope factors are expressed as inverse exposures (1/(mg/kg/d)).

Reference doses derive from the assumption that all non-cancer toxic effects have some threshold. That is, up to some finite level of exposure, physiological defense mechanisms ensure that no toxic effect will occur. Accordingly, hazard assessment for non-carcinogenic effects involve estimating an exposure that is less than this threshold level. This is done by applying "uncertainty factors" to exposures that appear to be near this threshold in laboratory toxicology studies. Reference doses are expressed as exposures (mg/kg/d).

RISK CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

3.0 Risk Estimates

Two different approaches are used in the calculation of toxic chemical risks. For agents that may cause cancer (carcinogens), an actual risk estimate (i.e. a probability value that is a function of potency and exposure) is calculated:

$$Risk = 1 - e^{-(Slope\ Factor\ *\ Lifetime\ Average\ Daily\ Exposure)}$$

The calculated risk estimates for carcinogens represent the theoretical excess cancer risk (i.e. risk over background cancer incidence) that a person exposed to an agent under the specified conditions will develop cancer. For example, if the calculated risk is 1 e-6, this would literally suggest that an individual exposed to the agent will have a one-in-a-million chance of getting cancer because of the exposure, in addition to her/his chance of getting cancer from other causes. However, in view of the large uncertainties associated with such risk estimates, they should always be interpreted as general indicators, rather than precise estimates. The U.S. Environmental Protection Agency (EPA) generally considers risks below 1 e-6 to be low.

RISK SUMMARY FOR ALL SCENARIOS - CARCINOGENIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION UNITS:SEE NOTE	CLASS	W.O.E.	LADE (mg/kg/d)	SLOPE FACT.* (1/(mg/kg/d))	RISK
Soil - Ingestion of Soil						
105-67-9 2,4-DIMETHYLPH	2.0e+003			1.2e-004	--------	------
108-95-2 PHENOL	3.3e+002			1.9e-005	--------	------
95-48-7 CRESOL, ORTHO	1.1e+003		C	6.5e-005	--------	------
106-44-5 CRESOL, PARA	1.4e+003		C	8.2e-005	--------	------
108-10-1 METHYL ISOBUTY	1.2e+000			7.0e-008	--------	------

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

For agents that cause non-cancer toxic effects, a Hazard Index (H.I.) is calculated, which compares the expected exposure to the agent to an exposure (the Reference Dose, or RfD) that is assumed not to be associated with toxic effects.

H.I. = Average Daily Exposure / Reference Dose

Hazard Indices of < 1.0 are generally considered by EPA to be associated with low risks on non-cancer toxic effects.

RISK SUMMARY FOR ALL SCENARIOS - NON-CANCER TOXIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION UNITS:SEE NOTE	ADE (mg/kg/d)	RfD* (mg/kg/d)	HI
Soil - Ingestion of Soil				
105-67-9 2,4-DIMETHYLPH	2.0e+003	2.7e-004	2.0e-002	1e-002
108-95-2 PHENOL	3.3e+002	4.5e-005	6.0e-001	8e-005
95-48-7 CRESOL, ORTHO	1.1e+003	1.5e-004	5.0e-002	3e-003
106-44-5 CRESOL, PARA	1.4e+003	1.9e-004	5.0e-002	4e-003
108-10-1 METHYL ISOBUTY	1.2e+000	1.6e-007	5.0e-002	3e-006

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

HAZARD INDEX for Soil ingestion PATHWAY (2nd file only)   .02

\ar Lenu T.12)

RISK CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

SITE: TarLake.SIT (filename)
Antrium, MI,

1.0 Approach

The procedures used by RISK*ASSISTANT to calculate exposures and risks have been reviewed by the Office of Health and Environmental Assessment of the U.S. EPA. Default parameters for calculating exposures have been extracted from EPA's EXPOSURE FACTORS HANDBOOK (EPA/600/8-89/043; March 1989). Where available, cancer potencies and reference doses were obtained from the Integrated Risk Information System (IRIS). All values in IRIS have been reviewed and accepted for Agency-wide use by EPA. For chemicals not included in IRIS, toxicity data were extracted from the Health Effects Assessment Summary Tables (HEAST), distributed quarterly by the Office of Emergency and Remedial Response.

The user of this software should confirm the reliability and appropriateness of e ironmental concentration data used as a starting point for the exposure calculations, and should indicate the rationale for making changes to EPA-supplied default values for exposure parameters.

The toxic hazard data used to prepare this report were current as of the date supplied for the database. However, these values may have been modified since the update of the database. Users are urged to consult IRIS and the latest HEAST tables directly.

2.0 Sample Data

RISK*ASSISTANT offers the user a variety of ways to aggregate sample data for use in its analyses. The user may select a single sample in an environmental medium (GROUNDWATER, SURFACE WATER, AIR, SOIL, SEDIMENT, or BIOTA), or may calculate the MAXIMUM, ARITHMETIC MEAN, or GEOMETRIC MEAN of either a SUBSET of the samples in a medium or of ALL SAMPLES in that medium. When calculating mean concentrations, NON-DETECTS can either be IGNORED (equivalent to setting non-detects at the average value for samples with measured values) set to ONE-H OF THE SAMPLE QUANTITATION LIMIT, or set to the SAMPLE QUANTITATION LIMIT. The aggregation method, as well as the actual sample data set entered into RISK*ASSISTANT for a site, will strongly influence the results of any subsequent analyses. The following table lists the media considered in this analysis, the aggregation technique applied for each medium, the sample set included in the aggregation, and the approach used to deal with chemicals that were only detected in some of the samples included in the aggregation.

MEDIUM	AGGREGATION STRATEGY	SAMPLE SET	TREATMENT OF NON-DETECTS
Soil	Single Sample		

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION	(UNITS)
Soil			
105-67-9	2,4-DIMETHYLPHENOL	2000.000	(ug/kg)
108-95-2	PHENOL	330.000	(ug/kg)
95-48-7	CRESOL, ORTHO	1100.000	(ug/kg)
106-44-5	CRESOL, PARA	1400.000	(ug/kg)
108-10-1	METHYL ISOBUTYL KETONE	1.200	(ug/kg)

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

Oral Exposures

RELATIVE CONTRIBUTION OF SCENARIOS AND MEDIA TO ROUTE SPECIFIC EXPOSURES(%)

MEDIA/SCENARIOS	ADE (% of user-specified) Average	Worst-Case	LADE (% of user specified) Average	Worst-Case
Soil				
Ingestion of Soil	6850.00	36500.00	685.00	7300.00
ALL SCENARIOS	6850.00	36500.00	685.00	7300.00

Inhalation Exposures

RELATIVE CONTRIBUTION OF SCENARIOS AND MEDIA TO ROUTE SPECIFIC EXPOSURES(%)

MEDIA/SCENARIOS	ADE (% of user-specified) Average	Worst-Case	LADE (% of user specified) Average	Worst-Case

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

Oral Exposure

Ingestion of Soil - Alternative Parameter Values

Parameter (units)	User Value	Average Value	(Percent of User)	Reasonable Worst-Case	(Percent of User)
Body Weight (kg)	70.00	16.00	22.9	16.00	22.9
Event Freq. (events/y)	350.00	274.00	78.3	365.00	104.3
Exposure Duration (y)	30.00	3.00	10.0	6.00	20.0
Lifetime (y)	70.00	70.00	100.0	70.00	100.0
Consum. Rate(units/event)	0.10	0.20	200.0	0.80	800.0
Conatam. Fraction	0.10	1.00	1000.0	1.00	1000.0

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

Inhalation Exposure

THESE ARE THE NOTES, IF ANY ENTERED BY THE USER DURING THIS ANALYSIS

None

6.0 References

. Konz, J.; K. Lisi and E. Friebele. 1989. Exposure Factors Handbook. Us EPA, Office of Health and Environmental Assessment. Washington, D.C.

. EXPOSURE NAME:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>END OF REPORT<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

5.0 Uncertainties

To understand the meaning of the quantitative exposure estimates presented above, it is necessary to consider the key assumptions used in deriving them, and the uncertainties associated with those assumptions:

- A key assumption is that the concentrations specified for various environmental media represent the true concentrations to which people will be exposed during the period of exposure. Actual contaminant concentrations will likely vary across both time and space.

- The selection of exposure scenarios will also have a significant influence on predicted exposures. Actual exposures to members of any specified population will vary in accordance with the degree to which they participate in the activities described by the exposure scenarios.

- Similarly, the numerical parameter values applied to each exposure scenario will have a marked effect on exposure. The default values provided are estimates for the entire U.S. population. Various demographic factors (including geographic region, rural or urban setting, socioeconomic status and ethnic heritage) may call for significant alterations in these values.

The uncertainty analyses provided as an option by RISK*ASSISTANT can illustrate the differences between your calculated exposures and exposures calculated using standard (average or reasonable worst-case) numerical parameter values for each scenario you have selected. They can also provide information on the way in which your selection of exposure scenarios influences the exposure estimates you have calculated. Because chemical concentrations will vary across space and time, and peoples activities that result in exposure are also highly variable, the actual range of possible exposures for your site is greater than the range covered by RISK*ASSISTANT's uncertainty analyses.

5.1 Uncertainties Regarding Exposure Parameters

Or estimate of the uncertainty associated with the exposure estimates pi sented above is provided by an examination of the ways in which using alternative values for numerical exposure parameters can change the resulting exposure values. The following table presents alternative exposure predictions (ADEs and LADEs) for each chemical, when exposure is calculated using 1) Average default values for all exposure parameters, and 2) Reasonable Worst-Case values for all parameters. In each case, the resulting ADE or LADE is presented as a percentage of the corresponding ADE or LADE calculated using user-specified parameter values. These values indicate the range of exposures that might be expected to occur for each scenario, and the position of the exposure calculated by the user within (or possibly outside of) this range. Following this table are additional tables that present, for each scenario, these alternative parameter values, both in absolute units and as a percentage of the parameter values actually used.

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

EXPOSURE SUMMARY - LIFETIME AVERAGE DAILY EXPOSURE (LADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL LADE	INHALATION LADE	DERMAL LADE
Soil - TOTAL				
95-48-7 CRESOL, ORTHO		6.5e-005	--------	
106-44-5 CRESOL, PARA		8.2e-005	--------	
108-10-1 METHYL ISOBUTYL		7.0e-008	--------	

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

It is important to remember that the calculated exposure values refer ONLY to the specific exposure pathways enumerated in this assessment. An exposure pathway combines contamination in an environmental medium, a scenario describing how a person contacts that medium, and a route of exposure (oral, inhalation, or dermal). An assessment that incorporates other pathways of exposure, or that does not incorporate all of the pathways described in this analysis, will yield different exposure values. The following list indicates t' ` pathways considered in this assessment:

Soil:

Ingestion of Soil (Oral)
Children are assumed to consume a significant amount of soil, relative to adults, as a result of outdoor play. When children have access to areas of contaminated soil, soil ingestion may represent a significant source of exposure to contaminants.

3.0 Parameters

The exposure values presented above reflect not only the concentrations of contaminants in various environmental media and the exposure pathways selected for analysis, but also the specific numerical parameters applied to each exposure scenario. Some scenarios also incorporate cross-media transfer equations (such as for the volatilization of contaminants from shower water i' ɔ bathroom air) that must be considered in reviewing the results of e.. osure calculations. The following tables summarize the exposure parameters and transfer equations used in this assessment.

Exposure Parameters Used to Generate Exposure Estimates

ORAL SCENARIOS	CONSUMPT RATE(units/event)	CONTAMIN FRAC	EVENT FREQ (event/y)	EXPOSURE PERIOD(y)	WEIGHT (kg)	LIFE-TIME(y)
Ingestion of Soil	0.10	0.10	350	30	70	70

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Exposure is defined as the CONTACT of an organism (humans in the case of health risk assessment) with a chemical or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of an agent available for absorption at the lungs, gut, or skin, not the amount absorbed.

Two different methods are used to calculate exposure. Average Daily Exposure (ADE) is an average exposure computed for the period over which exposure occurs, and is used to calculate risks for non-cancer toxic effects. Lifetime Average Daily Exposure (LADE), used to calculate carcinogenic risks, takes into account the fact that while carcinogenic hazard values are determined with an assumption of lifetime exposure, actual exposure may be over a shorter period.

ADE = (Contaminant Concentration x Contact Rate) / Body weight

LADE = ADE x (Exposure Period in Years / Lifetime)

Contact Rate is the amount of the contaminated medium (water, air, food) with which a person comes into contact (generally a daily average) for the period of exposure (e.g. liters per day of water ingested, kilograms per day of food ingested, cubic meters per day of air inhaled). Both ADE and LADE are generally expressed in units of milligrams of the contaminant available for absorption, per kilogram of body weight, per day.

EXPOSURE SUMMARY - AVERAGE DAILY EXPOSURE (ADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL ADE	INHALATION ADE	DERMAL ADE
Soil - Ingestion of Soil				
105-67-9 2,4-DIMETHYLPHE	2.0e+003	2.7e-004		
108-95-2 PHENOL	3.3e+002	4.5e-005		
95-48-7 CRESOL, ORTHO	1.1e+003	1.5e-004		
106-44-5 CRESOL, PARA	1.4e+003	1.9e-004		
108-10-1 METHYL ISOBUTYL	1.2e+000	1.6e-007		
Soil - TOTAL				
105-67-9 2,4-DIMETHYLPHE		2.7e-004	--------	
108-95-2 PHENOL		4.5e-005	--------	
95-48-7 CRESOL, ORTHO		1.5e-004	--------	
106-44-5 CRESOL, PARA		1.9e-004	--------	
108-10-1 METHYL ISOBUTYL		1.6e-007	--------	

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

EXPOSURE SUMMARY - LIFETIME AVERAGE DAILY EXPOSURE (LADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL LADE	INHALATION LADE	DERMAL LADE
Soil - Ingestion of Soil				
105-67-9 2,4-DIMETHYLPHE	2.0e+003	1.2e-004		
108-95-2 PHENOL	3.3e+002	1.9e-005		
95-48-7 CRESOL, ORTHO	1.1e+003	6.5e-005		
106-44-5 CRESOL, PARA	1.4e+003	8.2e-005		
108-10-1 METHYL ISOBUTYL	1.2e+000	7.0e-008		
Soil - TOTAL				
105-67-9 2,4-DIMETHYLPHE		1.2e-004	--------	
108-95-2 PHENOL		1.9e-005	--------	

Tar (2nd file)

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

SITE: TarLake.SIT (filename)
Antrium, MI,

1.0 Approach

The procedures used by RISK*ASSISTANT to calculate exposures have been reviewed by the Office of Health and Environmental Assessment of the U.S. EPA. Default parameters for calculating exposures have been extracted from EPA's EXPOSURE FACTORS HANDBOOK (EPA/600/8-89/043; March 1989).

The user of this software should confirm the reliability and appropriateness of environmental concentration data used as a starting point for the exposure calculations, and should indicate the rationale for making changes to EPA-supplied default values for exposure parameters.

2.0 Sample Data

RISK*ASSISTANT offers the user a variety of ways to aggregate sample data for use in its analyses. The user may select a single sample in an environmental medium (GROUNDWATER, SURFACE WATER, AIR, SOIL, SEDIMENT, or BIOTA), or may calculate the MAXIMUM, ARITHMETIC MEAN, or GEOMETRIC MEAN of either a SUBSET of the samples in a medium or of ALL SAMPLES in that medium. When calculating mean concentrations, NON-DETECTS can either be IGNORED (equivalent to setting non-detects at the average value for samples with measured values) set to ONE-HALF OF THE SAMPLE QUANTITATION LIMIT, or set to the SAMPLE QUANTITATION LIMIT. The aggregation method, as well as the actual sample data set entered into RISK*ASSISTANT for a site, will strongly influence the results of any subsequent analyses. The following table lists the media considered in this analysis, the aggregation technique applied for each medium, the sample set included in the aggregation, and the approach used to deal with chemicals that were only detected in some of the samples included in the aggregation.

MEDIUM	AGGREGATION STRATEGY	SAMPLE SET	TREATMENT OF NON-DETECTS
Soil	Single Sample		

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM		CHEMICAL NAME	CONCENTRATION	(UNITS)
Soil				
	105-67-9	2,4-DIMETHYLPHENOL	2000.000	(ug/kg)
	108-95-2	PHENOL	330.000	(ug/kg)
	95-48-7	CRESOL, ORTHO	1100.000	(ug/kg)
	106-44-5	CRESOL, PARA	1400.000	(ug/kg)
	108-10-1	METHYL ISOBUTYL KETONE	1.200	(ug/kg)

5.0 Combining Risks Across Chemicals and Routes

In general, RISK*ASSISTANT reports present risks that are specific to a particular chemical and route of exposure. Risks are not combined across chemicals, or across routes of exposure. This is because one can not assume that a given chemical will produce the same toxic effects by all routes of exposure, and different chemicals produce different ranges of toxic effects.

In some situations, it is appropriate for the user to calculate such combined risks. Many chemicals will produce the same toxic effect, regardless of the exposure route. For chemicals that cause cancer by several routes of exposure, the COMBINED RISK FROM ALL ROUTES may be more informative than route-specific risk estimates, unless there is evidence that carcinogenic risks from different routes reflect different mechanisms of action.
Similarly, for non-cancer toxic effects, differences between routes may only affect toxic potency, which will be reflected in the use of route-specific Reference Doses. A COMBINED HAZARD INDEX for all routes of exposure may be more informative than route-specific hazard indices in such cases.

When there is evidence that doing so would be toxicologically appropriate, you should consider calculating an estimate of TOTAL carcinogenic risk for all carcinogenic chemicals to which your population is exposed. Similarly, a GLOBAL HAZARD INDEX is appropriate for a set of chemicals that have overlapping patterns of toxicity. RISK*ASSISTANT does not automatically make such calculations, which should be preceded by careful consideration of the specific chemicals covered by the assessment.

In generating estimates of the combined toxic and carcinogenic risks of different chemicals, it is also important to bear in mind that the risks of exposure to multiple chemicals are not necessarily additive. Risks may be less than additive, or SYNERGISM may lead to risks that are greater than would be predicted by an additive model. Unfortunately, only very limited data are available on the risks of exposure to multiple chemicals.

In addition to considering the potential combined risks of the chemicals at a site, it is also important to identify those chemicals, routes of exposure, exposure scenarios, and media that are associated with the highest cancer risk and the greatest hazard indices. Such information will help in the selection of the most effective strategies for alleviating those risks.

THESE ARE THE NOTES, IF ANY, ENTERED BY THE USER DURING THIS ANALYSIS

None

6.0 References

.IRIS: Integrated Risk Information System.

.HEAST: Health Effects Assessment Summary Tables.

.Konz, J.; K. Lisi and E. Friebele. 1989. Exposure Factors Handbook. Us EPA, Office of Health and Environmental Assessment. Washington, D.C.

.EXPOSURE NAME:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>END OF REPORT<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Exposure is defined as the CONTACT of an organism (humans in the case of health risk assessment) with a chemical or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of an agent available for absorption at the lungs, gut, or skin, not the amount absorbed.

Two different methods are used to calculate exposure. Average Daily Exposure (ADE) is an average exposure computed for the period over which exposure occurs, and is used to calculate risks for non-cancer toxic effects. Lifetime Average Daily Exposure (LADE), used to calculate carcinogenic risks, takes into account the fact that while carcinogenic hazard values are determined with an assumption of lifetime exposure, actual exposure may be over a shorter period.

ADE = (Contaminant Concentration x Contact Rate) / Body weight

LADE = ADE x (Exposure Period in Years / Lifetime)

Contact Rate is the amount of the contaminated medium (water, air, food) with which a person comes into contact (generally a daily average) for the period of exposure (e.g. liters per day of water ingested, kilograms per day of food ingested, cubic meters per day of air inhaled). Both ADE and LADE are generally expressed in units of milligrams of the contaminant available for absorption, per kilogram of body weight, per day.

The risk values calculated by RISK*ASSISTANT reflect both the uncertainties associated with the estimation of toxic hazard information for each chemical and the uncertainties associated with the exposure estimates you have calculated. To understand the influence of the quantitative exposure estimates on the corresponding calculations of risk, it is necessary to consider the key assumptions used in deriving them, and the uncertainties associated with those assumptions:

- A key assumption is that the concentrations specified for various environmental media represent the true concentrations to which people will be exposed during the period of exposure. Actual contaminant concentrations will likely vary across both time and space.
- The selection of exposure scenarios will also have a significant influence on predicted exposures. Actual exposures to members of any specified population will vary in accordance with the degree to which they participate in the activities described by the exposure scenarios.
- Similarly, the numerical parameter values applied to each exposure scenario will have a marked effect on exposure. The default values provided are estimates for the entire U.S. population. Various demographic factors (including geographic region, rural or urban setting, socioeconomic status and ethnic heritage) may call for significant alterations in these values.

The uncertainty analyses provided as an option by RISK*ASSISTANT can illustrate the differences between the risk estimates that you have calculated and risks calculated using alternative assumptions.

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Where available, cancer potencies and reference doses have been obtained from the Integrated Risk Information System (IRIS). All values in IRIS have been reviewed and accepted for Agency-wide use by EPA. For chemicals not included in IRIS, toxicity data were extracted from the Health Effects Assessment Summary Tables (HEAST), distributed quarterly by the Office of Emergency and Remedial Response. These values, and risk estimates derived from them, are marked by an asterisk(*).

For a very limited set of chemicals, carcinogenic slope factors and/or reference doses may be estimated from epidemiologic data collected in humans. Most slope factors and RfDs, however, are derived from experimental studies in animals. Such extrapolations are based on the assumptions that 1) the physiological and biochemical responses of exposed persons will be qualitatively (but not necessarily quantitatively) the same as that seen in the experimental animals, 2) effects seen at high doses in a limited number of animals over a comparatively brief period of observation are predictive of toxicity at lower doses, if a sufficiently large group is exposed for a s ficiently long period. For some chemicals, hazard values may also have been extrapolated across differing routes of exposure. This introduces additional uncertainty to these estimates.
The slope (potency) factors for cancer risks are estimated as the 95th percentile confidence limits using the linearized multistage model. As such, they are conservative estimates of toxic hazard. Risks estimated by combining these hazard values with exposure estimates are commonly referred to as upper-bound risks, but because exposure estimates may not represent upper-bound estimates, risk estimates are not true upper-bound risks.
The exposure estimates used to calculate the risks presented in this assessment refer ONLY to the specific exposure pathways enumerated in the assessment, and depend upon the specific exposure parameters used for calculation. An exposure pathway combines contamination in an environmental medium, a scenario describing how a person contacts that medium, and a route of exposure (oral, inhalation, or dermal). An assessment that incorporates other pathways of exposure, or that does not incorporate all of the pathways described in this analysis, will yield different exposure values. Further, exposure and risk T' \LS for each medium involve the assumption that the same individual experiences ALL SCENARIOS corresponding to that medium.

Soil :

Ingestion of Soil (Oral)
Children are assumed to consume a significant amount of soil, relative to adults, as a result of outdoor play. When children have access to areas of contaminated soil, soil ingestion may represent a significant source of exposure to contaminants.

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

LADE	= Lifetime Average Daily Exposure
ADE	= Average Daily Exposure (during exposure period)
SLOPE FACTOR	= Cancer Potency (Slope of the Dose-Response Function)
W.O.E. CLASS	= Weight of evidence for HUMAN carcinogenicity
A	= Known human carcinogen.
B1	= Probable human carcinogen, limited human data.
B2	= Probable human carcinogen, inadequate or no human data.
C	= Possible human carcinogen.
D	= Not classifiable as human carcinogen.
E	= Evidence that not carcinogenic in humans.
RISK	= Lifetime probability of getting cancer from this exposure.
RfD	= Reference Dose (daily exposure NOT causing toxicity)
H.I.	= HAZARD INDEX (Ratio of ADE to RfD (ADE/RfD))

4 ^ Uncertainties

B ause risk values incorporate all of the estimates, default values, and assumptions used throughout risk assessment, the values presented in these tables must be understood in terms of key uncertainties regarding both the toxic hazard and the exposure estimates used to derive them.

The potency (slope factor) of a known or suspected human carcinogen is generally derived from a linearized multistage model of carcinogenesis. Such a model assumes that any non-zero exposure to a carcinogen is associated with a finite probability of cancer, and that at low doses, the relationship between exposure and probability of cancer can be approximated by a straight line. Accordingly, the potency of a carcinogen can be expressed as the slope of this straight line. Slope factors are expressed as inverse exposures (1/(mg/kg/d)).

Reference doses derive from the assumption that all non-cancer toxic effects have some threshold. That is, up to some finite level of exposure, physiological defense mechanisms ensure that no toxic effect will occur. Ac~ordingly, hazard assessment for non-carcinogenic effects involve estimating a. exposure that is less than this threshold level. This is done by applying "uncertainty factors" to exposures that appear to be near this threshold in laboratory toxicology studies. Reference doses are expressed as exposures (mg/kg/d).

RISK CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

RISK SUMMARY FOR ALL SCENARIOS - CARCINOGENIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION UNITS:SEE NOTE	CLASS W.O.E.	LADE (mg/kg/d)	SLOPE FACT.* (1/(mg/kg/d))	RISK
Soil	- Ingestion of Soil					
117-81-7	BIS(2-ETHYLHEX	2.8e+002	B2	1.6e-005	1.4e-002	2e-007
84-74-2	DIBUTYL PHTHAL	2.8e+002	D	1.6e-005	---------	------
86-73-7	FLUORENES	2.8e+002	D	5.9e-006	---------	------
91-20-3	NAPHTHALENE	1.0e+002		5.3e-005	---------	------
85-01-8	PHENANTHRENE	9.0e+002		1.6e-005	---------	------
129-00-0	PYRENE	2.8e+002		1.6e-005	---------	------

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

For agents that cause non-cancer toxic effects, a Hazard Index (H.I.) is calculated, which compares the expected exposure to the agent to an exposure (the Reference Dose, or RfD) that is assumed not to be associated with toxic effects.

H.I. = Average Daily Exposure / Reference Dose

Hazard Indices of < 1.0 are generally considered by EPA to be associated with low risks on non-cancer toxic effects.

RISK SUMMARY FOR ALL SCENARIOS - NON-CANCER TOXIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION UNITS:SEE NOTE	ADE (mg/kg/d)	RfD* (mg/kg/d)	HI
Soil	- Ingestion of Soil				
100-41-4	ETHYLBENZENE	--------	1.4e-005	1.0e-001	1e-004
108-88-3	TOLUENE	1.0e+002	1.4e-005	3.0e-001	5e-005
100-42-5	STYRENE	1.0e+002	3.2e-007	2.0e-001	2e-006
78-93-3	BUTANONE	2.3e+000	6.8e-007	5.0e-002	1e-005
1330-20-7	MIXED XYLENES	5.0e+000	3.8e-005	2.0e+000	2e-005
83-32-9	ACENAPHTHENE	2.8e+002	3.8e-005	6.0e-002	6e-004
208-96-8	ACENAPHTHYLENE	2.8e+002	3.8e-005	4.0e-002	1e-003
120-12-7	ANTHRACENE	2.8e+002	3.8e-005	3.0e-001	1e-004
56-55-3	BENZ(A)ANTHRAC	2.8e+002	3.8e-005	3.0e-002	1e-003
218-01-9	CHRYSENE	2.8e+002	3.8e-005	3.0e-002	1e-003
205-99-2	BENZO(B)FLUORA	2.8e+002	3.8e-005	3.0e-002	1e-003
207-08-9	BENZO(K)FLUORA	2.8e+002	3.8e-005	3.0e-002	1e-003
206-44-0	FLUORANTHENE	2.8e+002	3.8e-005	4.0e-002	1e-003
117-81-7	BIS(2-ETHYLHEX	2.8e+002	3.8e-005	2.0e-002	2e-003
84-74-2	DIBUTYL PHTHAL	2.8e+002	3.8e-005	1.0e-001	4e-004
86-73-7	FLUORENES	2.8e+002	1.4e-005	4.0e-002	3e-004
91-20-3	NAPHTHALENE	1.0e+002	1.2e-004	4.0e-003*	3e-002
85-01-8	PHENANTHRENE	9.0e+002	3.8e-005	4.0e-002	1e-003
129-00-0	PYRENE	2.8e+002	3.8e-005	3.0e-002	1e-003

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

2nd soil file   2e-002

IRIS DATABASE Update: 03/15/90
HEAST DATABASE Update: 03/15/90
EXPOSURE NAME:

HAZARD INDEX for SOIL INGESTION PATHWAY 2.9×10^{-2}

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION (UNITS)
Soil		
208-96-8	ACENAPHTHYLENE	280.000 (ug/kg)
120-12-7	ANTHRACENE	280.000 (ug/kg)
56-55-3	BENZ(A)ANTHRACENE	280.000 (ug/kg)
218-01-9	CHRYSENE	280.000 (ug/kg)
205-99-2	BENZO(B)FLUORANTHENE	280.000 (ug/kg)
207-08-9	BENZO(K)FLUORANTHENE	280.000 (ug/kg)
206-44-0	FLUORANTHENE	280.000 (ug/kg)
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	280.000 (ug/kg)
84-74-2	DIBUTYL PHTHALATE	280.000 (ug/kg)
86-73-7	FLUORENES	100.000 (ug/kg)
91-20-3	NAPHTHALENE	900.000 (ug/kg)
85-01-8	PHENANTHRENE	280.000 (ug/kg)
129-00-0	PYRENE	280.000 (ug/kg)

3.0 Risk Estimates

Two different approaches are used in the calculation of toxic chemical risks. For agents that may cause cancer (carcinogens), an actual risk estimate (i.e. a probability value that is a function of potency and exposure) is calculated:

$$\text{Risk} = 1 - e^{-(\text{Slope Factor} * \text{Lifetime Average Daily Exposure})}$$

The calculated risk estimates for carcinogens represent the theoretical excess cancer risk (i.e. risk over background cancer incidence) that a person exposed to an agent under the specified conditions will develop cancer. For example, if the calculated risk is 1 e-6, this would literally suggest that an individual exposed to the agent will have a one-in-a-million chance of getting cancer because of the exposure, in addition to her/his chance of getting cancer from other causes. However, in view of the large uncertainties associated with such risk estimates, they should always be interpreted as ç eral indicators, rather than precise estimates. The U.S. Environmental Protection Agency (EPA) generally considers risks below 1 e-6 to be low.

RISK SUMMARY FOR ALL SCENARIOS - CARCINOGENIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION UNITS:SEE NOTE	CLASS W.O.E.	LADE (mg/kg/d)	SLOPE FACT.* (1/(mg/kg/d))	RISK
Soil	- Ingestion of Soil					
100-41-4	ETHYLBENZENE	--------	D	5.9e-006	--------	------
108-88-3	TOLUENE	1.0e+002	D	5.9e-006	--------	------
100-42-5	STYRENE	1.0e+002	B2	1.4e-007	3.0e-002*	4e-009
78-93-3	BUTANONE	2.3e+000		2.9e-007	--------	------
1330-20-7	MIXED XYLENES	5.0e+000	D	1.6e-005	--------	------
83-32-9	ACENAPHTHENE	2.8e+002		1.6e-005	--------	------
208-96-8	ACENAPHTHYLENE	2.8e+002		1.6e-005	--------	------
120-12-7	ANTHRACENE	2.8e+002		1.6e-005	--------	------
56-55-3	BENZ(A)ANTHRAC	2.8e+002	B2	1.6e-005	11.5	2e-004
218-01-9	CHRYSENE	2.8e+002	B2	1.6e-005	11.5	2e-004
205-99-2	BENZO(B)FLUORA	2.8e+002	B2	1.6e-005	11.5	2e-004
207-08-9	BENZO(K)FLUORA	2.8e+002	B2	1.6e-005	11.5	2e-004
206-44-0	FLUORANTHENE	2.8e+002		1.6e-005	--------	------

TOTAL CANCER RISK from ingestion of SOIL 8e-004

Tar (1st f. 1c)

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

SITE: TarLake.SIT (filename)
Antrium, MI,

1.0 Approach

The procedures used by RISK*ASSISTANT to calculate exposures and risks have been reviewed by the Office of Health and Environmental Assessment of the U.S. EPA. Default parameters for calculating exposures have been extracted from EPA's EXPOSURE FACTORS HANDBOOK (EPA/600/8-89/043; March 1989). Where available, cancer potencies and reference doses were obtained from the Integrated Risk Information System (IRIS). All values in IRIS have been reviewed and accepted for Agency-wide use by EPA. For chemicals not included in IRIS, toxicity data were extracted from the Health Effects Assessment Summary Tables (HEAST), distributed quarterly by the Office of Emergency and Remedial Response.

The user of this software should confirm the reliability and appropriateness of (ironmental concentration data used as a starting point for the exposure calculations, and should indicate the rationale for making changes to EPA-supplied default values for exposure parameters.

The toxic hazard data used to prepare this report were current as of the date supplied for the database. However, these values may have been modified since the update of the database. Users are urged to consult IRIS and the latest HEAST tables directly.

2.0 Sample Data

RISK*ASSISTANT offers the user a variety of ways to aggregate sample data for use in its analyses. The user may select a single sample in an environmental medium (GROUNDWATER, SURFACE WATER, AIR, SOIL, SEDIMENT, or BIOTA), or may calculate the MAXIMUM, ARITHMETIC MEAN, or GEOMETRIC MEAN of either a SUBSET of the samples in a medium or of ALL SAMPLES in that medium. When calculating mean concentrations, NON-DETECTS can either be IGNORED (equivalent to setting non-detects at the average value for samples with measured values) set to ONE-H F OF THE SAMPLE QUANTITATION LIMIT, or set to the SAMPLE QUANTITATION LIMIT. The aggregation method, as well as the actual sample data set entered into RISK*ASSISTANT for a site, will strongly influence the results of any subsequent analyses. The following table lists the media considered in this analysis, the aggregation technique applied for each medium, the sample set included in the aggregation, and the approach used to deal with chemicals that were only detected in some of the samples included in the aggregation.

MEDIUM	AGGREGATION STRATEGY	SAMPLE SET	TREATMENT OF NON-DETECTS
Soil	Single Sample		

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM		CHEMICAL NAME	CONCENTRATION	(UNITS)
Soil				
	100-41-4	ETHYLBENZENE	100.000	(ug/kg)
	108-88-3	TOLUENE	100.000	(ug/kg)
	100-42-5	STYRENE	2.300	(ug/kg)
	78-93-3	BUTANONE	5.000	(ug/kg)
	1330-20-7	MIXED XYLENES	280.000	(ug/kg)
	83-32-9	ACENAPHTHENE	280.000	(ug/kg)

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Oral Exposures

RELATIVE CONTRIBUTION OF SCENARIOS AND MEDIA TO ROUTE SPECIFIC EXPOSURES(%)

MEDIA/SCENARIOS	ADE (% of user-specified)		LADE (% of user specified)	
	Average	Worst-Case	Average	Worst-Case
Soil				
Ingestion of Soil	6850.00	36500.00	685.00	7300.00
ALL SCENARIOS	6850.00	36500.00	685.00	7300.00

Inhalation Exposures

RELATIVE CONTRIBUTION OF SCENARIOS AND MEDIA TO ROUTE SPECIFIC EXPOSURES(%)

MEDIA/SCENARIOS	ADE (% of user-specified)		LADE (% of user specified)	
	Average	Worst-Case	Average	Worst-Case

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

O˙ ˡ. Exposure

Ingestion of Soil - Alternative Parameter Values

Parameter (units)	User Value	Average Value	(Percent of User)	Reasonable Worst-Case	(Percent of User)
Body Weight (kg)	70.00	16.00	22.9	16.00	22.9
Event Freq. (events/y)	350.00	274.00	78.3	365.00	104.3
Exposure Duration (y)	30.00	3.00	10.0	6.00	20.0
Lifetime (y)	70.00	70.00	100.0	70.00	100.0
Consum. Rate(units/event)	0.10	0.20	200.0	0.80	800.0
Conatam. Fraction	0.10	1.00	1000.0	1.00	1000.0

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

Inhalation Exposure

Th‿‿E ARE THE NOTES, IF ANY ENTERED BY THE USER DURING THIS ANALYSIS

None

6.0 References

. Konz, J.; K. Lisi and E. Friebele. 1989. Exposure Factors Handbook. Us EPA, Office of Health and Environmental Assessment. Washington, D.C.

. EXPOSURE NAME:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>END OF REPORT<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

5.0 Uncertainties

To understand the meaning of the quantitative exposure estimates presented above, it is necessary to consider the key assumptions used in deriving them, and the uncertainties associated with those assumptions:

- A key assumption is that the concentrations specified for various environmental media represent the true concentrations to which people will be exposed during the period of exposure. Actual contaminant concentrations will likely vary across both time and space.

- The selection of exposure scenarios will also have a significant influence on predicted exposures. Actual exposures to members of any specified population will vary in accordance with the degree to which they participate in the activities described by the exposure scenarios.

- Similarly, the numerical parameter values applied to each exposure scenario will have a marked effect on exposure. The default values provided are estimates for the entire U.S. population. Various demographic factors (including geographic region, rural or urban setting, socioeconomic status and ethnic heritage) may call for significant alterations in these values.

The uncertainty analyses provided as an option by RISK*ASSISTANT can illustrate the differences between your calculated exposures and exposures calculated using standard (average or reasonable worst-case) numerical parameter values for each scenario you have selected. They can also provide information on the way in which your selection of exposure scenarios influences the exposure estimates you have calculated. Because chemical concentrations will vary across space and time, and peoples activities that result in exposure are also highly variable, the actual range of possible exposures for your site is greater than the range covered by RISK*ASSISTANT's uncertainty analyses.

5.1 Uncertainties Regarding Exposure Parameters

One estimate of the uncertainty associated with the exposure estimates presented above is provided by an examination of the ways in which using alternative values for numerical exposure parameters can change the resulting exposure values. The following table presents alternative exposure predictions (ADEs and LADEs) for each chemical, when exposure is calculated using 1) Average default values for all exposure parameters, and 2) Reasonable Worst-Case values for all parameters. In each case, the resulting ADE or LADE is presented as a percentage of the corresponding ADE or LADE calculated using user-specified parameter values. These values indicate the range of exposures that might be expected to occur for each scenario, and the position of the exposure calculated by the user within (or possibly outside of) this range. Following this table are additional tables that present, for each scenario, these alternative parameter values, both in absolute units and as a percentage of the parameter values actually used.

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

EXPOSURE SUMMARY - LIFETIME AVERAGE DAILY EXPOSURE (LADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL LADE	INHALATION LADE	DERMAL LADE
Soil - TOTAL				
208-96-8 ACENAPHTHYLENE		1.6e-005	--------	
120-12-7 ANTHRACENE		1.6e-005	--------	
56-55-3 BENZ(A)ANTHRACE		1.6e-005	--------	
218-01-9 CHRYSENE		1.6e-005	--------	
205-99-2 BENZO(B)FLUORAN		1.6e-005	--------	
207-08-9 BENZO(K)FLUORAN		1.6e-005	--------	
206-44-0 FLUORANTHENE		1.6e-005	--------	
117-81-7 BIS(2-ETHYLHEXY		1.6e-005	--------	
84-74-2 DIBUTYL PHTHALA		1.6e-005	--------	
86-73-7 FLUORENES		5.9e-006	--------	
91-20-3 NAPHTHALENE		5.3e-005	--------	
85-01-8 PHENANTHRENE		1.6e-005	--------	
129-00-0 PYRENE		1.6e-005	--------	

N(': water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

It is important to remember that the calculated exposure values refer ONLY to the specific exposure pathways enumerated in this assessment. An exposure pathway combines contamination in an environmental medium, a scenario describing how a person contacts that medium, and a route of exposure (oral, inhalation, or dermal). An assessment that incorporates other pathways of exposure, or that does not incorporate all of the pathways described in this analysis, will yield different exposure values. The following list indicates the pathways considered in this assessment:

Soil:

Ingestion of Soil (Oral)
Children are assumed to consume a significant amount of soil, relative to adults, as a result of outdoor play. When children have access to areas of c(aminated soil, soil ingestion may represent a significant source of exposure to contaminants.

3.0 Parameters

The exposure values presented above reflect not only the concentrations of contaminants in various environmental media and the exposure pathways selected for analysis, but also the specific numerical parameters applied to each exposure scenario. Some scenarios also incorporate cross-media transfer equations (such as for the volatilization of contaminants from shower water into bathroom air) that must be considered in reviewing the results of exposure calculations. The following tables summarize the exposure parameters and transfer equations used in this assessment.

Exposure Parameters Used to Generate Exposure Estimates

ORAL SCENARIOS	CONSUMPT RATE(units/event)	CONTAMIN FRAC	EVENT FREQ (event/y)	EXPOSURE PERIOD(y)	WEIGHT (kg)	LIFE-TIME(y)
Ingestion of Soil	0.10	0.10	350	30	70	70

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

EXPOSURE SUMMARY - AVERAGE DAILY EXPOSURE (ADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION units:see note below	ORAL ADE	INHALATION ADE	DERMAL ADE
Soil - TOTAL					
108-88-3	TOLUENE		1.4e-005	--------	
100-42-5	STYRENE		3.2e-007	--------	
78-93-3	BUTANONE		6.8e-007	--------	
1330-20-7	MIXED XYLENES		3.8e-005	--------	
83-32-9	ACENAPHTHENE		3.8e-005	--------	
208-96-8	ACENAPHTHYLENE		3.8e-005	--------	
120-12-7	ANTHRACENE		3.8e-005	--------	
56-55-3	BENZ(A)ANTHRACE		3.8e-005	--------	
218-01-9	CHRYSENE		3.8e-005	--------	
205-99-2	BENZO(B)FLUORAN		3.8e-005	--------	
207-08-9	BENZO(K)FLUORAN		3.8e-005	--------	
206-44-0	FLUORANTHENE		3.8e-005	--------	
117-81-7	BIS(2-ETHYLHEXY		3.8e-005	--------	
34-74-2	DIBUTYL PHTHALA		3.8e-005	--------	
86-73-7	FLUORENES		1.4e-005	--------	
91-20-3	NAPHTHALENE		1.2e-004	--------	
85-01-8	PHENANTHRENE		3.8e-005	--------	
129-00-0	PYRENE		3.8e-005	--------	

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

EXPOSURE SUMMARY - LIFETIME AVERAGE DAILY EXPOSURE (LADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION units:see note below	ORAL LADE	INHALATION LADE	DERMAL LADE
Soil - Ingestion of Soil					
100-41-4	ETHYLBENZENE	1.0e+002	5.9e-006		
108-88-3	TOLUENE	1.0e+002	5.9e-006		
100-42-5	STYRENE	2.3e+000	1.4e-007		
78-93-3	BUTANONE	5.0e+000	2.9e-007		
30-20-7	MIXED XYLENES	2.8e+002	1.6e-005		
83-32-9	ACENAPHTHENE	2.8e+002	1.6e-005		
208-96-8	ACENAPHTHYLENE	2.8e+002	1.6e-005		
120-12-7	ANTHRACENE	2.8e+002	1.6e-005		
56-55-3	BENZ(A)ANTHRACE	2.8e+002	1.6e-005		
218-01-9	CHRYSENE	2.8e+002	1.6e-005		
205-99-2	BENZO(B)FLUORAN	2.8e+002	1.6e-005		
207-08-9	BENZO(K)FLUORAN	2.8e+002	1.6e-005		
206-44-0	FLUORANTHENE	2.8e+002	1.6e-005		
117-81-7	BIS(2-ETHYLHEXY	2.8e+002	1.6e-005		
84-74-2	DIBUTYL PHTHALA	2.8e+002	1.6e-005		
86-73-7	FLUORENES	1.0e+002	5.9e-006		
91-20-3	NAPHTHALENE	9.0e+002	5.3e-005		
85-01-8	PHENANTHRENE	2.8e+002	1.6e-005		
129-00-0	PYRENE	2.8e+002	1.6e-005		
Soil - TOTAL					
100-41-4	ETHYLBENZENE		5.9e-006	--------	
108-88-3	TOLUENE		5.9e-006	--------	
100-42-5	STYRENE		1.4e-007	--------	
78-93-3	BUTANONE		2.9e-007	--------	
1330-20-7	MIXED XYLENES		1.6e-005	--------	
83-32-9	ACENAPHTHENE		1.6e-005	--------	

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION (UNITS)
Soil		
129-00-0	PYRENE	280.000 (ug/kg)

Exposure is defined as the CONTACT of an organism (humans in the case of health risk assessment) with a chemical or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of an agent available for absorption at the lungs, gut, or skin, not the amount absorbed.

Two different methods are used to calculate exposure. Average Daily Exposure (ADE) is an average exposure computed for the period over which exposure occurs, and is used to calculate risks for non-cancer toxic effects. Lifetime Average Daily Exposure (LADE), used to calculate carcinogenic risks, takes into account the fact that while carcinogenic hazard values are determined with an assumption of lifetime exposure, actual exposure may be over a shorter period.

ADE = (Contaminant Concentration x Contact Rate) / Body weight

LADE = ADE x (Exposure Period in Years / Lifetime)

Contact Rate is the amount of the contaminated medium (water, air, food) with which a person comes into contact (generally a daily average) for the period of exposure (e.g. liters per day of water ingested, kilograms per day of food ingested, cubic meters per day of air inhaled). Both ADE and LADE are generally expressed in units of milligrams of the contaminant available for absorption, per kilogram of body weight, per day.

EXPOSURE SUMMARY - AVERAGE DAILY EXPOSURE (ADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL ADE	INHALATION ADE	DERMAL ADE
Soil - Ingestion of Soil				
0-41-4 ETHYLBENZENE	1.0e+002	1.4e-005		
08-88-3 TOLUENE	1.0e+002	1.4e-005		
100-42-5 STYRENE	2.3e+000	3.2e-007		
78-93-3 BUTANONE	5.0e+000	6.8e-007		
1330-20-7 MIXED XYLENES	2.8e+002	3.8e-005		
83-32-9 ACENAPHTHENE	2.8e+002	3.8e-005		
208-96-8 ACENAPHTHYLENE	2.8e+002	3.8e-005		
120-12-7 ANTHRACENE	2.8e+002	3.8e-005		
56-55-3 BENZ(A)ANTHRACE	2.8e+002	3.8e-005		
218-01-9 CHRYSENE	2.8e+002	3.8e-005		
205-99-2 BENZO(B)FLUORAN	2.8e+002	3.8e-005		
207-08-9 BENZO(K)FLUORAN	2.8e+002	3.8e-005		
206-44-0 FLUORANTHENE	2.8e+002	3.8e-005		
117-81-7 BIS(2-ETHYLHEXY	2.8e+002	3.8e-005		
84-74-2 DIBUTYL PHTHALA	2.8e+002	3.8e-005		
86-73-7 FLUORENES	1.0e+002	1.4e-005		
91-20-3 NAPHTHALENE	9.0e+002	1.2e-004		
85-01-8 PHENANTHRENE	2.8e+002	3.8e-005		
129-00-0 PYRENE	2.8e+002	3.8e-005		
Soil - TOTAL				
100-41-4 ETHYLBENZENE		1.4e-005	--------	

Tar (1st File)

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

SITE: TarLake.SIT (filename)
Antrium, MI,

1.0 Approach

The procedures used by RISK*ASSISTANT to calculate exposures have been reviewed by the Office of Health and Environmental Assessment of the U.S. EPA. Default parameters for calculating exposures have been extracted from EPA's EXPOSURE FACTORS HANDBOOK (EPA/600/8-89/043; March 1989).

The user of this software should confirm the reliability and appropriateness of environmental concentration data ... he exposure calculations, and should indicate ... ges to EPA-supplied default values for expos ...

2.0 Sample Data

RISK*ASSISTANT offers the user a ... ample data for use in its analyses. The user ma ... environmental medium (GROUNDWATER, SURFACE WATE ... TA), or may calculate the MAXIMUM, ARITHMETIC ... ther a SUBSET of the samples in a medium or of ... hen calculating mean concentrations, NON-DETECTS ... ent to setting non-detects at the average value ... es) set to ONE-HALF OF THE SAMPLE QUANTITATION L ... NTITATION LIMIT. The aggregation method, a ... ta set entered into RISK*ASSISTANT for a site, w ... ults of any subsequent analyses. The followi ... dered in this analysis, the aggregation techniq ... e sample set included in the aggregation, and ... chemicals that were only detected in some of the samples included in the aggregation.

Tar 1st file

MEDIUM	AGGREGATION STRATEGY	SAMPLE SET	TREATMENT OF NON-DETECTS
Soil	Single Sample		

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION	(UNITS)
Soil			
100-41-4	ETHYLBENZENE	100.000	(ug/kg)
108-88-3	TOLUENE	100.000	(ug/kg)
100-42-5	STYRENE	2.300	(ug/kg)
78-93-3	BUTANONE	5.000	(ug/kg)
1330-20-7	MIXED XYLENES	280.000	(ug/kg)
83-32-9	ACENAPHTHENE	280.000	(ug/kg)
208-96-8	ACENAPHTHYLENE	280.000	(ug/kg)
120-12-7	ANTHRACENE	280.000	(ug/kg)
56-55-3	BENZ(A)ANTHRACENE	280.000	(ug/kg)
218-01-9	CHRYSENE	280.000	(ug/kg)
205-99-2	BENZO(B)FLUORANTHENE	280.000	(ug/kg)
207-08-9	BENZO(K)FLUORANTHENE	280.000	(ug/kg)
206-44-0	FLUORANTHENE	280.000	(ug/kg)
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	280.000	(ug/kg)
84-74-2	DIBUTYL PHTHALATE	280.000	(ug/kg)
86-73-7	FLUORENES	100.000	(ug/kg)
91-20-3	NAPHTHALENE	900.000	(ug/kg)
85-01-8	PHENANTHRENE	280.000	(ug/kg)

6.0 References

.IRIS: Integrated Risk Information System.

.HEAST: Health Effects Assessment Summary Tables.

.Konz, J.; K. Lisi and E. Friebele. 1989. Exposure Factors Handbook. Us EPA, Office of Health and Environmental Assessment. Washington, D.C.

.EXPOSURE NAME:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>END OF REPORT<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

The exposure estimates used to calculate the risks presented in this assessment refer ONLY to the specific exposure pathways enumerated in the assessment, and depend upon the specific exposure parameters used for calculation. An exposure pathway combines contamination in an environmental medium, a scenario describing how a person contacts that medium, and a route of exposure (oral, inhalation, or dermal). An assessment that incorporates other pathways of exposure, or that does not incorporate all of the pathways described in this analysis, will yield different exposure values. Further, exposure and risk TOTALS for each medium involve the assumption that the same individual experiences ALL SCENARIOS corresponding to that medium.

Groundwater :

Ingestion of Drinking Water (Oral)
This includes oral exposures from domestic water used for drinking or cooking.

Exposure is defined as the CONTACT of an organism (humans in the case of health risk assessment) with a chemical or physical agent. The magnitude of exposure i: etermined by measuring or estimating the amount of an agent available for absorption at the lungs, gut, or skin, not the amount absorbed.

Two different methods are used to calculate exposure. Average Daily Exposure (ADE) is an average exposure computed for the period over which exposure occurs, and is used to calculate risks for non-cancer toxic effects. Lifetime Average Daily Exposure (LADE), used to calculate carcinogenic risks, takes into account the fact that while carcinogenic hazard values are determined with an assumption of lifetime exposure, actual exposure may be over a shorter period.

ADE = (Contaminant Concentration x Contact Rate) / Body weight

LADE = ADE x (Exposure Period in Years / Lifetime)

Contact Rate is the amount of the contaminated medium (water, air, food) with which a person comes into contact (generally a daily average) for the period of exposure (e.g. liters per day of water ingested, kilograms per day of food i sted, cubic meters per day of air inhaled). Both ADE and LADE are generally expressed in units of milligrams of the contaminant available for absorption, per kilogram of body weight, per day.

4.0 Uncertainties

Because risk values incorporate all of the estimates, default values, and assumptions used throughout risk assessment, the values presented in these tables must be understood in terms of key uncertainties regarding both the toxic hazard and the exposure estimates used to derive them.

The potency (slope factor) of a known or suspected human carcinogen is generally derived from a linearized multistage model of carcinogenesis. Such a model assumes that any non-zero exposure to a carcinogen is associated with a finite probability of cancer, and that at low doses, the relationship between exposure and probability of cancer can be approximated by a straight line. Accordingly, the potency of a carcinogen can be expressed as the slope of this straight line. Slope factors are expressed as inverse exposures (1/(mg/kg/d)).

Reference doses derive from the assumption that all non-cancer toxic effects have some threshold. That is, up to some finite level of exposure, physiological defense mechanisms ensure that no toxic effect will occur. Accordingly, hazard assessment for non-carcinogenic effects involve estimating a exposure that is less than this threshold level. This is done by applying "uncertainty factors" to exposures that appear to be near this threshold in laboratory toxicology studies. Reference doses are expressed as exposures (mg/kg/d).

Where available, cancer potencies and reference doses have been obtained from the Integrated Risk Information System (IRIS). All values in IRIS have been reviewed and accepted for Agency-wide use by EPA. For chemicals not included in IRIS, toxicity data were extracted from the Health Effects Assessment Summary Tables (HEAST), distributed quarterly by the Office of Emergency and Remedial Response. These values, and risk estimates derived from them, are marked by an asterisk(*).

For a very limited set of chemicals, carcinogenic slope factors and/or reference doses may be estimated from epidemiologic data collected in humans. Most slope factors and RfDs, however, are derived from experimental studies in animals. Such extrapolations are based on the assumptions that 1) the physiological and biochemical responses of exposed persons will be qualitatively (but not necessarily quantitatively) the same as that seen in the experimental animals, 2) effects seen at high doses in a limited number of animals over a comparatively brief period of observation are predictive of toxicity at lower doses, if a sufficiently large group is exposed for a sufficiently long period. For some chemicals, hazard values may also have been extrapolated across differing routes of exposure. This introduces additional uncertainty to these estimates.
The slope (potency) factors for cancer risks are estimated as the 95th percentile confidence limits using the linearized multistage model. As such, they are conservative estimates of toxic hazard. Risks estimated by combining these hazard values with exposure estimates are commonly referred to as upper-bound risks, but because exposure estimates may not represent upper-bound estimates, risk estimates are not true upper-bound risks.

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

For agents that cause non-cancer toxic effects, a Hazard Index (H.I.) is calculated, which compares the expected exposure to the agent to an exposure (the Reference Dose, or RfD) that is assumed not to be associated with toxic effects.

H.I. = Average Daily Exposure / Reference Dose

Hazard Indices of < 1.0 are generally considered by EPA to be associated with low risks on non-cancer toxic effects.

RISK SUMMARY FOR ALL SCENARIOS - NON-CANCER TOXIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION UNITS:SEE NOTE	ADE (mg/kg/d)	RfD* (mg/kg/d)	HI
	2-methylnaphthalene	4.8e+001	1.36e-003	4.0e-003	3.4e-001
Groundwater - Ingestion of Drinking Water					
71-43-2	BENZENE	4.9e+001	1.4e-003	--------	------
100-41-4	ETHYLBENZENE	1.9e+001	5.4e-004	1.0e-001	5e-003
08-88-3	TOLUENE	8.0e+001	2.3e-003	3.0e-001	8e-003
100-42-5	STYRENE	8.9e+000	2.5e-004	2.0e-001	1e-003
78-93-3	BUTANONE	9.6e+001	2.7e-003	5.0e-002	5e-002
1330-20-7	MIXED XYLENES	5.5e+001	1.6e-003	2.0e+000	8e-004
208-96-8	ACENAPHTHYLENE	1.4e+001	4.0e-004	3.0e-002	1e-002
117-81-7	BIS(2-ETHYLHEX	7.9e+000	2.3e-004	2.0e-002	1e-002
86-73-7	FLUORENES	9.5e+000	2.7e-004	4.0e-002	7e-003
91-20-3	NAPHTHALENE	1.1e+001	3.1e-004	4.0e-003*	8e-002
85-01-8	PHENANTHRENE	9.4e+000	2.7e-004	4.0e-002	7e-003
98-95-3	NITROBENZENE	9.5e+000	2.7e-004	5.0e-004	5e-001
105-67-9	2,4-DIMETHYLPH	3.2e+003	9.2e-002	2.0e-002	4.6e+000
108-95-2	PHENOL	1.4e+003	4.1e-002	6.0e-001	7e-002
95-48-7	CRESOL, ORTHO	2.9e+003	8.2e-002	5.0e-002	2e+000
106-44-5	CRESOL, PARA	5.4e+003	1.5e-001	5.0e-002	3e+000

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

I S DATABASE Update: 03/15/90
HEAST DATABASE Update: 03/15/90
EXPOSURE NAME:

LADE	= Lifetime Average Daily Exposure
ADE	= Average Daily Exposure (during exposure period)
SLOPE FACTOR	= Cancer Potency (Slope of the Dose-Response Function)
W.O.E. CLASS	= Weight of evidence for HUMAN carcinogenicity
A	= Known human carcinogen.
B1	= Probable human carcinogen, limited human data.
B2	= Probable human carcinogen, inadequate or no human data.
C	= Possible human carcinogen.
D	= Not classifiable as human carcinogen.
E	= Evidence that not carcinogenic in humans.
RISK	= Lifetime probability of getting cancer from this exposure.
RfD	= Reference Dose (daily exposure NOT causing toxicity)
H.I.	= HAZARD INDEX (Ratio of ADE to RfD (ADE/RfD))

RISK CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION (UNITS)	
Groundwater			
208-96-8	ACENAPHTHYLENE	13.900	(ug/l)
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	7.900	(ug/l)
86-73-7	FLUORENES	9.500	(ug/l)
91-20-3	NAPHTHALENE	10.700	(ug/l)
85-01-8	PHENANTHRENE	9.400	(ug/l)
98-95-3	NITROBENZENE	9.500	(ug/l)
105-67-9	2,4-DIMETHYLPHENOL	3227.600	(ug/l)
108-95-2	PHENOL	1437.000	(ug/l)
95-48-7	CRESOL, ORTHO	2886.000	(ug/l)
106-44-5	CRESOL, PARA	5397.000	(ug/l)

3.0 Risk Estimates

Two different approaches are used in the calculation of toxic chemical risks. Fo- agents that may cause cancer (carcinogens), an actual risk estimate (i.e. a p. ability value that is a function of potency and exposure) is calculated:

$$\text{Risk} = 1 - e^{-(\text{Slope Factor} * \text{Lifetime Average Daily Exposure})}$$

The calculated risk estimates for carcinogens represent the theoretical excess cancer risk (i.e. risk over background cancer incidence) that a person exposed to an agent under the specified conditions will develop cancer. For example, if the calculated risk is 1 e-6, this would literally suggest that an individual exposed to the agent will have a one-in-a-million chance of getting cancer because of the exposure, in addition to her/his chance of getting cancer from other causes. However, in view of the large uncertainties associated with such risk estimates, they should always be interpreted as general indicators, rather than precise estimates. The U.S. Environmental Protection Agency (EPA) generally considers risks below 1 e-6 to be low.

R. . SUMMARY FOR ALL SCENARIOS - CARCINOGENIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION UNITS:SEE NOTE	W.O.E. CLASS	LADE (mg/kg/d)	SLOPE FACT.* (1/(mg/kg/d))	RISK
Groundwater - Ingestion of Drinking Water						
71-43-2	BENZENE	4.9e+001	A	6.0e-004	2.9e-002	2e-005
100-41-4	ETHYLBENZENE	1.9e+001	D	2.3e-004	--------	------
108-88-3	TOLUENE	8.0e+001	D	9.8e-004	--------	------
100-42-5	STYRENE	8.9e+000	B2	1.1e-004	3.0e-002*	3e-006
78-93-3	BUTANONE	9.6e+001		1.2e-003	--------	------
1330-20-7	MIXED XYLENES	5.5e+001	D	6.8e-004	--------	------
208-96-8	ACENAPHTHYLENE	1.4e+001		1.7e-004	--------	------
117-81-7	BIS(2-ETHYLHEX	7.9e+000	B2	9.7e-005	1.4e-002	1e-006
86-73-7	FLUORENES	9.5e+000	D	1.2e-004	--------	------
91-20-3	NAPHTHALENE	1.1e+001		1.3e-004	--------	------
85-01-8	PHENANTHRENE	9.4e+000		1.2e-004	--------	------
98-95-3	NITROBENZENE	9.5e+000		1.2e-004	--------	------
105-67-9	2,4-DIMETHYLPH	3.2e+003		4.0e-002	--------	------
108-95-2	PHENOL	1.4e+003		1.8e-002	--------	------
95-48-7	CRESOL, ORTHO	2.9e+003		3.5e-002	--------	------
106-44-5	CRESOL, PARA	5.4e+003		6.6e-002	--------	------

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

TOTAL CANCER Risk for GW 2.4e-005

Titan Groundwater

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

SITE: TarLake.SIT (filename)
Antrium, MI,

1.0 Approach

The procedures used by RISK*ASSISTANT to calculate exposures and risks have been reviewed by the Office of Health and Environmental Assessment of the U.S. EPA. Default parameters for calculating exposures have been extracted from EPA's EXPOSURE FACTORS HANDBOOK (EPA/600/8-89/043; March 1989). Where available, cancer potencies and reference doses were obtained from the Integrated Risk Information System (IRIS). All values in IRIS have been reviewed and accepted for Agency-wide use by EPA. For chemicals not included in IRIS, toxicity data were extracted from the Health Effects Assessment Summary Tables (HEAST), distributed quarterly by the Office of Emergency and Remedial Response.

The user of this software should confirm the reliability and appropriateness of environmental concentration data used as a starting point for the exposure calculations, and should indicate the rationale for making changes to EPA-supplied default values for exposure parameters.

The toxic hazard data used to prepare this report were current as of the date supplied for the database. However, these values may have been modified since the update of the database. Users are urged to consult IRIS and the latest HEAST tables directly.

2.0 Sample Data

RISK*ASSISTANT offers the user a variety of ways to aggregate sample data for use in its analyses. The user may select a single sample in an environmental medium (GROUNDWATER, SURFACE WATER, AIR, SOIL, SEDIMENT, or BIOTA), or may calculate the MAXIMUM, ARITHMETIC MEAN, or GEOMETRIC MEAN of either a SUBSET of the samples in a medium or of ALL SAMPLES in that medium. When calculating mean concentrations, NON-DETECTS can either be IGNORED (equivalent to setting non-detects at the average value for samples with measured values) set to ONE-HALF OF THE SAMPLE QUANTITATION LIMIT, or set to the SAMPLE QUANTITATION LIMIT. The aggregation method, as well as the actual sample data set entered into RISK*ASSISTANT for a site, will strongly influence the results of any subsequent analyses. The following table lists the media considered in this analysis, the aggregation technique applied for each medium, the sample set included in the aggregation, and the approach used to deal with chemicals that were only detected in some of the samples included in the aggregation.

MEDIUM	AGGREGATION STRATEGY	SAMPLE SET	TREATMENT OF NON-DETECTS
Groundwater	Single Sample		

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION	(UNITS)
Groundwater			
71-43-2	BENZENE	49.200	(ug/l)
100-41-4	ETHYLBENZENE	18.950	(ug/l)
108-88-3	TOLUENE	80.050	(ug/l)
100-42-5	STYRENE	8.900	(ug/l)
78-93-3	BUTANONE	95.500	(ug/l)
1330-20-7	MIXED XYLENES	55.450	(ug/l)

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

Oral Exposure

Ingestion of Drinking Water - Alternative Parameter Values

Parameter (units)	User Value	Average Value	(Percent of User)	Reasonable Worst-Case	(Percent of User)
Conatam. Fraction	1.00	0.75	75.0	1.00	100.0

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

Inhalation Exposure

THESE ARE THE NOTES, IF ANY ENTERED BY THE USER DURING THIS ANALYSIS

None

6 References

. Konz, J.; K. Lisi and E. Friebele. 1989. Exposure Factors Handbook. Us EPA, Office of Health and Environmental Assessment. Washington, D.C.

. EXPOSURE NAME:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>END OF REPORT<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

The uncertainty analyses provided as an option by RISK*ASSISTANT can illustrate the differences between your calculated exposures and exposures calculated using standard (average or reasonable worst-case) numerical parameter values for each scenario you have selected. They can also provide information on the way in which your selection of exposure scenarios influences the exposure estimates you have calculated. Because chemical concentrations will vary across space and time, and peoples activities that result in exposure are also highly variable, the actual range of possible exposures for your site is greater than the range covered by RISK*ASSISTANT's uncertainty analyses.

5.1 Uncertainties Regarding Exposure Parameters

One estimate of the uncertainty associated with the exposure estimates presented above is provided by an examination of the ways in which using alternative values for numerical exposure parameters can change the resulting exposure values. The following table presents alternative exposure predictions (ADEs and LADEs) for each chemical, when exposure is calculated using 1) Average default values for all exposure parameters, and 2) Reasonable Worst-Case values for all parameters. In each case, the resulting ADE or LADE i presented as a percentage of the corresponding ADE or LADE calculated using user-specified parameter values. These values indicate the range of exposures that might be expected to occur for each scenario, and the position of the exposure calculated by the user within (or possibly outside of) this range. Following this table are additional tables that present, for each scenario, these alternative parameter values, both in absolute units and as a percentage of the parameter values actually used.

Oral Exposures

RELATIVE CONTRIBUTION OF SCENARIOS AND MEDIA TO ROUTE SPECIFIC EXPOSURES(%)

MEDIA/SCENARIOS	ADE (% of user-specified)		LADE (% of user specified)	
	Average	Worst-Case	Average	Worst-Case
Groundwater				
Drinking Water	52.50	100.00	15.75	100.00
ALL SCENARIOS	52.50	100.00	15.75	100.00

Innalation Exposures

RELATIVE CONTRIBUTION OF SCENARIOS AND MEDIA TO ROUTE SPECIFIC EXPOSURES(%)

MEDIA/SCENARIOS	ADE (% of user-specified)		LADE (% of user specified)	
	Average	Worst-Case	Average	Worst-Case

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

Oral Exposure

Ingestion of Drinking Water - Alternative Parameter Values

Parameter (units)	User Value	Average Value	(Percent of User)	Reasonable Worst-Case	(Percent of User)
Body Weight (kg)	70.00	70.00	100.0	70.00	100.0
Event Freq. (events/y)	365.00	365.00	100.0	365.00	100.0
Exposure Duration (y)	30.00	9.00	30.0	30.00	100.0
Lifetime (y)	70.00	70.00	100.0	70.00	100.0
Consum. Rate(units/event)	2.00	1.40	70.0	2.00	100.0

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

It is important to remember that the calculated exposure values refer ONLY to the specific exposure pathways enumerated in this assessment. An exposure pathway combines contamination in an environmental medium, a scenario describing how a person contacts that medium, and a route of exposure (oral, inhalation, or dermal). An assessment that incorporates other pathways of exposure, or that does not incorporate all of the pathways described in this analysis, will yield different exposure values. The following list indicates the pathways considered in this assessment:

Groundwater:

Ingestion of Drinking Water (Oral)
This includes oral exposures from domestic water used for drinking or cooking.

3.0 Parameters
The exposure values presented above reflect not only the concentrations of contaminants in various environmental media and the exposure pathways selected for analysis, but also the specific numerical parameters applied to each exposure scenario. Some scenarios also incorporate cross-media transfer equations (such as for the volatilization of contaminants from shower water into bathroom air) that must be considered in reviewing the results of exposure calculations. The following tables summarize the exposure parameters and transfer equations used in this assessment.

Exposure Parameters Used to Generate Exposure Estimates

ORAL SCENARIOS	CONSUMPT RATE(units/event)	CONTAMIN FRAC	EVENT FREQ (event/y)	EXPOSURE PERIOD(y)	WEIGHT (kg)	LIFE-TIME(y)
Drinking Water	2.00	1.00	365	30	70	70

5.0 Uncertainties
To understand the meaning of the quantitative exposure estimates presented above, it is necessary to consider the key assumptions used in deriving them, and the uncertainties associated with those assumptions:

- A key assumption is that the concentrations specified for various environmental media represent the true concentrations to which people will be exposed during the period of exposure. Actual contaminant concentrations will likely vary across both time and space.

- The selection of exposure scenarios will also have a significant influence on predicted exposures. Actual exposures to members of any specified population will vary in accordance with the degree to which they participate in the activities described by the exposure scenarios.

- Similarly, the numerical parameter values applied to each exposure scenario will have a marked effect on exposure. The default values provided are estimates for the entire U.S. population. Various demographic factors (including geographic region, rural or urban setting, socioeconomic status and ethnic heritage) may call for significant alterations in these values.

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

EXPOSURE SUMMARY - AVERAGE DAILY EXPOSURE (ADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL ADE	INHALATION ADE	DERMAL ADE
Groundwater - TOTAL				
85-01-8 PHENANTHRENE		2.7e-004	--------	
98-95-3 NITROBENZENE		2.7e-004	--------	
105-67-9 2,4-DIMETHYLPHE		9.2e-002	--------	
108-95-2 PHENOL		4.1e-002	--------	
95-48-7 CRESOL, ORTHO		8.2e-002	--------	
106-44-5 CRESOL, PARA		1.5e-001	--------	

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

EXPOSURE SUMMARY - LIFETIME AVERAGE DAILY EXPOSURE (LADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL LADE	INHALATION LADE	DERMAL LADE
Gr ndwater - Ingestion of Drinking Water				
1-43-2 BENZENE	4.9e+001	6.0e-004		
100-41-4 ETHYLBENZENE	1.9e+001	2.3e-004		
108-88-3 TOLUENE	8.0e+001	9.8e-004		
100-42-5 STYRENE	8.9e+000	1.1e-004		
78-93-3 BUTANONE	9.6e+001	1.2e-003		
1330-20-7 MIXED XYLENES	5.5e+001	6.8e-004		
208-96-8 ACENAPHTHYLENE	1.4e+001	1.7e-004		
117-81-7 BIS(2-ETHYLHEXY	7.9e+000	9.7e-005		
86-73-7 FLUORENES	9.5e+000	1.2e-004		
91-20-3 NAPHTHALENE	1.1e+001	1.3e-004		
85-01-8 PHENANTHRENE	9.4e+000	1.2e-004		
98-95-3 NITROBENZENE	9.5e+000	1.2e-004		
105-67-9 2,4-DIMETHYLPHE	3.2e+003	4.0e-002		
108-95-2 PHENOL	1.4e+003	1.8e-002		
95-48-7 CRESOL, ORTHO	2.9e+003	3.5e-002		
106-44-5 CRESOL, PARA	5.4e+003	6.6e-002		
Gr ndwater - TOTAL				
1-43-2 BENZENE		6.0e-004	--------	
100-41-4 ETHYLBENZENE		2.3e-004	--------	
108-88-3 TOLUENE		9.8e-004	--------	
100-42-5 STYRENE		1.1e-004	--------	
78-93-3 BUTANONE		1.2e-003	--------	
1330-20-7 MIXED XYLENES		6.8e-004	--------	
208-96-8 ACENAPHTHYLENE		1.7e-004	--------	
117-81-7 BIS(2-ETHYLHEXY		9.7e-005	--------	
86-73-7 FLUORENES		1.2e-004	--------	
91-20-3 NAPHTHALENE		1.3e-004	--------	
85-01-8 PHENANTHRENE		1.2e-004	--------	
98-95-3 NITROBENZENE		1.2e-004	--------	
105-67-9 2,4-DIMETHYLPHE		4.0e-002	--------	
108-95-2 PHENOL		1.8e-002	--------	
95-48-7 CRESOL, ORTHO		3.5e-002	--------	
106-44-5 CRESOL, PARA		6.6e-002	--------	

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Exposure is defined as the CONTACT of an organism (humans in the case of health risk assessment) with a chemical or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of an agent available for absorption at the lungs, gut, or skin, not the amount absorbed.

Two different methods are used to calculate exposure. Average Daily Exposure (ADE) is an average exposure computed for the period over which exposure occurs, and is used to calculate risks for non-cancer toxic effects. Lifetime Average Daily Exposure (LADE), used to calculate carcinogenic risks, takes into account the fact that while carcinogenic hazard values are determined with an assumption of lifetime exposure, actual exposure may be over a shorter period.

ADE = (Contaminant Concentration x Contact Rate) / Body weight

LADE = ADE x (Exposure Period in Years / Lifetime)

Contact Rate is the amount of the contaminated medium (water, air, food) with which a person comes into contact (generally a daily average) for the period of exposure (e.g. liters per day of water ingested, kilograms per day of food i sted, cubic meters per day of air inhaled). Both ADE and LADE are generally expressed in units of milligrams of the contaminant available for absorption, per kilogram of body weight, per day.

EXPOSURE SUMMARY - AVERAGE DAILY EXPOSURE (ADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL ADE	INHALATION ADE	DERMAL ADE
Groundwater - Ingestion of Drinking Water				
71-43-2 BENZENE	4.9e+001	1.4e-003		
100-41-4 ETHYLBENZENE	1.9e+001	5.4e-004		
108-88-3 TOLUENE	8.0e+001	2.3e-003		
100-42-5 STYRENE	8.9e+000	2.5e-004		
78-93-3 BUTANONE	9.6e+001	2.7e-003		
1330-20-7 MIXED XYLENES	5.5e+001	1.6e-003		
208-96-8 ACENAPHTHYLENE	1.4e+001	4.0e-004		
.7-81-7 BIS(2-ETHYLHEXY	7.9e+000	2.3e-004		
86-73-7 FLUORENES	9.5e+000	2.7e-004		
91-20-3 NAPHTHALENE	1.1e+001	3.1e-004		
85-01-8 PHENANTHRENE	9.4e+000	2.7e-004		
98-95-3 NITROBENZENE	9.5e+000	2.7e-004		
105-67-9 2,4-DIMETHYLPHE	3.2e+003	9.2e-002		
108-95-2 PHENOL	1.4e+003	4.1e-002		
95-48-7 CRESOL, ORTHO	2.9e+003	8.2e-002		
106-44-5 CRESOL, PARA	5.4e+003	1.5e-001		
Groundwater - TOTAL				
71-43-2 BENZENE		1.4e-003	--------	
100-41-4 ETHYLBENZENE		5.4e-004	--------	
108-88-3 TOLUENE		2.3e-003	--------	
100-42-5 STYRENE		2.5e-004	--------	
78-93-3 BUTANONE		2.7e-003	--------	
1330-20-7 MIXED XYLENES		1.6e-003	--------	
208-96-8 ACENAPHTHYLENE		4.0e-004	--------	
117-81-7 BIS(2-ETHYLHEXY		2.3e-004	--------	
86-73-7 FLUORENES		2.7e-004	--------	
91-20-3 NAPHTHALENE		3.1e-004	--------	

Mean Groundwater

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

SITE: TarLake.SIT (filename)
Antrium, MI,

1.0 Approach
The procedures used by RISK*ASSISTANT to calculate exposures have been reviewed by the Office of Health and Environmental Assessment of the U.S. EPA. Default parameters for calculating exposures have been extracted from EPA's EXPOSURE FACTORS HANDBOOK (EPA/600/8-89/043; March 1989).

The user of this software should confirm the reliability and appropriateness of environmental concentration data used as a starting point for the exposure calculations, and should indicate the rationale for making changes to EPA-supplied default values for exposure parameters.

2.0 Sample Data
RISK*ASSISTANT offers the user a variety of ways to aggregate sample data for use in its analyses. The user may select a single sample in an environmental medium (GROUNDWATER, SURFACE WATER, AIR, SOIL, SEDIMENT, or BIOTA), or may calculate the MAXIMUM, ARITHMETIC MEAN, or GEOMETRIC MEAN of either a SUBSET of the samples in a medium or of ALL SAMPLES in that medium. When calculating mean concentrations, NON-DETECTS can either be IGNORED (equivalent to setting non-detects at the average value for samples with measured values) set to ONE-HALF OF THE SAMPLE QUANTITATION LIMIT, or set to the SAMPLE QUANTITATION LIMIT. The aggregation method, as well as the actual sample data set entered into RISK*ASSISTANT for a site, will strongly influence the results of any subsequent analyses. The following table lists the media considered in this analysis, the aggregation technique applied for each medium, the sample set included in the aggregation, and the approach used to deal with chemicals that were only detected in some of the samples included in the aggregation.

MEDIUM	AGGREGATION STRATEGY	SAMPLE SET	TREATMENT OF NON-DETECTS
Groundwater	Single Sample		

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION	(UNITS)
Groundwater			
71-43-2	BENZENE	49.200	(ug/l)
100-41-4	ETHYLBENZENE	18.950	(ug/l)
108-88-3	TOLUENE	80.050	(ug/l)
100-42-5	STYRENE	8.900	(ug/l)
78-93-3	BUTANONE	95.500	(ug/l)
1330-20-7	MIXED XYLENES	55.450	(ug/l)
208-96-8	ACENAPHTHYLENE	13.900	(ug/l)
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	7.900	(ug/l)
86-73-7	FLUORENES	9.500	(ug/l)
91-20-3	NAPHTHALENE	10.700	(ug/l)
85-01-8	PHENANTHRENE	9.400	(ug/l)
98-95-3	NITROBENZENE	9.500	(ug/l)
105-67-9	2,4-DIMETHYLPHENOL	3227.600	(ug/l)
108-95-2	PHENOL	1437.000	(ug/l)
95-48-7	CRESOL, ORTHO	2886.000	(ug/l)
106-44-5	CRESOL, PARA	5397.000	(ug/l)

6.0 References

.IRIS: Integrated Risk Information System.

.HEAST: Health Effects Assessment Summary Tables.

.Konz, J.; K. Lisi and E. Friebele. 1989. Exposure Factors Handbook. Us EPA, Office of Health and Environmental Assessment. Washington, D.C.

.EXPOSURE NAME:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>END OF REPORT<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

RISK CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

The exposure estimates used to calculate the risks presented in this assessment refer ONLY to the specific exposure pathways enumerated in the assessment, and depend upon the specific exposure parameters used for calculation. An exposure pathway combines contamination in an environmental medium, a scenario describing how a person contacts that medium, and a route of exposure (oral, inhalation, or dermal). An assessment that incorporates other pathways of exposure, or that does not incorporate all of the pathways described in this analysis, will yield different exposure values. Further, exposure and risk TOTALS for each medium involve the assumption that the same individual experiences ALL SCENARIOS corresponding to that medium.

Groundwater :

Ingestion of Drinking Water (Oral)
This includes oral exposures from domestic water used for drinking or cooking.

Exposure is defined as the CONTACT of an organism (humans in the case of health risk assessment) with a chemical or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of an agent available for absorption at the lungs, gut, or skin, not the amount absorbed.

Two different methods are used to calculate exposure. Average Daily Exposure (ADE) is an average exposure computed for the period over which exposure occurs, and is used to calculate risks for non-cancer toxic effects. Lifetime Average Daily Exposure (LADE), used to calculate carcinogenic risks, takes into account the fact that while carcinogenic hazard values are determined with an assumption of lifetime exposure, actual exposure may be over a shorter period.

ADE = (Contaminant Concentration x Contact Rate) / Body weight

LADE = ADE x (Exposure Period in Years / Lifetime)

Contact Rate is the amount of the contaminated medium (water, air, food) with which a person comes into contact (generally a daily average) for the period of exposure (e.g. liters per day of water ingested, kilograms per day of food ingested, cubic meters per day of air inhaled). Both ADE and LADE are generally expressed in units of milligrams of the contaminant available for absorption, per kilogram of body weight, per day.

4.0 Uncertainties

Because risk values incorporate all of the estimates, default values, and assumptions used throughout risk assessment, the values presented in these tables must be understood in terms of key uncertainties regarding both the toxic hazard and the exposure estimates used to derive them.

The potency (slope factor) of a known or suspected human carcinogen is generally derived from a linearized multistage model of carcinogenesis. Such a model assumes that any non-zero exposure to a carcinogen is associated with a finite probability of cancer, and that at low doses, the relationship between exposure and probability of cancer can be approximated by a straight line. Accordingly, the potency of a carcinogen can be expressed as the slope of this straight line. Slope factors are expressed as inverse exposures (1/(mg/kg/d)).

Reference doses derive from the assumption that all non-cancer toxic effects have some threshold. That is, up to some finite level of exposure, physiological defense mechanisms ensure that no toxic effect will occur. Accordingly, hazard assessment for non-carcinogenic effects involve estimating an exposure that is less than this threshold level. This is done by applying "uncertainty factors" to exposures that appear to be near this threshold in laboratory toxicology studies. Reference doses are expressed as exposures (mg/kg/d).

Where available, cancer potencies and reference doses have been obtained from the Integrated Risk Information System (IRIS). All values in IRIS have been reviewed and accepted for Agency-wide use by EPA. For chemicals not included in IRIS, toxicity data were extracted from the Health Effects Assessment Summary Tables (HEAST), distributed quarterly by the Office of Emergency and Remedial Response. These values, and risk estimates derived from them, are marked by an asterisk(*).

For a very limited set of chemicals, carcinogenic slope factors and/or reference doses may be estimated from epidemiologic data collected in humans. Most slope factors and RfDs, however, are derived from experimental studies in animals. Such extrapolations are based on the assumptions that 1) the physiological and biochemical responses of exposed persons will be qualitatively (but not necessarily quantitatively) the same as that seen in the experimental animals, 2) effects seen at high doses in a limited number of animals over a comparatively brief period of observation are predictive of toxicity at lower doses, if a sufficiently large group is exposed for a sufficiently long period. For some chemicals, hazard values may also have been extrapolated across differing routes of exposure. This introduces additional uncertainty to these estimates.

The slope (potency) factors for cancer risks are estimated as the 95th percentile confidence limits using the linearized multistage model. As such, they are conservative estimates of toxic hazard. Risks estimated by combining these hazard values with exposure estimates are commonly referred to as upper-bound risks, but because exposure estimates may not represent upper-bound estimates, risk estimates are not true upper-bound risks.

RISK CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

For agents that cause non-cancer toxic effects, a Hazard Index (H.I.) is calculated, which compares the expected exposure to the agent to an exposure (the Reference Dose, or RfD) that is assumed not to be associated with toxic effects.

H.I. = Average Daily Exposure / Reference Dose

Hazard Indices of < 1.0 are generally considered by EPA to be associated with low risks on non-cancer toxic effects.

RISK SUMMARY FOR ALL SCENARIOS - NON-CANCER TOXIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION UNITS:SEE NOTE	ADE (mg/kg/d)	RfD* (mg/kg/d)	HI
Groundwater - Ingestion of Drinking Water					
71-43-2	BENZENE	1.2e+002	3.3e-003	--------	------
100-41-4	ETHYLBENZENE	3.8e+001	1.1e-003	1.0e-001	1e-002
3-88-3	TOLUENE	1.8e+002	5.1e-003	3.0e-001	2e-002
78-93-3	BUTANONE	4.9e+002	1.4e-002	5.0e-002	3e-001
1330-20-7	MIXED XYLENES	1.2e+002	3.4e-003	2.0e+000	2e-003
208-96-8	ACENAPHTHYLENE	2.0e+001	5.7e-004	4.0E-002	1E-002
117-81-7	BIS(2-ETHYLHEX	9.6e+000	2.7e-004	2.0e-002	1e-002
86-73-7	FLUORENES	1.0e+001	2.9e-004	4.0E-002	7E-003
91-20-3	NAPHTHALENE	1.2e+002 + METHYL-NAPHTHALENE	3.5e-003	4.0e-001*	9e-001
85-01-8	PHENANTHRENE	1.0e+001	2.9e-004	4.0E-002	7E-003
105-67-9	2,4-DIMETHYLPH	7.7e+003	2.2e-001	2.0E-002	1.1E+001
108-95-2	PHENOL	3.6e+003	1.0e-001	6.0e-001	2e-001
95-48-7	CRESOL, ORTHO	7.3e+003	2.1e-001	5.0e-002	4e+000
106-44-5	CRESOL, PARA	1.3e+004	3.7e-001	5.0e-002	7e+000
98-95-3	NITROBENZENE	1.0e+001	2.9e-004	5.0e-004	6e-001
108-10-1	METHYL ISOBUTY	2.7e+001	7.7e-004	5.0e-002	2e-002

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

TOTAL HAZARD INDEX for PATHWAY 24.1

IR DATABASE Update: 03/15/90
HEAST DATABASE Update: 03/15/90
EXPOSURE NAME:

LADE = Lifetime Average Daily Exposure
ADE = Average Daily Exposure (during exposure period)

SLOPE FACTOR = Cancer Potency (Slope of the Dose-Response Function)
W.O.E. CLASS = Weight of evidence for HUMAN carcinogenicity
A = Known human carcinogen.
B1 = Probable human carcinogen, limited human data.
B2 = Probable human carcinogen, inadequate or no human data.
C = Possible human carcinogen.
D = Not classifiable as human carcinogen.
E = Evidence that not carcinogenic in humans.
RISK = Lifetime probability of getting cancer from this exposure.

RfD = Reference Dose (daily exposure NOT causing toxicity)
H.I. = HAZARD INDEX (Ratio of ADE to RfD (ADE/RfD))

RISK CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION	(UNITS)
Groundwater			
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	9.600	(ug/l)
86-73-7	FLUORENES	10.300	(ug/l)
91-20-3	NAPHTHALENE	121.200	(ug/l)
85-01-8	PHENANTHRENE	10.300	(ug/l)
105-67-9	2,4-DIMETHYLPHENOL	7735.500	(ug/l)
108-95-2	PHENOL	3622.500	(ug/l)
95-48-7	CRESOL, ORTHO	7255.500	(ug/l)
106-44-5	CRESOL, PARA	13019.000	(ug/l)
98-95-3	NITROBENZENE	10.300	(ug/l)
108-10-1	METHYL ISOBUTYL KETONE	27.100	(ug/l)

3.0 Risk Estimates

Two different approaches are used in the calculation of toxic chemical risks. For agents that may cause cancer (carcinogens), an actual risk estimate (i.e. a I bability value that is a function of potency and exposure) is calculated:

$$\text{Risk} = 1 - e^{-(\text{Slope Factor} * \text{Lifetime Average Daily Exposure})}$$

The calculated risk estimates for carcinogens represent the theoretical excess cancer risk (i.e. risk over background cancer incidence) that a person exposed to an agent under the specified conditions will develop cancer. For example, if the calculated risk is 1 e-6, this would literally suggest that an individual exposed to the agent will have a one-in-a-million chance of getting cancer because of the exposure, in addition to her/his chance of getting cancer from other causes. However, in view of the large uncertainties associated with such risk estimates, they should always be interpreted as general indicators, rather than precise estimates. The U.S. Environmental Protection Agency (EPA) generally considers risks below 1 e-6 to be low.

F K SUMMARY FOR ALL SCENARIOS - CARCINOGENIC RISKS

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION UNITS:SEE NOTE	W.O.E. CLASS	LADE (mg/kg/d)	SLOPE FACT.* (1/(mg/kg/d))	RISK
Groundwater - Ingestion of Drinking Water						
71-43-2	BENZENE	1.2e+002	A	1.4e-003	2.9e-002	4e-005
100-41-4	ETHYLBENZENE	3.8e+001	D	4.6e-004	--------	------
108-88-3	TOLUENE	1.8e+002	D	2.2e-003	--------	------
78-93-3	BUTANONE	4.9e+002		6.0e-003	--------	------
1330-20-7	MIXED XYLENES	1.2e+002	D	1.4e-003	--------	------
208-96-8	ACENAPHTHYLENE	2.0e+001		2.4e-004	--------	------
117-81-7	BIS(2-ETHYLHEX	9.6e+000	B2	1.2e-004	1.4e-002	2e-006
86-73-7	FLUORENES	1.0e+001	D	1.3e-004	--------	------
91-20-3	NAPHTHALENE	1.2e+002		1.5e-003	--------	------
85-01-8	PHENANTHRENE	1.0e+001		1.3e-004	--------	------
105-67-9	2,4-DIMETHYLPH	7.7e+003		9.5e-002	--------	------
108-95-2	PHENOL	3.6e+003		4.4e-002	--------	------
95-48-7	CRESOL, ORTHO	7.3e+003		8.9e-002	--------	------
106-44-5	CRESOL, PARA	1.3e+004		1.6e-001	--------	------
98-95-3	NITROBENZENE	1.0e+001		1.3e-004	--------	------
108-10-1	METHYL ISOBUTY	2.7e+001		3.3e-004	--------	------

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

100-42-5 STYRENE 1.8E+001 B2 2.2E-004 3.0E-002 6E-006

TOTAL CANCER RISK FOR GW | 4E-005

95% UCL Groundwater

RISK CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

SITE: TarLake.SIT (filename)
Antrium, MI,

1.0 Approach

The procedures used by RISK*ASSISTANT to calculate exposures and risks have been reviewed by the Office of Health and Environmental Assessment of the U.S. EPA. Default parameters for calculating exposures have been extracted from EPA's EXPOSURE FACTORS HANDBOOK (EPA/600/8-89/043; March 1989). Where available, cancer potencies and reference doses were obtained from the Integrated Risk Information System (IRIS). All values in IRIS have been reviewed and accepted for Agency-wide use by EPA. For chemicals not included in IRIS, toxicity data were extracted from the Health Effects Assessment Summary Tables (HEAST), distributed quarterly by the Office of Emergency and Remedial Response.

The user of this software should confirm the reliability and appropriateness of environmental concentration data used as a starting point for the exposure calculations, and should indicate the rationale for making changes to EPA-supplied default values for exposure parameters.

The toxic hazard data used to prepare this report were current as of the date supplied for the database. However, these values may have been modified since the update of the database. Users are urged to consult IRIS and the latest HEAST tables directly.

2.0 Sample Data

RISK*ASSISTANT offers the user a variety of ways to aggregate sample data for use in its analyses. The user may select a single sample in an environmental medium (GROUNDWATER, SURFACE WATER, AIR, SOIL, SEDIMENT, or BIOTA), or may calculate the MAXIMUM, ARITHMETIC MEAN, or GEOMETRIC MEAN of either a SUBSET of the samples in a medium or of ALL SAMPLES in that medium. When calculating mean concentrations, NON-DETECTS can either be IGNORED (equivalent to setting non-detects at the average value for samples with measured values) set to ONE-HALF OF THE SAMPLE QUANTITATION LIMIT, or set to the SAMPLE QUANTITATION LIMIT. The aggregation method, as well as the actual sample data set entered into RISK*ASSISTANT for a site, will strongly influence the results of any subsequent analyses. The following table lists the media considered in this analysis, the aggregation technique applied for each medium, the sample set included in the aggregation, and the approach used to deal with chemicals that were only detected in some of the samples included in the aggregation.

MEDIUM	AGGREGATION STRATEGY	SAMPLE SET	TREATMENT OF NON-DETECTS
Groundwater	Single Sample		

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION	(UNITS)
Groundwater			
71-43-2	BENZENE	115.700	(ug/l)
100-41-4	ETHYLBENZENE	37.700	(ug/l)
108-88-3	TOLUENE	177.100	(ug/l)
78-93-3	BUTANONE	492.000	(ug/l)
1330-20-7	MIXED XYLENES	117.400	(ug/l)
208-96-8	ACENAPHTHYLENE	20.000	(ug/l)
100-42-5	STYRENE	18.300	(ug/l)

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

Oral Exposure

Ingestion of Drinking Water - Alternative Parameter Values

Parameter (units)	User Value	Average Value	(Percent of User)	Reasonable Worst-Case	(Percent of User)
Conatam. Fraction	1.00	0.75	75.0	1.00	100.0

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values

Inhalation Exposure

THESE ARE THE NOTES, IF ANY ENTERED BY THE USER DURING THIS ANALYSIS

None

6.0 References

. Konz, J.; K. Lisi and E. Friebele. 1989. Exposure Factors Handbook. Us EPA, Office of Health and Environmental Assessment. Washington, D.C.

. EXPOSURE NAME:

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>END OF REPORT<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

The uncertainty analyses provided as an option by RISK*ASSISTANT can illustrate the differences between your calculated exposures and exposures calculated using standard (average or reasonable worst-case) numerical parameter values for each scenario you have selected. They can also provide information on the way in which your selection of exposure scenarios influences the exposure estimates you have calculated. Because chemical concentrations will vary across space and time, and peoples activities that result in exposure are also highly variable, the actual range of possible exposures for your site is greater than the range covered by RISK*ASSISTANT's uncertainty analyses.

5.1 Uncertainties Regarding Exposure Parameters
One estimate of the uncertainty associated with the exposure estimates presented above is provided by an examination of the ways in which using alternative values for numerical exposure parameters can change the resulting exposure values. The following table presents alternative exposure predictions (ADEs and LADEs) for each chemical, when exposure is calculated using 1) Average default values for all exposure parameters, and 2) Reasonable Worst-Case values for all parameters. In each case, the resulting ADE or LADE is presented as a percentage of the corresponding ADE or LADE calculated using user-specified parameter values. These values indicate the range of exposures that might be expected to occur for each scenario, and the position of the exposure calculated by the user within (or possibly outside of) this range. Following this table are additional tables that present, for each scenario, these alternative parameter values, both in absolute units and as a percentage of the parameter values actually used.

Oral Exposures
RELATIVE CONTRIBUTION OF SCENARIOS AND MEDIA TO ROUTE SPECIFIC EXPOSURES(%)

MEDIA/SCENARIOS	ADE (% of user-specified)		LADE (% of user specified)	
	Average	Worst-Case	Average	Worst-Case
Groundwater				
Drinking Water	52.50	100.00	15.75	100.00
ALL SCENARIOS	52.50	100.00	15.75	100.00

Inhalation Exposures
RELATIVE CONTRIBUTION OF SCENARIOS AND MEDIA TO ROUTE SPECIFIC EXPOSURES(%)

MEDIA/SCENARIOS	ADE (% of user-specified)		LADE (% of user specified)	
	Average	Worst-Case	Average	Worst-Case

Alternative Exposure Parameters: Actual Values and Values Expressed as a Percentage of User-specified Values
Oral Exposure

Ingestion of Drinking Water - Alternative Parameter Values

Parameter (units)	User Value	Average Value	(Percent of User)	Reasonable Worst-Case	(Percent of User)
Body Weight (kg)	70.00	70.00	100.0	70.00	100.0
Event Freq. (events/y)	365.00	365.00	100.0	365.00	100.0
Exposure Duration (y)	30.00	9.00	30.0	30.00	100.0
Lifetime (y)	70.00	70.00	100.0	70.00	100.0
Consum. Rate(units/event)	2.00	1.40	70.0	2.00	100.0

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

It is important to remember that the calculated exposure values refer ONLY to the specific exposure pathways enumerated in this assessment. An exposure pathway combines contamination in an environmental medium, a scenario describing how a person contacts that medium, and a route of exposure (oral, inhalation, or dermal). An assessment that incorporates other pathways of exposure, or that does not incorporate all of the pathways described in this analysis, will yield different exposure values. The following list indicates the pathways considered in this assessment:

Groundwater:

Ingestion of Drinking Water (Oral)
This includes oral exposures from domestic water used for drinking or cooking.

3.0 Parameters
The exposure values presented above reflect not only the concentrations of contaminants in various environmental media and the exposure pathways selected for analysis, but also the specific numerical parameters applied to each e sure scenario. Some scenarios also incorporate cross-media transfer equations (such as for the volatilization of contaminants from shower water into bathroom air) that must be considered in reviewing the results of exposure calculations. The following tables summarize the exposure parameters and transfer equations used in this assessment.

Exposure Parameters Used to Generate Exposure Estimates

ORAL SCENARIOS	CONSUMPT RATE(units/event)	CONTAMIN FRAC	EVENT FREQ (event/y)	EXPOSURE PERIOD(y)	WEIGHT (kg)	LIFE-TIME(y)
Drinking Water	2.00	1.00	365	30	70	70

5.0 Uncertainties
To understand the meaning of the quantitative exposure estimates presented above, it is necessary to consider the key assumptions used in deriving them, and the uncertainties associated with those assumptions:

A key assumption is that the concentrations specified for various environmental media represent the true concentrations to which people will be exposed during the period of exposure. Actual contaminant concentrations will likely vary across both time and space.

- The selection of exposure scenarios will also have a significant influence on predicted exposures. Actual exposures to members of any specified population will vary in accordance with the degree to which they participate in the activities described by the exposure scenarios.

- Similarly, the numerical parameter values applied to each exposure scenario will have a marked effect on exposure. The default values provided are estimates for the entire U.S. population. Various demographic factors (including geographic region, rural or urban setting, socioeconomic status and ethnic heritage) may call for significant alterations in these values.

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM   PREPARED: 4/2/91

EXPOSURE SUMMARY - AVERAGE DAILY EXPOSURE (ADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL ADE	INHALATION ADE	DERMAL ADE
Groundwater - TOTAL				
105-67-9 2,4-DIMETHYLPHE		2.2e-001	--------	
108-95-2 PHENOL		1.0e-001	--------	
95-48-7 CRESOL, ORTHO		2.1e-001	--------	
106-44-5 CRESOL, PARA		3.7e-001	--------	
98-95-3 NITROBENZENE		2.9e-004	--------	
108-10-1 METHYL ISOBUTYL		7.7e-004	--------	

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

EXPOSURE SUMMARY - LIFETIME AVERAGE DAILY EXPOSURE (LADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)	CONCENTRATION units:see note below	ORAL LADE	INHALATION LADE	DERMAL LADE
100-42-5 STYRENE	1.8e+001	2.2e-004		
G[illegible]undwater - Ingestion of Drinking Water				
71-43-2 BENZENE	1.2e+002	1.4e-003		
100-41-4 ETHYLBENZENE	3.8e+001	4.6e-004		
108-88-3 TOLUENE	1.8e+002	2.2e-003		
78-93-3 BUTANONE	4.9e+002	6.0e-003		
1330-20-7 MIXED XYLENES	1.2e+002	1.4e-003		
208-96-8 ACENAPHTHYLENE	2.0e+001	2.4e-004		
117-81-7 BIS(2-ETHYLHEXY	9.6e+000	1.2e-004		
86-73-7 FLUORENES	1.0e+001	1.3e-004		
91-20-3 NAPHTHALENE	1.2e+002	1.5e-003		
85-01-8 PHENANTHRENE	1.0e+001	1.3e-004		
105-67-9 2,4-DIMETHYLPHE	7.7e+003	9.5e-002		
108-95-2 PHENOL	3.6e+003	4.4e-002		
95-48-7 CRESOL, ORTHO	7.3e+003	8.9e-002		
106-44-5 CRESOL, PARA	1.3e+004	1.6e-001		
98-95-3 NITROBENZENE	1.0e+001	1.3e-004		
108-10-1 METHYL ISOBUTYL	2.7e+001	3.3e-004		
G[illegible]ndwater - TOTAL				
71-43-2 BENZENE		1.4e-003	--------	
100-41-4 ETHYLBENZENE		4.6e-004	--------	
108-88-3 TOLUENE		2.2e-003	--------	
78-93-3 BUTANONE		6.0e-003	--------	
1330-20-7 MIXED XYLENES		1.4e-003	--------	
208-96-8 ACENAPHTHYLENE		2.4e-004	--------	
117-81-7 BIS(2-ETHYLHEXY		1.2e-004	--------	
86-73-7 FLUORENES		1.3e-004	--------	
91-20-3 NAPHTHALENE		1.5e-003	--------	
85-01-8 PHENANTHRENE		1.3e-004	--------	
105-67-9 2,4-DIMETHYLPHE		9.5e-002	--------	
108-95-2 PHENOL		4.4e-002	--------	
95-48-7 CRESOL, ORTHO		8.9e-002	--------	
106-44-5 CRESOL, PARA		1.6e-001	--------	
98-95-3 NITROBENZENE		1.3e-004	--------	
108-10-1 METHYL ISOBUTYL		3.3e-004	--------	

NOTE: water:ug/l; air: ug/cu m; soil,sediment & biota:ug/kg.'*' indicates HEAST.
Cl: indicates conc. in leaf; Cr: indicates conc. in root.

100-42-5 STYRENE   2.2e-004

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

Exposure is defined as the CONTACT of an organism (humans in the case of health risk assessment) with a chemical or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of an agent available for absorption at the lungs, gut, or skin, not the amount absorbed.

Two different methods are used to calculate exposure. Average Daily Exposure (ADE) is an average exposure computed for the period over which exposure occurs, and is used to calculate risks for non-cancer toxic effects. Lifetime Average Daily Exposure (LADE), used to calculate carcinogenic risks, takes into account the fact that while carcinogenic hazard values are determined with an assumption of lifetime exposure, actual exposure may be over a shorter period.

ADE = (Contaminant Concentration x Contact Rate) / Body weight

LADE = ADE x (Exposure Period in Years / Lifetime)

Contact Rate is the amount of the contaminated medium (water, air, food) with which a person comes into contact (generally a daily average) for the period of exposure (e.g. liters per day of water ingested, kilograms per day of food ingested, cubic meters per day of air inhaled). Both ADE and LADE are generally expressed in units of milligrams of the contaminant available for absorption, per kilogram of body weight, per day.

EXPOSURE SUMMARY - AVERAGE DAILY EXPOSURE (ADE) IN mg/kg/d

MEDIUM/SCENARIO CHEMICAL(S)		CONCENTRATION units:see note below	ORAL ADE	INHALATION ADE	DERMAL ADE
Groundwater - Ingestion of Drinking Water					
71-43-2	BENZENE	1.2e+002	3.3e-003		
100-41-4	ETHYLBENZENE	3.8e+001	1.1e-003		
108-88-3	TOLUENE	1.8e+002	5.1e-003		
78-93-3	BUTANONE	4.9e+002	1.4e-002		
1330-20-7	MIXED XYLENES	1.2e+002	3.4e-003		
208-96-8	ACENAPHTHYLENE	2.0e+001	5.7e-004		
117-81-7	BIS(2-ETHYLHEXY	9.6e+000	2.7e-004		
86-73-7	FLUORENES	1.0e+001	2.9e-004		
91-20-3	NAPHTHALENE	1.2e+002	3.5e-003		
85-01-8	PHENANTHRENE	1.0e+001	2.9e-004		
105-67-9	2,4-DIMETHYLPHE	7.7e+003	2.2e-001		
108-95-2	PHENOL	3.6e+003	1.0e-001		
95-48-7	CRESOL, ORTHO	7.3e+003	2.1e-001		
106-44-5	CRESOL, PARA	1.3e+004	3.7e-001		
98-95-3	NITROBENZENE	1.0e+001	2.9e-004		
108-10-1	METHYL ISOBUTYL	2.7e+001	7.7e-004		
Groundwater - TOTAL					
71-43-2	BENZENE		3.3e-003	--------	
100-41-4	ETHYLBENZENE		1.1e-003	--------	
108-88-3	TOLUENE		5.1e-003	--------	
78-93-3	BUTANONE		1.4e-002	--------	
1330-20-7	MIXED XYLENES		3.4e-003	--------	
208-96-8	ACENAPHTHYLENE		5.7e-004	--------	
117-81-7	BIS(2-ETHYLHEXY		2.7e-004	--------	
86-73-7	FLUORENES		2.9e-004	--------	
91-20-3	NAPHTHALENE		3.5e-003	--------	
85-01-8	PHENANTHRENE		2.9e-004	--------	
100-42-5	STYRENE		5.0e-004		

95% UCL Groundwater

EXPOSURE CALCULATIONS FOR Tar Lake T. Poy RPM PREPARED: 4/2/91

SITE: TarLake.SIT (filename)
Antrium, MI,

1.0 Approach

The procedures used by RISK*ASSISTANT to calculate exposures have been reviewed by the Office of Health and Environmental Assessment of the U.S. EPA. Default parameters for calculating exposures have been extracted from EPA'S EXPOSURE FACTORS HANDBOOK (EPA/600/8-89/043; March 1989).

The user of this software should confirm the reliability and appropriateness of environmental concentration data used as a starting point for the exposure calculations, and should indicate the rationale for making changes to EPA-supplied default values for exposure parameters.

2.0 Sample Data

RISK*ASSISTANT offers the user a variety of ways to aggregate sample data for use in its analyses. The user may select a single sample in an environmental medium (GROUNDWATER, SURFACE WATER, AIR, SOIL, SEDIMENT, or BIOTA), or may calculate the MAXIMUM, ARITHMETIC MEAN, or GEOMETRIC MEAN of either a SUBSET of the samples in a medium or of ALL SAMPLES in that medium. When calculating mean concentrations, NON-DETECTS can either be IGNORED (equivalent to setting non-detects at the average value for samples with measured values) set to ONE-HALF OF THE SAMPLE QUANTITATION LIMIT, or set to the SAMPLE QUANTITATION LIMIT. The aggregation method, as well as the actual sample data set entered into RISK*ASSISTANT for a site, will strongly influence the results of any subsequent analyses. The following table lists the media considered in this analysis, the aggregation technique applied for each medium, the sample set included in the aggregation, and the approach used to deal with chemicals that were only detected in some of the samples included in the aggregation.

MEDIUM	AGGREGATION STRATEGY	SAMPLE SET	TREATMENT OF NON-DETECTS
Groundwater	Single Sample		

CONCENTRATION OF CHEMICALS IN ENVIRONMENTAL MEDIA COVERED BY THIS ANALYSIS

MEDIUM	CHEMICAL NAME	CONCENTRATION	(UNITS)
Groundwater			
71-43-2	BENZENE	115.700	(ug/l)
100-41-4	ETHYLBENZENE	37.700	(ug/l)
108-88-3	TOLUENE	177.100	(ug/l)
78-93-3	BUTANONE	492.000	(ug/l)
1330-20-7	MIXED XYLENES	117.400	(ug/l)
208-96-8	ACENAPHTHYLENE	20.000	(ug/l)
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	9.600	(ug/l)
86-73-7	FLUORENES	10.300	(ug/l)
91-20-3	NAPHTHALENE	121.200	(ug/l)
85-01-8	PHENANTHRENE	10.300	(ug/l)
105-67-9	2,4-DIMETHYLPHENOL	7735.500	(ug/l)
108-95-2	PHENOL	3622.500	(ug/l)
95-48-7	CRESOL, ORTHO	7255.500	(ug/l)
106-44-5	CRESOL, PARA	13019.000	(ug/l)
98-95-3	NITROBENZENE	10.300	(ug/l)
108-10-1	METHYL ISOBUTYL KETONE	27.100	(ug/l)
100-42-5	STYRENE	18.300	(ug/l)

TABLE 2

Compounds Known or Presumed to be Present in Tar

Compound	Tar Concentration (mg/kg)
benzene	12
ethylbenzene	100
toluene	100
styrene	23
2-butanone	5
2-hexanone	11
4-methyl-2-pentanone	12
xylenes (total)	280
acenaphthene	280
acenaphthylene	280
anthracene	280
benzo(a)anthracene	280
benzo(b)fluoranthene	280
benzo(k)fluoranthene	280
bis(2-ethylhexyl)phthalate	280
chrysene	280
di-n-butyl phthalate	280
fluoranthene	280
fluorene	100
naphthalene	340
phenanthrene	280
pyrene	280
dibenzofuran	51
2-methylnaphthalene	560
2,4-dimethylphenol	2000
phenol	330
2-methylphenol	1100
4-methylphenol	1400

Adapted from: Table B4a, Phased Feasiblity Study for Tar Lake
Gradient Corporation, Febuary 12, 1991.

TABLE 1

Compounds Detected in On-Site Groundwater

MEAN CONCENTRATIONS 95th PERCENTILE OF THE MEAN CONCENTRATIONS

Compounds Detected in On-Site Groundwater	Mean concentration (ug/l)	95th percentile of the mean concentration (ug/l)
benzene	49.2	115.7
ethylbenzene	18.95	37.7
toluene	80.05	177.1
styrene	8.9	18.3
2-butanone	195.5	492
2-hexanone	95.5	237.2
4-methyl-2-pentanone	13.6	27.1
xylenes	55.45	117.4
acenaphthylene	13.9	20
bis(2-ethylhexyl)phthalate	7.9	9.6
fluorene	9.5	10.3
naphthalene	10.7	15.7
phenanthrene	9.4	10.3
dibenzofuran	9.4	10.3
2-methylnaphthalene	47.7	105.5
2,4-dimethylphenol	3228	7736
phenol	1437	3622.5
2-methylphenol	2886	7255.6
4-methylphenol	5397	13019
nitrobenzene	9.5	10.3

Adapted from Table B2a, Phased Feasibility Study, Tar Lake Superfund Site
Gradient Corporation, Febuary 12, 1991.

References

Schmahl, D. 1955. Testing of naphthalene and anthracene as carcinogenic agents in the rat. Krebsforsch. 60: 697-710 (Ger.)

U.S. EPA. 1988. 13-week mouse oral subchronic toxicity study. Prepared by Toxicity Research Laboratories, LTD., Muskegon, MI for the Office of Solid Waste, Washington, DC.

U.S. EPA. 1989a. Mouse oral subchronic study with acenapthene. Study conducted by Hazelton Laboratories, Inc., for the Office of Solid Waste, Washington, DC.

U.S. EPA. 1989b. Subchronic toxicity study in mice with anthracene. Conducted by Hazelton Laboratories, Inc., for the Office of Solid Waste, Washington, DC.

U.S. EPA. 1989c. 13-week mouse oral subchronic toxicity study. Prepared by Toxicity Research Laboratories, LTD., Muskegon, MI for Office of Solid Waste, Washington, DC.

U.S. EPA. 1989d. Mouse oral subchronic toxicity with pyrene. Study conducted by Toxicity Research Laboratories, LTD., Muskegon, MI for the Office of Solid, Washington, DC.

TABLE 1

Oral RfDs for PAHs

Compound/ Status	Exposure	Species	Critical Effect	Uncertainty Factor	Modifying Factor	Reference Dose	Reference
Acenapthene / Verified (11/15/89)							
	175 mg/kg/day daily by gavage for 90 days (NOAEL); 350 mg/kg/day (LOAEL)	Mouse	Hepatotoxicity	3000	1	6E-2 mg/kg/day	U.S. EPA, 1989a
Anthracene / Verified (11/15/89)							
	1000 mg/kg/day daily by gavage for 90 days (NOEL)(HDT)	Mouse	No effects	3000	1	3E-1 mg/kg/day	U.S. EPA, 1989b
Fluoranthene / Verified (11/15/89)							
	125 mg/kg/day daily by gavage via corn oil for 13 weeks (NOAEL); 250 mg/kg/day (LOAEL)	Mouse	Nephropathy, increased relative liver weights, hematological and clinical effects	3000	1	4E-2 mg/kg/day	U.S. EPA, 1988
Fluorene / Verified (11/15/89)							
	Gavaged via corn oil 125 mg/kg/day for 13 weeks (NOAEL); 250 mg/kg/day (LOAEL)	Mouse	Decreased RBC, packed cell volume and hemoglobin	3000	1	4E-2 mg/kg/day	U.S. EPA, 1989c
Napthalene							
	10-20 mg/day in diet for 6 days/week for approximately 700 days (41 mg/kg/day)	Rat	Ocular and internal lesions	10000	1	4E-3 mg/kg/day	U.S. EPA, 1988/ Schmahl, 1955

TABLE 1 (cont.)

Oral RfDs for PAHs

Compound/ Status	Exposure	Species	Critical Effect	Uncertainty Factor	Modifying Factor	Reference Dose	Reference
Pyrene / Verified (11/15/89)							
	75 mg/kg/day by gavage via corn oil for 13 weeks (NOAEL)	Mouse	Nephropathy and decreased kidney weight	3000	1	3E-2 mg/kg/day	U.S. EPA, 1989d

HDT = Highest Dose Tested

Benzene; CASRN 71-43-2 (01/01/91)

Health risk assessment information on a chemical is included in IRIS only after a comprehensive review of chronic toxicity data by work groups composed of U.S. EPA scientists f

rom several Program Offices. The summaries presented in Sections I and II represent a consensus reached in the review process. The other sections contain U.S. EPA information which is specific to a particular EPA program and has been subject to review procedures prescribed by that Program Office. The regulatory actions in Section IV may not be based on the ɔst current risk assessment, or may be based on a current, but unreviewed, ɹisk assessment, and may take into account factors other than health effects (e.g., treatment technology). When considering the use of regulatory action data for a particular situation, note the date of the regulatory action, the date of the most recent risk assessment relating to that action, and whether

More?...(Yes or No) --technological factors were considered. Background informa ations of the methods used to derive the values given in IRIS are provided in the five Background Documents in Service Code 5, which correspond to Sections I through V of the chemical files.

STATUS OF DATA FOR Benzene

File On-Line 03/01/88

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	pending	
Inhalation RfC Assessment (I.B.)	pending	
Carcinogenicity Assessment (II.)	on-line	01/01/91

More?...(Yes or No) --Drinking Water Health Advisories (III.A.) on-line

U.S. EPA Regulatory Actions (IV.)	on-line	08/01/90
Supplementary Data (V.)	no data	

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_I. CHRONIC HEALTH HAZARD ASSESSMENTS FOR NONCARCINOGENIC EFFECTS

__I.A. REFERENCE DOSE FOR CHRONIC ORAL EXPOSURE (RfD)

Substance Name -- Benzene
CASRN -- 71-43-2

More?...(Yes or No) --A risk assessment for this substance/agent will be reviewe
group.

__I.B. REFERENCE CONCENTRATION FOR CHRONIC INHALATION EXPOSURE (RfC)

Substance Name -- Benzene
CASRN -- 71-43-2

A risk assessment for this substance/agent is under review by an EPA work
'oup.

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More?...(Yes or No) --
_II. CARCINOGENICITY ASSESSMENT FOR LIFETIME EXPOSURE

Substance Name -- Benzene
CASRN -- 71-43-2
Last Revised -- 01/01/91

Section II provides information on three aspects of the carcinogenic risk assessment for the agent in question; the U.S. EPA classification, and quantitative estimates of risk from oral exposure and from inhalation exposure. e classification reflects a weight-of-evidence judgment of the likelihood ʟat the agent is a human carcinogen. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. Background Document 2

More?...(Yes or No) --(Service Code 5) provides details on the rationale and met the carcinogenicity values found in IRIS. Users are referred to Section I for information on long-term toxic effects other than carcinogenicity.

<<< Benzene >>>

__II.A. EVIDENCE FOR CLASSIFICATION AS TO HUMAN CARCINOGENICITY

___II.A.1. WEIGHT-OF-EVIDENCE CLASSIFICATION

Classification -- A; human carcinogen

Basis -- Several studies of increased incidence of nonlymphocytic leukemia from occupational exposure, increased incidence of neoplasia in rats and mice exposed by inhalation and gavage, and some supporting data form the basis for this classification.

<<< Benzene >>>

More?...(Yes or No) --
___II.A.2. HUMAN CARCINOGENICITY DATA

Aksoy et al. (1974) reported effects of benzene exposure among 28,500 Turkish workers employed in the shoe industry. Mean duration of employment was 9.7 years (1-15 year range) and mean age was 34.2 years. Peak exposure was reported to be 210-650 ppm. Twenty-six cases of leukemia and a total of 34 leukemias or preleukemias were observed, corresponding to an incidence of 13/100,000 (by comparison to 6/100,000 for the general population). A follow-up paper (Aksoy, 1980) reported eight additional cases of leukemia as well as evidence suggestive of increases in other malignancies.

In a retrospective cohort mortality study Infante et al. (1977a,b) examined leukemogenic effects of benzene exposure in 748 white males exposed while employed in the manufacturing of rubber products. Exposure occurred om 1940-1949, and vital statistics were obtained through 1975. A statistically significant increase (p less than or equal to 0.002) of leukemias was found by comparison to the general U.S. population. There was n evidence of solvent exposure other than benzene. Air concentrations were

More?...(Yes or No) --generally found to be below the recommended limits in effe period.

In a subsequent retrospective cohort mortality study Rinsky et al. (1981) observed seven deaths from leukemia among 748 workers exposed to benzene and followed for at least 24 years (17,020 person-years). This increased incidence was statistically significant; standard mortality ratio (SMR) was 560. For the five leukemia deaths that occurred among workers with more than 5 years exposure, the SMR was 2100. Exposures (which ranged from 10-100 ppm 8-hour TWA) were described as less than the recommended standards for the time period of 1941-1969.

In an updated version of the Rinsky et al. (1981) study, the authors followed the same cohort to 12/31/81 (Rinsky et al., 1987). An in his earlier study, cumulative exposure was derived from historic air-sampling data or interpolated estimates based on exisitng data. Standardized mortality rates ranged from 109 at cumulative benzene exposures under 40 ppm-years and increased montonically to 6637 (6 cases) at 400 ppm-years or more. The authors found significantly elevated risks of leukemia at cumulative exposures

More?...(Yes or No) --less than the equivalent current standard for occupational 10 ppm over a 40-year working lifetime.

Ott et al. (1978) observed three deaths from leukemia among 594 workers followed for at least 23 years in a retrospective cohort mortality study, but the increase was not statistically significant. Exposures ranged from <2 to >25 ppm 8-hour TWA.

Wong et al. (1983) reported on the mortality of male chemical workers who had been exposed to benzene for at least 6 months during the years 1946-1975. The study population of 4062 persons was drawn from seven chemical plants, and jobs were categorized as to peak exposure. Those with at least 3 days/week exposure (3036 subjects) were further categorizeed on the basis of an 8-hour TWA. The control subjects held jobs at the same plants for at least 6 months but were never subject to benzene exposure. Dose-dependent increases were seen in leukemia and lymphatic and hematopoietic cancer. The incidence of leukemia was responsible for the majority of the increase. It was noted that the significance of the increase is due largely to a less than expected incidence of neoplasia in the unexposed subjects.

More?...(Yes or No) --
Numerous other epidemiologic and case studies have reported an increased incidence or a causal relationship between leukemia and exposure to benzene (IARC, 1982).

<<< Benzene >>>

___II.A.3. ANIMAL CARCINOGENICITY DATA

Both gavage and inhalation exposure of rodents to benzene have resulted in development of neoplasia. Maltoni and Scarnato (1979) and Maltoni et al. (1983) administered benzene by gavage at dose levels of 0, 50, 250, and 500 mg/kg bw to 30-40 Sprague-Dawley rats/sex for life. Dose-related increased incidences of mammary tumors were seen in females and of Zymbal gland carcinomas, oral cavity carcinomas and leukemias/lymphomas in both sexes.

In an NTP (1986) study, benzene was administered by gavage doses of 0, 50, 100, or 200 mg/kg bw to 50 F344/N rats/sex or 0, 25, 50, or 100 mg/kg bw to 50 B6C3F1 mice/sex. Treatment was 5 times/week for 103 weeks. Significantly

More?...(Yes or No) --

increased incidences ($p<0.05$) of various neoplasic growths were seen in both sexes of both species. Both male and female rats and mice had increased incidence of carcinomas of the Zymbal gland. Male and female rats had oral cavity tumors, and males showed increased incidences of skin tumors. Mice of both sexes had increased incidence of lymphomas and lung tumors. Males were observed to have harderian and preputial gland tumors and females had tumors of mammary gland and ovary. In general, the increased incidence was dose-related.

Slightly increased incidences of hematopoietic neoplasms were reported for .le C57Bl mice exposed by inhalation to 300 ppm benzene 6 hours/day, 5 days/ week for 488 days. There was no increase in tumor incidence in male AKR or CD-1 mice similarly exposed to 100 ppm or 100 or 300 ppm benzene, respectively. Likewise male Sprague-Dawley rats exposed by inhalation to 300 ppm benzene were not observed to have increased incidence of neoplasia (Snyder et al., 1981).

Maltoni et al. (1983) treated male and female Sprague-Dawley rats in the following manner. Starting at 13 weeks of age rats were exposed to 200 ppm

More?...(Yes or No) --benzene 4 hours/day, 5 days/week for 7 weeks; 200 ppm 7 ho for 12 weeks; 300 ppm 7 hours/day, 5 days/week for 85 weeks. An 8-hour/day TWA for 5 days/week was calculated to be 241 ppm. A statistically significant increase was noted in hepatomas and carcinomas of the Zymbal gland.

<<< Benzene >>>

___II.A.4. SUPPORTING DATA FOR CARCINOGENICITY

Numerous investigators have found significant increases in chromosomal aberrations of bone marrow cells and peripheral lymphocytes from workers with exposure to benzene (IARC, 1982). Benzene also induced chromosomal aberrations in bone marrow cells from rabbits (Kissling and Speck, 1973), mice

(Meyne and Legator, 1980) and rats (Anderson and Richardson, 1979). Several investigators have reported positive results for benzene in mouse micronucleus assays (Meyne and Legator, 1980). Benzene was not mutagenic in several bacterial and yeast systems, in the sex-linked recessive lethal mutation assay with Drosophila melanogaster or in mouse lymphoma cell forward mutation assay.

More?...(Yes or No) --

---------<<< Benzene >>>---------

__II.B. QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM ORAL EXPOSURE

___II.B.1. SUMMARY OF RISK ESTIMATES

Oral Slope Factor -- 2.9E-2 per (mg/kg)/day

Drinking Water Unit Risk -- 8.3E-7 per (ug/L)

Extrapolation Method -- One-hit (pooled data)

Drinking Water Concentrations at Specified Risk Levels:

More?...(Yes or No) --

Risk Level	Concentration
E-4 (1 in 10,000)	1E+2 ug/L
E-5 (1 in 100,000)	1E+1 ug/L
E-6 (1 in 1,000,000)	1E+0 ug/L

<<< Benzene >>>

___II.B.2. DOSE-RESPONSE DATA (CARCINOGENICITY, ORAL EXPOSURE)

See table in Section II.C.2.

The slope factor was derived from human data for inhalation exposure as described in section II.C.2. The human respiratory rate was assumed to be 20 cu.m/day, inhalation absorption was taken as 100% and an air concentration of benzene of 1 ppm was taken to equal 3.25 mg/cu.m. The water unit risk was calculated on the assumption that an adult human consumes 2 L water/day.

<<< Benzene >>>

More?...(Yes or No) --___II.B.3. ADDITIONAL COMMENTS (CARCINOGENICITY, ORAL EXP

The unit risk estimate is the geometric mean of four ML point estimates using pooled data from the Rinsky et al. (1981) and Ott et al. (1978) studies, which was then adjusted for the results of the Wong et al. (1983) study as described in the additional comments section for inhalation data.

The unit risk should not be used if the water concentration exceeds 1E+4 ug/L, since above this concentration the unit risk may not be appropriate.

<<< Benzene >>>

___II.B.4. DISCUSSION OF CONFIDENCE (CARCINOGENICITY, ORAL EXPOSURE)

The pooled cohorts were sufficiently large and were followed for an adequate time period. The increases in leukemias were statistically significant and dose-related in one of the studies. Wong et al. (1983) disagrees that exposures reported in Rinsky et al. (1981) were within the recommended standards. For the five leukemia deaths in persons with 5 or more

More?...(Yes or No) --

years exposure, the author notes that mean exposure levels (range 15-70 ppm) exceeded the recommended standard (25 ppm) in 75% of the work locations sampled. A total of 21 unit risk estimates were prepared using 6 models and various combinations of the epidemiologic data. These range over slightly more than one order of magnitude. A geometric mean of these estimates is 2.7E-2. Regression models give an estimate similar to the geometric mean.

The risk estimate above based on reconsideration of the Rinsky et al. (1981) and Ott et al. (1978) studies is very similar to that of 2.4E-2/ppm (cited in U.S. EPA, 1980) based on Infante et al. (1977a,b), Ott et al. (1978) and Aksoy et al. (1974). It was felt by the authors of U.S. EPA (1985) that the exposure assessment provided by Aksoy was too imprecise to warrant inclusion in the current risk estimate.

Risk estimates based on animal gavage studies are about 5 times higher than those derived from human data. Pharmacokinetic data which could impact the risk assessment are currently being evaluated.

More?...(Yes or No) -----------<<< Benzene >>>---------

__II.C. QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM INHALATION EXPOSURE

__II.C.1. SUMMARY OF RISK ESTIMATES

Inhalation Unit Risk -- 8.3E-6 per (ug/cu.m)

Extrapolation Method -- One-hit (pooled data)

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	1E+1 ug/cu.m
E-5 (1 in 100,000)	1E+0 ug/cu.m

More?...(Yes or No) --

E-6 (1 in 1,000,000)	1E-1 ug/cu.m

<<< Benzene >>>

___II.C.2. DOSE-RESPONSE DATA FOR CARCINOGENICITY, INHALATION EXPOSURE

Species/Strain Tumor Type		Reference
Human/leukemia	Route: Occupational, inhalation	Rinsky et al., 1981; Ott et al., 1978; Wong et al., 1983

<<< Benzene >>>

___II.C.3. ADDITIONAL COMMENTS (CARCINOGENICITY, INHALATION EXPOSURE)

The unit risk estimate is the geometric mean of four ML point estimates

More?...(Yes or No) --using pooled data from the Rinsky et al. (1981) and Ott et which was then adjusted for the results of the Wong et al. (1983) study. The Rinsky data used were from an updated tape which reports one more case of leukemia than was published in 1981. Equal weight was given to cumulative dose and weighted cumulative dose exposure categories as well as to relative and absolute risk model forms. The results of the Wong et al. (1983) study were incorporated by assuming that the ratio of the Rinsky-Ott-Wong studies to the Rinsky-Ott studies for the relative risk cumulative dose model was the same as for other model-exposure category combinations and multiplying this ratio by the Rinsky-Ott geometric mean. The age-specific U.S. death rates for 1978 (the most current year available) were used for background leukemia and total death rates. It should be noted that a recently published paper (Rinsky et al., 1987) reported yet another case of leukemia from the study population.

The unit risk should not be used if the air concentration exceeds 100 ug/cu.m, since above this concentration the unit risk may not be appropriate.

<<< Benzene >>>

More?...(Yes or No) --

_II.C.4. DISCUSSION OF CONFIDENCE (CARCINOGENICITY, INHALATION EXPOSURE)

The pooled cohorts were sufficiently large and were followed for an ade quate time period. The increases in leukemias were statistically significant and dose-related in one of the studies. Wong et al. (1983) disagrees that exposures reported in Rinsky et al. (1981) were within the recommended standards. For the five leukemia deaths in persons with 5 or more years exposure, the author notes that mean exposure levels (range 15-70 ppm) exceeded the recommended standard (25 ppm) in 75% of the work locations sampled. The risk estimate above based on reconsideration of the Rinsky et al. (1981) and Ott et al. (1978) studies is very similar to that of 2.4E-2/ppm (cited in U.S. EPA, 1980) based on Infante et al. (1977a,b), Ott et al. (1978) and Aksoy et al. (1974). It was felt by the authors of U.S. EPA (1985) that the exposure assessment provided by Aksoy was too imprecise to warrant inclusion in the current risk estimate. A total of 21 unit risk estimates were prepared using 6 models and various combinations of the epidemiologic data. These range over slightly more than one order of magnitude. A geometric mean of these estimates is 2.7E-2/ppm. Regression models give an

More?...(Yes or No) --

estimate similar to the geometric mean.

---------<<< Benzene >>>---------

__II.D. EPA DOCUMENTATION, REVIEW, AND CONTACTS (CARCINOGENICITY ASSESSMENT)

___II.D.1. EPA DOCUMENTATION

U.S. EPA. 1980. Ambient Water Quality Criteria Document for Benzene. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office (Cincinnati, OH) and Carcinogen Assessment Group (Washington, DC), and the Environmental Research Labs (Corvalis, OR; Duluth, MN; Gulf Breeze, FL) for the Office of Water Regulations and Standards, Washington, DC. EPA 440/5-80-018.

U.S. EPA. 1985. Interim Quantitative Cancer Unit Risk Estimates Due to

More?...(Yes or No) --Inhalation of Benzene. Prepared by the Office of Health a Assessment, Carcinogen Assessment Group, Washington, DC for the Office of Air ılity Planning and Standards, Washington, DC.

U.S. EPA. 1987. Memorandum from J. Orme, HEB, CSD/ODW to C. Vogt, Criteria and Standards Division, ODW, June, 1987.

<<< Benzene >>>

___II.D.2. REVIEW (CARCINOGENICITY ASSESSMENT)

The 1985 Interim Evaluation was reviewed by the Carcinogen Assessment Group.

The 1987 memorandum is an internal document.

Agency Work Group Review: 03/05/87, 10/09/87

Verification Date: 10/09/87

More?...(Yes or No) --

___II.D.3. U.S. EPA CONTACTS (CARCINOGENICITY ASSESSMENT)

D.L. Bayliss / ORD -- (202)382-5726 / FTS 382-5726

R. McGaughy / ORD -- (202)382-5898 / FTS 382-5898

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_III. HEALTH HAZARD ASSESSMENTS FOR VARIED EXPOSURE DURATIONS

__III.A. DRINKING WATER HEALTH ADVISORIES

Substance Name -- Benzene
CASRN -- 71-43-2

More?...(Yes or No) --Last Revised -- 08/01/90

The Office of Drinking Water provides Drinking Water Health Advisories (HAs) as technical guidance for the protection of public health. HAs are not enforceable Federal standards. HAs are concentrations of a substance in drinking water estimated to have negligible deleterious effects in humans, when ingested, for a specified period of time. Exposure to the substance from other media is considered only in the derivation of the lifetime HA. Given the absence of chemical-specific data, the assumed fraction of total intake from drinking water is 20%. The lifetime HA is calculated from the Drinking Water Equivalent Level (DWEL) which, in turn, is based on the Oral Chronic Reference Dose. Lifetime HAs are not derived for compounds which are potentially carcinogenic for humans because of the difference in assumptions concerning toxic threshold for carcinogenic and noncarcinogenic effects. A more detailed description of the assumptions and methods used in the derivation of HAs is provided in Background Document 3 in Service Code 5.

More?...(Yes or No) --

<<< Benzene >>>

___III.A.1. ONE-DAY HEALTH ADVISORY FOR A CHILD

Appropriate data for calculating a One-day HA are not available. It is recommended that the Ten-day HA of 0.235 mg/L used as the One-day HA.

<<< Benzene >>>

___III.A.2. TEN-DAY HEALTH ADVISORY FOR A CHILD

Ten-day HA -- 2.35E-1 mg/L

NOAEL -- 2.35 mg/kg/day
UF -- 100 (allows for interspecies and intrahuman variability with the use of a NOAEL from an animal study)
Assumptions -- 1 L/day water consumption for a 10-kg child

Principal Study -- Deichman et al., 1963

More?...(Yes or No) --

Rats were exposed to benzene for 6 hours/day, 4 days/week by inhalation and their hematology was monitored weekly. By the second week of treatment, hematological impairment was observed at the 2659 mg/cu.m exposure concentration and there was some indication, especially in females, that white blood cells were depressed at the 103 mg/cu.m exposure concentration. No effect was seen when animals were exposed to 96 mg/cu.m for up to 4 months. Based on the conditions of exposure and an assumed absorption factor of 50%, a NOAEL of 2.35 mg/kg/day can be calculated.

<<< Benzene >>>

___III.A.3. LONGER-TERM HEALTH ADVISORY FOR A CHILD

A Longer-term HA has not been calculated for benzene because of its potent carcinogenicity.

<<< Benzene >>>

More?...(Yes or No) --

___III.A.4.   LONGER-TERM HEALTH ADVISORY FOR AN ADULT

A Longer-term HA has not been calculated for benzene because of its potent carcinogenicity.

<<< Benzene >>>

___III.A.5.   DRINKING WATER EQUIVALENT LEVEL / LIFETIME HEALTH ADVISORY

DWEL -- None

Lifetime HA -- None

Benzene is classified in Group A: Human carcinogen. Neither a DWEL nor a Lifetime HA have been calculated for benzene. Refer to Section II of this file for information on the carcinogenicity of this substance.

<<< Benzene >>>

More?...(Yes or No) --___III.A.6.   ORGANOLEPTIC PROPERTIES

Odor perception threshold (air) -- 4.9 mg/cu.m.

Odor perception threshold (water) -- 2.0 mg/L.

<<< Benzene >>>

___III.A.7.   ANALYTICAL METHODS FOR DETECTION IN DRINKING WATER

Analysis of benzene is by a purge-and-trap gas chromatographic procedure used for the determination of volatile aromatic and unsaturated organic compounds in water.

<<< Benzene >>>

___III.A.8.   WATER TREATMENT

Treatment technologies which will remove benzene from water include

More?...(Yes or No) --

granular activated carbon adsorption and air stripping.

<<< Benzene >>>

___III.A.9.   DOCUMENTATION AND REVIEW OF HAs

Deichman, W.B., W.E. MacDonald and E. Bernal. 1963. The hemopoietic toxicity of benzene vapors. Toxicol. Appl. Pharmacol. 5: 201-224.

U.S. EPA. 1985. Drinking Water Criteria Document for Benzene. Office of Drinking Water, Washington, DC. (Final draft)

EPA review of HAs in 1985.

Public review of HAs following notification of availability in October, 1985.

Scientific Advisory Panel review of HAs in January, 1986.

Preparation date of this IRIS summary -- 06/19/87

More?...(Yes or No) --

___III.A.10. EPA CONTACTS

Jennifer Orme / ODW -- (202)382-7586 / FTS 382-7586

Edward V. Ohanian / ODW -- (202)382-7571 / FTS 382-7571

__III.B. OTHER ASSESSMENTS

Substance Name -- Benzene
CASRN -- 71-43-2

More?...(Yes or No) --
Content to be determined.

===

_IV. U.S. EPA REGULATORY ACTIONS

Substance Name -- Benzene
CASRN -- 71-43-2
Last Revised -- 08/01/90

EPA risk assessments may be updated as new data are published and as assessment methodologies evolve. Regulatory actions are frequently not updated at the same time. Compare the dates for the regulatory actions in this section with the verification dates for the risk assessments in sections I and II, as this may explain inconsistencies. Also note that some regulatory actions consider factors not related to health risk, such as technical or

More?...(Yes or No) --

economic feasibility. Such considerations are indicated for each action. In addition, not all of the regulatory actions listed in this section involve enforceable federal standards. Please direct any questions you may have concerning these regulatory actions to the U.S. EPA contact listed for that particular action. Users are strongly urged to read the background information on each regulatory action in Background Document 4 in Service Code 5.

<<< Benzene >>>

__IV.A. CLEAN AIR ACT (CAA)

___IV.A.1. NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP)

Considers technological or economic feasibility? -- YES

Discussion -- Benzene has been listed as a hazardous air pollutant under Section 112 of the Clean Air Act. EPA promulgated NESHAP for benzene from equipment leaks on June 6, 1984 (49 FR 23498) and proposed regulations for

More?...(Yes or No) --coke oven by-product plants.

Reference -- 40 CFR Part 61, Subpart J

EPA Contact -- Emissions Standards Division, OAQPS
(917)541-5571 / FTS 629-5571

---------<<< Benzene >>>---------

__IV.B. SAFE DRINKING WATER ACT (SDWA)

___IV.B.1. MAXIMUM CONTAMINANT LEVEL GOAL (MCLG) for Drinking Water

Value (status) -- 0 mg/L (Final, 1985)

Considers technological or economic feasibility? -- NO

More?...(Yes or No) --
Discussion -- An MCLG of zero mg/L for benzene is proposed based on carcinogenic effects. In humans, exposure to benzene is associated with myelocytic anemia, thrombocytopenia and leukemia (acute myelogenous and monocytic leukemia). In animals, an increase in tumors and leukemia have been reported. EPA has classified benzene in Group A: sufficient evidence from epidemiological studies.

Reference -- 50 FR 46880 Part III (11/13/85)

EPA Contact -- Criteria and Standards Division, ODW /
(202)382-7571 / FTS 382-7571; or Drinking Water Hotline / (800)426-4791

<<< Benzene >>>

___IV.B.2. MAXIMUM CONTAMINANT LEVEL (MCL) for Drinking Water

Value (status) -- 5 ug/L (Final, 1987)

More?...(Yes or No) --Considers technological or economic feasibility? -- YES

Discussion -- The MCL is based on technology and cost factors.

Reference -- 52 FR 25690 (07/08/87)

EPA Contact -- Criteria and Standards Division, ODW /
(202)382-7571 / FTS 382-7571; or Drinking Water Hotline / (800)426-4791

---------<<< Benzene >>>---------

__IV.C. CLEAN WATER ACT (CWA)

___IV.C.1. AMBIENT WATER QUALITY CRITERIA, Human Health

Water and Fish Consumption -- 6.6E-1 ug/L

More?...(Yes or No) --

Fish Consumption Only -- 4.0E+1 ug/L

Considers technological or economic feasibility? -- NO

Discussion -- For the maximum protection from the potential carcinogenic properties of this chemical, the ambient water concentration should be zero. However, zero may not be attainable at this time, so the recommended criteria represents a E-6 estimated incremental increase of cancer risk over a lifetime.

Reference -- 45 FR 79318 (11/28/80)

EPA Contact -- Criteria and Standards Division, OWRS
(202)475-7315 / FTS 475-7315

<<< Benzene >>>

___IV.C.2. AMBIENT WATER QUALITY CRITERIA, Aquatic Organisms

More?...(Yes or No) --
Freshwater:

Acute LEC -- 5.3E+3 ug/L
Chronic LEC -- None

Marine:

Acute LEC -- 5.1E+3 ug/L
Chronic LEC -- 7.0E+2 ug/L

Considers technological or economic feasibility? -- NO

Discussion -- The values that are indicated as "LEC" are not criteria, but are the lowest effect levels found in the literature. LECs are given when the minimum data required to derive water quality criteria are not available.

Reference -- 45 FR 79318 (11/28/80)

More?...(Yes or No) --

EPA Contact -- Criteria and Standards Division, OWRS
(202)475-7315 / FTS 475-7315

---------<<< Benzene >>>---------

__IV.D. FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

No data available

---------<<< Benzene >>>---------

__IV.E. TOXIC SUBSTANCES CONTROL ACT (TSCA)

No data available

More?...(Yes or No) --
---------<<< Benzene >>>---------

__IV.F. RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

___IV.F.1. RCRA APPENDIX IX, for Ground Water Monitoring

Status -- Listed

Reference -- 52 FR 25942 (07/09/87)

EPA Contact -- RCRA/Superfund Hotline
(800)424-9346 / (202)382-3000 / FTS 382-3000

---------<<< Benzene >>>---------

More?...(Yes or No) --

__IV.G. SUPERFUND (CERCLA)

___IV.G.1. REPORTABLE QUANTITY (RQ) for Release into the Environment

Value (status) -- 10 pounds (Proposed, 1987)

Considers technological or economic feasibility? -- NO

Discussion -- The proposed RQ for benzene is 10 pounds, based on its potential carcinogenicity. The available data indicate a hazard ranking of medium based on a potency factor of 0.27/mg/kg/day and a weight-of-evidence group A, which corresponds to an RQ of 10 pounds.

Reference -- 52 FR 8140 (03/16/87)

EPA Contact -- RCRA/Superfund Hotline
(800)424-9346 / (202)382-3000 / FTS 382-3000

More?...(Yes or No) --

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_V. SUPPLEMENTARY DATA

Substance Name -- Benzene
CASRN -- 71-43-2

Not available at this time.

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_VI. BIBLIOGRAPHY

More?...(Yes or No) --

Substance Name -- Benzene
CASRN -- 71-43-2
Last Revised -- 03/01/90

__VI.A. ORAL RfD REFERENCES

None

---------<<< Benzene >>>---------

__VI.B. INHALATION RfD REFERENCES

None

More?...(Yes or No) --
---------<<< Benzene >>>---------

__VI.C. CARCINOGENICITY ASSESSMENT REFERENCES

Aksoy, M., S. Erdem and G. Dincol. 1974. Leukemia in shoeworkers exposed chronically to benzene. Blood. 44(6): 837-841.

Aksoy, M. 1980. Different types of malignancies due to occupational exposure to benzene: A review of recent observations in Turkey. Environ. Res. 23: 181.

Anderson, D. and C.R. Richardson. 1979. Chromosome gaps are associated with chemical mutagenesis (abstract No. Ec-9). Environ. Mutat. 1: 179.

IARC (International Agency for Research on Cancer). 1982. Benzene. In: Some industrial chemicals and dyestuffs. IARC Monographs on the evaluation of

More?...(Yes or No) --

carcinogenic risk of chemicals to humans. IARC, WHO, Lyon, France. 29: 93-148.

Infante, P.F., R.A. Rinsky, J.K. Wagoner and R.J. Young. 1977a. Benzene and Leukemia. The Lancet. 2(8043): 867-869.

Infante, P.F., R.A. Rinsky, J.K. Wagoner and R.J. Young. 1977b. Leukemia in benzene workers. Lancet. 19: 76-78.

Kissling, M. and B. Speck. 1973. Chromosome aberrations in experimental benzene intoxication. HELV. Med. Acta. 36: 59-66.

Maltoni, C. and C. Scarnato. 1979. First experimental demonstration of the carcinogenic effects of benzene. Long-term bioassays on Sprague-Dawley Rats by oral administration. Med. Lav. 70: 352-357.

Maltoni, C., B. Conti and G. Cotti. 1983. Benzene: A multipotential carcinogen. Results of long-term bioassays performed at the Bologna Institute of Oncology. Am. J. Ind. Med. 4: 589-630.

More?...(Yes or No) --

Meyne, J. and M.S. Legator. 1980. Sex-related differences in cytogenetic effects of benzene in the bone marrow of Swiss mice. Environ. Mutat. 2: 43-50.

NTP (National Toxicology Program). 1986. Toxicology and carcinogenesis studies of benzene (CAS No. 71-43-2) in F344/N rats and B6C3F mice (gavage studies). NTP Technical Report Series No. 289. NIH Publication No. 86-2545.

Ott, M.G., J.C. Townsend, W.A. Fishbeck and R.A. Langner. 1978. Mortality among individuals occupationally exposed to benzene. Arch. Environ. Health. 33: 3-10.

Rinsky. R.A., R.J. Young and A.B. Smith. 1981. Leukemia in benzene workers. Am. J. Ind. Med. 2: 217-245.

Rinsky, R.A., A.B. Smith, R. Hornung, et al. 1987. Benzene and Leukemia. New England J. Med. 316(17): 1044-1050.

More?...(Yes or No) --

Snyder, C.A., M.N. Erlichman, S. Laskin, B.D. Goldstein, and R.E. Albert. 1981. The pharmacokinetics of repetitive benzene exposure at 300 and 100 ppm in AKR mice and Sprague-Dawley rats. Toxicol. Appl. Pharmacol. 57: 164-171.

U.S. EPA. 1980. Ambient Water Quality Criteria Document for Benzene. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office (Cincinnati, OH) and Carcinogen Assessment Group (Washington, DC), and the Environmental Research Labs (Corvalis, OR; Duluth, MN; Gulf Breeze, FL) for the Office of Water Regulations and Standards, Washington, DC. EPA 440/5-80-018.

U.S. EPA. 1985. Interim Quantitative Cancer Unit Risk Estimates Due to Inhalation of Benzene. Prepared by the Office of Health and Environmental Assessment, Carcinogen Assessment Group, Washington, DC for the Office of Air Quality Planning and Standards, Washington, DC.

U.S. EPA. 1987. Memorandum from J. Orme, HEB, CSD/ODW to C. Vogt, Criteria and Standards Division, ODW, June 1987.

More?...(Yes or No) --Wong, O., R.W. Morgan and M.D. Whorton. 1983. Comments o
leukemia in benzene workers. Technical report submitted to Gulf Canada, Ltd.,
by Environmental Health Associates.

---------<<< Benzene >>>----------

__VI.D. DRINKING WATER HA REFERENCES

Deichman, W.B., W.E. MacDonald and E. Bernal. 1963. The hemopoietic toxicity of benzene vapors. Toxicol. Appl. Pharmacol. 5: 201-224.

U.S. EPA. 1985. Drinking Water Criteria Document for Benzene. Office of Drinking Water, Washington, DC. (Final draft)

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More?...(Yes or No) --

SYNONYMS

Substance Name -- Benzene
CASRN -- 71-43-2
Last Revised -- 03/01/88

71-43-2
Benzene
benzol
coal naphtha
cyclohexatriene
phene
phenyl hydride
polystream
pyrobenzol

More?...(Yes or No) --

Enter keywords or Read or Scan or Mail
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--106-44-5
Searching - Please wait...
1 Occurrences...

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Enter keywords or Read or Scan or Mail
--108-95-2
Searching - Please wait...
1 Occurrences...

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Phenol; CASRN 108-95-2 (03/01/91)

Health risk assessment information on a chemical is included in IRIS only after a comprehensive review of chronic toxicity data by work groups composed of U.S. EPA scientists from several Program Offices. The summaries presented in Sections I and II represent a consensus reached in the review process. The other sections contain U.S. EPA information which is specific to a particular EPA program and has been subject to review procedures prescribed by that Program Office. The regulatory actions in Section IV may not be based on the most current risk assessment, or may be based on a current, but unreviewed, risk assessment, and may take into account factors other than health effects (e.g., treatment technology). When considering the use of regulatory action data for a particular situation, note the date of the regulatory action, the date of the most recent risk assessment relating to that action, and whether

More?...(Yes or No) --technological factors were considered. Background informa ations of the methods used to derive the values given in IRIS are provided in the five Background Documents in Service Code 5, which correspond to Sections through V of the chemical files.

STATUS OF DATA FOR Phenol

File On-Line 01/31/87

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	02/01/90
Inhalation RfC Assessment (I.B.)	message	03/01/91
Carcinogenicity Assessment (II.)	on-line	11/01/90

More?...(Yes or No) --Drinking Water Health Advisories (III.A.) no data

U.S. EPA Regulatory Actions (IV.)	on-line	06/01/90
Supplementary Data (V.)	on-line	01/31/87

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_I. CHRONIC HEALTH HAZARD ASSESSMENTS FOR NONCARCINOGENIC EFFECTS

__I.A. REFERENCE DOSE FOR CHRONIC ORAL EXPOSURE (RfD)

Substance Name -- Phenol
CASRN -- 108-95-2
Last Revised -- 02/01/90

More?...(Yes or No) --
The Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis, but may not exist for other toxic effects such as carcinogenicity. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to Background Document 1 in Service Code 5 for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of compounds which are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file when a review of that evaluation is completed.

<<< Phenol >>>

___I.A.1. ORAL RfD SUMMARY

More?...(Yes or No) --

Critical Effect	Experimental Doses*	UF	MF	RfD
Reduced fetal body weight in rats Rat Oral Developmental Study NTP, 1983	NOAEL: 60 mg/kg/day LOAEL: 120 mg/kg/day	100	1	6E-1 mg/kg/day

*Conversion Factors: none

<<< Phenol >>>

___I.A.2. PRINCIPAL AND SUPPORTING STUDIES (ORAL RfD)

NTP (National Toxicology Program). 1983. Teratologic evaluation of phenol in

More?...(Yes or No) --CD rats and mice. Report prepared by Research Triangle In
Triangle Park, NC. NTIS PB83-247726. Gov. Rep. Announce. Index. 83(25):

6247.

Developmental effects of phenol were evaluated in timed-pregnant CD rats. Phenol was administered by gavage at 0, 30, 60, and 120 mg/kg/day in distilled water on gestational days 6 to 15. Females were weighed daily during treatment and observed for clinical signs of toxicity. A total of 20 to 22 females/group were confirmed to be pregnant at sacrifice on gestational day 20. Detailed teratological evaluations were conducted at sacrifice. Results of this study did not show any dose-related signs of maternal toxicity or any clinical symptoms of toxicity related to phenol treatment. The number of implantation sites per litter was approximately the same in all groups, as was the number of live fetuses per litter. However, since implantations in this strain take place prior to gestational day 6 (prior to dosing), no relationships between treatment and number of implantation sites can be established. The most important finding, however, was a highly significant reduction in fetal body weights in the high-dose group. The highest fetal NOAEL in this study was 60 mg/kg/day.

More?...(Yes or No) --
<<< Phenol >>>

___I.A.3. UNCERTAINTY AND MODIFYING FACTORS (ORAL RfD)

UF = 100. Uncertainty factor included 10 for interspecies extrapolation and 10 for sensitive human population.

MF = 1.

<<< Phenol >>>

___I.A.4. ADDITIONAL COMMENTS (ORAL RfD)

In NCI (1980) rat and mice 90-day subchronic studies, 10 animals/sex/group were exposed to 0, 100, 300, 1000, 3000, or 10,000 ppm phenol in water. Decreased water intake and body weight gain were noted for both sexes of rats and mice and rats exposed to the high dose (780 mg/kg/day for rats and 1700 mg/kg/day for mice). Lower doses of phenol exposure did not cause any adverse

More?...(Yes or No) --effects in either rats or mice (234 and 510 mg/kg/day, res
LOAEL for this study was 10,000 ppm.

In a subchronic oral study (Dow, 1945), 10 rats/group were gavaged 5 days/week with 0, 50, or 100 mg/kg (0, 35.7 or 71.4 mg/kg/day) phenol until 135 or 136 doses were administered. Rats in the high-dose group showed a more marked drop in body weight gain than did other groups, but the group rapidly recovered. Rats in both dosage groups showed some degree of unspecific kidney damage yielding a LOAEL of 50 mg/kg, or 5000 ppm, for this study. This difference between the LOAELs of the NCI (1980) and Dow (1945) studies may be attributed to differences in mode of administration, with the Dow gavage study showing the lower LOAEL (possibly explained as a bolus dosage effect).

The Dow research also indicates that the 100% lethal acute dose of phenol is 700 mg/kg (Dow, 1945). In contrast, in a well-designed dose selection study (NCI, 1980) conducted prior to the 2-year bioassay, all rats exposed to 10,000 ppm (780 mg/kg/day) phenol in the drinking water survived a 90-day exposure period. The Dow (1945) study contained several deficiencies, such

More?...(Yes or No) --as limited sample size, lack of details of pertinent exper
incomplete histopathological evaluations and unspecific high mortality rate in

control and exposed rats during early stages of the study. Therefore, the Dow (1945) study is not considered the best available study for risk assessment.

Other studies indicate no effects on water consumption and weight gain at phenol concentrations as high as 1600 mg/L (1600 ppm) (Deichmann and Oesper, 1940).

In a chronic drinking water study conducted by NCI (1980), rats (F344) and mice (B6C3F1) were dosed with 0, 2500, and 5000 ppm phenol (rats: 0, 153, 344 mg/kg/day; mice: 0, 313, 500 mg/kg/day) in the drinking water for 103 weeks. All the animals were sacrificed 2 weeks after dosing ceased; detailed histopathological and carcinogenic evaluations of target organs were conducted. Results of this bioassay indicated a dose-related depression in mean body weight gain in both sexes of mice and rats. Animals exposed to both dose levels of phenol showed a significant drop in water consumption (water consumption in mice was severely depressed) resulting in significant body weight depression in the high-dose animals. This study also reported an

More?...(Yes or No) --

creased incidence of chronic kidney inflammation in all dosed female rats and in the 5000-ppm male rats. The incidence of this lesion in females was: 7/50 (control); 13/50 (2500 ppm); 37/50 (5000 ppm), whereas in male rats the incidence was: 37/50 (control); 37/50 (2500 ppm) and 48/50 (5000 ppm). However, historical control data (Armed Forces Institute of Pathology, 1980) in the F344 rat indicated nephropathy that approaches an incidence of 100%. These rats were the same (comparable) age as the rats killed at the completion of this 2-year NCI (1980) study. In the absence of other toxicological parameters, such as mortality, percent survival, clinical signs of toxicity, and morphological alterations in target organs, the reduction in body weight in both high-dose mice and rats could be related to depressed water intake resulting from phenol exposure. Based on the body weight depression in both exposed mice and rats, the LOAELs in mice and rats, respectively, were 313 and 344 mg/kg/day and the NOAEL in rats was 153 mg/kg/day. A NOAEL for mice was not observed.

Heller and Pursell (1938) reported normal growth and reproduction at enol concentrations up to 5000 mg/L (400 mg/kg/day) in a multi-generation rat reproduction study.

More?...(Yes or No) --

In a mouse developmental toxicity study (NTP, 1983). phenol was administered by gavage at 0, 70, 140, or 280 mg/kg/day on gestational days 6 to 15. At the highest dose, 4/36 mice died; no deaths occurred in any other groups. Average maternal body weight gain and weight gain in survivors also were significantly reduced at the highest dose; significant clinical signs of toxicity (tremors) also were seen at that dose level. As in the rat study, there was a highly significant dose-related for reduced fetal body weight, statistically different from controls at the highest dose level. An increased incidence of cleft palate was also reported at the highest dose level. The highest NOAEL in this study was 140 mg/kg/day.

In an unpublished developmental toxicity study, Kavlock (1987) gavaged SD rats with phenol at doses of 0, 667, and 1000 mg/kg on gestational day 11; the females were allowed to deliver and postnatal weight, viability, and function were evaluated. Pup body weights at weaning was decreased in the 1000 mg/kg/day group; kidney weight decreased only in female pups at weaning (667 and 1000 mg/kg groups). On days 8 and 9 postnatally, pup kidney weights were increased at both dosages of phenol, while urine osmolality was decreased and

More?...(Yes or No) --

urine volume was increased at 1000 mg/kg. The most striking findings were limb abnormalities (paralysis and palsy) produced by phenol (667 and 1000 mg/kg groups) that were evident 10-14 days after birth. The LOAEL in this study was 667 mg/kg/day.

In summary, the evaluations of subchronic, chronic and reproductive/developmental studies indicated that phenol administered to pregnant rats at 120 mg/kg/day caused significant depression in fetal body weights, establishing this endpoint as the critical effect. Therefore, it is inappropriate to use NOAELs of 140 mg/kg/day for mice (NTP, 1983) or 153 mg/kg/day for rats (NCI, 1980). The LOAEL for fetotoxicity was established at 120 mg/kg/day and the highest NOAEL at 60 mg/kg/day (NTP, 1983).

<<< Phenol >>>

___I.A.5. CONFIDENCE IN THE ORAL RfD

Study: Low
Data Base: Medium

More?...(Yes or No) --RfD: Low

Confidence in the study is low because of the gavage nature of the dose administration. The data base contains several supporting studies (subchronic, chronic, and reproductive/developmental); thus, a medium confidence is recommended. Low-to-medium confidence in the RfD follows.

<<< Phenol >>>

___I.A.6. EPA DOCUMENTATION AND REVIEW OF THE ORAL RfD

U.S. EPA. 1985. Health and Environmental Effects Profile for Phenol. Errata, 1986. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

Agency RfD Work Group Review: 08/05/85, 10/28/86, 11/16/88, 03/22/89

Verification Date: 11/16/88

More?...(Yes or No) --

___I.A.7. EPA CONTACTS (ORAL RfD)

Harlal Choudhury / ORD -- (513)569-7536 / FTS 684-7536

Christopher DeRosa / ORD -- (513)569-7534 / FTS 684-7534

__I.B. REFERENCE CONCENTRATION FOR CHRONIC INHALATION EXPOSURE (RfC)

Substance Name -- Phenol

CASRN -- 108-95-2
Last Revised -- 03/01/91

More?...(Yes or No) --
The health effects data for phenol have been reviewed by the U.S. EPA RfD/RfC Work Group and determined to be inadequate for derivation of an inhalation RfC. The verification status of this chemical is currently not verifiable. For additional information on the health effects of this chemical, interested parties are referred to the EPA documentation listed below.

U.S. EPA. 1986. Summary Review of the Health Effects Associated with Phenol: Health Issue Assessment. Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA/600/8-86/003F.

Agency Work Group Review: 02/22/90

EPA Contacts:

Annie M. Jarabek / ORD -- (919)541-4847 / FTS 629-4847

More?...(Yes or No) --

Daniel J. Guth / ORD -- (919)541-4930 / FTS 629-4930

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_II. CARCINOGENICITY ASSESSMENT FOR LIFETIME EXPOSURE

Substance Name -- Phenol
CASRN -- 108-95-2
Last Revised -- 11/01/90

Section II provides information on three aspects of the carcinogenic risk assessment for the agent in question; the U.S. EPA classification, and quantitative estimates of risk from oral exposure and from inhalation exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a

More?...(Yes or No) --low-dose extrapolation procedure and is presented as the r
The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. Background Document 2 (Service Code 5) provides details on the rationale and methods used to derive the carcinogenicity values found in IRIS. Users are referred to Section I for information on long-term toxic effects other than carcinogenicity.

<<< Phenol >>>

__II.A. EVIDENCE FOR CLASSIFICATION AS TO HUMAN CARCINOGENICITY

6 weeks and a 95% response had occurred by week 13; carcinomas first appeared at 19 weeks with a 73% response by week 42. In mice receiving only the 10% phenol treatments (no initiator), 4% of the mice had papillomas at week 12 and 36% had papillomas at week 32. The incidence of carcinomas was not reported. In the same series of studies, groups of 30 female mice/dose received twice-weekly dermal applications of 5, 10 or 20% phenol in benzene after an initial treatment of benzene (control) or benzene with 75 ug DMBA. In the noninitiated groups (those receiving only the dermal phenol applications) the percentage of mice bearing papillomas was 74, 100 and 100% in the 5, 10 and

More?...(Yes or No) --20% phenol treatment groups, respectively, and in the grou initial DMBA application, 56, 95 and 90% of the mice bore papillomas in the 5, 10 and 20% treatment groups, respectively. Papillomas occurred in 11% of the mice treated with benzene alone. The percentage of mice bearing carcinomas (between weeks 38 and 40) in the noninitiated groups was 26, 93 and 70% in the 5, 10 and 20% phenol groups. In the groups receiving the initial DMBA application, the percentage of mice bearing carcinomas was 12, 68 and 65% in the 5, 10 and 20% phenol groups. No carcinomas were reported in the group receiving only benzene.

Similar results were obtained by Salaman and Glendenning (1957). "S" strain albino mice (20 mice/group) showed strong tumor-promoting activity after initiation with 0.15% DMBA and subsequent, repeated weekly applications of 5 or 20% phenol (w/v in acetone) for 24 to 32 weeks. At the 20% level, phenol induced ulceration of the skin and had a strong promoting effect on tumor induction. At the 0.5% level, no ulceration was found; phenol had a moderate promoting effect but did not act as an initiator. Housing conditions of the animals were not indicated.

More?...(Yes or No) --

Analytical grade phenol (99.9% pure) (up to 10 mg/plate) was not mutagenic in Salmonella typhumurium strains TA98, TA100, TA1535, TA1537, or TA1538 with or without addition of rat liver homogenates (Florin et al., 1980; Pool and Lin, 1982; Haworth et al., 1983). However, Gocke et al. (1981) reported that phenol was mutagenic in TA98 with hepatic homogenates. Phenol was not mutagenic in Neurospora crassa (Dickey et al., 1949) and was not positive in the micronucleus test on mouse bone marrow from male and female NMRI mice treated in vivo (Gocke et al., 1981). In a study by Demerec et al. (1951), phenol exhibited mutagenic activity in Escherichia coli but only at highly toxic concentrations (0.1-0.2%).

---------<<< Phenol >>>---------

__II.B. QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM ORAL EXPOSURE

None.

More?...(Yes or No) -----------<<< Phenol >>>---------

__II.C. QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM INHALATION EXPOSURE

None.

___II.A.1. WEIGHT-OF-EVIDENCE CLASSIFICATION

Classification -- D; not classifiable as to human carcinogencity

Basis -- Based on no human carcinogenicity data and inadequate animal data.

More?...(Yes or No) --

<<< Phenol >>>

___II.A.2. HUMAN CARCINOGENICITY DATA

None.

<<< Phenol >>>

_ II.A.3. ANIMAL CARCINOGENICITY DATA

Inadequate. In carcinogenicity bioassays conducted by the National Cancer Institute (NCI, 1980), B6C3F1 mice (50/sex/dose) and F344 rats (50/sex/dose) were administered analytical grade phenol (approximately 98.5% pure) in the drinking water at concentrations of 0, 2500 or 5000 ppm for 103 weeks. Dose-related decreases in weight gain in treated mice were attributed to decreased water consumption. No other clinical signs of toxicity were observed, and mortality rates (approximately 14%) were comparable between experimental and control groups. Histopathological examination and statistical analyses

More?...(Yes or No) --revealed no phenol-related toxic or carcinogenic effects i

At the end of the study the survival rate of male rats was comparable among the three groups (approximately 52%) and the survival rate among the female rat groups was comparable (approximately 76%). No trends in cancer incidence were seen when compared with controls, however, low-dose male rats had, by pair-wise comparison, a statistically significant increase in the idences of pheochromocytomas of the adrenal medulla (13/50, 22/50 and 9/50 in the control, low-, and high-dose groups, respectively), interstitial cell tumors of the testes (42/48, 49/50 and 47/50), and leukemias or lymphomas (18/50, 31/50 and 25/50). There was no significant increase in tumor incidence in any tissue in female rats. Based on a high spontaneous tumor rate in matched controls, comparable survival patterns with no major fall off, and the lack of a positive association between phenol administration and tumor incidence in high-dose male rats, NCI concluded that, under these conditions, phenol was not carcinogenic in mice or rats (NCI, 1980).

<<< Phenol >>>

___II.A.4. SUPPORTING DATA FOR CARCINOGENICITY

More?...(Yes or No) --

Studies indicate that phenol may be a promoter and/or weak skin carcinogen in specially inbred sensitive mouse strains. Boutwell and Bosch (1959) demonstrated that repeated dermal applications of phenol promoted the development of skin papillomas and carcinomas in Sutter, Holtzman, CHF1, and C3H mouse strains exposed to a single dermal application of an initiator, 7,12-dimethylbenz[a]anthracene (DMBA, 75 ug). In this series of studies, groups of 23 to 30 mice/sex were treated twice a week for up to 72 weeks with equivalent volumes of benzene- or acetone-based solutions containing 10% phenol. Housing conditions were not described. Papillomas first appeared at

Content to be determined.

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_IV. U.S. EPA REGULATORY ACTIONS

Substance Name -- Phenol
CASRN -- 108-95-2
Last Revised -- 06/01/90

EPA risk assessments may be updated as new data are published and as

More?...(Yes or No) --assessment methodologies evolve. Regulatory actions are f updated at the same time. Compare the dates for the regulatory actions in this section with the verification dates for the risk assessments in sections I and II, as this may explain inconsistencies. Also note that some regulatory actions consider factors not related to health risk, such as technical or conomic feasibility. Such considerations are indicated for each action. In addition, not all of the regulatory actions listed in this section involve enforceable federal standards. Please direct any questions you may have concerning these regulatory actions to the U.S. EPA contact listed for that particular action. Users are strongly urged to read the background information on each regulatory action in Background Document 4 in Service Code 5.

<<< Phenol >>>

__IV.A. CLEAN AIR ACT (CAA)

___IV.A.1. CAA REGULATORY DECISION

More?...(Yes or No) --

:tion -- Decision not to regulate

Considers technological or economic feasibility? -- NO

Discussion -- The U.S. EPA concluded that the available health information on phenol at concentrations measured or estimated to occur in the ambient air is insufficient to warrant specific Federal regulation of routine phenol emissions under the CAA at this time.

Reference -- 51 FR 22854 (06/23/86)

EPA Contact -- Emissions Standards Division, OAQPS
(919)541-5571 / FTS 629-5571

---------<<< Phenol >>>---------

__IV.B. SAFE DRINKING WATER ACT (SDWA)

More?...(Yes or No) --
No data available

---------<<< Phenol >>>---------

__II.D. EPA DOCUMENTATION, REVIEW, AND CONTACTS (CARCINOGENICITY ASSESSMENT)

___II.D.1. EPA DOCUMENTATION

U.S. EPA. 1988. Updated Health Effects Assessment for Phenol. Prepared by the Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency

More?...(Yes or No) --

Response, Washington, DC.

<<< Phenol >>>

__II.D.2. REVIEW (CARCINOGENICITY ASSESSMENT)

The 1988 Health Effects Assessment for Phenol has received Agency review.

Agency Work Group Review: 08/02/89

Verification Date: 08/02/89

___II.D.3. U.S. EPA CONTACTS (CARCINOGENICITY ASSESSMENT)

Charli Hiremath / ORD -- (202)382-5725 / FTS 382- 5725

More?...(Yes or No) --===

_III. HEALTH HAZARD ASSESSMENTS FOR VARIED EXPOSURE DURATIONS

__III.A. DRINKING WATER HEALTH ADVISORIES

Substance Name -- Phenol
CASRN -- 108-95-2

Not available at this time.

__III.B. OTHER ASSESSMENTS

More?...(Yes or No) --

Substance Name -- Phenol
CASRN -- 108-95-2

More?...(Yes or No) --

__IV.D. FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

No data available

---------<<< Phenol >>>---------

__IV.E. TOXIC SUBSTANCES CONTROL ACT (TSCA)

No data available

---------<<< Phenol >>>---------

_IV.F. RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

More?...(Yes or No) --

___IV.F.1. RCRA APPENDIX IX, for Ground Water Monitoring

Status -- Listed

Reference -- 52 FR 25942 (07/09/87)

EPA Contact -- RCRA/Superfund Hotline
(800)424-9346 / (202)382-3000 / FTS 382-3000

---------<<< Phenol >>>---------

__IV.G. SUPERFUND (CERCLA)

___IV.G.1. REPORTABLE QUANTITY (RQ) for Release into the Environment

More?...(Yes or No) --

Value (status) -- 1000 pounds (Final, 1986)

Considers technological or economic feasibility? -- NO

Discussion-- The final RQ takes into account the natural biodegradation and photolysis of this hazardous substance. The biological oxygen demand in 5 days (BOD5) is between 58-83% of the theoretcial oxygen demand. The lowest primary RQ adjustment criteria for phenol (100 pounds based on chronic toxicity composite score of 35) has been adjusted upward one RQ level.

Reference -- 51 FR 34534 (09/29/86)

EPA Contact -- RCRA/Superfund Hotline
(800)424-9346 / (202)382-3000 / FTS 382-3000

---------<<< Phenol >>>---------

__IV.C. CLEAN WATER ACT (CWA)

___IV.C.1. AMBIENT WATER QUALITY CRITERIA, Human Health

Water and Fish Consumption: 3E+2 ug/L

Fish Consumption Only: None

Considers technological or economic feasibility? -- NO

Discussion -- The WQC of 3E+2 ug/L is based upon organoleptic effects (taste

More?...(Yes or No) --

and odor thresholds). However, organoleptic endpoints have limited value in setting water quality standards, since there is no demonstrated relationship between taste/odor effect and adverse health effects. If there is significant chlorination of water containing phenol, reference should be made to the criteria for 2-chlorophenol and 2,4-dichlorophenol.

Reference -- 45 FR 79318 (11/28/80)

EPA Contact -- Criteria and Standards Division, OWRS
(202)475-7315 / FTS 475-7315

<<< Phenol >>>

___IV.C.2. AMBIENT WATER QUALITY CRITERIA, Aquatic Organisms

Freshwater:

Acute LEC -- 1.02E+4 ug/L
Chronic LEC -- 2.56E+3 ug/L

More?...(Yes or No) --
Marine:

Acute LEC -- 5.8E+3 ug/L
Chronic -- None

Considers technological or economic feasibility? -- NO

Discussion -- The values that are indicated as "LEC" are not criteria, but are the lowest effect levels found in the literature. LECs are given when the minimum data required to derive water quality criteria are not available.

Reference -- 45 FR 79318 (11/28/80)

EPA Contact -- Criteria and Standards Division, OWRS
(202)475-7315 / FTS 475-7315

---------<<< Phenol >>>---------

Melting Point -- 109F, 43C

Vapor Density (AIR=1) -- 3.24

Evaporation Rate (Butyl acetate=1) -- Not Found

More?...(Yes or No) --
Solubility in Water -- 93 g/L at 25C

Flash Point [Method Used] -- 79C (CC)

Flammable Limits:
LEL -- 1.7%
UEL -- 8.6%

Appearance and Odor -- Colorless crystals or white crystalline mass (Merck, 1976), with aromatic, somewhat sickening sweet and acrid odor (Clayton and Clayton, 1981-82). Phenol is liquefied by mixing with about 8% water (Merck, 1983, p. 1043).

Conditions or Materials to Avoid -- Phenol decomposes slowly on air contact (Merck, 1976). Avoid contact with strong oxidizing agents (CHRIS, 1978), aluminum chloride/nitrobenzene mixture, peroxodisulfuric acid, and peroxomonosulfuric acid (Bretherick, 1979).

More?...(Yes or No) --
Hazardous Decomposition or Byproducts -- Not Found

Use -- Used as a disinfectant, antiseptic, and bactericide (Merck, 1976); as a chemical intermediate for phenolic resins, medicinals, and many other chemicals; and as a solvent for petroleum refining (SRI).

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_VI. BIBLIOGRAPHY

Substance Name -- Phenol
CASRN -- 108-95-2
Last Revised -- 03/01/91

__VI.A. ORAL RfD REFERENCES

More?...(Yes or No) --

Deichmann, W. and P. Oesper. 1940. Ingestion of phenol-effects on the albino rat. Ind. Med. 9: 296.

Dow Chemical Co. 1945. The toxicity of phenol. Biochem. Res. Lab. Unpublished report dated 04/12/45.

Heller, V.G. and L. Pursell. 1938. J. Pharmacol. Exp. Ther. 63: 99. (Cited in Deichmann and Oesper, 1940)

Kavlock, R.J. 1987. Interim Report on Structure-Activity Relationships in the Developmental Toxicity of Substituted Phenols. Health Effects Research

==

More?...(Yes or No) --

_V. SUPPLEMENTARY DATA

Substance Name -- Phenol
CASRN -- 108-95-2
Last Revised -- 01/31/87

The information contained in this section (subsections A and B) has been extracted from the EPA Chemical Profiles Database, which has been compiled from a number of secondary sources and has not undergone formal Agency review. The complete reference listings for the citations in this section are provided in Service Code 5. The user is urged to read Background Document 5 in Service Code 5 for further information on the sources and limitations of the data presented here.

<<< Phenol >>>

__V.A. ACUTE HEALTH HAZARD INFORMATION

More?...(Yes or No) --

Toxicity -- Phenol's toxic hazard rating is very toxic. The probable oral lethal dose (human) is 50-500 mg/kg (Gosselin et al., 1976). Ingestion of 1 gram has been lethal to humans (Encyc. Occupat. Health and Safety, 1971). Lethal amounts may be absorbed through skin or inhaled (NFPA, 1978).

Medical Conditions Generally Aggravated by Exposure -- Persons affected with hepatic or kidney diseases are at a greater risk (Clayton and Clayton, 1981-82).

Signs and Symptoms of Exposure -- Symptoms include burning pain in the mouth nd throat, bloody diarrhea, pallor, sweating, weakness, headache, dizziness, ringing in the ears, shock, and profound fall in body temperature. Oral exposure signs and symptoms include sonorous breathing, and frothing at the mouth and nose. Skin exposure may cause pain followed by numbness (Gosselin et al., 1976).

---------<<< Phenol >>>---------

More?...(Yes or No) --

__V.B. PHYSICAL-CHEMICAL PROPERTIES

Chemical Formula -- C6H6O

Molecular Weight -- 94.11

Boiling Point -- 359.1F, 181.75C

Specific Gravity (H2O=1) -- 1.0722 at 20/4C

Vapor Pressure (mmHg) -- 0.3513 at 25C

Mutagen.1Suppl. 1: 3-142.

NCI (National Cancer Institute). 1980. Bioassay of phenol for possible carcinogenicity. Prepared by the National Cancer Institute, Bethesda, MD for the National Toxicology Program, Research Triangle Park, NC. NCI-CG-TR-203, DHHS/PUB/NIH80-1759.

Pool, B.L. and P.Z. Lin. 1982. Mutagenicity testing in the Salmonella typhimurium assay of phenolic compounds and phenolic fractions obtained from smokehouse smoke condensates. Food Chem. Toxicol. 20: 383-391.

More?...(Yes or No) --

Salaman, M.H. and O.M. Glendenning. 1957. Tumor promotion in mouse skin by sclerosing agents. Br. J. Cancer. 11: 434-444.

U.S. EPA. 1988. Updated Health Effects Assessment for Phenol. Prepared by the Office of Health and Environment Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

---------<<< Phenol >>>----------

__VI.D. DRINKING WATER HA REFERENCES

None

More?...(Yes or No) --

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SYNONYMS

Substance Name -- Phenol
CASRN -- 108-95-2
Last Revised -- 01/31/87

108-95-2
Benzenol
Carbolic Acid
Hydroxybenzene
Izal
Monohydroxybenzene
Monophenol
NCI-C50124
Oxybenzene

More?...(Yes or No) --n

Enter keywords or Read or Scan or Mail
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Laboratory, Research Triangle Park, NC.

NCI (National Cancer Institute). 1980. Bioassay of phenol for possible carcinogenicity in F344 rats and B6C3F1 mice. NIH Publ. No. 80-1759. August 1980.

NTP (National Toxicology Program). 1983. Teratologic evaluation of phenol in

More?...(Yes or No) --
CD rats and mice. Report prepared by Research Triangle Institute, Research Triangle Park, NC. NTIS PB83-247726. Gov. Rep. Announce. Index. 83(25): 6247.

U.S. EPA. 1985. Health and Environmental Effects Profile for Phenol. Errata, 1986. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

---------<<< Phenol >>>---------

__VI.B. INHALATION RfD REFERENCES

U.S. EPA. 1986. Summary Review of the Health Effects Associated with Phenol: Health Issue Assessment. Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC.

More?...(Yes or No) --
EPA/600/8-86/003F.

---------<<< Phenol >>>---------

_VI.C. CARCINOGENICITY ASSESSMENT REFERENCES

Boutwell, R.K. and D.K. Bosch. 1959. The tumor-promoting action of phenol and related compounds for mouse skin. Cancer Res. 19: 413-424.

Demerec, M., G. Bertani and J. Flint. 1951. A survey of chemicals for mutagenic action on E. coli. Am. Natur. 85(821): 119-135.

Dickey, F.H., G.H. Cleland and C. Lotz. 1949. The role of organic peroxides in the induction of mutations. Proc. Natl. Acad. Sci. 35: 581-586.

Florin, I., L. Rutberg, M. Curvall and C.R. Enzell. 1980. Screening of

More?...(Yes or No) --
tobacco smoke constituents for mutagenicity using the Ames test. Toxicology. 18: 219-232.

Gocke, E., M.-T. King, K. Eckhardt and D. Wild. 1981. Mutagenicity of cosmetics ingredients licensed by the European communities. Mutat. Res. 90: 91-109.

Haworth, S., T. Lawlor, K. Mortelmans, W. Speck and E. Zeiger. 1983. Salmonella mutagenicity test results for 250 chemicals. Environ.

Substance Name -- p-Cresol
CASRN -- 106-44-5
Last Revised -- 09/01/90

More?...(Yes or No) --
The Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis, but may not exist for other toxic effects such as carcinogenicity. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to Background Document 1 in Service Code 5 for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of compounds which are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file when a review of that evaluation is completed.

<<< p-Cresol >>>

___I.A.1. ORAL RfD SUMMARY

More?...(Yes or No) --

Critical Effect	Experimental Doses*			UF
Decreased body weights and neurotoxicity	NOAEL: 50 mg/kg/day	1000	1	5E-2 mg/kg/day
90-Day Oral Subchronic Neurotoxicity Study in Rats	LOAEL: 150 mg/kg/day			
U.S. EPA, 1986, 1987				

*Conversion Factors: None

<<< p-Cresol >>>

___I.A.2. PRINCIPAL AND SUPPORTING STUDIES (ORAL RfD)

U.S. EPA. 1986. o, m, p-Cresol. 90-Day oral subchronic toxicity studies in rats. Office of Solid Waste, Washington, DC.

More?...(Yes or No) --
U.S. EPA. 1987. o, m, p-Cresol. 90-Day oral subchronic neurotoxicity study in rats. Office of Solid Waste, Washington, DC.

In a 90-day subchronic toxicity study (U.S. EPA, 1986), p-cresol was administered by gavage to 30 Sprague-Dawley rats/sex/dose at 0, 50, 175, or 600 mg/kg/day, once daily. The following parameters were evaluated: body and organ weights, food consumption, mortality, clinical signs of toxicity, and clinical pathology. At sacrifice, animals were necropsied and tissues and organs were subjected to histopathological evaluation. At 600 mg/kg/day of p-cresol, there was a significant reduction in weight gain (15% for females, 25% for males), significantly reduced food consumption at weeks 1 through 7 and 9 in males and significant increased incidence of CNS effects such as lethargy, excessive salivation, tremors, and diarrhea. Also, at 600 mg/kg/day the read

p-Cresol; CASRN 106-44-5 (10/01/90)

Health risk assessment information on a chemical is included in IRIS only after a comprehensive review of chronic toxicity data by work groups composed of U.S. EPA scientists from several Program Offices. The summaries presented in Sections I and II represent a consensus reached in the review process. The other sections contain U.S. EPA information which is specific to a particular EPA program and has been subject to review procedures prescribed by that Program Office. The regulatory actions in Section IV may not be based on the most current risk assessment, or may be based on a current, but unreviewed, risk assessment, and may take into account factors other than health effects (e.g., treatment technology). When considering the use of regulatory action data for a particular situation, note the date of the regulatory action, the date of the most recent risk assessment relating to that action, and whether

More?...(Yes or No) --technological factors were considered. Background informa ations of the methods used to derive the values given in IRIS are provided in the five Background Documents in Service Code 5, which correspond to Sections I through V of the chemical files.

STATUS OF DATA FOR p-Cresol

File On-Line 08/22/88

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	09/01/90
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	on-line	09/01/90

More?..,(Yes or No) --Drinking Water Health Advisories (III.A.) no data

U.S. EPA Regulatory Actions (IV.)	no data	
Supplementary Data (V.)	no data	

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_I. CHRONIC HEALTH HAZARD ASSESSMENTS FOR NONCARCINOGENIC EFFECTS

__I.A. REFERENCE DOSE FOR CHRONIC ORAL EXPOSURE (RfD) this value; this lends support to the RfD derived from the subchronic toxicity studies (U.S. EPA, 1986, 1987).

<<< p-Cresol >>>

___I.A.5. CONFIDENCE IN THE ORAL RfD

Study: High
Data Base: Medium

More?...(Yes or No) --RfD: Medium

Confidence in the study is high because the critical studies provided adequate toxicological endpoints that included both general toxicity and neurotoxicity. The data base is medium because there are adequate supporting subchronic studies. Thus, until additional chronic toxicity studies and reproductive studies are available, medium confidence in the study, RfD is recommended.

<<< p-Cresol >>>

___I.A.6. EPA DOCUMENTATION AND REVIEW OF THE ORAL RfD

U.S. EPA. 1985. Health and Environmental Effects Profile for Cresols. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

The Health and Environmental Effects Profile has received an Agency-wide

More?...(Yes or No) --

review with the help of two external scientists.

Agency RfD Work Group Review: 06/24/85, 07/08/85, 08/13/87

Verification Date: 08/13/87

___I.A.7. EPA CONTACTS (ORAL RfD)

Harlal Choudhury / ORD -- (513)569-7536 / FTS 684-7536

Christopher DeRosa / ORD -- (513)569-7534 / FTS 684-7536

__I.B. REFERENCE CONCENTRATION FOR CHRONIC INHALATION EXPOSURE (RfC)

More?...(Yes or No) --
Substance Name -- p-Cresol
CASRN -- 106-44-5

Not available at this time.

liver-to-body and kidney-to-body weight ratios were significantly increased, and there was a greater incidence of tracheal epithelial metaplasia compared with the animals in the control, low- or mid-dose groups. At the mid-dose group (175 mg/kg/day) the reduction in weight gain was 5 to 10% in males between weeks 1 and 3; liver-to-body weight ratio was elevated (though not

More?...(Yes or No) --

statistically significant) in both sexes, and kidney-to-body weight ratio was significantly elevated in males. Although there was a slight reduction in weight gain and a small increase in kidney-to-body weight ratio at the 50 mg/kg/day level, these effects were not statistically significant.

In a 90-day neurotoxicity study (U.S. EPA, 1987), 10 Sprague-Dawley rats/sex/dose, were gavaged daily with 0, 50, 75, or 600 mg/kg/day p-cresol. In addition to the parameters evaluated by U.S. EPA (1986), the following were monitored for signs of neurotoxicity: salivation, urination, tremor, piloerection, diarrhea, pupil size, pupil response, lacrimation, hypothermia, vocalization, exophthalmia, palpebral closure, convulsions (type and severity), respiration (rate and type), impaired gait, positional passivity, locomotor activity, stereotypy, startle response, righting reflex, performance on a wire maneuver, forelimb strength, positive geotrophism, extensor thrust, limb rotation, tail pinch reflex, toe pinch reflex. and hind limb splay. The lowest dose (50 mg/kg/day) caused clinical signs of CNS-stimulation post dosing such a salivation, rapid respiration, and hypoactivity; however, they were low in incidence and sporadic in nature. The highest dose of p-cresol (600 mg/kg/day) produced significant neurological effects, such as increased

More?...(Yes or No) --salivation and urination, tremors, lacrimation, palpebral respiration. High-dose animals also showed abnormal patterns in the neurobehavioral tests. The NOAEL based on systemic toxicity was 50 mg/kg/day in rats.

<<< p-Cresol >>>

__I.A.3. UNCERTAINTY AND MODIFYING FACTORS (ORAL RfD)

UF = 1000. 10 for interspecies and 10 for intraspecies variability and 10 for uncertainty in extrapolation of subchronic data to levels of chronic effects.

MF = 1.

<<< p-Cresol >>>

___I.A.4. ADDITIONAL COMMENTS (ORAL RfD)

More?...(Yes or No) --

In a series of subchronic inhalation studies, Uzhdavine et al. (1972) exposed rats and guinea pigs to o-cresol at a concentration of 9.0 (plus or minus 0.9) mg/cu.m. No effect was seen in guinea pigs. In rats, the authors reported various hematopoietic effects, respiratory tract irritation and sclerosis of lungs. Uzhdavine et al. (1972) also reported that humans exposed to 6 mg/cu.m cresol (duration unspecified) experienced nasopharyngeal irritation. Other studies support the findings (effects) reported in this study. Based on a review and assessment of the available literature, primarily Uzhdavine et al. (1972), NIOSH (1978) recommended a TLV-TWA of 10 mg/cu.m (0.05 mg/kg/day). An RfD of 0.05 mg/kg/day can also be derived from

Limited. Four skin application studies which had positive results are reported; however, the final two studies are of limited value due to the application of a mixture of chemicals. In a study by Boutwell and Bosch (1959), female Sutter mice (27-29/group; 2-3 months of age) received a single dermal application of 25 uL of 0.3% dimethylbenzanthracene (DMBA) in acetone as the initiator, followed 1 week later by 25 uL of 20% (v/v) o-, m- or p-cresol in benzene twice weekly for 12 weeks. Skin papillomas were evaluated at 12 weeks. Many of the cresol-treated mice died, presumably of cresol toxicity. There was no mortality or evidence of skin papillomas in the benzene control group (benzene weekly after DMBA initiation). The numbers of surviving mice that developed skin papillomas at 12 weeks were as follows: 10/17, o-cresol; 7/14, m-cresol; and 7/20, p-cresol. None of the 12 mice in the benzene control group died or developed skin papillomas.

In another experiment, groups of 20 mice received a single dose (25 uL)

More?...(Yes or No) --of 0.3% DMBA in acetone, followed by twice weekly applicat cresol in benzene or 5.7% p-cresol in benzene for 20 weeks. No skin papillomas were observed in the 18 surviving benzene control mice; 4/17 m-cresol- and 4/14 p-cresol-treated mice developed skin papillomas (Boutwell and osch, 1959). These two experiments indicate that cresols can serve as tumor promoters of a polycyclic aromatic hydrocarbon.

Kaiser (1977), using spectroscopic and gas chromatographic analysis, showed that o-, m-, and p-cresol were present in a phenolic fraction isolated from tea. Two groups of 15 Swiss mice (age and sex not specified) received a single dermal application of 1% benzo[a]pyrene in acetone. On alternate days one group received dermal applications of tea (1g/155 ml water, dose unspecified). The type of housing used in these studies was not specified. At the end of 110 days (55 total treatments), 6/15 mice had epithelial cell carcinomas and 9/15 had developed precarcinogenic or carcinogenic stages of squamous-cell tumors. Control mice, which received only the initial benzo[a]pyrene treatment, developed no pathologic lesions. Bock et al. (1971) used steam distillation to isolate subfractions of an acid fraction of cigarette smoke condensate; this fraction was previously shown to be a tumor

More?...(Yes or No) --

promoter (Bock et al., 1969). Phenolic compounds including o-, m-, and p-cresol were detected in the steam distillate subfraction. A synthetic distillate with the same composition was prepared. Groups of fifty 14-week-old Swiss mice (gender unspecified) were administered 0.2 ml of the nonvolatile fraction of the distillate, the distillate, the synthetic distillate, or acetone (for the control group) by dermal application, 5 times per week for 61 weeks. Approximately 45% of the mice survived in each group. Skin tumors developed with the following incidence: 4/23, 4/26, 2/21, and 14/21 for the control group, the distillate application group, the synthetic distillate application group, and the nonvolatile fraction group, respectively. (The tumor type was not specified.) These studies are of limited value in determining the tumor-promoting activity of cresol, since both tea and cigarette smoke condensate contain numerous other compounds.

In an acute dermal toxicity study, technical grade o-, m-, and p-cresol caused severe skin damage on at least 2/6 shaved, female, albino New Zealand rabbits within 4 hours of application of 2000 mg/kg of technical grade cresol, 890 mg/kg of o-cresol, 2830 mg/kg of m-cresol, or 300 mg/kg p-cresol (Vernot et al. 1977).

More?...(Yes or No) --

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_II. CARCINOGENICITY ASSESSMENT FOR LIFETIME EXPOSURE

Substance Name -- p-Cresol
CASRN -- 106-44-5
Last Revised -- 09/01/90

Section II provides information on three aspects of the carcinogenic risk

More?...(Yes or No) --

assessment for the agent in question; the U.S. EPA classification, and quantitative estimates of risk from oral exposure and from inhalation exposure. The classification reflects a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per mg/kg/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. Background Document 2 (Service Code 5) provides details on the rationale and methods used to derive the carcinogenicity values found in IRIS. Users are referred to Section I for information on long-term toxic effects other than carcinogenicity.

<<< p-Cresol >>>

__II.A. EVIDENCE FOR CLASSIFICATION AS TO HUMAN CARCINOGENICITY

More?...(Yes or No) --___II.A.1. WEIGHT-OF-EVIDENCE CLASSIFICATION

Classification -- C; possible human carcinogen

Basis -- Based on an increased incidence of skin papillomas in mice in an initiation-promotion study. The three cresol isomers produced positive results in genetic toxicity studies both alone and in combination.

<<< p-Cresol >>>

___II.A.2. HUMAN CARCINOGENICITY DATA

Inadequate. Only anecdotal data available. Garrett (1975) reported two cases of multifocal transitional cell carcinoma of the bladder following chronic occupational exposure to cresol and creosote. Wodyka (1964, as cited in U.S. EPA., 1979) described a squamous cell carcinoma of the vocal cords in a petroleum refinery worker with a long history of exposure to cresol, dichlorooctane, and chromic acid.

More?...(Yes or No) --

<<< p-Cresol >>>

___II.A.3. ANIMAL CARCINOGENICITY DATA

More?...(Yes or No) --

---------<<< p-Cresol >>>---------

__II.D. EPA DOCUMENTATION, REVIEW, AND CONTACTS (CARCINOGENICITY ASSESSMENT)

___II.D.1. EPA DOCUMENTATION

U.S. EPA. 1979. The Carcinogen Assessment Group's Preliminary Risk Assessment on Cresols: Type 1 - Air Program. Prepared by the Office of Health and Environment Assessment for the Office of Air Quality Planning and Standards, Washington, DC.

U.S. EPA. 1985. Health and Environmental Effects Profiles for Cresols. Prepared by the Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Solid Waste and Emergency Response, Washington, DC.

<<< p-Cresol >>>

More?...(Yes or No) --___II.D.2. REVIEW (CARCINOGENICITY ASSESSMENT)

The 1985 Health and Environmental Effects Profile for Cresols is an external draft for review only and does not constitute Agency policy.

Agency Work Group Review: 07/11/88, 10/5/89

Verification Date: 10/5/89

___II.D.3. U.S. EPA CONTACTS (CARCINOGENICITY ASSESSMENT)

Herman Gibb / ORD -- (202)382-5720 / FTS 382-5720

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More?...(Yes or No) --

_III. HEALTH HAZARD ASSESSMENTS FOR VARIED EXPOSURE DURATIONS

__III.A. DRINKING WATER HEALTH ADVISORIES

Substance Name -- p-Cresol
CASRN -- 106-44-5

Not available at this time.

__III.B. OTHER ASSESSMENTS

<<< p-Cresol >>>

___II.A.4. SUPPORTING DATA FOR CARCINOGENICITY

Studies on the induction of unscheduled DNA synthesis showed p-cresol to be positive in human lung fibroblast cells in the presence of hepatic homogenates (Crowley and Margard, 1978), the mixture of the three isomers to be weakly positive in primary rat hepatocytes (Litton Bionetics, 1980d), and o-cresol to be negative in rat hepatocytes (Litton Bionetics, 1981e).

In cell transformation assays using BALB/3T3 cells, a mixture of 3 cresol isomers was positive (Litton Bionetics, 1980d), and o-cresol was negative. Positive mutagenic responses were found at noncytotoxic doses (Litton Bionetics, 1980e). In another cell transformation assay using p-cresol, negative results were obtained with the mouse fibroblast cell line C3H10T1/2 (Crowley and Margard, 1978).

Cresols (o-, m- and p-) are not mutagenic for various strains of

More?...(Yes or No) --Salmonella typhimurium both in the presence and absence of homogenates (Crowley and Margard, 1978; Litton Bionetics, 1980a, 1981a; Florin et al., 1980; Douglas et al., 1980; Pool and Lin, 1982; Haworth et al., 1983).

A mixture of the three isomers was mutagenic in a mouse lymphoma forward mutation assay with mammalian liver homogenates, while o-cresol was not mutagenic both with and without liver homogenates (Litton Bionetics, 1980b, 1981b).

No isomer, when tested individually, induced sister chromatid exchanges (SCEs) in vivo, but the mixture of the three isomers induced SCEs in Chinese hamster ovary (CHO) cells in vitro (Litton Bionetics, 1980c). Only o-cresol induced SCEs in human lung fibroblasts (Cheng and Kligerman, 1984) and CHO cells (Litton Bionetics, 1981c).

In a screening test for putative carcinogens, infectious virus particles were produced from SV40-transformed weanling Syrian hamster kidney cells exposed to m-cresol (Moore and Coohill, 1983).

More?...(Yes or No) --

---------<<< p-Cresol >>>---------

__II.B. QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM ORAL EXPOSURE

None.

---------<<< p-Cresol >>>---------

__II.C. QUANTITATIVE ESTIMATE OF CARCINOGENIC RISK FROM INHALATION EXPOSURE

None.

in rats. Office of Solid Waste, Washington, DC.

U.S. EPA. 1987. o, m, p-Cresol. 90-Day oral subchronic neurotoxicity study in rats. Office of Solid Waste, Washington, DC.

More?...(Yes or No) --

Uzhdavini, E.R., I.K. Astaf'yeva, A.A. Mamayeva and G.Z. Bakhtizina. 1972. Inhalation toxicity of o-cresol. Tr. Ufimskogo Nauchno-Issledovatel'skogo Instituta Gigiyeny Profzabolevaniya. 7: 115-119. (Eng. trans.)

---------<<< p-Cresol >>>----------

__VI.B. INHALATION RfD REFERENCES

None

---------<<< p-Cresol >>>----------

__VI.C. CARCINOGENICITY ASSESSMENT REFERENCES

More?...(Yes or No) --

Bock, F.G., A.P. Swain and R.L. Stedman. 1969. Bioassay of major fractions of cigarette smoke condensate by an accelerated technic. Cancer Res. 29: 584-587.

Bock, F.G., A.P. Swain and R.L. Stedman. 1971. Composition studies on tobacco. XLIV. Tumor-promoting activity of subfractions of the weak acid fraction of cigarette smoke condensate. J. Natl. Cancer Inst. 47: 429-436.

Boutwell, R.K. and D.K. Bosch. 1959. The tumor-promoting action of phenol and related compounds for mouse skin. Cancer Res. 19: 413-424.

Cheng, M. and A.O. Kligerman. 1984. Evaluation of the genotoxicity of cresols using sister-chromatid-exchange (SCE). Mutat. Res. 137: 51-55.

Crowley, J.P. and W. Margard. 1978. Summary reports on determination of mutagenic/carcinogenic and cytotoxic potential of four chemical compounds to Sherwin Williams Company. Unpublished data.

More?...(Yes or No) --Douglas, G.R., E.R. Nestmann and E.R. Betts. 1980. Mutag pulp mill effluents. Water chlorination: Environ. Impact Health Effects. 3: 865-880.

Florin, I., L. Rutbert, M. Curvall and C.R. Enzell. 1980. Screening of tobacco smoke constituents for mutagenicity using the Ames' test. Toxicology 15(3): 219-232.

Garrett, J.S. 1975. Association between bladder tumors and chronic exposure to cresols and creosote. (Letter) J. Occup. Med. 17: 492.

Substance Name -- p-Cresol
CASRN -- 106-44-5

More?...(Yes or No) --

Content to be determined.

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_IV. U.S. EPA REGULATORY ACTIONS

Substance Name -- p-Cresol
CASRN -- 106-44-5

Not available at this time.

==

More?...(Yes or No) --

_V. SUPPLEMENTARY DATA

Substance Name -- p-Cresol
CASRN -- 106-44-5

Not available at this time.

==

_VI. BIBLIOGRAPHY

Substance Name -- p-Cresol
CASRN -- 106-44-5
Last Revised -- 09/01/90

More?...(Yes or No) --
__VI.A. ORAL RfD REFERENCES

NIOSH (National Institute for Occupational Safety and Health). 1978. Criteria for a recommended standard...Occupational exposure to cresol. U.S. DHEW, DHEW (NIOSH) Publ. No. 78-133.

U.S. EPA. 1985. Health and Environmental Effects Profile for Cresols. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

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Substances, U.S. EPA. FYI-OTS-0981-0126.

Litton Bionetics. 1981e. Evaluation of N50C-81-3 [o-cresol] in the primary rat hepatocyte unscheduled DNA synthesis assay -- Final report. Unpublished data submitted by the Cresol Task Force to the Office of Toxic Substances, U.S. EPA. FYI-OTS-0981-0126.

Moore, S.P. and T.P. Coohill. 1983. An SV40 mammalian inductest for putative carcinogen. Prog. Nucleic Acid Res. Mol. Biol. 29: 149-153.

Pool, B.L. and P.Z. Lin. 1982. Mutagenicity testing in the Salmonella typhimurium assay of phenolic compounds and phenolic fractions obtained from

More?...(Yes or No) --smokehouse smoke condensates. Food Chem. Toxicol. 20(4):

U.S. EPA. 1979. The Carcinogen Assessment Group's Preliminary Risk Assessment on Cresols: Type 1 - Air Program. Prepared by the Office of Health and Environment Assessment for the Office of Air Quality Planning and Standards, Washington, DC.

U.S. EPA. 1985. Health and Environmental Effects Profiles for Cresols. Prepared by the Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Solid Waste and Emergency Response, Washington, DC.

Vernot, E. H., J. D. MacEwen, C. C. Haun, and E. R. Kinkead. 1977. Acute Toxicity and Skin Corrosion Data for some Organic and Inorganic Compounds and Aqueous Solutions. Toxicol. Appl. Pharmacol. 42(2): 417-423.

Wodyka, J. 1964. Precancerous states of the larynx. Pol. Tyg. Ted. 19: 91-94. Reviewed in Albert, R.E. 1979. The Carcinogen Assessment Group's Preliminary Risk Assessment on Cresols. Type I - Air Program. U.S. EPA.

More?...(Yes or No) --

---------<<< p-Cresol >>>---------

__VI.D. DRINKING WATER HA REFERENCES

None

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SYNONYMS

Substance Name -- p-Cresol
CASRN -- 106-44-5
Last Revised -- 08/22/88

More?...(Yes or No) --
106-44-5
p-Cresol
Cresol, para

Haworth, S., T. Lawlor, K. Mortelmans, W. Speck and E. Zeiger. 1983. Salmonella mutagenicity test results for 250 chemicals. Environ. Mutagen. 1: 3-142.

Kaiser, H. E. J. D. MacEwen, C. D. Haun, and E. R. Kinkead. 1977. Acute Toxicity and Skin Corrosion Data for some Organic and Inorganic Compounds and Aqueous Solutions. Toxicol. Appl. Pharmacol. 42(2): 417-423.

More?...(Yes or No) --

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Litton Bionetics. 1980b. Mutagenic evaluation of ortho-, meta- and para-cresol 33.3% each in the mouse lymphoma forward mutation assay -- Final report. Unpublished data submitted by the Cresol Task Force to the Office of Toxic Substances, U.S. EPA. FYI-OTS-0780-0079.

Litton Bionetics. 1980c. Mutagenic evaluation of sample containing 33.3% each of ortho-, meta- and para-cresol in the sister chromatid exchange assay with Chinese hamster ovary cells. -- Final report. Unpublished data submitted by the Cresol Task Force to the Office of Toxic Substances, U.S. EPA. FYI-OTS-0780-0079.

Litton Bionetics. 1980d. Evaluation of sample containing 33.3% each of ortho-, meta- and para-cresol in the primary rat hepatocyte unscheduled DNA assay. Unpublished data submitted by the Cresol Task Force to the Office of

More?...(Yes or No) --Toxic Substances, U.S. EPA. FYI-OTS-0780-0079.

Litton Bionetics. 1980e. Evaluation of sample containing 33.3% each of ortho-, meta- and para-cresol in the in vitro transformation of BALB/3T3 cells assay with activation by primary rat hepatocytes -- Final report. Unpublished data submitted by the Cresol Task Force to the Office of Toxic Substances, U.S. EPA. FYI-OTS-0780-0079.

Litton Bionetics. 1981a. Mutagenic evaluation of N50C-81-3 [o-cresol] in the Ames Salmonella/microsome plate test -- Final report. Unpublished data submitted by the Cresol Task Force to the Office of Toxic Substances, U.S. EPA. FYI-OTS-0981-0126.

Litton Bionetics. 1981b. Mutagenic evaluation of N50C-81-3 [o-cresol] in the mouse lymphoma forward mutation assay -- Final report. Unpublished data submitted by the Cresol Task Force to the Office of Toxic Substances, U.S. EPA. FYI-OTS-0981-0126.

Litton Bionetics. 1981c. Mutagenic evaluation of N50C-81-3 [o-cresol]

More?...(Yes or No) --

sister-chromatid-exchange assay with Chinese hamster ovary cells -- Final report. Unpublished data submitted by the Cresol Task Force to the Office of Toxic Substances, U.S. EPA. FYI-OTS-0981-0126.

Litton Bionetics. 1981d. Evaluation of N50C-81-3 [o-cresol] in the in vitro transformation of BALB/3T3 cells assay [without activation] -- Final report. Unpublished data submitted by the Cresol Task Force to the Office of Toxic

from: Dangerous Properties of Industrial Materials
 N. Irving Sax Sixth ED 1984

SYNS:

CREATINOLO-O-FOSFATO (ITALIAN)
CREATINOL-O-PHOSPHATE
1-(2-HYDROXYETHYL)-1-METHYLGUANIDINE DIHYDROGEN PHOSPHATE (ESTER)
N-METHYL-N-(BETA-HYDROXYAETHYL)GUANIDINE-O-PHOSPHATE (GERMAN)
N-METHYL-N-(BETA-HYDROXYETHYL)GUANIDINE-O-PHOSPHATE

TOXICITY DATA: 2	CODEN:
ipr-rat LD50:4800 mg/kg	ARZNAD 29,1449,79
ivn-rat LD50:1300 mg/kg	ARZNAD 29,1449,79
ipr-mus LD50:3000 mg/kg	ARZNAD 29,1449,79
ivn-mus LD50:1200 mg/kg	ARZNAD 29,1449,79
ipr-gpg LD50:3200 mg/kg	ARZNAD 29,1449,79
ivn-gpg LD50:1500 mg/kg	ARZNAD 29,1449,79

THR: MOD ipr, ivn. LOW ipr.
Disaster Hazard: When heated to decomp it emits very tox fumes of PO_x and NO_x.

CRESOL

CAS RN: 1319773 NIOSH #: GO 5950000
mf: C_7H_8O; mw: 108.15

Description (U.S.P. XVI): mixture of isomeric cresols obtained from coal tar, colorless or yellowish to brown-yellow or pinkish liquid, phenolic odor. mp: 10.9°-35.5°, bp: 191°-203°, flash p: 178°F, d: 1.030-1.038 @ 25°/25°, vap. press: 1 mm @ 38-53°, vap. d: 3.72.

SYNS:

ACIDE CRESYLIQUE (FRENCH)
CRESOLI (ITALIAN)
CRESYLIC ACID
HYDROXYTOLUOLE (GERMAN)
KRESOLE (GERMAN)
KRESOLEN (DUTCH)
KREZOL (POLISH)

TOXICITY DATA: 2	CODEN:
orl-rat LD50:1454 mg/kg	NTIS** PB214-270
orl-mus LD50:861 mg/kg	NTIS** PB214-270
skn-rbt LD50:2000 mg/kg	TXAPA9 42,417,77

Aquatic Toxicity Rating: TLm96:10-1 ppm WQCHM* 4,-,74.
TLV: Air: 5 ppm DTLVS* 4,106,80. Toxicology Review: 27ZTAP 3,42,69. OSHA Standard: Air: TWA 5 ppm (skin) (SCP-L) FEREAC 39,23540,74. Occupational Exposure to Cresol recm std: Air: TWA 10 mg/m3 NTIS**. "NIOSH Manual of Analytical Methods" vol 3 S167. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8(a) Preliminary Assessment Information Proposed Rule FERREAC 45,13646,80.
THR: MOD via oral and inhal routes. Cresol is similar to phenol in its action on the body, but it is less severe in its effects. It has corrosive action on the skin and mu mem. Systemic poisoning has rarely been reported, but it is possible that absorption may result in damage to the kidneys, liver and nervous system. The main hazard accompanying its use in industry lies in its action on the skin and mu mem, with production of severe chemical burns and dermatitis.
Fire Hazard: Mod, when exposed to heat or flame.
Explosion Hazard: Slight, in the form of vapor when exposed to heat or flame. Reacts violently with HNO_3, oleum, chlorosulfonic acid.
Explosive Range: 1.35% @ 300°F.

Disaster Hazard: Dangerous; when heated to [illegible] emits highly tox fumes; can react vigorously [illegible]dizing materials.
To Fight Fire: Foam, CO_2, dry chemical.

m-CRESOL

CAS RN: 108394 NIOSH #: GO [illegible]
mf: C_7H_8O; mw: 108.15

Colorless to yellowish liquid, phenolic odor. mp [illegible] bp: 202.8°, lel: 1.1% @ 302°F, flash p: 202°F, [illegible] @ 20°/4°, autoign. temp.: 1038°F, vap. press [illegible] @ 52.0°, vap. d: 3.72.

SYNS:

3-CRESOL
M-CRESYLIC ACID
1-HYDROXY-3-METHYLBENZENE
M-HYDROXYTOLUENE
M-KRESOL
M-METHYLPHENOL
3-METHYLPHENOL
M-OXYTOLUENE

TOXICITY DATA: 3	CODEN:
skn-rbt 517 mg/24H SEV	BIOFX* 3-5/69
eye-rbt 103 mg SEV	BIOFX* 3-5/69
skn-mus TDLo:2280 mg/kg/20W-I:NEO	CNREA8 19,413,59
orl-rat LD50:242 mg/kg	BIOFX* 3-5/69
skn-rat LD50:620 mg/kg	GTPZAB 18,58,74
scu-rat LDLo:900 mg/kg	HBTXAC 5,56,59
unk-rat LD50:350 mg/kg	JPETAB 51,227,34
orl-mus LD50:828 mg/kg	GTPZAB 18,58,74
ipr-mus LD50:168 mg/kg	HBTXAC 5,56,59
scu-mus LDLo:450 mg/kg	HBAMAK 4,1361,35
ivn-dog LDLo:150 mg/kg	HBTXAC 5,56,59
scu-cat LDLo:180 mg/kg	JPETAB 80,233,44
orl-rbt LDLo:1400 mg/kg	JPETAB 80,233,44
skn-rbt LD50:2050 mg/kg	BIOFX* 3-5/69
scu-rbt LDLo:500 mg/kg	HBAMAK 4,1361,35
ivn-rbt LDLo:280 mg/kg	JPETAB 80,233,44
ipr-gpg LDLo:100 mg/kg	HBAMAK 4,1361,35
scu-gpg LDLo:300 mg/kg	HBTXAC 5,56,59
scu-frg LDLo:250 mg/kg	HBAMAK 4,1361,35

TLV: Air: 5 ppm DTLVS* 3,61,71. *Toxicology Rev*[illegible] MUREAV 47(2),75,78. OSHA Standard: Air: TW[illegible] 5 ppm (skin) (SCP-L) FEREAC 39,23540,74. Occup[illegible]tional Exposure to Cresol recm std: Air: TWA 10 m[illegible] m3 NTIS**. Reported in EPA TSCA Inventory, 19[illegible] EPA TSCA 8(a) Preliminary Assessment Informati[illegible] Proposed Rule FERREAC 45,13646,80.
THR: An exper NEO. HIGH-MOD orl, skn, scu, un[illegible] ipr, ivn. SEV eye, skn irr in rbt. See cresol.
Fire Hazard: See cresol.
Explosion Hazard: Mod, in the form of vapor when ex[illegible]posed to heat or flame.
Disaster Hazard: See cresol.

o-CRESOL

CAS RN: 95487 NIOSH #: GO 6300000
mf: C_7H_8O; mw: 108.15

Crystals or liquid darkening with exposure to air and light. mp: 30.8°, bp: 190.8°, flash p: 178°F, d: 1.047 @ 20°/4°, autoign. temp.: 1110°F, vap. press: 1 mm [illegible] 38.2°, vap. d. 3.72, lel = 1.4% @ 300°F.

Enter keywords or Read or Scan or Mail
--

from: Dangerous Properties of Industrial Materials
N. Irving Sax Sixth Ed. 1984

SYNS:

CREATINOLO-O-FOSFATO (ITALIAN)
CREATINOL-O-PHOSPHATE
1-(2-HYDROXYETHYL)-1-METHYLGUANIDINE DIHYDROGEN PHOSPHATE (ESTER)
N-METHYL-N-(BETA-HYDROXYAETHYL)GUANIDINE-O-PHOSPHATE (GERMAN)
N-METHYL-N-(BETA-HYDROXYETHYL)GUANIDINE-O-PHOSPHATE

TOXICITY DATA: 2	CODEN:
ipr-rat LD50:4800 mg/kg	ARZNAD 29,1449,79
ivn-rat LD50:1300 mg/kg	ARZNAD 29,1449,79
ipr-mus LD50:3000 mg/kg	ARZNAD 29,1449,79
ivn-mus LD50:1200 mg/kg	ARZNAD 29,1449,79
ipr-gpg LD50:3200 mg/kg	ARZNAD 29,1449,79
ivn-gpg LD50:1500 mg/kg	ARZNAD 29,1449,79

THR: MOD ipr, ivn. LOW ipr.
Disaster Hazard: When heated to decomp it emits very tox fumes of PO_x and NO_x.

CRESOL

CAS RN: 1319773 NIOSH #: GO 5950000
mf: C_7H_8O; mw: 108.15

Description (U.S.P. XVI): mixture of isomeric cresols obtained from coal tar, colorless or yellowish to brown-yellow or pinkish liquid, phenolic odor. mp: 10.9°-35.5°, bp: 191°-203°, flash p: 178°F, d: 1.030-1.038 @ 25°/25°, vap. press: 1 mm @ 38-53°, vap. d: 3.72.

SYNS:

ACEDE CRESYLIQUE (FRENCH)
CRESOLI (ITALIAN)
CRESYLIC ACID
HYDROXYTOLUOLE (GERMAN)
KRESOLE (GERMAN)
KRESOLEN (DUTCH)
KREZOL (POLISH)

TOXICITY DATA: 2	CODEN:
orl-rat LD50:1454 mg/kg	NTIS** PB214-270
orl-mus LD50:861 mg/kg	NTIS** PB214-270
skn-rbt LD50:2000 mg/kg	TXAPA9 42,417,77

Aquatic Toxicity Rating: TLm96:10-1 ppm WQCHM* 4,-,74.
TLV: Air: 5 ppm DTLVS* 4,106,80. Toxicology Review: 27ZTAP 3,42,69. OSHA Standard: Air: TWA 5 ppm (skin) (SCP-L) FEREAC 39,23540,74. Occupational Exposure to Cresol recm std: Air: TWA 10 mg/m3 NTIS**. "NIOSH Manual of Analytical Methods" vol 3 S167. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8(a) Preliminary Assessment Information Proposed Rule FERREAC 45,13646,80.
THR: MOD via oral and inhal routes. Cresol is similar to phenol in its action on the body, but it is less severe in its effects. It has corrosive action on the skin and mu mem. Systemic poisoning has rarely been reported, but it is possible that absorption may result in damage to the kidneys, liver and nervous system. The main hazard accompanying its use in industry lies in its action on the skin and mu mem, with production of severe chemical burns and dermatitis.
Fire Hazard: Mod, when exposed to heat or flame.
Explosion Hazard: Slight, in the form of vapor when exposed to heat or flame. Reacts violently with HNO_3, oleum, chlorosulfonic acid.
Explosive Range: 1.35% @ 300°F.
Disaster Hazard: Dangerous; when heated to de[...] emits highly tox fumes; can react vigorously [...] dizing materials.
To Fight Fire: Foam, CO_2, dry chemical.

m-CRESOL

CAS RN: 108394 NIOSH #: GO [...]
mf: C_7H_8O; mw: 108.15

Colorless to yellowish liquid, phenolic odor. m[...] bp: 202.8°, lel: 1.1% @ 302°F, flash p: 202°F, [...] @ 20°/4°, autoign. temp.: 1038°F, vap. press[...] @ 52.0°, vap. d: 3.72.

SYNS:

3-CRESOL
m-CRESYLIC ACID
1-HYDROXY-3-METHYLBENZENE
m-HYDROXYTOLUENE
m-KRESOL
m-METHYLPHENOL
3-METHYLPHENOL
m-OXYTOLUENE

TOXICITY DATA: 3	CODEN:
skn-rbt 517 mg/24H SEV	BIOFX* 3-5/69
eye-rbt 103 mg SEV	BIOFX* 3-5/69
skn-mus TDLo:2280 mg/kg/20W-I:NEO	CNREA8 19,413,59
orl-rat LD50:242 mg/kg	BIOFX* 3-5/69
skn-rat LD50:620 mg/kg	GTPZAB 18,58,74
scu-rat LDLo:900 mg/kg	HBTXAC 5,56,59
unk-rat LD50:350 mg/kg	JPETAB 51,227,34
orl-mus LD50:828 mg/kg	GTPZAB 18,58,74
ipr-mus LD50:168 mg/kg	HBTXAC 5,56,59
scu-mus LDLo:450 mg/kg	HBAMAK 4,1361,35
ivn-dog LDLo:150 mg/kg	HBTXAC 5,56,59
scu-cat LDLo:180 mg/kg	JPETAB 80,233,44
orl-rbt LDLo:1400 mg/kg	JPETAB 80,233,44
skn-rbt LD50:2050 mg/kg	BIOFX* 3-5/69
scu-rbt LDLo:500 mg/kg	HBAMAK 4,1361,35
ivn-rbt LDLo:280 mg/kg	JPETAB 80,233,44
ipr-gpg LDLo:100 mg/kg	HBAMAK 4,1361,35
scu-gpg LDLo:300 mg/kg	HBTXAC 5,56,59
scu-frg LDLo:250 mg/kg	HBAMAK 4,1361,35

TLV: Air: 5 ppm DTLVS* 3,61,71. *Toxicology Re[...]* MUREAV 47(2),75,78. OSHA Standard: Air: TW[A] 5 ppm (skin) (SCP-L) FEREAC 39,23540,74. Occup[a]tional Exposure to Cresol recm std: Air: TWA 10 m[g/]m3 NTIS**. Reported in EPA TSCA Inventory, 19[80]. EPA TSCA 8(a) Preliminary Assessment Informat[ion] Proposed Rule FERREAC 45,13646,80.
THR: An exper NEO. HIGH-MOD orl, skn, scu, un[k], ipr, ivn. SEV eye, skn irr in rbt. See cresol.
Fire Hazard: See cresol.
Explosion Hazard: Mod, in the form of vapor when ex[...]posed to heat or flame.
Disaster Hazard: See cresol.

o-CRESOL

CAS RN: 95487 NIOSH #: GO 6300000
mf: C_7H_8O; mw: 108.15

Crystals or liquid darkening with exposure to air an[d] light. mp: 30.8°, bp: 190.8°, flash p: 178°F, d: 1.047 @ 20°/4°, autoign. temp.: 1110°F, vap. press: 1 mm @ 38.2°, vap. d. 3.72, lel = 1.4% @ 300°F.

...L	O-KRESOL (GERMAN)
...LIC ACID	O-METHYLPHENOL
...CRESOL	2-METHYLPHENOL
...OXY-2-METHYLBENZENE	O-OXYTOLUENE
...OXYTOLUENE	

...ICITY DATA: 3	CODEN:
... 524 mg/24H SEV	BIOFX* 4-5/69
... 105 mg SEV	BIOFX* 4-5/69
... TDLo:4800 mg/kg/12W-...NEO	CNREA8 19,413,59
... LD50:121 mg/kg	BIOFX* 4-5/69
... LD50:1100 mg/kg	GTPZAB 18,58,74
... LDLo:65 mg/kg	RMSRA6 15,561,1895
... LD50:344 mg/kg	GTPZAB 18,58,74
... LDLo:410 mg/kg	ZHINAV 64,113,1909
...dog LDLo:80 mg/kg	HBTXAC 5,56,59
...cat LDLo:55 mg/kg	JPETAB 80,233,44
...rbt LDLo:940 mg/kg	JPETAB 80,233,44
...rbt LD50:890 mg/kg	TXAPA9 42,417,77
...rbt LDLo:450 mg/kg	HBAMAK 4,1361,35
...rbt LDLo:180 mg/kg	JPETAB 80,233,44
...gpg LDLo:360 mg/kg	HBAMAK 4,1361,35
...frg LDLo:200 mg/kg	

TLV: Air: 5 ppm DTLVS* 3,61,71. *Toxicology Review:* MUREAV 47(2),75,78. OSHA Standard: Air: TWA 5 ppm (skin) (SCP-L) FEREAC 39,23540,74. Occupational Exposure to Cresol recm std: Air: TWA 10 mg/m3 NTIS**. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8(a) Preliminary Assessment Information Proposed Rule FERREAC 45,13646,80.
THR: HIGH oral and MOD dermal. See cresol. An exper NEO.
Fire Hazard: Mod via heat, flame, oxidants.
Explosion Hazard: See cresol.
Disaster Hazard: See cresol.
To Fight Fire: Water may be used to blanket fire; foam, fog, mist, dry chemical.

p-CRESOL

CAS RN: 106445 NIOSH #: GO 6475000
mf: C_7H_8O; mw: 108.15

Found in a score of essential oils, including Ylang-Ylang and Oil of Jasmine (FCTXAV 12,385,74)
Crystals, phenolic odor. mp: 35.5°, bp: 201.8°, lel = 1.1% @ 302°F, flash p: 202°F, d: 1.0341 @ 20°/4°, autoign. temp.: 1038°F, vap. press 1 mm @ 53.0°, vap. d: 3.72.

SYNS:

4-CRESOL	1-METHYL-4-HYDROXYBENZENE
p-CRESYLIC ACID	p-METHYLPHENOL
1-HYDROXY-4-METHYLBENZENE	4-METHYLPHENOL
p-HYDROXYTOLUENE	p-OXYTOLUENE
4-HYDROXYTOLUENE	PARA-CRESOL
p-KRESOL	PARAMETHYL PHENOL

TOXICITY DATA: 3	CODEN:
skn-rbt 517 mg/24H SEV	BIOFX* 5-5/69
eye-rbt 103 mg SEV	BIOFX* 5-5/69
skn-mus TDLo:2280 mg/kg/20W-I:NEO	CNREA8 19,413,59
orl-rat LD50:207 mg/kg	BIOFX* 5-5/69
skn-rat LD50:750 mg/kg	GTPZAB 18,58,74
scu-rat LDLo:500 mg/kg	HBTXAC 5,58,59
orl-mus LD50:344 mg/kg	GTPZAB 18,58,74
ipr-mus LD50:25 mg/kg	HBTXAC 5,58,59
scu-mus LDLo:150 mg/kg	HBAMAK 4,1361,35
unk-mus LD50:160 mg/kg	BJCAAI 6,160,52
scu-cat LDLo:80 mg/kg	JPETAB 80,233,44
orl-rbt LDLo:620 mg/kg	JPETAB 80,233,44
skn-rbt LD50:301 mg/kg	BIOFX* 5-5/69
scu-rbt LDLo:300 mg/kg	HBAMAK 4,1361,35
ivn-rbt LDLo:180 mg/kg	JPETAB 80,233,44
scu-gpg LDLo:200 mg/kg	HBTXAC 5,58,59
scu-frg LDLo:150 mg/kg	HBAMAK 4,1361,35

TLV: Air: 5 ppm DTLVS* 3,61,71. *Toxicology Review:* MUREAV 47(2),75,78. OSHA Standard: Air: TWA 5 ppm (skin) (SCP-L) FEREAC 39,23540,74. Occupational Exposure to Cresol recm std: Air: TWA 10 mg/m3 NTIS**. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8(a) Preliminary Assessment Information Proposed Rule FERREAC 45,13646,80.
THR: A SEV skn, eye irr in rbt. HIGH via oral and MOD via dermal routes. With 7,12-dimethyl benz (a)anthracene it is an exper NEO. See cresol.
Fire Hazard: Low, when exposed to heat or flame.
Spontaneous Heating: No.
Explosion Hazard: Mod, in the form of vapor when exposed to heat or flame.
Disaster Hazard: See cresol.
To Fight Fire: CO_2, dry chemical, alcohol foam.

o-CRESOLPHTHALEIN

CAS RN: 596270 NIOSH #: SM 8390000
mf: $C_{22}H_{18}O_4$; mw: 346.40

SYN: 3',3''-DIMETHYLPHENOLPHTHALEIN

TOXICITY DATA: 3	CODEN:
ivn-mus LD50:320 mg/kg	CSLNX* NX#02167

Reported in EPA TSCA Inventory, 1980.
THR: HIGH ivn.
Disaster Hazard: When heated to decomp it emits acrid smoke and irr fumes.

CROCIDOLITE (see also ASBESTOS)

CAS RN: 12001284 NIOSH #: GP 8225000

SYNS:

BLUE ASBESTOS	KROKYDOLITH (GERMAN)
CROCIODOLITE	

TOXICITY DATA: 3	CODEN:
cyt-ham:lng 5 mg/L/24H	MUREAV 57,225,78
msc-ham:lng 10 mg/L	MUREAV 68,265,79
ihl-rat TCLo:11 mg/m3/1Y-I:CAR	BJCAAI 29,252,74
ipr-rat TDLo:100 mg/kg:CAR	PBPHAW 14,47,78
scu-rat TDLo:112 mg/kg:CAR	ANYAA9 271,431,76
ipl-rat TDLo:100 mg/kg:CAR	BJCAAI 23,567,69
scu-mus TDLo:2400 mg/kg/12W-I:CAR	FCTXAV 6,566,68
ipl-mus TDLo:200 mg/kg:ETA	31BYAP -,97,74
ipl-rbt TDLo:8 mg/kg:ETA	ENVRAL 4,496,71
ipl-ham TDLo:83 mg/kg:NEO	31BYAP -,96,74
ipr-rat TD:90 mg/kg:ETA	ENVRAL 4,496,71
scu-rat TD:112 mg/kg:ETA	PBPHAW 14,47,78
ihl-rat TC:12 mg/m3/13W-I:NEO	RRCRBU 39,37,72
ipl-rat TD:10 mg/kg:NEO	JNCIAM 48,797,72
ipr-rat LDLo:300 mg/kg	AJPAA4 70,291,73

APPENDIX B

THESE COST FIGURES WERE USED TO DERIVE THE COST ESTIMATES FOR THE ALTERNATIVES IN THE PHASED FEASIBILITY STUDY

THE ALTERNATIVES INDICATED IN THIS APPENDIX DO NOT NECESSARILY CORRESPOND DIRECTLY TO PARTICULAR ALTERNATIVES IN THE TEXT

Remedial Alternatives for Tar Lake Superfund Site

Alternative 1

Excavation and onsite incineration of 30,000 cubic yards of tar and 20,000 cubic yards of contaminated soil with an excess cancer risk level greater than or equal to 1×10^{-2}.

Alternative 2

Insitu bioremediation of 20,000 cubic yards of contaminated soils with an excess cancer risk level less than 1×10^{-2}.

Alternative 3

Installation of a cap to contain the bioremediated soils over the 4 acres of Tar Lake.

Alternative 4

Excavation and transportation of 20,000 cubic yards of contaminated soils with an excess cancer risk of less than 1×10^{-2} to a solid waste landfill within 40 miles of the site.

Alternative 5

Excavation and treatment of 20,000 cubic yards of contaminated soils with an excess cancer risk of less than 1×10^{-2} with a solvent extraction process.

Alternative 6A

Construction of interim ground water extraction and treatment facilities to contain the contaminated ground water plume. The extraction and treatment facilities should be capable of handling 500 gallons per minute. The treatment facilities will utilize ozonation.

Alternative 6A(1) would have a ozonation feed rate of 80 mg/L. Alternative 6A(2) would have an ozonation feed rate of 200 mg/L.

Alternative 6B

Construction of interim ground water extraction and treatment facilities that are similar to Alternative 6A. The treatment facilities in Alternative 6A will utilize carbon rather than ozonation.

Assumptions Made to Determine Costs of Remedial Alternatives at Tar Lakes Superfund Site

Alternative 1

1. BTU value of tar is 10,000 BTU/pound.

2. BTU value of soil is 1,000 BTU/pound.

3. Density of tar is 75 pounds/cubic foot.

4. Density of soil is 100 pounds/cubic foot.

5. Foam will be sprayed on the contaminated tar to control air emissions during excavation.

6. Residue from incineration of tar and contaminated soil will be stored onsite and backfilled in Tar Lake after remediation is completed.

7. Unit cost to incinerate tar is higher than unit cost to incinerate soil because of the tar's higher BTU value.

8. Decontamination facilities constructed for Alternative 1 would be used for work performed for all of the alternatives.

Alternative 2

1. The extraction wells and water treatment facilities used to contain the contaminated ground water plume will be used as a source of water for the insitu bioremediation facilities.

2. Alternative 1 is implemented.

Alternative 3

1. Ash from incineration of tar and contaminated soil would be backfilled onsite prior to capping.

2. Alternative 1 is implemented.

Alternative 4

1. The transportation costs for transporting the contaminated soils to a sanitary landfill within 40 miles of the Tar Lake site is $3.00 per loaded mile.

2. Soil would be hauled in trucks having a capacity of 20 cubic yards.

3. Alternative 1 is implemented.

Alternative 5

1. The quantity of oil recovered in the solvent extraction process will be five percent of the weight of the soil treated.

2. The recovered oil will be incinerated onsite.

3. Alternative 1 is implemented.

Alternative 6A(1)

1. Water table is located at a depth of 15 feet.

2. Extraction wells are installed 15 feet below water table.

3. Ozone usage is 80 mg/L.

Alternative 6A(2)

1. Water table is located at a depth of 15 feet.

2. Extraction wells are installed 15 feet below water table.

3. Ozone usage is 200 mg/L.

Alternative 6B

1. Water table is located at a depth of 15 feet.
2. Extraction wells are installed 15 feet below water table.
3. Carbon usage is 2 pounds per 1000 gallons of water treated.
4. Hydraulic loading is 5 gpm/ft^2.

ALTERNATIVE 1
EXCAVATION/INCINERATION
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
MOBILIZATION/DEMOBILIZATION	1	LS	5000.00	$5,000	
MATERIAL HANDLING					
Excavate Tar and Soil	50,000	CU YD	50.00	2,500,000	
Health and Safety Equipment	1	LS	10000.00	10,000	
Confirmation Sampling	25	EA	350.00	8,750	
Foam for Air Emission Control	700,000	SQ FT	0.70	490,000	
				$3,009,000	
INCINERATION					
Mobilization/Demobilization	1	LS	800000.00	800,000	
Thermal Destruction					
-Tar	30,375	TON	600.00	18,225,000	
-Soil	27,000	TON	300.00	8,100,000	
				$27,125,000	
DISPOSAL OF RESIDUE					
Backfill/Compact	29,000	TON	2.50	72,500	
				$73,000	
SITE RESTORATION					
Borrow Fill	23,000	CU YD	12.00	276,000	
Topsoil, 6"	3,225	CU YD	18.40	59,340	
Grading	3,225	CU YD	1.20	3,870	
Revegetation	19,360	SQ YD	0.60	11,620	
				$351,000	
DECONTAMINATION STATION	1	LS	50000.00	$50,000	
ESTIMATED MAINTENANCE - Site Grading, Seeding, Mowing - YEAR 1-30					$1,900
GROUNDWATER MONITORING					
Years 1-5 (Quarterly)	20	MANDAY	600.00		12,000
Years 5-30 (Biannual)	10	MANDAY	600.00		6,000
					$18,000
SAMPLE ANALYSIS					
Years 1-5 (Quarterly)	12	EA	1500.00		18,000
Years 5-30 (Biannual)	6	EA	1500.00		9,000
					$27,000

ALTERNATIVE 1 (Continued)
EXCAVATION/INCINERATION
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
SUBTOTAL				$30,613,000	
BID CONTINGENCIES (15%)				4,592,000	
SCOPE CONTINGENCIES (15%)				4,592,000	
CONSTRUCTION TOTAL				$39,797,000	
PERMITTING AND LEGAL (3%)				1,194,000	
CONSTRUCTION SERVICES (5%)				1,990,000	
TOTAL IMPLEMENTATION COSTS				$42,981,000	
ENGINEERING DESIGN COSTS (5%)				2,149,000	
TOTAL CAPITAL COST				$45,130,000	
TOTAL ANNUAL COST					
Years 1-5					$31,900
Years 5-10					$16,900
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$45,455,000

NOTES:

Alternative consists of excavation and incineration of 30,000 cubic yards of tar and 20,000 cubic yards of contaminated soils with an excess cancer risk level of greater than or equal to 1×10^{-2}.

Costs to dewater area below Tar Lake are not included. If dewatering is requied, the present worth cost of a 2,200 gallon per minute activated sludge/carbon plant is $26,757,000.

ALTERNATIVE 2
INSITU BIOREMEDIATION
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
MOBILIZATION/DEMOBILIZATION	1	LS	5000.00	$5,000	
HEALTH AND SAFETY EQUIPMENT	1	LS	5000.00	$5,000	
EXTRACTION WELLS/TREATMENT (SEE NOTES)	-	-	-	-	
INJECTION WELLS	8	EA	10000.00	$80,000	
TRENCHING AND PIPING	1	LS	20000.00	$20,000	
OXYGEN AND NUTRIENT					
DELIVERY SYSTEM	1	LS	35000.00	$35,000	
PILOT STUDY	1	LS	30000.00	$30,000	
OPERATION AND MAINTENANCE					
Injection Well Labor	125	MD	600.00		$75,000
Analytical Costs	1	LS	2000.00		$2,000
Nutrients/O2	1	LS	3000.00		$3,000
Delivery System	1	LS	3000.00		$3,000
SUBTOTAL				$175,000	
BID CONTINGENCIES (15%)				$26,250	
SCOPE CONTINGENCIES (15%)				$26,250	
CONSTRUCTION TOTAL				$227,500	
PERMITTING AND LEGAL (3%)				6,800	
CONSTRUCTION SERVICES (5%)				118,200	
TOTAL IMPLEMENTATION COSTS				$252,500	
ENGINEERING DESIGN COSTS (8%)				20,200	
TOTAL CAPITAL COST				$272,700	
TOTAL ANNUAL COST					
Years 1-30					$83,000
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$1,548,600

NOTES:

Alternative consists of insitu bioremediation of 20,000 cubic yards of contaminated soils with an excess cancer risk of less than 1×10^{-2}.

Costs associated with excavation and incineration of tar and soils with an excess cancer risk greater than 1×10^{-2} would be incurred and would be the same as shown in Alternative 1.

The extraction wells and ground water treatment facilities used for containment of the ground water will be used as a source of water for this alternative. The costs associated with these facilities are identified in alternative 6 and are not included in this alternative.

ALTERNATIVE 3
CAPPING
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
MOBILIZATION/DEMOBILIZATION	1	LS	5000.00	$5,000	
CAP CONSTRUCTION					
Clay Cap, 3'	$19,360	CU YD	21.00	406,560	
Sand Drainage Layer, 2'	$12,900	CU YD	15.75	203,180	
Synthetic Cap, 40 mil	$174,240	CU YD	0.45	78,410	
Geotextile	$174,240	CU YD	0.20	34,850	
Off Site Borrow Soil, 2'	$12,900	CU YD	12.00	154,800	
Top Soil, 6"	$3,225	CU YD	18.40	59,340	
Revegetation	$19,360	CU YD	0.65	12,580	
				$949,720	
HEALTH AND SAFETY EQUIPMENT	1	LS	5000.00	$5,000	
ESTIMATED MAINTENANCE					
CAP grading, seeding mowing					$2,500
SUBTOTAL				$959,720	
BID CONTINGENCIES (15%)				143,960	
SCOPE CONTINGENCIES (15%)				143,960	
CONSTRUCTION TOTAL				$1,247,640	
PERMITTING AND LEGAL (3%)				37,430	
CONSTRUCTION SERVICES (5%)				99,810	
TOTAL IMPLEMENTATION COSTS				$1,384,880	
ENGINEERING DESIGN COSTS (8%)				110,790	
TOTAL CAPITAL COST				$1,495,670	
TOTAL ANNUAL COST					
Years 1-30					$2,500
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$1,534,100

NOTES:

Alternative consists of constructing a multilayer clay-synthetic membrane cap over the four acres of Tar Lake to cap the site if the insitu bioremediation alternative does not reduce the excess cancer risk in the lower soils to 1×10^{-2} levels.

Except for the costs for site restoration and maintenance, the costs associated with excavation and incineration of tar and soils having an excess cancer risk greater than 1×10^{-2} would be incurred and would be the same as shown in Alternative 1.

ALTERNATIVE 4
OFFSITE SOLID WASTE LANDFILL
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
MOBILIZATION/DEMOBILIZATION	1	LS	5000.00	$5,000	
MATERIAL HANDLING					
Excavate Soil	20,000	CU YD	50.00	1,000,000	
Health and Safety Equipment	1	LS	10000.00	10,000	
				$1,010,000	
MATERIAL LOADING					
Equipment Rental, 2 Loaders	4	MONTH	3625.00	14,500	
Hourly Operation	1,000	HOUR	13.00	13,000	
Labor, 5 people	1,280	HOUR	100.00	128,000	
Health and Safety Equipment	1	LS	10000.00	10,000	
				$165,500	
SITE RESTORATION					
Borrow for Excavated Area, Compacted	20,000	CU YD	12.00	$240,000	
TRANSPORTATION/DISPOSAL					
Transportation	20,000	CU YD	6.00	120,000	
Disposal	20,000	CU YD	25.00	500,000	
				$620,000	
SUBTOTAL				$2,040,500	
BID CONTINGENCIES (15%)				306,080	
SCOPE CONTINGENCIES (15%)				306,080	
CONSTRUCTION TOTAL				$2,652,660	
PERMITTING AND LEGAL (3%)				79,580	
CONSTRUCTION SERVICES (5%)				212,210	
TOTAL IMPLEMENTATION COSTS				$2,944,450	
ENGINEERING DESIGN COSTS (8%)				235,560	
TOTAL CAPITAL COST				$3,180,010	
TOTAL ANNUAL COST					
Years 1-30					$0
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$3,180,010

NOTES:

Alternative consists of excavation of 20,000 cubic yards of contaminated soils with an excess cancer risk of less than 1 x 10^{-2} and disposal in an offsite solid waste landfill within 40 miles of the Tar Lakes site.

Costs associated with excavation and incineration of tar and soils with an excess cancer risk greater than 1 x 10^{-2} would be incurred and would be the same as shown in Alternative 1.

ALTERNATIVE 5
ONSITE SOLVENT EXTRACTION
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
MOBILIZATION/DEMOBILIZATION	1	LS	10000.00	$10,000	
MATERIAL HANDLING					
Excavate Soil	20,000	CU YD	50.00	1,000,000	
Return Treated Soil to Pit	20,000	CU YD	2.50	50,000	
Health and Safety Equipment	1	LS	10000.00	10,000	
				$1,060,000	
SOLVENT EXTRACTION TREATMENT					
Pilot Study	1	LS	20000.00	20,000	
Soil Preparation	265	DAY	3800.00	1,007,000	
Treatment	27,000	TON	175.00	4,725,000	
				$5,752,000	
INCINERATION OF RECOVERED					
Oil	1,350	TON	600.00	$810,000	
SAMPLING AND ANALYSIS					
Confirmation Sampling	25	EA	350.00	$8,750	
SUBTOTAL				$7,640,750	
BID CONTINGENCIES (15%)				1,146,110	
SCOPE CONTINGENCIES (15%)				1,146,110	
CONSTRUCTION TOTAL				$9,932,970	
PERMITTING AND LEGAL (3%)				297,990	
CONSTRUCTION SERVICES (5%)				496,650	
TOTAL IMPLEMENTATION COSTS				$10,727,610	
ENGINEERING DESIGN COSTS (8%)				536,380	
TOTAL CAPITAL COST				$11,263,990	
TOTAL ANNUAL COST					$0
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$11,263,990

NOTES:

Alternative consists of excavation and treatment of 20,000 cubic yards of contaminated soil with an excess cancer risk of less than 1×10^{-6}. The soil will be treated by a solvent extraction process and disposed onsite. The oil recovered from the soil will be incinerated onsite.

Costs associated with excavation and incineration of tar and soils with an excess cancer risk greater than 1×10^{-2} would be incurred and would be the same costs presented in Alternative 1.

ALTERNATIVE 6A(1)
CONTAINMENT WELL SYSTEM/OZONATION SYSTEM
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
EXTRACTION WELLS					
Surveying/Staking	1	LS	1000.00	1,000	
Permitting/Utility Checks	1	LS	500.00	500	
Mobilization/Demobilization	1	LS	2500.00	2,500	
6 in. Well Boring and Installation	300	FT	75.00	22,500	
Geophysical and Analytical Testing	1	LS	5000.00	5,000	
Well Development	20	HR	100.00	2,000	
Equipment Decontamination	15	HR	100.00	1,500	
Standby	5	HR	100.00	500	
Drums	20	EACH	60.00	1,200	
RCRA Disposal of liquid and solid wastes	20	DRUM	200.00	4,000	
				$40,700	
EXTRACTION PIPING, PUMPS, WELL VAULTS					
Vaults	10	EACH	5000.00	50,000	
Pumps	10	EACH	3375.00	33,750	
Piping	1	LS	195000.00	195,000	
				$278,750	
TREATMENT SYSTEM					
Influent Holding Tank	1	LS	34100.00	34,100	
Feed Pump	1	LS	8600.00	8,600	
Ozonation System (80 mg/L O3)	1	LS	780000.00	780,000	
Effluent Tank	1	LS	22800.00	22,800	
Effluent Pump	1	LS	8600.00	8,600	
Effluent Piping	1	LS	78000.00	78,000	
				$932,100	
OPERATION & MAINTENANCE					
Extraction Well Pumps	1	LS	32700.00		32,700
Ozonation System (80 mg/L O3)	1	LS	198000.00		198,000
Feed Pump	1	LS	20400.00		20,400
Effluent Pump	1	LS	20400.00		20,400
					$271,500
SUBTOTAL-CAPITAL COST				$1,251,550	
BID CONTINGENCIES (15%)				188,000	
SCOPE CONTINGENCIES (15%)				188,000	
CONSTRUCTION TOTAL				$1,627,550	
PERMITTING AND LEGAL (3%)				244,000	
CONSTRUCTION SERVICES (5%)				244,000	
TOTAL IMPLEMENTATION COST				$2,115,550	
ENGINEERING DESIGN COSTS (5%)				317,000	
TOTAL CAPITAL COST				$2,432,550	
TOTAL ANNUAL COST					$271,500
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$6,606,170

ALTERNATIVE 6A(2)
CONTAINMENT WELL SYSTEM/OZONATION SYSTEM
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
EXTRACTION WELLS					
Surveying/Staking	1	LS	1000.00	1,000	
Permitting/Utility Checks	1	LS	500.00	500	
Mobilization/Demobilization	1	LS	2500.00	2,500	
6 in. Well Boring and Installation	300	FT	75.00	22,500	
Geophysical and Analytical Testing	1	LS	5000.00	5,000	
Well Development	20	HR	100.00	2,000	
Equipment Decontamination	15	HR	100.00	1,500	
Standby	5	HR	100.00	500	
Drums	20	EACH	60.00	1,200	
RCRA Disposal of liquid and solid wastes	20	DRUM	200.00	4,000	
				$40,700	
EXTRACTION PIPING, PUMPS, WELL VAULTS					
Vaults	10	EACH	5000.00	50,000	
Pumps	10	EACH	3375.00	33,750	
Piping	1	LS	195000.00	195,000	
				$278,750	
TREATMENT SYSTEM					
Influent Holding Tank	1	LS	34100.00	34,100	
Feed Pump	1	LS	8600.00	8,600	
Ozonation System (200 mg/L O3)	1	LS	3900000.00	3,900,000	
Effluent Tank	1	LS	22800.00	22,800	
Effluent Pump	1	LS	8600.00	8,600	
Effluent Piping	1	LS	78000.00	78,000	
				$4,052,100	
OPERATION & MAINTENANCE					
Extraction Well Pumps	1	LS	32700.00		32,700
Ozonation System (200 mg/L O3)	1	LS	660000.00		660,000
Feed Pump	1	LS	20400.00		20,400
Effluent Pump	1	LS	20400.00		20,400
					$733,500
SUBTOTAL-CAPITAL COST				$4,371,550	
BID CONTINGENCIES (15%)				656,000	
SCOPE CONTINGENCIES (15%)				656,000	
CONSTRUCTION TOTAL				$5,683,550	
PERMITTING AND LEGAL (3%)				853,000	
CONSTRUCTION SERVICES (5%)				853,000	
TOTAL IMPLEMENTATION COST				$7,389,550	
ENGINEERING DESIGN COSTS (5%)				1,108,000	
TOTAL CAPITAL COST				$8,497,550	
TOTAL ANNUAL COST					$733,500
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$19,773,243

ALTERNATIVE 6B
CONTAINMENT WELL SYSTEM/CARBON ADSORPTION SYSTEM
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
EXTRACTION WELLS					
Surveying/Staking	1	LS	1000.00	1,000	
Permitting/Utility Checks	1	LS	500.00	500	
Mobilization/Demobilization	1	LS	2500.00	2,500	
6 in. Well Boring and Installation	300	FT	75.00	22,500	
Geophysical and Analytical Testing	1	LS	5000.00	5,000	
Well Development	20	HR	100.00	2,000	
Equipment Decontamination	15	HR	100.00	1,500	
Standby	5	HR	100.00	500	
Drums	20	EACH	60.00	1,200	
RCRA Disposal of liquid and solid wastes	20	DRUM	200.00	4,000	
				$40,700	
EXTRACTION PIPING, PUMPS, WELL VAULTS					
Vaults	10	EACH	5000.00	50,000	
Pumps	10	EACH	3375.00	33,750	
Piping	1	LS	195000.00	195,000	
				$278,750	
TREATMENT SYSTEM					
Influent Holding Tank	1	LS	34100.00	34,100	
Feed Pump	1	LS	8600.00	8,600	
Carbon Adsorption System	1	LS	556000.00	556,000	
Effluent Tank	1	LS	22800.00	22,800	
Effluent Pump	1	LS	8600.00	8,600	
Effluent Piping	1	LS	78000.00	78,000	
				$708,100	
OPERATION & MAINTENANCE					
Extraction Well Pumps	1	LS	32700.00		32,700
Carbon Adsorption System (2 lb carbon/1000 gal)	1	LS	574300.00		574,300
Feed Pump	1	LS	20400.00		20,400
Effluent Pump	1	LS	20400.00		20,400
					$647,800
SUBTOTAL-CAPITAL COST				$1,027,550	
BID CONTINGENCIES (15%)				154,000	
SCOPE CONTINGENCIES (15%)				154,000	
CONSTRUCTION TOTAL				$1,335,550	
PERMITTING AND LEGAL (3%)				200,000	
CONSTRUCTION SERVICES (5%)				200,000	
TOTAL IMPLEMENTATION COST				$1,735,550	
ENGINEERING DESIGN COSTS (5%)				260,000	
TOTAL CAPITAL COST				$1,995,550	
TOTAL ANNUAL COST					$647,800
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$11,953,824

DEWATERING WELL SYSTEM / ACTIVATED SLUDGE SYSTEM / CARBON ADSORPTION SYSTEM
TAR LAKE SUPERFUND SITE

ITEM	QUANTITY	UNITS	UNIT COST $	CAPITAL COST $	ANNUAL COST $
EXTRACTION WELLS					
Surveying/Staking	1	LS	1000.00	1,000	
Permitting/Utility Checks	1	LS	500.00	500	
Mobilization/Demobilization	1	LS	2500.00	2,500	
12 in. Well Boring and Installation	330	FT	100.00	33,000	
	275	FT	125.00	34,375	
Geophysical and Analytical Testing	1	LS	5000.00	5,000	
Well Development	44	HR	100.00	4,400	
Equipment Decontamination	15	HR	100.00	1,500	
Standby	5	HR	100.00	500	
Drums	44	EACH	60.00	2,640	
RCRA Disposal of liquid and solid wastes	44	DRUM	200.00	8,800	
				$94,215	
EXTRACTION PIPING, PUMPS, WELL VAULTS					
Vaults	11	EACH	5000.00	55,000	
Pumps	11	EACH	8750.00	96,250	
Piping	1	LS	291000.00	291,000	
				$442,250	
TREATMENT SYSTEM					
Influent Holding Tank	1	LS	75800.00	75,800	
Feed Pump	1	LS	23400.00	23,400	
Activated Sludge System	1	LS	4850000.00	4,850,000	
Carbon Adsorption System	1	LS	915000.00	915,000	
Effluent Tank	1	LS	53100.00	53,100	
Effluent Pump	1	LS	23400.00	23,400	
Effluent Piping	1	LS	116000.00	116,000	
				$6,056,700	
OPERATION & MAINTENANCE					
Extraction Well Pumps	1	LS	144000.00		144,000
Activated Sludge System	1	LS	392000.00		392,000
Carbon Adsorption System (0.05 lb carbon/1000 gal)	1	LS	159000.00		159,000
Feed Pump	1	LS	106000.00		106,000
Effluent Pump	1	LS	106000.00		106,000
					$907,000
SUBTOTAL-CAPITAL COST				$6,593,165	
BID CONTINGENCIES (15%)				989,000	
SCOPE CONTINGENCIES (15%)				989,000	
CONSTRUCTION TOTAL				$8,571,165	
PERMITTING AND LEGAL (3%)				1,286,000	
CONSTRUCTION SERVICES (5%)				1,286,000	
TOTAL IMPLEMENTATION COST				$11,143,165	
ENGINEERING DESIGN COSTS (5%)				1,671,000	
TOTAL CAPITAL COST				$12,814,165	
TOTAL ANNUAL COST					$907,000
TOTAL PRESENT WORTH (30 YEARS, 5% DISCOUNT RATE)					$26,756,978

Remedial Alternatives

For

Tar Lake Superfund Site

Alternative 7A

Excavation and disposal of 30,000 cubic yards of tar and 40,000 cubic yards of contaminated soil at an approved hazardous waste landfill.

Alternative 7B

Excavation and disposal of 30,000 cubic yards of tar and 20,000 cubic yards of contaminated soil at an approved hazardous waste landfill.

Alternative 8

Excavation and disposal of 30,000 cubic yards of tar and 40,000 cubic yards of contaminated soils on-site in two adjoining RCRA containment cells.

Assumptions made to determine costs of remedial alternatives at Tar Lake Superfund Site

Alternative 7A

1) Tar Material can be excavated/handled with conventional earth excavation equipment.

2) Density of tar is 75 pounds/cubic feet.

3) Density of soil is 100 pounds/cubic feet.

4) Foam will be sprayed on the tar to control air emissions during excavation.

5) The transportation costs for transporting the contaminated soils and tar to a hazardous waste landfill within 250 miles of the Tar Lake site is $3.00 per loaded mile.

6) The contaminated soil and tar can be mixed with conventional earth excavation equipment and the soil/tar mixture will be acceptable at a hazardous waste landfill with no further stabilization.

7) The soil/tar mixture will be hauled in trucks having a capacity of 20 cubic yards.

Alternative 7B

1) All unit costs are the same as Alternative 7A.
2) All assumptions used in Alternative 7A apply to this alternative.

Alternative 8

1) Cells are constructed separately at two different time intervals.
2) Tar material can be excavated and placed in the proposed RCRA cell using conventional soil excavation equipment.

Alternative 7A

Excavation/Disposal at a Hazardous Waste Landfill

70000 Cubic Yards

Tar Lake Superfund Site

ITEM	QUANTITY	UNITS	UNIT COST	CAPITAL COST	ANNUAL COST
Mobilization	1	LS	5000.00	5,000	
Material Handling					
Tar Excavation	30000	CU YD	50.00	1,500,000	
Soil Excavation	40000	CU YD	50.00	2,000,000	
Soil/Tar Mixing	70000	CU YD	75.00	5,250,000	
Health & Safety Equipment	1	LS	10000.00	10,000	
Foam Air Emission Control	700000	SQ FT	0.70	490,000	
Confirmation Sampling	25	EA	350.00	8,800	
Material Loading					
Equip Rental 4 Loaders	6	MONTHS	7250.000	43,500	
Hourly Operation	2900	HOURS	13.00	37,700	
Labor, 7 people	1000	HOURS	140.00	140,000	
Health & Safety Equipment	1	LS	10000.00	10,000	
Transportation/Disposal					
Transportation	70000	CU YD	37.50	2,625,000	
Disposal	70000	CU YD	160.00	11,200,000	
SUBTOTAL				$23,320,000	
Bid Contingencies (15%)				3,498,000	
Scope Contingencies (15%)				3,498,000	
Construction Total				30,316,000	
Permitting and Legal (3%)				909,500	
Construction Services (5%)				1,516,000	
Total Implementation Costs				32,741,500	
Engineering Design Costs (8%)				2,620,000	
Total Capital Cost				$ 35,361,500	
Total Annual Cost Years 1-30					$ 0
Total Present Worth (30 yrs, 5% discount rate)					$35,361,500

Alternative 7B

Excavation/Disposal at a Hazardous Waste Landfill

50000 Cubic Yards

Tar Lake Superfund Site

ITEM	QUANTITY	UNITS	UNIT COST	CAPITAL COST	ANNUAL COST
Mobilization	1	LS	5000.00	5,000	
Material Handling					
Tar Excavation	30000	CU YD	50.00	1,500,000	
Soil Excavation	20000	CU YD	50.00	1,000,000	
Soil/Tar Mixing	50000	CU YD	75.00	3,750,000	
Health & Safety Equipment	1	LS	10000.00	10,000	
Foam Air Emission Control	700000	SQ FT	0.70	490,000	
Confirmation Sampling	25	EA	350.00	8,800	
Material Loading					
Equip Rental 4 Loaders	4	MONTHS	7250.000	29,000	
Hourly Operation	2000	HOURS	13.00	26,000	
Labor, 7 people	650	HOURS	140.00	91,000	
Health & Safety Equipment	1	LS	10000.00	10,000	
Transportation/Disposal					
Transportation	50000	CU YD	37.50	1,875,000	
Disposal	50000	CU YD	160.00	8,000,000	
SUBTOTAL				$16,794,800	
Bid Contingencies (15%)				2,519,000	
Scope Contingencies (15%)				2,519,000	
Construction Total				21,832,800	
Permitting and Legal (3%)				655,000	
Construction Services (5%)				1,092,000	
Total Implementation Costs				23,579,800	
Engineering Design Costs (8%)				1,886,400	
Total Capital Cost				$ 25,466,200	
Total Annual Cost Years 1-30					$ 0
Total Present Worth (30 yrs, 5% discount rate)					$25,466,200

Alternative 8

On-Site RCRA Cell Disposal

Tar Lake Superfund Site

ITEM	QUANTITY	UNITS	UNIT COST	CAPITAL COST	ANNUAL COST
Mobilization/Demobilization	1	LS	2200.00	2,200	
Landfill Construction - Cell One					
Excavation Cell Area	53,556	CU YD	4.21	225,500	
Clay, Liner and Cap	29,000	CU YD	22.00	638,000	
Sand, Leak Detection and Cap	14,000	CU YD	16.50	231,000	
Top Soil	4,800	CU YD	19.80	95,000	
Synthetic Liners (Base and Cap, 40 ml)	388,200	FT^2	0.44	170,800	
Geotextile Filter Fabric	242,000	FT^2	0.22	53,200	
Collector Pipe, 6" PVC	3,600	FT	5.50	19,800	
Manhole	2	EA	2200.00	4,400	
Sump	1	EA	2200.00	2,200	
Revegetation	14,833	SQ YD	0.66	9,800	
Drainage Channel	1,450	FT	4.95	7,200	
Monitoring Wells (3)	180	IN FT	126.50	22,800	
Waste Placement and Compaction	30,000	CU YD	4.40	132,000	
Protective Clothing	100	SET	33.00	3,300	
				$1,615,000	
Material Handling					
Excavate Tar	30,000	CU YD	50.00	1,500,000	
Protective Clothing	400	SET	33.00	13,200	
Foam for Air Emission Control	300,000	SQ FT	0.70	210,000	
Confirmation Sampling	25	EA	350.00	8,800	
				$1,732,000	
SUBTOTAL (CELL ONE)				$3,349,200	

Alternative 8

On-Site RCRA Cell Disposal

Tar Lake Superfund Site

ITEM	QUANTITY	UNITS	UNIT COST	CAPITAL COST
Mobilization/Demobilization	1	CU YD	2200.00	2,200
Landfill Construction - Cell Two				
Excavate Cell Area	70,852	CU YD	4.21	298,300
Clay, Liner and Cap	37,377	CU YD	22.00	822,300
Sand, Leak Detection and Cap	18,014	CU YD	16.50	297,000
Top Soil	6,135	CU YD	19.80	121,500
Synthetic Liners(Base & Cap, 40 ml)	502,991	SQ FT	0.44	221,300
Geotextile Filter Fabric	315,220	SQ FT	0.22	69,400
Collector Pipe, 6" PVC	2	FT	5.50	26,600
Manhole	1	EA	2,200.00	4,400
Sump	18,405	EA	2,200.00	2,200
Revegetation	1,650	SQ YD	0.66	12,100
Drainage Channel	180	FT	4.95	8,200
Monitor Wells (3)	40,000	LN FT	126.50	22,800
Waste Placement and Composition	100	CU YD	4.40	176,000
Protective Clothing		SET	33.00	3,300
				$2,085,400
Material Handling				
Excavate Contaminated Soil	40,000	CU YD	50.00	2,000,000
Protective Clothing	400	SET	33.00	13,200
Confirmation Sampling	25	EA	350.00	8,800
				$2,022,000
SUBTOTAL (CELL TWO)				$4,109,600