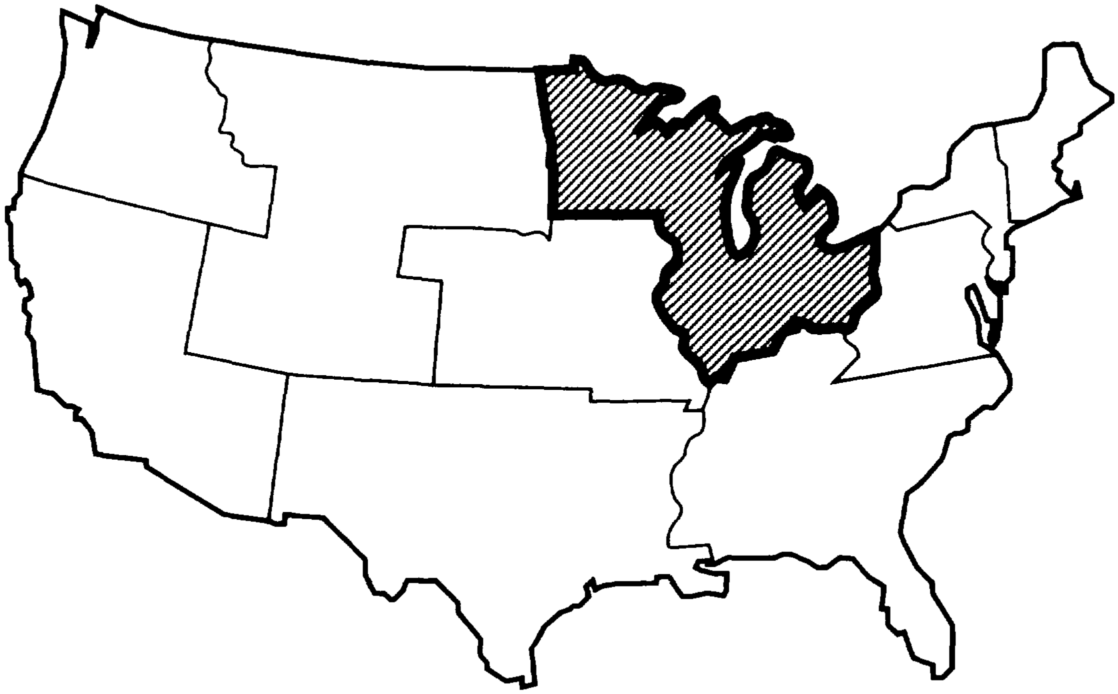
ARCS V

Remedial Activities at Uncontrolled Hazardous Waste Sites in Region V

EPA United States Environmental Protection Agency

Final Risk Assessment

Tomah Municipal Sanitary Landfill
Tomah, Wisconsin



CH2M HILL

6/12/96

Final Risk Assessment

Tomah Municipal Sanitary Landfill
Tomah, Wisconsin

WA No. 80-5P3F/Contract No. 68-WA-0040

June 12, 1996

Prepared by

CH2M HILL

CH2M HILL
Engineers
Planners
Economists
Scientists

June 12, 1996

104195.01.PM

Mr. Matt Mankowski/WAM
U.S. Environmental Protection Agency, Region 5
77 West Jackson Boulevard (HSRW-6J)
Chicago, IL 60604-3590

Dear Matt:

Subject: Final Risk Assessment Submittal
Tomah Municipal Sanitary Landfill, WI
WA No. 80-5P3F
Contract No. 68-W8-0040

Please find attached three copies of the Final Risk Assessment for the Tomah Municipal Sanitary Landfill. As we've discussed, I've also sent copies directly to Wendy Anderson/WDNR and Kim Bro/WDH.

If you have any questions, please call me at (414) 272-1052, ext. 469. Thank you.

Sincerely,

CH2M HILL

Jewelle I. Keiser
Site Manager

Attachment
MKE/10016B50.DOC
cc: Stephen Nathan, PO/USEPA (w/o encl.)
Peggy Hendrixson, CO/U.S, EPA (w/o encl.)
Cindy Boyd, Human Health Risk Assessor/MKE
Mike Mischuk, Eco Risk Assessor/MKE
Alpheus Sloan III, p.m./MKE
Ike Johnson, APM-OPNS/MKE
John Fleissner, QAM/MKE
Steve Keith, RTL/MKE
Wendy Anderson/WDNR
Kim Bro/WDH
Gail Gill, AA/MKE
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Executive Summary

Introduction

This report presents the results of the human health and ecological risk assessments performed by CH2M HILL for the U. S. Environmental Protection Agency (EPA) at the Tomah Municipal Sanitary Landfill (TMSL) site in Tomah, Monroe County, Wisconsin (WA No. 80-5P3F). The purpose of the risk assessments is to evaluate the potential existing and future threats to public health and the environment assuming that a source control remedy (i.e., a landfill cap and gas collection system) will be implemented on the landfill and that no additional corrective actions will take place under the most reasonably expected future use of Deer Creek and adjacent wetlands.

The risk assessments were based on the information of the physical site setting and the analytical results as presented in the *Remedial Investigation Draft Final Report* prepared by Dames & Moore (January 1996). The ecological setting is based on an ecological survey performed by CH2M HILL in September 1994.

Site Description

History

The City of Tomah (City) owns and formerly operated the solid waste landfill from 1959 to 1977. An unknown quantity of residential, commercial, and industrial wastes were disposed of at the site. The waste containment area, which encompassed 18 acres of the 40-acre site, consisted of shallow trenches excavated in sandy soil which were covered with native sandy soil and topsoil, and planted with grass. Union Camp Corporation reportedly disposed of 75,700 gallons of solvent wastes from plastics and printing operations in the landfill from 1960 to 1977.

Physical Setting

The TMSL is a 40-acre site bounded by Deer Creek and its associated wetland to the north; 24th Avenue and agricultural property to the east; single family/duplex residential properties and a mobile home park to the southeast; Sunnyvale Subdivision to the south; and agricultural fields and wetlands to the west. The landfill is currently covered by grass, brush, and rows of planted immature red and white pine trees.

Currently, the TMSL site is zoned conservancy. The areas to the north, east, and west are classified as vacant or agricultural. The agricultural land located to the east is currently not used; the land to the west of the landfill is used as pasture. A trailer park and additional residential development activities have recently been added to the north and northeast of the site.

ES-2 RISK CHARACTERIZATION SUMMARY

Land use	Receptor	Media	Route	Cancer Risk	Hazard Index
Recreational	Adult	Surface Water	Dermal	5×10^{-8}	0.005
		Sediment	Dermal	3×10^{-9}	0.0001
	Child	Surface Water	Dermal	1×10^{-8}	0.008
		Sediment	Dermal	6×10^{-9}	0.0001
Residential	Adult	Groundwater	Ingestion	3×10^{-2}	135
			Inhalation	2×10^{-4}	0.01
			Dermal	8×10^{-2}	2.3
			Total	3×10^{-2}	137
	Child	Groundwater	Ingestion	1×10^{-2}	315
			Inhalation	2×10^{-4}	0.1
			Dermal	3×10^{-4}	5
			Total	1×10^{-2}	320

A 1×10^{-6} excess lifetime cancer risk level or lower is generally considered to be a level at which cancer is not distinguishable from naturally occurring cancers. A hazard index of less than 1.0 indicates that observable adverse health effects due to exposure is unlikely.

In general, the majority of the predicted potential health impacts were associated with exposure to contaminants detected in groundwater. Dermal exposures to contaminants in the surface water and sediment resulted in excess lifetime cancer risks below 1×10^{-6} and hazard indices below 1 for recreational receptors. Contaminants in groundwater were evaluated for residential ingestion, inhalation, and dermal exposures. The total excess lifetime cancer risk for adult residents was 3×10^{-2}, while that for child residents was 1×10^{-2}. The adult resident's hazard index was 139 and the child's hazard index was estimated to be 325. Ingestion of groundwater contaminants (i.e., vinyl chloride) resulted in the majority of the estimated risk and hazard.

The total overall risk for adult residents using the groundwater and utilizing the wetlands for fishing or other recreational activities is 3×10^{-2}, while that for the child is 1×10^{-2}. The risk is primarily due to the presence of vinyl chloride in the groundwater.

It should be noted that at least two exposure pathways were not evaluated quantitatively in this baseline human health risk assessment. Because no soil samples were collected from the landfill itself and a source control action has been proposed, no assessment of risk to persons having contact with landfill soil and contents were estimated. However, hazardous material are present in the landfill that could pose some level of hazard should exposure occur.

Sampling from gas probes has confirmed the presence of landfill gases including VOCs. These gases have been found to contain vinyl chloride, 1,2-dichloroethene, 1,1,1-

The soil pathway was not addressed because the analytical data was not collected for surface soil on the landfill during the RI. In addition, it was assumed that the proposed source control action (landfill cap and gas collection system) and maintenance would adequately prevent access to COPCs by terrestrial organisms.

The groundwater pathway was also not addressed. Based on the hydrogeologic data in the RI, the shallow groundwater discharges to Deer Creek and its associated wetlands. Thus, the exposure to COPCs in the groundwater would occur through the surface water pathway, not directly from groundwater.

Exposure and risk to aquatic organisms was evaluated by directly comparing surface water and sediment exposure dose to National Ambient Water Quality Criteria, state standards, or other literature based benchmark values. Based on this analysis, cobalt and manganese in surface water were the only metals found that would potentially pose a risk to aquatic organisms.

Terrestrial organisms associated with the TMSL were not considered at risk based on literaturederived benchmark values.

Actual damage to the aquatic and terrestrial ecosystem of Deer Creek and the adjacent wetlands were not observed. Based on this analysis, ecological effects from TMSL contaminants are considered nonexistent at this time. However, this assessment does not preclude the possibility that future impacts could occur to the aquatic and terrestrial resources of Deer Creek area from potentially contaminated groundwater reaching the surface water system.

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SECTION 1

Introduction

This report presents the results of the human health and ecological risk assessments performed by CH2M HILL for the U.S. Environmental Protection Agency (EPA) at the Tomah Municipal Sanitary Landfill (TMSL) site in Tomah, Monroe County, Wisconsin (WA No. 80-5P3F). The purpose of the risk assessment is to evaluate the potential existing and future threats to public health and the environment, assuming that a source control remedy (i.e., landfill cap and gas collection) will be implemented. Guidelines for conducting the baseline human health risk assessments are provided in EPA's *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual* (Part A) (EPA 1989) and *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual* (Part B) (EPA 1991). In this risk assessment, these guidance documents are referred to as RAGS Parts A and B. Guidelines for conducting ecological risk assessments are provided in EPA's *Framework for Ecological Risk Assessments* (1992).

This risk assessment consists of four sections and four supporting appendixes. Section 1 summarizes the site history and the findings of the Phase I and II investigations as presented in the *Remedial Investigation Draft Final Report* (Dames & Moore 1996). Sections 2 and 3 present the results of the human health assessment and ecological risk assessment, respectively. Section 4 presents a list of the references cited.

Site Background

Site Description

The TMSL is a 40-acre site located in the SW1/4 of the NE1/4 of Section 32, Township 18N, Range 1W in the City of Tomah, Monroe County, Wisconsin (Figure 1-1). The landfill occupies approximately 18 acres within the 40-acre site (Figure 1-2). The site is bounded by Deer Creek and its associated wetland to the north; 24th Avenue (also referred to as Noth Avenue or County Trunk Highway E) and agricultural property to the east; single family/duplex residential properties and a mobile home park to the southeast; Sunnyvale Subdivision to the south; and agricultural fields and wetlands to the west. The landfill is currently covered by grass, brush, and rows of planted immature red and white pine trees.

Site History

The City of Tomah (City) owns and formerly operated the solid waste landfill from 1959 to 1977. An unknown quantity of residential, commercial, and industrial wastes were disposed in about 18-acres in the southern half of the site. Wastes were placed in shallow (3 to 8 feet) unlined trenches in the sandy soil, and covered with native soil.

In August 1975, the Wisconsin Department of Natural Resources (WDNR) ordered the City to abandon the landfill alleging potential degradation of local groundwater quality. In February 1976, the City submitted an abandonment plan to the WDNR. The site was closed

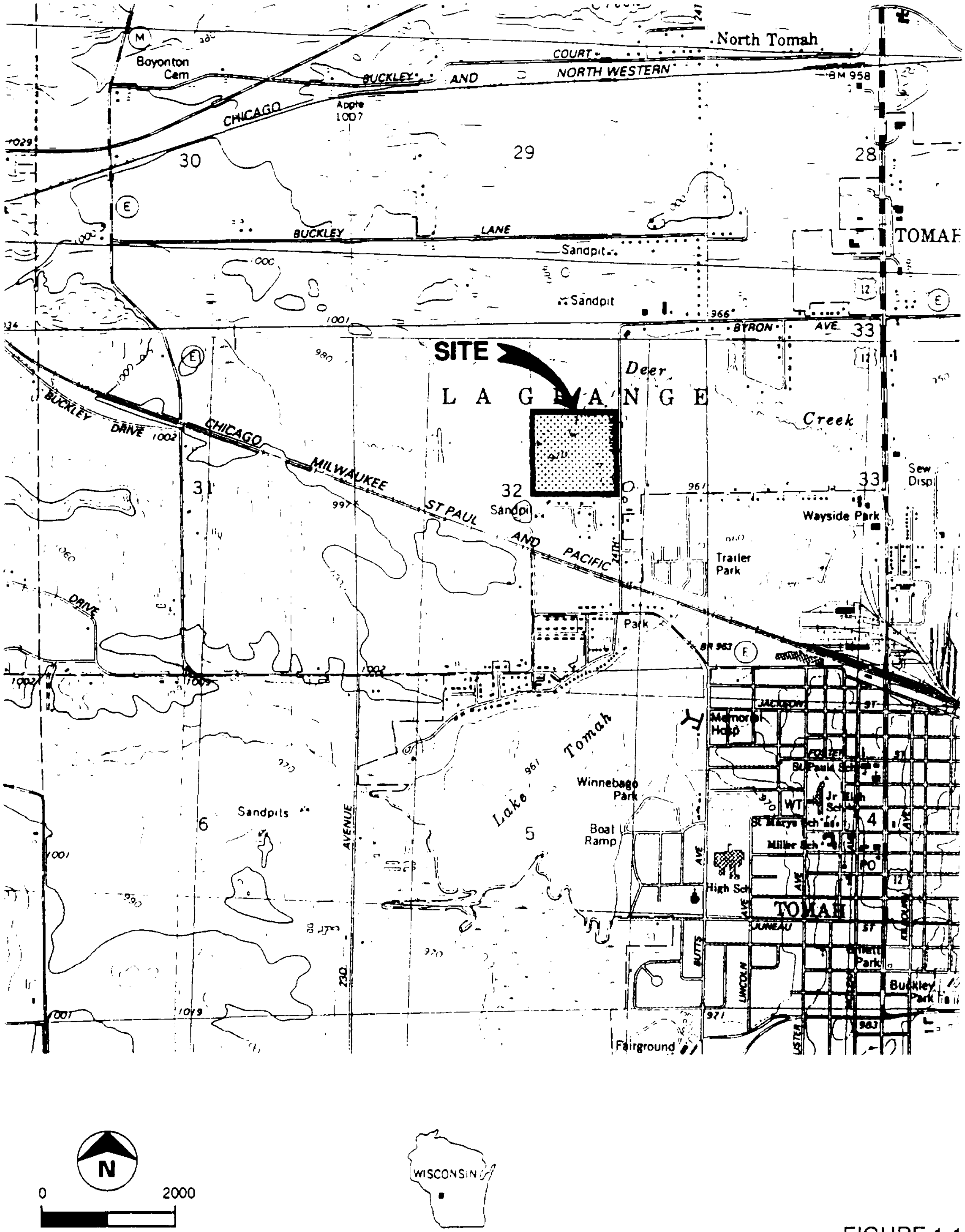
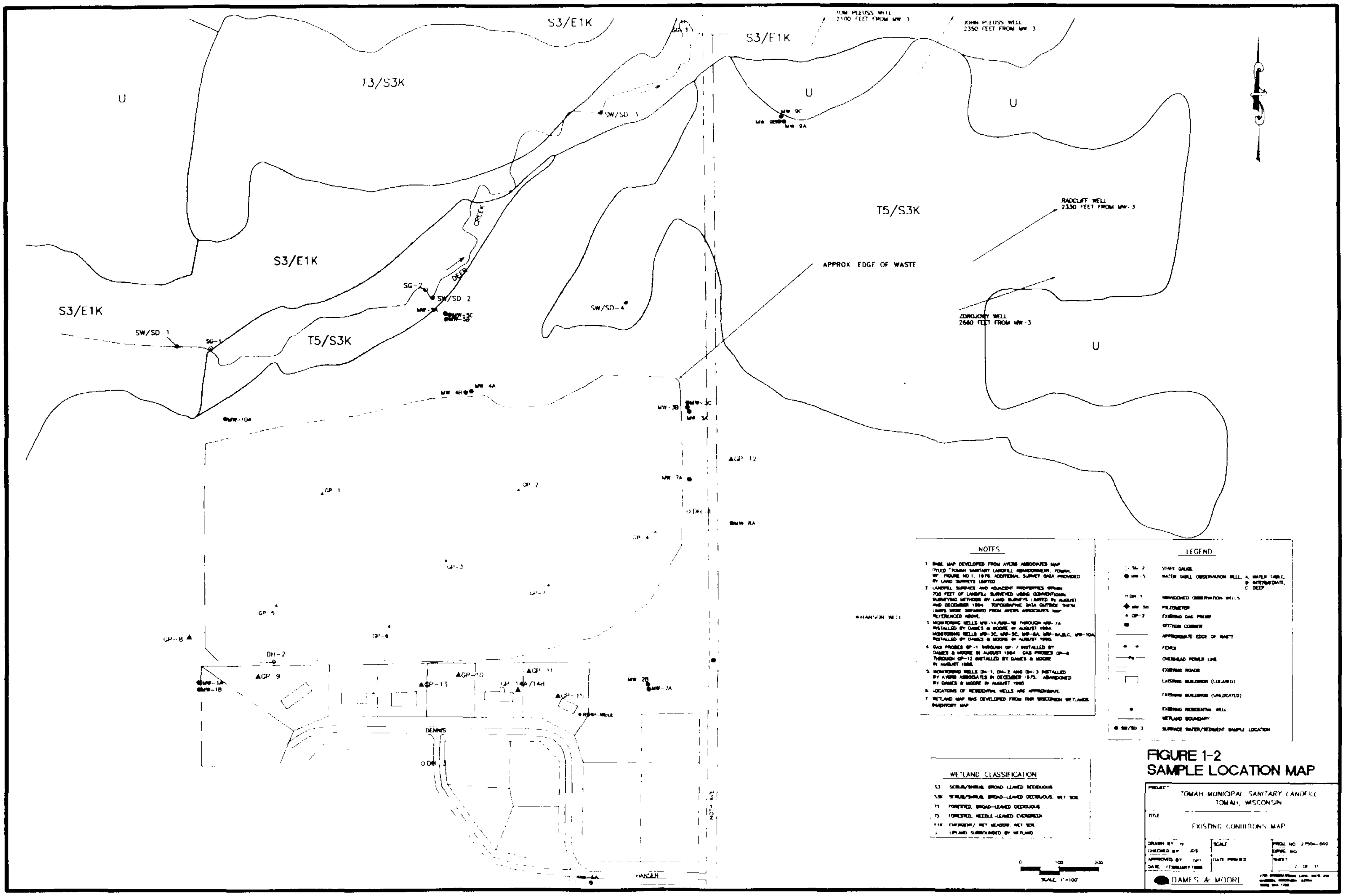


FIGURE 1-1

Site Location Map

Tomah Muncipal Sanitary
Landfill Risk Assessment Report

CH2MHILL



NOTES

1. BASE MAP DEVELOPED FROM AYERS ASSOCIATES MAP TITLED "TOMAH SANITARY LANDFILL ABANDONMENT, TOMAH, WI", FIGURE NO 1, 1976. ADDITIONAL SURVEY DATA PROVIDED BY LAND SURVEYS LIMITED
2. LANDFILL SURFACE AND ADJACENT PROPERTIES WITHIN 200 FEET OF LANDFILL SURVEYED USING CONVENTIONAL SURVEYING METHODS BY LAND SURVEYS LIMITED IN AUGUST AND DECEMBER 1994. TOPOGRAPHIC DATA OUTSIDE THESE LIMITS WERE OBTAINED FROM AYERS ASSOCIATES MAP REFERENCED ABOVE.
3. MONITORING WELLS MW-1A/MW-1B THROUGH MW-7A INSTALLED BY DAMES & MOORE IN AUGUST 1994. MONITORING WELLS MW-3C, MW-5C, MW-8A, MW-9A,B,C, MW-10A INSTALLED BY DAMES & MOORE IN AUGUST 1995.
4. GAS PROBES GP-1 THROUGH GP-7 INSTALLED BY DAMES & MOORE IN AUGUST 1994. GAS PROBES GP-8 THROUGH GP-12 INSTALLED BY DAMES & MOORE IN AUGUST 1995.
5. MONITORING WELLS DH-1, DH-2 AND DH-3 INSTALLED BY AYERS ASSOCIATES IN DECEMBER 1975. ABANDONED BY DAMES & MOORE IN AUGUST 1995.
6. LOCATIONS OF RESIDENTIAL WELLS ARE APPROXIMATE.
7. WETLAND MAP WAS DEVELOPED FROM DNR WISCONSIN WETLANDS INVENTORY MAP

LEGEND

SG-2	STAFF GAUGE
● MW-5	WATER TABLE OBSERVATION WELL. A. WATER TABLE, B. INTERMEDIATE, C. DEEP
○ DH-1	ABANDONED OBSERVATION WELLS
◆ MW 5B	PIEZOMETER
▲ GP-2	EXISTING GAS PROBE
■	SECTION CORNER
	APPROXIMATE EDGE OF WASTE
	FENCE
	OVERHEAD POWER LINE
	EXISTING ROADS
	EXISTING BUILDINGS (LOCATED)
	EXISTING BUILDINGS (UNLOCATED)
●	EXISTING RESIDENTIAL WELL
	WETLAND BOUNDARY
● SW/SD 2	SURFACE WATER/SEDIMENT SAMPLE LOCATION

WETLAND CLASSIFICATION

S3	SCRUB/SHRUB, BROAD LEAVED DECIDUOUS
S3K	SCRUB/SHRUB, BROAD-LEAVED DECIDUOUS, WET SOIL
T3	FORESTED, BROAD-LEAVED DECIDUOUS
T5	FORESTED, NEEDLE-LEAVED EVERGREEN
E1K	EMERGENT/ WET MEADOW, WET SOIL
U	UPLAND SURROUNDED BY WETLAND

FIGURE 1-2
SAMPLE LOCATION MAP

PROJECT
TOMAH MUNICIPAL SANITARY LANDFILL
TOMAH, WISCONSIN

TITLE
EXISTING CONDITIONS MAP

DRAWN BY
CHECKED BY JDS
APPROVED BY
DATE FEBRUARY
SCALE
DATE PRINTED
PROJ. NO. 27504-002
DWG. NO.
SHEET 2 OF 11

DAMES & MOORE

in 1979-1980, at which time it was covered with native sandy soil and topsoil, and planted with grass.

In June 1981, Union Camp Corporation submitted a Notification of Hazardous Waste Activity for a facility in Tomah. The company reported that from 1960 to 1977 it had disposed of 75,700 gallons of solvent waste from plastics and printing operations in the TMSL. These wastes contained ethyl acetate, 1,1,1-trichloroethane, spent halogenated and nonhalogenated solvents, lead, chromium and barium.

In December 1983, WDNR conducted a Potential Hazardous Waste Site Preliminary Assessment for TMSL. The assessment indicated that the landfill was a potential hazard to groundwater and surface water, and that there could be other migration pathways.

In June 1984, personnel from WDNR and Ecology and Environment, Inc. (an EPA contractor) conducted a site inspection. The sample from a downgradient groundwater monitoring well contained organic contaminants, including but not limited to, vinyl chloride and trans-1,2-dichloroethene.

In April 1985, WDNR nominated the site for inclusion on the National Priorities List (NPL). On June 10, 1986, EPA proposed that the TMSL be added to the NPL. The TMSL was added to the NPL on March 31, 1989 (54 Federal Register 19526).

In February 1992, EPA's Technical Assistance Team (TAT) sampled nine residential wells in the Sunnyvale Subdivision adjacent to the TMSL. In addition, two surface water samples were collected from Deer Creek, approximately 1/4-mile northeast of the landfill. The samples were analyzed for volatile organic compounds (VOCs), and selected samples were analyzed for semi-volatile organic compounds (SVOCs). Surface water samples were also analyzed for pesticides and PCBs. One residential well contained elevated levels of vinyl chloride at 2.6 µg/L. No contaminants were detected in the remaining residential well samples or the two surface water samples.

On January 11, 1994, EPA signed the Administrative Order on Consent (AOC) for remedial investigation/feasibility study (RI/FS) activities. The AOC directs the potentially responsible parties (PRPs) to conduct the RI/FS with oversight by the EPA. Dames & Moore (the PRP's consultant) conducted the Phase I field investigation in accordance with the approved *Work Plan for the Tomah Municipal Sanitary Landfill* (March 10, 1994) and *Addendum I Revisions to the Work Plan* (June 18, 1994). The results of investigation were presented in the *Remedial Investigation Report* (February 21, 1995). A Phase II investigation was completed in accordance with the *Work Plan for Phase II of the RI/FS Study at the Tomah Municipal Sanitary Landfill* (June 13, 1995). The summary of the Phase I and II investigations is presented in the *Remedial Investigation Draft Final Report* (Dames & Moore, January 1996).

Physical Setting

The following discussion on the physical site setting has been summarized from the *Remedial Investigation Draft Final Report* (Dames & Moore 1996). The regional and local physical setting of the site are presented in the RI report Sections 4.0 and 5.0, respectively. The site hydrogeology is presented in RI report Section 6.0.

Surface Water Hydrology

The site lies in the Deer Creek valley and is the primary drainageway near the site. Deer Creek flows northeast across the northwestern corner of the property, within 230 feet of the northwest corner of the landfilled area. Deer Creek originates in a marshy area 3/4-mile to the west and flows through an abandoned cranberry bog before passing the site. The creek meanders through an extensive emergent wetland area located on the northwest portion of the property, and joins Lemonweir Creek 1 mile east of the site. Based on stream gauging data obtained from WDNR, the average discharge for Deer Creek is 2.1 cubic feet/second. Deer Creek is classified as a cold water sport fishery (trout stream).

The moderately permeable site soil permit infiltration and restrict the volume of overland flow. Surface runoff across the landfill is generally north toward Deer Creek, with the exception of the low area along the southern property boundary where runoff drains to the south.

Geology

Based on borings advanced during the RI, the site stratigraphy consists of residual sand materials, formed by the in-place weathering of sandstone bedrock, and alluvial unconsolidated sands overlying the sandstone bedrock. The unconsolidated material consists of silty sands to poorly graded fine- to medium-grained sand. The thickness of the unconsolidated deposits in the immediate vicinity of the landfill ranges from 1 to 19 feet and generally increases toward Deer Creek. North-northeast of the site, the unconsolidated deposits are 55 feet thick.

Underlying the unconsolidated sands is sandstone bedrock of Cambrian age. The sandstone is soft and poorly cemented, and consists of well sorted very fine to fine-grained quartz arenite. Two sandstone mounds are located in the southwest and southeast corners of the site. The bedrock surface slopes down from the sandstone mounds in all directions.

Landfill Construction

Data obtained from borings advanced through the landfill during the RI, indicate that the refuse is overlain by fill consisting of 6 inches of topsoil and an average of 4 feet of fine- to medium-grained sand. The thickness of refuse ranged between 7 feet (GP-6) and 14 feet (GP-2). The base of the landfill slopes gently downward to the north, likely following the prelandfill topography. The elevation of the base of the landfill ranges from 975.5 to 966 feet.

Hydrogeology

Groundwater was encountered within the unconsolidated deposits, the landfill waste, and the bedrock. The water level data indicate that the groundwater flow beneath the site is northeast toward Deer Creek and its surrounding wetlands. The horizontal gradients range from 0.002 to 0.007 ft/ft. Based on the data collected, the average horizontal groundwater velocity in the upper portion of the unconfined aquifer ranges from 0.02 to 0.38 ft/day.

The potentiometric data indicate that groundwater flow, within the unconfined sandstone aquifer, is toward the northeast under an average horizontal gradient of 0.004 ft/ft. The average horizontal groundwater velocity in the sandstone ranges from 0.08 to 0.31 ft/day.

Vertical groundwater gradients were calculated from well nests across the site. The highest downward vertical gradient was measured at the MW-3 well nest located adjacent to the landfill. The downward gradient may provide a mechanism for contaminant transport to deeper portions of the unconsolidated aquifer. Vertical gradient at the MW-5 well nest located near Deer Creek suggests that the groundwater contribution to Deer Creek may be only from the shallow flow system. The presence of downward gradients between the piezometers also indicate deeper flow beneath Deer Creek. The hydrogeologic data indicate that the aquifer below the site generally functions as a single hydrogeologic unit.

Water Supply

The City and the majority of the private well owners obtain their water supply from the Cambrian age sandstone aquifers. The City provides municipal water for all residential properties within the city limits. Residents living outside the city limits obtain their water supply from private wells. (Sunnyvale Subdivision receives city water, but is not located within the city limits).

The City obtains groundwater from three high capacity wells located 1.2 to 3 miles from the site. The available well logs indicate that the production zone for the wells are within the sandstone aquifer at depths of greater than 100 feet.

The data collected during the RI indicate the existence of 30 private water wells within a 1/2- mile radius of the landfill. Sixteen of the private wells are owned by residents of the Sunnyvale Subdivision, located south of the site. Municipal water service was extended to the Sunnyvale Subdivision in 1994. None of the 16 wells are presently used to supply potable water. Three additional wells are located a significant distance upgradient or sidegradient from the site, and will not be impacted by site contamination.

Ten of the wells are located north and northeast of the site, and north of Deer Creek. Well logs from the current property owners indicate that several wells downgradient of the site are screened in the sandstone at depths of 50 to 80 feet.

One additional well (Hanson well) is located approximately 500 feet east of the landfill. No well log was could be located for this well.

Ecological Setting

In September 1994, CH2M HILL performed an ecological survey to observe and describe the flora and fauna in the vicinity of the site; to identify any sensitive habitats or species; and to identify potential biological receptors. The detailed findings of the ecological survey are presented in Appendix D. A summary of the terrestrial and aquatic ecology is presented below.

The TMSL site is zoned as conservancy. Surrounding land use upstream of the site is predominately agricultural. Adjacent to the site, the predominant land use is forested (wetlands). Deer Creek flows northeast across the northwestern corner of the site.

Aquatic Ecology

In the vicinity of the TMSL site, Deer Creek averages approximately 20 centimeters (0.7 ft) in depth. Bottom inorganic substrate is composed mainly of sand (60 to 80 percent) and silt

(20 to 40 percent), with little gravel. The organic substrates are mostly composed of woody debris with some coarse particulate organic matter. Some pockets of fine organic matter were also present. Canopy cover adjacent to the creek consists of alders and tall grasses. The stream was clear throughout the study area, and no unusual odors or sheens were observed from the sediment or surface water.

Biologically, Deer Creek is designated as Class II trout waters, supporting primarily brook trout (see Appendix D). Other potential fish species in the watershed are presented in Table 1-1.

TABLE 1-1
Potential Fish Species

Common Name	Scientific Name
Bluntnose minnow	*Pimephales notatus*
Common creek chub	*Semotilus atromaculatus*
Johnny darter	*Etheostoma nigrum*
White sucker	*Catostomus commersoni*
Faintail darter	*Etheostoma flabellare*
Blacknose dace	*Rhinichthys atratulus*
Northern redbelly dace	*Phoxinus eos*
Brook stickleback	*Culeau inconstans*

In general, benthic macroinvertebrate diversity was high. Species of the pollution intolerant families (Ephemeroptera and Trichoptera) were present (see Appendix D). Amphipods were quite prevalent due to the high amount of coarse particulate organic matter present. Other abundant groups included isopods and chironomids. Leeches, predaceous diving beetles, snails, and damselflies were also common. General macroinvertebrate community structure was similar between upstream and downstream locations.

Terrestrial Ecology

Vegetation

Onsite. Field habitat predominates over the waste containment portion of the site. Grass, with some scattered shrubs, and rows of planted red and white pines characterize the vegetation on the landfill. The pines are localized, mainly near the southern and eastern boundaries, and in the northwestern portion of the landfill. The surface vegetation is primarily grass. Shrubs are found mainly in the areas of pine trees. Plants observed on the landfill include prickly ash, buckthorn, early goldenrod, slender fragrant goldenrod, butter-and-eggs, common milkweed, ragweed, and daisy fleabane.

Wetland habitat associated with Deer Creek is present at the north portion of the site (Figure 1-2). The wetland area at the site is a mixture of woody vegetation (T5/S3K), including trees and shrubs, and herbaceous vegetation (E1K). Woody vegetation is more common near the upland edges, with emergent (herbaceous) vegetation predominating north of the creek. Plants observed on the landfill and in the adjacent wetlands are presented in Table 1-2.

Offsite. Habitat surrounding the TMSL site includes a small residential subdivision along the south side of the site; farm fields and wetlands are located to the north, east, and west; and agricultural land (including pasture and fallow field) are adjacent to the western boundary. An emergent and scrub/shrub wetland is also west of the site along Deer Creek. The wetland associated with Deer Creek extends beyond the northern site boundary. Woody vegetation (T3/S3K) predominates in this location. The woody wetland vegetation associated with Deer Creek continues to the east of Noth Avenue. Upland field habitat is also present east of the landfill area.

TABLE 1-2
Plant Species Observed at the TMSL Site

Common Name	Scientific Name
Woody Vegetation	
Trembling aspen	*Populus tremuloides*
Black oak	*Quercus velutina*
Prickly ash	*Zanthoxylum americana*
Red oak	*Quercus borealus*
Bramble	*Rubus spp*
Buckthorn	*Rhamnus catharticus*
White pine	*Pinus strobus*
Red pine	*Pinus resinosa*
Willow	*Salix spp*
Box elder	*Acer negundo*
Eastern red cedar	*Juniperus virginiana*
Paper birch	*Betula papyrifera*
Speckled alder	*Alnus rugosa*
Herbaceous Vegetation	
Butter- and- eggs	*Linaria vulgaris*
Common milkweed	*Asclepias syriaca*
Sedge	*Carex spp.*
Ragweed	*Ambrosia artemisiifolia*
Daisy fleabane	*Erigeron annuus*
Early goldenrod	*Solidago juncea*
Slender fragrant goldenrod	*Solidago tenuifolia*

TABLE 1-2 (continued)
Plant Species Observed at the TMSL Site

Common Name	Scientific Name
Common mullein	*Verbascum thapsus*
Reed canary grass	*Phalaris arundinacea*
Blue vervain	*Verbena hastata*
Jewelweed	*Impatiens capensis*
Stinging nettle	*Laportea canadensis*

Wildlife

Onsite. Field habitat with areas of woody vegetation at the landfill site provide a suitable habitat for variety of small mammals and birds. Whitetail deer, crows, blue jays, mourning doves, and monarch butterflies were observed at the TMSL site.

Offsite. The wetland and upland habitats adjacent to the site, which include wooded areas and fields, provide good habitat for a variety of animal species and add diversity to the area as a whole. This area is also relatively undisturbed except for traffic along an adjacent road and some residential development. Due to the transient nature of some animal species, including large mammals and birds, their home ranges can be large. Therefore, they may utilize both onsite and offsite habitats. Animal species potentially occurring at the TMSL site are presented in Table 1-3.

TABLE 1-3
Animal Species Potentially Occurring at TMSL

Common Name	Scientific Name
Mammals	
Raccoon	*Procyon lotor*
Deer mouse	*Peromyscus maniculatus*
Meadow vole	*Microtus pennsylvanicus*
House mouse	*Mus musculus*
Masked shrew	*Sorex cinereus*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Woodchuck	*Marmota monax*
Cottontail rabbit	*Sylvilagus floridanus*
Whitetail deer *	*Odocoileus virginianus**
Beaver *	*Castor canadensis*

TABLE 1-3 (continued)
Animal Species Potentially Occurring at TMSL

Common Name	Scientific Name
Birds	
Black-capped chickadee *	*Parus atricapillu)* *
Cardinal	*Cardinalis cardinalis*
Robin	*Turdus migratorius*
House sparrow	*Passser domesticus*
Goldfinch	*Carduelis tristis*
Red-winged blackbird	*Agelaius phoeniceus*
American crow *	*Corvus ossifragus* *
Mourning dove *	*Zenaida macroura* *
Northern flicker *	*Colaptes auratus* *
Blue jay *	*Cyanocitta cristata* *
Other	
Monarch *	*Danus plexippus* *

* Indicates that the animal observed during site survey

Threatened and Endangered Species

The Bureau of Endangered Resources at the WDNR has indicated that the Natural Heritage Inventory data files contain no occurrence records of endangered (E), threatened (T), or special concern species; natural communities; or State Natural Areas that would be affected by remedial actions at the TMSL site. Because comprehensive resource surveys have not been conducted at the site, the WDNR's data files may be incomplete. The lack of known occurrences does not preclude the possibility that endangered resources may be present (see Appendix D).

The U.S. Fish and Wildlife Service (FWS) stated in their January 23, 1995 letter that two federally listed species occur in Monroe County: the Karner blue butterfly (E) and northern monkshood (T). The FWS concluded that due to the nature and location of the proposed activities, the species identified as occurring in the county would not be affected. The habitat of the Karner blue butterfly includes prairie, oak savanna, and jack pine areas, and is always associated with wild blue lupine plants. The habitat of the threatened plant, northern monkshood, is mainly north-facing slopes (see Appendix D).

Nature and Extent of Contamination

The following discussion on the nature and extent of contamination has been summarized from the *Remedial Investigation Draft Final Report* (Dames & Moore 1996). The nature and extent of contamination is presented in the RI report Section 7.0; the discussion on landfill gas migration is presented in the RI report Section 9.0. The data validation and laboratory reports and a complete summary of all analytical results are included in Appendix F and Appendix G of the RI report, respectively.

Surface Water and Sediment

Surface water and sediment samples were collected from four locations as part of the Phase I investigation (see Figure 1-2). Three of the four surface water/sediment samples were collected from Deer Creek. The fourth sample was collected in the emergent wetland adjacent to the Creek.

VOCs and SVOCs were not detected in the four surface water samples. 2-Butanone was detected in both the upstream and downstream sediment samples. Low levels (56 to 60 µg/kg) of three polynuclear aromatic hydrocarbons (PAHs) were detected in the most downstream sediment sample location.

Comparable values for inorganic constituents were measured for surface water and sediment samples collected at upstream and downstream sample locations, as well as in the wetland. The data collected did not indicate that the surface water and sediment have been significantly impacted by landfill-related contaminants.

Groundwater

The nature and extent of groundwater contamination was evaluated based on the results from 12 groundwater monitoring wells sampled during Phase I, and 7 additional wells installed and sampled during the Phase II investigation. In addition, six private wells were sampled during Phase II (see Figure 1-2).

Seven chlorinated VOCs were detected in the samples collected from the monitoring wells. These VOCs include chloroethane, 1,1-dichloroethane, 1,2-dichloroethene (cis and trans), 1,2-dichloropropane, 1,2-dichloroethane, and vinyl chloride. Five aromatic VOCs were also detected including benzene, toluene, ethylbenzene, xylenes, and chlorobenzene. Vinyl chloride and benzene were detected most frequently and exhibited the highest concentrations. The vinyl chloride (0.7 to 1,200 µg/L) and benzene (0.5 to 48 µg/L) concentrations exceeded the WDNR's Chapter NR 140 Preventative Action Limit (PAL) and Enforcement Standard (ES) in each sample they were detected. Vinyl chloride appears to be the most persistent and widespread. The vinyl chloride concentrations decreased from 1,200 µg/L adjacent to the landfill (in MW-7) to 36 µg/L approximately 800 feet downgradient from the site (in MW-9B). Analytical data from individual well nests indicated that concentrations of both benzene and vinyl chloride were typically higher in samples collected at depth compared with those collected at the water table. VOCs were not detected in the upgradient or residential wells.

Several SVOCs were also detected in the groundwater samples. The only SVOC to exceed ES limits was bis(2-ethylhexyl) phthalate.

Various inorganic constituents were detected in groundwater samples. Twelve of the inorganic parameters were detected in groundwater samples at concentrations exceeding primary or secondary drinking-water standards. Inorganic constituents detected in downgradient groundwater may have migrated from the landfill. Downgradient concentrations of aluminum, iron, and manganese were significantly higher than those concentrations found in upgradient wells. Thallium, cadmium, and chromium concentrations measured downgradient of the landfill also exceeded the federal drinking-water standards.

Groundwater samples collected from the downgradient wells during the Phase I were also analyzed for pesticides, PCBs, dioxins, and furans. The results of these analyses indicate trace concentrations of octachloro-dibenzopara-dioxin (OCDD) in three of the samples. Three pesticides were detected: endrin, 2,4,5-TP, and chlordane. No PCBs or furans were detected.

Landfill Gas

Data collected from the investigation indicate that landfill gas is being generated at the site. Methane concentrations, as measured in the gas probes and monitoring wells, ranged from 4 to 71 percent (by volume in air). Data collected from gas probes installed beyond the boundary of the landfill indicate that landfill gas is migrating offsite. The methane concentrations measured from zero to 37 percent. The lower explosive limit (LEL) reaches 100 percent at a methane concentration of 5 percent. WDNR's Chapters NR 504 and NR 506 of the Wisconsin Administrative Code require that all waste disposal facilities have an effective means for controlling landfill gas migration such that the concentration of explosive gases at or beyond the property boundary do not exceed 25 percent of the LEL. This concentration of methane is exceeded in all gas probes, except for GP-8 which is not located within the boundary of the site.

Gas samples were also analyzed using a portable gas chromatograph. VOCs detected include vinyl chloride, 1,2-dichloroethene, 1,1,1-trichloroethane, trichloroethene, and toluene. In general, the highest (338.7 to 773.10 ppm) and most consistent contaminant measured was 1,1,1-trichloroethane.

The source control measure proposed in the RI indicates that the landfill gases will be collected with an active gas collection system and treated prior to release. The gas collection and treatment system will reduce explosion hazards and residential exposures to landfill gases.

SECTION 2

Human Health Risk Assessment

Introduction

The baseline human health risk assessment is an evaluation of potential existing and future threats to public health and the environment in the absence of remedial action (EPA 1989a). According to EPA guidance on risk assessments for NPL sites, a risk assessment has four components: data collection and evaluation, an exposure evaluation, a toxicity assessment, and risk characterization. A discussion of uncertainty is also an integral part of any risk assessment.

Guidelines for conducting baseline risk assessments for the evaluation of potential public health impacts are contained in *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A)* (EPA 1989a) and *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B)* (EPA 1991a). In this risk assessment, these guidance documents are referred to as RAGS Part A and Part B.

Data Collection and Evaluation

Data collection and evaluation involve gathering and analyzing relevant site data. The sampling results from the various environmental media are reviewed to determine what compounds are detected above background levels. Contaminants detected above background levels, whether naturally occurring or from anthropogenic sources (i.e., human-made but not site-related, such as those associated with automobile or power plant emissions) or site-related are called chemicals of potential concern (COPC). The COPCs are then screened to determine which compounds drive the risk. The compounds that contribute the majority of the risk are called the chemicals of concern (COCs); the COCs are the compounds evaluated quantitatively and qualitatively in a risk assessment.

Exposure Evaluation

In the exposure evaluation, the pathways, magnitude, frequency, and duration of potential human exposure are evaluated. Current and future land use and the location of potentially exposed populations are identified. Sources of contamination, contaminated media, exposure points and concentrations, and potential exposure routes are also identified. This information is used to determine the completeness of the different exposure pathways. Concentrations of contaminants in the environmental media to which individuals may be exposed are derived from sampling or from the results of fate and transport modeling. Current and future chemical intakes are then estimated for the potentially complete exposure pathways.

Toxicity Assessment

The toxicity assessment presents available evidence on the potential for contaminants to cause adverse health effects. Toxicity assessments have two steps: hazard identification and dose-response evaluation. The hazard identification determines whether exposure to a chemical can result in an increase in the incidence of a particular adverse health effect and whether the effect is likely to occur in humans. Data from human and animal studies are used to quantify the dose-response relationship. The toxicity values derived from the dose-response evaluation are used in the risk characterization step to estimate the potential for adverse effects to occur in exposed humans.

Risk Characterization

The toxicity and exposure assessments are summarized in the risk characterization, and are integrated into quantitative and qualitative expressions of risk. Noncarcinogenic effects are presented as the ratio between projected intakes and toxicity values (reference doses). These ratios are known as hazard quotients for individual chemicals or summed to give hazard indices for multiple chemicals or pathways. Potential carcinogenic effects are presented as risks; or the probability that an individual will develop a cancer exceeding that already expected because of exposure to the COC averaged over a lifetime. The intake of a chemical evaluated for carcinogenic health effects is calculated by prorating the entire cumulative dose of the chemical from an exposure duration usually assumed to be 30 years for residential exposure (25 years for occupational exposure), over the averaging time of an entire life span (assumed to be 70 years). This is based on EPA guidance found in RAGS Part A (EPA 1989a), which states: "The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime." The occurrence of cancer in the U.S. population is in the range of one in three to one in four (25 to 30 percent) (American Cancer Society 1995).

Identification of Chemicals of Potential Concern

The analytical data collected for the site was validated by Dames & Moore. Documentation on this validation effort can be found in Appendix F of the RI (Dames & Moore, 1996). Based on the RI, the laboratory data were reviewed and validated using EPA guidance. Following validation, the data were reviewed to eliminate results that could represent contamination of samples in the laboratory or in the field, or that failed to meet quality control guidelines. An electronic copy of the analytical data was submitted to CH2M HILL for review and use in the baseline risk assessment (see Appendix A).

Data were also reviewed and screened on the basis of background concentrations and essential nutrients. Data interpretation was performed to eliminate chemicals only in cases where either the background data were limited or the contamination was clearly not site-related (see Appendix B).

Data Management and Consolidation

The surface water, sediment, and groundwater analytical data were validated and evaluated by Dames & Moore. The RI report indicates that the data validation was based primarily on the guidelines outlined in the *National Functional Guidelines for Organic Data Review* (EPA 1991b) and the *Laboratory Data Functional Guidelines for Evaluating Inorganic Analyses* (EPA 1990a). Further information on the data validation techniques and results are provided in Appendix F of the RI (Dames & Moore 1996). Consolidation of the two phases of investiga-tion data into the risk assessment database is discussed in Appendix A.

Incorporation of Data from Multiple Sampling Rounds

Two rounds of groundwater sampling data were available for use in the baseline risk assessment. The maximum contaminant concentration at each well from the two rounds was used as the well concentration. For instance, if analysis at MW-4A indicated that benzene was present at 4 mg/L in Phase I, but present at 1 mg/L during Phase II, the well concentration used for MW-4A was 4 mg/L.

Several of the groundwater monitoring wells at the TMSL are nested wells. Because the aquifer beneath the site functions as a single hydrologic unit, the maximum detected concentration for each well nest was used as the sampling point concentration. For instance, if analysis indicated that the benzene concentration in MW-4A was 2 mg/L, MW-4B was 7 mg/L, and MW-4C was 5 mg/L; the sampling point concentration used for MW-4 was 7 mg/L.

Treatment of Samples Involving Multiple Analyses

Matrix interferences or elevated concentrations may result in samples being diluted and reanalyzed (see Appendix A). This procedure can result in high quantitation limits. Guidance found in RAGS Part A (Section 5.3.2) was followed in any instances that high quantitation limits were noted.

All of the analyses were performed using the EPA Contract Laboratory Program (CLP) methods. However, additional analysis methods were also used (e.g., SW-846). In instances where contaminants were analyzed using different methodologies, the methods, detection limits, and results were compared and the maximum concentration was used. Three contaminants that are of interest in the baseline risk assessment were analyzed for using different methodologies.

Vinyl chloride in the groundwater was analyzed for using both the CLP method and SW-846 Method 8021. Both methodologies utilize gas chromatography to quantitate results, and the detection limits were similar. The maximum detected concentration of vinyl chloride using the CLP method was 1,200 mg/L, while that using SW-846 (8021) was 470 mg/L. Therefore, the CLP concentration was used in the baseline risk assessment.

Octachlorinated dibenzo-*p*-dioxins in the groundwater were also analyzed for using both CLP methods and SW-846 Method 8290. The maximum detected concentrations using both the CLP method and that using SW-846 (8290) was 380 pg/L. Therefore, the CLP concentration was used in the baseline risk assessment.

One pesticide (2,4,5-TP, or silvex) was detected in the groundwater using the SW-846 Method 8150A, but not detected using the CLP method. Silvex was detected in two groundwater samples (and one duplicate sample). The SW-846 method detected concentration of 0.61 mg/L was used in the baseline risk assessment.

Treatment of Blind Field Duplicates

For each location where both a sample and a replicate were collected, the highest of the two values was used, and the other deleted.

Evaluation of Qualified and Coded Data

Per guidance in RAGS Part A, data with qualifiers that indicate uncertainties in concentration but not identification are to be included. Data qualified with an "R" (indicating the data was rejected) were eliminated. When chemicals were detected in some samples of a media group but not in others, the chemicals that were not detected were assumed to be present at one-half the chemical detection limit, provided those chemicals met all other criteria for possible consideration as chemicals of potential concern. Data with "J" qualifiers (indicating an estimated concentration) were included at the indicated concentrations. When detection limits were estimated (data with "UJ" qualifiers), the estimated detection limits were used as normal detection limits.

Comparison of Blanks and Sample Concentrations

For risk assessment purposes, all downgradient groundwater, surface water, and sediment samples were combined within their respective media groups. Field and laboratory blanks were compared to environmental media samples by Dames & Moore; results are presented in Appendix F of the RI Report (Dames & Moore, 1996).

Comparison of Samples with Background Concentrations

Concentrations of contaminants in samples taken hydraulically upgradient to the TMSL were compared to concentrations of contaminants in downgradient samples. Background levels may be naturally occurring (i.e., not influenced by humans) or anthropogenic (i.e., produced as a result of human activities but not site-related).

EPA guidance indicates that inorganic constituents which are present at the site at naturally-occurring levels may be eliminated from the quantitative risk assessment. However, according to RAGS Part A, the majority of organic compounds found at remediation sites are not naturally occurring, and should not be eliminated from the quantitative risk assessment unless further justification is provided.

One upgradient surface water and one upgradient sediment sample were collected. Sample concentrations from three wells (MW-1A, MW-1B, and MW-6A) were used as upgradient data for comparison purposes. The limited amount of background concentration data precluded parametric statistical tests to determine if downgradient concentrations were statistically different from upgradient concentrations (the null hypothesis). Therefore, a nonparametric test was performed to test the null hypothesis. The comparison of downgradient data to upgradient data is presented in Appendix B.

Essential Nutrients as Chemicals of Potential Concern

Guidance presented in RAGS Part A indicates that compounds considered essential human nutrients which are present at low concentrations and toxic only at very high doses need not be considered in the quantitative risk assessment. Compounds such as calcium, iron, magnesium, potassium, and sodium are examples of essential human nutrients. Site-related concentrations of these compounds in groundwater were compared with background levels to determine if elevated concentrations are present (Table 2-1). Only groundwater concentrations were compared, because groundwater exposure will result in the greatest intake of these chemicals.

The recommended daily allowance (RDA) for essential nutrients was exceeded by the downgradient groundwater concentration for iron. All other essential nutrients were below their respective RDAs. Little toxicological information is available for essential nutrients. Chronic iron overload may result in disturbances in liver function, diabetes mellitus, and disturbances to the endocrine and cardiovascular systems. Because most of the information available for essential nutrients is primarily concerned with dietary deficiencies, the essential nutrient chemicals were not evaluated in the quantitative risk assessment.

Concentration-Toxicity Screen

This screening procedure identifies the chemicals in a particular medium which significantly contribute to risks. To use this screening method, the chemical's risk via all available exposure pathways (ingestion, inhalation, and dermal absorption) in a medium is calculated and summed to determine the total risk due to all chemicals. The ratio of each individual chemical's risk to the sum is then calculated. For this risk assessment, the contaminants were retained if they were found to contribute at least 1 percent of the total risk, had a carcinogenic risk potential equal to or greater than $1x10^{-6}$, or had a hazard index (HI) greater than 1.0. Chemicals that contributed less than 1 percent of the risk (provided cancer risks were less than $1x10^{-6}$ or HI was less than 1) were eliminated from the quantitative assessment. An exception to this rule is the retention of Class A carcinogens, which were retained regardless of ranking. The remaining chemicals were retained in the final list of compounds of concern. The screening summaries are presented in Tables 2-2 through 2-4.

Summary

The screening processes described above were used to identify the chemicals of concern (COCs). Tables 2-2 through 2-4 summarize by media the compounds that underwent this screening process, and the results of those screening processes. Table 2-5 presents the detected contaminants that were carried through the quantitative risk assessment (the COCs), if toxicity values were available.

Exposure Evaluation

The exposure evaluation consisted of three steps: characterization of the exposure setting, identification of exposure pathways, and quantification of exposure.

Characterization of Exposure Setting

The physical setting and the potentially exposed human populations were presented in the RI are summarized in Section 1. The characteristics that influence exposure were used in the identification of exposure pathways and intake variable values. Assumed current and future exposure scenarios are presented in Table 2-6.

Currently, the TMSL site is zoned conservancy. The areas to the north, east, and west are classified as vacant or agricultural. Deer Creek and wetlands are located north of the

Table 2-1
Essential Nutrient Screen of TMSL Groundwater

Intake By Ingestion of Groundwater	Recommended Daily Allowance (RDA) (mg/day)	Chemical Daily Intake (a) (mg/day)	Exposure Basis	Ratio of Chemical Daily Intake to RDA	Criteria Exceeded? (b)
Essential Nutrient					
Calcium	1200	300	Maximum Detected	2.5E-01	No
Iron	18	706	Maximum Detected	3.9E+01	Yes
Magnesium	400	228	Maximum Detected	5.7E-01	No
Potassium	1200	228	Maximum Detected	1.9E-01	No
Sodium	2400	502	Maximum Detected	2.1E-01	No

Notes:

(a) Based on an ingestion rate of 2 liters of groundwater per day by a 70 kg adult.

(b) The "criteria" is for a required qualitative discussion of the essential nutrient if the ratio of the daily intake to the RDA is 1.0 or greater. A dietary limit or advisory is not to be interpreted by this criteria. Other criteria may result in the need for qualitative discussion of essential nutrients beyond this screen.

Table 2-2
Identification of Chemicals of Concern
Process Summary - Surface Water

List of Positively Detected Compounds in Surface Water	Chemicals Preceeded by " ü " Were Removed After Comparison to Background	Chemicals Preceeded by " ü " Were Removed Due to the Unavailability of Toxicity Values (RfDs, slope factors)	Chemicals Preceeded by " ü " Were Removed Because They Contributed Less Than 1% of the Total Risk (all receptor groups)	Chemicals of Concern in Surface Water (COCs)
Metals	**Metals**	**Metals**	**Metals**	**Metals**
Aluminum	✓ Aluminum	--	--	--
Antimony	✓ Antimony	--	--	--
Arsenic	Arsenic	Arsenic	Arsenic	Arsenic
Barium	Barium	Barium	✓ Barium	--
Calcium	Calcium	✓ Calcium	--	--
Chromium, total	✓ Chromium, total	--	--	--
Cobalt	Cobalt	✓ Cobalt	--	--
Iron	✓ Iron	--	--	--
Lead	✓ Lead	--	--	--
Magnesium	Magnesium	✓ Magnesium	--	--
Manganese	Manganese	Manganese	Manganese	Manganese
Mercury	✓ Mercury	--	--	--
Potassium	Potassium	✓ Potassium	--	--
Selenium	✓ Selenium	--	--	--
Sodium	Sodium	✓ Sodium	--	--
Vanadium	✓ Vanadium	--	--	--

Table 2-3
Identification of Chemicals of Concern
Process Summary - Sediment

List of Positively Detected Compounds in Sediment	Chemical Preceeded by "✓" Were Removed After Comparison to Background	Chemicals Preceeded by "✓" Were Removed Due to the Unavailability of Toxicity Values (RfDs, slope factors)	Chemicals Preceeded by "✓" Were Removed Because They Contributed Less Than 1% of the Total Risk (all receptor groups)	Chemicals of Concern in Sediment (COCs)
Volatiles	**Volatiles**	**Volatiles**	**Volatiles**	**Volatiles**
Methyl Ethyl Ketone	Methyl Ethyl Ketone	Methyl Ethyl Ketone	✓ Methyl Ethyl Ketone	--
Semivolatiles	**Semivolatiles**	**Semivolatiles**	**Semivolatiles**	**Semivolatiles**
Benzo(b)fluoranthene	Benzo(b)fluoranthene	Benzo(b)fluoranthene	Benzo(b)fluoranthene	Benzo(b)fluoranthene
Fluoranthene	Fluoranthene	Fluoranthene	Fluoranthene	Fluoranthene
Pyrene	Pyrene	Pyrene	Pyrene	Pyrene
Metals	**Metals**	**Metals**	**Metals**	**Metals**
Aluminum	✓ Aluminum	--	--	--
Antimony	✓ Antimony	--	--	--
Arsenic	✓ Arsenic	--	--	--
Barium	✓ Barium	--	--	--
Calcium	✓ Calcium	--	--	--
Chromium	✓ Chromium	--	--	--
Cobalt	✓ Cobalt	--	--	--
Copper	Copper	Copper	Copper	Copper
Iron	✓ Iron	--	--	--
Lead	✓ Lead	--	--	--
Magnesium	✓ Magnesium	--	--	--
Manganese	✓ Manganese	--	--	--
Nickel	✓ Nickel	--	--	--
Potassium	✓ Potassium	--	--	--
Selenium	✓ Selenium	--	--	--
Vanadium	✓ Vanadium	--	--	--
Zinc	✓ Zinc	--	--	--

Table 2-4
Identification of Chemicals of Concern
Process Summary - Groundwater

List of Positively Detected Compounds in Groundwater	Chemicals Preceeded by "✓" Were Removed After Comparison to background	Chemicals Preceeded by "✓" Were Removed Due to the Unavailability of Toxicity Values (RfDs, slope factors)	Chemicals Preceeded by "✓" Were Removed Because They Contributed Less Than 1% of the Total Risk (all receptor groups)	Chemicals of Concern in Groundwater (COCs)
Volatiles	**Volatiles**	**Volatiles**	**Volatiles**	**Volatiles**
1,1-Dichloroethane	1,1-Dichloroethane	1,1-Dichloroethane	✓ 1,1-Dichloroethane	--
1,2-Dichloroethane	1,2-Dichloroethane	1,2-Dichloroethane	1,2-Dichloroethane	1,2-Dichloroethane
1,2-Dichloropropane	1,2-Dichloropropane	1,2-Dichloropropane	1,2-Dichloropropane	1,2-Dichloropropane
2-Hexanone	2-Hexanone	✓ 2-Hexanone	--	--
Acetone	Acetone	Acetone	✓ Acetone	--
Benzene	Benzene	Benzene	Benzene	Benzene
Carbon Disulfide	Carbon Disulfide	Carbon Disulfide	✓ Carbon Disulfide	--
Chlorobenzene	Chlorobenzene	Chlorobenzene	✓ Chlorobenzene	--
Chloroethane	Chloroethane	Chloroethane	✓ Chloroethane	--
cis-1,2-Dichloroethene	cis-1,2-Dichloroethene	cis-1,2-Dichloroethene	✓ cis-1,2-Dichloroethene	--
Ethylbenzene	Ethylbenzene	Ethylbenzene	✓ Ethylbenzene	--
Methyl Ethyl Ketone	Methyl Ethyl Ketone	Methyl Ethyl Ketone	✓ Methyl Ethyl Ketone	--
Methyl Isobutyl Ketone	Methyl Isobutyl Ketone	Methyl Isobutyl Ketone	✓ Methyl Isobutyl Ketone	--
Styrene	Styrene	Styrene	Styrene	Styrene
Toluene	Toluene	Toluene	✓ Toluene	--
Total 1,2-Dichloroethene	Total 1,2-Dichloroethene	Total 1,2-Dichloroethene	Total 1,2-Dichloroethene	Total 1,2-Dichloroethene
trans-1,2-Dichloroethene	trans-1,2-Dichloroethene	trans-1,2-Dichloroethene	✓ trans-1,2-Dichloroethene	--
Vinyl Chloride	Vinyl Chloride	Vinyl Chloride	Vinyl Chloride	Vinyl Chloride
Xylene, total	Xylene, total	Xylene, total	✓ Xylene, total	--
Semivolatiles	**Semivolatiles**	**Semivolatiles**	**Semivolatiles**	**Semivolatiles**
1,2-Dichlorobenzene	1,2-Dichlorobenzene	1,2-Dichlorobenzene	✓ 1,2-Dichlorobenzene	--
1,4-Dichlorobenzene	1,4-Dichlorobenzene	1,4-Dichlorobenzene	1,4-Dichlorobenzene	1,4-Dichlorobenzene
2,4-Dimethylphenol	2,4-Dimethylphenol	2,4-Dimethylphenol	✓ 2,4-Dimethylphenol	--
2-Methylnaphthalene	2-Methylnaphthalene	✓ 2-Methylnaphthalene	--	--
2-Methylphenol (o-cresol)	2-Methylphenol (o-cresol)	2-Methylphenol (o-cresol)	✓ 2-Methylphenol (o-cresol)	--
4-Chloro-3-Methylphenol	4-Chloro-3-Methylphenol	✓ 4-Chloro-3-Methylphenol	--	--
4-Methylphenol (p-cresol)	4-Methylphenol (p-cresol)	4-Methylphenol (p-cresol)	4-Methylphenol (p-cresol)	4-Methylphenol (p-cresol)
bis(2-Chloroethyl)ether	bis(2-Chloroethyl)ether	bis(2-Chloroethyl)ether	bis(2-Chloroethyl)ether	bis(2-Chloroethyl)ether
bis(2-Ethylhexyl)phthalate	bis(2-Ethylhexyl)phthalate	bis(2-Ethylhexyl)phthalate	bis(2-Ethylhexyl)phthalate	bis(2-Ehtylhexyl)phthalate
di-n-Butyl Phthalate	di-n-Butyl Phthalate	di-n-Butyl Phthalate	✓ di-n-Butyl Phthalate	--
Diethyl Phthalate	Diethyl Phthalate	Diethyl Phthalate	✓ Diethyl Phthalate	--
N-Nitrosodiphenylamine	N-Nitrosodiphenylamine	N-Nitrosodiphenylamine	✓ N-Nitrosodiphenylamine	--
Napthalene	Napthalene	Napthalene	✓ Napthalene	--
Phenol	Phenol	Phenol	✓ Phenol	--

Table 2-4
Identification of Chemicals of Concern
Process Summary - Groundwater

List of Positively Detected Compounds in Groundwater	Chemicals Preceeded by "✓" Were Removed After Comparison to background	Chemicals Preceeded by "✓" Were Removed Due to the Unavailability of Toxicity Values (RfDs, slope factors)	Chemicals Preceeded by "✓" Were Removed Because They Contributed Less Than 1% of the Total Risk (all receptor groups)	Chemicals of Concern in Groundwater (COCs)
Pesticides	**Pesticides**	**Pesticides**	**Pesticides**	**Pesticides**
Endrin	Endrin	Endrin	✓ Endrin	--
Gamma-Chlordane	Gamma-Chlordane	Gamma-Chlordane	✓ Gamma-Chlordane	--
Octachlorodibenzo-p-Dioxin	Octachlorodibenzo-p-Dioxin	✓ Octachlorodibenzo-p-Dioxin	--	--
2,4,5-TP (Silvex)	2,4,5-TP (Silvex)	2,4,5-TP (Silvex)	✓ 2,4,5-TP (Silvex)	--
Metals	**Metals**	**Metals**	**Metals**	**Metals**
Aluminum	Aluminum	✓ Aluminum	--	--
Antimony	Antimony	Antimony	Antimony	Antimony
Arsenic	Arsenic	Arsenic	Arsenic	Arsenic
Barium	Barium	Barium	✓ Barium	--
Beryllium	Beryllium	Beryllium	Beryllium	Beryllium
Cadmium	Cadmium	Cadmium	Cadmium	Cadmium
Calcium	Calcium	✓ Calcium	--	--
Chromium	Chromium	Chromium	Chromium	Chromium
Cobalt	Cobalt	✓ Cobalt	--	--
Copper	Copper	Copper	✓ Copper	--
Iron	Iron	✓ Iron	--	--
Lead	Lead	✓ Lead	--	--
Magnesium	Magnesium	✓ Magnesium	--	--
Manganese	Manganese	Manganese	Manganese	Manganese
Mercury	Mercury	Mercury	✓ Mercury	--
Nickel	Nickel	Nickel	✓ Nickel	--
Potassium	Potassium	✓ Potassium	--	--
Selenium	Selenium	Selenium	✓ Selenium	--
Silver	Silver	Silver	✓ Silver	--
Sodium	Sodium	✓ Sodium	--	--
Thallium	Thallium	Thallium	Thallium	Thallium
Vanadium	Vanadium	Vanadium	Vanadium	Vanadium
Zinc	Zinc	Zinc	✓ Zinc	--

Table 2-5
Chemicals of Concern
by Media

	Surface Water	Sediment	Groundwater
Volatile Organic Compounds			
1,2-Dichloroethane			X
1,2-Dichloropropane			X
Benzene			X
Styrene			X
1,2-Dichloroethene, Total			X
Vinyl Chloride			X
Semivolatile Organic Compounds			
Benzo(b)Anthracene		X	
Fluorathene		X	
1,4-ichlorobenzene			X
4-Methylphenol (p-Cresol)			X
bis(2-Chloroethyl)ether			X
bis(2-Ethylhexyl)phthalate			X
Pyrene		X	
Inorganic Chemicals			
Antimony			X
Arsenic	X		X
Beryllum			X
Cadmium			X
Chromium, Total			X
Copper		X	X
Manganese	X		X
Thallium			X
Vanadium			X

Table 2-6
Exposure Scenarios to be Evaluated for Tomah Municipal Sanitary Landfill

Exposed Population

	Adult		Child		
Land Use	**Current**	**Future**	**Current**	**Future**	**Exposure Route**
Recreational	X	X	X	X	Surface Water Dermal Contact
(Trespasser)	X	X	X	X	Sediment Dermal Contact
Residential	X	X	X	X	Groundwater Ingestion
	X	X	X	X	Groundwater Inhalation
	X	X	X	X	Groundwater Dermal Contact

X = route evaluated

landfill (within the site boundary), while open agricultural land is located east and west of the site. The agricultural land located to the east is currently not used; the land to the west of the landfill is used as pasture. A trailer park and additional residential development activities have recently been added to the north and northeast of the landfill site. The trailer part is located approximately 2,000 ft north-northeast of the site. The Sunnyvale residential subdivision adjoins the landfill property to the south, and residential properties and a mobile home park are located to the southeast of the site.

Currently, drinking water is supplied by the municipal water supply system to residents living within the city limits. Residents living outside the city limits obtain their water supply from private wells, except for those living in the Sunnyvale subdivision south of the site who are serviced by City water. Ten of the eleven private wells currently used within one-half mile of the site are located north and northeast of the site. The one remaining well is located approximately 500 feet east of the landfill.

Identification of Exposure Pathways

An exposure pathway is the route a chemical agent takes from its source to the individual exposed. Exposure pathways are based on consideration of the following factors: sources, releases, types and location of chemicals at the site; the environmental fate of the chemical; and the location and activities of the potentially exposed populations. An exposure pathway consists of four elements:

- A contaminant source and mechanism for release
- Environmental transport media
- A point of potential receptor contact
- An exposure route

Since the refuse is presently covered with fine to medium-grained sand and the landfill is not lined, water may percolate through the waste and soil column into the underlying groundwater. Surface soil, subsurface soil, surface water, sediment, and groundwater can therefore act as transport media and/or contact points for potential receptors. No soil samples were collected from the landfill during the RI; therefore, risks due to potential exposure to hazardous materials in or on the landfill could not be quantified.

Data are available regarding concentrations of VOCs in landfill gases. However, the lack of quality assurance/quality control (QA/QC) documentation of the data preclude its use in this quantitative risk assessment. Risks due to potential inhalation of landfill gases are discussed qualitatively in the summary of findings.

Current and future residents could potentially have contact with contaminated groundwater. Current and future recreational users (trespassers) may have contact with contaminated surface water and sediment. Exposure routes that were quantitatively evaluated for the potential residential receptors included inhalation, ingestion, and dermal absorption of contaminants in groundwater. Exposure routes that were quantitatively evaluated for the potential trespassers were dermal absorption of contaminants in surface water and sediment.

Quantification of Exposure

The magnitude, frequency, and duration of exposure were quantified for the populations and exposure pathways. Quantification included two steps: estimating the exposure point concentration to which the populations are exposed, and quantifying the pathway-specific intakes. The methods used for quantifying these exposures are consistent with EPA guidance in RAGS Part A.

Exposure Point Concentrations

Exposure point concentrations are the media-specific chemical concentrations that receptors may contact. Exposure point concentrations were calculated according to guidance found in EPA's *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA 1992a). The guidance states that the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used for data sets with more than 10 samples per exposure area. For data sets with fewer than 10 samples per area, for compounds with low detection percentages, and for data that are highly variable, the guidance suggests that the maximum concentrations be used.

Because there were only three downgradient surface water and sediment samples, the 95% UCL was calculated but not used. The maximum detected contaminant concentrations in the surface water and sediment were used as their respective exposure point concentrations (see Tables 2-7 and 2-8, respectively).

For the groundwater evaluation, the total metals ("unfiltered") results were used. The maximum detected concentrations for each downgradient well from both sampling rounds were grouped, and a 95% UCL was calculated. Because there were only eight data points, the overall maximum detected contaminant concentration was used as the groundwater exposure point concentration (see Table 2-9).

Estimated Intake for Individual Pathways

Exposure is the contact of an organism with a chemical or physical agent. In this assessment, exposure (or intake) is normalized for time and body weight and is expressed as milligrams of chemical per kilogram of body weight per day (mg/kg/day). Six basic factors are used to estimate intake: exposure frequency, exposure duration, contact rate, chemical concentrations, body weight, and averaging time. Exposure is described by the equation:

$$\text{Exposure} = \frac{\text{Concentration} \times \text{Contact Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration}}{\text{Body Weight} \times \text{Averaging Time}}$$

The generic equation is modified for the various exposure pathways to reflect pathway-specific parameters. For example, the intake equation for dermal contact with chemicals in water takes into account the skin surface area available for contact and the chemical-specific dermal permeability constant.

The estimation of dermal exposures was calculated using the methodology suggested in RAGS Part A. This methodology allows for adjustment of an administered dose (the form in which most toxicity values are expressed) to an absorbed (dermal) dose. For dermal contact with sediment, absorption factors are used to reflect the desorption of the chemical from the sediment, across the skin, and into the blood stream. In addition, adjustment for the oral

Table 2-7
Exposure Point Concentrations for Downgradient Surface Water

Parameter	Maximum Detected Value	Units
Inorganic Compounds		
Arsenic	6.30	ug/L
Manganese	2,380	ug/L

Table 2-8
Exposure Point Concentrations for Downgradient Sediments

Parameter	Maximum Detected Value	Units
Semivolatile Organic Compounds		
Benzo(b)fluoranthene	56.0	µg/kg
Fluorathene	56.0	µg/kg
Pyrene	60.0	µg/kg
Inorganic Compounds		
Copper	14,000	µg/kg

Table 2-9
Exposure Point Concentrations for Downgradient TMSL Groundwater

Parameter	Maximum Detected Value	Units
Volatile Organic Compounds		
1,2-Dichloroethane	4.00	µg/L
1,2-Dichloropropane	16.0	µg/L
Benzene	48.0	µg/L
Styrene	3.00	µg/L
1,2-Dichlorothene, Total	200	µg/L
Vinyl Chloride	1,200	µg/L
Semivolatile Organic Compounds		
1,4-Dichlorobenzene	22.0	µg/L
4-Methylphenol (p-cresol)	1,100	µg/L
bis(2-Chloroethyl)ether	7.00	µg/L
bis(2-Ethylhexyl)phthalate	27.0	µg/L
Inorganics		
Antimony	53.2	µg/L
Arsenic	112	µg/L
Beryllium	11.0	µg/L
Cadmium	11.5	µg/L
Chromium, total	320	µg/L
Manganese	19,000	µg/L
Thallium	20.7	µg/L
Vanadium	233	µg/L

reference dose is accomplished by multiplying the administered reference dose by an oral absorption efficiency, whereas the slope factor is divided by the oral absorption efficiency value. Chemical-specific oral absorption efficiency factors were used in this baseline risk assessment. Unless compound-specific dermal absorption efficiencies were found, the default dermal absorption factor across the skin for VOCs in sediment was 25 percent, while that for SVOCs was 10 percent. Because most metals are absorbed slowly across the skin, a default value of 1 percent was used.

Dermal contact with chemicals in water is generally calculated in much the same way; however, the dermal contact equation also considers the chemical-specific dermal permeability constant. Information on the dermal permeability constants was taken from EPA's *Interim Report—Dermal Exposure Assessment: Principles and Applications* (EPA 1992b).

The intake parameters used in the quantitative risk assessment are presented in Table 2-10.

Guidance provided by EPA was used to calculate the appropriate exposure concentrations and intakes for the environmental media considered. The exposure factors used likely result in an overestimate of the potential exposure intakes, rather than an overestimate of risk. Uncertainties associated with estimating exposure occur because of variations in the following areas:

- Land use assumptions
- Sampling and analyses
- Fate and transport modeling
- Parameter values

These uncertainty factors and their possible effect on the exposure assessment are discussed later in this section.

Toxicity Assessment

The toxicity assessment contains two steps: hazard identification and dose-response evaluation. Hazard identification is the process of determining what adverse health effects, if any, could result from exposure to a particular chemical. The dose-response evaluation quantitatively examines the relationship between the level of exposure and the incidence of adverse health effects in an exposed population.

Hazard Identification

For the purpose of this risk assessment, human health effects are divided into carcinogenic and noncarcinogenic effects. Consequently, human health risks are evaluated in this assessment in terms of carcinogenic and noncarcinogenic risks. Chemicals that pose carcinogenic risk often have noncarcinogenic effects. For instance, a chemical that causes lung cancer could also cause short-term and/or long-term noncancer neurological effects.

Carcinogen Classification

EPA has developed a carcinogen classification system that uses a weight-of-evidence approach to classify the likelihood of a chemical being a human carcinogen. Information considered in developing a classification includes human studies of the association between cancer incidence and exposure as well as long-term animal studies under controlled

Table 2-10
Exposure Parameter Values Used to Estimate Intake
Tomah Municipal Sanitary Landfill

Route	Parameter	Units	Children	Adult
Sediment Dermal Contact (Evaluated for Trespasser)	Ingestion Rate (IR)	mg/day	200	100
	Exposure Frequency (EF)	days/year	46	46
	Exposure Duration (ED)	years	6	30
	Conversion Factor (CF)	kg/mg	1.00E-06	1.00E-06
	Skin Surface Area (SA)	cm^2/day	2010	5800
	Soil to Skin Adherence Factor (AF)	mg/cm^2	1	1
	Body Weight (BW)	kg	15	70
	Averaging Time - Carcinogen (ATc)	days	25550	25550
	Averaging Time-Noncarcinogen (ATnc)	days	2190	10950
Surface Water Dermal Contact (Evaluated for Trespasser)	Exposure Time (ET)	hour/day	1	1
	Exposure Frequency (EF)	days/year	46	46
	Exposure Duration (ED)	years	6	30
	Conversion Factor (CF)	L/cm^3	1.00E-03	1.00E-03
	Skin Surface Area (SA)	cm^2/day	2010	5800
	Permeability Coefficient (PC)	cm^2/hour	chemical-specific	chemical-specific
	Body Weight (BW)	kg	15	70
	Averaging Time - Carcinogen (ATc)	days	25550	25550
	Averaging Time-Noncarcinogen (ATnc)	days	2190	10950
Groundwater Ingestion (Evaluated for Resident)	Ingestion Rate (IR)	L/day	1	2
	Exposure Frequency (EF)	days/year	350	350
	Exposure Duration (ED)	years	6	30
	Body Weight (BW)	kg	15	70
	Averaging Time - Carcinogen (ATc)	days	25550	25550
	Averaging Time-Noncarcinogen (ATnc)	days	2190	10950
Inhalation of Groundwater Vapor-Phase Chemicals (Evaluated for Resident)	Inhalation Rate (IR)	m^3/hour	0.6	0.6
	Exposure Time (ET)	hour/day	0.25	0.25
	Exposure Frequency (EF)	days/year	350	350
	Exposure Duration (ED)	years	6	30
	Volatilization Factor (VF)	m^3/kg	0.5	0.5
	Body Weight (BW)	kg	15	70
	Averaging Time - Carcinogen (ATc)	days	25550	25550
	Averaging Time-Noncarcinogen (ATnc)	days	2190	10950
Dermal Contact with Groundwater (Evaluated for Resident)	Exposure Time (ET)	hour/day	0.25	0.25
	Exposure Frequency (EF)	days/year	350	350
	Exposure Duration (ED)	years	6	30
	Conversion Factor (CF)	L/cm^3	1.00E-03	1.00E-03
	Skin Surface Area (SA)	cm^2/day	10600	23000
	Permeability Coefficient (PC)	cm^2/hour	chemical-specific	chemical-specific
	Body Weight (BW)	kg	15	70
	Averaging Time - Carcinogen (ATc)	days	25550	25550
	Averaging Time-Noncarcinogen (ATnc)	days	2190	10950

laboratory conditions. Other supporting evidence considered includes short-term tests for genotoxicity; metabolic and pharmacokinetic properties; toxicological effects other than cancer; structure activity relationships; and physical and chemical properties of the chemical. EPA classifies chemicals as:

- A—Known human carcinogen
- B1—Probable human carcinogen; limited human data available
- B2—Probable human carcinogen; sufficient evidence in animals and inadequate or no evidence in humans
- C—Possible human carcinogen
- D—Not classifiable as to human carcinogenicity
- E—Evidence of noncarcinogenicity for humans

The classification of the carcinogenicity of the chemicals assessed is listed in Tables 2-11.

Noncarcinogenic Effects

Noncarcinogenic health effects include a variety of toxic effects on body systems, ranging from renal toxicity (i.e., toxicity to the kidney) to central nervous system disorders. It is believed that organisms might have protective mechanisms that must be overcome before a toxic endpoint (effect) is manifest. The toxicity of a chemical is assessed through a review of toxic effects noted in short-term (acute) and long-term (chronic) animal studies, and epidemiological investigations. The noncarcinogenic effects of the chemicals at the site are summarized in the toxicity profiles provided as Attachment C-1 of Appendix C. Toxicity depends on the dose or concentration of the substance (i.e., the dose-response relationship). Toxicity values are a quantitative expression of the dose-response relationship for a chemical. Toxicity values take the form of reference doses, slope factors, and unit risks, each of which are specific to exposure by different routes.

Dose-Response Evaluation

Source of Toxicity Values

Two primary sources of toxicity values were used. The primary source is the EPA's Integrated Risk Information System (IRIS) database (EPA 1996). The IRIS database contains up-to-date health risk and EPA regulatory information. IRIS contains only reference doses and slope factors that have been verified by EPA work groups, and is EPA's preferred source of toxicity information.

If a toxicity value was not available through IRIS, the next data source consulted was the most recently available Health Effects Assessment Summary Tables (HEAST), issued by the EPA's Office of Research and Development (EPA 1995). HEAST summarizes interim (and some verified) reference doses and slope factors.

Table 2-11
Toxicity Values
for Contaminants of Concern

Chemical	Carcinogenic Weight-of-Evidence	Oral Reference Dose (mg/kg-day)	Inhalation Reference Dose (mg/kg-day)	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Slope Factor $(mg/kg\text{-}day)^{-1}$
Volatile Organic Compounds					
1,2-Dichloroethane	B2	-	-	0.091	0.091
1,2-Dichloropropane	B2	-	0.001142857	0.068	-
Benzene	A	-	-	0.029	0.02905
Styrene	C	0.2	0.285714286	2.47	-
1,2-Dichloroethene (mixed isomers)	NA	0.009	-	-	-
Vinyl Chloride	A	-	-	1.9	0.294
Semivolatile Organic Compounds					
4-Methylphenol	C	0.005	-	-	-
bis(2-Chloroethyl)either	B2	-	-	1.1	1.155
bis(2-Ethylhexyl)phthalate	B2	0.02	-	0.014	-
Pyrene	D	0.03	-	-	-
Inorganic Compounds					
Antimony	D	0.0004	-	-	-
Arsenic	A	0.0003	-	1.75	15.05
Beryllium	B2	0.005	-	4.3	8.4
Cadmium (water	B1	0.0005	-	-	-
Chromium (hexavalent)	A	0.005	-	-	42
Copper	D	0.037	-	-	-
Manganese	D	0.005	1.42857E-05	-	-
Thallium	D	0.005	-	-	-
Vanadium	NA	0.007	-	-	-

Definition of Reference Dose

The toxicity values describing the dose-response relationship for noncarcinogenic effects are the reference dose (RfD) or reference concentration (RfC). Three categories of RfD are potentially available: chronic RfDs (RfD_o for oral, and RfD_i for inhalation), subchronic RfDs (RfD_s), and developmental RfDs (RfD_{dt}). The RfD is generally expressed in units of mg/kg/day. Inhalation RfDs may be expressed as either mg/kg/day or mg/m^3 (RfC).

The EPA (EPA 1989a) defines RfDs in the following manner:

- Chronic Reference Dose (RfD): An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure to the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RfDs are specifically developed to be protective for long-term exposure to a compound (as a Superfund program guideline, 7 years to lifetime).

- Subchronic Reference Dose (RfD_s): An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure to the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during exposure lasting 2 weeks to 7 years in duration. Few values are currently available.

- Developmental Reference Dose (RfD_{dt}): An estimate (with uncertainty spanning perhaps an order-of-magnitude or greater) of a daily exposure to the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of developmental effects. Developmental RfDs are used to evaluate the effects of a single exposure event. Few values are currently available.

RfDs for some metals are for specific forms (e.g., hexavalent and trivalent chromium). The CLP analyses do not, however, report concentrations of specific forms, but rather give results in terms of "total" metal. In such situations it was conservatively assumed that the most toxic form was present, and its RfD was used.

Definition of Slope Factor

Carcinogenesis is a phenomenon for which risk evaluation based on a presumption of threshold is considered inappropriate. For carcinogens, EPA conservatively assumes that a small number of molecular events can provoke changes in a single cell that can eventually lead to cancer. This hypothesized mechanism for carcinogenesis is referred to as "nonthreshold" because there is believed to be essentially no level of exposure to such a chemical that does not pose finite probability, however small, of generating a carcinogenic response.

The dose-response relationship for carcinogens is expressed as a cancer slope factor. Generally, the slope factor is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is usually the upper 95 percent confidence limit of the slope of the dose-response curve and is expressed as the inverse of $mg/kg/day^{-1}$. The slope factor value represents an upper 95 percent confidence limit of the probability of a response per unit intake of a chemical over a lifetime (i.e., there is only a 5 percent chance that the probability of a response could be greater than the estimated value on the basis of the experimental data and model used).

For practical reasons, risk at low exposure levels are difficult to measure directly either by animal experiments or epidemiologic studies. The development of a slope factor generally entails applying a model to the available data set and using the model to extrapolate from the relatively high doses administered to experimental animals (or exposures noted in epidemiologic studies) to lower exposure levels expected for human contact in the environment. The basic non-threshold assumption is that if a carcinogenic response occurs at the dose levels used in any study, a response will occur at all lower doses.

If the extrapolation model selected is the linearized, multistage model, the slope factor is also known as the q_1^*. This value is derived by fitting animal data to the linearized multistage model and calculating the 95% UCL of the slope of the curve. Occasionally, slope factors are based on human epidemiologic data (e.g., arsenic and benzene) and are based on the "best" estimate instead of the 95% UCL. Use of slope factors conservatively assumes that cancer risk is probabilistic and any degree of exposure leads to some degree of risk.

EPA's approach to estimate the slope factor from animal studies or human data assumes a dose-response relationship with no threshold. There is uncertainty and conservatism built into this risk extrapolation approach. EPA has stated that cancer risks estimated by this method provide a rough but plausible upper limit of risk (i.e., it is not likely that the true risk would be more than the estimated risk, but it could be considerably lower [EPA 1989a]). Therefore, the actual risk will most likely be in the range between zero and the calculated quantity.

Toxicity Uncertainty

Sources of uncertainty associated with toxicity values used in the toxicity assessment will be discussed in more detail later.

In sediment, surface water, and groundwater, chemicals are present for which toxicity values are not available. This does not indicate that adverse health effects will not be experienced by exposed individuals. Chemicals without toxicity values are identified in Table 2-12 (see also Attachment C-1 of Appendix C).

Lead was detected in upgradient and downgradient surface water, sediment, and groundwater. The surface water sample concentration was 3 mg/L (both upgradient and downgradient); the maximum sediment concentration detected in upgradient sediment was 17,700 mg/kg. The maximum downgradient sediment concentration was 16,500 mg/kg. The upgradient groundwater lead concentration was 32.6 mg/L, while the maximum downgradient groundwater lead concentration was 158 mg/L. Soil lead levels of 400 mg/kg or less typically do not require further action based on *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities* (OSWER Directive 9355.4-12). The sediment concentration of 17,700 mg/kg (17.7 mg/kg) is below both the OSWER guidance and the WDNR Cleanup standard of 50 mg/kg. A toxicity value for lead is not currently available; however, an EPA-approved biokinetic model is available for modeling the impact environmental lead concentrations have on children's blood lead levels. This model was utilized; the results are summarized below and presented in Attachment C-2 of Appendix C.

Risk Characterization

This section presents an evaluation of the potential risks to public health associated with the TMSL site. Exposure situations are evaluated by estimating the carcinogenic and noncarcinogenic risks associated with them. The estimation of risk assumed that contaminant concentrations and intake levels remain constant over the exposure periods assessed. Where appropriate, exposure media concentrations are also compared to standards and criteria for protection of human health.

Noncarcinogenic Risks

The estimated intake of each chemical through an individual route of exposure is divided by its RfD. The resulting quotients are termed noncancer hazard quotients. When the hazard quotient exceeds 1 (i.e., intake exceeds RfD), there may be potential for health concern.

If exposure to multiple chemicals might occur, it is evaluated by a "hazard index" (EPA 1989a). The method assumes dose additivity. Hazard quotients are summed to provide a hazard index. When the hazard index exceeds 1, there is potential for adverse health effects. The hazard index can exceed 1 even if no single chemical intake exceeds its reference dose. If this occurs, the chemicals may be segregated by similar effect or target organ to determine the potential health risks.

Carcinogenic Risks

The estimated intake of each chemical through an individual route of exposure is multiplied by its appropriate cancer slope factor. (Some chemicals are carcinogenic only when inhaled or ingested, while others may be considered carcinogenic by any means of exposure.) The results are termed potential excess lifetime cancer risks.

Attachment C-3 contains the calculation tables for the estimation of potential excess lifetime cancer risk and hazard indices for each exposure scenario evaluated.

Current and Future Land Uses/Exposures

Chronic daily intakes were calculated using the methodologies previously discussed. Potential excess lifetime cancer risks for carcinogenic and noncarcinogenic health effects posed by potential exposure to site-related concentrations of contaminants were calculated. Current and future land uses, exposure pathways and routes, and intakes are the same. The results of these calculations are summarized in Tables 2-13 and 2-14.

Surface Water

Dermal contact with surface water contaminants was evaluated for adult and child recreational users (trespassers). The estimated potential lifetime excess cancer risk for an adult receptor was 5×10^{-8}, while that for a child receptor was 1×10^{-8}. The cancer risk was due to the presence of arsenic, a class A carcinogen, in the downgradient surface water. The noncancer hazard indices for both adults and children were both two orders of magnitude below one.

Table 2-12
Chemicals Without Toxicity Values

Chemical
Semivolatile Organic Compounds
Benzo(b)fluoranthene
Fluoranthene
1,4-Dichlorobenzene
Inorganic Compounds
Lead

Table 2-13
Summary of Risks
for Surface Water and Sediment Exposures

Receptor	Environmental Media			
	Surface Water		Sediment	
	Cancer Risk	Hazard Index	Cancer Risk	Hazard Index
Recreational Adult	5×10^{-8}	0.005	3×10^{-9}	0.0001
Recreational Child	1×10^{-8}	0.008	6×10^{-9}	0.0001

Table 2-14
Summary of Risks
for Groundwater Exposures

Receptor	Cancer Risk	Hazard Index
Residential Adult		
Ingestion	3×10^{-2}	135
Inhalation	2×10^{-4}	0.01
Dermal Contact	8×10^{-4}	2.3
Total	**3×10^{-2}**	**137**
Residential Child		
Ingestion	1×10^{-2}	315
Inhalation	2×10^{-4}	0.07
Dermal Contact	3×10^{-4}	5
Total	**1×10^{-2}**	**320**

Sediment

Dermal contact with contaminants in sediment was evaluated for adult and child recreational users (trespassers). The estimated potential lifetime excess cancer risk for an adult receptor was 3×10^{-9}, while that for a child receptor was 6×10^{-9}. The cancer risk was due to the presence of benzo(b)fluoranthene in the downgradient sediment. Benzo(b)fluoranthene is a class B2 carcinogen. The noncancer hazard indices for adults and children were both several orders of magnitude below 1. The HI for the both the child and adult were 0.0001.

Groundwater

Groundwater use by residential receptors was evaluated assuming three potential exposure routes: ingestion, inhalation, and dermal contact. The results for the groundwater risk evaluation are presented in Table 2-14.

Adults. The overall excess lifetime cancer risk estimated for residential adults was 3×10^{-2}. The estimated potential lifetime excess cancer risk for residential adults due to ingestion was 3×10^{-2}, while that for inhalation was 2×10^{-4}. Approximately 90 percent of the ingestion risk was attributable to ingestion of vinyl chloride in the groundwater. The ingestion of arsenic in the groundwater was estimated to contribute about 7 percent of the ingestion risk. Vinyl chloride was present in all eight monitoring well samples; arsenic was detected in seven of the eight monitoring wells. Dermal contact was estimated to result in an excess cancer risk of 8×10^{-4}. Vinyl chloride and bis(2-ethylhexyl)phthalate contributed the majority of the excess lifetime cancer risk.

The overall hazard index for the adult was 137. The ingestion hazard index for the adult was 135, with manganese in the groundwater contributing about 75 percent of the ingestion hazard. The hazard quotients for arsenic, thallium, *p*-cresol, antimony, and chromium also exceeded one. The hazard index for inhalation was less than 1. The dermal hazard index for the adult was 2.3. The dermal hazard quotient for bis(2-ethylhexyl)phthalate exceeded 1; however, bis(2-ethylhexyl)phthalate was detected in only one of eight downgradient samples.

Manganese, an essential nutrient, is thought to enhance turnover of neurotransmitters, leading to selective destruction of dopaminergic neurons. Both inhalation (at concentrations of 1 to 30 mg/m^3) and ingestion lead to neurological effects. Inhalation may also lead to respiratory effects such as edema and emphysema; however, these effects are thought to be due to inhalation of particulates, and not manganese per se.

Arsenic inhibits tissue respiration. Target organs include the liver, kidneys, skin, and lungs. Inhalation of arsenic affects the respiratory, cardiovascular, gastrointestinal, dermal, and neurological systems. Inhalation of arsenic is also linked to lung cancer. However, most of these effects are observed at higher concentrations (e.g., 50 to 500 mg/m^3) than those present at TMSL. Ingestion of arsenic affects the cardiovascular, gastrointestinal, dermal, neurological, and hepatic systems. These effects are seen at concentrations ranging from 10 to 500 mg/kg/day. Skin cancer has also been linked to ingestion of arsenic.

Thallium is one of the more toxic metals, causing liver, kidney, and nerve damage. Ingestion may result in acute effects such as hair loss, gastrointestinal irritation, paralysis, and psychic disturbances. Long-term intake may result in liver damage, kidney damage, and degeneration of the peripheral and central nervous system.

Contact with cresols may result in irritation of the skin, eyes, mouth, and throat. Abdominal pain, vomiting, anemia, kidney damage, and death may result from ingestion. The kidneys and the hematopoetic system are target organs for cresols.

Many antimony compounds irritate the gastrointestinal tract; intoxication results in vomiting and diarrhea. Inhalation can produce rhinitis, and other symptoms of mucosal irritation. Pulmonary edema and emphysema have also been reported.

Trivalent chromium (+3) is the most common form found in nature. Chromium present in biologic materials is usually the trivalent form. Trace quantities of Cr^{+3} are essential for carbohydrate metabolism. It is a cofactor for insulin action, and is found in ribonucleic acid (RNA). Most known harmful effects of chromium have been attributed to the hexavalent form (Cr^{+6}). It has been speculated that the reduction of Cr^{+6} to Cr^{+3} and the formation of complexes with intracellular macromolecules are the mechanism of biologic action of chromium. The target organ for chromium (the organ where the most serious health effects are noted) is the respiratory system. Inhalation of soluble Cr^{+6} compounds has been linked to ulceration and perforation of the nasal septum, and bronchogenic and nasal cancers. Burns, blisters, and skin rashes (dermatitis) are observed after skin contact with Cr^{+6} compounds.

Children. The overall potential lifetime excess cancer risk estimated for residential children was 1×10^{-2}. The cancer risk for residential children due to ingestion was 1×10^{-2}, while that for inhalation was 2×10^{-4} . Approximately 85 percent of the ingestion risk was attributable to ingestion of vinyl chloride in the groundwater. The ingestion of arsenic in the groundwater was estimated to contribute about 9 percent of the ingestion risk. Vinyl chloride was present in all eight of the monitoring well samples, while arsenic was detected in seven of the eight monitoring wells. Dermal contact was estimated to result in an excess cancer risk of 3.2×10^{-4}. Vinyl chloride and bis(2-ethylhexyl)phthalate contributed the majority of the excess lifetime dermal cancer risk. The overall hazard index for the child was 320. The ingestion hazard index for the child was 315, with manganese in the groundwater contributing about 75 percent of the ingestion hazard. The hazard quotients for arsenic, thallium, *p*-cresol, antimony, chromium, vanadium, barium, cadmium, and 1,2-dichloroethene also exceeded 1. The hazard index for inhalation was less than one. The dermal hazard index for the child was 5.0. The dermal hazard quotient for bis(2-ethylhexyl) phthalate exceeded 1; however, bis(2-ethylhexyl)phthalate was detected in only one of eight downgradient samples.

Summary of Findings

The current and future potential excess lifetime cancer risks and hazard indices estimated for onsite sampling locations in each environmental medium are summarized in Tables 2-13 and 2-14. In general, the majority of potential health impacts predicted were associated with exposure to contaminants detected in groundwater.

Surface Water

Dermal exposures to contaminants in surface water were estimated to result in excess lifetime cancer risks below 1×10^{-6}, and hazard indices below 1.

Sediment

Dermal exposures to contaminants in sediment were estimated to result in excess lifetime cancer risks below 1×10^{-6}, and hazard indices below 1.

Groundwater

Contaminants in groundwater were evaluated for ingestion, inhalation, and dermal exposures. The excess lifetime cancer risk estimated for adult residents was 3×10^{-2}, while that for child residents was 1×10^{-2}. The adult resident's hazard index was 137; the child resident's hazard index was estimated to be 320. Ingestion of groundwater contaminants resulted in the majority of the estimated risk and hazard.

Summary

It is entirely likely that residents use the groundwater and also use the wetlands for fishing or other recreational activities; therefore, it is appropriate to sum the risks for the residential and recreational receptors. The adult's overall risk is therefore 3×10^{-2}, while that for the child is 1×10^{-2}. The risk is primarily due to the presence of vinyl chloride in the groundwater.

It should be noted that at least two exposure pathways were not evaluated in this baseline risk assessment. Since no soil samples were collected from the landfill, no risk to persons having contact with landfill soil or contents was estimated. Hazardous materials present in the landfill that could pose some level of hazard should exposure occur.

Similarly, sampling from gas probes has confirmed the presence of landfill gases including VOCs. In addition to methane, these gases have been found to contain the following VOCs: vinyl chloride, 1,2-dichloroethene, 1,1,1-trichloroethane, toluene, and trichloroethene. Because the available data is considered field screening level quality and QA/QC documentation was not provided, the results could not be used in this quantitative risk assessment. No quantitative risk was estimated for nearby residents who may be exposed to ambient concentrations of these landfill gases.

A brief review of the data indicates that the maximum vinyl chloride concentration in the landfill gas was approximately 20 ppm, while that in groundwater was 1.2 ppm. Given that inhalation of vinyl chloride vapors from groundwater was estimated to result in a risk of approximately 2×10^{-4} and the landfill gas concentration is one order of magnitude higher than the groundwater concentration, a rough estimate is that the cancer risk due to inhalation of vinyl chloride in the landfill gas would result in risks of approximately 2×10^{-3}. Additional cancer risk would be contributed by the other carcinogenic compounds (e.g., trichloroethene) detected in the landfill gases.

The source control measure proposed in the RI indicates that the landfill gases will be collected with an active gas collection system and treated prior to release. The gas collection system and gas treatment will reduce exposures to ambient concentrations inhaled by nearby residents.

Comparison of Groundwater Results to Human Health ARARs

A comparison of positively detected compounds in groundwater to the applicable or relevant and appropriate requirements (ARARs) was performed. Maximum Contaminant Levels (MCLs), Maximum Contaminant Level Goals (MCLGs), Secondary MCLs (SMCLs),and Lifetime Health Advisories are exceeded by several groundwater contaminants downgradient from the site.

MCLs are enforceable drinking water standards developed under the Safe Drinking Water Act and are part of the National Primary Drinking Water Regulations. MCLGs are non-enforceable health goals, developed under the Safe Drinking Water Act and are set at levels at which there are no known or anticipated adverse effects to health. Lifetime Health Advisories assumes that other sources besides water contribute to exposure. When other sources are not known, a 20 percent contribution from the drinking water source is assumed. It is based on ingestion of 2 liters of water per day for a 70 kg adult.

All of these ARARs are exceeded by groundwater at the site. Groundwater results from the monitoring well data show 20 chemicals that were detected above regulatory standards. See Table 2-15 for a comparison of positively detected compounds in onsite groundwater to these ARARs.

The MCLs or MCLGs were exceeded by the following VOCs: 1,2-dichloroethane, 1,2-dichloropropane, benzene, *cis*-1,2-dichloroethene, total 1,2-dichloroethene, and vinyl chloride. Pentachlorophenol was the only SVOC to exceed its MCL and MCLG. Octachlorinated dioxin exceeded its MCL and MCLG.

Twelve inorganic chemicals were detected at concentrations which exceeded either their MCLs, MCLGs, or SMCLs. These chemicals included the following: aluminum, antimony, arsenic, beryllium, cadmium, total chromium, iron, lead, manganese, mercury, nickel, and thallium.

Uncertainty

Uncertainties associated with this risk assessment are due to uncertainties in the risk assessment process in general (i.e., the toxicological database), specific uncertainties in characterizing the site, and uncertainties associated with describing exposures. This risk assessment is subject to uncertainty associated with such sources as sampling and analysis, exposure estimation, and toxicological data. Uncertainty in the risk assessment is a function of the "state of the practice" of risk assessment and also of the uncertainty specific to TMSL site in particular. Site-specific uncertainties for the TMSL site include current and future land uses (likelihood of development for residential land use); exposure pathways (possibility for inhalation, ingestion, or dermal contact with groundwater by residents); and selection of substances (effect of not including chemicals in the quantitative risk estimate because of missing toxicological information or elimination due to low concentration or frequency of detection). Table 2-16 lists general uncertainty factors in risk assessment.

Table 2-15

Comparison of Groundwater Results to Human Health ARARs

Groundwater Constituents	Maximum Detected Downgradient (mg/L)	Federal Drinking Water Standards(3)			Health Advisories					Health Criteria Exceeded
		MCL (mg/L)	MCLG (mg/L)	SMCL (mg/L)	1-day HA - Child (mg/l)	10-day HA Child (mg/l)	Long-term HA - Child (mg/l)	Long-term HA - Adults (mg/l)	Lifetime HA (mg/L)	
Volatile Organic Compounds										
1,1-Dichloroethane	0.027	-	-	-	-	-	-	-	-	none
1,2-Dichloroethane	0.004	0.005	0	-	0.7	0.7	0.7	2.6	-	MCLG
1,2-Dichloropropane	0.016	0.005	0	-	-	0.09	-	-	-	MCL, MCLG
2-Hexanone	0.086	-	-	-	-	-	-	-	-	none
Acetone	0.320	-	-	-	-	-	-	-	-	none
Benzene	0.048	0.005	0	-	0.2	0.2	-	-	-	MCL, MCLG
Carbon Disulfide	0.001	-	-	-	-	-	-	-	-	none
Chlorobenzene	0.008	-	-	-	-	-	-	-	-	none
Chloroethane	0.013	-	-	-	-	-	-	-	-	none
cis-1,2-Dichloroethene	0.210	0.07	0.07	-	4	3	3	11	0.07	MCL, MCLG, lifetime HA
Ethylbenzene	0.048	0.7	0.7	-	30	3	1	3	0.7	none
2-Butanone (MEK)	0.280	-	-	-	-	-	-	-	-	none
4-Methyl-2-Pentanone (MIBK)	0.032	-	-	-	-	-	-	-	-	none
Styrene	0.003	0.1	0.1	-	20	2	2	7	0.1	none
Toluene	0.550	1	1	-	20	2	2	7	1	none
1,2-Dichloroethene, total(1)	0.200	0.07	0.07	-	4	3	3	11	0.07	MCL, MCLG, lifetime HA
trans-1,2-Dichloroethene	0.001	0.1	0.1	-	20	2	2	6	0.1	none
Vinyl Chloride	1.200	0.002	0	-	3	3	0.01	0.05	-	MCL, MCLG, longterm HA (child and adult)
Xylenes, total	0.170	10	10	-	40	40	40	100	10	none
Semivolatile Organic Compounds										
1,2-Dichlorobenzene	0.001	0.6	0.6	-	9	9	9	30	0.6	none
1,4-Dichlorobenzene	0.022	0.075	0.075	--	10	10	10	40	0.075	none
2,4-Dimethylphenol	0.016	-	-	-	-	-	-	-	-	none
2-Methylnaphthalene	0.005	-	-	-	-	-	-	-	-	none
2-Methylphenol (o-cresol)	0.018	-	-	-	-	-	-	-	-	none
4-Chloro-3-Methylphenol	0.011	-	-	-	-	-	-	-	-	none
4-Methylphenol (p-cresol)	1.100	-	-	-	-	-	-	-	-	none
bis(2-Chloroethyl)ether	0.007	-	-	-	-	-	-	-	-	none
bis(2-Ethylhexyl)phthalate	0.027	-	-	-	-	-	-	-	-	none
di-n-Butylphthalate	0.001	-	-	-	-	-	-	-	-	none
Diethylphthalate	0.110	-	-	-	-	-	-	-	5	none
n-Nitrosodiphenylamine	0.002	-	-	-	-	-	-	-	-	none
Naphthalen	0.016	-	-	-	0.5	0.5	0.4	1	0.02	none
Phenol	0.054	-	-	-	6	6	6	20	4	none
Pesticides/TCDDs										
Endrin	5.00E-06	0.002	0.002	-	0.02	0.02	0.003	0.01	0.002	none
gamma-Chlordane	1.20E-05	0.002	0	-	0.06	0.06	-	-	-	MCLG

Table 2-15
Comparison of Groundwater Results to Human Health ARARs

Groundwater Constituents	Maximum Detected Downgradient (mg/L)	Federal Drinking Water Standards(3)			Health Advisories					Health Criteria Exceeded
		MCL (mg/L)	MCLG (mg/L)	SMCL (mg/L)	1-day HA - Child (mg/l)	10-day HA Child (mg/l)	Long-term HA - Child (mg/l)	Long-term HA - Adults (mg/l)	Lifetime HA (mg/L)	
Octachlorodibenzo-p-dixoin(2)	3.80E-07	3.00E-08	0	-	1.00E-06	1.00E-07	1.00E-08	4.00E-08	-	MCL, MCLG, longterm HA (child and adult)
2,4,5-TP (Silvex)	6.10E-04	0.05	0.05	-	0.2	0.2	0.07	0.3	0.05	none
Inorganic Constituents										
Aluminum	186.000	-	-	0.05 to 0.2	-	-	-	-	-	SMCL
Antimony	0.053	0.006	0.006	-	0.01	0.01	0.01	0.015	0.003	MCL,MCLG, child HA, adult HA
Arsenic	0.112	0.05	-	-	-	-	-	-	-	MCL
Barium	1.730	2	2	-	-	-	-	-	2	none
Beryllium	0.011	0.004	0.004	-	30	30	4	20	-	MCL, MCLG
Cadmium	0.012	0.005	0.005	-	0.04	0.04	0.005	0.02	0.005	MCL,MCLG, longterm HA (child), lifetime HA
Calcium	150.000	-	-	-	-	-	-	-	-	none
Chromium, total	0.320	0.1	0.1	-	1	1	0.2	0.8	0.1	MCL,MCLG, longterm HA (child), lifetime HA
Cobalt	0.103	-	-	-	-	-	-	-	-	none
Copper	0.232	1.3(4)	1.3	1	-	-	-	-	-	none
Iron	353.000	-	-	0.3	-	-	-	-	-	SMCL
Lead	0.158	0.015(5)	0	-	-	-	-	-	-	MCL, MCLG
Magnesium	114.000	-	-	-	-	-	-	-	-	none
Manganese	19.000	-	-	0.05	-	-	-	-	-	SMCL
Mercury	0.003	0.002	0.002	-	-	-	-	0.002	0.002	MCL, MCLG, adult HA (longterm and lifetime)
Nickel	0.143	0.1	0.1	-	1	1	0.5	1	0.1	MCL, MCLG, lifetime HA
Potassium	114.000	-	-	-	-	-	-	-	-	none
Selnium	0.024	0.05	0.05	-	-	-	-	-	-	none
Silver	0.022	-	-	0.1	0.2	0.2	0.2	0.2	0.1	none
Sodium	251.000	-	-	-	-	-	-	-	-	none
Thallium	0.021	0.002	0.0005	-	0.007	0.007	0.007	0.02	0.0004	all
Vanadium	0.233	-	-	-	-	-	-	-	-	none
Zinc	0.439	-	-	5	6	6	3	12	2	none

Notes:

(1) ARARs shown are most conservative of 1,2-dichloroethene isomers (cis and trans).

(2) ARARs shown are for TCDD.

(3) Abbreviations for Federal Drinking Water Standards:
MCL = Maximum Contaminant Limit
MCLG = Maximum Contaminant Limit Goal
SMCL = Secondary Maximum Contaminant Limit

(4) Represents action level for copper.

(5) Represents action level for lead.

Table 2-16
Summary of Risk Assessment Methodology Uncertainties

Uncertainty Factor	Effect of Uncertainty	Comment
Environment Sampling and Analysis Samples collected were representative of conditions to which various populations may be exposed Errors in chemical analysis	May Over- or Underestimate Risks	Due to biases and random variability of samples, collected samples may not be completely representative of the site.
Errors in Chemical Analysis	May Over- or Underestimate Risks	
Chemical concentrations reported as "below method detection limit" are used at one-half detection limit when calculating mean chemical concentrations	May Overestimate Risks	Use of one-half the sample quantitation limit may result in assumption of higher or lower concentrations for all locations in sampling group.
Exposure Point Concentration Steady state concentrations (no attenuation/degradation)	May Overestimate Risks	Does not account for environmental fate, transport, or transfer which may alter concentration.
Toxicological Data Conservative U.S. EPA methodology for slope factors and reference doses	May Overestimate Risks	Slope factors are upper 95th percent confidence limits derived from linearized model; considered unlikely to underestimate true risk.
Hazard indices were developed assuming all toxic effects were additive	May Over- or Underestimate Risks	Does not consider possible potentiation or inactivation
Exposure Parameters Conservative values were used for exposure duration, frequency, and ingestion/inhalation rates	May Over- or Underestimate Risks	Values chosen for the most part represent site-specific values based on available USEPA default values and guidance. RMEs represent an upper-bound estimate.
Exposure pathways were not evaluated if no sampling data were available.	May Underestimate Risks	

Sampling and Analyses

Uncertainty associated with sampling and analysis includes the inherent variability (standard error) in the analysis, representativeness of samples, sampling errors, and the heterogeneity of the sample matrix. While the RI QA/QC program serves to reduce errors, it cannot eliminate all errors associated with sampling and analysis.

Exposure Point Concentration

The estimation of exposure required numerous assumptions to describe potential exposure situations. There are a number of uncertainties regarding likelihood of exposure, frequency of contact with contaminated media, the concentration of contaminants at exposure points, and the period of exposure. A brief overview of some of the assumptions is presented below.

An individual may be exposed to substances through several pathways. In those situations, the total exposure is summed to provide a more accurate estimate of the potential risk. This information was presented as the total excess lifetime cancer risk from inhalation, ingestion, and dermal absorption.

The exposure settings and contact times and frequencies assumed are conservative

No samples were taken from soil on or within the landfill itself, thus, no risk was estimated. However, hazardous materials present in the landfill could pose some level of hazard if exposure did occur. Likewise, no risk was estimated for nearby residents exposed to landfill gases. Gas probes installed in the landfill indicate landfill gases are being generated, and VOCs are carried with the landfill gases.

Toxicological Data

The toxicological database is also a source of uncertainty. EPA outlined some sources of uncertainty in its *Guidelines for Carcinogen Risk Assessment* (EPA 1986). They include extrapolation from high to low doses and from animals to humans; species, gender, age, and strain differences in uptake, metabolism, organ distribution, and target site susceptibility; and human population variability with respect to diet, environment, activity patterns, and cultural factors.

Toxicity values have been derived primarily from short-term, high concentration doses and extrapolated down to the low-level chronic doses observed in environmental exposures. Because of the inherent uncertainty in this approach, the EPA has used various modifying factors in the development of toxicity values (reference doses and cancer slope factors). The dose-response curve for exposures, which may be linear at higher concentrations, is assumed to remain linear at low doses. These approaches may result in an over- or underestimate of risk.

Another source of uncertainty in the toxicity values is extrapolation from animal studies to human exposures. Errors and uncertainties arise from species differences in absorption, distribution, metabolism, and excretion of xenobiotics. Other areas ot differences in species include target organs and population variability. Many rat species are inbred and, therefore, represent a much more homogeneous population than humans. Even toxicity values derived from human studies may not be truly representative of human heterogeneity.

Occupational epidemiological studies have generally been conducted with white, middle-aged males whose responses may not be indicative of responses in children, females, or the elderly.

A rigorous methodology has been developed to determine toxicity values. The cancer slope factors represent the 95 % UCL derived from the linearized model. It is believed that the EPA toxicity values used in this risk assessment result in estimates of risk that overestimate true risk.

Exposure Parameters

The exposure parameter values used for the most part reflect professional judgment. Although many of the values were based on EPA default values, they were prorated to reflect site-specific information. It is believed these values represent realistic yet conservative estimates for the exposure parameters noted. Their use is thought to result in low to moderate effects on the magnitude of risk.

An additional source of uncertainty that should be recognized is the limited data set. Although risks were estimated based on the data set provided, the power of the comparison to background was limited (may have resulted in contaminants being eliminated or retained incorrectly). Additional data would have provided a more accurate charactization of the site and potential risks.

As a comparative measure, the excess lifetime cancer risks to residential adults and children due to exposure to vinyl chloride in the groundwater were also estimated using the arithmetic average concentration. Vinyl chloride was detected in all eight of the downgradient groundwater samples; the arithmetic average concentration was 279 mg/L. The overall vinyl chloride cancer risk (sum of risks for ingestion, inhalation, and dermal contact) for adults was estimated at 6.5×10^{-3}, while that for children was 3×10^{-3}. Use of the arithmetic average concentration results in risks approximately five to ten times less than those estimated when using the maximum concentration. The risks estimated using the arithmetic average concentration, however, still exceed the EPA-acceptable range of 1×10^{-4} to 1×10^{-6} excess lifetime cancer risk.

In addition, RAGS Part A indicates that it is inappropriate to use an adjusted oral slope factor to evaluate cancer risks for compounds such as PAHs, which may cause skin cancer through a direct action at the point of application. Since there is no EPA-approved method for estimating risks due to dermal contact with PAHs, the method used herein utilizes adjusted oral slope factors.

The methodology used to estimate risk posed by dermal exposure, although representing EPA's current guidance, may underestimate risk. This is because, in the absence of information on absorption, one assumes an oral absorption efficiency of 100 percent. This is considered nonconservative because the true absorbed dose might be lower, therefore, the absorbed-dose RfD should be lower or the slope factor should be higher. However, chemical-specific values were used whenever possible.

The risk calculations presented herein represent excess lifetime risk (i.e., over and above the cancer rate observed in the U.S. population). Current estimates of the cancer rate for the U.S. population are that one in three or four people will develop cancer at some time in their lives (American Cancer Society, 1995).

SECTION 3

Ecological Risk Assessment

Introduction

A screening level ecological risk assessment (ERA) is defined as "a qualitative and/or quantitative appraisal of the actual or potential effects of a hazardous waste site on plants and animals other than people and domesticated species" (EPA 1989b). The ERA is part of the risk assessment process to evaluate if the contaminants of potential concern (COPCs) from the site pose a risk to the biotic environment (aquatic organisms and terrestrial animals).

The ERA was conducted to meet applicable regulatory requirements and to provide the information needed to evaluate whether remedial action is warranted in an off-source area (i.e., Deer Creek and its associated wetlands) based on actual or potential ecological risks. Sections of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) include statements which indicate both human health and the environment must be considered when assessing risk associated with releases from hazardous waste sites. The National Contingency Plan (NCP) specifically states that an environmental evaluation must be performed to assess threats to the environment during the overall process of assessing the need to remediate a hazardous waste site (40 CFR Part 300.430[e][2][i][G]).

The ERA is limited to assessing only specific ecological endpoints; it does not necessarily prove cause-and-effect relationships. The principal objectives of the ERA are:

- To identify the ecosystem and biological receptors potentially exposed to site-related COPCs
- To determine the types, forms, and quantities of COPCs in the media of concern
- To identify, where possible, complete exposure pathways between COPC sources and biological receptors
- To quantify, where possible, target receptor risk by exposure to site-related COPC exposure
- To identify areas of uncertainty involved with the development of the ERA

Scope and Organization of ERA

The ERA is based primarily on the following guidance documents:

- Framework for Ecological Risk Assessment (EPA/630/R-92/001, February 1992)

- Risk Assessment Guidance for Superfund, Volume II Environmental Evaluation Manual, Interim Final (EPA/540/1-89/001, March 1989)

- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference Document (EPA 600/3-89/013, March 1989)

The ERA closely follows the guidance in the EPA framework document (EPA 1992c). The framework document recommends three major components: (1) problem formulation, which establishes the goals and focus of the ERA; (2) analyses of exposure and effects (analysis phase); and (3) risk characterization

Problem Formulation

Problem formulation characterizes the potential stressors that the ecosystem components are exposed to, and the assessment and measurement endpoints of the ERA. A stressor is defined as "any physical, chemical, or biological entity that can induce an adverse response" (EPA 1992c). The problem formulation step is based upon analytical information collected during the RI, and identifies the components of the site aquatic and terrestrial ecosystems exposed to potential site-related contaminant stressors (also referred to as COPCs).

To define the extent of the potential problem, literature assessing the known effects of the COPCs to biological receptors is collected and reviewed. Site-specific information is then used to identify exposure pathways and the biological receptors of concern. The end product of the problem formulation is a conceptual model which defines the exposure pathways linking the COPCs to the receptors, and provides the rationale for identifying those exposure pathways most significant in assessing risk. The conceptual model is used in the analysis of exposure and effects presented in the analysis phase.

Analysis Phase

The RI results and quantitative assessment of exposure are presented in the analysis phase. The analysis phase is comprised of two major components: characterization of exposure and ecological effects assessment.

The exposure characterization process identifies the COPC exposure dose (or concentration) for the identified receptors of concern. The observed 95 percent UCL of the mean or maximum COPC concentrations, were calculated to determine the potential exposure point concentrations to the ecological receptors and the actual dose received by the exposed organism.

The effects assessment presents the results of site-specific, RI-generated results to determine the ongoing responses of biological receptors to the site-related stressor.

Risk Characterization

Risk is characterized by comparing the exposure doses to literature derived toxicological benchmark values. The hazard quotient method was used to quantify the risk. The hazard quotient is calculated by dividing the exposure dose by a comparable literature based benchmark value.

The risk characterization, combines the information developed in the exposure and ecological assessments to evaluate if there are existing or potential ecological risks. This ERA component also summarizes the evidence for ecological risks at the TMSL site; discusses the magnitude of those risks; and describes the ecological significance of the risks observed or estimated. It also presents a discussion of the uncertainty associated with exposure and effects assessment, as well as with the risk characterization.

Limitations and Assumptions of the ERA

The limitations of this ERA include the following:

- The investigation was conducted within a limited time period
- Limited information was available regarding contaminant effects to particular species of interest
- Conservative assumptions regarding exposure conditions could lead to an overconservative characterization

The investigation results provide only a "snapshot in time" which is representative of conditions occurring only within that sampling event. Extrapolation of the results to conditions outside that period introduces uncertainty.

The ERA is based on the following assumptions:

A source control remedy (i.e., landfill cap and gas collection system) will be implemented for the landfill and no additional corrective actions will occur under the most reasonably expected future use of Deer Creek and adjacent wetlands.

Only site-related COPCs contribute risk to ecological receptors. Potential effects of agricultural land use will not be included in the evaluation.

The media of concern are surface water and sediment in Deer Creek.

The soil pathway was not addressed because the RI did not collect analytical data for surface soils on the landfill. In addition, it was assumed that the proposed source control action (landfill cap and gas collection) would adequately prevent access to COPCs by terrestrial organisms.

The groundwater pathway was not addressed as there is no direct route for biological receptors to be exposed to contaminated groundwater. However, because the shallow groundwater discharges to Deer Creek and its associated wetlands, the affects of potentially contaminated groundwater on the environment will be indirectly assessed through the surface water pathway.

Problem Formulation

The problem formulation step of the ERA identifies the goals, breadth, and focus of this assessment. The problem formulation includes a discussion of the potential site-related stressors; the ecosystems potentially at risk as a result of chemical stress or exposure; and a description of the assessment and measurement endpoints. The final outcome of this effort is the formulation of a conceptual site model which describes how a site-related stressor may affect a component of the ecosystem. As a result, the conceptual model provides input and guidance for the analysis phase of this report.

Step One—Identify and preliminary characterize the site-related potential stressors. Stressors are defined as "any physical, chemical, or biological entity that can induce an adverse response" (EPA 1992c). The specific potential stressors attributed to the landfill, and potentially of concern, are chemical compounds or elements that are organic (specifically vinyl chloride and benzene) or inorganic components (specifically lead and manganese) (Dames & Moore, 1996).

Step Two—Define the potentially exposed ecosystem receptors. A brief discussion of the ecological setting was presented in Section 1. The chemical, physical, and toxicological properties of the site-related contaminant stressors will determine the potential effects to the exposed ecological components. The problem formulation serves to link the existing ecology to the chemical and physical nature of the potential stressors to define the effects on components that may be exposed.

Step Three—Determine the measurement and assessment endpoints. An assessment endpoint is "the actual environmental value that is to be protected" and a measurement endpoint is "the measurable responses to a stressor that are related to the valued characteristics chosen as the assessment endpoints" (Suter 1993 and EPA 1992c). The assessment and measurement endpoints were focused to address potential effects attributable to site-related contaminant stressor influences to the site ecology.

The combined information from the stressor characterization, the ecosystem at risk, and the endpoint assessment was used to formulate a conceptual model. The conceptual model summarizes the potential exposure pathways and the components measured to ultimately assess the site-related potential stressor exposure and risk to the ecological receptors.

Stressor Characterization

Site-Related Stressors

The site-related contaminant stressors occurring at the TMSL site are organic and inorganic contaminants. Contaminants can stress an ecosystem if they are present at concentrations that could cause deleterious effects to the exposed biotic components.

The analytical results of abiotic media are presented in Tables 3-1 through 3-4. Onsite data were compared to applicable background concentrations. The chemicals detected in downstream surface water and sediment above appropriate background levels are presented in Tables 3-2 and 3-4, respectively.

Nonsite-Related Stressors

Potential nonsite-related stressors to the site ecosystem fall into three categories: physical, chemical, and biological. Physical stressors are created by mechanical disturbances to the habitat and seasonal disturbances resulting from the climate. Mechanical disturbances include building of roads, movement of surface soil for construction, presence of other facilities for various uses, and periodic cutting of cover vegetation. Seasonal disturbances include changes in temperature, freezing-thawing, flooding conditions, and the stratification of water bodies. Defining the effects that these influences cause on a specific

Table 3-1

Upgradient (Background) Surface Water Data Summary

Tomah Municipal Sanitary Landfill

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	UCL 95%[a]	Exposure Conc.	Units	Comments
METALS									
ALUMINUM	1	1	100.0%	669	669	n/a	669	ug/L	Single sample collected
ANTIMONY	1	1	100.0%	2.00	2.00	n/a	2.00	ug/L	Single sample collected
BARIUM	1	1	100.0%	41.7	41.7	n/a	41.7	ug/L	Single sample collected
CALCIUM	1	1	100.0%	12700	12700	n/a	12700	ug/L	Single sample collected
CHROMIUM, TOTAL	1	1	100.0%	2.00	2.00	n/a	2.00	ug/L	Single sample collected
IRON	1	1	100.0%	2040	2040	n/a	2040	ug/L	Single sample collected
LEAD	1	1	100.0%	3.00	3.00	n/a	3.00	ug/L	Single sample collected
MAGNESIUM	1	1	100.0%	5360	5360	n/a	5360	ug/L	Single sample collected
MANGANESE	1	1	100.0%	507	507	n/a	507	ug/L	Single sample collected
MERCURY	1	1	100.0%	0.200	0.200	n/a	0.20	ug/L	Single sample collected
NICKEL	1	1	100.0%	3.70	3.70	n/a	3.70	ug/L	Single sample collected
POTASSIUM	1	1	100.0%	3060	3060	n/a	3060	ug/L	Single sample collected
SELENIUM	1	1	100.0%	4.00	4.00	n/a	4.00	ug/L	Single sample collected
SODIUM	1	1	100.0%	3260	3260	n/a	3260	ug/L	Single sample collected
THALLIUM	1	1	100.0%	8.90	8.90	n/a	8.90	ug/L	Single sample collected
VANADIUM	1	1	100.0%	1.70	1.70	n/a	1.70	ug/L	Single sample collected

a. Insufficient number of samples to compute the 95% UCL as the exposure concentration.

Table 3-2
Downgradient Surface Water Data Summary
Tomah Municipal Sanitary Landfill

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	UCL 95%	Exposure Conc. [a]	Background Exposure Conc.	Units	Retain as COPC
METALS										
ALUMINUM	3	2	66.7%	519	522	2.98E+11	522	669	ug/L	no
ANTIMONY	3	3	100.0%	2.00	2.00	2.00	2.00	2.0	ug/L	no
ARSENIC	3	1	33.3%	6.30	6.30	30.10	6.30	ND	ug/L	yes
BARIUM	3	3	100.0%	37.8	68.8	172	69	41.7	ug/L	yes
CALCIUM	3	3	100.0%	12600	26000	119367.652	26000	12700	ug/L	yes
CHROMIUM, TOTAL	3	3	100.0%	2.00	2.00	2.00	2.00	2.0	ug/L	no
COBALT	3	2	66.7%	2.10	3.30	111	3.30	ND	ug/L	yes
IRON	3	3	100.0%	1,590	1,670	1,705	1,670	2040	ug/L	no
LEAD	3	3	100.0%	3.00	3.00	3.00	3.00	3.00	ug/L	no
MAGNESIUM	3	3	100.0%	5270	9150	21505.1634	9150	5360	ug/L	yes
MANGANESE	3	3	100.0%	260	2380	1725689434	2380	507	ug/L	yes
MERCURY	3	3	100.0%	0.200	0.200	0.200	0.200	0.200	ug/L	no
POTASSIUM	3	3	100.0%	2900	7030	74557.21137	7030	3060	ug/L	yes
SELENIUM	3	3	100.0%	4.00	4.00	4.00	4.00	4.00	ug/L	no
SODIUM	3	3	100.0%	3170	8060	90523.26447	8060	3260	ug/L	yes
VANADIUM	3	3	100.0%	1.00	2.00	6.00	2.00	1.7	ug/L	yes

a. Insufficient number of samples to use the 95% UCL as the exposure concentration.

Table 3-3
Upgradient (Background) Sediment Data Summary
Tomah Municipal Sanitary Landfill

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	UCL 95%[a]	Exposure Conc.	Units	Comments
VOLATILE ORGANIC									
2-BUTANONE (MEK)	1	1	100.0%	49.0	49.0	n/a	49.0	µg/kg	*single sample collected*
METALS									
ALUMINUM	1	1	100.0%	14000000	14000000	n/a	14000000	µg/kg	single sample collected
ANTIMONY	1	1	100.0%	1700	1700	n/a	1700	µg/kg	single sample collected
ARSENIC	1	1	100.0%	3600	3600	n/a	3600	µg/kg	single sample collected
BARIUM	1	1	100.0%	245000	245000	n/a	245000	µg/kg	single sample collected
CALCIUM	1	1	100.0%	6320000	6320000	n/a	6320000	µg/kg	single sample collected
CHROMIUM TOTAL	1	1	100.0%	33000	33000	n/a	33000	µg/kg	single sample collected
COBALT	1	1	100.0%	11600	11600	n/a	11600	µg/kg	single sample collected
IRON	1	1	100.0%	15200000	15200000	n/a	15200000	µg/kg	single sample collected
LEAD	1	1	100.0%	17700	17700	n/a	17700	µg/kg	single sample collected
MAGNESIUM	1	1	100.0%	2390000	2390000	n/a	2390000	µg/kg	single sample collected
MANGANESE	1	1	100.0%	796000	796000	n/a	796000	µg/kg	single sample collected
NICKEL	1	1	100.0%	21100	21100	n/a	21100	µg/kg	single sample collected
POTASSIUM	1	1	100.0%	1290000	1290000	n/a	1290000	µg/kg	single sample collected
SELENIUM	1	1	100.0%	3600	3600	n/a	3600	µg/kg	single sample collected
VANADIUM	1	1	100.0%	30000	30000	n/a	30000	µg/kg	single sample collected
ZINC	1	1	100.0%	101000	101000	n/a	101000	µg/kg	single sample collected

a. Insufficient number of samples to compute the 95% UCL as the exposure concentration.

Table 3-4
Downgradient Sediment Data Summary
Tomah Municipal Sanitary LandfillL

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	UCL 95%	Exposure Conc.[a]	Background Exposure Conc.	Units	Retain As COPC
VOLATILE ORGANIC										
2-BUTANONE (MEK)	3	3	100.0%	5.0	20.0	4251	20.0	49.0	µg/kg	no
SEMIVOLATILE ORGANIC										
BENZO(b)FLUORANTHENE	3	1	33.3%	56.0	56.0	794661282	56.0	ND	µg/kg	yes
FLUORANTHENE	3	1	33.3%	56.0	56.0	794661282	56.0	ND	µg/kg	yes
PYRENE	3	1	33.3%	60.0	60.0	491211079	60.0	ND	µg/kg	yes
METALS										
ALUMINUM	3	3	100.0%	7410000	10900000	14611451	10900000	14000000	µg/kg	no
ANTIMONY	3	3	100.0%	920	1300	1647	1300	1700	µg/kg	no
ARSENIC	3	2	66.7%	2100	3700	2061225	3700	3600	µg/kg	yes
BARIUM	3	3	100.0%	90200	192000	866309	192000	245000	µg/kg	no
CALCIUM	3	3	100.0%	1240000	4720000	781995359	4720000	6320000	µg/kg	no
CHROMIUM TOTAL	3	3	100.0%	13200	26500	72026	26500	33000	µg/kg	no
COBALT	3	3	100.0%	3500	8400	61445	8400	11600	µg/kg	no
COPPER	3	2	66.7%	10100	14000	97063	14000	ND	µg/kg	yes
IRON	3	3	100.0%	5350000	17900000	624108416	17900000	15200000	µg/kg	yes
LEAD	3	3	100.0%	5800	16500	324009	16500	17700	µg/kg	no
MAGNESIUM	3	3	100.0%	1530000	1770000	1888722	1770000	2390000	µg/kg	no
MANGANESE	3	3	100.0%	453000	973000	2880101	973000	796000	µg/kg	yes
NICKEL	3	3	100.0%	8000	16600	47074	16600	21100	µg/kg	no
POTASSIUM	3	3	100.0%	665000	953000	1319791	953000	1290000	µg/kg	no
SELENIUM	3	3	100.0%	1800	2600	3350	2600	3600	µg/kg	no
VANADIUM	3	3	100.0%	20300	23900	25815	23900	30000	µg/kg	no
ZINC	3	2	66.7%	46200	82100	55018378	82100	101000	µg/kg	no

a. Insufficient number of samples to use the 95% UCL as the exposure concentration.

ecosystem is very subjective. Many species die or migrate in response to seasonal changes. Many species (if mobile) can be affected adversely by mechanical alteration of habitat resulting in mortality, higher incidence of disease, and/or decreased natality. Other species, more opportunistic in nature, may thrive in the presence of mechanical or seasonal disturbance because of their tolerance for disturbances and the decreased competition from organisms unable to withstand the effects.

Physical disturbances observed within and around the TMSL site include:

- Seasonal influences (annual drought periods contributing to a loss of water in wetland areas)
- Habitat alterations around area due to the presence of farming and inactive cranberry bogs upstream

These physical alterations may have affected habitat suitability and water quality conditions. Changes in temperature and dissolved oxygen (DO) can introduce stresses to organisms that require a defined temperature and DO range for survival.

Potential chemical stressors include releases of chemicals for weed/ pest control and chemical imbalances in the natural system. Increased sedimentation (turbidity) is one of many factors that can influence critical water quality characteristics.

Potential biological stressors are a combination of the following: natural predation; competition for resources; occurrence of opportunistic species; and disease. Herbivorous animals consuming plants and predators consuming animals are a normal function of a natural ecosystem. These biological factors become a stressor with the removal of limits on the natural ecosystem function (e.g., overconsumption of vegetation in a pasture can greatly reduce productivity). Competition between and within plant and animal species can cause shifts in species composition within a community. These shifts are generally minor and localized with a disturbance such as water erosion. However, introduced plant and animal species can often out-compete native species, resulting in "weed" vegetation communities and elimination or great reduction in native animal species.

Ecosystem Potentially at Risk

The ecosystem at risk is defined as the ecological components likely to be affected by the stressors of concern. Therefore, the TMSL ecosystem at risk comprises organisms that can be exposed to COPCs.

Potential and occurring aquatic and terrestrial receptors were identified by conducting a site survey and a literature search of various agency resources (see Appendix D). Because comprehensive resource surveys were not conducted at the site, the results of the site species survey may not yield a comprehensive species list.

Exposure routes were identified by determining which existing and potentially existing aquatic and terrestrial receptor organisms of Deer Creek and adjacent wetlands could become exposed to COPCs. The major pathway for aquatic biota is potential exposure to chemicals in surface water and sediment, and for terrestrial biota is uptake from surface water. Direct exposure of aquatic and terrestrial life to contaminated groundwater was not evaluated; however, this exposure was addressed as a component of the surface water and sediment assessment.

In summary, because of site conditions and COPC characteristics, the principal ecosystem components at risk are the organisms directly exposed to contaminated surface water and sediment in Deer Creek and adjacent wetlands. Receptors indirectly exposed to COPCs by ingestion of contaminated prey may also be at risk. However, the TMSL site will supply only a partial amount of an organism's total foraging/hunting area. Therefore, these organisms are likely to be less at risk than receptors that may reside within the area throughout their lifetimes and are in continuous, direct contact with contaminated media.

Endpoint Selection

Assessment endpoints are expressions of the environmental value to be protected. Measurement endpoints are measurable responses to a stressor which are related to the valued characteristics chosen as the assessment endpoint. The assessment and measurement endpoints of an ERA can involve components from any level of biological organization, ranging from individual organisms to measurements of the ecosystem directly. In general, components of as many organizational levels as possible are investigated to lend confidence to the correlation between measurement and assessment endpoints. Effects directly attributable to TMSL stressor influences serve as the basis for selection of the assessment and measurement endpoints. No specific ecological effects from exposure to site-related stressors were readily apparent from field observations.

The identified assessment endpoints for the TMSL study area included the concentration of organic compounds and metals at levels in surface water and sediment sufficient enough to cause adverse effects (diminished growth, reproduction and survival) to exposed aquatic and terrestrial receptors. The measurement endpoints for this site include measurement of potential contaminant content in surface water and sediment. No other abiotic media (i.e., soil, air) were evaluated.

Site Conceptual Model

The conceptual model incorporates information regarding the nature and extent of the contaminants within the TMSL study area (as presented in the RI), and the potential effects of those contaminants on ecological receptors.

The COPCs are the residual concentrations of organic compounds and metals attributable to past waste disposal activities at the TMSL site and present in abiotic media. The ecosystems identified within the potentially affected area include the aquatic and terrestrial habitat of Deer Creek and adjacent wetlands that are in contact with contaminated surface water and sediment.

A toxicity approach to the ERA was conducted since biometric measures of species diversity and density would potentially be influenced by habitat conditions not attributable to COPC effects. Therefore, occurrence of COPCs within the surface water and sediment was measured. These measurements (measurement endpoints) provide a direct assessment of the toxicity potential, and subsequently the potential exposure and risk, to organisms.

The assessment endpoint that applies to the TMSL site is the concentration of site-related COPCs occurring in surface water and sediment that may cause an adverse effect to aquatic and terrestrial organisms exposed through ingestion (aquatic and terrestrial) or total body contact (aquatic only—fish and macroinvertebrates).

Because of the chemical, physical, and toxicological nature of the COPCs, it was determined that the principal ecological components at risk are those organisms directly exposed to contaminated media (e.g., direct ingestion of surface water by terrestrial organisms, and direct absorption of COPCs in surface water and sediment by aquatic organisms). Organisms exposed by indirect pathways (e.g., ingestion of contaminated food sources) are less likely to be at risk since some of the COPCs are not highly bioaccumulative. Therefore, the emphasis of this assessment is the determination of risk to organisms directly exposed to COPCs in contaminated media.

Analysis Phase

The analysis phase of the ERA consists of the technical evaluation of the data collected to determine the potential exposure and effects to the site ecology as a result of COPC occurrence. For the purpose of the TMSL ERA, it was determined that the contaminant concentrations in the surface water and sediment for contaminant content would provide a direct measure (measurement endpoint) of the assessment endpoint. The occurrence of contaminants in surface water and sediment at concentrations deemed to have no observable effects on biotic communities within the study area was determined to be the environmental value.

The characterization of exposure discusses the analytical results that were used to determine the COPCs. The COPCs include only those analytes attributable to the landfill which were detected above background levels. The characterization of exposure also discusses the potential exposure pathways and evaluation of target receptor organisms from the potentially affected environments.

Since the ERA was based upon a toxicity screening approach, the COPCs were evaluated to determine if there is potential toxicity attributable to the observed concentrations. Because of the limited number of samples collected during the RI, the maximum COPC concentrations detected in surface water and sediment were used to evaluate potential exposure point concentrations. These concentrations were then evaluated to determine the actual dose to the exposed organism by direct contact and ingestion (surface water and sediment) for aquatic organisms, and direct ingestion of surface water for terrestrial organisms. The exposure doses were compared to literature toxicological benchmark values or criteria for the determination of risk.

Characterization of Exposure

There are three primary components to the evaluation of exposure and risk:

- A source of contamination
- An exposure pathway
- An ecological receptor

If any of these components is missing, the exposure is incomplete and risk by definition can not occur. The following subsections address the contamination source, the exposure pathways, and the receptors present within the TMSL study area. An evaluation of contaminant occurrence (frequency of detection) and comparison to background was used to determine COPCs. The COPCs were further evaluated to determine the exposure dose for the identified receptors.

Summary of Site-Specific COPC

The characterization and distribution of the COPC (site-related stressors) occurring within the TMSL site were determined by sampling and analyses of various abiotic media for chemical content. Surface water and sediment samples were collected and analyzed for organic and inorganic chemical occurrence as part of the RI (Dames & Moore 1996). Because of the small number of samples collected, if a chemical was detected the chemical remained on the list of COPCs for further analysis.

The results of the analysis of abiotic media are presented in Tables 3-1 through 3-4. Onsite data were compared to background concentrations, and the chemicals detected in surface water and sediment below background levels were not considered. Certain inorganic constituents are commonly found in the environment and are relatively nontoxic. Therefore, various inorganic constituents that may pass the detection frequency screen (e.g., sodium, potassium, calcium, and magnesium) may not be of toxicological concern to environmental receptors and were excluded from further analysis as COPCs.

Exposure Pathways

The COPCs include organic and inorganic constituents in the surface water and sediment. Therefore, exposure pathways depend on the chemical and physical properties of those constituents. The COPCs for surface water and sediment were not considered volatile, therefore, the inhalation pathway was considered inappropriate for terrestrial organisms. Dermal adsorption by terrestrial organisms was not addressed because of the lack of available information and the uncertainty involved with the determination of dermal dose to ecological organisms. Also, the physical and chemical properties of the COPCs preclude their bioavailability and uptake by this exposure route. The quantified exposure pathways include:

- Aquatic organisms
  - Uptake of contaminants from surface water (all pathways)
  - Uptake of contaminants from sediment (all pathways)
- Terrestrial organisms
  - Ingestion of surface water

Aquatic Organisms. Once in an aquatic system, metal ions and organic compounds either precipitate in bottom sediments, remain in suspension, or are absorbed directly from water by aquatic organisms (by ingestion or absorption through the integument or gill epithelia). The hydrodynamic processes that dictate flow through a system and the disruptive events (e.g., storms and floods) will govern the transport of dissolved chemicals through an aquatic system; sediment transport of bound contaminants will determine rates and area of contaminant deposition.

Aquatic organisms (fish and macroinvertebrates) can become exposed to waterborne chemicals through a variety of routes. Fish and invertebrates can become exposed through ingestion or by absorption through the integument (skin) or gill surfaces. Most aquatic organisms have a protective integument layer which limits exposure to potentially toxic chemicals. Exposure through gill transfer and ingestion have been documented as the most significant exposure routes for fish (Rand and Petrocelli, 1985).

Fish are constantly immersed in an aquatic media and are therefore subject to acute and potentially chronic exposures. Exposure to an aquatic organism is a function of the bioavailibility of the chemical within the aquatic medium. Fish can become exposed to waterborne as well as sediment-related chemicals. However, chemicals that are not water soluble and that adhere to sediment or suspended particulate surfaces are generally unavailable for uptake through the skin or gills. Therefore, the chemical and physical properties of the chemical and the aquatic environment will influence the bioavailability of a chemical. These influences can be demonstrated by the relationship between water hardness levels and bioavailable levels of certain metals. Metals such as copper, cadmium, chromium, nickel, and zinc become less bioavailable in the presence of competing ions of calcium and magnesium. The uptake of these metals is limited in the presence of these ions.

In general, sediment can represent a potential source for contaminants if environmental conditions such as temperature, pH, microbial activity, DO, and acid volatile sulfide concentrations are conducive to their release into interstitial water (i.e., the water between sediment particles). Sediments also play an important role in contaminant transport because many contaminants are readily absorbed onto and transported with sediment particles. Once released from the sediments, contaminants can be absorbed directly by benthic organisms. In addition to direct absorption, numerous benthic organisms ingest sediments when they feed. In this instance, contaminants may be absorbed through the intestinal wall, or can become available to predators if the benthic organisms are consumed.

Terrestrial Organisms. The most likely route of exposure at the TMSL site is ingestion of contaminated surface waters.

Ecological Receptors

The quantitative exposure and risk assessment efforts were focused upon indicator groups of organisms or target species that represent sensitive components of the ecosystem at risk. Organisms that are chronically exposed or exposed through the duration of a life-cycle (and thus during sensitive life-stages) can exhibit more effects than organisms exposed only incidentally.

Aquatic Target Receptors. Fish and macroinvertebrates were selected as the target organisms for the ERA because of the following:

- They live in direct contact with surface water or sediment, increasing the probability that they will come in contact with contaminants in those media.
- Mobility within the ecosystem is limited; thus, it is likely that individuals would spend much of their lives within the study area.

Terrestrial Target Receptors. White-footed mouse, cottontail rabbit, American robin and whitetail deer (see Table 3-5) were selected as the terrestrial target animals for the ERA because of:

- Known occurrence in the study area

Table 3-5
Terrestrial Target Receptors Selected for Exposure and Risk Evaluation
Vicinity of Deer Creek

Ecosystem	Common Name	Scientific Name	Feeding Guild	Exposure and Toxicity Evaluation Rationale for Selection as Target Species	Routes Addressed	Method for Risk Estimation
Terrestrial	White-footed mouse	*Peromyscus leucops*	Omnivore	Potential occurance, sensitivity to toxicity, ecological relevance	I-SW	Contaminant concentration in media to benchmark value[a]
	Cottontail rabbit	*Sylvilagus floridanus*	Herbivore	Potential occurance, sensitivity to toxicity, ecological relevance	I-SW	Contaminant concentration in media to benchmark value[a]
	American Robin	*Turdus migratorius*	Omnivore	Potential occurance, sensitivity to toxicity, ecological relevance	I-SW	Contaminant concentration in media to benchmark value[a]
	Whitetail Deer	*Odocoileus virginianus*	Herbivore	Potential occurance, sensitivity to toxicity, ecological relevance	I-SW	Contaminant concentration in media to benchmark value[a]

Routes Addressed

I - SW - Ingestion of surface water.

Methods for Toxicity Assessment

Contaminant concentration in media compared to benchmark value.

[a] benchmark values from Opresko et al., 1994.

- Ecological relevance and representativeness (important in the local ecosystem)
- Sensitivity to the mechanism of toxicity of COPCs
- The small size of their home or breeding ranges, which makes it likely that sensitive life stages of individuals could spend part of their lives onsite

Determination of Exposure

Dose to Target Receptors. Results of the chemical analyses obtained from the abiotic surface water and sediment samples were used to determine the COPC exposure point concentrations to the ecological receptors. The maximum observed concentration was used for the organism exposure point concentration as a conservative estimate. Because the sample size was small, the 95 percent UCLs were calculated but not used in this ERA.

In conducting the data evaluations to determine exposure point concentrations and to establish reasonable exposure profiles, the following assumptions were made:

- The detected COPC concentrations were assumed to be 100 percent bioavailable.
- The maximum detected concentration within each medium was considered a reasonable maximum exposure point concentration.
- All receptor activities take place on the TMSL site (Deer Creek or adjacent wetlands).
- Surface water and sediment exposure routes were considered for aquatic organisms. The predominant exposure route to terrestrial organisms was ingestion of surface water. The inhalation pathway for terrestrial was considered incomplete, and the dermal pathway was not addressed because of the high uncertainty involved with this evaluation. Groundwater was not considered a direct exposure route. However, groundwater was considered as a contributor to surface water, and addressed under that route of exposure.
- All target receptor exposure is chronic.

Aquatic Final Contaminant of Concern (FCOC) Selection

Surface Water. The results of the comparison of observed maximum surface water concentrations with National Ambient Water Quality Criteria (NAWQC) or Wisconsin ambient water quality standards for the protection of aquatic life are summarized in Table 3-6. In some cases NAWQC and state standards have not been established for the chemicals detected. In those cases the observed concentrations were compared to values derived from literature (Suter and Mabrey, 1994). The comparison of observed COPC concentrations in surface water to water quality criteria/standards showed that:

- Observed maximum concentrations of barium, cobalt, and manganese occurred above the lowest chronic value reported in the literature
- Observed maximum concentrations of arsenic, barium, cobalt, and vanadium occurred below specified benchmark levels

Table 3-6

Summary of Available Water Quality Criteria/Standards for the Protection of Aquatic Life

Vicinity of Deer Creek

Tomah Municipal Sanitary Landfill

			NAWQC for the Protection of Aquatic Life							
			EPA Federal Criteria[a]		Wisconsin State Standards[b]					
Analyte	**Exposure Point Concentration**	**Units**	**Acute**	**Chronic**	**Acute**	**Chronic**	**Tier II[c]**	**Lowest Chronic Value[d]**	**Citation for Lowest Chronic Values[d]**	**Retained as FCOC**
Inorganics										
Arsenic	6.3	ug/L	360	190	363.8	153				No
Barium	68.8	ug/L					3.9	5800	Biesinger et al. (1972)	Yes
Cobalt	3.3	ug/L					3	5.1	Kimball (n.d.)	Yes
Manganese	2380	ug/L					80	<1100	Kimball (n.d.)	Yes
Vanadium	2	ug/L					19	80	Holdway et al. (1979)	No

[a] National Ambient Water Quality Criteria (NAWQC) for the protection of aquatic life.

[b] State of Wisconsin Water Quality Standards, Cold Water

[c] Values calculated using Great Lakes Water Quality Initiative Tier II methodology (40 CFR 9 et al.) and presented in Table 2 of ECO Update, Publication 9345.0-12FSI, EPA 540/F-95/038, January, 1996.

[d] Suter and Mabrey, 1994.

n.d. (no date)

Sediment. The results of the comparison of observed maximum sediment concentrations with literature derived benchmark values for the protection of aquatic life are summarized in Table 3-7. The comparison of observed COPC concentrations in sediment to benchmark values showed that:

- Observed maximum concentrations of arsenic, iron, and manganese, occurred above the most conservative benchmark values reported in the literature

- Observed maximum concentrations of copper, fluoranthene, benzo(b)fluoranthene and pyrene occurred below specified benchmark levels

Terrestrial Final Contaminant of Concern (FCOC) Selection

In the FCOC screen, toxicological benchmarks for endpoint species were developed based on the methods outlined in Table 3-8 (Opresko et al. 1994). Maximum observed concentrations were compared to developed screening level benchmarks (Table 3-9). The route of exposure was ingestion of contaminated surface water. Appropriate estimates of exposure are generally based on knowledge of the organisms' natural history, behavior, and diet. This information is combined with the concentrations of the COPCs' concentration to quantify chemical intake.

The following assumptions were made during the screening process:

- COPCs are 100 percent bioavailable
- Animals are exposed to the contaminants 100 percent of the time
- The receptor of concern absorbs 100 percent of the contaminant
- The COPCs are the only contaminants at the site

The comparison of exposure point concentrations in surface water to target receptors and benchmark values showed that all contaminants occurred below specified benchmark levels.

Characterization of Effects

A toxicity assessment approach, whereby toxicological information was acquired, was used to evaluate the potential adverse effects of the exposure of biota to the FCOCs at the TMSL site.

Evaluation of Relevant Effects Data

As part of an ERA, a cause-and-effect approach (otherwise known as an effects assessment) can be used. This approach can entail the implementation of onsite or in-laboratory exposures of test organisms to site-related contamination. Co-located measurement of onsite effects (i.e., percent cover of vegetation) to abiotic media contaminant occurrence may also be conducted. It was determined to be inappropriate to implement this form of assessment for the TMSL site because of the small size of the site and occurrence of other nonsite-related factors and stressors that can influence the outcome of such tests.

Qualitative observations of species occurrence and habitat condition were made, including a field survey of aquatic and terrestrial habitats. The results of the in-field observations indicate that the predominant factor controlling the site ecology structure appeared to be habitat suitability. Much of the area onsite has been physically disturbed in the past, but the

Table 3-7
Summary of Available Literature Derived Sediment Benchmark Values for the Protection of Aquatic Life
Vicinity of Deer Creek
Tomah Municipal Sanitary Landfill

Potential Chemical of Concern	Maximum Observed Concentration (Exposure Point Concentration)	Units	Wisconsin[A]	Ontario[B]		NOAA[C]		Hull et al.[D]	EPA Region V Sediment Classification[E]		Retain as FCOC
				LEL	SEL	ER-L	ER-M		Nonpolluted	Polluted	
Metals											
Arsenic	3.7	mg/kg	10	6	33	8.2	70		<3	3-8	Yes
Copper	14	mg/kg	100	16	110	34	270		<25	25-75	No
Iron	17900	mg/kg							<17000	17000-25000	Yes
Manganese	973	mg/kg		460	1110				<300	300-500	Yes
Semivolatile Organics											
Benzo(b)Fluoranthene[F]	0.056	mg/kg				400	2500	0.14			No
Fluoranthene	0.056	mg/kg				600	3600	6.2			No
Pyrene	0.06	mg/kg				350	2200				No

Notes:

[A] Wisconsin Department of Natural Resources Sediment Quality Criteria : Source (Sullivan, et al., 1985)

[B] Ontario Ministry of the Environment-Sediment Management Guidelines (Persaud, et al., 1989)
LEL = Lowest Effect Level, SEL = Severs Effect Level

[C] National Oceanic and Atmospheric Administration: ER-L = Effects Range Low, ER-M = Effects Range Medium (Long, et al., 1990)

[D] Recommended criterion suggested in guidance provided in Hull and Sutter, 1994.

[E] U.S. Environmental Protection Agency (1977). Unpublished guidelines. Region 5.

[F] Substituted benzo(a)pyrene benchmark values since no benchmark values exist for benzo(b)fluorene.

Tabie 3-8
Toxicological Information for Deriving Benchmark Values for Terrestrial Receptors
Vicinity of Deer Creek
Tomah Municipal Sanitary Landfill

Analyte	Test Species	Test Species NOAEL[a] (mg/kg/bw day)	Reference	Endpoint Species - Target Receptor	Estimated Wildlife NOAEL[b] (mg/kg/bw day)	Toxicological Benchmark water (ug/L)[c]
Arsenic	Mouse	0.126	Schroeder and Mitchner. 1971	White-footed-mouse	0.14	465
				Cottontail rabbit	0.037	386
				Whitetail deer	0.01	160
	Brown-headed Cowbird	2.46	USFWS. 1969	American robin	2.119	86933
Barium	Rat	5.06	Perry et al.. 1983	White-footed-mouse	13.547	45158
				Cottontail rabbit	3.62	37450
				Whitetail deer	1.015	15507
	Chicken	20.86	Johnson et al., 1960	American robin	24.215	175904
Cobalt	Rat	0.05	ATSDR. 1992	White-footed-mouse	0.12	400
				Cottontail rabbit	0.03	310
				Whitetail deer	0.009	137
Manganese	Rat	88	Laskey et al., 1982	White-footed-mouse	219.293	730978
				Cottontail rabbit	58.6	606208
				Whitetail deer	16.434	251019
Vanadium	Rat	0.21	Domingo et al., 1986	White-footed-mouse	0.474	1581
				Cottontail rabbit	0.127	1311
				Whitetail deer	0.036	543

[a] From Opresko et al.. 1994

[b] Calculation from Opresko et al., 1994

$NOAEL_w = NOAEL_t (bw_t/bw_w)^{.3}$

Where: $NOAEL_w$ = Equivalent NOAEL for a species of wildlife
$NOAEL_t$ = NOAEL for available test species
$(bw_t/bw_w)^{.3}$ = Adjustment factor for differences in body size

[c] Calculation from Opresko et al. 1994

$C_w = NOAEL_w X bw_w /W$

Where: C_w = Concentration of the contaminant in the drinking water of the animal
$NOAEL_w$ = Dose equivalent for a species of wildlife
W = Daily water consumption rate (L/day) for the target species
bw_w = Average body weight for the target species

Tabie 3-9
Terrestrial Target Receptor
Daily Dose Compared to Surface Water Ingestion Benchmark
Tomah Muncipal Sanitary Landfill

Analyte	Maximum Observed Concentration (Exposure Point Concentration)[a]	Units	Target Receptor	Screening Level Benchmark (ug/L)[b]	Retained as FCOC
Arsenic	6.3	ug/L	White-footed-mouse	465	no
			Cottontail rabbit	386	no
			American robin	86933	no
			Whitetail deer	160	no
Barium	68.8	ug/L	White-footed-mouse	45158	no
			Cottontail rabbit	37450	no
			American robin	175904	no
			Whitetail deer	15507	no
Cobalt	3.3	ug/L	White-footed-mouse	400	no
			American robin	310	no
			Cottontail rabbit	137	no
Manganese	2380	ug/L	White-footed-mouse	730978	no
			Cottontail rabbit	606208	no
			Whitetail deer	251019	no
Vanadium	2	ug/L	White-footed-mouse	1581	no
			Cottontail rabbit	1311	no
			Whitetail deer	543	no

[a] These values from Table 3-2.

[b] These values are from Table 3-8 .

new growth of trees contains suitable habitat. This was evident on the landfill. Also, farm land upstream may effect current conditions in the stream and wetlands adjacent to the site.

Ecological Response Analysis

The potential effects of stressors related to the TMSL site on aquatic and terrestrial receptors stem from the ability of the contaminants to disrupt the individuals' ability to grow, reproduce, and survive. The stress on the individual can then be reflected in biomass production, species composition, and population structure size. Measurable effects on the ecosystem, community and population are influenced more by the limited amount of available habitat or ongoing mechanical disturbance than by site contaminants.

Risk Characterization

Risk Estimation

The third component of the ERA is the risk characterization (EPA 1992c). The risk characterization relates exposure concentrations of FCOCs to concentrations of chemicals known to cause adverse effects, essentially the integration of exposure and toxicity. The hazard quotient method was selected to characterize risk associated with the FCOCs previously described. Hazard quotient values were derived by dividing the exposure point concentrations for each FCOC by the same benchmark toxicity criteria used to identify media-specific FCOCs. For this ERA, a hazard quotient value of less than 1.0 was considered to be associated with insignificant risk (Suter 1993). The general formula for a hazard quotient for exposed receptors is:

$$\text{Hazard Quotient} = \frac{[\text{Observed contaminant concentration or derived exposure dose}]}{[\text{Effective Concentration or Surrogate}]}$$

The hazard quotient method is probably the most common method for risk characterization used in ERAs. Its advantages, according to Barnthouse et al. (1986), are:

- Usefulness when a large number of chemicals must be screened
- Relative ease of implementation, general acceptance, and applicability to any data
- If the toxicity quotient is less than 1, the probability of an adverse ecological effect is negligible; if the toxicity quotient is between 1 and 10, ecological effects are possible. This method was considered the most suitable for the ERA. The hazard quotients for the FCOCs are summarized in Table 3-10.

Risk to Aquatic Organisms

For this effort, the following benchmark values used to identify FCOCs included: acute and chronic NAWQC; State of Wisconsin Water Quality Standards; literature based toxicity effects benchmarks; and literature derived sediment benchmark values. Actual exposures to potential receptors expected to occur in Deer Creek and the adjacent wetlands were assumed to be both acute (short-term) lethal concentrations and chronic (long-term) sublethal concentrations if directly exposed to contaminated surface water and sediment. The EPA Office of Water Quality and WDNR developed water quality criteria/standards

Table 3-10
Hazard Quotient Evaluation of FCOCs
Tomah Municipal Sanitary Landfill

	Contaminant Concentration in Media		Benchmarks for Aquatic Life Use			Comparison of Media Concentration to Benchmark (HQ)[a]			
Analyte	Surface water ug/L	Sediment mg/kg	Acute (Water) ug/L	Chronic (Water) ug/L	Sediment mg/kg	Acute (Water)	Chronic (Water)	Sediment	Retain as FCOC
Metals									
Arsenic		3.7			3			1.2	yes
Barium	68.8			3.9			17.6		yes
Cobalt	3.3			3			1.1		yes
Iron		17900			17000			1.05	yes
Manganese	2380	973		80	300		29.75	3.24	yes

[a] HQ = Hazard Quotient = Media Concentration(or Dose)/Benchmark.

(WQC/S) and sediment benchmarks to protect sensitive species from exposure to lethal and sublethal contaminant concentrations. The criteria, standards, and benchmarks were selected as conservative, appropriate screening criteria.

Results of the hazard quotient assessment of surface water and sediment FCOCs indicate a potential for ecological effects (HQ > 1) (see Table 3-10). A possible risk to aquatic organisms exists based on the hazard quotient methods; manganese in surface water; and arsenic, iron, and manganese in sediment.

Risk to Terrestrial Organisms

Based on the analysis, none of the FCOCs pose a risk to terrestrial organisms from ingestion of surface water from Deer Creek and adjacent wetlands from the TMSL site. Surface water concentrations were below benchmark values for all target receptors.

Summary of Risk Characterization

Aquatic Communities

Exposure and risk to aquatic organisms was evaluated by directly comparing surface water and sediment exposure dose to NAWQC, state standards, or literature based benchmark values. The NAWQC and benchmark values were considered very conservative in this assessment. The evaluation indicated that barium, cobalt, and manganese in surface water, and arsenic, iron, and manganese in sediment pose a possible risk to aquatic organisms.

A comparison of background concentrations of barium, cobalt, and manganese to surface water benchmark levels revealed a background level above the benchmark for barium and manganese. Thus, barium and manganese were eliminated as FCOCs in surface water.

A comparison of background concentrations of arsenic to sediment benchmark levels revealed a background level above the benchmark. Thus, arsenic was eliminated as a FCOC in sediment. Iron concentrations in background sediment were of the same order of magnitude as the downstream concentrations. Although the background iron concentrations were below benchmark values it is assumed that background and downgradient iron values in sediment were the same. Thus, iron concentrations in the sediment adjacent to the TMSL site were not considered ecologically significant. Manganese concentrations in the upstream sediment samples were also above benchmark levels and were also eliminated from consideration. Therefore, only cobalt concentrations in surface water adjacent to the TMSL site pose risk to aquatic organisms.

Actual damage to the aquatic ecosystem (i.e., dead fish, lack of macroinvertebrate diversity) and adjacent wetlands to the TMSL site were not observed. Based on this analysis, ecological effects from TMSL contaminants are considered nonexistent at this time. This assessment does not, however, preclude the possibility that future impacts could occur to the aquatic resources of Deer Creek from continued groundwater discharge into the creek and wetlands.

Terrestrial Community

Terrestrial organisms associated with the TMSL were not considered at risk based on literature derived benchmark values. The risk assessment for the terrestrial component was based on conservative assumptions. In addition, actual ecological effects were not observed during the field reconnaissance. As with the aquatic community, this assessment does not preclude the possibility that future impacts could occur to terrestrial resources in the vicinity of Deer Creek from continued groundwater discharge into the creek and wetlands.

Uncertainty

This risk assessment is subject to uncertainty from such sources as:

- Sampling and analysis
- Exposure estimations
- Toxicological data and risk estimation

General and site-specific uncertainties are discussed in the following sections and summarized in Table 3-11. Uncertainty associated with sampling and analysis includes the inherent variability (standard error) in the analysis, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. While the QA/QC program serves to reduce these errors, it cannot eliminate all errors associated with the sampling and analysis. The degree to which sample collection and analysis reflect real exposure point concentrations determines the reliability of resulting risk estimates.

The estimation of exposure requires numerous assumptions to describe potential exposure situations. There are a number of uncertainties which include: the likelihood of exposure; frequency of contact with potentially contaminated media; the concentrations of chemicals at exposure points; and the time period of exposure. Assumptions used in the ERA tend to simplify and approximate actual site conditions. The use of maximum exposure point concentrations to estimate exposures provides an upper-estimate on exposure.

Because the risk characterization is essentially the integration of the exposure assessment and toxicity screening, sources of uncertainty associated with either of these two processes also contribute to the uncertainty in the risk characterization. The hazard quotient method has some inherent limitations. One primary limitation is that the quotient method is a "yes/no" method for relating toxicity to exposure. It uses single values for exposure concentrations and toxicity values and does not account for incremental or cumulative toxicity and may \- or underestimate actual effects.

Species-specific toxicological information is often limited. Surrogate species information was often used when data were unavailable. Extrapolating intra-species toxicity values is less uncertain than extrapolating inter-species toxicity values.

Table 3-11
Sources of Uncertainty Within the ERA
Tomah Municipal Sanitary Landfill

Phase	General Factors Contributing to Uncertainity	Site-Specific Factors Contributing to Uncertainity
Problem Formulation	1. Sample collection activities	Relialibility of sampling activity may have limitations for useability.
	2. Analytical methods-appropriate analysis sensitivity and QA/QC	(See above comment)
	3. Appropriate and reasonable assumptions concerning the exposure pathways	Over conservative estimates of exposure and identification of complete exposure routes.
Analysis Phase	1. Selection of COPCs	Over conservative assumptions regarding background.
	2. Appropriate and accepted sources of literature toxicity data	Data used for the exposure assessment and toxicity assessment (NAWQC, State Standards for WQ, LOAELs) acute and chronic criteria levels were primarily obtained from EPA, WDNR, USFWS Insufficient data from thesesources were supplemented with data from peer-reviewed journals where available.
	a. Inter- and Intra-species extrapolations	Test species used to derive protective criteria may or may not be representative of species found on-site.
	b. Simple point toxicity values may or may not depict potential toxicity	Uncertainity was incorporated into the calculation of acute and chronic benchmark values from acute or subchronic values.
	c. Laboratory result applications may or may not be representative of the field	In general, laboratory-to-field extrapolations of toxicity data are considered to be acceptable under most conditions. Howerer, uncertainity is involved with the extrapolation of laboratory data to field situations.
	3. Exposure point concentration	It was assumed that the detected COPC concentration was 100% bioavailable. This is a conservative assumption. In addition, site-wide exposure point deviation can either dilute or over estimate true exposure point concentrations.
Risk Characterization	1. Use of benchmark values for the quantification of risk	The benchmark toxicity values may not adequately represent the most sensitive species or conversely be overprotective of the species present.
	2. Determination of additive risk based upon the summary of the hazard quotient indices	(See above comment)

SECTION 4

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APPENDIX A

TECHNICAL MEMORANDUM
TOMAH LANDFILL DATA MANAGEMENT

TECHNICAL MEMORANDUM CH2M HILL

Tomah Landfill Data Management

PREPARED FOR: U.S. EPA

PREPARED BY: CH2M HILL

DATE: April 3, 1996

In order to complete risk assessment tasks for the Tomah Municipal Sanitary Landfill, a database was created from data collected during the Phase I and Phase II investigations conducted by Dames & Moore (see Table A-1).

TABLE A-1
Summary of Phase I and Phase II Sampling

		Phase I			Phase II				
Matrix	**StationID**	**9/20/94**	**9/21/94**	**9/22/94**	**8/28/95**	**8/29/95**	**8/30/95**	**9/5/95**	**9/11/95**
Groundwater	MW-01A	1			1				
	MW-01B	1			1				
	MW-02A	1			1				
	MW-02B	1			1				
	MW-03A			1			1		
	MW-03B			1			2		
	MW-03C						5		
	MW-04A		2				1		
	MW-04B		1				2		
	MW-05A		1			1			
	MW-05B		1			2			
	MW-05C					2			
	MW-06A	2			1				1
	MW-07A			2	2				
	MW-08A				2				
	MW-09A					1			
	MW-09B					1			
	MW-09C					1			
	MW-10A					1			
Residential Wells	[redacted]				1				
	[redacted]				1				
	[redacted]				1				
	[redacted]							1	
	[redacted]				1				
	[redacted]				1				
Sediment	SC-01		2						
	SC-02		2						
	SC-03		1						
	SC-04		1						
Surface Water	SW-01			1					
	SW-02			2					
	SW-03		1	1					
	SW-04			1					

Electronic copies of Phase I data from the 1994 sampling event were received directly from Dames & Moore. The Phase I data consisted of analytical results from surface water, groundwater, and stream sediment samples. Samples were analyzed for the parameters listed in Table A-2.

TABLE A-2
Number of Samples Taken Per Analyses

			Groundwater			
Name	**Method**	**Sediment**	**Phase I**	**Phase II**	**Drinking Water**	**Surface Water**
Chloride	E325.2		6			
Chlorinated Herbicides by GC	SW8150		6			
CLP Pesticides 3/90	CP390		6			
CLP Semivolatiles 3/90	CSV390	5	15			5
CLP Volatiles 3/90	CV390	6	14			5
Color	E110.2		6	22	6	
Cyanide	SW9010			22	6	
Inorganic Anions by Ion Chromatography	E300.0			22	6	
Fecal Coliforms	SM909A		6	22	6	
Fluoride	E340.2		6	22	6	
ICI America Proprietary Pesticides	WR8945		6			
Inductively Coupled Plasma (ICP)	CI390P	5	14			5
Inductively Coupled Plasma (ICP)	SW6010			22	6	
Mercury	SW7470			22	6	
N-Methylcarbamates by HPLC	SW8318		6			
Nitrates	E353.2		6	22	6	
Odor	E140.1		6	22	6	
Organophosphorus Compounds by GC	SW8141		6			
PCDDs and PCDFs	SW8290		6			
Semivolatile Organics by GC/MS	SW8270			25	6	
Sulfate (as SO4), Turbidimetric	E375.4		6			
Surfactants	E425.1		6	22	6	
Volatile Organics by GC/MS	SW8240			28	6	
Volatiles by GC	SM504		14			5
Volatiles by GC	SW8021		14			5

The Phase II data consisted of analytical results from groundwater and residential well analyses (see Tables A-1 and A-2). Phase II data from the 1995 sampling event were received directly from Pace Laboratories.

Twelve separate files were combined into two database tables corresponding to the two sampling events. In general, Phase I data were received according to analyte groups (e.g., metals, volatile organic compounds, etc.). Phase II data were grouped according to sampling date (or order received by the laboratory). The data were spot checked by comparing with Appendices F (Data Validation Technical Memoranda) and G (Laboratory Data Summary) in the *Remedial Investigation Draft Final Report* prepared by Dames & Moore (January 1996) and cross tabulation reports generated using the database.

According to the RI Report, the analytical results were validated using the *National Functional Guidelines for Organic Data Review* (EPA, 1991) and the *Laboratory Data Functional Guidelines for Evaluating Inorganic Analyses* (EPA, 1990). CH2M HILL did not validate data or verify any of the validation. Project qualifiers assigned by Dames & Moore were assumed to be correct.

Once the initial spot checking was complete, Phase I and Phase II data were combined into one database for use in the risk assessment. Initial population of the database involved creation of new data fields by either combining existing data from separate fields or assigning new values (e.g. site ID = "TMSL", station ID = "SW-01"). New data elements were necessary to insure data integrity and uniqueness of each record. The data were again spot checked against hardcopy reports included in the RI (Appendix F) and project qualifiers added as noted for data received directly from the laboratory or for data with no qualifiers (e.g., "=" for detects). Duplicate sample results were received due to dilutions or re-extractions. In these cases, the most quantitative value for each parameter was selected based on the project qualifier (i.e. select detected value of "500" over "800U").

The majority of data provided by Dames and Moore or Pace Laboratories were unaltered. When changes were necessary, either new fields were created or existing data were combined in new data elements. However, once the database was complete and queries run, certain problems were encountered that required modification of original data. The first involved the VOC results for three sediment samples and pentachlorophenol results for nine samples. These laboratory results were qualified as "U" (i.e. not detected), which were changed upon review by Dames & Moore to "J" (i.e. estimated value). Results presented on Form I were not clear, but it was assumed that the new qualifiers were intended to be "UJ" (i.e. not detected) and the project qualifiers for the twelve samples (ten compounds) were modified accordingly.

TABLE A-3
Samples and Parameters with Modified Qualifiers

Matrix	Samples Affected	Parameter ID	Parameter
Sediment	SC010101 SC010101RE SC020101	MIBK HXO2 PCE PCA BZME CLBZ EBZ STY XYLENES	4-Methyl-2-pentanone 2-Hexanone Tetrachloroethene 1,1,2,2-Tetrachloroethane Toluene Chlorobenzene Ethylbenzene Styrene Xylenes (Total)
Sediment	SC010101 SC020101 SC030101 SC020101D SC040101	PCP	Pentachlorophenol
Groundwater	GW3B0101 GW4A0101 GW4A0101D GW4B0101	PCP	Pentachlorophenol

Second, Phase I metals data were reported by the laboratory using the Contract Required Detection Limits (CRDL) instead of Method Detection Limits (MDL). As a result, the detection limits for metals were reported as less than the CRDL in electronic data and less than MDL in the hardcopy laboratory reports in Appendix F of the Dames & Moore report. Detection limits in the database were revised for metals (at non-detect concentrations) to reflect MDL values. Twenty-four samples were affected.

TABLE 4
Phase I Samples With CRDL Reported

			Parameter														
Matrix	**Station ID**	**SampleID**	**AG**	**AS**	**BE**	**CD**	**CN**	**CO**	**CR**	**CU**	**HG**	**NI**	**PB**	**SB**	**SE**	**TL**	**V**
Groundwater	MW-01A	GW1A0101	10 (1)	10 (6)	5 (1)	5 (1)			10 (2)	25 (2)		40 (2)		60 (2)	5 (4)	10 (8)	50 (1)
	MW-01B	GW1B0101	10 (1)	10 (6)	5 (1)				10 (2)	25 (2)				60 (2)	5 (4)	10 (8)	50 (1)
	MW-02A	GW2A0101	10 (1)	10 (6)	5 (1)	5 (1)			10 (2)					60 (2)	5 (4)	10 (8)	50 (1)
	MW-02B	GW2B0101	10 (1)	10 (6)	5 (1)	5 (1)			10 (2)	25 (2)				60 (2)	5 (4)	10 (8)	50 (1)
	MW-03A	GW3A0101	10 (1)			5 (1)								60 (2)		10 (8)	
	MW-03B	GW3B0101	10 (1)		5 (1)								3 (1)	60 (2)	5 (4)	10 (6)	
	MW-04A	GW4A0101	10 (1)		5 (1)	5 (1)								60 (2)		10 (8)	
	MW-04A	GW4A0101D	10 (1)		5 (1)	5 (1)								60 (2)	5 (4)	10 (8)	
	MW-04B	GW4B0101	10 (1)		5 (1)	5 (1)								60 (2)	5 (4)	10 (8)	
	MW-05A	GW5A0101	10 (1)		5 (1)	5 (1)								60 (2)	5 (4)	10 (8)	
	MW-05B	GW5B0101	10 (1)	10 (6)	5 (1)	5 (1)			10 (2)					60 (2)	5 (4)	10 (8)	50 (1)
	MW-06A	GW6A0101	10 (1)			5 (1)									5 (4)	10 (8)	
	MW-06A	GW6A0101D	10 (1)			5 (1)									5 (4)	10 (8)	
	MW-07A	GW7A0101	10 (1)		5 (1)	5 (1)									5 (4)	10 (8)	
Sediment	SC-01	SC010101	10 (.86)		5 (.86)	5 (.86)	10 (2.1)				.2 (.43)			60 (1.7)		10 (5.2)	
	SC-02	SC020101	10 (.34)	10 (1)	5 (.34)	5 (.34)	10 (.9)				.2 (.17)			60 (.67)		10 (2)	
	SC-02	SC020101D	10 (.49)	10 (1.5)	5 (.49)	5 (.49)	10 (1.2)				.2 (.24)			60 (.98)		10 (2.9)	
	SC-03	SC030101	10 (.66)		5 (.66)	5 (.66)	10 (1.5)				.2 (.33)			60 (1.3)	5 (2.6)	10 (3.9)	
	SC-04	SC040101	10 (.46)		5 (.46)	5 (.46)	10 (1.2)				.2 (.22)			60 (.92)	5 (1.8)		
Surface Water	SW-01	SW010101	10 (1)	10 (6)	5 (1)	5 (1)		50 (2)	10 (2)					60 (2)	5 (4)		
	SW-02	SW020101	10 (1)	10 (6)	5 (1)	5 (1)		50 (2)	10 (2)			40 (2)		60 (2)	5 (4)	10 (8)	
	SW-02	SW020101D	10 (1)	10 (6)	5 (1)	5 (1)			10 (2)					60 (2)	5 (4)	10 (8)	
	SW-03	SW030101B	10 (1)		5 (1)	5 (1)		50 (2)	10 (2)			40 (2)		60 (2)	5 (4)	10 (8)	
	SW-04	SW040101	10 (1)	10 (6)	5 (1)	5 (1)			10 (2)			40 (2)		60 (2)	5 (4)	10 (8)	50 (1)

APPENDIX B

COMPARISON OF DOWNGRADIENT DATA TO UPGRADIENT DATA

APPENDIX B

Comparison Of Downgradient Data To Upgradient Data

This appendix describes the methodology and assumptions used to establish background inorganic concentrations for surface water, sediment, and groundwater. Background samples were collected from areas upgradient to the landfill. Background concentrations were compared to the downgradient surface water, sediment, or groundwater concentrations to determine if contaminants detected downgradient are potentially related to contaminant releases from the Tomah Municipal Sanitary Landfill (TMSL).

Methodology

The comparison of downgradient and upgradient concentrations are typically evaluated using parametric statistical tests. However, a rigorous, statistically valid approach requires a large number of samples to accurately characterize the distribution of the population. Because of the limited number of upgradient samples (one surface water, one sediment, and three groundwater samples) collected during the remedial investigation, the comparisons of downgradient and upgradient concentrations in environmental media were performed less rigorously.

The following approach was used to compare upgradient and downgradient environmental media concentrations at the TMSL. First, the analytical data was summarized. Next, the maximums were determined for both the upgradient and downgradient samples. Finally, the evaluation of whether an analyte was present downgradient at concentrations less than or equal to those upgradient was based on the ratio of maximum concentrations for the two groups. The comparison to background was as follows:

1. If the ratio between the downgradient and upgradient maximum concentration was less than 1.5, then the analyte was considered to be present at concentrations similar to upgradient levels. If the contaminant was determined to be present at concentrations similar to upgradient concentrations, the contaminant was eliminated from further evaluation (unless it was a Class A carcinogen).

2. If the ratio between the downgradient and upgradient maximum concentration was greater than 1.5, then the analyte was considered to be present at concentrations possibly higher than upgradient levels. These contaminants were retained for further evaluation.

   A ratio between the downgradient and upgradient maximum detected concentration was used because only one upgradient surface water, one upgradient sediment, and three upgradient groundwater samples were available for comparison purposes. Other statistical representation of the data (i.e., geometric mean or 95 percent upper confidence limit of the arithmetic mean) could not be evaluated because of the limited data set. The ratio between upgradient and downgradient samples was chosen to be 1.5 to allow for some natural variability in the environmental samples.

The results of the comparison between upgradient and downgradient surface water, sediments, and groundwater using maximum values were also examined to determine if the exceedance was based on a single outlier result.

Comparison of Downgradient and Upgradient Data

Only the inorganic data were evaluated in the comparison of upgradient to downgradient conditions. Metals occur naturally in the environment, whereas organic contamination is generally indicative of human activity. Therefore, organic compounds were retained for further evaluation without comparison to upgradient data; inorganic contaminants detected in downgradient samples with concentrations below those of upgradient samples were eliminated from further consideration.

Surface Water

Table B-1 summarizes the maximum concentrations for inorganic contaminants detected in the surface water samples collected upgradient of the landfill, while those for downgradient surface water samples are presented in Table B-2. One upgradient sample and three downgradient samples were collected. No organic compounds were detected in the surface water samples. Eighteen inorganic chemicals were detected in surface water samples.

The comparisons of upgradient and downgradient surface water contaminant concentrations are presented in Table B-3. An analysis of the ratios of the maximum surface water values indicated that the ratios of ten downgradient contaminant concentrations had ratios below 1.5. Chemicals with ratios over 1.5 were the following: arsenic, barium, calcium, cobalt, magnesium, manganese, potassium, and sodium. The inorganic chemicals detected are discussed briefly below.

Aluminum—Aluminum was detected in the upgradient sample at a concentration of 669 µg/L, and in two of the three downgradient samples. The maximum detected downgradient sample concentration was 522 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was less than 1.5, aluminum was eliminated from further evaluation.

Antimony—Antimony was detected in the upgradient sample at a concentration of 2 µg/L, and in all three downgradient samples. The maximum detected downgradient sample concentration was 2 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was less than 1.5, antimony was eliminated from further evaluation.

Arsenic—Arsenic was not detected in the one upgradient sample. It was detected in one of three downgradient samples at a concentration of 6.3 µg/L. It was retained for further evaluation.

Barium—Barium was detected in the upgradient sample at a concentration of 41.7 µg/L, and in all three downgradient samples. The maximum detected downgradient sample concentration was 68.8 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was 1.6, barium was retained for further evaluation.

Calcium—The maximum detected downgradient concentration of calcium (26,000 µg/L) was twice that of the upgradient sample (12,700 µg/L). Calcium was retained for further evaluation.

Chromium—Chromium was detected in the upgradient sample at a concentration of 2 µg/L, and in all three downgradient samples. The maximum detected downgradient sample concentration was 2 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was less than 1.5, chromium was eliminated from further evaluation.

Cobalt—Cobalt was not detected in the one upgradient sample. It was detected in two of three downgradient samples; the maximum detected concentration was 3.3 µg/L. It was retained for further evaluation.

Iron—Iron was detected in the upgradient sample at a concentration of 2,040 µg/L, and in all three downgradient samples. The maximum detected downgradient sample concentration was 1,670 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was less than 1.5, iron was eliminated from further evaluation.

Lead—Lead was detected in the upgradient sample at a concentration of 3 µg/L, and in all three downgradient samples. The maximum detected downgradient sample concentration was 3 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was less than 1.5, lead was eliminated from further evaluation.

Magnesium—The maximum detected downgradient concentration of magnesium (9,150 µg/L) was 1.7 times that of the upgradient sample (5,360 µg/L). Magnesium was retained for further evaluation.

Manganese—Manganese was detected in the upgradient sample at a concentration of 507 µg/L, and in all three downgradient samples. The maximum detected downgradient sample concentration was 2,380 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was over 1.5, manganese was retained for further evaluation.

Mercury—Mercury was detected in the upgradient sample at a concentration of 0.2 µg/L, and in all three downgradient samples. The maximum detected downgradient sample concentration was 0.2 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was less than 1.5, mercury was eliminated from further evaluation.

Nickel—Nickel was detected in the upgradient sample, but not in any of the downgradient samples. It was eliminated from further evaluation.

Potassium—The maximum detected downgradient concentration of potassium (7,030 µg/L) was over twice that of the upgradient sample (3,060 µg/L). Potassium was retained for further evaluation.

Selenium—Selenium was detected in the upgradient sample and in all three downgradient samples at a concentration of 4 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was less than 1.5, selenium was eliminated from further evaluation.

Sodium—Sodium was detected in the upgradient sample at a concentration of 3,260 µg/L, and in all three downgradient samples. The maximum detected downgradient sample concentration was 8,060 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was over 1.5, sodium was retained for further evaluation.

Thallium—Thallium was detected in the upgradient sample, but not in any of the downgradient samples. Because it was not detected in downgradient samples it is considered unlikely to be a site-related contaminant, and was eliminated from further evaluation.

Vanadium—The maximum detected downgradient concentration of vanadium (2 µg/L) was similar to that of the upgradient sample (1.7 µg/L). Vanadium was eliminated from further evaluation.

Sediment

Table B-4 presents the maximum concentrations for inorganic contaminants detected in the sediment samples collected upgradient of the landfill. Concentrations of downgradient sediment samples are presented in Table B-5. Table B-6 compares the maximum concentrations for inorganic contaminants detected in the sediment samples collected upgradient and downgradient of the landfill. One upgradient sample and three downgradient samples were collected. Four organic and seventeen inorganic chemicals were detected in the sediment samples. Per EPA guidance, all organic chemicals were retained for further evaluation. An analysis of the ratios of the maximum sediment inorganic values indicated that the majority of the ratios were below 1.5. Indeed, only one inorganic chemical (copper) was retained for further evaluation.

Methyl Ethyl Ketone (2-Butanone)—The maximum detected downgradient concentration of methyl ethyl ketone (MEK) was 20 µg/kg, half of the upgradient sample concentration (49.0 µg/kg). Because it is an organic compound, it was retained for further evaluation.

Benzo(b)fluoranthene—The maximum detected downgradient concentration of benzo(b)fluoranthene was 56.0 µg/kg. It was not detected in the upgradient sample. Benzo(b)fluoranthene in the sediment samples was retained for further evaluation.

Fluoranthene—The maximum detected downgradient concentration of fluoranthene was 56.0 µg/kg. It was not detected in the upgradient sample. As an organic compound, the fluoranthene was retained for further evaluation.

Pyrene—Pyrene was not detected in the upgradient sample. It was detected in the downgradient samples at a maximum concentration of 60.0 µg/kg. It was retained for further evaluation.

Aluminum—The maximum detected downgradient concentration of aluminum (10,900,000 µg/kg) was lower than that of the upgradient sample (14,000,000 µg/kg). Aluminum was eliminated from further evaluation.

Antimony—Antimony was detected in the downgradient sample at a concentration of 1,300 µg/kg, less than that of the upgradient sample (1,700 µg/kg). Antimony was eliminated from further evaluation.

Arsenic—The maximum detected downgradient concentration of arsenic (3,700 µg/kg) was similar to that of the upgradient sample (3,600 µg/kg). Arsenic was eliminated from further evaluation.

Barium—Barium was detected in all three downgradient samples, with a maximum concentration of 192,000 µg/kg. The upgradient concentration of barium was 245,000 µg/kg. Barium was therefore eliminated from further evaluation.

Calcium—The maximum detected downgradient concentration of calcium (4,720,000 µg/kg) was similar to that of the upgradient sample (6,320,000 µg/kg). Calcium was eliminated from further evaluation.

Chromium—Chromium was detected in all three downgradient sediment samples. The maximum detected downgradient concentration (26,500 µg/kg) was similar to that of the upgradient sample (33,000 µg/kg). Chromium was eliminated from further evaluation.

Cobalt—The maximum detected downgradient concentration of cobalt (8,400 µg/kg) was less than that of the upgradient sample (11,600 µg/kg). Cobalt was therefore eliminated from further evaluation.

Copper—The maximum detected downgradient concentration of copper was 14,000 µg/kg. Copper was not detected in the upgradient sample. Copper was therefore retained for further evaluation.

Iron—The maximum detected downgradient concentration of iron was 17,900,000 µg/kg, while that in the upgradient sample was 15,200,000 µg/kg. Iron was eliminated from further evaluation.

Lead—Lead was detected in the three downgradient samples at a maximum concentration of 16,500 µg/kg. The upgradient sample had a lead concentration of 17,700 µg/kg. Lead was therefore eliminated from further evaluation.

Magnesium—The maximum detected downgradient concentration of magnesium (1,770,000 µg/kg) was less than that of the upgradient sample (2,390,000 µg/kg). Magnesium was eliminated from further evaluation.

Manganese—Manganese was detected in all three of the downgradient samples, with a maximum downgradient concentration of 973,000 µg/kg. The upgradient sample concentration was 796,000 µg/kg. Because the ratio between the upgradient and downgradient concentrations was less than 1.5, manganese was eliminated from further evaluation.

Nickel—The maximum detected downgradient concentration of nickel (16,600 µg/kg) was similar to that of the upgradient sample (21,100 µg/kg). Nickel was eliminated from further evaluation.

Potassium—The maximum detected downgradient concentration of potassium (953,000 µg/kg) was less than that of the upgradient sample (1,290,000 µg/kg). Potassium was therefore eliminated from further evaluation.

Selenium—Selenium was detected in all three of the downgradient samples, with a maximum detected downgradient concentration of 2,600 µg/kg. The upgradient sample concentration was 3,600 µg/kg. Selenium was eliminated from further evaluation.

Vanadium—The maximum detected downgradient concentration of vanadium (23,900 µg/kg) was similar to that of the upgradient sample (30,000 µg/kg). Vanadium was eliminated from further evaluation.

Zinc—The maximum detected downgradient concentration of zinc (82,100 µg/kg) was similar to that of the upgradient sample (101,000 µg/kg). Zinc was therefore eliminated from further evaluation.

Groundwater

Upgradient groundwater contaminant concentrations from MW-1 and -6 are presented in Table B-7, while those for downgradient groundwater are shown in Table B-8. Note that only onsite monitoring well data was used. No data from the private residential wells was used in this comparison. Table B-9 compares the data for the inorganic contaminants detected in the groundwater samples. Four organic compounds and twenty-one inorganic chemicals were detected in the upgradient samples. Thirty-seven organic compounds and 23 inorganic chemicals were detected in the downgradient groundwater samples. Per EPA guidance, all organic compounds detected in the downgradient samples were retained for further evaluation.

All 23 inorganic chemicals detected in the downgradient groundwater samples were present at concentrations greater than 1.5 times the upgradient concentrations. The downgradient groundwater concentrations were found to range from 1.6 to 20 times the upgradient groundwater concentrations. All 23 inorganic chemicals were therefore retained for further evaluation. The inorganic chemicals detected are discussed briefly below.

Aluminum—Aluminum was detected in the upgradient samples at a maximum concentration of 95,500 µg/L, and in all eight of the downgradient samples. The maxi-mum detected downgradient sample concentration was 186,000 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was greater than 1.5, aluminum was retained for further evaluation.

Antimony—Antimony was detected in one of the upgradient samples at a concentration of 2 µg/L, and in four of eight downgradient samples. The maximum detected downgradient sample concentration was 53.2 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was greater than 1.5, antimony was retained for further evaluation.

Arsenic—Arsenic was detected in one of two upgradient samples at a concentration of 28.8 µg/L. It was detected in seven of eight downgradient samples at a maximum concentration of 112 µg/L. It was retained for further evaluation.

Barium—Barium was detected in both upgradient samples; the maximum upgradient concentration was 374 µg/L. It was detected in all eight downgradient samples. The maximum detected downgradient sample concentration was 1,730 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was over 1.5, barium was retained for further evaluation.

Beryllium—Beryllium was detected in one of two upgradient samples at a concentration of 2.4 µg/L. It was detected in four of eight downgradient samples at a maximum concentration of 11 µg/L. It was retained for further evaluation.

Cadmium—Cadmium was detected in one of two upgradient samples at a concentration of 1.1 µg/L. It was detected in two of eight downgradient samples at a maximum concentration of 11.5 µg/L. It was retained for further evaluation.

Calcium—The maximum detected downgradient concentration of calcium (150,000 µg/L) was 13 times that of the upgradient sample (11,300 µg/L). Calcium was retained for further evaluation.

Chromium—Chromium was detected in both of the upgradient samples at a maximum concentration of 162 µg/L, and in seven of eight downgradient samples. The maximum detected downgradient sample concentration was 320 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was greater than 1.5, chromium was retained for further evaluation.

Cobalt—Cobalt was detected in both the upgradient samples. The maximum upgradient concentration detected was 23.2 µg/L. It was detected in all eight of the downgradient samples; the maximum detected concentration was 103 µg/L. It was retained for further evaluation.

Copper—The maximum detected downgradient concentration of copper (232 µg/L) was over twice that of the upgradient sample (93.6 µg/L). Copper was retained for further evaluation.

Iron—Iron was detected in both of the upgradient samples the maximum detected upgradient concentration was 81,700 µg/L. It was detected in all eight of the downgradient samples. The maximum detected downgradient sample concentration was 353,000 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was greater than 1.5, iron was retained for further evaluation.

Lead—Lead was detected in both the upgradient samples at a maximum concentration of 32.6 µg/L, and in all eight downgradient samples. The maximum detected downgradient sample concentration was 158 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was greater than 1.5, lead was retained for further evaluation.

Magnesium—The maximum detected downgradient concentration of magnesium (114,000 µg/L) was twelve times that of the upgradient sample (9,460 µg/L). Magnesium was retained for further evaluation.

Manganese—Manganese was detected in both the upgradient samples at a maximum concentration of 938 µg/L, and in all eight downgradient samples. The maximum detected downgradient sample concentration was 19,000 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was over 1.5, manganese was retained for further evaluation.

Mercury—Mercury was detected in the upgradient samples at a maximum concentration of 0.88 µg/L, and in six of the eight downgradient samples. The maximum detected downgradient sample concentration was 2.5 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was greater than 1.5, mercury was retained for further evaluation.

Nickel—The maximum detected concentration of nickel in the upgradient samples was 64.4 µg/L, while that in the downgradient samples was 143 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was greater than 1.5, nickel was retained for further evaluation.

Potassium—The maximum detected downgradient concentration of potassium (114,000 µg/L) was almost an order of magnitude greater than that of the upgradient sample (11,600 µg/L). Potassium was retained for further evaluation.

Selenium—Selenium was detected in both the upgradient samples at a concentration of 4 µg/L. It was also detected in all eight downgradient samples; the maximum concentration was 24 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was greater than 1.5, selenium was retained for further evaluation.

Silver—Silver was not detected in the upgradient samples. It was detected in three of the eight downgradient samples, with a maximum reported concentration of 22 µg/L. It was retained for further evaluation.

Sodium—Sodium was detected in the upgradient samples at a maximum concentration of 9,620 µg/L. The maximum of the eight downgradient sample concentrations was 251,000 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was over 1.5, sodium was retained for further evaluation.

Thallium—Thallium was not detected in the upgradient samples. It was detected in five of the eight downgradient samples, with a maximum reported concentration of 20.7 µg/L. It was retained for further evaluation.

Vanadium—The maximum detected downgradient concentration of vanadium (233 µg/L) was 1.6 times that of the upgradient sample (142 µg/L). Vanadium was retained for further evaluation.

Zinc—Zinc was detected in both of the upgradient samples at a maximum concentration of 161 µg/L. It was detected in seven of the downgradient samples at a maximum concentration of 439 µg/L. Because the ratio between the maximum downgradient and upgradient concentrations was over 1.5, zinc was retained for further evaluation.

Table B-1
Contaminants Detected in Upgradient Surface Water

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Units
Inorganic Compounds						
Aluminum	1	1	100.0%	669	669	µg/L
Antimony	1	1	100.0%	2.00	2.00	µg/L
Barium	1	1	100.0%	41.7	41.7	µg/L
Calcium	1	1	100.0%	12,700	12,700	µg/L
Chromium, Total	1	1	100.0%	2.00	2.00	µg/L
Iron	1	1	100.0%	2,040	2,040	µg/L
Lead	1	1	100.0%	3.00	3.00	µg/L
Magnesium	1	1	100.0%	5,360	5,360	µg/L
Manganese	1	1	100.0%	507	507	µg/L
Mercury	1	1	100.0%	0.200	0.200	µg/L
Nickel	1	1	100.0%	3.70	3.70	µg/L
Potassium	1	1	100.0%	3,060	3,060	µg/L
Selenium	1	1	100.0%	4.00	4.00	µg/L
Sodium	1	1	100.0%	3,260	3,260	µg/L
Thallium	1	1	100.0%	8.90	8.90	µg/L
Vanadium	1	1	100.0%	1.70	1.70	µg/L

Table B-2
Contaminants Detected in Downgradient Surface Water

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Units
Inorganic Compounds						
Aluminum	3	2	66.7%	519	522	µg/L
Antimony	3	3	100.0%	2	2	µg/L
Arsenic	3	1	33.3%	6	6	µg/L
Barium	3	3	100.0%	38	69	µg/L
Calcium	3	3	100.0%	12,600	26,000	µg/L
Chromium, Total	3	3	100.0%	2	2	µg/L
Cobalt	3	2	66.7%	2	3	µg/L
Iron	3	3	100.0%	1,590	1,670	µg/L
Lead	3	3	100.0%	3	3	µg/L
Magnesium	3	3	100.0%	5,270	9,150	µg/L
Manganese	3	3	100.0%	260	2,380	µg/L
Mercury	3	3	100.0%	0	0	µg/L
Potassium	3	3	100.0%	2,900	7,030	µg/L
Selenium	3	3	100.0%	4	4	µg/L
Sodium	3	3	100.0%	3,170	8,060	µg/L
Vanadium	3	3	100.0%	1	2	µg/L

NOTE: "X" means was detected; "ND" means not detected.

Table B-3
Comparison of Upgradient and Downgradient Surface Water Contaminant Concentrations (μg/L)

Parameter	Upgradient Maximum Detected Value	Downgradient Maximum Detected Value	Downgradient Frequency of Detection	Ratio of Upgradient to Down-gradient	Chemical Retained for Evaluation
Inorganic Chemicals					
Aluminum	669	522	2 of 3	0.78	N
Antimony	2	2	3 of 3	1.00	N
Arsenic	ND	6	1 of 3	--	Y
Barium	42	69	3 of 3	1.65	Y
Calcium	12,700	26,000	3 of 3	2.05	Y
Chromium, Total	2	2	3 of 3	1.00	N
Cobalt	ND	3	2 of 3	--	Y
Iron	2,040	1,670	3 of 3	0.82	N
Lead	3	3	3 of 3	1.00	N
Magnesium	5,360	9,150	3 of 3	1.71	Y
Manganese	507	2,380	3 of 3	4.69	Y
Mercury	0	0	3 of 3	1.00	N
Nickel	4	ND	0 of 3	--	N
Potassium	3,060	7,030	3 of 3	2.30	Y
Selenium	4	4	3 of 3	1.00	N
Sodium	3,260	8,060	3 of 3	2.47	Y
Thallium	9	ND	0 of 3	--	N
Vanadium	2	2	3 of 3	1.18	N

NOTE: ND = not detected in samples.
"--" indicates a ratio could not be calculated.

Table B-4
Contaminants Detected in Upgradient Sediments

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Units
Volatile Organic Compounds						
2-Butanone (MEK)	1	1	100.0%	49.0	49.0	µg/kg
Inorganic Compounds						
Aluminum	1	1	100.0%	14,000,000	14,000,000	µg/kg
Antimony	1	1	100.0%	1,700	1,700	µg/kg
Arsenic	1	1	100.0%	3,600	3,600	µg/kg
Barium	1	1	100.0%	245,000	245,000	µg/kg
Calcium	1	1	100.0%	6,320,000	6,320,000	µg/kg
Chromium, Total	1	1	100.0%	33,000	33,000	µg/kg
Cobalt	1	1	100.0%	11,600	11,600	µg/kg
Iron	1	1	100.0%	15,200,000	15,200,000	µg/kg
Lead	1	1	100.0%	17,700	17,700	µg/kg
Magnesium	1	1	100.0%	2,390,000	2,390,000	µg/kg
Manganese	1	1	100.0%	796,000	796,000	µg/kg
Nickel	1	1	100.0%	21,100	21,100	µg/kg
Potassium	1	1	100.0%	1,290,000	1,290,000	µg/kg
Selenium	1	1	100.0%	3,600	3,600	µg/kg
Vanadium	1	1	100.0%	30,000	30,000	µg/kg
Zinc	1	1	100.0%	101,000	101,000	µg/kg

Table B-5
Contaminants Detected in Downgradient Sediments

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Units
Volatile Organic Compounds						
2-Butanone (MEK)	3	3	100.0%	5	20	μg/kg
Semivolatile Organic Compounds						
Benzo(b)fluoranthene	3	1	33.3%	56	56	μg/kg
Fluoranthene	3	1	33.3%	56	56	μg/kg
Pyrene	3	1	33.3%	60	60	μg/kg
Inorganic Compounds						
Aluminum	3	3	100.0%	7,410,000	10,900,000	μg/kg
Antimony	3	3	100.0%	920	1,300	μg/kg
Arsenic	3	2	66.7%	2,100	3,700	μg/kg
Barium	3	3	100.0%	90,200	192,000	μg/kg
Calcium	3	3	100.0%	1,240,000	4,720,000	μg/kg
Chromium, Total	3	3	100.0%	13,200	26,500	μg/kg
Cobalt	3	3	100.0%	3,500	8,400	μg/kg
Copper	3	2	66.7%	10,100	14,000	μg/kg
Iron	3	3	100.0%	5,350,000	17,900,000	μg/kg
Lead	3	3	100.0%	5,800	16,500	μg/kg
Magnesium	3	3	100.0%	1,530,000	1,770,000	μg/kg
Manganese	3	3	100.0%	453,000	973,000	μg/kg
Nickel	3	3	100.0%	8,000	16,600	μg/kg
Potassium	3	3	100.0%	665,000	953,000	μg/kg
Selenium	3	3	100.0%	1,800	2,600	μg/kg
Vanadium	3	3	100.0%	20,300	23,900	μg/kg
Zinc	3	2	66.7%	46,200	82,100	μg/kg

Table B-6
Comparison of Upgradient and Downgradient Sediment Contaminant Concentrations (µg/kg)

Parameter	Upgradient Maximum Detected Value	Downgradient Maximum Detected Value	Downgradient Frequency of Detection	Ratio of Upgradient to Down-gradient	Chemical Retained for Evaluation
Volatile Organic Compounds					
2-Butanone (MEK)	49	20	3 of 3	0.41	N*
Semivolatile Organic Compounds					
Benzo(b)fluoranthene	ND	56	1 of 3	--	Y*
Fluoranthene	ND	56	1 of 3	--	Y*
Pyrene	ND	60	1 of 3	--	Y*
Inorganic Chemicals					
Aluminum	14,000,000	10,900,000	3 of 3	0.78	N
Antimony	1,700	1,300	3 of 3	0.76	N
Arsenic	3,600	3,700	2 of 3	1.03	N
Barium	245,000	192,000	3 of 3	0.78	N
Calcium	6,320,000	4,720,000	3 of 3	0.75	N
Chromium, Total	33,000	26,500	3 of 3	0.80	N
Cobalt	11,600	8,400	3 of 3	0.72	N
Copper	ND	14,000	2 of 3	--	Y
Iron	15,200,000	17,900,000	3 of 3	1.18	N
Lead	17,700	16,500	3 of 3	0.93	N
Magnesium	2,390,000	1,770,000	3 of 3	0.74	N
Manganese	796,000	973,000	3 of 3	1.22	N
Nickel	21,100	16,600	3 of 3	0.79	N
Potassium	1,290,000	953,000	3 of 3	0.74	N
Selenium	3,600	2,600	3 of 3	0.72	N
Vanadium	30,000	23,900	3 of 3	0.80	N
Zinc	101,000	82,100	2 of 3	0.81	N

*Organic contaminants were retained for further evaluation regardless of ratio.
NOTE: ND = not detected in samples.
"--" indicates a ratio could not be calculated.

Table B-7
Contaminants Detected
in Upgradient TMSL Groundwater

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Units
Volatile Organic Compounds						
Acetone	2	1	50.0%	1	1	μg/L
Ethyl acetate	2	1	50.0%	2	2	μg/L
Semivolatile Organic Compounds						
Di-n-butyl phthalate	2	1	50.0%	1	1	μg/L
Phenanthrene	2	1	50.0%	1	1	μg/L
Inorganic Compounds						
Aluminum	2	2	100.0%	577	95,500	μg/L
Antimony	2	1	50.0%	2	2	μg/L
Arsenic	2	1	50.0%	29	29	μg/L
Barium	2	2	100.0%	83	374	μg/L
Beryllium	2	1	50.0%	2	2	μg/L
Cadmium	2	1	50.0%	1	1	μg/L
Calcium	2	2	100.0%	8,530	11,300	μg/L
Chromium, Total	2	2	100.0%	2	162	μg/L
Cobalt	2	2	100.0%	11	23	μg/L
Copper	2	2	100.0%	8	94	μg/L
Iron	2	2	100.0%	107	81,700	μg/L
Lead	2	2	100.0%	3	33	μg/L
Magnesium	2	2	100.0%	6,800	9,460	μg/L
Manganese	2	2	100.0%	874	938	μg/L
Mercury	2	2	100.0%	0	1	μg/L
Nickel	2	2	100.0%	10	64	μg/L
Potassium	2	2	100.0%	10,000	11,600	μg/L
Selenium	2	2	100.0%	4	4	μg/L
Sodium	2	2	100.0%	1,080	9,620	μg/L
Vanadium	2	2	100.0%	1	142	μg/L
Zinc	2	2	100.0%	67	161	μg/L

Table B-8
Contaminants Detected in Downgradient TMSL Groundwater

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Units
Volatile Organic Compounds						
1,1-Dichloroethane	8	4	50.0%	1	27	µg/L
1,2-Dichloroethane	8	2	25.0%	3	4	µg/L
1,2-Dichloropropane	8	2	25.0%	5	16	µg/L
2-Hexanone	8	1	12.5%	86	86	µg/L
Acetone	8	2	25.0%	2	320	µg/L
Benzene	8	5	62.5%	5	48	µg/L
Carbon Disulfide	8	3	37.5%	0	1	µg/L
Chlorobenzene	8	5	62.5%	1	8	µg/L
Chloroethane	8	5	62.5%	1	13	µg/L
cis-1,2-dichloroethene	8	4	50.0%	1	210	µg/L
Ethylbenzene	8	4	50.0%	1	48	µg/L
2-Butanone (MEK)	8	1	12.5%	280	280	µg/L
4-Methyl-2-pentanone (MIBK)	8	1	12.5%	32	32	µg/L
Styrene	8	1	12.5%	3	3	µg/L
Toluene	8	5	62.5%	1	550	µg/L
1,2-Dichloroethene (total)	8	5	62.5%	1	200	µg/L
trans-1,2-dichloroethene	8	1	12.5%	1	1	µg/L
Vinyl Chloride	8	8	100.0%	3	1,200	µg/L
Xylenes (total)	8	3	37.5%	59	180	µg/L
Semivolatile Organic Compounds						
1,2-Dichlorobenzene	8	2	25.0%	1	1	µg/L
1,4-Dichlorobenzene	8	5	62.5%	2	22	µg/L
2,4-Dimethylphenol	8	2	25.0%	5	16	µg/L
2-Methylnaphthalene	8	3	37.5%	2	5	µg/L
2-Methylphenol (o-cresol)	8	1	12.5%	18	18	µg/L
4-Chloro-3-methylphenol	8	2	25.0%	8	11	µg/L
4-Methylphenol (p-cresol)	8	1	12.5%	1,100	1,100	µg/L
bis(2-chloroethyl) ether	8	1	12.5%	7	7	µg/L
bis(2-ethylhexyl) phthalate	8	1	12.5%	27	27	µg/L
Di-n-butyl phthalate	8	1	12.5%	1	1	µg/L
Diethylphthalate	8	4	50.0%	4	110	µg/L
N-Nitrosodiphenylamine	8	1	12.5%	2	2	µg/L
Naphthalene	8	3	37.5%	5	16	µg/L
Phenol	8	1	12.5%	54	54	µg/L
Pesticides/TCDDs						
Endrin	3	1	33.3%	0	0	µg/L
Gamma-Chlordane	3	1	33.3%	0	0	µg/L
Octachlorodibenzo-p-dioxin	3	2	66.7%	63	380	pg/L
2,4,5-TP (Silvex)	3	1	33.3%	1	1	µg/L

Table B-8
Contaminants Detected
in Downgradient TMSL Groundwater

Parameter	Total Analyses	Positive Detections	Detection Frequency	Minimum Detected Value	Maximum Detected Value	Units
Inorganics						
Aluminum	8	8	100.0%	515	186,000	µg/L
Antimony	8	4	50.0%	2	53	µg/L
Arsenic	8	7	87.5%	4	112	µg/L
Barium	8	8	100.0%	117	1,730	µg/L
Beryllium	8	4	50.0%	2	11	µg/L
Cadmium	8	2	25.0%	8	12	µg/L
Calcium	8	8	100.0%	4,960	150,000	µg/L
Chromium, Total	8	7	87.5%	2	320	µg/L
Cobalt	8	8	100.0%	6	103	µg/L
Copper	8	6	75.0%	14	232	µg/L
Iron	8	8	100.0%	825	353,000	µg/L
Lead	8	8	100.0%	3	158	µg/L
Magnesium	8	8	100.0%	1,020	114,000	µg/L
Manganese	8	8	100.0%	811	19,000	µg/L
Mercury	8	6	75.0%	0	3	µg/L
Nickel	8	8	100.0%	8	143	µg/L
Potassium	8	8	100.0%	1,360	114,000	µg/L
Selenium	8	8	100.0%	3	24	µg/L
Silver	8	3	37.5%	11	22	µg/L
Sodium	8	8	100.0%	6,390	251,000	µg/L
Thallium	8	5	62.5%	3	21	µg/L
Vanadium	8	8	100.0%	1	233	µg/L
Zinc	8	7	87.5%	52	439	µg/L

Table B-9
Comparison of Upgradient and Downgradient Groundwater Contaminant Concentrations (µg/L)

Parameter	Upgradient Maximum Detected Value	Downgradient Maximum Detected Value	Downgradient Frequency of Detection	Ratio of Upgradient to Down-gradient	Compound Retained for Evaluation
Volatile Organic Compounds					
1,1-Dichloroethane	ND	27	4 of 8	--	Y*
1,2-Dichloroethane	ND	4	2 of 8	--	Y*
1,2-Dichloropropane	ND	16	2 of 8	--	Y*
2-Hexanone	ND	86	1 of 8	--	Y*
Acetone	1	320	2 of 8	640.0	Y*
Ethyl acetate	2	ND	--	--	Y*
Benzene	ND	48	3 of 8	--	Y*
Carbon disulfide	ND	1	3 of 8	--	Y*
Chlorobenzene	ND	8	5 of 8	--	Y*
Chloroethane	ND	13	5 of 8	--	Y*
cis-1,2-dichloroethene	ND	210	4 of 8	--	Y*
Ethylbenzene	ND	48	4 of 8	--	Y*
2-Butanone (MEK)	ND	280	1 of 8	--	Y*
4-Methyl-2-pentanone (MIBK)	ND	32	1 of 8	--	Y*
Styrene	ND	3	1 of 8	--	Y*
Toluene	ND	550	5 of 8	--	Y*
1,2-Dichloroethene (total)	ND	200	5 of 8	--	Y*
trans-1,2-dichloroethene	ND	1	1 of 8	--	Y*
Vinyl chloride	ND	1,200	8 of 8	--	Y*
Xylenes (total)	ND	180	3 of 8	--	Y*
Semiviolatile Organic Compounds					
Phenanthrene	1	ND	--	--	N
1,2-Dichlorobenzene	ND	1	2 of 8	--	Y*
1,4-Dichlorobenzene	ND	22	5 of 8	--	Y*
2,4-Dimethylphenol	ND	16	2 of 8	--	Y*
2-Methylnaphthalene	ND	5	3 of 8	--	Y*
2-Methylphenol (o-cresol)	ND	18	1 of 8	--	Y*
4-Chloro-3-methylphenol	ND	11	2 of 8	--	Y*
4-Methylphenol (p-cresol)	ND	1,100	1 of 8	--	Y*
bis(2-chloroethyl) ether	ND	7	1 of 8	--	Y*
bis(2-ethylhexyl) phthalate	ND	27	1 of 8	--	Y*
Di-n-butyl phthalate	1	1	1 of 8	2.0	Y*
Diethylphthalate	ND	110	4 of 8	--	Y*
N-Nitrosodiphenylamine	ND	2	1 of 8	--	Y*
Naphthalene	ND	16	3 of 8	--	Y*
Phenol	ND	54	1 of 8	--	Y*
Pesticides/TCDDs					
Endrin	ND	0	1 of 8	--	Y*
2,4,5-Tp (Silvex)	ND	1	2 of 8	--	Y*
Gamma-chlordane	ND	0	1 of 8	--	Y*
Octachlorodibenzo-p-dioxin	ND	380	2 of 8	--	Y*

Table B-9

Comparison of Upgradient and Downgradient Groundwater Contaminant Concentrations (μg/L)

Parameter	Upgradient Maximum Detected Value	Downgradient Maximum Detected Value	Downgradient Frequency of Detection	Ratio of Upgradient to Down-gradient	Compound Retained for Evaluation
Inorganic Chemicals					
Aluminum	95,500	186,000	8 of 8	1.9	Y
Antimony	2	53	4 of 8	26.6	Y
Arsenic	29	112	7 of 8	3.9	Y
Barium	374	1,730	8 of 8	4.6	Y
Beryllium	2	11	4 of 8	4.6	Y
Cadmium	1	12	2 of 8	10.5	Y
Calcium	11,300	150,000	8 of 8	13.3	Y
Chromium, Total	162	320	7 of 8	2.0	Y
Cobalt	23	103	8 of 8	4.4	Y
Copper	94	232	6 of 8	2.5	Y
Iron	81,700	353,000	8 of 8	4.3	Y
Lead	33	158	8 of 8	4.8	Y
Magnesium	9,460	114,000	8 of 8	12.1	Y
Manganese	938	19,000	8 of 8	20.3	Y
Mercury	1	3	6 of 8	2.8	Y
Nickel	64	143	8 of 8	2.2	Y
Potassium	11,600	114,000	8 of 8	9.8	Y
Selenium	4	24	8 of 8	6.0	Y
Silver	ND	22	3 of 8	--	Y
Sodium	9,620	251,000	8 of 8	26.1	Y
Thallium	ND	21	5 of 8	--	Y
Vanadium	142	233	8 of 8	1.6	Y
Zinc	161	439	7 of 8	2.7	Y

*Organic contaminants were retained for further evaluation regardless of ratio.
NOTE: ND = not detected in samples.
"--" *indicates a ratio could not be calculated.*

APPENDIX C

HUMAN HEALTH RISK ASSESSMENT SUPPORTING DOCUMENTATION

APPENDIX C

Human Health Risk Assessment Supporting Documentation

This appendix contains supporting documentation for the human health risk assessment methodology. It includes four attachments: the toxicity profiles for the COCs, the results of the lead uptake modeling, the risk calculation spreadsheets, and the toxicity-concentration screen spreadsheets.

Attachment C-1, the toxicity profiles, provide information regarding reported adverse effects of acute and chronic exposures. Information regarding potential carcinogenicity, teratogenicity, or mutagenicity is also presented.

Exposure to lead in groundwater was evaluated for children using EPA's Integrated Exposure Uptake Biokinetic Model (version 0.99d). The results of the bio-uptake model are found in Attachment C-2. Default values for all parameters except groundwater lead concentration were used when running the model.

The risk and hazard index calculation spreadsheets are presented in Attachment C-3. The calculation results are organized by environmental medium (surface water, sediment, and groundwater), exposure scenario (recreational adult, recreational child, residential adult, and residential child), and by exposure route (ingestion, inhalation, and dermal contact).

Attachment C-4 presents the toxicity-concentration screening spreadsheets used to determine the final list of contaminants of concern for the TMSL site. The toxicity-concentration screen process identifies which chemicals contributed less than 1% of the risk or hazard index. These chemicals are eliminated from further evaluation (unless there is additional justification for retaining them, such as status as a Class A carcinogen).

ATTACHMENT C-1
TOXICITY PROFILES FOR COCS

Attachment C-1
Toxicity Profiles for COCs

Toxicity information for the chemicals of concern (COCs) in the various environmental media at the Tomah Municipal Sanitary Landfill is presented in this attachment.

The toxicity profiles for each contaminant of concern consist of summaries for acute and chronic health effects reported in the literature, and each contaminant's cancer potential as given in IRIS (1996). Other information, such as mutagenicity or teratogenicity or potentiation effects, are also noted. The EPA Carcinogen Classification, slope factor, and reference dose for each contaminant are summarized in Table 2-11.

Summary Toxicity Profiles of Selected Chemicals

Antimony

Acute Toxicity Summary

Many antimony compounds irritate the gastrointestinal tract; antimony tartar has been used as an emetic; intoxication results in severe vomiting and diarrhea. With occupational inhalation exposures, rhinitis and acute pulmonary edema may occur.

Chronic Toxicity Summary

Inhalation of some antimony compounds can produce rhinitis, pharyngitis, tracheitis, bronchitis, and pneumoconiosis with obstructive lung disease and emphysema. Transient spots on the skin have been reported in workers. Antimony may form stibine gas, which causes hemolysis.

Cancer Potential

Not indicated.

Other

Trivalent or pentavalent compounds. In mutation tests, some antimony compounds were positive in human lymphocytes and Syrian hamster embryo cells. Trivalent antimony compounds were used for treatment of parasites.

Arsenic

Acute Toxicity Summary

Acute oral exposure can cause muscular cramps, facial swelling, cardiovascular reactions, severe gastrointestinal damage, and vascular collapse leading to death. Sensory loss and hematopoietic symptoms delayed after exposure to high concentrations are usually reversible. Inhalation exposures can cause severe irritation of nasal lining, larynx, and bronchi.

Chronic Toxicity Summary

Chronic oral or inhalation exposure can produce changes in skin, including hyperpigmentation and hyperkeratosis; peripheral neuropathy; liver injury; cardiovascular disorders; oral exposures associated with peripheral vascular disease; and blackfoot disease.

Cancer Potential

Known human carcinogen; oral exposures associated with skin cancer, inhalation exposures with lung cancer.

Other

Toxicity varies for different compounds; inorganic trivalent arsenic compounds usually more toxic than pentavalent compounds; high doses of some inorganic arsenic compounds to pregnant laboratory animals produced malformations in offspring.

Benzene

Acute Toxicity Summary

Acute exposures (inhalation) to high levels of benzene may lead to depression of the central nervous system, unconsciousness, and death or may cause fatal cardiac arrhythmias.

Chronic Toxicity Summary

Major toxic effect is hematopoietic toxicity (affects formation of blood); chronic exposure of workers to low levels has been associated with blood disorders, such as leukemia and aplastic anemia (depression of all three cell types of the blood in the absence of functioning marrow).

Cancer Potential

Sufficient evidence that benzene is a human and animal carcinogen; classified by EPA as an A human carcinogen. Strong correlation between exposure to benzene by inhalation and leukemia.

Other

Chromosomal aberrations in bone marrow and blood have been reported in experimental animals and some workers.

Beryllium

Acute Toxicity Summary

Acute lung disease (chemical pneumonitis) has been observed immediately after inhalation of aerosols of soluble beryllium compounds, such as beryllium fluoride and compounds (probably zinc beryllium silicate) in broken fluorescent light tubes. Several months after exposure the entire respiratory tract may become inflamed with fulminating pneumonitis in severe reactions. Recoveries usually occur within weeks, but fatalities have occurred. In studies with monkeys, high concentrations of aerosols of beryllium fluoride or beryllium phosphate produced severe lung reactions in all animals and damaged the liver and kidney as well as affecting adrenals, pancreas, thyroid, and spleen; many lesions were similar to those in patients who died of pneumonitis. Conjunctivitis and contact dermatitis may follow exposure to beryllium, with skin lesions or ulcerations. Beryllium compounds may produce hypersensitivity with delayed allergic reactions.

Chronic Toxicity Summary

The lung is a major target organ for toxic effects of beryllium. Berylliosis, a chronic granulomatous lung disease that is frequently fatal, has been described for over 40 years among workers exposed to insoluble beryllium compounds; symptoms may include shortness of breath, cyanosis, clubbed fingers, lesions that progress to fibrotic tissue and nodules with respiratory dysfunction.

Cancer Potential

Beryllium compounds or alloys have produced cancer in rats, rabbits, and monkeys. Lung tumors have been reported in rats and monkeys exposed by inhalation, intratracheally, or intrabronchial implantation, and bone tumors have been produced in rabbits after intravenous or intraosseus administration. Excess lung cancer has been observed in some studies of workers occupationally exposed to beryllium, but data on exposure and confounding factors were lacking. Beryllium and its compounds have been classified by IARC as having sufficient evidence of being carcinogenic in animals and limited evidence in humans (group 2B) and by EPA as B1, probable human carcinogen.

Other

Wide variations in individual sensitivity have been reported, perhaps because of an immune reaction; individuals exposed to low doses may exhibit severe effects. Beryllium is stored in the body for many years with detectable amounts in lung reported as long as 23 years after exposure. Some beryllium compounds are mutagenic in vitro tests.

Bis(2-ethylhexyl)phthalate (Di(2-ethylhexyl)phthalate or DEHP or BEHP)

Acute Toxicity Summary

In general, low acute toxicity in experimental animals; accidental acute exposure in man resulted in mild gastric disturbance and catharsis.

Chronic Toxicity Summary

Chronic exposure at relatively high concentration have retarded growth and resulted in increased liver and kidney weight in experimental animals.

Cancer Potential

Oral administration to rats and mice resulted in increased hepatocellular carcinomas or neoplastic nodules. Classified by EPA as a B2 carcinogen.

Other

Some evidence in animals of teratogenic and fetotoxic effects. Reproductive effects, decreased fertility and testicular damage have been noted in rodents. Poorly absorbed through skin; rapidly metabolized.

Cadmium

Acute Toxicity Summary

For acute exposures by ingestion, symptoms of cadmium toxicity included nausea, vomiting, diarrhea, muscular cramps, salivation, spasms, drop in blood pressure, vertigo, loss of consciousness, and collapse. Acute renal failure, liver damage, and death may occur. Exposure by inhalation can cause irritation, coughing, labored respiration, vomiting, acute chemical pneumonitis, and pulmonary edema.

Chronic Toxicity Summary

Respiratory and renal toxicity are major effects in workers. Chronic oral exposures can produce kidney damage. Cadmium accumulates in kidney, and nephropathy results after critical concentration in kidney is reached, probably about 200 mg/g. Inhalation can cause chronic obstructive pulmonary disease, including bronchitis, progressive fibrosis, and emphysema. Chronic exposure affects calcium metabolism and can cause loss of calcium from bone, bone pain, osteomalacia, and osteoporosis. Chronic exposure may be associated with hypertension. Cadmium can produce testicular atrophy, sterility, and teratogenic effects in experimental animals.

Cancer Potential

Increased risk of prostate cancer and perhaps respiratory tract cancer in workers exposed by inhalation. No evidence of carcinogenicity from chronic oral exposure.

Other

A nonessential element.

Cresols

Acute Toxicity Summary

Contact with cresols may result in irritation or burning of the skin, eyes, mouth, and throat. Ingestion may result in abdominal pain, vomiting, hemolytic anemia, kidney damage, facial paralysis, coma, and even death. Acute exposures may also result in mild nervous excitation.

Chronic Toxicity Summary

Target organs for cresol exposures appear to be the kidneys and the blood system.

Cancer Potential

The cresols are classified as possible human carcinogens (Class C).

Other

Chromium

Acute Toxicity Summary

Major acute effect from oral exposure is renal tubular necrosis. Inhalation of chromate salts results in irritation and inflammation of nasal mucosa, ulceration, and perforation of nasal septum.

Chronic Toxicity Summary

Chronic exposure to hexavalent chromium has resulted in kidney damage in animals and humans. Inhalation exposures to chromates in industrial settings have resulted in nasal membrane inflammation, chronic rhinitis, laryngitis, and pharyngitis. Exposures to skin can result in allergic skin reactions in sensitive individual. Overall, hexavalent forms are usually more toxic than trivalent forms.

Cancer Potential

Excess lung cancer has been associated with chromate-producing industry workers. Chromatic salts are carcinogenic in rats exposed by inhalation.

Other

Essential element. Toxicity is related to valence state.

Copper

Acute Toxicity Summary

Inhalation of copper dusts result in symptoms similar to metal fume fever. Exposure to metal fumes results in upper respiratory tract irritation, metallic or sweet taste, metal fume fever, and skin and hair discoloration. Exposure to dusts and mists of copper salt result in congestion of nasal mucous membranes, sometimes of pharynx, and occasional ulceration with perforation of nasal septum. Acute copper sulfate poisoning in humans (oral) sometimes fatal; includes vomiting, diarrhea, hypotension, coma, and jaundice.

Chronic Toxicity Summary

Hemolytic anemia after chronic exposure in some dialysis patients. Sensitive individuals with disorders of metabolism—Wilson's disease and Menke's disease.

Cancer Potential

Not indicated.

Other

Essential nutrient. Organoleptic threshold in water between 1 to 5 mg/L.

1,2-Dichloroethane

Acute Toxicity Summary

CNS depression, lung irritation, and injury to liver, kidney, and adrenal have been reported. Deaths in humans exposed by ingestion or inhalation may result from circulatory and respiratory failure.

Chronic Toxicity Summary

Chronic exposure can cause liver degeneration and kidney damage in laboratory animals. Eye damage (necrosis of corneal epithelium) has been observed in dogs injected with 1,2-dichloroethane. Repeated exposures have been associated with anorexia, nausea, liver and kidney dysfunction, and neurological disorders in workers.

Cancer Potential

Carcinogenic in mice and rats exposed orally.

Other

Mutagenic in some tests in bacteria, barley, and fruit flies.

p-Dichlorobenzene

Acute Toxicity Summary

Skin lesions, irritation to eye and upper respiratory tract, vomiting, headache, anorexia, and anemia and blood dyscrasias reported in humans exposed to dichlorobenzene. Two cases of cataracts described. Tingling of hands, vertigo, weight loss in worker exposed to mixture containing p-dichlorobenzene.

Chronic Toxicity Summary

Hepatic effects have been observed in rats and mice administered p-chlorobenzene by gavage; these effects included cloudiness, swelling, necrosis, porphyria, and increased liver weight. Renal lesions have also been reported in rats and mice receiving p-dichlorobenzene by gavage; in some studies, multifocal degeneration and necrosis occurred. Effects on bone marrow, nasal turbinates, small intestine, spleen, and thymus have also been described in rodents. Changes in weight of spleen, liver, heart, kidney, and lungs were noted in rats exposed by inhalation, as well as liver and kidney lesions, pulmonary edema and congestion, and reversible changes in the eye.

Cancer Potential

In rats administered p-dichlorobenzene by gavage, renal adenocarcinomas developed in males; liver adenomas and carcinomas appeared in male and female mice. Classification as B2 or C considered by EPA.

Other

Lipophilic. In one study no fetotoxicity or teratogenicity in rabbits. Negative in most mutagenicity studies but abnormal mitotic diversion in higher plants.

cis-1,2-Dichloroethene

Acute Toxicity Summary

Anesthetic at high concentrations; appears half as potent as transisomer in depressing CNS; elevated liver enzymes in rats reported after one exposure.

Chronic Toxicity Summary

Minimal fatty accumulation in liver of rats chronically exposed to high doses of cis-1,2-DCE in drinking water.

Cancer Potential

Not indicated.

trans-1,2-Dichloroethene

Acute Toxicity Summary

Inhalation exposure to high levels can cause narcosis and death in rats.

Chronic Toxicity Summary

Rats exposed by inhalation exhibited fatty accumulation in liver and infiltration of lungs.

Cancer Potential

Not indicated.

Fluoranthene

Acute Toxicity Summary

Toxic by oral and dermal absorption. Can cross epithelial membranes. A defatting agent that may affect the skin.

Chronic Toxicity Summary

Limited information available.

Cancer Potential

IARC [1983] concluded there is no evidence that fluoranthene is carcinogenic on the basis of available data.

When applied to laboratory animal skin simultaneously with other carcinogenic PAHs, has increased the carcinogenicity of the compound (i.e., cocarcinogenic effects).

Lead

Acute Toxicity Summary

Acute inorganic lead intoxication in humans is characterized by encephalopathy, abdominal pain, hemolysis, liver damage, renal tubular necrosis, seizures, coma, and respiratory arrest.

Chronic Toxicity Summary

Chronic low levels of exposure to lead can affect the hematopoietic system, the nervous system, and the cardiovascular system. Lead inhibits several key enzymes involved in heme biosyntheses. One characteristic effect of chronic lead intoxication is anemia, by reduced hemoglobin production and shortened erythrocyte survival. In humans, lead exposure has resulted in nervous system injury including reduced hand-eye coordination, reaction time, visual motor performance, and nerve conduction velocity. The developing child appears especially sensitive to lead-induced nervous system injury. Lead can also affect the immune system and produce gingival lead lines. Epidemio-logical studies have indicated that chronic lead exposure may be associated with increased blood pressure in humans. Exposure to lead is associated with sterility, abortion, neonatal mortality, and morbidity. Organolead compounds are neurotoxic.

Cancer Potential

Lead salts have some evidence of carcinogenicity in animals.

Other

Children are especially sensitive to low level effects.

Manganese

Acute Toxicity Summary

Acute inhalation exposures to very high concentrations can cause manganese pneumonitis.

Chronic Toxicity Summary

Chronic manganese poisoning results from inhalation of high concentrations of manganese dust. Chronic manganese poisoning is characterized by psychiatric symptoms, such as irritability, difficulty in walking, speed disturbances and compulsive behavior, and by encephalopathy and progressive deterioration of the CNS. Chronic effects of manganese poisoning are similar to Parkinson's disease. Liver changes are also frequently seen. Individuals with an iron deficiency may be more susceptible to chronic poisoning.

Cancer Potential

Not indicated.

Other

Manganese is an essential nutrient. Manganese concentrations in water at 50 mg/L may exhibit undesirable taste and discoloration.

Pyrene

Acute Toxicity Summary

Limited information is available.

Chronic Toxicity Summary

Limited information is available.

Cancer Potential

Evidence suggests that pyrene is cocarcinogenic in laboratory animal experiments.

Styrene

Acute Toxicity Summary

Irritating to eyes, skin, mucous membranes, and respiratory system. Can cause CNS impairment in humans and animals. A case of accidental human poisoning has been reported. In animals, depression of growth and of liver and kidney weight gain have been observed. In oral subacute exposures, styrene was highly irritating to the esophagus and gastrointestinal tract. Rats and guinea pigs exposed to fatal doses of styrene died acutely from CNS depression or experienced delayed death from pneumonia and congestion of lungs, liver, and kidney.

Chronic Toxicity Summary

Irritating to eyes; dermatitis with repeated or prolonged contact. "Styrene sickness" of a few hours duration was reported in some workers, with symptoms of nausea, vomiting, decreased appetite, drowsiness, headache, fatigue, and weakness. Neurological and psychological disturbances have been reported often. In animals, decreased growth and changes in organ weight have been noted. Eye and nasal irritation and extensive irritation to stomach and esophagus have also been observed. Effects on liver and red blood cells have been demonstrated in dogs.

Cancer Potential

Positive and negative results in bioassays; increased incidence of lung or liver tumors in offspring of mice exposed orally; possible increased frequency of lymphoid or hematopoietic tumors in rats; epidemiology on styrene-butadiene copolymer workers suggests increased incidence of lymphatic and hematopoietic tumors. IARC classification of limited evidence for carcinogenicity to animals, inadequate evidence for humans; classified as Category C by EPA but other classifications being considered.

Other

Malformations in chick embryos have been seen. Embryotoxicity occurred in rats inhaling styrene throughout pregnancy. Rates of spontaneous abortions were increased in Finnish female styrene industry workers and increased rate of malformations was suggested in Finnish reinforced plastic industry workers exposed to styrene and other chemicals. Conflicting mutation data in bacterial tests; chromosomal aberrations in bone marrow of rats exposed by inhalation and in cultured peripheral lymphocytes of some workers. Absorbed rapidly after respiratory and oral exposures; absorbed through skin after direct contact with liquid; metabolites differ with route and dose of administration; styrene oxide may be active metabolite.

Thallium

Acute Toxicity Summary

Acute thallium poisoning is characterized by gastrointestinal irritation, paralysis, cardiovascular effects, and psychic disturbances.

Chronic Toxicity Summary

Signs of chronic thallium poisoning include liver and kidney damage, gastroenteritis, pulmonary edema, degeneration of peripheral and central nervous system, and hair loss.

Cancer Potential

Thallium is listed as a Class D compound.

Vanadium

Acute Toxicity Summary

Irritation of the skin, eyes, and respiratory system are the most commonly reported symptoms of occupational vanadium exposure. Gastrointestinal disturbances (such as nausea, pain, and vomiting) are also reported, along with depression of the nervous system.

Chronic Toxicity Summary

Respiratory effects, including bronchitis and bronchopneumonia, are frequently reported in workers exposed to vanadium compounds. Investigations also suggest the liver, adrenals, and bone marrow may be targets after subacute exposures to high concentrations.

Cancer Potential

No information regarding the carcinogenic potential of vanadium was found.

Vinyl Chloride

Acute Toxicity Summary

Acute occupational exposure to high concentrations of vinyl chloride can produce symptoms of narcosis in humans. Respiratory tract irritation, bronchitis, headache, irritability, memory disturbances, and tingling sensations may also occur. Deaths have been reported. In animals, ataxia, narcosis, blood clotting difficulties, congestion and edema in lungs, and kidney and liver effects have been demonstrated. At high doses excitement, contractions, convulsions, and an increase in respiration followed by respiratory failure precede death.

Chronic Toxicity Summary

Human health effects associated with chronic occupational exposure to vinyl chloride include hepatitis-like liver changes, decreased blood platelets, enlarged spleens, decreased pulmonary function, acroosteolyis (sometimes with Raynaud-like syndrome), sclerotic syndrome, thrombocytopenia, cardiovascular and gastrointestinal toxicity, and disturbances in vision and in the CNS. In laboratory animals, liver and kidney toxicity may be severe and histopathological changes in lung and spleen may also occur with vinyl chloride exposure.

Cancer Potential

Vinyl chloride is a known human carcinogen causing liver angiosarcomas (a very rare tumor in humans) and possibly increasing incidence of tumors of the brain, lung, and hemolymphopoietic system in humans. Vinyl chloride is carcinogenic in mice, rats, and hamsters.

Other

Vinyl chloride is mutagenic in several test systems. Chromosome aberrations have been reported in exposed workers. In humans, possible relationships between exposure and birth defects and fetal death have been reported. Possible increased fetal mortality among wives of occupationally exposed workers has been debated. Increased skeletal variants were found in offspring of mice exposed during gestation.

1,2-Dichloropropane

Acute Toxicity Summary

Exposure to 1,2-dichloropropane can cause irritation of the eyes and the respiratory tract. It may cause dermatitis by defatting the skin. The compound has anesthetic effects, and results in depression of the central nervous system. Three cases of 1,2-dichloropropane intoxication reported in the literature indicated that acute renal and hepatic injury, hemolytic anemia, and disseminated intravascular coagulation occurred after brief contact with cleaning solutions containing 1,2-dichloropropane.

Chronic Toxicity Summary

Kidney and liver damage have been reported following chronic exposures to 1,2-dichloropropane. Hepatomas were observed in a chronic inhalation study with mice.

Cancer Potential

1,2-Dichloropropane is classified as a Class B2 compound, indicating that there is sufficient evidence of carcinogenicity in animal studies but inadequate or no evidence in human studies.

Benzo(b)fluoranthene

Acute Toxicity Summary

Acute toxicity is rarely reported.

Chronic Toxicity Summary

Exposure to polycyclic aromatic hydrocarbons (PAHs) may result in increased incidences of skin, respiratory tract, bladder, and kidney cancers. There is an increasing body of evidence which suggests that carcinogenic PAHs may produce immunotoxicity.

Cancer Potential

Benzo(b)fluoranthene is classified as a B2 (probable) human carcinogen. This classification is based on studies which found increased incidences of tumors in mice after lung implantation, injections (intraperitoneal and subcutaneous), and skin painting. There are no human data that specifically link exposure to benzo(b)fluoranthene to human cancers; however, benzo(b)fluoranthene is a component of mixtures such as coal tar and cigarette smoke that have been associated with human cancers.

4-Methylphenol (*p*-Cresol)

Acute Toxicity Summary

Exposure to 4-Methylphenol can cause irritation of the eyes, skin, and respiratory tract. Depression of the central nervous system and narcosis can occur following inhalation of high concentrations of 4-methylphenol; nausea and coma have been described in some cases of people accidentally exposed to high concentrations of 4-methylphenol. Animal studies have indicated that acute exposures to high concentrations of 4-methylphenol may result in liver and kidney damage, and changes in blood composition.

Chronic Toxicity Summary

Studies in animals have not indicated additional effects that would occur after chronic low-level exposure to cresols. No chronic toxicity studies for humans were reported.

Cancer Potential

The compound is classified as a Class C compound, indicating limited evidence is available from animal studies and no or inadequate data is available from human studies. The chronic oral reference dose is 0.005 mg/kg-day.

Bis(2-chloroethyl)ether

Acute Toxicity Summary

Exposure to bis(2-chloroethyl)ether can cause irritation of the eyes, skin, and respiratory tract. Human volunteers exposed to various concentrations reported the following effects: (1) 35 ppm was not irritating, but was detectable by its nauseous odor; (2) 100 to 260 ppm was irritating but not intolerable; (3) 550 to 1,000 ppm resulted in coughing, nausea, and retching. Exposures above 550 ppm can cause profuse lacrimation. Inhalation of the vapor can result in delayed pulmonary edema.

Chronic Toxicity Summary

The chief hazard reported for industrial practice was mild bronchitis, which can be caused by repeated exposures to low concentrations.

Cancer Potential

Bis(2-chloroethyl)ether is classified as a B2 (probable) human carcinogen, based on positive carcinogenicity results in two strains of mice. It also showed evidence of mutagenicity in several strains of bacteria). No human carcinogenicity data is available.

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29 CFR 1910:50412-99. OSHA, Occupational Exposure to Formaldehyde. December 10, 1985.

40 CFR 141:25720-34. EPA, Drinking Water. July 8, 1987.

NOTE: Health effects may be based on animal studies and do not imply that human exposure will have the same results.

ATTACHMENT C-2

INTEGRATED EXPOSURE UPTAKE BIOKINETIC MODEL FOR LEAD

Attachment C-2

Integrated Exposure Uptake Biokinetic Model for Lead

Residential children's exposures to contaminated environmental media were evaluated, since they represent a sensitive subpopulation. The exposure scenarios for the TMSL site included the use of groundwater for residential purposes. Exposure to lead in groundwater was evaluated for children using EPA's Integrated Exposure Uptake Biokinetic Model (version 0.99d). The bio-uptake model utilized default values for all parameters except groundwater.

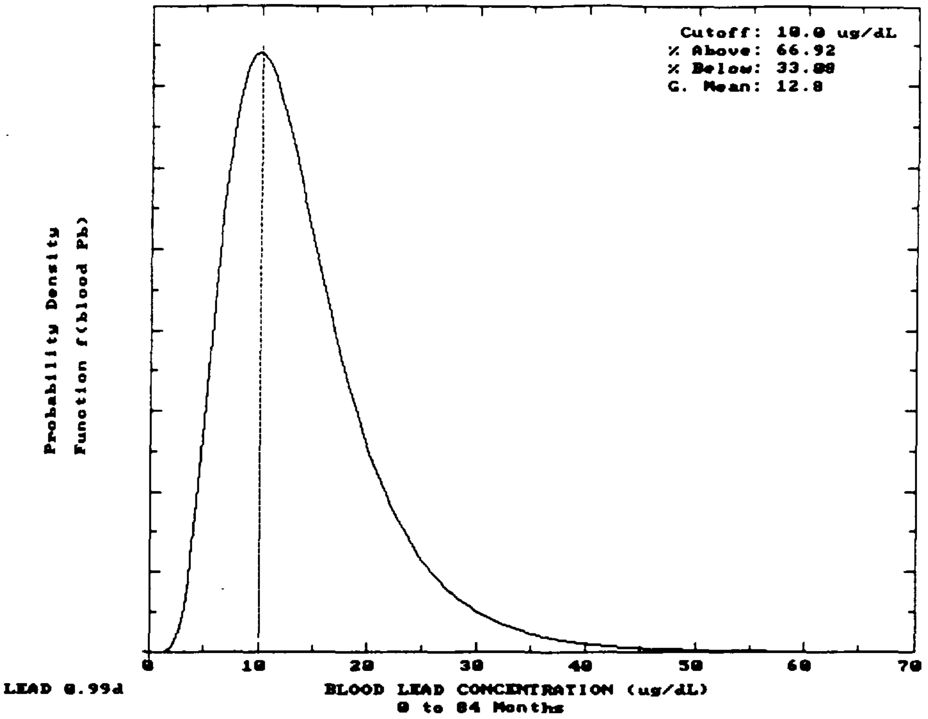
The model simulation was run three times. The first model run used the maximum detected groundwater lead concentration of 158.0 µg/L. Because a histogram of the groundwater lead concentrations indicated this value was possibly an outlier (more than double the next highest concentration), the second highest concentration of 69.6 µg/L was used as the groundwater concentration for the second iteration. The third model run used the arithmetic average (46.8 µg/L) as the groundwater lead concentration.

The results for the model simulation using the maximum detected concentration indicate the mean blood lead concentration would be 12.8 µg/dL, which exceeds the cutoff of 10 µg/dL. Using the second highest detected lead concentration resulted in a mean blood lead concentration of 8.0 µg/dL, below the cutoff blood lead concentration. The third and final model simulation using the average groundwater lead concentration of 46.8 µg/L resulted in a blood lead concentration of 6.6 µg/dL, below the 10.0 µg/dL blood lead concentration cutoff value.

The output tables and probability density curves are included in this attachment.

```
LEAD MODEL Version 0.99d

AIR CONCENTRATION:  0.100  ug Pb/m3    DEFAULT
  Indoor AIR Pb Conc:  30.0  percent of outdoor.
  Other AIR Parameters:
     Age    Time Outdoors (hr)      Vent. Rate (m3/day)      Lung Abs. (%)
     0-1          1.0                     2.0                    32.0
     1-2          2.0                     3.0                    32.0
     2-3          3.0                     5.0                    32.0
     3-4          4.0                     5.0                    32.0
     4-5          4.0                     5.0                    32.0
     5-6          4.0                     7.0                    32.0
     6-7          4.0                     7.0                    32.0

DIET:   DEFAULT

DRINKING WATER Conc:  158.00 ug Pb/L
   WATER Consumption:  DEFAULT

SOIL & DUST:
   Soil:  constant conc.
   Dust:  constant conc.

     Age        Soil (ug Pb/g)     House Dust (ug Pb/g)
     0-1           200.0              200.0
     1-2           200.0              200.0
     2-3           200.0              200.0
     3-4           200.0              200.0
     4-5           200.0              200.0
     5-6           200.0              200.0
     6-7           200.0              200.0

   Additional Dust Sources:  None   DEFAULT

PAINT Intake:  0.00 ug Pb/day    DEFAULT

MATERNAL CONTRIBUTION:  Infant Model
   Maternal Blood Conc:  2.50  ug Pb/dL


CALCULATED BLOOD Pb and Pb UPTAKES:

             Blood Level        Total Uptake        Soil+Dust Uptake
 YEAR          (ug/dL)           (ug/day)              (ug/day)
------       -----------       ------------         ------------
0.5-1:          10.0              18.97                 4.08
  1-2:          14.1              36.28                 5.82
  2-3:          14.0              38.87                 6.00
  3-4:          13.8              40.68                 6.20
  4-5:          13.4              41.53                 4.74
  5-6:          13.0              43.77                 4.34
  6-7:          12.4              44.99                 4.15

             Diet Uptake       Water Uptake         Paint Uptake      Air Uptake
 YEAR          (ug/day)          (ug/day)             (ug/day)         (ug/day)
------       -----------       ------------         ------------      --------
0.5-1:          2.21              12.65                 0.00             0.02
  1-2:          2.07              28.36                 0.00             0.03
  2-3:          2.40              30.41                 0.00             0.06
```

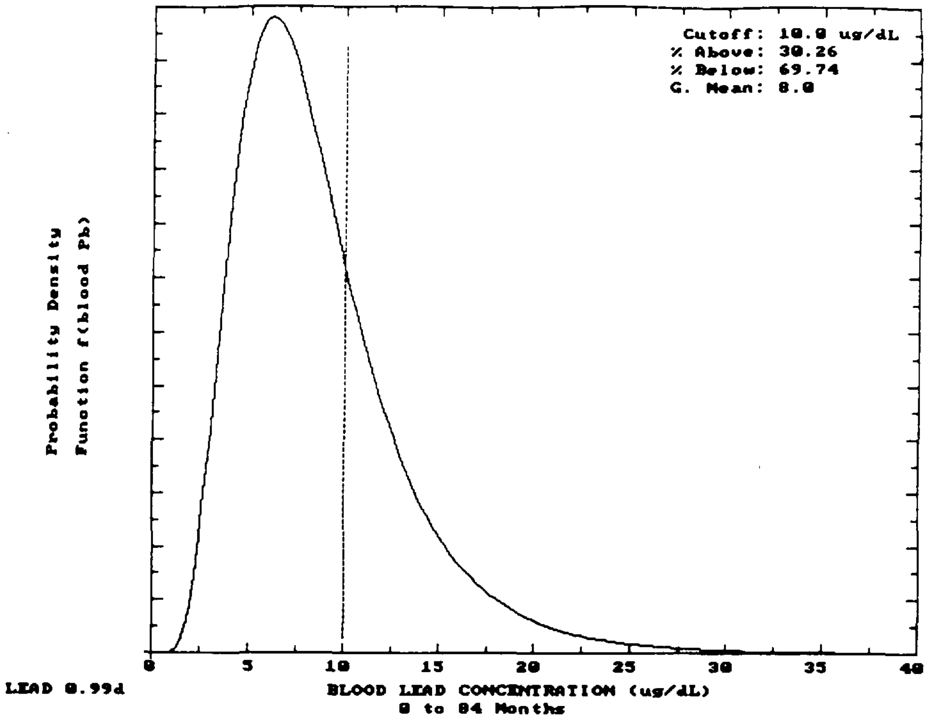
```
3-4:        2.39        32.03        0.00        0.07
4-5:        2.38        34.34        0.00        0.07
5-6:        2.55        36.79        0.00        0.09
6-7:        2.85        37.91        0.00        0.09
```



Cutoff: 10.0 ug/dL
% Above: 66.92
% Below: 33.08
G. Mean: 12.8
Probability Density
Function f(blood Pb)
0
10
20
30
40
50
60
70
LEAD 0.99d
BLOOD LEAD CONCENTRATION (ug/dL)
0 to 84 Months

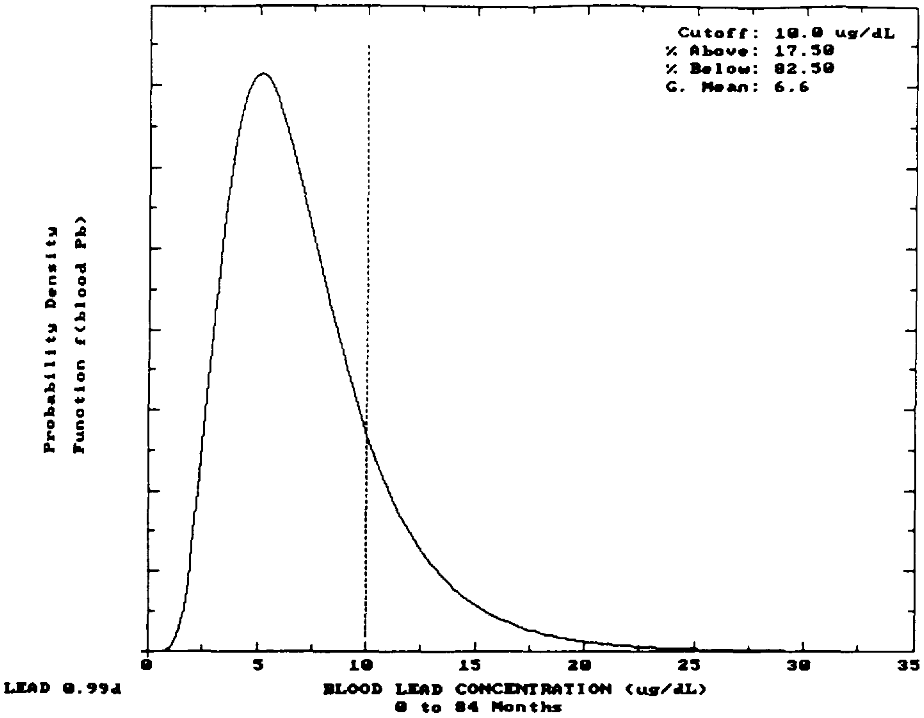
```
LEAD MODEL Version 0.99d

AIR CONCENTRATION:  0.100  ug Pb/m3    DEFAULT
  Indoor AIR Pb Conc:  30.0  percent of outdoor.
  Other AIR Parameters:
     Age    Time Outdoors (hr)     Vent. Rate (m3/day)     Lung Abs. (%)
     0-1          1.0                    2.0                   32.0
     1-2          2.0                    3.0                   32.0
     2-3          3.0                    5.0                   32.0
     3-4          4.0                    5.0                   32.0
     4-5          4.0                    5.0                   32.0
     5-6          4.0                    7.0                   32.0
     6-7          4.0                    7.0                   32.0

DIET:   DEFAULT

DRINKING WATER Conc:  69.60 ug Pb/L
   WATER Consumption:  DEFAULT

SOIL & DUST:
   Soil:  constant conc.
   Dust:  constant conc.

     Age       Soil (ug Pb/g)     House Dust (ug Pb/g)
     0-1          200.0             200.0
     1-2          200.0             200.0
     2-3          200.0             200.0
     3-4          200.0             200.0
     4-5          200.0             200.0
     5-6          200.0             200.0
     6-7          200.0             200.0

   Additional Dust Sources:  None   DEFAULT

PAINT Intake:  0.00 ug Pb/day    DEFAULT

MATERNAL CONTRIBUTION:  Infant Model
   Maternal Blood Conc:  2.50  ug Pb/dL


CALCULATED BLOOD Pb and Pb UPTAKES:

             Blood Level       Total Uptake       Soil+Dust Uptake
 YEAR          (ug/dL)           (ug/day)             (ug/day)
------       -----------       ------------        ------------
0.5-1:         6.8                 12.81              4.40
  1-2:         9.2                 23.10              6.58
  2-3:         9.0                 24.49              6.72
  3-4:         8.7                 25.25              6.88
  4-5:         8.2                 24.61              5.23
  5-6:         7.7                 25.46              4.76
  6-7:         7.3                 26.00              4.54

             Diet Uptake       Water Uptake        Paint Uptake     Air Uptake
 YEAR          (ug/day)          (ug/day)            (ug/day)        (ug/day)
------       -----------       ------------        ------------     --------
0.5-1:         2.38               6.00                0.00            0.02
  1-2:         2.35              14.14                0.00            0.03
  2-3:         2.69              15.02                0.00            0.06
```

3-4:	2.65	15.66	0.00	0.07
4-5:	2.62	16.69	0.00	0.07
5-6:	2.80	17.80	0.00	0.09
6-7:	3.11	18.26	0.00	0.09


Cutoff: 10.0 ug/dL
% Above: 30.26
% Below: 69.74
G. Mean: 8.0
Probability Density
Function f(blood Pb)
0
5
10
15
20
25
30
35
40
LEAD 0.99d
BLOOD LEAD CONCENTRATION (ug/dL)
0 to 84 Months

```
LEAD MODEL Version 0.99d

AIR CONCENTRATION:  0.100  ug Pb/m3    DEFAULT
  Indoor AIR Pb Conc:  30.0  percent of outdoor.
  Other AIR Parameters:
     Age    Time Outdoors (hr)     Vent. Rate (m3/day)     Lung Abs. (%)
     0-1          1.0                   2.0                    32.0
     1-2          2.0                   3.0                    32.0
     2-3          3.0                   5.0                    32.0
     3-4          4.0                   5.0                    32.0
     4-5          4.0                   5.0                    32.0
     5-6          4.0                   7.0                    32.0
     6-7          4.0                   7.0                    32.0

DIET:   DEFAULT

DRINKING WATER Conc:  46.80 ug Pb/L
   WATER Consumption:  DEFAULT

SOIL & DUST:
   Soil:  constant conc.
   Dust:  constant conc.

     Age       Soil (ug Pb/g)     House Dust (ug Pb/g)
     0-1          200.0              200.0
     1-2          200.0              200.0
     2-3          200.0              200.0
     3-4          200.0              200.0
     4-5          200.0              200.0
     5-6          200.0              200.0
     6-7          200.0              200.0

   Additional Dust Sources:  None   DEFAULT

PAINT Intake:  0.00 ug Pb/day    DEFAULT

MATERNAL CONTRIBUTION:  Infant Model
   Maternal Blood Conc:  2.50  ug Pb/dL


CALCULATED BLOOD Pb and Pb UPTAKES:

             Blood Level        Total Uptake        Soil+Dust Uptake
 YEAR          (ug/dL)            (ug/day)             (ug/day)
------       -----------        ------------        ------------
0.5-1:          5.9                11.07               4.49
  1-2:          7.7                19.15               6.83
  2-3:          7.4                20.24               6.95
  3-4:          7.2                20.74               7.09
  4-5:          6.6                19.68               5.38
  5-6:          6.2                20.16               4.89
  6-7:          5.8                20.53               4.65

             Diet Uptake        Water Uptake        Paint Uptake      Air Uptake
 YEAR          (ug/day)           (ug/day)            (ug/day)         (ug/day)
------       -----------        ------------        ------------      --------
0.5-1:          2.43               4.12                0.00             0.02
  1-2:          2.44               9.86                0.00             0.03
  2-3:          2.78              10.44                0.00             0.06
```

3-4:	2.73	10.85	0.00	0.07
4-5:	2.69	11.54	0.00	0.07
5-6:	2.87	12.30	0.00	0.09
6-7:	3.19	12.59	0.00	0.09


Cutoff: 10.0 ug/dL
% Above: 17.50
% Below: 82.50
G. Mean: 6.6
Probability Density
Function f(blood Pb)
0
5
10
15
20
25
30
35
LEAD 0.99d
BLOOD LEAD CONCENTRATION (ug/dL)
0 to 84 Months

ATTACHMENT C-3

RISK AND HAZARD INDEX CALCULATION SPREADSHEETS

Attachment C-3
Risk and Hazard Index Calculation Spreadsheets

This attachment contains the risk calculation spreadsheets used to estimate the potential maximum excess lifetime cancer risk and potential for noncancer health effects from exposure to contaminated environmental media at TMSL.

A summary of the risk calculation spreadsheets is presented below.

Media	Exposure Route	Exposed Population	Table Number
Surface Water	Dermal Contact	Recreational Adult	1
		Recreational Child	2
Sediments	Dermal Contact	Recreational Adult	3
		Recreational Child	4
Groundwater	Ingestion	Residential Adult	5
		Residential Child	6
	Inhalation	Residential Adult	7
		Residential Child	8
	Dermal Contact	Residential Adult	9
		Residential Child	10

TOMAH MUNICIPAL SANITARY LANDFILL

TABLE 1

Area: Downgradient

Media: Surface Water

Land Use: Recreational

Exposure Route: Dermal Absorption

Receptor: Trespasser Adult

		Exposure Based Risk											
Chemical	**Concentration in Surface Water ug/l**	**Cancer Risk**	**Non-cancer Hazard Index**	Oral Slope Factor (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Oral Absorption Efficiency	Adjusted Oral Slope Factor (mg/kg/day)$^{-1}$	Adjusted Oral RfD (mg/kg/day)	Permeability Constant (cm/hr)	Lifetime Average Media Intake (l/kg/day)	Lifetime Average Chemical Intake (mg/kg/day)	Daily Intake (DI) (mg/kg/day)	Water Intake l/kg/day
METALS													
ARSENIC	6.3	**4.5E-08**	**0.00023**	1.5	0.0003	0.95	1.5789	0.0003	1.0E-03	4.475E-06	2.819E-08	6.579E-08	1.04E-05
MANGANESE	2380.0	--	**0.00497**	--	0.005	1	--	0.0050	1.0E-03	4.475E-06	1.065E-05	2.485E-05	1.04E-05
SUM OF RISKS		**4.5E-08**	**0.005**										

Assumptions

Body weight (kg)	70
Surface area (cm2)	5800
Percent submerged	100
Time in water (hrs/day)	1
Number of days per week	2
Number of weeks per year	23
Exposure frequency (days/yr)	46
Number of years exposed	30
Years in lifetime	70
Cancer Averaging time (days)	25550
Noncancer Averaging time (days)	10950

TOMAH MUNICIPAL SANITARY LANDFILL

TABLE 2

Area: Downgradient

Media: Surface Water

Land Use: Recreational

Exposure Route: Dermal Absorption

Receptor: Trespasser Child

		Exposure Based Risk											
Chemical	**Concentration in Surface Water ug/l**	**Cancer Risk**	**Non-cancer Hazard Index**	Oral Slope Factor (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Oral Absorption Efficiency	Adjusted Oral Slope Factor (mg/kg/day)$^{-1}$	Adjusted Oral RfD (mg/kg/day)	Permeability Constant (cm/hr)	Lifetime Average Media Intake (l/kg/day)	Lifetime Average Chemical Intake (mg/kg/day)	Daily Intake (DI) (mg/kg/day)	Water Intake l/kg/day
METALS													
ARSENIC	6.3	**1.4E-08**	**0.00037**	1.5	0.0003	0.95	1.5789	0.0003	1.0E-03	1.448E-06	9.119E-09	1.064E-07	1.69E-05
MANGANESE	2380.0	--	**0.00804**	--	0.005	1	--	0.0050	1.0E-03	1.448E-06	3.445E-06	4.019E-05	1.69E-05
SUM OF RISKS		**1.4E-08**	**0.008**										

Assumptions

Body weight (kg)	15
Surface area (cm2)	2010
Time in water (hrs/day)	1
Exposure frequency (days/yr)	46
Number of years exposed	6
Years in lifetime	70
Cancer Averaging time (days)	25550
Noncancer Averaging time (days)	2190

TOMAH MUNICIPAL SANITARY LANDFILL

TABLE 3

Area: Downgradient
Media: Sediment
Land Use: Recreational
Exposure Route: Dermal Absorption
Receptor: Recreational Adult

		Exposure Based Risk									
Chemical	Concentration In Sediment ug/kg	Cancer Risk	Non-cancer Hazard Index	Oral Slope Factor (mg/kg/ day)$^{-1}$	Oral RfD (mg/kg/ day)	Oral Absorption Efficiency	Adjusted Oral S.F. (mg/kg/ day)$^{-1}$	Adjusted Oral RfD (mg/kg/ day)	Percent Absorbed	Lifetime Average Chemical Intake (mg/kg/day)	Daily Intake (DI) (mg/kg/day)
SEMIVOLATILE ORGANIC											
BENZO(b)FLUORANTHENE (a)	56.0	**3.2E-09**	--	0.73	--	1	0.73	--	10%	2.51E-08	5.85E-08
FLUORANTHENE	56.0	--	**2.5E-07**	--	0.04	1	--	0.04	10%	2.51E-08	5.85E-08
PYRENE	60.0	--	**3.6E-07**	--	0.03	1	--	0.03	10%	2.69E-08	6.27E-08
METALS											
COPPER	14000.0	--	**0.00004**	--	0.037	1	--	0.037	1%	6.27E-07	1.46E-06
SUM OF RISKS		**3.2E-09**	**0.0000**								

EXPOSURE ASSUMPTIONS

Exposure frequency (events/yr)	46
Exposure duration (yrs)	30
Cancer Averaging time (days/lifetime)	25550
Noncancer Averaging time (days)	10950
Soil to skin adherence factor (mg/cm2)	1.0
Surface area exposed (cm2/event)	5800
Body weight (kg)	70
Lifetime average soil exposure (mg/kg body weight per day)	4.48
Soil Ingestion Rate (mg/day)**	100

a. Dermal risk due to contact with PAHs is comparable to direct ingestion of the soil. (Interim Default Values for the Estimation of the Dermal Absorption of Chemicals from Soil, IEPA, 1994.

TOMAH MUNICIPAL SANITARY LANDFILL

TABLE 4

Area: Downgradient
Media: Sediment
Land Use: Recreational
Exposure Route: Dermal Absorption
Receptor: Recreational Child

Chemical	Concentration In Sediment ug/kg	Exposure Based Risk		Oral Slope Factor (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Oral Absorption Efficiency	Adjusted Oral S.F. (mg/kg/day)$^{-1}$	Adjusted Oral RfD (mg/kg/day)	Percent Absorbed	Lifetime Average Chemical Intake (mg/kg/day)	Daily Intake (DI) (mg/kg/day)
		Cancer Risk	**Non-cancer Hazard Index**								
SEMIVOLATILE ORGANIC											
BENZO(b)FLUORANTHENE (a)	56.0	**5.9E-09**	--	0.73	--	1	0.73	--	10%	8.11E-09	9.46E-08
FLUORANTHENE	56.0	--	**0.000002**	--	0.04	1	--	0.04	10%	8.11E-09	9.46E-08
PYRENE	60.0	--	**0.000003**	--	0.03	1	--	0.03	10%	8.69E-09	1.01E-07
METALS											
COPPER	14000.0	--	**0.00006**	--	0.037	1	--	0.037	1%	2.03E-07	2.36E-06
SUM OF RISKS		**5.9E-09**	**0.0001**								

EXPOSURE ASSUMPTIONS

Exposure frequency (events/yr)	46
Exposure duration (yrs)	6
Cancer Averaging time (days/lifetime)	25550
Noncancer Averaging time (days)	2190
Soil to skin adherence factor (mg/cm2)	1.0
Surface area exposed (cm2/event)	2010
Body weight (kg)	15
Lifetime average soil exposure (mg/kg body weight per day)	1.45
Soil Ingestion Rate (mg/day)**	200

a. Dermal risk due to contact with PAHs is comparable to direct ingestion of the soil. (Interim Default Values for the Estimation of the Dermal Absorption of Chemicals from Soil, IEPA, 1994.

TOMAH MUNICIPAL SANITARY LANDFILL TABLE 5

Area: Downgradient

Media: Groundwater from Monitoring Wells

Land Use: Residential

Exposure Route: Ingestion

Receptor: Residential Adult

Chemical	Concentration in Groundwater ug/l	Exposure Based Risk		Oral Slope Factor (mg/kg/day)	Oral RfD (mg/kg/day)
		Cancer Risk	Non-cancer Hazard Index		
VOLATILE ORGANIC					
1,2-DICHLOROETHANE	4.0	4.3E-06	--	0.091	--
1,2-DICHLOROPROPANE	16.0	1.3E-05	--	0.068	--
BENZENE	48.0	1.6E-05	--	0.029	--
STYRENE	3.0	8.7E-05	0.00041	2.47	0.2
Total 1,2-DICHLOROETHENE	200.0	--	0.60883	--	0.009
VINYL CHLORIDE	1200.0	2.7E-02	--	1.9	--
SEMIVOLATILE ORGANIC					
1,4-DICHLOROBENZENE	22.0	6.2E-06	--	0.024	--
4-METHYLPHENOL (p-CRESOL)	1100.0	--	6.02740	--	0.005
bis(2-CHLOROETHYL)ETHER	7.0	9.0E-05	--	1.1	--
bis(2-ETHYLHEXYL) PHTHALATE	27.0	4.4E-06	0.03699	0.014	0.02
METALS					
ANTIMONY	53.2	--	3.64384	--	0.0004
ARSENIC	112.0	2.0E-03	10.22831	1.5	0.0003
BERYLLIUM	11.0	5.6E-04	0.06027	4.3	0.005
CADMIUM	11.5	--	0.63014	--	0.0005
CHROMIUM (hexachrome assumed)	320.0	--	1.75342	--	0.005
MANGANESE	19000.0	--	104.10959	--	0.005
THALLIUM	20.7	--	7.08904	--	0.00008
VANADIUM	233.0	--	0.91194	--	0.007
SUM OF RISKS		3.0E-02	135		

Assumptions

Body Weight (kg)	70
Averaging Time - Cancer risk (yr)	70
Averaging Time - Noncancer risk (yr)	30
Exposure Frequency (d/yr)	350
Exposure Duration (yr)	30
Daily Water Ingestion Rate (l/day)	2
Inhalation Rate (m3/day)	0.15
Volatilization Factor (unitless)	0.50

TOMAH MUNICIPAL SANITARY LANDFILL TABLE 6

Area: Downgradient
Media: Groundwater from Monitoring Wells
Land Use: Residential
Exposure Route: Ingestion
Receptor: Residential Child

Chemical	Concentration in Groundwater ug/l	Exposure Based Risk		Oral Slope Factor (mg/kg/ day)	Oral RfD (mg/kg/ day)
		Cancer Risk	Non-cancer Hazard Index		
VOLATILE ORGANIC					
1,2-DICHLOROETHANE	4.0	**2.0E-06**	**--**	0.091	--
1,2-DICHLOROPROPANE	16.0	**6.0E-06**	**--**	0.068	--
BENZENE	48.0	**7.6E-06**	**--**	0.029	--
STYRENE	3.0	**4.1E-05**	**0.00096**	2.47	0.2
Total 1,2-DICHLOROETHENE	200.0	**--**	**1.42060**	--	0.009
VINYL CHLORIDE	1200.0	**1.2E-02**	**--**	1.9	--
SEMIVOLATILE ORGANIC					
1,4-DICHLOROBENZENE	22.0	**2.9E-06**	**--**	0.024	--
4 METHYLPHENOL (p-CRESOL)	1100.0	**--**	**14.06393**	--	0.005
bis(2-CHLOROETHYL)ETHER	7.0	**4.2E-05**	**--**	1.1	--
bis(2-ETHYLHEXYL) PHTHALATE	27.0	**2.1E-06**	**0.08630**	0.014	0.02
METALS					
ANTIMONY	53.2	**--**	**8.50228**	--	0.0004
ARSENIC	112.0	**9.2E-04**	**23.86606**	1.5	0.0003
BERYLLIUM	11.0	**2.6E-04**	**0.14064**	4.3	0.005
CADMIUM	11.5	**--**	**1.47032**	--	0.0005
CHROMIUM (hexachrome assumed)	320.0	**--**	**4.09132**	--	0.005
MANGANESE	19000.0	**--**	**242.92237**	--	0.005
THALLIUM	20.7	**--**	**16.54110**	--	0.00008
VANADIUM	233.0	**--**	**2.12785**	--	0.007
SUM OF RISKS		**1.4E-02**	**315**		

Assumptions

Body Weight (kg)	15
Averaging Time - Cancer risk (yr)	70
Averaging Time - Noncancer risk (yr)	6
Exposure Frequency (d/yr)	350
Exposure Duration (yr)	6
Daily Water Ingestion Rate (l/day)	1
Inhalation Rate (m3/day)	0.15
Volatilization Factor (unitless)	0.50

TOMAH MUNICIPAL SANITARY LANDFILL TABLE 7

Area: Downgradient

Media: Groundwater from Monitoring Wells

Land Use: Residential

Exposure Route: Inhalation of Chemicals Released from Groundwater

Receptor: Residential Adult

Chemical	Concentration in Groundwater ug/l	Exposure Based Risk		Inhalation Slope Factor (mg/kg/day)	Inhalation RfD (mg/kg/day)
		Cancer Risk	Non-cancer Hazard Index		
VOLATILE ORGANIC					
1,2-DICHLOROETHANE	4.0	**1.6E-07**	**--**	0.091	--
1,2-DICHLOROPROPANE	16.0	**--**	**0.01438**	--	0.0011
BENZENE	48.0	**6.1E-07**	**--**	0.02905	--
STYRENE	3.0	**--**	**0.00001**	--	0.2857
VINYL CHLORIDE	1200.0	**1.6E-04**	**--**	0.294	--
SEMIVOLATILE ORGANIC					
1,4-DICHLOROBENZENE	22.0	**--**	**0.00010**	--	0.2286
bis(2-CHLOROETHYL)ETHER	7.0	**3.6E-06**	**--**	1.155	--
SUM OF RISKS		**1.6E-04**	**0.01**		

Assumptions

Body Weight (kg)	70
Averaging Time - Cancer risk (yr)	70
Averaging Time - Noncancer risk (yr)	30
Exposure Frequency (d/yr)	350
Exposure Duration (yr)	30
Daily Water Ingestion Rate (l/day)	2
Inhalation Rate (m3/day)	0.15
Volatilization Factor (unitless)	0.50

TOMAH MUNICIPAL SANITARY LANDFILL TABLE 8

Area: Downgradient

Media: Groundwater from Monitoring Wells

Land Use: Residential

Exposure Route: Inhalation of Chemicals Released from Groundwater

Receptor: Residential Child

		Exposure Based Risk			
Chemical	**Concentration In Groundwater ug/l**	**Cancer Risk**	**Non-cancer Hazard Index**	Inhalation Slope Factor (mg/kg/day)	Inhalation RfD (mg/kg/day)
VOLATILE ORGANIC					
1,2-DICHLOROETHANE	4.0	**1.5E-07**	--	0.091	--
1,2-DICHLOROPROPANE	16.0	--	**0.06712**	--	0.0011
BENZENE	48.0	**5.7E-07**	--	0.02905	--
STYRENE	3.0	--	**0.00005**	--	0.2857
VINYL CHLORIDE	1200.0	**1.4E-04**	--	0.294	--
SEMIVOLATILE ORGANIC					
1,4-DICHLOROBENZENE	22.0	--	**0.00046**	--	0.2286
bis(2-CHLOROETHYL)ETHER	7.0	**3.3E-06**	--	1.155	--
SUM OF RISKS		**1.5E-04**	**0.07**		

Assumptions

Body Weight (kg)	15
Averaging Time - Cancer risk (yr)	70
Averaging Time - Noncancer risk (yr)	6
Exposure Frequency (d/yr)	350
Exposure Duration (yr)	6
Daily Water Ingestion Rate (l/day)	1
Inhalation Rate (m3/day)	0.15
Volatilization Factor (unitless)	0.50

TOMAH MUNICIPAL SANITARY LANDFILL

TABLE 9

Area: Downgradient

Media: Groundwater from Monitoring Wells

Land Use: Residential

Exposure Route: Dermal Absorption

Receptor: Residential Adult

		Exposure Based Risk											
Chemical	Concentration In Groundwater ug/l	Cancer Risk	Non-cancer Hazard Index	Oral Slope Factor (mg/kg/day)	Oral RfD (mg/kg/day)	Oral Absorption Efficiency	Adjusted Oral Slope Factor (mg/kg/day)	Adjusted Oral RfD (mg/kg/day)	Permeability Constant (cm/hr)	Lifetime Average Media Intake (l/kg/day)	Lifetime Average Chemical Intake (mg/kg/day)	Daily Intake (DI) (mg/kg/day)	Water Intake l/kg/day
VOLATILE ORGANIC													
1,2-DICHLOROETHANE	4.0	**6.5E-08**	--	0.091	--	1	0.0910	--	5.3E-03	1.789E-04	7.157E-07	1.670E-06	4.17E-04
1,2-DICHLOROPROPANE	16.0	**5.9E-07**	--	0.068	--	1	0.0680	--	1.6E-02	5.401E-04	8.642E-06	2.016E-05	1.26E-03
BENZENE	48.0	**1.0E-06**	--	0.029	--	0.97	0.0299	--	2.1E-02	7.089E-04	3.403E-05	7.940E-05	1.65E-03
STYRENE	3.0	**6.0E-06**	**0.00003**	2.47	0.2	1	2.4700	0.2000	2.4E-02	8.044E-04	2.413E-06	5.631E-06	1.88E-03
Total 1,2-DICHLOROETHENE	200.0	--	**0.01750**	--	0.009	1	--	0.0090	1.0E-02	3.376E-04	6.751E-05	1.575E-04	7.88E-04
VINYL CHLORIDE	1200.0	**5.8E-04**	--	1.9	--	1	1.9000	--	7.5E-03	2.534E-04	3.041E-04	7.096E-04	5.91E-04
SEMIVOLATILE ORGANIC													
1,4-DICHLOROBENZENE	22.0	**1.1E-06**	--	0.024	--	1	0.0240	--	6.2E-02	2.093E-03	4.605E-05	1.074E-04	4.88E-03
4-METHYLPHENOL (p-CRESOL)	1100.0	--	**0.16636**	--	0.005	1	--	0.0050	9.6E-03	3.241E-04	3.565E-04	8.318E-04	7.56E-04
bis(2-CHLOROETHYL)ETHER	7.0	**8.8E-07**	--	1.1	--	1	1.1000	--	3.4E-03	1.148E-04	8.034E-07	1.875E-06	2.68E-04
bis(2-ETHYLHEXYL) PHTHALATE	27.0	**1.6E-04**	**1.31789**	0.014	0.02	1	0.0140	0.0200	1.2E+01	4.184E-01	1.130E-02	2.636E-02	9.76E-01
METALS													
ANTIMONY	53.2	--	**0.01048**	--	0.0004	1	--	0.0004	1.0E-03	3.376E-05	1.796E-06	4.190E-06	7.88E-05
ARSENIC	112.0	**6.0E-06**	**0.03095**	1.5	0.0003	0.95	1.5789	0.0003	1.0E-03	3.376E-05	3.781E-06	8.822E-06	7.88E-05
BERYLLIUM	11.0	**1.6E-06**	**1.73E-04**	4.3	0.005	1	4.3000	0.0050	1.0E-03	3.376E-05	3.713E-07	8.664E-07	7.88E-05
CADMIUM	11.5	--	**0.00181**	--	0.0005	1	--	0.0005	1.0E-03	3.376E-05	3.882E-07	9.058E-07	7.88E-05
CHROMIUM (hexachrome assumed)	320.0	--	**0.40329**	--	0.005	0.0125	--	0.0001	1.0E-03	3.376E-05	1.080E-05	2.521E-05	7.88E-05
MANGANESE	19000.0	--	**0.29932**	--	0.005	1	--	0.0050	1.0E-03	3.376E-05	6.414E-04	1.497E-03	7.88E-05
THALLIUM	20.7	--	**0.02038**	--	0.00008	1	--	0.0001	1.0E-03	3.376E-05	6.988E-07	1.630E-06	7.88E-05
VANADIUM	233.0	--	**0.00262**	--	0.007	1	--	0.0070	1.0E-03	3.376E-05	7.865E-06	1.835E-05	7.88E-05
SUM OF RISKS		**7.5E-04**	**2.3**										

Assumptions

Body weight (kg)	70
Surface area (cm2)	23000
Percent submerged	100
Time in water (hrs/day)	0.25
Number of days per week	7
Number of weeks per year	50
Exposure frequency (days/yr)	350
Number of years exposed	30
Years in lifetime	70
Cancer Averaging time (days)	25550
Noncancer Averaging time (days)	10950

TOMAH MUNICIPAL SANITARY LANDFILL

TABLE 10

Area: Downgradient
Media: Groundwater from Monitoring Wells
Land Use: Residential
Exposure Route: Dermal Absorption
Receptor: Residential Child

Chemical	Concentration In Groundwater ug/l	Exposure Based Risk		Oral Slope Factor (mg/kg/day)	Oral RfD (mg/kg/day)	Oral Absorption Efficiency	Adjusted Oral Slope Factor (mg/kg/day)	Adjusted Oral RfD (mg/kg/day)	Permeability Constant (cm/hr)	Lifetime Average Media Intake (l/kg/day)	Lifetime Average Chemical Intake (mg/kg/day)	Daily Intake (DI) (mg/kg/day)	Water Intake l/kg/day
		Cancer Risk	**Non-cancer Hazard Index**										
VOLATILE ORGANIC													
1,2-DICHLOROETHANE	4.0	**2.8E-08**	**--**	0.091	--	1	0.091	--	5.3E-03	7.696E-05	3.078E-07	3.591E-06	8.98E-04
1,2-DICHLOROPROPANE	16.0	**2.5E-07**	**--**	0.068	--	1	0.068	--	1.6E-02	2.323E-04	3.717E-06	4.337E-05	2.71E-03
BENZENE	48.0	**4.4E-07**	**--**	0.029	--	0.97	0.030	--	2.1E-02	3.049E-04	1.464E-05	1.708E-04	3.56E-03
STYRENE	3.0	**2.6E-06**	**0.00006**	2.47	0.2	1	2.470	0.2	2.4E-02	3.460E-04	1.038E-06	1.211E-05	4.04E-03
Total 1,2-DICHLOROETHENE	200.0	**--**	**0.03765**	--	0.009	1	--	0.009	1.0E-02	1.452E-04	2.904E-05	3.388E-04	1.69E-03
VINYL CHLORIDE	1200.0	**2.5E-04**	**--**	1.9	--	1	1.900	--	7.5E-03	1.090E-04	1.308E-04	1.526E-03	1.27E-03
SEMIVOLATILE ORGANIC													
1,4-DICHLOROBENZENE	22.0	**4.8E-07**	**--**	0.024	--	1	0.024	--	6.2E-02	9.003E-04	1.981E-05	2.311E-04	1.05E-02
4-METHYLPHENOL (p-CRESOL)	1100.0	**--**	**0.35779**	--	0.005	1	--	0.005	9.6E-03	1.394E-04	1.533E-04	1.789E-03	1.63E-03
bis(2-CHLOROETHYL)ETHER	7.0	**3.8E-07**	**--**	1.1	--	1	1.100	--	3.4E-03	4.937E-05	3.456E-07	4.032E-06	5.76E-04
bis(2-ETHYLHEXYL) PHTHALATE	27.0	**6.8E-05**	**2.83442**	0.014	0.02	1	0.014	0.02	1.2E+01	1.800E-01	4.859E-03	5.669E-02	2.10E+00
METALS													
ANTIMONY	53.2	**--**	**0.02253**	--	0.0004	1		0.0004	1.0E-03	1.452E-05	7.725E-07	9.012E-06	1.69E-04
ARSENIC	112.0	**2.6E-06**	**0.06657**	1.5	0.0003	0.95	1.579	0.000285	1.0E-03	1.452E-05	1.626E-06	1.897E-05	1.69E-04
BERYLLIUM	11.0	**6.9E-07**	**0.00037**	4.3	0.005	1	4.300	0.005	1.0E-03	1.452E-05	1.597E-07	1.863E-06	1.69E-04
CADMIUM	11.5	**--**	**0.00390**	--	0.0005	1	--	0.0005	1.0E-03	1.452E-05	1.670E-07	1.948E-06	1.69E-04
CHROMIUM (hexachrome assumed)	320.0	**--**	**0.86736**	--	0.005	0.0125	--	0.0000625	1.0E-03	1.452E-05	4.647E-06	5.421E-05	1.69E-04
MANGANESE	19000.0	**--**	**0.64374**	--	0.005	1	--	0.005	1.0E-03	1.452E-05	2.759E-04	3.219E-03	1.69E-04
THALLIUM	20.7	**--**	**0.04383**	--	0.00008	1	--	0.00008	1.0E-03	1.452E-05	3.006E-07	3.507E-06	1.69E-04
VANADIUM	233.0	**--**	**0.00564**	--	0.007	1	--	0.007	1.0E-03	1.452E-05	3.383E-06	3.947E-05	1.69E-04
SUM OF RISKS		**3.2E-04**	**4.9**										

Assumptions

Body weight (kg)	15
Surface area (cm2)	10600
Percent submerged	100
Time in water (hrs/day)	0.25
Number of days per week	7
Number of weeks per year	50
Exposure frequency (days/yr)	350
Number of years exposed	6
Years in lifetime	70
Cancer Averaging time (days)	25550
Noncancer Averaging time (days)	2190

ATTACHMENT C-4
TOXICITY CONCENTRATION SCREENING PROCESS

Attachment C-4
Toxicity-Concentration Screening Process

This attachment contains the toxicity-concentration screening spreadsheets used to determine the final list of contaminants of concern for the TMSL site. The toxicity-concentration screen process identifies which chemicals contributed less than 1% of the risk or hazard index. These chemicals are eliminated from further evaluation (unless there is additional justification for retaining them, such as status as a Class A carcinogen).

The risk for each chemical via each exposure route is estimated and summed. The overall risk is then summed for each environmental media. Each chemical's risk is then compared to the overall risk, and the ratio calculated. This process is repeated for each receptor (residential adult, residential child, commercial/industrial adult) appropriate for the media. If a chemical contributes more than 1% of the overall risk for any one receptor scenario, it is retained as a COC. For instance, if the risk due to methyl ethyl ketone is less than 1% for the commercial/industrial adult and the residential adult but more than 1% for the residential child, the chemical would be retained as a COC for all three receptors.

A summary of the toxicity-concentration screen spreadsheets is presented below.

Media	Exposed Population	Table Number
Surface Water	Recreational Adult Recreational Child	1
Sediments	Recreational Adult Recreational Child	2
Groundwater	Residential Adult	3
	Residential Child	4

Tomah Municipal Sanitary Landfill
Tomah, Wisconsin

Table 1
TOXICITY SCREENING
Surface Water

Receptor: Recreational Adult

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
METALS			
ARSENIC	4.45E-08	1.00000	**YES**
BARIUM			
MANGANESE			
Sum:	4.45E-08	1.00	

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
METALS			
ARSENIC	2.31E-04	0.04429	**YES**
BARIUM	1.03E-05	0.00197	**NO**
MANGANESE	4.97E-03	0.95374	**YES**
Sum:	5.21E-03	1.00	

Receptor: Recreational Child

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
METALS			
ARSENIC	1.44E-08	1.00000	**YES**
BARIUM			
MANGANESE			
Sum:	1.44E-08	1.00	

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
METALS			
ARSENIC	3.73E-04	0.04429	**YES**
BARIUM	1.66E-05	0.00197	**NO**
MANGANESE	8.04E-03	0.95374	**YES**
Sum:	8.43E-03	1.00	

TOMAH FAIRGROUNDS LANDFILL
Tomah, Wisconsin

Table 2
TOXICITY SCREENING
Sediment

Receptor: Recreational Adult

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	**PCOC? (>1%)**
VOLATILE ORGANIC			
2-BUTANONE (MEK)			
SEMIVOLATILE ORGANIC			
BENZO(b)FLUORANTHENE	3.15E-09	0.02129	**YES**
FLUORANTHENE			
PENTACHLOROPHENOL	1.45E-07	0.97871	**YES**
PYRENE			
METALS			
COPPER			
	1.48E-07	1.00	

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
VOLATILE ORGANIC			
2-BUTANONE (MEK)	8.70E-08	0.00065	**NO**
SEMIVOLATILE ORGANIC			
BENZO(b)FLUORANTHENE			
FLUORANTHENE	2.52E-07	0.00188	**NO**
PENTACHLOROPHENOL	9.40E-05	0.70035	**YE**
PYRENE	3.60E-07	0.00268	**NO**
METALS			
COPPER	3.95E-05	0.29444	**YES**
	1.34E-04	1.00	

Receptor: Recreational Child

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	**PCOC? (>1%)**
VOLATILE ORGANIC			
2-BUTANONE (MEK)			
SEMIVOLATILE ORGANIC			
BENZO(b)FLUORANTHENE	5.89E-09	0.11154	**YES**
FLUORANTHENE			
PENTACHLOROPHENOL	4.69E-08	0.88846	**YES**
PYRENE			
METALS			
COPPER			
	5.28E-08	1.00	

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1
VOLATILE ORGANIC			
2-BUTANONE (MEK)	1.41E-07	0.00063	**NO**
SEMIVOLATILE ORGANIC			
BENZO(b)FLUORANTHENE			
FLUORANTHENE	2.35E-06	0.01061	**YES**
PENTACHLOROPHENOL	1.52E-04	0.68543	**YES**
PYRENE	3.36E-06	0.01516	**YES**
METALS			
COPPER	6.39E-05	0.28817	**YES**
	2.22E-04	1.00	

Tomah Municipal Sanitary Landfill
Tomah, Wisconsin

Table 3
TOXICITY SCREENING
Groundwater (Monitoring Wells)

Receptor: Residential Adult

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	**PCOC? (>1%)**
VOLATILE ORGANIC			
1,1-DICHLOROETHANE			
1,2-DICHLOROETHANE	4.50E-06	0.00015	**YES (c)**
1,2-DICHLOROPROPANE	1.34E-05	0.00044	**YES (c)**
ACETONE			
BENZENE	1.80E-05	0.00059	**YES (b)**
CARBON DISULFIDE			
CHLOROBENZENE			
CHLOROETHANE			
ETHYLBENZENE			
2-BUTANONE (MEK)			
4-METHYL-2-PENTANONE (MIBK)			
STYRENE	9.30E-05	0.00304	**YES (c)**
TOLUENE			
Total 1,2-DICHLOROETHENE			
VINYL CHLORIDE	2.75E-02	0.90075	**YES**
XYLENES, TOTAL			
SEMIVOLATILE ORGANIC			
1,2-DICHLOROBENZENE			
1,4-DICHLOROBENZENE	7.30E-06	0.00024	**YES (c)**
2,4-DIMETHYLPHENOL			
2-METHYLPHENOL (o-CRESOL)			
4-METHYLPHENOL (p-CRESOL)			
bis(2-CHLOROETHYL)ETHER	9.49E-05	0.00311	**YES (c)**
bis(2-ETHYLHEXYL) PHTHALATE	1.63E-04	0.00532	**YES (c)**
DI-N-BUTYL PHTHALATE			
DIETHYLPHTHALATE			
N-NITROSODIPHENYLAMINE	1.27E-07	0.000004	**NO**
NAPHTHALENE			
PENTACHLOROPHENOL	1.01E-04	0.00331	**YES (c)**
PHENOL			
PESTICIDES/PCBs			
ENDRIN			
gamma-CHLORDANE	1.83E-07	0.00001	**NO**
2,4,5-TP (Silvex)			

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
VOLATILE ORGANIC			
1,1-DICHLOROETHANE	7.78E-03	0.00006	**NO**
1,2-DICHLOROETHANE			
1,2-DICHLOROPROPANE	1.44E-02	0.00010	**NO**
ACETONE	8.78E-02	0.00063	**NO**
BENZENE			
CARBON DISULFIDE	6.51E-04	0.000005	**NO**
CHLOROBENZENE	1.37E-02	0.00010	**NO**
CHLOROETHANE	4.67E-06	0.00000003	**NO**
ETHYLBENZENE	1.61E-02	0.00012	**NO**
2-BUTANONE (MEK)	1.38E-02	0.00010	**NO**
4-METHYL-2-PENTANONE (MIBK)	1.92E-02	0.00014	**NO**
STYRENE	4.50E-04	0.000003	**NO**
TOLUENE	9.00E-02	0.00065	**NO**
Total 1,2-DICHLOROETHENE	6.26E-01	0.00450	**NO**
VINYL CHLORIDE			
XYLENES, TOTAL	2.86E-03	0.00002	**NO**
SEMIVOLATILE ORGANIC			
1,2-DICHLOROBENZENE	3.00E-04	0.000002	**NO**
1,4-DICHLOROBENZENE	9.89E-05	0.000001	**NO**
2,4-DIMETHYLPHENOL	2.28E-02	0.00016	**NO**
2-METHYLPHENOL (o-CRESOL)	1.01E-02	0.00007	**NO**
4-METHYLPHENOL (p-CRESOL)	6.19E+00	0.04445	**YES**
bis(2-CHLOROETHYL)ETHER			
bis(2-ETHYLHEXYL) PHTHALATE	1.35E+00	0.00972	**YES (c)**
DI-N-BUTYL PHTHALATE	5.60E-04	0.000004	**NO**
DIETHYLPHTHALATE	3.82E-03	0.00003	**NO**
N-NITROSODIPHENYLAMINE			
NAPHTHALENE	1.10E-02	0.00008	**NO**
PENTACHLOROPHENOL	6.55E-02	0.00047	**NO**
PHENOL	2.50E-03	0.00002	**NO**
PESTICIDES/PCBs			
ENDRIN	5.68E-04	0.000004	**NO**
gamma-CHLORDANE	5.49E-03	0.00004	**NO**
2,4,5-TP (Silvex)	2.10E-03	0.00002	**NO**

Table 3

TOXICITY SCREENING

Groundwater (Monitoring Wells)

Receptor: Residential Adult

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	**PCOC? (>1%)**
VOLATILE ORGANIC			
1,1-DICHLOROETHANE			
1,2-DICHLOROETHANE	4.50E-06	0.00015	**YES (c)**
1,2-DICHLOROPROPANE	1.34E-05	0.00044	**YES (c)**
ACETONE			
BENZENE	1.80E-05	0.00059	**YES (b)**
CARBON DISULFIDE			
CHLOROBENZENE			
CHLOROETHANE			
ETHYLBENZENE			
2-BUTANONE (MEK)			
4-METHYL-2-PENTANONE (MIBK)			
STYRENE	9.30E-05	0.00304	**YES (c)**
TOLUENE			
Total 1,2-DICHLOROETHENE			
VINYL CHLORIDE	2.75E-02	0.90075	**YES**
XYLENES, TOTAL			
SEMIVOLATILE ORGANIC			
1,2-DICHLOROBENZENE			
1,4-DICHLOROBENZENE	7.30E-06	0.00024	**YES (c)**
2,4-DIMETHYLPHENOL			
2-METHYLPHENOL (o-CRESOL)			
4-METHYLPHENOL (p-CRESOL)			
bis(2-CHLOROETHYL)ETHER	9.49E-05	0.00311	**YES (c)**
bis(2-ETHYLHEXYL) PHTHALATE	1.63E-04	0.00532	**YES (c)**
DI-N-BUTYL PHTHALATE			
DIETHYLPHTHALATE			
N-NITROSODIPHENYLAMINE	1.27E-07	0.000004	**NO**
NAPHTHALENE			
PENTACHLOROPHENOL	1.01E-04	0.00331	**YES (c)**
PHENOL			
PESTICIDES/PCBs			
ENDRIN			
gamma-CHLORDANE	1.83E-07	0.00001	**NO**
2,4,5-TP (Silvex)			

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
VOLATILE ORGANIC			
1,1-DICHLOROETHANE	7.78E-03	0.00006	**NO**
1,2-DICHLOROETHANE			
1,2-DICHLOROPROPANE	1.44E-02	0.00010	**NO**
ACETONE	8.78E-02	0.00063	**NO**
BENZENE			
CARBON DISULFIDE	6.51E-04	0.000005	**NO**
CHLOROBENZENE	1.37E-02	0.00010	**NO**
CHLOROETHANE	4.67E-06	0.00000003	**NO**
ETHYLBENZENE	1.61E-02	0.00012	**NO**
2-BUTANONE (MEK)	1.38E-02	0.00010	**NO**
4-METHYL-2-PENTANONE (MIBK)	1.92E-02	0.00014	**NO**
STYRENE	4.50E-04	0.000003	**NO**
TOLUENE	9.00E-02	0.00065	**NO**
Total 1,2-DICHLOROETHENE	6.26E-01	0.00450	**NO**
VINYL CHLORIDE			
XYLENES, TOTAL	2.86E-03	0.00002	**NO**
SEMIVOLATILE ORGANIC			
1,2-DICHLOROBENZENE	3.00E-04	0.000002	**NO**
1,4-DICHLOROBENZENE	9.89E-05	0.000001	**NO**
2,4-DIMETHYLPHENOL	2.28E-02	0.00016	**NO**
2-METHYLPHENOL (o-CRESOL)	1.01E-02	0.00007	**NO**
4-METHYLPHENOL (p-CRESOL)	6.19E+00	0.04445	**YES**
bis(2-CHLOROETHYL)ETHER			
bis(2-ETHYLHEXYL) PHTHALATE	1.35E+00	0.00972	**YES (c)**
DI-N-BUTYL PHTHALATE	5.60E-04	0.000004	**NO**
DIETHYLPHTHALATE	3.82E-03	0.00003	**NO**
N-NITROSODIPHENYLAMINE			
NAPHTHALENE	1.10E-02	0.00008	**NO**
PENTACHLOROPHENOL	6.55E-02	0.00047	**NO**
PHENOL	2.50E-03	0.00002	**NO**
PESTICIDES/PCBs			
ENDRIN	5.68E-04	0.000004	**NO**
gamma-CHLORDANE	5.49E-03	0.00004	**NO**
2,4,5-TP (Silvex)	2.10E-03	0.00002	**NO**

Tomah Municipal Sanitary Landfill
Tomah, Wisconsin

Table 3 Continued

TOXICITY SCREENING

Groundwater (Monitoring Wells)

Receptor: Residential Adult

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	**PCOC? (>1%)**
METALS			
ANTIMONY			
ARSENIC	1.98E-03	0.06480	**YES**
BARIUM			
BERYLLIUM	5.57E-04	0.01824	**YES**
CADMIUM			
CHROMIUM (hexachrome assumed)			
COPPER			
MANGANESE			
MERCURY			
NICKEL			
SELENIUM			
SILVER			
THALLIUM			
VANADIUM			
ZINC			
Sum:	3.05E-02	1.00	

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
METALS			
ANTIMONY	3.65E+00	0.02623	**YES**
ARSENIC	1.03E+01	0.07363	**YES**
BARIUM	6.79E-01	0.00487	**NO**
BERYLLIUM	6.04E-02	0.00043	**NO**
CADMIUM	6.32E-01	0.00454	**NO**
CHROMIUM (hexachrome assumed)	2.16E+00	0.01548	**YES**
COPPER	1.72E-01	0.00124	**NO**
MANGANESE	1.04E+02	0.74935	**YES**
MERCURY	2.29E-01	0.00164	**NO**
NICKEL	1.96E-01	0.00141	**NO**
SELENIUM	1.32E-01	0.00095	**NO**
SILVER	1.21E-01	0.00087	**NO**
THALLIUM	7.11E+00	0.05103	**YES**
VANADIUM	9.15E-01	0.00656	**NO**
ZINC	4.02E-02	0.00029	**NO**
Sum:	1.39E+02	1.00	

a. Chemical is retained because risk exceeds 1x10-6

b. Chemical is retained because it is a Class A carcinogen

c. Chemical is retained because HI exceeds 1

Tomah Municipal Sanitary Landfill
Tomah, Wisconsin

Table 4

TOXICITY SCREENING

Groundwater (Monitoring Wells)

Receptor: Residential Child

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
VOLATILE ORGANIC			
1,1-DICHLOROETHANE			
1,2-DICHLOROETHANE	2.17E-06	0.00015	**YES (c)**
1,2-DICHLOROPROPANE	6.21E-06	0.00043	**YES (c)**
ACETONE			
BENZENE	8.64E-06	0.00060	**YES (b)**
CARBON DISULFIDE			
CHLOROBENZENE			
CHLOROETHANE			
ETHYLBENZENE			
2-BUTANONE (MEK)			
4-METHYL-2-PENTANONE (MIBK)			
STYRENE	4.32E-05	0.00302	**YES (c)**
TOLUENE			
Total 1,2-DICHLOROETHENE			
VINYL CHLORIDE	1.29E-02	0.90154	**YES**
XYLENES, TOTAL			
SEMIVOLATILE ORGANIC			
1,2-DICHLOROBENZENE			
1,4-DICHLOROBENZENE	3.37E-06	0.00024	**YES (c)**
2,4-DIMETHYLPHENOL			
2-METHYLPHENOL (o-CRESOL)			
4-METHYLPHENOL (p-CRESOL)			
bis(2-CHLOROETHYL)ETHER	4.59E-05	0.00321	**YES (c)**
bis(2-ETHYLHEXYL) PHTHALATE	7.01E-05	0.00490	**YES (c)**
DI-N-BUTYL PHTHALATE			
DIETHYLPHTHALATE			
N-NITROSODIPHENYLAMINE	5.88E-08	0.00000	**NO**
NAPHTHALENE			
PENTACHLOROPHENOL	4.48E-05	0.00313	**YES (c)**
PHENOL			
PESTICIDES/PCBs			
ENDRIN			
gamma-CHLORDANE	8.56E-08	0.00001	**NO**
2,4,5-TP (Silvex)			

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
VOLATILE ORGANIC			
1,1-DICHLOROETHANE	1.86E-02	0.00006	**NO**
1,2-DICHLOROETHANE			
1,2-DICHLOROPROPANE	6.71E-02	0.00021	**NO**
ACETONE	2.05E-01	0.00063	**NO**
BENZENE			
CARBON DISULFIDE	2.35E-03	0.00001	**NO**
CHLOROBENZENE	3.51E-02	0.00011	**NO**
CHLOROETHANE	2.18E-05	0.00000	**NO**
ETHYLBENZENE	3.75E-02	0.00012	**NO**
2-BUTANONE (MEK)	3.46E-02	0.00011	**NO**
4-METHYL-2-PENTANONE (MIBK)	4.81E-02	0.00015	**NO**
STYRENE	1.07E-03	0.00000	**NO**
TOLUENE	2.20E-01	0.00068	**NO**
Total 1,2-DICHLOROETHENE	1.46E+00	0.00449	**YES (c)**
VINYL CHLORIDE			
XYLENES, TOTAL	6.59E-03	0.00002	**NO**
SEMIVOLATILE ORGANIC			
1,2-DICHLOROBENZENE	7.27E-04	0.00000	**NO**
1,4-DICHLOROBENZENE	4.61E-04	0.00000	**NO**
2,4-DIMETHYLPHENOL	5.31E-02	0.00016	**NO**
2-METHYLPHENOL (o-CRESOL)	2.36E-02	0.00007	**NO**
4-METHYLPHENOL (p-CRESOL)	1.44E+01	0.04441	**YES**
bis(2-CHLOROETHYL)ETHER			
bis(2-ETHYLHEXYL) PHTHALATE	2.92E+00	0.00899	**YES (c)**
DI-N-BUTYL PHTHALATE	1.25E-03	0.00000	**NO**
DIETHYLPHTHALATE	8.91E-03	0.00003	**NO**
N-NITROSODIPHENYLAMINE			
NAPHTHALENE	2.56E-02	0.00008	**NO**
PENTACHLOROPHENOL	1.45E-01	0.00045	**NO**
PHENOL	5.84E-03	0.00002	**NO**
PESTICIDES/PCBs			
ENDRIN	1.31E-03	0.00000	**NO**
gamma-CHLORDANE	1.28E-02	0.00004	**NO**
2,4,5-TP (Silvex)	4.90E-03	0.00002	**NO**

Tomah Municipal Sanitary Landfill
Tomah, Wisconsin

Table 4 Continued

TOXICITY SCREENING

Groundwater (Monitoring Wells)

Receptor: Residential Child

CANCER RISK	Risk - Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	**PCOC? (>1%)**
METALS			
ANTIMONY			
ARSENIC	*9.23E-04*	*0.06458*	**YES**
BARIUM			
BERYLLIUM	2.60E-04	0.01818	**YES**
CADMIUM			
CHROMIUM (hexachrome assumed)			
COPPER			
MANGANESE			
MERCURY			
NICKEL			
SELENIUM			
SILVER			
THALLIUM			
VANADIUM			
ZINC			
Sum:	1.43E-02	1.00	

NONCANCER RISK	Sum of Pathways	Ratio of Individual Risk to Sum of Pathways	PCOC? (>1%)
METALS			
ANTIMONY	8.52E+00	0.02625	**YES**
ARSENIC	*2.39E+01*	*0.07370*	**YES**
BARIUM	1.58E+00	0.00488	**NO**
BERYLLIUM	1.41E-01	0.00043	**NO**
CADMIUM	1.47E+00	0.00454	**YES (c)**
CHROMIUM (hexachrome assumed)	4.96E+00	0.01527	**YES**
COPPER	4.02E-01	0.00124	**NO**
MANGANESE	2.44E+02	0.75004	**YES**
MERCURY	5.34E-01	0.00164	**NO**
NICKEL	4.58E-01	0.00141	**NO**
SELENIUM	3.08E-01	0.00095	**NO**
SILVER	2.82E-01	0.00087	**NO**
THALLIUM	1.66E+01	0.05107	**YES**
VANADIUM	2.13E+00	0.00657	**YES (c)**
ZINC	9.38E-02	0.00029	**NO**
Sum:	3.25E+02	1.00	

a. Chemical is retained because risk exceeds 1x10-6

b. Chemical is retained because it is a Class A carcinogen

c. Chemical is retained because HI exceeds 1

APPENDIX D

TECHNICAL MEMORANDUM ECOLOGICAL SURVEY RESULTS

TECHNICAL MEMORANDUM

CH2M HILL

PREPARED FOR: Matt Mankowski/USEPA

PREPARED BY: Linda Hoehne/CH2M HILL
Mike Mischuk/CH2M HILL

DATE: February 3, 1995

SUBJECT: Ecological Survey Results
Tomah Municipal Sanitary Landfill Site

PROJECT: 104195.AR.ER

Introduction

This memorandum summarizes the results of the ecological survey performed by CH2M HILL on September 15 and 16, 1994 at the Tomah Municipal Sanitary Landfill (TMSL) site in Tomah, Wisconsin. The purpose of this survey was to describe the flora and fauna at the site, identify any sensitive habitats or species, and identify potential biological receptors.

Procedure

Aquatic habitat at the site was surveyed qualitatively to determine general physical characteristics. Benthic macroinvertebrates in Deer Creek were observed from grab samples from three locations (upstream reference location, adjacent to the site, and west of County Highway E). The samples were used qualitatively as an indicator of stream health at the secondary food chain level. Observations at the three locations are presented on data sheets in Attachment 1.

Terrestrial habitat at the TMSL was identified during a general walk-over of the landfill, which included areas of grass, scattered shrubs, and rows of planted red and white pines. Habitat adjacent to the landfill was also identified. Vegetation in these areas was described and any animals or their signs (i.e., tracks) were noted. No formal vegetation sampling was conducted nor were any animals trapped or surveyed.

Results

Aquatic Ecology

Surrounding land use upstream of the site is predominately agricultural. Adjacent to the site, the predominant land use is forested (wetlands). Deer Creek flows northeast across the northwestern corner of the site.

The depth of the Deer Creek stream channel at the three sample locations averaged approximately 20 cm (0.7 ft). Bottom inorganic substrate was composed mainly of sand (60 to 80 percent) and silt (20 to 40 percent), with little gravel. Organic substrates were composed largely of woody debris with some coarse particulate organic matter. Some pockets of fine organic matter were also present. Canopy cover adjacent to the creek consists of alders and tall grasses. There were no unusual sediment odors or oils. There were no unusual surface water odors or sheens. The stream was clear throughout the study area.

Biologically, WDNR has designated Deer Creek as a Class II trout water, supporting primarily brook trout (see Attachment 2). Other potential fish species in the watershed are presented in Table 1:

TABLE 1
Potential Fish Species

Common Name	Scientific Name
Bluntnose minnow	*Pimephales notatus*
Common creek chub	*Semotilus atromaculatus*
Johnny darter	*Etheostoma nigrum*
White sucker	*Catostomus commersoni*
Faintail darter	*Etheostoma flabellare*
Blacknose dace	*Rhinichthys atratulus*
Northern redbelly dace	*Phoxinus eos*
Brook stickelback	*Culeau inconstans*

In general, benthic macroinvertebrate diversity was high. Species of the pollution intolerant families (Ephemeroptera and Trichoptera) were present (see Attachment 1). Amphipods were quite prevalent due to the high amount of coarse particulate organic matter (cpom) present. Other abundant groups were isopods and chironomids. Leeches, predaceous diving beetles, snails, and damselflies were common. General macroinvertebrate community structure was similar between the upstream reference location and the two downstream sampling locations.

Terrestrial Ecology

Vegetation

Onsite. Field habitat predominates at the waste containment portion of the site. Grass, with some scattered shrubs, and rows of planted red and white pines characterize the vegetation in this location. The pines are localized, mainly near the southern and eastern boundaries, and in the northwestern portion of the waste containment area. The groundlayer of vegetation is primarily grass. Shrubs are found mainly in the areas of pine trees. Plants observed on the waste containment area include prickly ash, buckthorn, early goldenrod, slender fragrant goldenrod, butter-and-eggs, common milkweed, ragweed, and daisy fleabane.

Wetland habitat associated with Deer Creek is present across the northern portion of the site. The wetland area at the site is a mixture of woody vegetation (T5/S3K), including trees and shrubs, and herbaceous vegetation (E1K). Woody vegetation is more common near the upland edges, with emergent (herbaceous) vegetation predominating north of the creek.

Plants observed include willow, speckled alder, reed canary grass, blue vervain, stinging nettle, and jewelweed. See Table 2 for additional species observed at the site.

TABLE 2
Plant Species Observed at the TMSL Site

Common Name	Scientific Name
Woody Vegetation	
Trembling aspen	*Populus tremuloides*
Black oak	*Quercus velutina*
Prickly ash	*Zanthoxylum americana*
Red oak	*Quercus borealus*
Bramble	*Rubus spp.*
Buckthorn	*Rhamnus catharticus*
White pine	*Pinus strobus*
Red pine	*Pinus resinosa*
Willow	*Salix spp.*
Box elder	*Acer negundo*
Eastern red cedar	*Juniperus virginiana*
Paper birch	*Betula papyrifera*
Speckled alder	*Alnus rugosa*
Herbaceous Vegetation	
Butter-and-eggs	*Linaria vulgaris*
Common milkweed	*Asclepias syriaca*
Sedge	*Carex spp.*
Ragweed	*Ambrosia artemisiifolia*
Daisy fleabane	*Erigeron annuus*
Early goldenrod	*Solidago juncea*
Slender fragrant goldenrod	*Solidago tenuifolia*
Grass	*Poa spp.*
Common mullen	*Verbascum thapsus*
Reed canary grass	*Phalaris arundinacea*
Blue vervain	*Verbena hastata*
Jewelweed	*Impatiens capensis*
Stinging nettle	*Laportea canadensis*

Offsite. Habitat surrounding the TMSL includes a small residential subdivision south of the site, with farm fields and wetlands to the north, east, and west. Agricultural land, including pasture and fallow field, are adjacent to the western boundary. An emergent and scrub/

shrub wetland is also west of the site along Deer Creek. The wetland associated with Deer Creek extends beyond the northern site boundary. Woody vegetation (T3/S3K) predominates in this location. County Highway E forms the eastern boundary of the site. The woody wetland vegetation associated with Deer Creek continues east of County Highway E. Upland field habitat is also present east of the landfill area.

Wildlife

Field habitat with areas of woody vegetation at the site would provide habitat for variety of small mammals and birds. Whitetail deer, crows, blue jays, mourning doves, and monarch butterflies were observed at the TMSL. The wetland and upland habitats adjacent to the site, which include wooded areas and fields, provide good habitat for a variety of animal species and adds diversity to the area as a whole.

Due to the transient nature of some animal species, such as large mammals and birds, their home ranges can be large, thus they may utilize both onsite and offsite habitats. Table 3 lists species that could potentially be found at the site.

TABLE 3
Animal Species Potentially Occurring at TMSL

Common Name	Scientific Name
Mammals	
Raccoon	*Procyon lotor*
Deer mouse	*Peromyscus maniculatus*
Meadow vole	*Microtus pennsylvanicus*
House mouse	*Mus musculus*
Masked shrew	*Sorex cinereus*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Woodchuck	*Marmota monax*
Cottontail rabbit	*Sylvilagus floridanus*
Whitetail deer *	*Odocoileus virginianus**
Beaver *	*Castor canadensis* *
Birds	
Black-capped chickadee*	*Parus atricapillus**
Cardinal	*Cardinalis cardinalis*
Robin	*Turdus migratorius*
House sparrow	*Passser domesticus*
Goldfinch	*Carduelis tristis*
Red-winged blackbird	*Agelaius phoeniceus*
American crow*	*Corvus ossifragus**
Mourning dove*	*Zenaida macroura**
Northern flicker*	*Colaptes auratus**

TABLE 3
Animal Species Potentially Occurring at TMSL

Common Name	Scientific Name
Mammals	
Blue jay *	*Cyanocitta cristata**
Other	
Monarch*	*Danus plexippus**

* Indicates that the animal observed during site survey

Threatened and Endangered Species

In a letter dated October 6, 1994, the Bureau of Endangered Resources at the Wisconsin Department of Natural Resources (WDNR) indicates that the Natural Heritage Inventory data files contain no occurrence records of endangered (E), threatened (T), or special concern species, natural communities, or State Natural Areas that would be affected by remedial actions at the landfill site. Since comprehensive resource surveys have not been conducted at the site, the DNR's data files may be incomplete and the lack of known occurrences does not preclude the possibility that endangered resources may be present (see Attachment 2).

The U.S. Fish and Wildlife Service (FWS) stated in their letter of January 23, 1995, that two federally listed species occur in Monroe County, namely the Karner blue butterfly (E) and northern monkshood (T). The FWS concluded that due to the nature and location of the proposed activities the species identified as occurring in the county would not be affected. The habitat of the Karner blue butterfly includes prairie, oak savanna, and jack pine areas and is always associated with wild blue lupine plants. The habitat of the threatened plant, northern monkshood, is mainly north-facing slopes (see Attachment 2).

Conclusions

Aquatic Ecology

The limited ecological survey of Deer Creek did not indicate any noticeable impairment that could be attributed to potential site contaminants.

Terrestrial Ecology

Vegetation at the TMSL consists mainly of a grassy field with areas of pine trees and shrubs. Adjacent woodlands, wetlands and fields add to the diversity of wildlife habitat in the area. Wildlife species found at the site would be typical of an urbanizing rural area or transients from adjacent habitats.

ATTACHMENT D-1
FIELD DATA SHEETS

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

DATE: 9-15-94
FIELD CREW: M. Mischuk
PROJECT #: GLE 65674. AR. EA.
PROJECT NAME: Tomah Landfill
STATION NAME/NUMBER: Reference, 65674. AR. EA-01

PHYSICAL CHARACTERIZATION

RIPARIAN ZONE/WATER

Predominant Surrounding Land Use:

Forest [✓ Field/Pasture] [✓ Agriculture] Residential Commercial Industrial Other

High Water Mark 0.5 (m) Velocity N/M Dam Present: Yes__ No X Channelized: Yes__ No X

depth on staff gauge was (14.25)

Sample Area : Ave. Depth 30 cm Width 180 cm Length 90 ft

Canopy Cover: [✓ Open] Partly Open Partly Shaded Shaded

channel small

SEDIMENT/SUBSTRATE:

Sediment Odors: Normal [✓ None] Sewage Petroleum Chemical Anaerobic Other____

Sediment Oils: [✓ Absent] Slight Moderate Profuse

Sediment Deposits: Sludge Sawdust Paper Fiber Sand Relict Shells [✓ Leaf Litter/Woody Debris] Other____

Are the undersides of stones which are not deeply embedded black? Yes___ No___ None Present

Inorganic Substrate Components			Organic Substrate Components		
Substrate Type	Diameter	Percent Composition in sampling area	Substrate Type	Characteristic	Percent Composition in Sampling Area
Bedrock			Detritus	Sticks, Wood, Coarse Plant Material (CPOM)	80%
Boulder	>256mm (10 in.)				
Cobble	64-256mm (2.5-10 in.)				
Gravel	2-64mm (0.1-2.5 in.)	2%	Muck-Mud	Black, Very Fine Organic (FPOM)	20%
Sand	0.06-2.00mm (gritty)	80%			
Silt	0.004-.06mm	18%	Marl	Grey, Shell Fragments	
Clay	<0.004mm (slick)				

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

DATE: 9-15-94
PROJECT #: GLE 65C74. AR. ER
STATION NAME/NUMBER: Reference, 65674-01

WATER QUALITY

Stream Type: [✓ Coldwater] Warmwater

Water Odors: Normal Sewage Petroleum Chemical [✓ None] Other ________

Water Surface Oils: Slick Sheen Globs Flecks [✓ None]

Turbidity: [✓ Clear] Slightly Turbid Turbid Opaque Water Color ________

WATER CHEMISTRY

None taken

Time ________

Dissolved Oxygen ________ MG/L

D.O. Temperature ________ (C)

Conductivity ________ µmhos/cm

Cond. Temperature ________ (C)

pH ________

pH Temperature ________ (C)

NOTES:

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

DATE: 9-16-94
FIELD CREW: M. Mischuk
PROJECT #: GLE 65674. AP.ER
PROJECT NAME: Tomah Landfill
STATION NAME/NUMBER: Middle / 65674-02

PHYSICAL CHARACTERIZATION

RIPARIAN ZONE/WATER MW 5B, MW 5A } wells adjacent to sample site (75 ft away to gauge from wells, sample and site description Downstr from gauge

Predominant Surrounding Land Use:

[✓ Forest] → Wetland (largely Alder, buckthorn, reed canary grass, jewelweed, nettle) Field/Pasture Agriculture Residential Commercial Industrial Other

High Water Mark 0.5 (m) Velocity N/M Dam Present: Yes__ No X Channelized: Yes__ No X

→ rain night before (Gauge reading – 9-15-94 = 7" 9-16-94 = 7⅞"

Sample Area : Ave. Depth 10cm Width 180cm Length 100ft

Canopy Cover: Open Partly Open [✓ Partly Shaded] → from Alder and tall grasses Shaded

SEDIMENT/SUBSTRATE:

Sediment Odors: Normal [✓ None] Sewage Petroleum Chemical Anaerobic Other________

Sediment Oils: [✓ Absent] Slight Moderate Profuse

Sediment Deposits: Sludge Sawdust Paper Fiber Sand Relict Shells [✓ Leaf Litter/Woody Debris] Other___

Are the undersides of stones which are not deeply embedded black? Yes__ No__

Inorganic Substrate Components			Organic Substrate Components		
Substrate Type	Diameter	Percent Composition in sampling area	Substrate Type	Characteristic	Percent Composition In Sampling Area
Bedrock			Detritus	Sticks, Wood, Coarse Plant Material (CPOM)	80%
Boulder	>256mm (10 In.)				
Cobble	64-256mm (2.5-10 in.)				
Gravel	2-64mm (0.1-2.5 in.)		Muck-Mud	Black, Very Fine Organic (FPOM)	20%
Sand	0.06-2.00mm (gritty)	80 %			
Silt	0.004-.06mm	20%	Marl	Grey, Shell Fragments	
Clay	<0.004mm (slick)				

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

DATE: 9-16-94
PROJECT #: GLE 65674.AR.ER
STATION NAME/NUMBER: Middle / 65674-02

WATER QUALITY

Stream Type: [✓ Coldwater] Warmwater

Water Odors: Normal Sewage Petroleum Chemical [✓ None] Other ______

* Water Surface Oils: Slick Sheen Globs Flecks [✓ None]

Turbidity: [✓ Clear] Slightly Turbid Turbid Opaque Water Color ______

WATER CHEMISTRY N/T

Time ______

Dissolved Oxygen ______ MG/L

D.O. Temperature ______ (C)

Conductivity ______ µmhos/cm

Cond. Temperature ______ (C)

pH ______

pH Temperature ______ (C)

______

______

______

______

NOTES:

* globs of sheen near wells in wet area but not in creek

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

DATE: 9-16-94
FIELD CREW: Mike Mischuk
PROJECT #: GLE 65674.AR.ER
PROJECT NAME: Tomah landfill
STATION NAME/NUMBER: Downstream station/65674-03

PHYSICAL CHARACTERIZATION

RIPARIAN ZONE/WATER

Predominant Surrounding Land Use: wetland (Alder, reed canary grass, Buckthorn, jewel weed, Nettle)

[✓ Forest] Field/Pasture Agriculture Residential Commercial Industrial Other

High Water Mark 0.5 (m) Velocity N/M Dam Present: Yes__ No X Channelized: Yes__ No X

Sample Area : Ave. Depth 10cm Width 180cm Length 100 ft

Canopy Cover: Open Partly Open [✓ Partly Shaded] by Alder + Reed Canary grass Shaded

SEDIMENT/SUBSTRATE:

Sediment Odors: Normal None Sewage Petroleum Chemical [✓ Anaerobic] Other____

Sediment Oils: [✓ Absent] Slight Moderate Profuse

Sediment Deposits: Sludge Sawdust Paper Fiber Sand Relict Shells [✓ Leaf Litter/Woody Debris] → pockets of Sediment Other____

Are the undersides of stones which are not deeply embedded black? Yes__ No ✓

Inorganic Substrate Components			Organic Substrate Components		
Substrate Type	Diameter	Percent Composition in sampling area	Substrate Type	Characteristic	Percent Composition in Sampling Area
Bedrock			Detritus	Sticks, Wood, Coarse Plant Material (CPOM)	40%
Boulder	>256mm (10 in.)				
Cobble	64-256mm (2.5-10 in.)		Muck-Mud	Black, Very Fine Organic (FPOM)	60%
Gravel	2-64mm (0.1-2.5 in.)				
Sand	0.06-2.00mm (gritty)	60%			
Silt	0.004-.06mm	40%	Marl	Grey, Shell Fragments	
Clay	<0.004mm (slick)				

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET

DATE: 9-16-94
PROJECT #: GLE 65674, AR. CL
STATION NAME/NUMBER: Downstream Location

WATER QUALITY

Stream Type: [✓ Coldwater] Warmwater

Water Odors: Normal Sewage Petroleum Chemical [✓ None] Other

Water Surface Oils: Slick Sheen Globs Flecks [✓ None]

Turbidity: [✓ Clear] Slightly Turbid Turbid Opaque Water Color

WATER CHEMISTRY N/T

Time

Dissolved Oxygen MG/L

D.O. Temperature (C)

Conductivity µmhos/cm

Cond. Temperature (C)

pH

pH Temperature (C)

NOTES:
Rainfall night before, water up about 1 inch.

RAPID BIOASSESSMENT PROTOCOL

Biosurvey Field Data Sheet

Project Name Tomah Landfill

Date 9-15-94

Time 1438

Project # GLE 65674.AR.ER

Location Reference, Deer Creek

Sample # 65674-01

Biologist/Asst. M. Mischuk

Relative Abundance of Aquatic Biota

Periphyton	[✓ 0]	1	2	3	4	Slimes	[✓ 0]	1	2	3	4
Filamentous Algae	[✓ 0]	1	2	3	4	Macroinvertebrates	0	1	2	3	[✓ 4]
Macrophytes	0	1	2	[✓ 3]	4	Fish	0	[✓ 1]	2	3	4

0 = Absent/Not Observed 1 = Rare 2 = Common 3 = Abundant 4 = Dominant

MACROBENTHOS QUALITATIVE SAMPLE LIST(Indicate Relative Abundance R = Rare, C = Common, A = Abundant, D = Dominant)

Porifera	R	**Anisoptera**	R	**Chironomidae**	C
Hydrozoa	R	**Zygoptera**	R	**Plecoptera**	R
Platyhelminthes	R	**Hemiptera** – Predaceous diving beetle	C	**Ephemeroptera**	A
Turbellaria	R	**Coleoptera**	R	**Trichoptera**	D
Hirudinea	C	**Lepidoptera**	R	**Other**	
Oligochaeta	R	**Sialidae**	R		
Isopoda	A	**Corydalidae**	R		
Amphipoda	A	**Tipulidae**	R		
Decopoda	R	**Empididae**	R		
Gastropoda one live specimen observed.	R	**Simuliidae**	R		
Bivalvia	R	**Tabanidae**	R		
		Culicidae	R		

Rare < 3 **Common 3 - 9** **Abundant > 10** **Dominant > 50 (Estimate)**

Observations

Macrophytes – Potamongeton,

Isopods and Amphipods very abundant due to large amount of veg. detritus.

Ephemeroptera – probably Ephemerellidae – very small } present on logs, sticks + veg.

Trichoptera – Dominate of sample – Hydropsychidae – }

RAPID BIOASSESSMENT PROTOCOL

Biosurvey Field Data Sheet

Project Name Tomah Landfill

Date 9-16-94

Time 0931

Project # GLE 65674, AP, ER

Location Approx. middle of delignation Area

Sample # 65674-02

Biologist/Asst. M. Mischuk

Relative Abundance of Aquatic Biota

Periphyton	[✓ 0]	1	2	3	4		Slimes	[✓ 0]	1	2	3	4
Filamentous Algae	[✓ 0]	1	2	3	4		Macroinvertebrates	0	1	2	3	[✓ 4]
* Macrophytes	0	1	2	[✓ 3]	4	**	Fish	0	1	[✓ 2]	3	4

0 = Absent/Not Observed 1 = Rare 2 = Common 3 = Abundant 4 = Dominant

MACROBENTHOS QUALITATIVE SAMPLE LIST(Indicate Relative Abundance R = Rare, C = Common, A = Abundant, D = Dominant)

Porifera	R	**Anisoptera**	R	**Chironomidae**	A
Hydrozoa	R	**Zygoptera**	R	**Plecoptera**	R
Platyhelminthes	R	**Hemiptera**	R	**Ephemeroptera**	C
Turbellaria	R	**Coleoptera**	R	**Trichoptera**	A
Hirudinea	C	**Lepidoptera**	R	**Other**	
Oligochaeta	R	**Sialidae**	R		
Isopoda	C	**Corydalidae**	R		
Amphipoda	D	**Tipulidae**	R		
Decopoda	R	**Empididae** one noted	R		
Gastropoda	R	**Simuliidae**	R		
Bivalvia	R	**Tabanidae**	R		
		Culicidae	R		

Rare < 3 **Common 3 - 9** **Abundant > 10** **Dominant > 50 (Estimate)**

Observations

* - Mostly wild celery and sumac

** - Possibly bluntnose minnow

Scuds dominante due to large amounts of CPOM, principally leafy detritus.

Tricoptera mostly Hydropsychidae

RAPID BIOASSESSMENT PROTOCOL

Biosurvey Field Data Sheet

Project Name Tomah landfill

Date 9-16-94
Time 1152
Project # GLE 65674.AR.ER

Location Deer Creek just upstream of culvert under 24th Str
Sample # 65674.AR.ER
Biologist/Asst. M. Mischuk

Relative Abundance of Aquatic Biota

Periphyton	[✓ 0]	1	2	3	4	Slimes	[✓ 0]	1	2	3	4
Filamentous Algae	[✓ 0]	1	2	3	4	Macroinvertebrates	0	1	2	[✓ 3]	4
Macrophytes	0	1	2	[✓ 3]	4	Fish	[✓ 0]	1	2	3	4

→ wild Celery (Vallisneria)
water weed (Elodea)

0 = Absent/Not Observed   1 = Rare   2 = Common   3 = Abundant   4 = Dominant

MACROBENTHOS QUALITATIVE SAMPLE LIST (Indicate Relative Abundance R = Rare, C = Common, A = Abundant, D = Dominant)

Porifera	R	**Anisoptera**	R	**Chironomidae**	C
Hydrozoa	R	**Zygoptera**	C	**Plecoptera**	R
Platyhelminthes	R	**Hemiptera**	R	**Ephemeroptera**	A
Turbellaria	R	**Coleoptera**	R	**Trichoptera**	C
Hirudinea	C	**Lepidoptera**	R	**Other**	
Oligochaeta	R	**Sialidae**	R		
Isopoda	C	**Corydalidae**	R		
Amphipoda	D	**Tipulidae**	R		
Decopoda	R	**Empididae**	R		
Gastropoda	C	**Simuliidae** one noted	R		
Bivalvia	R	**Tabanidae**	R		
		Culicidae	R		

Rare < 3   **Common 3 - 9**   **Abundant > 10**   **Dominant > 50 (Estimate)**

Observations: Greater Amount of silt noted probably due to constriction At culvert
Several species of leeches were noted, sow bugs and especially scuds quite prevalent. Gastropoda represented by Ferrissia sp., Damselflies present (Calopterygidae). One simuliidae noted. Ephemeroptera also noted, principally Ephemerellidae and Heptageniidae. Trichoptera were principally Hydropsychidae

ATTACHMENT D-2

THREATENED AND ENDANGERED SPECIES DOCUMENTATION

WISCONSIN
DEPT. OF NATURAL RESOURCES

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

State Office Building, Room 104
3550 Mormon Coulee Road
La Crosse, Wisconsin 54601
TELEPHONE 608-785-9000
TELEFAX 608-785-9990

George E. Meyer
Secretary

September 7, 1994

Ms. Linda Hoehne
CH2M Hill
P. O. Box 2090
Milwaukee, Wisconsin 53201-2090

File Ref: 1600

Dear Ms. Hoehne:

The Department has designated Deer Creek as Class II trout water, supporting primarily brook trout.

Enclosed is a limnology report for Deer Creek in T18N, R1W, Section 33. Please note the date of the report is November 22 ,1968. No recent data is available.

I was not able to locate anything else that I thought would be pertinent to your effort. Feel free to call me at 608/785-9014 should you have any questions.

Sincerely,

Craig D. Thompson

Craig D. Thompson
Assistant Environmental Impact Coordinator

CDT:ak

WISCONSIN
DEPT. OF NATURAL RESOURCES

George E. Meyer
Secretary

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

101 South Webster Street
Box 7921
Madison, Wisconsin 53707
TELEPHONE 608-266-2621
TELEFAX 608-267-3579
TDD 608-267-6897

RECE

OCT 17 1994

October 6, 1994

IN REPLY REFER TO: 1650

Ms. Linda Hoehne
CH2M Hill
P.O. Box 2090
Milwaukee, WI 53201-2090

SUBJECT: Endangered Resources Information Review (Log Number 94-273)

Dear Ms. Hoehne:

The Bureau of Endangered Resources has reviewed the project area described in your letter of August 26, 1994 for the preparation of an ecological assessment for the Tomah Municipal Landfill as part of the Remedial Investigation for the site.

Our Natural Heritage Inventory (NHI) data files contain no occurrence records of Endangered, Threatened, or Special Concern species or natural communities, nor of any State Natural Areas that I believe would be impacted by any remedial actions at the landfill site. The landfill is located in T18N R1W Section 32, Monroe County.

Comprehensive endangered resource surveys have not been completed for the project area. As a result, our data files may be incomplete. The lack of known occurrences does not preclude the possibility that endangered resources may be present.

This letter is for informational purposes and only addresses endangered resource issues. This letter does not constitute Department of Natural Resources authorization of the proposed project and does not exempt the project from securing necessary permits and approvals from the Department.

Please contact John Pohlman at (608) 264-6263 if you have any questions about this information.

Sincerely,

Charles M. Pils

Charles M. Pils
Director, Bureau of Endangered Resources

cc: Bob Roden - EA/6
Tom Lovejoy/Wendy Anderson - WD

jdp:CMP/[er:r.sw]swrmtmhl.10

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Green Bay ES Field Office
1015 Challenger Court
Green Bay, Wisconsin 54311-8331

January 23, 1995

Ms. Linda Hoehne
CH2M Hill
411 E. Wisconsin Avenue
Suite 1600
Milwaukee, Wisconsin 53202-4421

re: Tomah Municipal Sanitary Landfill
Endangered Species Comment
Monroe County, Wisconsin

Dear Ms. Hoehne:

Your letter of December 29, 1995, requested a U.S. Fish and Wildlife Service review of the subject projects. We offer the following comments for your consideration.

Federally-Listed Threatened and Endangered Species

A review of information in our files indicates the following federally-listed threatened or endangered species occur in Monroe County:

Classification	Common Name	Scientific Name	Habitat
endangered	Karner blue butterfly	*Lycaeides melissa samuelis*	prairie, oak savanna, and jack pine areas w/wild lupine
threatened	northern monkshood	*Aconitum noveboracense*	north-facing slopes

Due to the nature and location of the proposed activities, we conclude that the above listed species will not be affected. This precludes the need for further action on this project as required by the 1973 Endangered Species Act, as amended. Should the project be modified or new information become available that indicates listed or proposed species may be affected, consultation should be initiated.

We appreciate the opportunity to respond. Questions pertaining to these comments can be directed to Joel Trick by calling 414-433-3803.

Sincerely,

Janet M. Smith

Janet M. Smith
Field Supervisor