CDM Camp Dresser & McKee

Report

Minnesota Pollution Control Agency

Human Health and Ecological Risk Assessments for the Freeway Landfill - Burnsville, Minnesota

October 1993

CDM

environmental engineers, scientists, planners, & management consultants

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October 7, 1993

Mr. Don Abrams, Project Manager
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Minnesota Pollution Control Agency
520 Lafayette Road
St. Paul, MN 55155

RE: Final Human Health and Ecological Risk Assessments for the Freeway Landfill - Burnsville, Minnesota

Dear Mr. Abrams:

Camp Dresser & McKee (CDM) is pleased to submit five (5) copies of the Human Health and Ecological Risk Assessments for the Freeway Landfill. This document incorporates all of the comments prepared by the Minnesota Pollution Control Agency (MPCA) on the draft report. Per your comments, CDM exercised the option to fully document the semi-quantitative Ecological Risk Assessment approach rather than eliminating sections of the report to reflect a qualitative approach. The substantive revisions to the draft document reflected in this final document can be summarized as follows:

1. Additional detail was added to substantiate the semi-quantitative approach used in the Ecological Risk Assessment. All relevant calculations, footnotes, and references have been provided; and

2. Three additional figures were added which illustrate (1) Local Wildlife Refuges and Management Areas; (2) Local Wetlands; and (3) Habitat Areas for Threatened and Endangered Species.

CDM is confident that you will find the enclosed document to be complete. We look forward to working with you again in the future.

Sincerely yours,

CAMP DRESSER & McKEE

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Executive Summary

The objective of this risk assessment is to evaluate potential human health and ecological risks that may result from exposures to chemicals at—or originating from—the Freeway Landfill in Burnsville, Minnesota. Risks to human health were evaluated for two receptors: (1) Freeway Landfill workers; and (2) residents living near the Freeway Landfill. The overall approach to the risk assessment follows guidance provided by the EPA in *Risk Assessment Guidance for Superfund—Human Health Evaluation Manual (Part A) Volume 1. Interim Final* (EPA, 1989), and the Minnesota Pollution Control Agency (MPCA). Risks for ecological receptors were evaluated using an approach consistent with that presented in the EPA Risk Assessment Guidance for Superfund—*Environmental Evaluation Manual Volume II. Interim Final* (EPA, 1989). The ecological risk assessment considered risks to ecological receptors via direct exposure to leachate and surface water. Risks to ecological receptors via exposure to landfill gas was eliminated as an exposure pathway in the scope of work.

Human Health Risk Assessment

The scope of the human health risk assessment (HHRA) includes a quantitative evaluation of non-carcinogenic and carcinogenic health risks associated with chronic exposures for landfill workers and nearby residents; and a semi-quantitative evaluation of the health risks associated with acute exposure of scale-house workers to landfill gas chemicals. Health risk estimates are based on modeled chemical concentrations in air which were derived from landfill gas data provided by MPCA.

Landfill gas data were compiled by the MPCA for landfill gas control systems at five landfills in Minnesota. In addition, landfill gas data compiled by EPA were employed for those compounds found at the Minnesota landfills in trace quantities below the detection limit, and for which no other MPCA data were available. These data were used to evaluate chronic exposures for workers and the public. Methane concentrations were obtained from scale-house indoor air at the Freeway Landfill and served as the data source for evaluation of acute exposures to scale-house workers.

As recommended by the EPA, potential human exposures were evaluated based upon a reasonable maximum exposure (RME) approach. By using this approach, conservative exposure estimates (i.e., well above the average case) are obtained. The RME exposure point concentrations were based upon air dispersion modeling estimates using site-specific meteorologic conditions. Nine receptor locations were selected as representative of existing residences and/or schools in all directions around the Freeway Landfill.

Exposure assumptions were based on EPA exposure guidance documents and best professional judgement. Potential human health risks were estimated by using modified risk estimate equations and toxicity values developed by the EPA.

Table E-1 summarizes risks for the inhalation route of exposure associated with exposures to chemicals at the Freeway Landfill. Non-carcinogenic risks to landfill workers were estimated at 1.1×10^{-2} (or 0.011), a value well below the EPA target non-carcinogenic risk limit (hazard

Table E-1 **Summary of Risks to Human Health**
Freeway Landfill Risk Assessment - Burnsville, MN

	Excess Lifetime Cancer Risk	Exceeds Risk Range (1)	Hazard Index	Exceeds Risk Limit (2)
1) ON-SITE LANDFILL WORKERS				
Inhalation	1.4E-06	NO	1.1E-02	NO
2) NEARBY RESIDENTS				
Inhalation	5.0E-07	NO	1.1E-03	NO

Notes:
(1) Cancer Risk Range: 1.0E-06 to 1.0E-04
(2) Non-Cancer Risk Limit: 1.0 Hazard Index

index) of 1.0. Carcinogenic risks were estimated at 1.4×10^{-6}, a value within the EPA target risk range of 1×10^{-6} to 1×10^{-4}. Action generally is not warranted for sites where the cumulative site risk to an individual based on reasonable maximum exposure is less than 10^{-4}. Action may be warranted if a chemical-specific standard defining acceptable risk is violated or there are non-carcinogenic effects or an adverse environmental impact.

Non-carcinogenic risks to nearby residents were estimated at 1.1×10^{-3} (or 0.0011), a value well below a hazard index of 1.0. Carcinogenic risks were estimated at 5×10^{-7}, a value lower than the EPA target risk of 1×10^{-6} to 1×10^{-4}, and therefore, not of concern. Indoor air concentrations at the Freeway Landfill scale-house do not exceed occupational exposure limits for the chemicals of concern. A degree of uncertainty arises in the general practice of risk assessment and the estimation of risks. The main contributors to uncertainty are identified and discussed in Section 7.0.

The risk estimates derived in this HHRA are based on quantitative assumptions specific to the Freeway Landfill site, landfill workers and nearby residents. Estimated risks would no longer be valid for the populations assessed should conditions change at the Freeway Landfill.

Ecological Risk Assessment

The ecological risk assessment (ERA) qualitatively evaluated risks to ecological receptors associated with exposure to landfill contaminants. Specifically, the scope of work called for evaluation of risks associated with direct contact (dermal) or ingestion of leachate by wildlife. In addition, the ERA evaluated risks to aquatic biota associated with exposures to landfill-related contaminants transported to surface water by either groundwater or leachates.

Risks were estimated qualitatively in this ERA by use of the toxicity quotient (TQ) method. The TQ method takes the estimated exposure concentration and divides it by a toxicity reference value (TRV). If the TQ is greater than one, potential risk exists; if the TQ is less than one, a risk is considered unlikely.

Potential risks to aquatic species exist from exposure to certain COCs in groundwater and surface water. Table E-2 summarizes these potential risks. However, the potential risks associated with release of groundwater to surface water are based on a worst case assumption that the entire concentration detected in groundwater is discharged to surface water. Concentrations in surface water are generally lower than those found in groundwater. In addition, surface water exposure concentrations are based on an upper confidence concentration estimated using t-statistics. However, there were only two samples taken at SW-3 and six samples taken at SW-6, thus the use of an upper confidence level based on t-statistics would overestimate the exposure concentration and thereby overestimate risk.

Table E-2 **Summary of Potential Risks to Ecological Receptors**
Freeway Landfill Risk Assessment - Burnsville, MN

Groundwater

Compound	Toxicity Quotient	Notes
Aluminum	1.36	Based on chronic exposure.
Iron	4.37	Based on chronic exposure.
Silver	3.26	Based on acute exposure. The Toxicity Reference Value is a proposed Ambient Water Quality Criterion.
	25.00	Based on chronic exposure.
Thallium	3.83	Based on chronic exposure.
Zinc	2.17	Based on chronic exposure.

Surface Water (SW - 6)

Compound	Toxicity Quotient	Notes
Aluminum	2.18	Based on chronic exposure.
Copper	1.38	Based on chronic exposure.
Iron	1.07	Based on chronic exposure.
Lead	0.16 - 2.3	Based on chronic exposure. TQ only exceeds one at certain water hardnesses.
Selenium	1.60	Based on chronic exposure.
Silver	0.16 - 2.3	Based on acute exposure. TQ is greater than one only at certain water hardnesses.
	7.83	Based on acute exposure. Toxicity Reference Value is a proposed Ambient Water Quality Criterion.
	60.00	Based on chronic exposure.

Table E-2 (continued)

Summary of Potential Risks to Ecological Receptors
Freeway Landfill Risk Assessment - Burnsville, MN

Surface Water (SW - 3)

Compound	Toxicity Quotient	Notes
Aluminum	1.22	Based on acute exposure.
	10.47	Based on chronic exposure.
Iron	68.7	Based on chronic exposure.
Lead	0.35 - 2.5	Based on chronic exposure. TQ exceeds one only at certain water hardnesses.
Zinc	2.97	Based on chronic exposure.

Section 1
Introduction to Human Health and Ecological Risk Assessment

This Human Health and Ecological Risk Assessment, prepared by Camp Dresser & McKee Inc. (CDM), evaluates potential risks to workers, nearby residents and ecological receptors at the Freeway Landfill site in Burnsville, Minnesota. This Risk Assessment was prepared for the Minnesota Pollution Control Agency (MPCA) under the amended Multi-Site II Contract.

The objective of the focused human health risk assessment is to evaluate the potential on-site and off-site air impacts to human health under baseline conditions, namely, in the absence of remediation. In the human health risk assessment (HHRA) non-carcinogenic and carcinogenic risks are estimated for the on-site landfill workers and nearby residents with the potential for chronic exposure to landfill gas chemicals at or originating from Freeway Landfill. In addition, indoor air concentrations to which scale-house workers are exposed were compared to available occupational standards and guidelines of non-methane organic compounds (NMOC).

The objective of the ecological risk assessment (ERA) is to qualitatively evaluate the potential ecological risks associated with direct contact and/or ingestion of leachate seeps by selected species under current conditions. In addition, risks associated with direct contact and/or ingestion of chemicals in surface water were also evaluated qualitatively.

The procedures in this risk assessment conform to those presented in Deliverable No. 2—Protocol Document and Exposure Point Concentrations (CDM, 1993). This Deliverable No. 3 has been prepared in consideration of the Risk Assessment Contract Management Technical Support Document (RACM TSD) prepared by MPCA.

1.1 Scope

The HHRA evaluates the potential human health risks that chemicals in landfill gas may have on human populations working at and/or living near the Freeway Landfill site. The scope is outlined in the Technical Assistance Work Plan (CDM, October 14, 1992).

Because groundwater downgradient of the site is not used as a potable water source, and surface waters (e.g. on-site ponds and off-site ponds and rivers), while used for fishing and boating, are not classified for protection to the standard of full body contact, pathways associated with exposures to chemicals in these media were not evaluated in this HHRA.

Direct contact and subsequent exposures to leachate and surface soil contaminants is also believed to be limited at this time for HHRA purposes. While leachate seeps exist at the Freeway Landfill, exposure to contaminants in these seeps would be of limited duration and are likely to contribute negligibly to overall risks to workers in proximity to the site. Hence, this exposure pathway is not believed to be significant, and was not evaluated in the HHRA.

While current exposures to contaminated soils are possible, and future exposure to landfill materials during a future construction scenario may be possible, the potential for these exposures cannot be addressed at this time given the absence of site-specific soil data. This pathway was not evaluated in the HHRA.

The ERA evaluates exposures associated with direct contact or ingestion of leachate seeps and surface water. Exposure to groundwater chemicals of concern (COCs) was also considered in light of the potential of these COCs to discharge to surface waters. Risks associated with exposure to landfill gas were not evaluated in the ERA for reasons discussed in the Technical Assistance Work Plan and in Section 8.2.

1.2 Approach

This document follows an approach agreed upon by CDM and the MPCA after a series of negotiations and modifications to the Final Technical Assistance Work Plan. The overall approach to the ERA and HHRA will follow guidance provided by the MPCA. MPCA's approach takes into consideration guidance provided by the U.S. EPA in *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual Volume II - Environmental Evaluation Manual (Part A))* (EPA, 1989). The human health evaluation document provides guidance on evaluating data and identifying chemicals selected for quantitative analysis, developing exposure scenarios depicting expected exposure conditions, assessing chemical toxicity and combining this information to estimate non-carcinogenic and carcinogenic risks. The environmental evaluation document provides guidance on evaluating data, identifying chemicals of concern, describing the site and study area, and characterizing exposure and risk.

COCs for the Freeway Landfill site were selected from data provided by MPCA. For HHRA purposes, two datasets—Dataset Nos. 1 and 2—were prepared and are the basis of this risk evaluation. Dataset No. 1 consists of all COCs which will be quantitatively evaluated in the chronic exposure scenarios involving on-site landfill workers and off-site nearby residents. Dataset No. 2 consists of all COCs which will be semi-quantitatively evaluated in the acute exposure scenario involving scale-house workers. Dataset No. 1 will be assessed by estimating risks associated with exposure to these COCs. Dataset No. 2 will be assessed by comparing exposure point concentrations (EPCs) for each scale-house COCs to available occupational exposure limits developed by the Occupational Safety and Health Agency (OSHA), the National Institute of Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists (ACGIH).

COCs for the Freeway Landfill ERA were selected for groundwater, surface water, and leachate. The data for selection of COCs was provided by MPCA. Exposure to groundwater and surface water was considered for aquatic organisms while exposure and ingestion of leachate were considered for terrestrial organisms.

The degree of conservatism that is appropriate when assessing human health risks is a topic that has been widely discussed. For this risk assessment, CDM will adhere to EPA guidance by selecting intake variables that, in combination, reflect the Reasonable Maximum Exposure (RME), i.e., the maximum exposure that may reasonably be expected to occur at the site. These

selections will be based on EPA guidance, site-specific considerations, quantitative air emissions modeling results, and professional judgement.

The Freeway Landfill Human Health and Ecological Risk Assessment has been organized in the following format, consistent with EPA guidance:

- Section 2.0 - Data Evaluation for HHRA and ERA - evaluates and reviews available site data
- Section 3.0 - Selection of Chemicals of Concern for HHRA - chemicals of concern at the site are identified and the two databases used to evaluate exposures are presented.
- Section 4.0 - Exposure Assessment for HHRA - the potentially exposed populations are identified, exposure assumptions are presented and exposure point concentrations are developed.
- Section 5.0 - Toxicity Assessment for HHRA - qualitative and quantitative toxicological information is presented for all chemicals of concern.
- Section 6.0 - Risk Characterization for HHRA - risk estimates are presented for workers and nearby residents.
- Section 7.0 - Uncertainty Assessment for HHRA - sources of uncertainty and potential for over- and underestimation of risk is evaluated.
- Section 8.0 - Ecological Risk Assessment - qualitatively evaluates risks to ecological receptors.
  - Section 8.1 - Ecological Receptors - describes ecological setting and selects species of concern.
  - Section 8.2 - Selection of COCs - presents criteria for selection of COCs and the chemicals selected as COCs in groundwater, surface water, and leachate.
  - Section 8.3 - Exposure Scenarios and Pathways to be Evaluated - describes the exposure pathways evaluated and calculates exposure point concentrations.
  - Section 8.4 - Toxicity Reference Values - presents the toxicity reference values for aquatic organisms and terrestrial wildlife.
  - Section 8.5 - Risk Characterization - estimates risk using the Toxicity Quotient Method and discusses uncertainties associated with the risk estimates.

1.3 Interim Deliverables

In accordance with the Contract Management Protocol and as stated in the Freeway Technical Assistance Work Plan (CDM, October 14, 1992), a total of six deliverables were to be submitted to the MPCA by CDM. The deliverables identified in the Work Plan—to be submitted under separate covers to facilitate MPCA review—include:

(1) Data Summary and Selection of Chemicals of Concern
(2) Protocol Document
(3) Exposure Point Concentrations
(4) Draft Risk Assessment Report
(5) Response to MPCA Comment Memorandum
(6) Final Risk Assessment Report

Given the need to expedite the deliverable comment and review process, it was agreed that Deliverable Nos. 2 and 3 would be combined. This modified approach was a result of extensive conversations between CDM and MPCA personnel.

Figure 1.1-1 presents the interim deliverables which have been submitted to MPCA by CDM to date. The following sections briefly describe the scope of these Interim Deliverables.

1.3.1 Data Summary and Selection of Chemicals of Concern

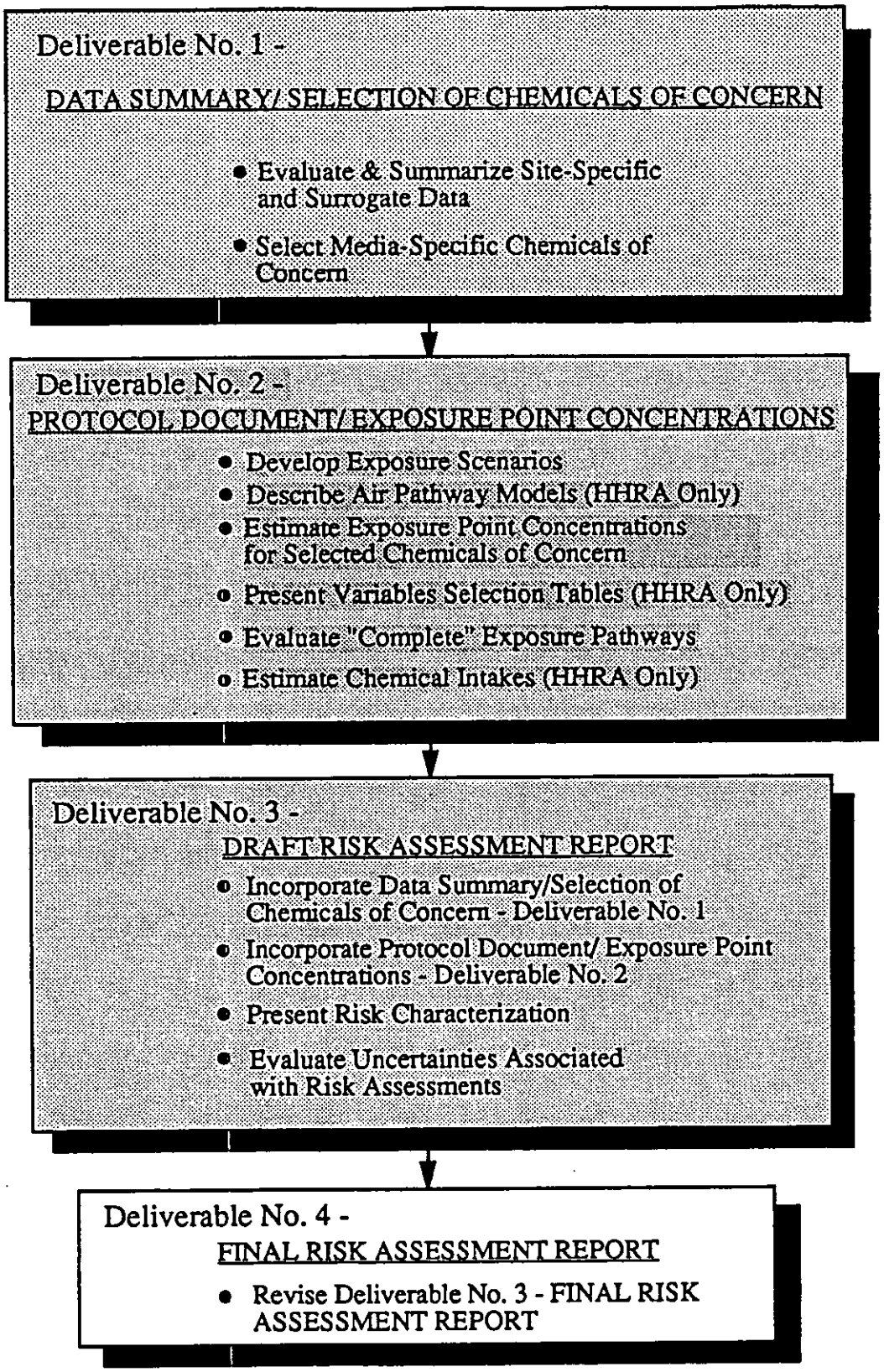
Task 1 - Data Summary and Selection of Chemicals of Concern deliverable was initially submitted on December 22, 1992 to the MPCA. For this deliverable, a summary and evaluation of the analytical data provided to assess risks associated with exposure to chemicals at or originating from the Freeway Landfill was presented. In addition, COCs were selected for both the HHRA and ERA, using an approach described in this deliverable and consistent with the Work Plan. This deliverable was later revised on February 28, 1993, in response to MPCA comments. MPCA comments and revisions performed by CDM have been incorporated as currently presented in Section 2.0 of this deliverable.

1.3.2 Protocol Document and Exposure Point Concentrations (EPCs)

Task 2 - Protocol Document and Exposure Point Concentrations deliverable was submitted to MPCA in March 1993. This document was prepared to provide MPCA's technical review panel an overview of the approaches and assumptions that CDM used in assessing the potential human health and ecological risks associated with contaminants originating from the Freeway Landfill site. The need for a protocol document arose in part because, although a number of assumptions and approaches used to estimate risks to human health have become standardized by the U.S. Environmental Protection Agency (EPA) many other assumptions are site-specific or based on disciplines that are evolving. While committed to utilizing the most current and applicable approaches, CDM also recognizes the importance of evaluating and presenting risks in a manner consistent with MPCA-preferred approaches.

In addition, EPA guidance on preparing ERAs has not advanced as far as EPA guidance for HHRAs. While there are several basic components which comprise most ERAs, a standard

Figure 1.1 - 1. Human Health and Ecological Risk Assessment Deliverables Freeway Landfill Risk Assessment- Burnsville, MN



Notes: **The shaded deliverables have been completed.**

Applies to both human health and ecological risk assessment unless otherwise noted.

design does not exist and the scope of ERAs are often driven by site-specific factors. These issues are fully discussed in Deliverable No. 2. In addition, exposure point concentrations (EPCs) for both the HHRA and ERA were derived in this deliverable and the approach to their derivation was extensively discussed.

Section 2
Introduction to Data Evaluation

This section provides a summary and evaluation of the analytical data provided by the Minnesota Pollution Control Agency (MPCA) to assess risks associated with exposure to chemicals at, or originating from, the Freeway Landfill site. Data, originally presented in the 1988 Remedial Investigation (RI) (Conestoga-Rovers Associates, 1988) report and collected through December 1992 (MVTL Laboratories, Inc., December 16, 1992 Work Order Number 31-0011), are summarized and chemicals of concern (COCs) are selected for every media for which an exposure pathway exists. Physical and chemical properties for chemicals of concern to be evaluated in the chronic exposure scenarios of the human health risk assessment are identified and discussed in this section.

Analytical data employed in the HHRA and ERA include groundwater, surface water, and leachate data which were provided by the MPCA. As outlined in the Scope of Work, MPCA provided CDM with validated data for use in the risk assessments. Most groundwater, surface water, and leachate samples were validated, except for the Spring 1992 sampling program samples (MVTL Laboratories, Inc., March 23, 1992, Work Order Number 31-0042). Parameters of critical importance in assuring quality and useability for risk assessment purposes include holding times, laboratory/reagent blank analyses, matrix spike/matrix spike duplicate analyses, field quality assurance/quality control data including trip and field blanks and detection limits.

Landfill gas data were compiled by MPCA for five local landfills. This data has not been validated, but is considered reliable and representative of landfill gas emissions at the Freeway Landfill.

2.1 Summary of Available Data

Sampling programs are typically designed to achieve a number of goals such as the identification of hot spots and the extent of contamination. The sampling programs performed at the Freeway Landfill site were primarily developed to provide an overall characterization of site conditions relevant to the potential for on-site and off-site contaminant transport.

A characterization of the Freeway Landfill site has been performed by two consultants—Conestoga-Rovers Associates 1988 Remedial Investigation (RI) report and B.A. Liesch and Associates 1991 Supplemental Remedial Investigation (SRI) report.

Both the RI and SRI reports present and discuss site data for a variety of media, including groundwater, surface water and leachate. MPCA provided surrogate landfill gas data from five Minnesota landfills, as well as methane air monitoring data from the scale-house at the BFI weight station located on the landfill site. Local background air, ground water, and surface water data were not evaluated for risk assessment purposes. Site-specific soils data were not available to estimate the magnitude of risk associated with exposure to chemicals in this medium. Although Minnesota soil background data were provided to CDM, the lack of site-specific soils data precluded the use of these data (for comparison purposes) at this point.

Should site-specific soils data be collected in the future, this background data should be used to estimate risks from exposure to chemicals in site-specific soils.

Figure 2.1-1 presents the location of the Freeway Landfill site on a U.S.G.S. Topographic Quadrangle. Figure 2.1-2 illustrates the site and sampling locations evaluated in the SRI report.

2.1.1 Groundwater Data

The Freeway Landfill site is underlain by the following aquifers, presented in descending order: (1) Prairie du Chien Group (dolomite, sandstone); (2) Jordan (sandstone); (3) Ironton-Galesville (sandstone); and (4) Mt. Simon-Hinkley (sandstone). The Prairie du Chien-Jordan aquifer system is the most significant aquifer in terms of usage in the area.

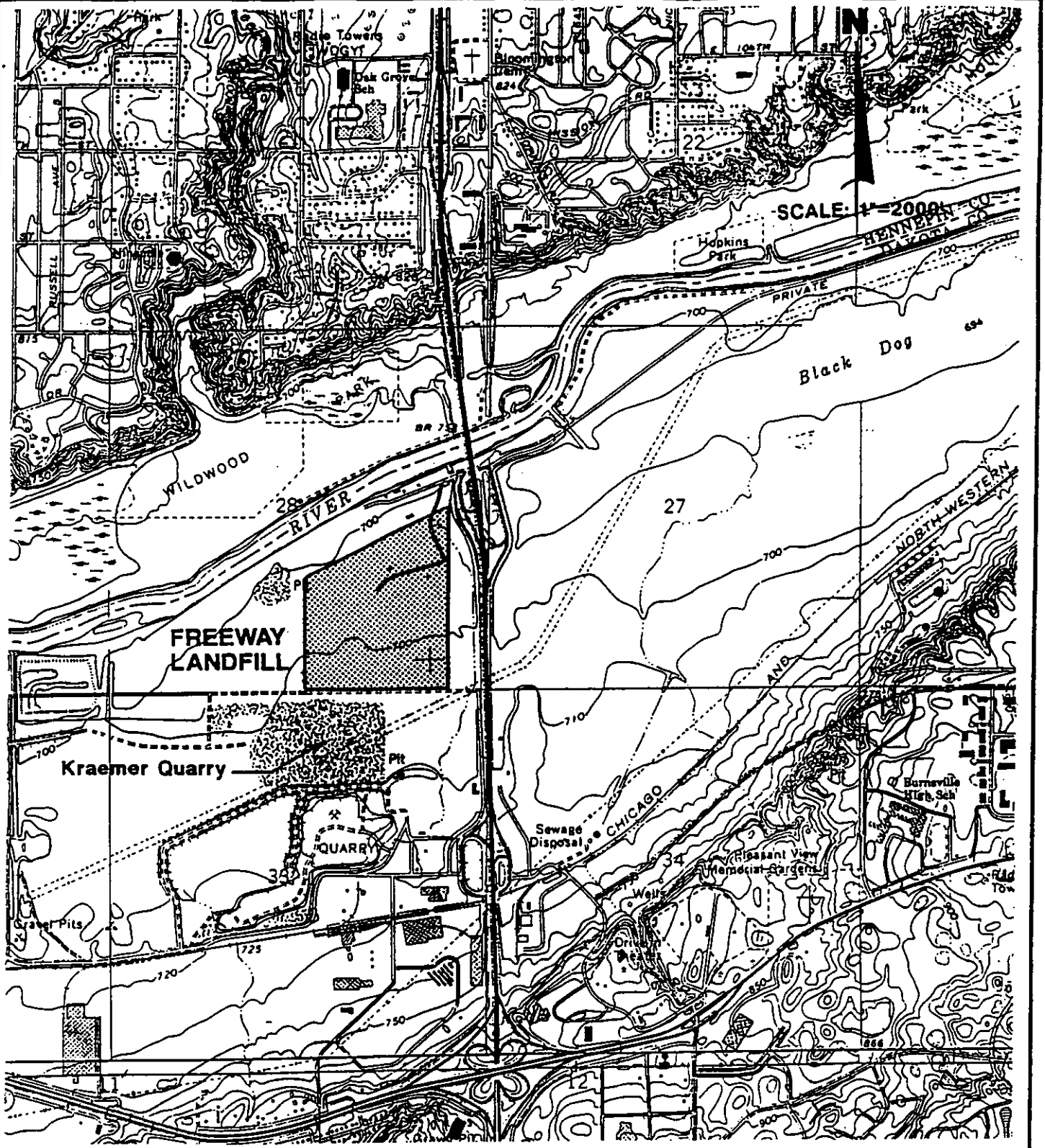
Regional groundwater flow would be expected to be toward the Minnesota River, which is a groundwater discharge zone. However, the 1991 SRI report presented groundwater elevation data collected between May 29, 1990 and February 22, 1991 showing local divergence from the regional flow patterns. Specifically, the flow patterns in the Prairie du Chien-Jordan are influenced by dewatering operations at the Kramer quarry, adjacent to the southern boundary of the Freeway Landfill. Groundwater withdrawals at the quarry produce a cone of depression which causes local flow to move toward the quarry sump and away from the river. If dewatering activities cease at the quarry, flow would resume along more natural lines and move toward the river.

For site characterization purposes, groundwater quality data have been collected from 1970 to 1992 from wells within and adjacent to the Freeway Landfill site. Groundwater samples were analyzed for the following parameters: (1) volatile organic compounds (VOCs) (Method 624); (2) priority pollutant metals (Method 200 series); and (3) additional metals including aluminum, iron, calcium, magnesium potassium and sodium. The lists of metals varied according to whether the samples were analyzed by Pace Laboratories, Inc. or MVTL Laboratories, Inc. The Pace list included beryllium, thallium and cyanide, while the MVTL list included aluminum, iron and the four minerals.

Table 2.1-1 presents a summary of the chemicals detected in groundwater along with their respective frequency of detection, detected concentration/range of detected concentrations and minimum detection limits/range of detection limits.

The standard minimum detection limits for metals are not available in MVTL laboratory reports dated March 6, 1991 and January 21, 1991 from the SRI report. This missing information led to statistics that appear contradictory on groundwater Table 2.1-1. Groundwater Table 2.1-1 presents detected concentrations of manganese and selenium from the MVTL report that were below the standard detection limits cited on this table from the Pace and MVTL reports from 1987, 1988 and 1992.

The nine most frequently detected inorganics in groundwater include: aluminum (10/29), barium (21/29), cadmium (25/43), calcium (29/29), iron (29/29), magnesium (29/29), manganese (26/29), potassium (29/29) and sodium (29/29). Ethyl ether (20/49), cis-1,2-dichloroethylene



USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAP

Source: B.A. Liesch Associates, Inc.

MINNESOTA POLLUTION CONTROL AGENCY

CDM
environmental engineers, scientists planners, & management consultants

FIGURE 2.1-1
SITE LOCATION PLAN

Table 2.1-1. **Frequency of Detection, Range of Detected Concentrations and Detection Limits for Chemicals Detected in Groundwater Freeway Landfill Risk Assessment - Burnsville, MN**

Chemical	Frequency of Detection	Range of Detected Concentrations, µg/l	Range of Detection Limits, µg/l	Laboratory Data Source (1)
Inorganics				
Aluminum	10/29	12 - 290	3.0 - 250	C, D, E
Arsenic	10/43	1.0 - 28	1.0 - 2.0	A, B, C, D, E
Barium	21/29	19 - 761	2.0 - 100	C, D, E
Beryllium	4/14	0.4 - 1.6	0.2	A, B
Cadmium	25/43	0.1 - 6.1	0.1	A, B, C, D, E
Calcium	29/29	3,100 - 406,000	100	C, D, E
Chromium	7/43	1.0 - 9.0	1.0	A, B, C, D, E
Copper	13/33	1.1 - 50	1.0 - 4.0	A, B, D, E
Iron	29/29	3.8 - 33,400	1.0 - 50	C, D, E
Lead	8/43	1.0 - 14	1.0	A, B, C, D, E
Magnesium	29/29	1,000 - 188,000	50	C, D, E
Manganese	26/29	30 - 3,200	50	C, D, E
Mercury	1/43	0.39	0.2	A, B, C, D, E
Nickel	17/43	1.3 - 100	1.0 - 40	A, B, C, D, E
Potassium	29/29	1,600 - 16,700	100	C, D, E
Selenium	5/43	1.5 - 19	2.0 - 3.0	A, B, C, D, E
Silver	4/43	0.2 - 0.6	0.2 - 10	A, B, C, D, E
Sodium	29/29	3,900 - 208,000	50	C, D, E
Thallium	1/14	43	3.0 - 400	A, B
Zinc	21/43	10 - 740	10 - 20	A, B, C, D, E
Volatiles				
Acetone	1/39	21	10 - 40	A, B, C, D, E, F
Benzene	2/49	1.3 - 2.1	1.0 - 2.0	A, B, C, D, E, F
Chlorobenzene	1/49	0.9	0.3 - 1.0	A, B, C, D, E, F
Chloroethane	2/49	2.1 - 5.5	1.0 - 2.0	A, B, C, D, E, F
Chloromethane	1/39	4.2	1.0 - 2.0	A, B, D, E, F
1, 4 - Dichlorobenzene	2/49	0.6 - 0.8	0.2 - 4.0	A, B, C, D, E, F
Dichlorodifluoromethane	4/49	2.9 - 7.0	1.5 - 2.0	A, B, C, D, E, F
1,1-Dichloroethane	3/49	0.4 - 0.8	0.2	A, B, C, D, E, F
cis-1,2-Dichloroethylene	13/49	0.4 - 10	0.5 - 0.8	A, B, C, D, E, F
trans-1,2-Dichloroethylene	9/49	0.4 - 5.8	0.3	A, B, C, D, E, F
Ethyl Ether	20/49	1.1 - 19	0.3 - 3.0	A, B, C, D, E, F
Tetrahydrofuran	7/39	15 - 29	6.0 - 15	A, B, D, E, F
1,1,2-Trichloroethylene	8/49	0.8 - 1.9	0.4 - 0.5	A, B, C, D, E, F
Vinyl Chloride	2/49	1.1 - 1.3	0.5 - 1.5	A, B, C, D, E, F

Notes:

(1) Data Summary for each parameter was derived from the following laboratory report source(s):

A = Pace Laboratories, Inc., July 13, 1987 Pace Project Number 870612521 (RI Report)
B = Pace Laboratories, Inc., February 5, 1988 Pace Project Number 880113510 (RI Report)
C = MVTL Laboratories, Inc., March 6, 1991 (Amended) Work Order Number 31 - 320 (SRI Report) (Data originally submitted in November 1990).
D = MVTL Laboratories, Inc., January 21, 1991 Work Order Number 31 - 0010 (SRI Report)
E = MVTL Laboratories, Inc., March 23, 1992 Work Order Number 31 - 0042 (POST -SRI Report)
F = MVTL Laboratories, Inc., December 16, 1992 Work Order Number 31 - 0011 (POST -SRI Report)

(13/49) and trans-1,2-dichloroethylene (9/49) were the most frequently detected volatile contaminants.

Because groundwater downgradient of the site is not used as a source of potable water, exposure pathways involving this medium are not believed complete. Therefore chemicals of concern were not selected for this medium for human health risk assessment purposes.

Chemicals of concern for groundwater and surface water were selected for ecological risk assessment purposes and are presented and discussed in further detail in Section 8.0.

2.1.2 Surface Water Data

Surface water data were obtained from two surface water locations (SW-3 and SW-6) in two distinctive bodies of water. The first location is the intermittent stream which runs between the landfill and the highway (SW-3). The second location is the quarry south of the landfill (SW-6). For this reason, data obtained from these two locations will be evaluated separately. Surface water samples were analyzed for volatile organic compounds (VOCs) and priority pollutant metals along with additional inorganic parameters. The inorganic parameters list varied according to the laboratory performing the analyses. These data are summarized in Tables 2.1-2 and 2.1-3.

For both locations, however, the eight most frequently detected inorganics include barium (4/5), calcium (5/5), iron (5/5), magnesium (5/5), manganese (5/5), potassium (4/5), sodium (5/5) and zinc (5/5). Cis-1,2-dichloroethylene was the most frequently detected volatile organic compound detected in three out of nine samples.

Because surface waters adjacent to the site are not classified for direct contact recreational purposes, exposure pathways involving surface waters are not believed complete. Therefore, chemicals of concern were not selected for this medium for human health risk assessment purposes. Chemicals of concern for surface water were selected for ecological risk assessment purposes, as further presented in Section 8.0.

2.1.3 Landfill Gas Data

The human health risk assessment focuses on landfill gas as the predominant transport media by which chemicals at the Freeway Landfill site may reach residential receptors and local landfill workers.

Two available sources of landfill gas data were used to represent emissions at the Freeway Landfill. The primary source is landfill gas data compiled by the MPCA in its regulatory oversight role for landfill gas control systems at five landfills in Minnesota: Pine Bend Landfill, Inver Grove Heights; Flying Cloud Landfill, Eden Prairie; Hopkins Landfill, Hopkins; Bemidiji Landfill, and Olmsted County Landfill Rochester. Landfill gas sampling was conducted at one collection point on five separate days (spanning four seasons) at each of the first two landfills. At the Hopkins Landfill, landfill gas was collected for analysis at seven different wells, four of them on two separate days. The Pine Bend and Flying Cloud data are from

Table 2.1-2. **Frequency of Detection, Range of Detected Concentrations and Detection Limits for Chemicals Detected in Surface Water (Sampling Location SW - 3) Freeway Landfill Risk Assessment - Burnsville, MN**

Chemical	Frequency of Detection	Range of Detected Concentrations, µg/l	Range of Detection Limits, µg/l	Laboratory Data Source (1)
Inorganics				
Aluminum	1/2	340	3.0 - 250	C, D
Barium	2/2	300 - 900	2.0 - 100	C, D
Cadmium	1/2	0.19	0.1	C, D
Calcium	2/2	355,000 - 504,000	100	C, D
Chromium	1/2	1.4	1.0 - 4.0	C, D
Iron	2/2	1,380 - 19,800	50	C, D
Lead	2/2	2.2 - 3.4	1.0	C, D
Magnesium	2/2	113,000 - 152,000	10 - 100	C, D
Manganese	2/2	3,200 - 7,000	50	C, D
Nickel	1/2	40	1.0 - 40	C, D
Potassium	2/2	22,400 - 26,500	100	C, D
Sodium	2/2	259,000 - 303,000	50	C, D
Zinc	2/2	30 - 60	10	C, D
Volatiles				
Acetone	1/2	13	10 - 25	C, F
cis-1,2-Dichloroethylene	1/3	2.3	0.8	C, D, F
Ethyl Ether	1/3	2.5	1.6 - 3.0	C, D, F

Notes:

(1) Data Summary for each parameter was derived from the following laboratory report source(s):

A = Pace Laboratories, Inc., July 13, 1987 Pace Project Number 870612521 (RI Report)
B = Pace Laboratories, Inc., February 5, 1988 Pace Project Number 880113510 (RI Report)
C = MVTL Laboratories, Inc., March 6, 1991 (Amended) Work Order Number 31 - 320 (SRI Report) (Data originally submitted in November 1990).
D = MVTL Laboratories, Inc., January 21, 1991 Work Order Number 31 - 0010 (SRI Report)
E = MVTL Laboratories, Inc., March 23, 1992 Work Order Number 31 - 0042 (POST -SRI Report)
F = MVTL Laboratories, Inc., December 16, 1992 Work Order Number 31 - 0011 (POST -SRI Report)

Table 2.1-3. Frequency of Detection, Range of Detected Concentrations and Detection Limits for Chemicals Detected in Surface Water (Sampling Location SW - 6) Freeway Landfill Risk Assessment - Burnsville, MN

Chemical	Frequency of Detection	Range of Detected Concentrations, µg/l	Range of Detection Limits, µg/l	Laboratory Data Source (1)
Inorganics				
Aluminum	1/3	43	3.0 - 250	C, D, E
Barium	2/3	184 - 300	2.0 - 100	C, D, E
Cadmium	2/5	0.1 - 0.8	0.1	A, B, C, D, E
Calcium	3/3	101,000 - 109,100	100	C, D, E
Chromium	1/5	1.2	1.0	A, B, C, D, E
Copper	2/4	2.7 - 18	1.0 - 4.0	A, B, D, E
Iron	3/3	160 - 740	50	C, D, E
Lead	2/5	4.0 - 4.7	1.0	A, B, C, D, E
Magnesium	3/3	41,000 - 44,000	10 - 100	C, D, E
Manganese	2/3	100 - 110	50	C, D, E
Nickel	1/5	2.4	1.0 - 40	A, B, C, D, E
Potassium	3/3	2,600 - 3,500	100	C, D, E
Selenium	3/5	3.5 - 7.2	3.0	A, B, C, D, E
Silver	1/5	0.2	0.2 - 10	A, B, C, D, E
Sodium	3/3	18,500 - 19,300	50	C, D, E
Zinc	2/5	10 - 40	10.0	A, B, C, D, E
Volatiles				
cis-1,2-Dichloroethylene	2/6	0.5 - 1.0	0.5 - 0.8	A, B, C, D, E, F
trans-1,2-Dichloroethylene	1/6	0.3	0.3	A, B, C, D, E, F
Ethyl Ether	1/6	0.7	0.3 - 3.0	A, B, C, D, E, F

Notes:

(1) Data Summary for each parameter was derived from the following laboratory report source(s):

A = Pace Laboratories, Inc., July 13, 1987 Pace Project Number 870612521 (RI Report)
B = Pace Laboratories, Inc., February 5, 1988 Pace Project Number 880113510 (RI Report)
C = MVTL Laboratories, Inc., March 6, 1991 (Amended) Work Order Number 31 - 320 (SRI Report) (Data originally submitted in November 1990).
D = MVTL Laboratories, Inc., January 21, 1991 Work Order Number 31 - 0010 (SRI Report)
E = MVTL Laboratories, Inc., March 23, 1992 Work Order Number 31 - 0042 (POST -SRI Report)
F = MVTL Laboratories, Inc., December 16, 1992 Work Order Number 31 - 0011 (POST -SRI Report)

landfill gas samples taken at the inlets to the flares. The Hopkins data are from samples taken in landfill gas wells. The Bemidji samples were taken at six passive gas vents on two separate days. The Olmsted data were taken from one sample at each of three vents and two landfill probes. As reported by MPCA, monitoring data for cis-1,2-dichloroethylene and 1, 1-dichloroethylene at the Pine Bend and Flying Cloud Landfills may have been reversed in the test result submittals for two test days. Therefore, the four questionable data points for each of these two pollutants were removed from the data base as directed by MPCA. All of the landfill gas constituents analyzed by MPCA were selected as chemicals of concern.

The secondary source of data in landfill gas was compiled by the U.S. EPA, (March 1991, Air Emissions from Municipal Solid Waste Landfills, EPA-450/3-90-011a). These landfill gas composition data were obtained from 46 landfills. The identities of the landfills have been withheld to ensure confidentiality. However, it is likely that much of the data are for California landfills, because the South Coast Air Quality Management District is cited as one of two sources. The other source is listed generically as "responses to Section 114 questionnaires".

Dataset No. 1

Dataset No. 1 represents the universe of data employed in the evaluation of chronic exposures for landfill workers and nearby off-site resident scenarios. This dataset is comprised of all compounds in the MPCA landfill gas dataset. For those compounds from the MPCA landfill gas data list found in quantities above the detection limit, the value selected for use as input to the air models is the 95 percent upper confidence level on the mean of all the concentrations sampled for each VOC. For those compounds that were found in trace quantities below the detection limit and for which no other MPCA data are available, EPA landfill gas data are used. Insufficient information has been presented to calculate a standard deviation, or upper 95 percent confidence limit on the mean concentrations from the U.S. EPA data. The MPCA has directed, therefore, that where the EPA data are used, the average concentration detected should be selected as a conservatively representative concentration of the constituent in landfill gas.

Table 2.1-4 presents a summary of the MPCA landfill gas dataset (Dataset No. 1) to be evaluated in the chronic exposure scenarios. A total of thirty-one (31) chemicals are considered chemicals of concern in Dataset No. 1. Section 3.0 presents the approach to determining which chemicals of concern will be evaluated in a quantitative fashion, and which chemicals of concern will be evaluated semi-quantitatively and further subjected to uncertainty analysis.

The use of EPA landfill gas surrogate data introduces some non-quantifiable uncertainties. The MPCA landfill gas dataset is best suited for use at the Freeway Landfill site because it is comprised of data from regional landfills of similar size, waste composition and climatic influences. The EPA landfill gas data set includes information on forty-six (46) California landfills of similar waste characteristics. However, size and climatic differences of the California region make the data less representative than regional data. For these reasons and uncertainties, the MPCA data base is the preferred data source.

Table 2.1-4. Summary of Landfill Gas Data - Dataset No. 1 to be Evaluated for Chronic Exposures Freeway Landfill Risk Assessment - Burnsville, MN

Chemical	Range of Detected Concentrations (ppm)	Mean Concentration (ppm)	Standard Deviation	Concentration Used For Modeling (ppm)	Source (1)
Acetone	0.019-3.6	1.22	2.06	3.55	MPCA 95%UCL
Acrylonitrile	--	--	--	0.32	EPA Avg.
Benzene	0.0015-2.7	0.92	0.80	1.21	MPCA 95%UCL
Carbon Tetrachloride	0.00003-0.003	0.0005	0.0009	0.001	MPCA 95%UCL
Chlorobenzene	0.00047-9.3	0.72	2.74	2.017	MPCA 95%UCL
Chloroethane	--	--	--	2.03	EPA Avg.
Chloromethane	--	--	--	0.94	MPCA 95%UCL
Chloroform	0.0001-1.33	0.124	0.36	0.321	MPCA 95%UCL
1,2-Dibromoethane	0.0001-0.55	0.162	0.184	0.266	MPCA 95%UCL
m-Dichlorobenzene	0.00099-8.4	0.98	2.35	2.31	MPCA 95%UCL
Dichlorodifluoromethane	--	--	--	13.1	EPA Avg.
1,1-Dichloroethane	0.00082-4.1	0.9	0.98	1.27	MPCA 95%UCL
1,2-Dichloroethane	0.00005-0.73	0.103	0.23	0.22	MPCA 95%UCL
1,1-Dichloroethylene	0.0002-0.3	0.023	0.083	0.069	MPCA 95%UCL
cis-1,2-Dichloroethylene	0.005-60	4.84	12.27	9.46	MPCA 95%UCL
trans-1,2-Dichloroethylene	0.2	0.2	NA	0.20	MPCA
1,2-Dichloropropane	--	--	--	0.12	EPA Avg.
Ethylbenzene	0.004-31	7.66	7.82	10.18	MPCA 95%UCL
Hexane	--	--	--	5.33	EPA Avg.
Methyl Ethyl Ketone	0.023-9.3	2.54	4.52	6.97	MPCA 95%UCL
Methyl Isobutyl Ketone	--	--	--	1.38	EPA Avg.
Methyl Mercaptan	13-23	18	7.07	27.8	MPCA 95%UCL
Methylene Chloride	0.0003-42	8.62	15.30	13.68	MPCA 95%UCL
1,1,2,2-Tetrachloroethane	--	--	--	0.1	EPA Avg.
Tetrachloroethylene	0.00029-10.9	1.94	2.30	2.70	MPCA 95%UCL
Toluene	0.01-110	21.80	23.37	29.04	MPCA 95%UCL
Total Xylenes	0.14-36	17.05	12.88	21.77	MPCA 95%UCL
1,1,1-Trichloroethane	0.00075-4.4	0.54	1.08	1.03	MPCA 95%UCL
Trichloroethylene	0.12-9.9	2.75	2.37	3.82	MPCA 95%UCL
Trichlorofluoromethane	--	--	--	0.99	EPA Avg.
Vinyl Chloride	0.0039-26	3.19	5.88	5.37	MPCA 95%UCL

Notes:

(1) Sources of data are the MPCA 95 percent upper confidence limit on the mean, or the EPA average detected concentration. See text for more explanation of sources of data.

-- = Value not reported

2.1.4 Scale-House Methane Data

Methane concentrations are currently being monitored in the scale-house indoor air at the Freeway Landfill. This is being done to ensure that concentrations do not exceed twenty-five (25) percent of the Lower Explosive Limit (LEL) for methane. The LEL is a concentration of five percent methane in air. Twenty-five percent of the LEL is a methane concentration of 1.25 percent (12,500 ppm). Minnesota regulations (Minnesota Rules part 7035.2815, subpart 11) stipulate that indoor air concentrations of methane must not exceed 25 percent of the LEL. The scale-house has ventilation systems that are activated when the monitored methane concentration reaches eight (8) percent of the LEL. In addition, the methane monitor has a warning light to alert workers to leave the scale-house before methane concentrations reach 25 percent of the LEL.

One of the objectives of the HHRA is to use these methane data to assess acute exposures of workers to acutely toxic substances in the landfill gas. Two years of almost daily readings of methane concentrations in the scale-house are available to assess acute exposures for scale-house workers. As presented in Table 2.1-5, the highest values found for each month tend to range from four (4) percent of the LEL to twenty-four (24) percent of the LEL. However, as presented in Figure 2.1-4, the record shows that 25 percent of the LEL was equaled or exceeded on three days in two years. Therefore, the reasonable maximum methane concentration from which to derive toxic non-methane organic compound concentration at the scale-house workers' breathing zone was selected to be 25 percent of the LEL. Based on the March, April, and June 1992 results, it is possible for methane concentrations to reach or exceed this level even though, the ventilation and warning systems are designed to prevent worker exposures to concentrations any greater than this level.

CDM obtained the methane monitoring data for the Pine Bend and Flying Cloud landfills from the MPCA, and will use the average value found as representative of the methane concentration in the Freeway Landfill gas. With this information, CDM will use the ratio of the scale-house methane concentration to the landfill gas methane concentration (estimated to be about 1:37 or 0.027) to calculate the proportional toxic non-methane organic compound concentrations in the scale house. This will be done by multiplying the concentration of non-methane compound in the landfill gas (see Table 2.1-6) by this dilution ratio to obtain the concentration of the non-methane compounds in the scale-house.

Dataset No. 2

Both the MPCA and EPA landfill gas database constitute the universe of chemicals of concern in Dataset No. 2. Dataset No. 2 represents the universe of data employed in the evaluation of acute exposures for scale-house workers. A total of ninety-one (91) chemicals are considered of concern in Dataset No. 2.

The EPA dataset contains additional acutely toxic landfill gas compounds not found in the MPCA database. Table 2.1-6 summarizes all chemicals of concern in Dataset No. 2 and presents the landfill gas concentrations which will be employed in the "rationing" exercise. CDM will compare the calculated proportional toxic non-methane organic compound concentrations in

Table 2.1-5. **Frequency Distribution of Methane %LEL Readings in Scale-House, January 1991 - November 1992**
Freeway Landfill Risk Assessment - Burnsville, MN

Month	Number of Recordings (1)																			
% LEL->	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100
Jan-91	4	2																		
Feb-91	20	1																		
Mar-91	3																			
Apr-91	12	9	2																	
May-91	16	2																		
Jun-91	1																			
Jul-91		14	1																	
Aug-91	7	5	1																	
Sep-91	8	18	10	8	7	3	3	2			1	1								
Oct-91	15	1																		
Nov-91	20	5																		
Dec-91	12	16	2																	
Jan-92	16	11	1																	
Feb-92	22	3																		
Mar-92	27																			
Apr-92	25	1																		
May-92	23	1																		
Jun-92	27																			
Jul-92	23	1																		
Aug-92	24	1																		
Sep-92 (2)	NA																			
Oct-92	19	3																		
Nov-92	20	3																		
TOTAL:	344	97	17	8	7	3	3	2	0	0	1	1	0	0	0	0	0	0	0	0

Notes:
(1) Data which was suspected as "inadequate" (e.g. negative sign qualifiers) was not included.
(2) LEL readings for September 1992 are unavailable.

Figure 2.1-4. Frequency Distribution of Methane %LEL Readings in Scale House, January 1991 - November 1992 Freeway Landfill - Burnsville, MN

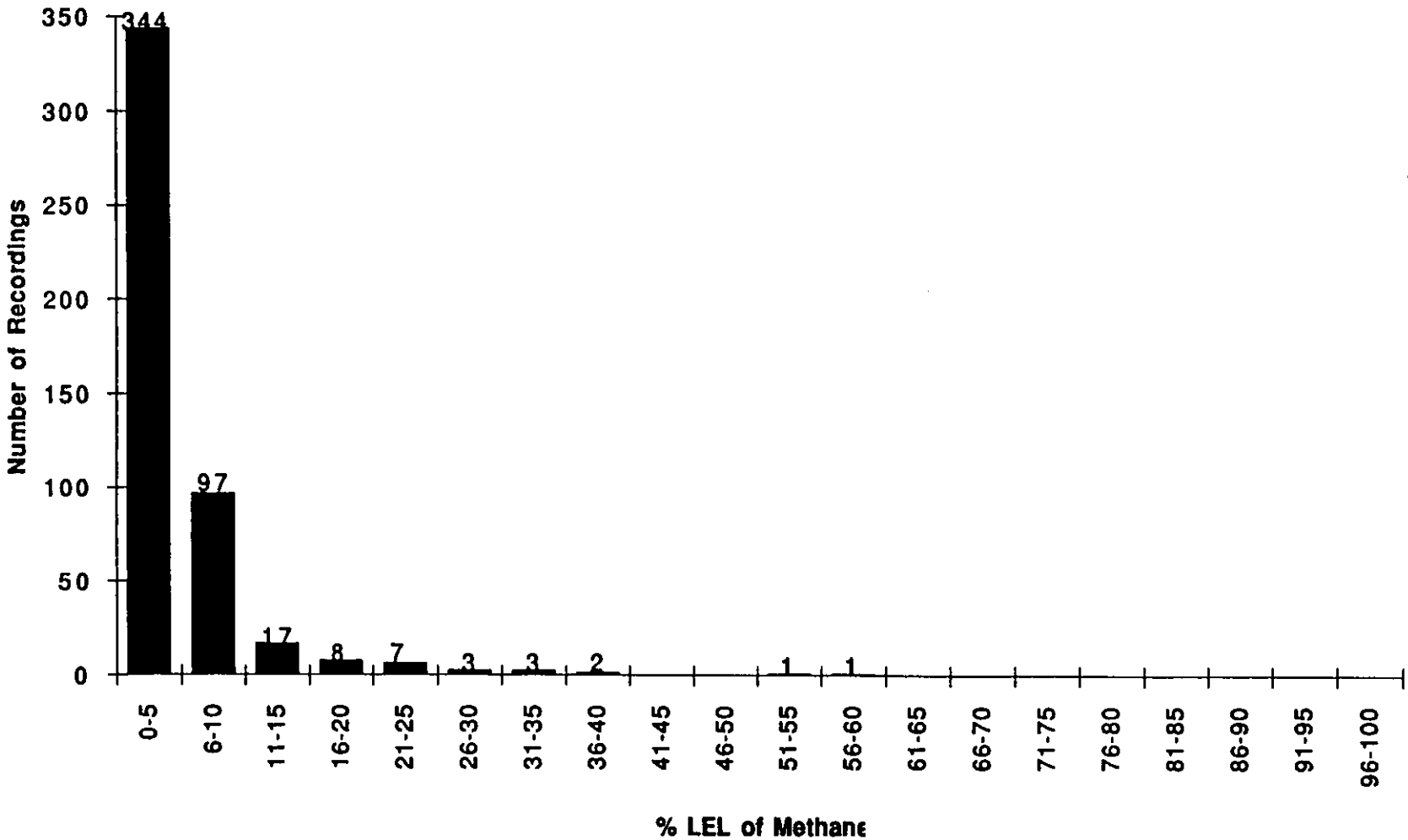


Table 2.1-6. **Summary of Chemicals of Concern in Landfill Gas (Dataset No. 2) and Availability of Occupational Exposure Limits Freeway Landfill Risk Assessment-Burnsville, MN**

Chemical of Concern	Concentration Used in Analysis (ppm)	Source	OSHA (1)	NIOSH (2)	ACGIH (3)
α- Pinene	446	EPA			
1-Butanol	100	EPA	C	I	T
2-Butanol	152	EPA			
1,3-Dichlorobenzene	0	EPA			
1,3-Dichloropropane	0	EPA			
1,4-Dichlorobenzene	0	EPA	T		S
2-Chloroethylvinyl Ether	0.08	EPA			
2-Methyl Furan	40	EPA			
2-Methyl, Methylester Propanoic Acid	69	EPA			
2-Methyl Propane	84	EPA			
2-Methyl 1-Propanol	51	EPA			
2,5-Dimethyl Furan	41	EPA			
3-Methylhexane	20	EPA			
4-Methyl 2-Pentanone	89	EPA	S15	I	S
Acetone	3.6	MPCA	T	I	S
Acrolein	0	EPA	T	I	S
Acrylonitrile	0.32	EPA	C	CA	CA
Benzene	1.2	MPCA	S, A	CA	CA
1,3-Bromochloropropane	0.01	EPA			
Bromodichloromethane	26	EPA			
Bromoform	0	EPA	T		T
Bromomethane	0	EPA	T	CA	T
Butane	3.68	EPA	T		T
c-1,3-Dichloropropene	0	EPA			T
C10H16 Unsaturated Hydrocarbon	15	EPA			
Carbon Tetrachloride	0.001	MPCA	C	CA,C	CA
Carbonyl Sulfide	1.0	EPA			
Chlorobenzene	2	MPCA	T	I	T
Chlorodifluoromethane	1.35	EPA	T		S
Chloroethane	2.03	EPA	T	I	T
Chloroform	0.3	MPCA	C	C	CA
cis-1,2-Dichloroethene	9.5	MPCA			
Chloromethane	1.38	EPA			
Dibromochloromethane	0	EPA			
1,2-Dichlorobenzene	0	EPA	C	I	C
1,2-Dichloroethane	0.2	MPCA	S15	CA	S15
1,2-Dichloroethene	6.33	EPA	T	I	T
Dichlorodifluoromethane	43.99	EPA	T	I	T
1,1-Dichloroethane	3.51	EPA	T	I	S
1,1-Dichloroethene	0.07	MPCA	T		S
Dichlorofluoromethane	1.2	EPA	T	I	T
Dichlorotetrafluoroethane	1.1	EPA	T	I	T
1,2-Dichloropropane	0.12	EPA	T	I	S
1,2-Dimethyl Benzene	588	EPA	T	I	S
Dimethyl Sulfide	0.55	EPA			
Dimethyl Disulfide	0.55	EPA			
Ethanol	157	EPA	T		T
Ethyl Acetate	20	EPA	T	I	T
Ethyl Mercaptan	11.93	EPA		I	T

Table 2.1-6.
(continued)

Summary of Chemicals of Concern in Landfill Gas (Dataset No. 2) and Availability of Occupational Exposure Limits
Freeway Landfill Risk Assessment-Burnsville, MN

Chemical of Concern	Concentration Used in Analysis (ppm)	Source	OSHA (1)	NIOSH (2)	ACGIH (3)
Ethylbenzene	10.2	MPCA	T	I	S
Ethylester Acetic Acid	282	EPA			
Ethylester Butanoic Acid	398	EPA			
Ethylester Propanoic Acid	26	EPA			
Hexane	5.33	EPA		T	T
Hydrogen Sulfide	252.97	EPA	S15, T	I,C	S, T
i-Propyl Mercaptan	1.55	EPA			
Methyl Isobutyl Ketone	1.38	EPA	S15, T	I,T	S, T
Methyl Mercaptan	1.55	EPA	C	I, C	T
Methyl Ethyl Ketone	7	MPCA	T	I	S, T
Methylcyclohexane	99.7	EPA		I	T
Methylene Chloride	13.7	MPCA			
Methylester Butanoic Acid	305	EPA			
Methylester Acetic Acid	136	EPA			
1-Methylester Butanoic Acid	69	EPA			
Methylethylpropanoate	7.3	EPA			
Methylpropane	12	EPA			
1-Methoxy-2-Methyl Propane	136	EPA			
Nonane	167	EPA	T		T
Octane	152	EPA	S15, T	I	S, T
Pentane	5.64	EPA	S15, T	I	S, T
Propane	13.59	EPA	T	I	AX
Propylester Butanoic Acid	253	EPA			
t-1,3-Dichloropropene	0	EPA			T
t-Butyl Mercaptan	0.64	EPA		I	T
1,1,2,2-Tetrachloroethane	0.1	EPA	T	CA, T	T
Tetrachloroethylene	2.7	MPCA	C	CA	S, T
Tetrahydrofuran	30	EPA		I	S, T
Toluene	29	MPCA		I, C	S, T
Total Xylenes	21.8	MPCA	T	I, C	S, T
1,1,1-Trichloroethane	0.84	EPA	T	I, C	S, T
Trichloroethylene	3.8	MPCA	T, C	T	S, T
Trichlorofluoromethane	0.99	EPA		I	C
Vinyl Chloride	5.4	MPCA	T	CA	T

NOTES:

(1) Occupational Safety and Health Agency (OSHA). As presented in TOMES (R) 1991. Hazardous Substance Data Bank.
(2) National Institute of Occupational Safety and Health (NIOSH). As presented in TOMES (R) 1991.
(3) American Conference of Governmental Industrial Hygenists (ACGIH). As presented in TOMES (R) 199 Hazardous Substance Data Bank.

(C) = Ceiling value
(CA) = Carcinogen
(I) = Immediately Dangerous to Life or Health (IDLH)
(T) = Time Weighted Average (TWA)
(S15) = 15-minute Short-Term Exposure Limit (STEL)
(A) = Recommended action level
(AX) = Asphyxiant
(S) = Short-Term Exposure Limit (STEL)

the scale-house with acute permissible exposure limit guidelines and/or standards from various industrial hygiene information sources including: (1) Occupational Safety and Health Administration (OSHA) time-weighted averages (TWA), recommended action levels and ceiling values; (2) National Institute for Occupational Safety and Health (NIOSH) immediately dangerous to life or health (IDLH) and ceiling values; and (3) the American Conference of Governmental Industrial Hygienists (ACGIH) short-term exposure limit (STEL).

2.1.5 Leachate Data

Two leachate samples (WT-6 and Kraemer quarry seep) were available to characterize contamination in this medium (see Figure 2.1-2 for sample locations). CDM was directed by MPCA staff to use data from WT-6 for both groundwater and leachate as this sample was drilled in refuse. These samples were analyzed during the previously discussed groundwater and surface water sampling events and the results are presented in Table 2.1-7. Table 2.1-7 reflects one laboratory anomaly where the detection limit for cis-1,2-dichloroethylene was presented as 0.5 µg/l, but the detected concentration was 0.4 µg/l. These data were presented in the 1987 Pace laboratory report.

The leachate seep samples were analyzed for volatile organic compounds as well as metals. As presented in Table 2.1-7, eighteen inorganic chemicals were detected, as well as ten volatile organic compounds. Calcium (339,000 µg/L), iron (16,600 µg/L), magnesium (155,000 µg/L), potassium (156,000 µg/L) and sodium (810,000 µg/L) are all human nutrients detected at moderately high concentrations, but not above a concentration deemed toxic to human health (ATSDR, 1987 - 1991).

While leachate seeps exist at Freeway Landfill, exposure to these seeps would be of limited duration and are likely to contribute negligibly to overall risks to workers presently working at the Kraemer quarry. Therefore, chemicals of concern were not selected for this medium for human health risk assessment purposes. Chemicals of concern for leachate seeps were selected for the ERA as discussed in Section 8.0.

2.2 Data Useability in Risk Assessment

In order to assess the useability of data for assessing risks, data quality parameters as well as data representativeness must be evaluated. Data useability refers to the adequacy of the analytical methods used, spike recovery, and quality control, as demonstrated in holding times, laboratory, trip and field blanks and duplicate samples.

All information on the validation of analytical data for groundwater was provided in the February 15, 1988 memorandum from Dave Brown, Conestoga-Rovers Associates to Terry Obal, Conestoga-Rovers Associates (Reference No. 1922) and from the QA/QC data provided in the data packages from Pace Laboratories and MVTL.

2.2.1 Data Quality Parameters

Section 2.2.1 addresses quality assurance/quality control issues and are specific to groundwater, surface water and leachate seep sampling data.

Table 2.1-7 Frequency of Detection, Range of Detected Concentrations and Detection Limits for Chemicals Detected in Leachate Freeway Landfill Risk Assessment - Burnsville, MN

Chemical	Frequency of Detection	Range of Detected Concentrations, µg/l	Range of Detection Limits, µg/l	Laboratory Data Source (1)
Inorganics				
Aluminum	3/6	32 - 290	250	C, D, E
Arsenic	8/8	2.0 - 28	1.0 - 2.0	A, B, C, D, E
Barium	6/6	180 - 500	2 - 100	C, D, E
Beryllium	1/2	1.2	0.2	A, B
Cadmium	6/8	0.1 - 6.1	0.1	A, B, C, D, E
Calcium	6/6	81,200 - 406,000	100	C, D, E
Chromium	4/8	1.0 - 11	1.0	A, B, C, D, E
Copper	3/6	2.0 - 50	1.0 - 12	A, B, D, E
Iron	6/6	80 - 33,400	50	C, D, E
Lead	1/8	14	1.0	A, B, C, D, E
Magnesium	6/6	102,000 - 188,000	50	C, D, E
Manganese	6/6	60 - 3,200	50	C, D, E
Nickel	8/8	6.0 - 160	1.0 - 40	A, B, C, D, E
Potassium	6/6	13,600 - 156,000	100	C, D, E
Silver	2/6	0.6 - 10	0.6 - 10	A, B, C E
Sodium	6/6	183,000 - 810,000	50	C, D, E
Thallium	1/3	3.0 - 400	3.0 - 400	A, B
Zinc	7/8	10 - 740	10 - 20	A, B, C, D, E
Volatiles				
Acetone	1/8	21	10 - 40	A, B, C E, F
Chlorobenzene	1/10	0.9	0.3 - 1.0	A, B, C, D, E, F
Chloroethane	1/10	2.1	1.0 - 2.0	A, B, C, D, E, F
Chloromethane	1/10	4.2	1.0 - 2.0	A, B, C, D, E, F
1, 4 - Dichlorobenzene	1/10	1.2	0.2 - 4.0	A, B, C, D, E, F
Dichlorodifluoromethane	2/10	2.9 - 3.8	1.5 - 2.0	A, B, C, D, E, F
cis-1,2-Dichloroethylene	3/10	0.4 - 1.0	0.5 - 0.8	A, B, C, D, E, F
trans-1,2-Dichloroethylene	2/10	0.4 - 0.6	0.3	A, B, C, D, E, F
Ethyl Ether	10/10	2.1 - 37	0.3 - 3.0	A, B, C, D, E, F
Tetrahydrofuran	2/8	22 - 79	6.0 - 15	A, B D, E, F

Notes:

(1) Date Summary for each parameter was derived from the following laboratory report source(s):

A Pace Laboratories, Inc., July 13, 1987 Pace Project Number 870612521 (RI Report)
B Pace Laboratories, Inc., February 5, 1988 Pace Project Number 880113510 (RI Report)
C MVTL Laboratories, Inc., March 6, 1991 (Amended) Work Order Number 31 - 320 (SRI Report) (Data originally submitted in November 1990).
D MVTL Laboratories, Inc., January 21, 1991 Work Order Number 31 - 0010 (SRI Report)
E MVTL Laboratories, Inc., March 23, 1992 Work Order Number 31 - 0042 (POST -SRI Report)
F MVTL Laboratories, Inc., December 16, 1992 Work Order Number 31 - 0011 (POST -SRI Report)

Holding Times

As presented in "*Test Methods for Evaluating Solid Waste*" (U.S. EPA SW-846, current edition), the holding time for volatile organic compounds is 14 days and for metals is 180 days. All samples considered in this deliverable were analyzed within their respective holding time period, therefore all samples are considered useable for risk assessment purposes, relative to this parameter.

Laboratory/Reagent Blank Analyses

No volatile organic compounds were detected in any of the laboratory/reagent blank analyses performed during the 1987 to 1992 sampling programs. Therefore, all samples are considered useable for risk assessment purposes, relative to this parameter.

Matrix Spike/Matrix Spike Duplicate Analyses

All samples employed in the risk assessments were within the surrogate recoveries stipulated in testing methods outlined in U.S. EPA SW-846, current edition. These data are considered usable and within the QA/QC limits established for this validation parameter. Precision, as measured by the relative percent difference (RPD), is the ability to reproduce the concentrations detected in the parent sample. All RPDs were within satisfactory QA/QC standards.

Field Quality Assurance and Quality Control (QA/QC)

For all samples collected throughout the Freeway Landfill sampling programs (1987-1992), field, laboratory and trip blanks have also been collected and analyzed. Laboratory contaminants were detected in the 1987 and 1988 laboratory blanks, but MPCA validated the sampling data. For the 1991 and 1992 sampling round, contaminants were detected in a number of field and trip blank samples collected, meaning that contamination from sample shipping or field equipment affected the associated samples.

Methylene chloride was detected at 1.9 µg/l in a field blank (F-1) analyzed by MVTL in March 1992. In addition, the following analytes were detected in field blanks analyzed by MVTL: (1) copper [23 µg/L in F-1 (March 1991); 6.7 µg/L in F-2 (March 1991)]; and (2) tetrahydrofuran [70.5 µg/L in F-1 (March 1991); and 281.7 µg/l in F-2 (March 1991)]. Copper was also detected at a concentration of 2.4 µg/L in the field blank sample identified as F-2 as reported by MVTL in January 1991.

Acetone was detected at a concentration of 17.2 µg/l in a trip blank analyzed by MVTL and reported in January 1991. MPCA was notified of these "hits" in the QA/QC samples and CDM was instructed to proceed with the risk assessment task upon validation of these data, via application of the 5-10x rule.

If a compound is found in a QA/QC blank and also detected in the associated sample, validation action is required, as is the case for the site-specific groundwater, surface water and leachate seep data. The 10x rule applies to the four common laboratory contaminants (i.e., methylene chloride, acetone, toluene, and 2-butanone (methyl ethyl ketone)). If a laboratory contaminant is found in a sample at a concentration less than 10 times the concentration found in the blank, the concentration for that chemical is no longer considered valid and therefore

regarded as a false-positive. This chemical is excluded from further evaluation. The same procedure was employed for compounds other than the four laboratory contaminants cited previously, except that the concentration was regarded as a false-positive when the compound was detected in a sample at a concentration less than 5 times the concentration found in the blank.

Detection Limits

In general, detection limits were within acceptable limits indicating that there were no matrix interference problems with any of the groundwater, surface water or leachate samples. One exception was the elevated detection limit of 400 µg/l for thallium from the 1987 Pace report that was later reduced to 3.0 µg/l in the 1988 Pace report.

2.2.2 Data Representativeness

There were forty-three (43) samples analyzed for various metals over the course of five (5) sampling rounds and an additional six (6) samples from a sixth sampling round analyzed for volatile organic compounds only. A sample size ranging from forty-three (43) to forty-nine (49) samples should be representative of the groundwater conditions. However, some variability does exist with the minimum and maximum detected values for arsenic, cadmium, copper, lead, nickel, selenium and zinc, varying by more than an order of magnitude.

Surface water from location SW-6 was analyzed once each of the five sampling rounds between 1981 and 1992 for metals and then again in December 1992 for volatiles only. Surface water sample SW-3 was only analyzed twice for metals in 1991 and three times for VOCs. It is unlikely that sample sizes ranging from two to five samples is adequate to accurately characterize these surface water bodies.

The two leachate samples, Kraemer Quarry seep and WT-6, were analyzed eight times for various metals over the course of five sampling rounds from 1987 and 1992. The additional sampling round in December 1992 resulted in a total of ten volatile results. A sample size ranging from eight to ten samples is probably not representative of leachate in this landfill. A great deal of variability exists with parameters such as arsenic, cadmium, chromium, copper, nickel, silver, thallium and zinc all with minimum and maximum concentrations varying by more than an order of magnitude.

The use of EPA landfill gas surrogate data introduces some non-quantifiable uncertainties. The MPCA landfill gas database is best suited for use at the Freeway Landfill site because it is comprised of data from regional landfills of similar size, waste composition (MSW) and climatic influences. The EPA landfill gas dataset includes information on forty-six (46) California landfills of similar waste characteristics. However, size and climatic differences of the California region make the data less representative than regional data. For these reasons and uncertainties, the MPCA database is the preferred data source.

Section 3
Selection of Chemicals of Concern for HHRA

Because groundwater in the vicinity of the site is not used as a potable water source, and surface water exposures are not believed to exist, chemicals of concern for these media were not selected nor further evaluated for human health risk assessment purposes. Direct contact and subsequent exposures with leachate and surface soil contaminants is also believed to be limited at this time. While leachate seeps exist at the Freeway Landfill, exposure to these seeps would be of limited duration and are likely to contribute negligibly to overall worker risks at the Kraemer Quarry. Therefore, chemicals of concern were not selected for this medium for human health risk assessment purposes.

3.1 Chemicals of Concern in the Landfill Gas

The human health risk assessment evaluates risks associated with exposures to three receptors: (1) landfill workers (chronic exposure scenario); (2) nearest off-site residents (chronic exposure scenario); and (3) scale-house workers (acute exposure scenario). To conduct this evaluation, two datasets were employed. Each dataset was tailored to the specific nature of the exposures evaluated in the human health risk assessment.

All chemicals listed in the MPCA landfill gas database (using the EPA landfill gas database as a surrogate concentration for those chemicals which were not detected during the MPCA monitoring program) constitute the universe of chemicals of concern in landfill gas as represented by Dataset No. 1. Only those landfill gas constituents for which inhalation toxicity values (i.e., reference concentrations [R_fCs] and unit risk values) currently exist were evaluated quantitatively. The hierarchy of data sources for these toxicity values included the following references: (1) U.S. EPA's Integrated Risk Information System (IRIS), (2) U.S. EPA's Health Effects Assessment Summary Table (HEAST) document; and (3) Environmental Criteria and Assessment Office will be evaluated quantitatively in the chronic exposure scenarios of this Human Health Risk Assessment. The chemicals presented in Table 3.1-1 represent all COCs from Dataset No. 1.

Dataset No. 2 includes all chemicals of concern employed in the semi-quantitative evaluation of acute exposures to scale-house workers. Dataset No. 2 consists of a total of ninety-one (91) chemicals of concern resulting from the combination of both MPCA and EPA landfill gas datasets.

3.2 Physical and Chemical Properties of Chemicals of Concern in Landfill Gas

Chemical and physical properties are important factors which determine the movement and environmental fate of a chemical and aid in assessing potential exposure pathways at a site. Properties for each of the COCs in the landfill gas database (with EPA data as a surrogate source) are presented in Table 3.1-2. The following section presents a brief discussion of

Table 3.1-1 **Summary of Selected Chemicals of Concern for HHRA**
Freeway Landfill Risk Assessment - Burnsville, MN

Media	Chemicals Selected as COCs			
Landfill Gas	Acetone	1,2-Dibromoethane	1,2-Dichloropropane	Tetrachloroethylene
-Dataset No. 1 (Chronic Exposures)	Acrylonitrile	m-Dichlorobenzene	Ethylbenzene	Toluene
	Benzene	Dichlorodifluoromethane	Hexane	Total Xylenes
	Carbon Tetrachloride	1,1-Dichloroethane	Methyl Ethyl Ketone	1,1,1-Trichloroethane
	Chlorobenzene	1,2-Dichloroethane	Methyl Isobutyl Ketone	Trichloroethylene
	Chloroethane	1,1-Dichloroethylene	Methyl Mercaptan	Trichlorofluoromethane
	Chloroform	cis-1,2-Dichloroethylene	Methylene Chloride	Vinyl Chloride
	Chloromethane	trans-1,2-Dichloroethylene	1,1,2,2 - Tetrachloroethane	

Media	Chemicals Selected as COCs			
Landfill Gas	1-Butanol	1,2-Dichloroethane	Ethyl Mercaptan	Propane
-Dataset No. 2 (Acute Exposures)	4-Methyl 2-Pentanone	1,2-Dichloroethene	Ethylbenzene	t-Butyl Mercaptan
	Acetone	Dichlorodifluoromethane	Hexane	1,1,2,2-Tetrachloroethane
	Acrylonitrile	1,1-Dichloroethane	Hydrogen Sulfide	Tetrachloroethylene
	Benzene	1,1-Dichloroethene	Methyl Isobutyl Ketone	Tetrahydrofuran
	Butane	Dichlorofluoromethane	Methyl Mercaptan	Toluene
	Carbon Tetrachloride	Dichlorotetrafluoroethane	Methyl Ethyl Ketone	Total Xylenes
	Chlorobenzene	1,2-Dichloropropane	Methylcyclohexane	1,1,1-Trichloroethane
	Chlorodifluoromethane	1,2-Dimethyl Benzene	Nonane	Trichloroethylene
	Chloroethane	Ethanol	Octane	Trichlorofluoromethane
	Chloroform	Ethyl Acetate	Pentane	Vinyl Chloride

Table 3.1-2 Physical-Chemical Properties of Chemicals of Concern in Landfill Gas (Dataset No. 1)
Freeway Landfill Risk Assessment - Burnsville, MN

Chemical of Concern	Molecular Weight (g/mol)	Vapor Pressure (mm Hg)	Henry's Law Constant (atm-m^3/mol)
Acetone	58.09 (a)	40 @ 39.5 Deg C (b)	3.67E-5 (a)
Acrylonitrile (d)	53.06	107.8 @ 25 Deg C	1.10E-4 @ 25 Deg C
Benzene (e)	78.11	95.19 @ 25 Deg C	5.43E-3
Carbon Tetrachloride (e)	153.84	113.8 @ 25 Deg C	3.04E-2 @ 24.8 Deg C
Chlorobenzene	112.56 (a)	11.8 @ 25 Deg C (a)	3.45E-3 (b)
Chloroethane (a)	64.52	1000 @ 20 Deg C	NA
Chloroform (e)	119.39	246 @ 25 Deg C	4.35E-3 @ 25 Deg C
Chloromethane (a)	64.52	5 ATM @20 Deg C	NA
1,2-Dibromoethane	187.88 (a)	11 @ 20 Deg C (a)	NA
m-Dichlorobenzene (b)	147.00	1.6 @ 20 Deg C	3.55E-3 @ 25 Deg C
Dichlorodifluoromethane (f)	120.9	4882 @ 25 Deg C	4.0E-1 @ 25 Deg C
1,1-Dichloroethane (b)	98.97	182 @ 20 Deg C	5.70E-3 @ 25 Deg C
1,2-Dichloroethane (e)	98.96	78.7 @ 20 Deg C	9.77E-4
1,1-Dichloroethylene (b)	96.95	500 @ 20 Deg C	1.54E-1
cis-1,2-Dichloroethylene (e)	96.94	200 @ 35 Deg C	3.37E-3
trans-1,2-Dichloroethylene (e)	96.94	340 @ 25 Deg C	6.72E-3
1,2-Dichloropropane (e)	112.99	49.67 @ 25 Deg C	2.07E-3
Ethylbenzene (d)	106.16	9.53 @ 25 Deg C	8.44E-3
Hexane (a)	86.18	150 @ 24.8 Deg C	NA
Methyl Ethyl Ketone (e)	72.10	90.6 @ 25 Deg C	1.05E-5
Methyl Isobutyl Ketone (c)	72.10	70.6 @ 20 Deg C	4.35E-5 @ 20 Deg C
Methyl Mercaptan	48.11 (a)	1520 @ 26.1 Deg C (a)	NA
Methylene Chloride (b)	84.94	350 @ 20 Deg C	2.57E-3 @ 25 Deg C
1,1,2,2 - Tetrachloroethane (e)	167.86	6.1 @ 25 Deg C	4.55E-4 @ 25 Deg C
Tetrachloroethylene (a)	165.83	18.47 @ 25 Deg C	NA
Toluene (e)	92.13	28.4 @ 25 Deg C	5.94E-3
Total Xylenes	106.16 (a)	9 @ 20 Deg C (b)	7.01E-3 (b)
1,1,1-Trichloroethane (b)	133.42	100 @ 20 Deg C	2.76E-2 @ 25 Deg C
Trichloroethylene (e)	131.40	69 @ 25 Deg C	1.03E-2
Trichlorofluoromethane (b)	137.36	690 @ 20 Deg C	1.10E-1 @ 20 Deg C
Vinyl Chloride (d)	62.50	2660 @ 25 Deg C	1.07E-2

NOTES:
- Henry's Law Constants are at room temperature unless otherwise stated.
- NA = Not available

SOURCES:
(a) TOMES(R). 1993. Hazardous Substance Data Bank.
(b) Arthur D. Little. Installation Restoration Program Toxicology Guide. Volume I. 1985-1987.
(c) Arthur D. Little. Installation Restoration Program Toxicology Guide. Volume II. 1985-1987.
(d) Philip H. Howard. Handbook of Environmental Fate & Exposure Data. Volume I. 1990.
(e) Philip H. Howard. Handbook of Environmental Fate & Exposure Data. Volume II. 1990.
(f) Donald Mackay. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. Volume III. 1993.

physical and chemical properties associated with each and how these properties apply to the fate and transport of various groups.

Vapor Pressure and Henry's Law Constant - These two parameters serve as a measure for chemical volatility. They are particularly important factors in evaluating the air exposure pathway, as is the case for Freeway Landfill. Vapor pressure, which identifies the volatility of a chemical in its pure state at a specific temperature, is an indicator of the rate of vaporization (USEPA, 1989). Henry's law constant is the ratio, at equilibrium, of the gas phase concentration to the aqueous phase concentration of a chemical present at low concentration. A higher Henry's law constant is indicative of a greater tendency for a chemical to move from water into air.

For chemicals of limited water solubility (e.g. <1 ml/L), Henry's law constants may be estimated using the following formula:

$$H\ (\text{atm-m}^3/\text{mole}) = \frac{\text{Vapor Pressure (atm)} * \text{MW (g/mole)}}{\text{Water Solubility}}$$

All landfill gas chemicals of concern have moderate vapor pressure and Henry's law constant values at ambient temperatures, thus, an air pathway is considered significant.

Section 4
Exposure Assessment for HHRA

The exposure assessment is one of the key components of a HHRA, providing an evaluation of the type and magnitude of potential exposure to the COCs. The selection of exposure pathways for quantitative evaluation is based upon the estimated fate and transport of the chemicals of concern, the likelihood that the pathway will be complete, and current exposure assessment methods. In this assessment, contaminants at or originating from the Freeway Landfill are assumed to be emitted and eventually dispersed to ambient air and become available for inhalation by individuals working and/or residing next to the landfill.

Based upon site-specific observations and information gathered during site visits, it is assumed that the receptor populations that would receive the greatest exposure from the site are: (1) the on-site landfill workers; (2) scale-house workers; and (3) nearby off-site residents. The potential exposure pathways for all three receptors involve inhalation of volatile compounds of landfill gas origin. CDM will quantitatively evaluate risks to on-site landfill worker and off-site residents and semi-quantitatively evaluate risks to scale-house workers.

The following subsections provide more detail and discussion regarding the reasonable maximum exposure (RME) approach, the derivation of exposure point concentrations, selection of values for the exposure variables, and evaluation of exposures associated with the inhalation of landfill gas compounds (chronic exposures) and non-methane organic compound concentrations (acute exposures).

4.1 Reasonable Maximum Exposure (RME) Approach

Table 4.1-1 presents a summary of exposure pathways evaluated in the HHRA. For the exposure pathways evaluated, a modified RME approach is used which incorporates standard values from EPA, and site-specific values. The RME is defined by the EPA (1989) as the highest exposure that is reasonably expected to occur at a site. The intent of the RME is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of plausible exposures.

The RME approach requires a combination of high (upper 95 percent confidence limit) and average exposure values to be used to estimate exposures for the assessed individuals. As discussed in Section 1.0, the chemical concentrations reported by MPCA are the 95 percent upper confidence interval on the mean of all the concentrations sampled. For those compounds that were detected in trace quantities (below the detection limit or not detected at all), EPA landfill gas data were employed. Although not enough information was available to calculate an upper 95 percent confidence interval for the EPA data, these data are conservative in nature because "non-detects" were not taken into account in the derivation of average landfill gas concentrations (i.e., average values represent the average of detected values only).

Table 4.1-1

Summary of Exposure Pathways Evaluated
Freeway Landfill Risk Assessment - Burnsville, MN

EXPOSURE MEDIUM	EXPOSURE PATHWAY/ SCENARIO	EXPOSURE RECEPTOR	MECHANISM OF CHEMICAL RELEASE	EXPOSURE POINT	EXPOSURE ROUTE	RISK EVALUATION APPROACH
Landfill Gas	ON - SITE (current) chronic exposure to landfill gas constituents while working in landfill (occupational scenario)	landfill workers	volatilization of landfill gas constituents from surface and subsurface soils to on-site ambient air	points of potential human contact with contaminated ambient air (e.g., landfill premises)	inhalation	quantitative (risk estimates) and semi-quantitative (comparison of landfill gas EPCs to MPCA air concentration limits)
	ON - SITE (current) acute exposure to non-methane organic compounds of landfill gas origin while working in the scale-house (occupational scenario)	scale-house workers	volatilization and infiltration of landfill gas constituents from surface and subsurface soils to scale-house	points of potential human contact with contaminated air (e.g., scale-house)	inhalation	semi-quantitative (comparison of scale-house EPCs to MPCA air concentration limits and occupational acute permissible exposure limits)
	OFF - SITE (current) chronic exposure to landfill gas constituents in ambient air (residential scenario)	nearby residents	volatilization of landfill gas constituents from surface and subsurface soils to off-site ambient air	points of potential human contact with contaminated air (e.g., residences)	inhalation	quantitative (risk estimates) and semi-quantitative (comparison of landfill gas EPCs to MPCA air concentration limits)

4.2 Derivation of Exposure Point Concentrations (EPCs) for Chemicals of Concern (COCs) in Datasets No. 1 and No. 2

Exposure point concentrations (EPCs) are concentrations of chemicals at the point of human contact, such as at a receptor's breathing zone. These are calculated to estimate risks for the receptor evaluated. The EPA recommends that EPCs be calculated as the upper 95 percent confidence interval around the arithmetic mean of the available analytical data (EPA, 1982).

The following section discusses the approach employed in the derivation of EPCs. These are presented in summary tables.

4.2.1 Chronic Exposures

Emission Rates of Chemicals of Concern

Landfill gas is produced naturally by the aerobic and anaerobic decomposition of the refuse in the landfill. There are four distinct phases of the gas generation process (O'Leary and Walsh, 1991). The first phase, lasting from several days to weeks, is an aerobic process. Oxygen is present at the time of waste placement, and carbon dioxide is the principal gas produced. In the second phase, an anaerobic condition exists once oxygen has been depleted. Acid-forming bacteria break down complex organic molecules into simpler organic acids. The bacteria produce volatile acids and carbon dioxide, and reduce the pH to 4 or 5. Methane production begins in the third phase, as methane producing bacteria become more predominant, and degrade the volatile acids to methane. In this phase, the pH in the landfill rises to more neutral values, and carbon dioxide levels decrease as methane concentrations increase in the landfill gas. The fourth phase is a steady state condition lasting from approximately 15 to 60 years. Gas generated during this phase contains 25 to 60 percent methane and 40 to 75 percent carbon dioxide, with trace amounts of other gases. After 60 years, landfill gas generation decreases rapidly.

The gas generation rate depends on the following site-specific factors:

- the amount of moisture present,
- waste mass, composition of the waste,
- temperature, the age of the refuse,
- pH, and quantity; and
- quality of nutrients.

The EPA published a proposed draft rule in May, 1991, (56 FR 24468, May 30, 1991) which would set a first-time emission standard for municipal solid waste landfills. The pending rule would become a New Source Performance Standard (NSPS), and would require that new or modified landfills (after May 30, 1991) have gas collection and combustion systems, if the landfill could emit more than 150 megagrams (approximately 167 tons) of non-methane organic compounds (NMOC) per year. The proposed rule contains several formulae for calculating a worst-case estimate of an annual NMOC emission rate as a function of waste mass and age in the landfill, if site-specific landfill gas monitoring data is not available. The EPA intends to promulgate the final rule in the fall of 1993.

As a part of this proposed rulemaking, EPA has published the following criteria document: U.S. EPA, March 1991, *Air Emissions from Municipal Solid Waste Landfills - Background Information for Proposed Standards and Guidelines*, EPA-450/3-90-011a. In addition to containing information on total NMOC emission rates, the document also summarizes the results of landfill gas sampling at forty-six landfills for ninety-four individual organic compounds. These are summarized in Appendix A of this document. EPA has also developed a landfill gas emissions model, called LANDFILL 2. The model is available for downloading by computer from EPA's Support Center for Regulatory Air Models Bulletin Board and incorporates the NMOC emissions equation from the proposed New Source Performance Standards.

The conservative landfill NMOC emission rate formula contained in the New Source Performance Standards and the LANDFILL 2 model is a first-order decay model (the Scholl-Canyon model) fit to EPA sampling data. The model provides default values for two decay constants, the NMOC concentration (8000 ppmdv as hexane), the methane concentration (50 percent by volume), and the carbon dioxide concentration (50 percent by volume). If the default values are used, the only input parameters required are the year the landfill opened, the year it closed, the mass of waste in the landfill each year it accepted waste, and the total landfill capacity.

The LANDFILL 2 model was used to calculate year-by-year emission rates of total NMOCs from the Freeway Landfill. The default value for methane was adjusted to 46.04 percent, which is the average of the methane sampling data results for the Pine Bend and Flying Cloud Landfills (see Appendix A). The year the landfill opened was set as 1970; the year it closed, 1990; and the landfill's capacity was input as 1,550,767 megagrams (about 5,692,977 cubic yards) of waste. LANDFILL 2 model output is contained in Appendix B. The LANDFILL 2 year-by-year predicted emission rates of total NMOCs was imported directly into a spreadsheet for calculation of the emission rates of individual toxic volatile organic compounds (the chemicals of concern). This calculation is also shown in Appendix B.

The peak emission rate for both total NMOCs and all of the individual chemicals of concern occurred in 1990. Although these peak-year emission rates are those used in the HHRA, the 25-year average and 30-year average emission rates are also calculated in Appendix B for the purposes of comparison.

Dispersion Modeling

A computer-based mathematical dispersion model approved by the MPCA and the EPA, Industrial Source Complex, Long-Term, Version 2 (ISCLT2) was used to predict exposure point concentrations for chronic exposure scenarios. The most recent version, dated 92062, was used. This date citation represents the julian date system used by the EPA Support Center for Regulatory Air Models.

The landfill was represented as a set of 74 square area sources, some 100 meters and some 50 meters on a side. Because the model will not include emissions from any source touching a receptor in the calculation of concentrations at that receptor, this resolution enabled the model to predict concentrations on and near the landfill without excluding large areas of the landfill from the calculation.

A polar receptor grid was used. The origin of the grid was placed at the center of the landfill. Concentrations were predicted for points located every ten degrees around rings at set distances from the center: every 100 meters out to 1,000 meters; and every 200 meters from 1,000 to 2,000 meters from the center of the landfill. Receptors within about 400 meters of the center were on the landfill itself. Receptors beyond 400 meters were off-site receptors. An additional 36 receptors were placed around the landfill edges, and an additional nine receptors were placed at the locations of the nearest residences. Nine residential receptors were selected and these are the nearest existing residences and/or schools in all directions around the landfill. Because this is a source area, the closer the receptor, the higher the predicted concentration for any given wind direction. This was confirmed by the dispersion modeling on the polar receptor grid. These locations were approved by MPCA on January 15, 1992. Figure 4.2-1 shows the locations of the residential receptors.

Five years of meteorological data (1982 - 1986) were used with the dispersion model. Hourly surface meteorological data (wind speed, direction, atmospheric stability and temperature) collected at the Minneapolis - St. Paul International Airport for these five years was combined with mixing height data for the same five years, monitored at the St. Cloud Airport. This hourly data was then processed into a statistical frequency distribution of the occurrence of each meteorological condition for each of the four seasons in each of the five years. The MPCA conducted this pre-processing, and provided the resulting statistical meteorological data for use in the air quality dispersion modeling.

Predicted Concentrations of Chemicals of Concern at Exposure Points

The dispersion modeling results for a normalized emission rate are shown in Appendix B. The highest annual-average result was selected from the five years of results for each of the following classes of receptors: on-site (worker), off-site (at highest exposure point concentration), and off-site (residential). In all cases (except the residential), and for all five years of meteorological data, the points of highest impact tended to be toward the east from the center of the landfill. This reflects prevailing winds (as monitored at the Minneapolis - St. Paul Airport) out of the west and toward the east.

The point of highest ground-level ambient landfill gas concentrations for an on-site worker exposure (and the highest ambient concentrations found anywhere on the receptor grid), was found to occur about 200 meters due east of the center of the landfill, for meteorological data year 1985. The point of highest off-site landfill gas concentrations was also found to occur due east of the center of the landfill, right at the landfill property boundary and the edge of the Interstate 35 right-of-way. The nearest residential area is almost one mile from this point of highest concentration. This concentration was also predicted for meteorological data year 1985.

The highest landfill gas concentrations found for the residential receptors was modeled to occur at Residential Receptor No. 2 (See Figure 4.2-1) for meteorological data year 1986. This residential receptor had the highest concentrations of all the residential receptors in all of the meteorological data years. This receptor is in Bloomington, on the ridge immediately across the Minnesota River from the Freeway Landfill. Although north, and slightly west of the

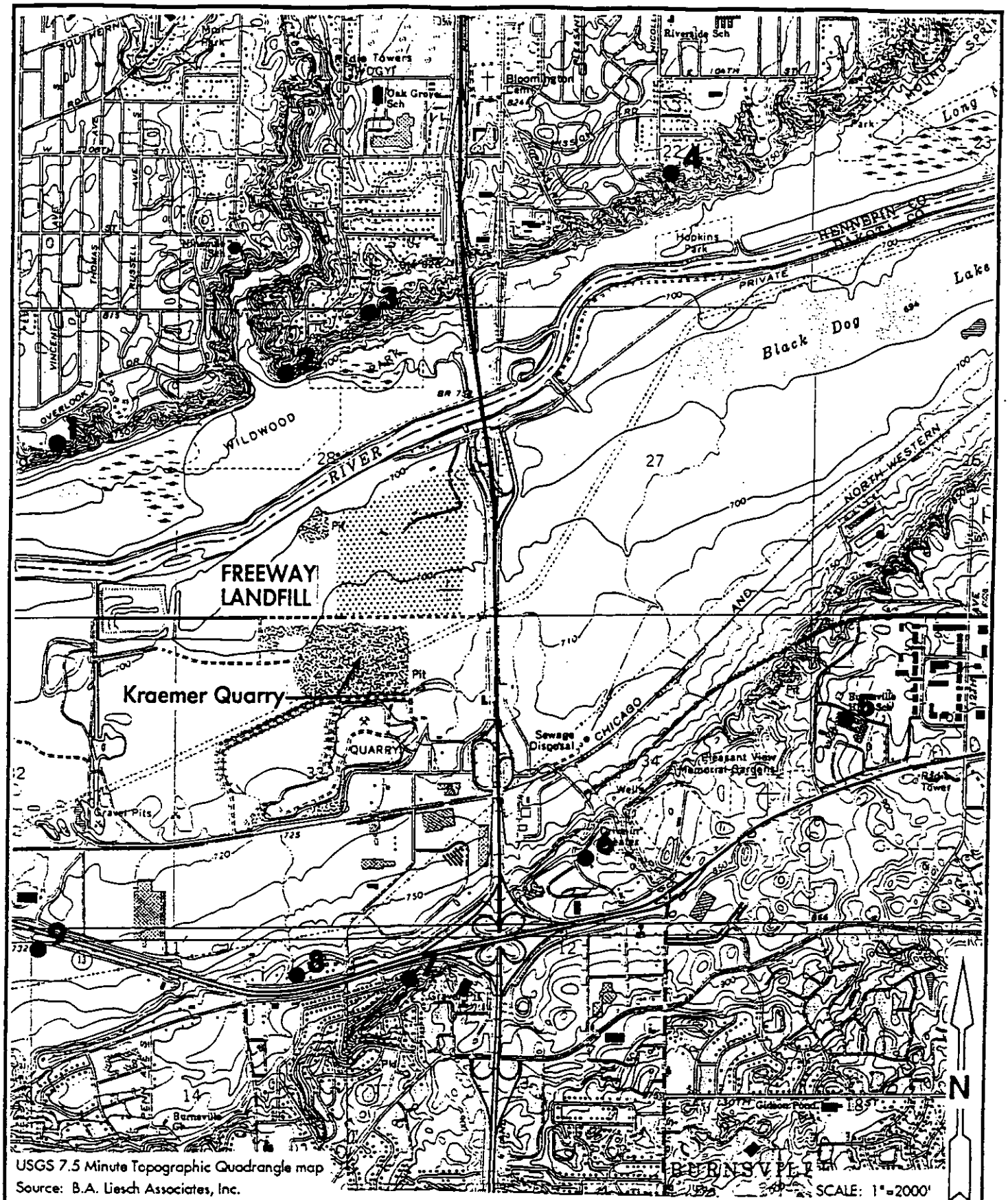


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FIGURE 4.2-1
LOCATIONS OF DISCRETE RESIDENTIAL RECEPTORS FOR DISPERSION MODELING

landfill, this residence is the closest (about 800 meters or 2600 feet from the nearest landfill edge).

Table 4.2-1 shows the modeled highest annual-average concentrations for on-site, off-site and residential locations. The concentrations of each of the compounds of concern are also calculated on the basis of the peak-year landfill gas emission rate, which occurred in 1990. The highest on-site location (on the landfill), highest off-site location (beyond the property boundary), and highest residential location results are listed for each compound. The highest on-site and the highest residential values are highlighted in boldface, because these are the values carried forward through the rest of this HHRA. The highest on-site annual average air contaminant concentrations are the representative exposure point concentrations used to assess the chronic landfill worker exposure scenario. The highest residential annual average air contaminant concentrations are the exposure point concentrations used to assess the nearby resident exposure scenario.

Table 4.2-2 shows the same information as Table 4.2-1, but for long-term-average landfill gas emission rates, not the peak-year emission rate. These are more realistic (and less conservative) estimates of the chronic exposure concentrations. They are presented here for comparison purposes only. These values were not carried through the quantitative risk evaluation presented in Section 6.0.

4.2.2 Acute Exposure

An acute exposure scenario was considered for the landfill workers who work inside the scale-house. Landfill gas seeps through the building floor, and is not dispersed as readily as in the ambient outdoor air. Methane concentrations have been continuously monitored in the scale house for several years. These data are presented in Section 1.0, Data Evaluation and Selection of Chemicals of Concern.

On the basis of the methane monitoring data, and for reasons developed in Section 1.0, the reasonable maximum methane concentration in the scale-house was assumed to be 25 percent of the Lower Explosive Limit (LEL) for methane for eight hours. The LEL is a concentration of five percent methane in air. Twenty-five percent of this value is a methane concentration of 1.25 percent, or 12,500 ppm.

An average methane concentration of 46.04 percent (460,400 ppm) in landfill gas was calculated from data for the Pine Bend and Flying Cloud Landfills (see Appendix A). The ratio of the scale house methane concentration to the landfill gas methane concentration produces a dilution ratio. This dilution ratio was used as shown in Appendix B of this document to calculate resulting reasonable maximum exposure levels (eight-hour average) for all of the Dataset No. 2 compounds. Table 4.2-3 shows the resulting exposure point concentrations for the chemicals of concern assessed in the acute exposure scenario at the scale-house. This list includes all chemicals in Dataset No. 2 with non-zero concentrations in landfill gas for which acute exposure standards are available (see Table 1.1-6).

Table 4.2-1 **Peak-Year Exposure Point Concentrations for Chronic Exposure Scenarios Freeway Landfill Risk Assessment - Burnsville, MN**

Chemical of Concern	CAS No.	Peak-Year Predicted Ambient Concentration (µg/m3) By Chronic Exposure Scenario (1)		
		On-Site	Off-Site	*Residence*
Acetone	67-64-1	**5.27E-02**	5.20E-02	**5.27E-03**
Acrylonitrile	107-13-1	**4.34E-03**	4.28E-03	**4.34E-04**
Benzene	71-43-2	**2.42E-02**	2.38E-02	**2.42E-03**
Carbon Tetrachloride	56-23-5	**3.93E-05**	3.88E-05	**3.93E-06**
Chlorobenzene	108-90-7	**5.81E-02**	5.73E-02	**5.81E-03**
Chloroethane	75-00-3	**3.35E-02**	3.30E-02	**3.35E-03**
Chloromethane	74-87-3	**1.78E-02**	1.76E-02	**1.78E-03**
Chloroform	67-66-3	**9.81E-03**	9.68E-03	**9.81E-04**
1,2-Dibromoethane	106-93-4	**1.28E-02**	1.26E-02	**1.28E-03**
m-Dichlorobenzene	541-73-1	**8.69E-02**	8.57E-02	**8.68E-03**
Dichlorodifluoromethane	75-71-8	**4.05E-01**	4.00E-01	**4.05E-02**
1,1-Dichloroethane	75-34-3	**3.21E-02**	3.17E-02	**3.21E-03**
1,2-Dichloroethane	107-06-2	**5.57E-03**	5.49E-03	**5.57E-04**
1,1-Dichloroethylene	75-35-4	**1.71E-03**	1.69E-03	**1.71E-04**
cis-1,2 Dichloroethylene	540-59-0	**2.35E-01**	2.31E-01	**2.35E-02**
trans-1,2 Dichloroethylene	540-59-0	**4.96E-03**	4.89E-03	**4.96E-04**
1,2 Dichloropropane	78-87-5	**3.47E-03**	3.42E-03	**3.47E-04**
Ethylbenzene	100-41-4	**2.76E-01**	2.73E-01	**2.76E-02**
Hexane	110-54-3	**1.17E-01**	1.16E-01	**1.17E-02**
Methyl Ethyl Ketone	78-93-3	**1.29E-01**	1.27E-01	**1.29E-02**
Methyl Isobutyl Ketone	108-10-1	**3.46E-02**	3.42E-02	**3.46E-03**
Methyl Mercaptan	74-93-1	**3.42E-01**	3.37E-01	**3.42E-02**
Methylene Chloride	75-09-2	**2.97E-01**	2.93E-01	**2.97E-02**
1,1,2,2-Tetrachloroethane	79-34-5	**4.29E-03**	4.23E-03	**4.29E-04**
Tetrachloroethylene	127-18-4	**1.15E-01**	1.13E-01	**1.14E-02**
Toluene	108-88-3	**6.84E-01**	6.75E-01	**6.84E-02**
Total Xylenes	1330-20-7	**5.91E-01**	5.83E-01	**5.91E-02**
1,1,1-Trichloroethane	71-55-6	**3.44E-02**	3.40E-02	**3.44E-03**
Trichloroethylene	79-01-6	**1.28E-01**	1.27E-01	**1.28E-02**
Trichlorofluoromethane	75-69-4	**3.48E-02**	3.43E-02	**3.48E-03**
Vinyl Chloride	75-01-4	**8.58E-02**	8.47E-02	**8.58E-03**

Note:

(1) The boldface numbers indicate the exposure point concentrations used in the Human Health Risk Assessment.

Table 4.2-2 **Long-Term Exposure Point Concentrations (1) for Chronic Exposure Scenarios Freeway Landfill Risk Assessment - Burnsville, MN**

Chemical of Concern	CAS No.	Long-Term Predicted Ambient Concentration (ug/m3) By Chronic Exposure Scenario		
		On-Site 25-yr Avg.	Off-Site 25-yr Avg.	Residence 30-yr Avg.
Acetone	67-64-1	4.44E-02	4.38E-02	4.29E-03
Acrylonitrile	107-13-1	3.66E-03	3.61E-03	3.54E-04
Benzene	71-43-2	2.04E-02	2.01E-02	1.97E-03
Carbon Tetrachloride	56-23-5	3.32E-05	3.27E-05	3.20E-06
Chlorobenzene	108-90-7	4.89E-02	4.83E-02	4.73E-03
Chloroethane	75-00-3	2.82E-02	2.78E-02	2.73E-03
Chloromethane	74-87-3	1.50E-02	1.48E-02	1.45E-03
Chloroform	67-66-3	8.27E-03	8.16E-03	7.99E-04
1,2-Dibromoethane	106-93-4	1.08E-02	1.06E-02	1.04E-03
m-Dichlorobenzene	541-73-1	7.32E-02	7.22E-02	7.07E-03
Dichlorodifluoromethane	75-71-8	3.41E-01	3.37E-01	3.30E-02
1,1-Dichloroethane	75-34-3	2.71E-02	2.67E-02	2.62E-03
1,2-Dichloroethane	107-06-2	4.69E-03	4.63E-03	4.53E-04
1,1-Dichloroethylene	75-35-4	1.44E-03	1.42E-03	1.39E-04
cis-1,2 Dichloroethylene	540-59-0	1.98E-01	1.95E-01	1.91E-02
trans-1,2 Dichloroethylene	540-59-0	4.18E-03	4.12E-03	4.04E-04
1,2 Dichloropropane	78-87-5	2.92E-03	2.88E-03	2.82E-04
Ethylbenzene	100-41-4	2.33E-01	2.30E-01	2.25E-02
Hexane	110-54-3	9.90E-02	9.77E-02	9.56E-03
Methyl Ethyl Ketone	78-93-3	1.08E-01	1.07E-01	1.05E-02
Methyl Isobutyl Ketone	108-10-1	2.92E-02	2.88E-02	2.82E-03
Methyl Mercaptan	74-93-1	2.88E-01	2.84E-01	2.78E-02
Methylene Chloride	75-09-2	2.50E-01	2.47E-01	2.42E-02
1,1,2,2-Tetrachloroethane	79-34-5	3.62E-03	3.57E-03	3.49E-04
Tetrachloroethylene	127-18-4	9.65E-02	9.52E-02	9.32E-03
Toluene	108-88-3	5.77E-01	5.69E-01	5.57E-02
Total Xylenes	1330-20-7	4.98E-01	4.91E-01	4.81E-02
1,1,1-Trichloroethane	71-55-6	2.90E-02	2.86E-02	2.80E-03
Trichloroethylene	79-01-6	1.08E-01	1.07E-01	1.04E-02
Trichlorofluoromethane	75-69-4	2.93E-02	2.89E-02	2.83E-03
Vinyl Chloride	75-01-4	7.23E-02	7.14E-02	6.99E-03

Note:

(1) These results are presented for the purposes of comparison with the Peak-Year results. These results are not carried through the Human Health Risk Assessment.

Table 4.2-3 **Exposure Point Concentrations for Scale-House Workers - Acute Exposure Scenario**
Freeway Landfill Risk Assessment - Burnsville, MN

Chemical of Concern	Concentration in Scale House (ppm)
1-Butanol	2.7
4-Methyl-2-Pentanone	2.42
Acetone	0.098
Acrylonitrile	0.0087
Benzene	0.033
Butane	0.10
Carbon Tetrachloride	0.000027
Chlorobenzene	0.054
Chlorodifluoromethane	0.037
Chloroethane	0.055
Chloroform	0.0081
1,2-Dichloroethane	0.034
1,2-Dichloroethene	0.17
Dichlorodifluoromethane	1.2
1,1-Dichloroethane	0.095
1,1-Dichloroethene	0.0019
Dichlorofluoromethane	0.033
Dichlorotetrafluoroethane	0.030
1,2-Dichloropropane	0.0033
1,2-Dimethyl Benzene	16
Ethanol	4.3
Ethyl Acetate	0.54
Ethyl Mercaptan	0.32
Ethylbenzene	0.28
Hexane	0.14
Hydrogen Sulfide	6.9
Methyl Isobutyl Ketone	0.037
Methyl Mercaptan	0.042
Methyl Ethyl Ketone	0.19
Methylcyclohexane	2.7
Nonane	4.5
Octane	4.1
Pentane	0.15
Propane	0.37
t-Butyl Mercaptan	0.017
1,1,2,2-Tetrachloroethane	0.0027
Tetrachloroethylene	0.073
Tetrahydrofuran	0.81
Toluene	0.79
Total Xylenes	0.59
1,1,1-Trichloroethane	0.023
Trichloroethylene	0.10
Trichlorofluoromethane	0.027
Vinyl Chloride	0.15

4.3 Values for Exposure Variables

As previously discussed, exposures received by two receptors are the main focus of the quantitative portion of the HHRA (chronic exposure scenarios). The receptor populations assessed in these scenarios (i.e., landfill workers and off-site residents) are evaluated as adult receptors (ages 18-70 years). It is assumed that workers are employed at the landfill for 25 years and individuals reside near the landfill site for 30 years (EPA, 1991). Table 4.3-1 presents values for each exposure variable employed in the risk estimation equations of this HHRA.

4.4 Evaluation of Exposures Associated with the Inhalation of Landfill Gas Compounds (Chronic Exposures)

The MPCA is in the process of updating the Air Toxics Source Review Guide (Version 2.1, February, 1991), which establishes a review procedure for new or modified sources of toxic ("non-criteria") air pollutants. In the meantime, MPCA has updated the tables presenting air concentration limits (ACLs). The ACLs are guideline policy, and are not strictly enforceable as regulations or air quality standards. The Air Toxics Source Review Guide used in this section has been developed for both non-carcinogens and carcinogens and, as directed by MPCA, have been used in this HHRA. The ACLs replace the allowable air limits (AALs) for assessing the severity of predicted impacts for toxic air pollutants.

Table 4.4-1 compares the modeled worst-case annual average exposure point concentrations for the peak-year landfill gas emission rate with MPCA air concentration units (ACLs). Worst-case annual average refers to the fact that the highest annual average of five years of meteorological data were used to represent a 30-year average. The worst year out of five years was taken to represent long-term average, and is consistent with the RME-approach. The Hazard Index shown in the table is calculated according to the procedure specified in the Toxics Source Review Guide and is the ratio of the predicted concentration to the ACL. The Guide states that none of the Hazard Indices should equal or exceed 1.0. In addition, the Guide specifies that the total Hazard Indices for each receptor location should be less than 1.0 when added.

Table 4.4-1 shows that none of the estimated worst-case peak-year concentrations exceed an ACL. However, for the on-site worker the total of all of the Hazard Indices is 1.25, which slightly exceeds the total Hazard Index of 1. For the off-site residential scenario, the concentrations of the chemicals of concern in landfill gas are well below MPCA criteria levels, and the Hazard Index of 1.

Vinyl Chloride, with a Hazard Index of 0.86 for the peak-year chronic worker exposure, is the principal contributor to inhalation risk. Its Hazard Index accounts for more than half of the total Hazard Index of 1.25 for this scenario.

Table 4..4-2 contains the same information as Table 4.4-1, but for a long-term average landfill gas emission rate, not the peak-year landfill gas emission rate. This information is presented solely for the purpose of comparison. It is not carried through the rest of the HHRA. The 25-year average results are approximately 84 percent of the peak-year results. The 30-year average results are about eighty-two percent of the peak-year results.

Table 4.3-1 **Summary of Exposure Variables**
Freeway Landfill Risk Assessment - Burnsville, MN

RISK MODEL NAME: **Inhalation of Air**
SOURCE: **MPCA, 1993**

Non-Carcinogens: $HQ = \frac{Ca\ (mg/m^3)}{RfC\ (mg/m^3)}$

Carcinogens: Cancer Risk = Ca (µg/m^3) * ET (hrs/24 hrs) * AT (yrs/70 yrs) * UR (µg/m^3)^-1

Variable Symbol	Variable Definition	Variable Values That Could Be Selected	Variable Value Selected/Percentile	Reason for Variable Selection	Reference	Comments
Ca	Contaminant Concentration in Air (mg/m^3 or µg/m^3)	Minimum to Maximum Concentrations	Upper 95th percentile of geometric mean estimated from ISLCT model	Consistent with RME Approach	EPA, 1990	· Based on air modeling
ET	Exposure Time	residents: 0 to 24 hours/day workers: 0 to 24 hours/day	24 hours/day 8 hours/day	Consistent with RME Approach	EPA, 1989	
AT	Averaging Time	residents: 0 to 70 years workers: 0 to 70 years	30 years 25 years	Consistent with RME Approach	EPA, 1989	
RfC	Reference Concentration (mg/m^3)	chemical-specific	See Table 5.1-1	Consistent with EPA guidance	EPA, 1993	
UR	Unit Risk	chemical-specific	See Table 5.1-1	Consistent with EPA guidance	EPA, 1993	

Table 4.4-1 **Comparison of Peak-Year Results for Chronic Exposure Scenarios to MPCA Air Concentration Limits Freeway Landfill Risk Assessment - Burnsville, MN**

Chemical of Concern	MPCA ACL(2) (ug/m3)	On-Site Exposure(1) Conc. (ug/m3)	On-Site Exposure(1) Hazard Index	Off-Site Exposure Conc. (ug/m3)	Off-Site Exposure Hazard Index	Residential Exposure(1) Conc. (ug/m3)	Residential Exposure(1) Hazard Index
Acetone	NA	**5.27E-02**	NA	5.20E-02	NA	**5.27E-03**	NA
Acrylonitrile	2.0	**4.34E-03**	2.17E-03	4.28E-03	2.14E-03	**4.34E-04**	2.17E-04
Benzene	1.0	**2.42E-02**	2.42E-02	2.38E-02	2.38E-02	**2.42E-03**	2.42E-03
Carbon Tetrachloride	0.7	**3.93E-05**	5.62E-05	3.88E-05	5.54E-05	**3.93E-06**	5.62E-06
Chlorobenzene	20.0	**5.81E-02**	2.90E-03	5.73E-02	2.86E-03	**5.81E-03**	2.90E-04
Chloroethane	NA	**3.35E-02**	NA	3.30E-02	NA	**3.35E-03**	NA
Chloromethane	5.6	**1.78E-02**	3.18E-03	1.76E-02	3.14E-03	**1.78E-03**	3.18E-04
Chloroform	0.4	**9.81E-03**	2.45E-02	9.68E-03	2.42E-02	**9.81E-04**	2.45E-03
1,2-Dibromoethane	0.05	**1.28E-02**	2.56E-01	1.26E-02	2.52E-01	**1.28E-03**	2.55E-02
m-Dichlorobenzene	800.0	**8.69E-02**	1.09E-04	8.57E-02	1.07E-04	**8.68E-03**	1.09E-05
Dichlorodifluoromethane	200.0	**4.05E-01**	2.03E-03	4.00E-01	2.00E-03	**4.05E-02**	2.03E-04
1,1-Dichloroethane	500.0	**3.21E-02**	6.43E-05	3.17E-02	6.34E-05	**3.21E-03**	6.43E-06
1,2-Dichloroethane	0.4	**5.57E-03**	1.39E-02	5.49E-03	1.37E-02	**5.57E-04**	1.39E-03
1,1-Dichloroethylene	0.2	**1.71E-03**	8.55E-03	1.69E-03	8.44E-03	**1.71E-04**	8.55E-04
cis-1,2 Dichloroethylene	NA	**2.35E-01**	NA	2.31E-01	NA	**2.35E-02**	NA
trans-1,2 Dichloroethylene	NA	**4.96E-03**	NA	4.89E-03	NA	**4.96E-04**	NA
1,2 Dichloropropane	4.0	**3.47E-03**	8.67E-04	3.42E-03	8.55E-04	**3.47E-04**	8.67E-05
Ethylbenzene	1,000.0	**2.76E-01**	2.76E-04	2.73E-01	2.73E-04	**2.76E-02**	2.76E-05
Hexane	200.0	**1.17E-01**	5.85E-04	1.16E-01	5.80E-04	**1.17E-02**	5.85E-05
Methyl Ethyl Ketone	1,000.0	**1.29E-01**	1.29E-04	1.27E-01	1.27E-04	**1.29E-02**	1.29E-05
Methyl Isobutyl Ketone	80.0	**3.46E-02**	4.33E-04	3.42E-02	4.27E-04	**3.46E-03**	4.33E-05
Methyl Mercaptan	NA	**3.42E-01**	NA	3.37E-01	NA	**3.42E-02**	NA
Methylene Chloride	3,000.0	**2.97E-01**	9.90E-05	2.93E-01	9.77E-05	**2.97E-02**	9.90E-06
1,1,2,2-Tetrachloroethane	0.2	**4.29E-03**	2.15E-02	4.23E-03	2.12E-02	**4.29E-04**	2.15E-03
Tetrachloroethylene	17.2	**1.15E-01**	6.69E-03	1.13E-01	6.57E-03	**1.14E-02**	6.63E-04
Toluene	400.0	**6.84E-01**	1.71E-03	6.75E-01	1.69E-03	**6.84E-02**	1.71E-04
Total Xylenes	NA	**5.91E-01**	NA	5.83E-01	NA	**5.91E-02**	NA
1,1,1-Trichloroethane	1,000.0	**3.44E-02**	3.44E-05	3.40E-02	3.40E-05	**3.44E-03**	3.44E-06
Trichloroethylene	5.9	**1.28E-01**	2.18E-02	1.27E-01	2.15E-02	**1.28E-02**	2.18E-03
Trichlorofluoromethane	700.0	**3.48E-02**	4.97E-05	3.43E-02	4.90E-05	**3.48E-03**	4.97E-06
Vinyl Chloride	0.1	**8.58E-02**	8.58E-01	8.47E-02	8.47E-01	**8.58E-03**	8.58E-02
Total Hazard Index (3)			1.25E+00		1.23E+00		1.25E-01

Notes:

(1) The boldface numbers indicate the exposure point scenarios to be used in the Human Health Risk Assessment.

(2) MPCA Annual Average Air Concentration Limits (ACLs) for both non-carcinogens and carcinogens. The Hazard Index is the ratio of the predicted concentration to the ACL. MPCA has specified an acceptable Hazard Index of 1.0.

(3) Total Hazard Index for both non-carcinogens and carcinogens.

Table 4.4-2 **Comparison of Long-Term Results for Chronic Exposure Scenarios to MPCA Air Concentration Limits Freeway Landfill Risk Assessment - Burnsville, MN**

		On-Site Exposure		Off-Site Exposure		Residential Exposure	
Chemical of Concern	MPCA ACL(1) (ug/m3)	25-yr Avg. Conc. (ug/m3)	Hazard Index	25-yr Avg. Conc. (ug/m3)	Hazard Index	30-yr Avg. Conc. (ug/m3)	Hazard Index
Acetone	NA	4.44E-02	NA	4.38E-02	NA	4.29E-03	NA
Acrylonitrile	2.0	3.66E-03	1.83E-03	3.61E-03	1.81E-03	3.54E-04	1.77E-04
Benzene	1.0	2.04E-02	2.04E-02	2.01E-02	2.01E-02	1.97E-03	1.97E-03
Carbon Tetrachloride	0.7	3.32E-05	4.74E-05	3.27E-05	4.67E-05	3.20E-06	4.57E-06
Chlorobenzene	20.0	4.89E-02	2.45E-03	4.83E-02	2.41E-03	4.73E-03	2.36E-04
Chloroethane	NA	2.82E-02	NA	2.78E-02	NA	2.73E-03	NA
Chloromethane	5.6	1.50E-02	2.68E-03	1.48E-02	2.65E-03	1.45E-03	2.59E-04
Chloroform	0.4	8.27E-03	2.07E-02	8.16E-03	2.04E-02	7.99E-04	2.00E-03
1,2-Dibromoethane	0.05	1.08E-02	2.15E-01	1.06E-02	2.12E-01	1.04E-03	2.08E-02
m-Dichlorobenzene	800.0	7.32E-02	9.15E-05	7.22E-02	9.03E-05	7.07E-03	8.84E-06
Dichlorodifluoromethane	200.0	3.41E-01	1.71E-03	3.37E-01	1.69E-03	3.30E-02	1.65E-04
1,1-Dichloroethane	500.0	2.71E-02	5.42E-05	2.67E-02	5.34E-05	2.62E-03	5.23E-06
1,2-Dichloroethane	0.4	4.69E-03	1.17E-02	4.63E-03	1.16E-02	4.53E-04	1.13E-03
1,1-Dichloroethylene	0.2	1.44E-03	7.21E-03	1.42E-03	7.11E-03	1.39E-04	6.96E-04
cis-1,2 Dichloroethylene	NA	1.98E-01	NA	1.95E-01	NA	1.91E-02	NA
trans-1,2 Dichloroethylene	NA	4.18E-03	NA	4.12E-03	NA	4.04E-04	NA
1,2 Dichloropropane	4.0	2.92E-03	7.31E-04	2.88E-03	7.21E-04	2.82E-04	7.06E-05
Ethylbenzene	1,000.0	2.33E-01	2.33E-04	2.30E-01	2.30E-04	2.25E-02	2.25E-05
Hexane	200.0	9.90E-02	4.95E-04	9.77E-02	4.89E-04	9.56E-03	4.78E-05
Methyl Ethyl Ketone	1,000.0	1.08E-01	1.08E-04	1.07E-01	1.07E-04	1.05E-02	1.05E-05
Methyl Isobutyl Ketone	80.0	2.92E-02	3.65E-04	2.88E-02	3.60E-04	2.82E-03	3.53E-05
Methyl Mercaptan	NA	2.88E-01	NA	2.84E-01	NA	2.78E-02	NA
Methylene Chloride	3,000.0	2.50E-01	8.35E-05	2.47E-01	8.23E-05	2.42E-02	8.06E-06
1,1,2,2-Tetrachloroethane	0.2	3.62E-03	1.81E-02	3.57E-03	1.79E-02	3.49E-04	1.75E-03
Tetrachloroethylene	17.2	9.65E-02	5.61E-03	9.52E-02	5.53E-03	9.32E-03	5.42E-04
Toluene	400.0	5.77E-01	1.44E-03	5.69E-01	1.42E-03	5.57E-02	1.39E-04
Total Xylenes	NA	4.98E-01	NA	4.91E-01	NA	4.81E-02	NA
1,1,1-Trichloroethane	1,000.0	2.90E-02	2.90E-05	2.86E-02	2.86E-05	2.80E-03	2.80E-06
Trichloroethylene	5.9	1.08E-01	1.83E-02	1.07E-01	1.81E-02	1.04E-02	1.77E-03
Trichlorofluoromethane	700.0	2.93E-02	4.19E-05	2.89E-02	4.13E-05	2.83E-03	4.04E-06
Vinyl Chloride	0.1	7.23E-02	7.23E-01	7.14E-02	7.14E-01	6.99E-03	6.99E-02
Total Hazard Index			1.05E+00		1.04E+00		1.02E-01

Notes:

(1) MPCA Annual Average Air Concentration Limits for both non-carcinogens and carcinogens. The Hazard Index is the ratio of the predicted concentration to the ACL. MPCA has specified an acceptable Hazard Index of 1.0.

4.5 Evaluation of Exposures Associated with the Inhalation of Non-Methane Organic Compounds (Acute Exposures)

EPCs for COCs in Dataset No. 1 and No. 2 were compared to available MPCA air concentration limits (ACLs) and permissible acute occupational exposure limits. Acute occupational guidelines and standards include: (1) Occupational Safety and Health Agency (OSHA) time-weighted averages (TWA), recommended action levels and ceiling values; (2) National Institute of Occupational Safety and Health (NIOSH) immediately dangerous to life or health (IDLH) and ceiling values; and (3) American Conference of Governmental Industrial Hygienists (ACGIH) short-term exposure limits (STEL), ceiling values, and TWAs.

Table 4.5-1 compares scale-house EPCs (Dataset No. 2 COCs) to the chemical-specific air concentration limits and standards. This table shows that none of these calculated reasonable maximum exposure levels for any of the chemicals of concern exceed any of the identified acute occupational guidelines or standards.

Table 4.5-1 **Comparison of Estimated Exposure Point Concentrations in the Scale-House to Occupational Exposure Levels Freeway Landfill Risk Assessment - Burnsville, MN**

Chemical of Concern	Concentration in Scale House (ppm)	OSHA (1) (ppm)	NIOSH (2) (ppm)	ACGIH (3) (ppm)
1-Butanol	2.7	50 C	800 I	50 T
Acetone	0.098	1000 T	250 T	1000 S
			20,000 I	750 T
Acrylonitrile	0.0087	10 C	Carcinogen	Carcinogen
		2 T		
Benzene	0.033	5 S	Carcinogen	Carcinogen
		1 T		
		0.5 A		
Butane	0.10	800 T		800 T
Carbon Tetrachloride	0.000027	25 C	Carcinogen	Carcinogen
		10 T	2 C	5 T
Chlorobenzene	0.054	75 T	2400 I	75 T
Chlorodifluoromethane	0.037	1000 T		1250 S
				1000 T
Chloroethane	0.055	1000 T	20,000 I	1000 T
Chloroform	0.0081	50 C	2 C	Carcinogen
		2 T		10 T
1,2-Dibromoethane	0.0081		Carcinogen	
1,2-Dichloroethane	0.034	2 S15	Carcinogen	2 S15
		1 T		1 T
1,2-Dichloroethene	0.17	200 T	4000 I	200 T
Dichlorodifluoromethane	1.2	1000 T	50,000 I	1000 T
1,1-Dichloroethane	0.095	100 T	4000 I	250 S
				200 T
1,1-Dichloroethene	0.0019	1 T		20 S
				5 T
Dichlorofluoromethane	0.033	10 T	50,000 I	10 T
Dichlorotetrafluoroethane	0.030	1000 T	50,000 I	1000 T
1,2-Dichloropropane	0.0033	75 T	2000 I	110 S
				75 T
1,2-Dimethyl Benzene	16	100 T	1000 I	150 S
				100 T
Ethane	6.9			Asphyxiant
Ethanol	4.3	1000 T		1000 T
Ethyl Acetate	0.54	400 T	10,000 I	400 T
Ethyl Mercaptan	0.32		2500 I	0.5 T
Ethylbenzene	0.28	100 T	2000 I	125 S
				100 T
Hexane	0.14	50 T		50 T
Hydrogen Sulfide	6.9	15 S15	300 I	15 S
		10 T	10 C	10 T
Methyl Isobutyl Ketone	0.037	75 S15	3000 I	75 S
		50 T	50 T	50 T
Methyl Mercaptan	0.042	10 C	400 I	0.5 T

Table 4.5-1 (continued) **Comparison of Estimated Exposure Point Concentrations in the Scale-House to Occupational Exposure Levels Freeway Landfill Risk Assessment - Burnsville, MN**

Chemical of Concern	Concentration in Scale House (ppm)	OSHA (1) (ppm)	NIOSH (2) (ppm)	ACGIH (3) (ppm)
			0.5 C	
Methyl Ethyl Ketone	0.19	200 T	3000 I	300 S 200 T
Methylcyclohexane	2.7		10,000 I	400 T
Nonane	4.5	200 T		200 T
Octane	4.1	375 S15 300 T	5000 I	375 S 300 T
Pentane	0.15	750 S15 600 T	5000 I	750 S 600 T
Propane	0.37	1000 T	20,000 I	Asphyxiant
Propene	0.98			Asphyxiant
t-Butyl Mercaptan	0.017		2500 I	0.5 T
1,1,2,2-Tetrachloroethane	0.0027	5 T	Carcinogen 1 T	1 T
Tetrachloroethene	0.073	300 C	Carcinogen	200 S 50 T
Tetrahydrofuran	0.81		20,000 I	250 S 200 T
Toluene	0.79		2000 I 100 C	150 S 100 T
Total Xylene Isomers	0.59	100 T	1000 I 100 C	150 S 100 T
1,1,1-Trichloroethane	0.023	350 T	1000 I 350 C	450 S 350 S
Trichloroethene	0.10	100 T 300 C	Carcinogen 25 T	200 S 50 ¥
Trichlorofluoromethane	0.027		10,000 I	1000 C
Vinyl Chloride	0.15	1 T	Carcinogen	5 T

Notes:

(1) Occupational Safety and Health Agency (OSHA). As presented in TOMES (R) 1991. Hazardous Substance Data Bank.

(2) National Institute of Occupational Safety and Health (NIOSH). As presented in TOMES (R) 1991. Hazardous Substance Data Bank.

(3) American Conference of Governmental Industrial Hygenists (ACGIH). As presented in TOMES (R) 1991. Hazardous Substance Data Bank.

(C) = Ceiling value
(I) = Immediately Dangerous to Life or Health (IDLH)
(T) = Time Weighted Average (TWA)
(S15) = 15-minute Short-Term Exposure Limit (STEL)
(A) = Recommended action level
NA = Data not available
-- = Value not reported

Section 5
Toxicity Assessment

A toxicity assessment evaluates the potential for each chemical to pose adverse health effects in exposed individuals and provides an estimate of the dose/response relationship between the extent of exposure to a particular contaminant and adverse effects. For the Freeway Landfill HHRA, only toxicity values for chronic exposures were employed.

For the toxicity assessment component of the HHRA, qualitative and quantitative information is provided to describe the non-carcinogenic and carcinogenic health effects associated with COCs presented in Dataset No. 1. Two measures used to quantify the toxic effects of a chemical on human health include an inhalation non-carcinogenic reference concentration (R_fC), and a carcinogenic unit risk (UR).

5.1 Assessment of Chemicals of Concern in Dataset No. 1

Non-carcinogenic and carcinogenic inhalation toxicity values were obtained from EPA's current Integrated Risk Information System (IRIS) on-line database files (EPA, 1993). Values for COCs not listed in IRIS were obtained from the EPA's Health Effects Assessment Summary Tables (HEAST) (EPA, 1992). Additional toxicity values were also obtained from EPA's Environmental Criteria and Assessment Office (ECAO) for compounds which are currently undergoing toxicity review.

COCs for which inhalation toxicity data are not presented in these EPA sources were not evaluated in this portion of the HHRA. These COCs were addressed in the uncertainty assessment component of the HHRA.

Inhalation toxicity values (R_fCs and URs) were not available for the following compounds: acetone, m-dichlorobenzene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, methyl mercaptan, total xylenes, 1,1-1 trichloroethane and trichlorofluoromethane.

Available inhalation toxicity values for COCs in Dataset No. 1 are presented in Table 5.1-1. Table 5.1-2 presents summarized toxicity data for all non-carcinogenic Dataset No. 1 COCs with readily available R_fCs. Carcinogenic toxicity data is presented in Table 5.1-3 for Dataset No. 1 COCs with readily available inhalation unit risks.

5.2 Assessment of Chemicals of Concern in Dataset No. 2

A limited qualitative toxicity evaluation has been conducted to assess the estimated EPCs derived for non-methane organic compounds of landfill gas origin in the scale-house. Acute toxicity data were presented in tabular form and were limited to readily available data sources. These toxicity values will be combined with the modeled air concentrations and selected exposure variables to derive non-carcinogenic and carcinogenic risk estimates, as presented in Section 6.0.

Table 5.1-1 **Availability of Non-Carcinogenic (RfC) and Carcinogenic (UR) Inhalation Toxicity Values for Chemicals of Concern in Dataset No. 1 Freeway Landfill Risk Assessment - Burnsville, MN**

Chemical of Concern	CAS No.	Inhalation RfC (mg/m^3)	Inhalation Unit Risk (µg/m^3)
Acetone	67-64-1	NA	NA
Acrylonitrile	107-13-1	2.0E-03 (EPA, 1993)	6.8E-05 (EPA, 1993)
Benzene	71-43-2	NA	8.3E-06 (EPA, 1993)
Carbon Tetrachloride	56-23-5	NA	1.5E-05 (EPA, 1993)
Chlorobenzene	108-90-7	2.0E-02 (EPA, 1992b)	NA
Chloroethane	75-00-3	1.0E+01 (EPA, 1993)	NA
Chloromethane	74-87-3	NA	1.8E-06 (EPA, 1992a)
Chloroform	67-66-3	NA	2.3E-05 (EPA, 1993)
1,2-Dibromoethane	106-93-4	NA	2.2E-04 (EPA, 1993)
m-Dichlorobenzene	541-73-1	NA	NA
Dichlorodifluoromethane	75-71-8	2.0E-01 (EPA, 1992b)	NA
1,1-Dichloroethane	75-34-3	5.0E-01 (EPA, 1992b)	NA
1,2-Dichloroethane	107-06-2	NA	2.6E-05 (EPA, 1993)
1,1-Dichloroethylene	75-35-4	NA	5.0E-05 (EPA, 1993)
cis-1,2-Dichloroethylene	540-59-0	NA	NA
trans-1,2-Dichloroethylene	540-59-0	NA	NA
1,2-Dichloropropane	78-87-5	4.3E-03 (EPA, 1993)	NA
Ethyl Benzene	100-41-4	1.0E+00 (EPA, 1993)	NA
Hexane	110-54-3	2.0E-01 (EPA, 1993)	NA
Methyl Ethyl Ketone	78-93-3	1.0E+00 (EPA, 1993)	NA
Methyl Isobutyl Ketone	108-10-1	8.0E-02 (EPA, 1992b)	NA
Methyl Mercaptan	74-93-1	NA	NA
Methylene Chloride	75-09-2	NA	4.7E-07 (EPA, 1993)
1,1,2,2-Tetrachloroethane	79-34-5	NA	5.8E-05 (EPA, 1993)
Tetrachloroethylene	127-18-4	NA	5.8E-07 (ECAO, 1993)
Toluene	108-88-3	4.0E-01 (EPA, 1993)	NA
Total Xylenes	1330-20-7	NA	NA
1,1,1-Trichloroethane	71-55-6	NA	NA
Trichloroethylene	79-01-6	NA	1.76E-06 (ECAO, 1993)
Trichlorofluoromethane	75-69-4	NA	NA
Vinyl Chloride	75-01-4	NA	8.4E-05 (EPA, 1992a)

Notes:

NA = Not Available

References:

EPA, 1993. Integrated Risk Information System (IRIS). On-line database.

EPA, 1992a. Health Effects Assessment Summary Tables (HEAST). Annual FY 1992, as amended in the November update. Office of Emergency and Remedial Response. OERR 9200.6-303(92-1). March.

EPA, 1992b. Health Effects Assessment Summary Tables (HEAST). Annual FY 1992, as amended in the November update. Office of Emergency and Remedial Response. OERR 9200.6-303(92-1). March. Alternate Methods Value.

ECAO Fax received by CDM on May 3, 1993 from EPA, ECAO, Cincinnati, OH.

Table 5.1-2 **Toxicity Data for Non-Carcinogenic Chemicals of Concern in Data Set No. 1 (1)**

Chemical of Concern	Principal Study / Basis for RfC	Type of Study	Critical Effect(s)	Study Synopsis / Source
Acrylonitrile	Quast et al., 1980	rat; 2 years; inhalation	degeneration and inflammation of nasal respiratory epithelium; hyperplasia of mucous secreting cells	Rats were exposed 6 hours/day, 5 days/week for 2 years to concentrations of 0, 20, or 80 ppm. Control group only exposed to air. Statistically significant increase in mortality was observed within the first year for both male and female rats. (EPA, 1993)
Chlorobenzene	(2)	rat; 120 days; inhalation	liver and kidney effects	Currently undergoing review by EPA work group (EPA, 1993). Alternate RfC values derived from methodology that is not current with the interim inhalation methodology used by the RfD/RfC Work Group. (EPA, 1992b)
Chloroethane	Scortichi et al.1986: Inhalation Teratology Study in CF-1 Mice.	mouse; 10 days; inhalation (developmental study)	delayed fetal ossification; fetotoxicity	Mice were exposed to chloroethane at mean time-weighted averages of 0 g/cu.m. (air), 1.3 g/cu.m., 4,000 g/cu.m., and 13,000 g/cu. m. for 6 hours/day on days 6 through 15 of gestation. Upon sacrifice, lesions in skull bones were observed. (EPA,1993)
Dichlorodifluoromethane	(2)	guinea pig; 6 weeks; inhalation	liver lesions	Currently undergoing review by EPA work group (EPA, 1993). Alternate RfC value derived from methodology that is not current with the interim inhalation methodology used by the RfD/RfC Work Group. (EPA, 1992b)
1,1-Dichloroethane	(2)	cat; 13 weeks; inhalation	kidney damage	Currently undergoing review by EPA work group (EPA, 1993). Alternate RfC values derived from methodology that is not current with the interim inhalation methodology used by the RfD/RfC Work Group. (EPA, 1992b)
1,2-Dichloropropane	Nitschke et al., 1988; propylene dichloride: A 13 Week Inhalation Toxicity Study With Rats, Mice, and Rabbits.	rat; 13 weeks; inhalation	hyperplasia of the nasal mucosa	Male and female rats were exposed to 0, 15, 50 and 150 ppm of dichloropropane for 6 hours/day, 5 days/week for 13 weeks. Histopathological effects were observed in the upper respiratory tract of the rats at a LOAEL of 15 ppm. (EPA, 1993)

Table 5.1-2 (continued) **Toxicity Data for Non-Carcinogenic Chemicals of Concern in Data Set No. 1 (1)**

Chemical of Concern	Principal Study / Basis for RfC	Type of Study	Critical Effect(s)	Study Synopsis / Source
Ethyl Benzene	Andrew et al., 1981; Teratologic Assessment of Ethylbenzene and 2-Ethyoxyethanol; Hardin et al., 1981. Testing of Selected Workplace Chemicals for Teratogenic Potential	rat and rabbit; 19 days; inhalation (developmental study)	developmental toxicity	Rats and rabbits were exposed 6-7 hours/day to concentrations of 434 or 4,342 mg/cu. m. of ethylbenzene. The principal observation following sacrificing of animals was a reduced number of live rabbit kits per litter and in rats an increased incident of extra ribs. (EPA, 1993)
Hexane	Sanagai et al., 1980; Peripheral Nervous System Functions of Workers Exposed to n-Hexane at a Low Level	human; 2 years; inhalation (epidemiological study)	neurotoxicity; electrophysiological alterations	Sanagai conducted an epidemiological study on two age-matched groups consisting of 14 control workers and 14 exposed workers employed in a factory producing tungsten carbide alloys. 8-Hour time weighted average exposure to solvent vapors consisted of 73 mg/ cu. m. Both groups suffered neuro-toxicity and slowed neurological conductivity. (EPA, 1993)
	Dunnick et al., 1989; 13 week toxicity study of n-hexane in B6C3F1 mice after inhalation exposure	mouse; 90 days; inhalation	epithelial lesions in the nasal cavity	Inhalation of n-hexane resulted in morphologic alterations in the respiratory tract in mice at a LOAEL of 1,762 mg/cu. m. (EPA, 1993)
Methyl Ethyl Ketone	Schwetz et al., 1991; Developmental Toxicity of Inhaled Methyl Ethyl Ketone in Mice; Mast et al., 1989. (both considered as one single study)	mouse; 12 weeks; inhalation (developmental study)	decreased fetal birth weight	Mice were exposed to 0, 1,742,978, or 8,906 mg/cu. m. of MEK for 7 hours/day during gestational days 6-15. Fetal body decrease was observed in the 8,906 mg/cu. m. exposed group.

Table 5.1-2 (continued) **Toxicity Data for Non-Carcinogenic Chemicals of Concern in Data Set No. 1** (1)

Chemical of Concern	Principal Study / Basis for RfC	Type of Study	Critical Effect(s)	Study Synopsis / Source
Methyl Isobutyl Ketone	(2)	rat; 90 days; inhalation	liver and kidney effects; increased weight effects	RfC is currently undergoing review and value may be subject to change (EPA, 1992). Alternate RfC values derived from methodology that is not current with the interim inhalation methodology used by the RfD/RfC Work Group. (EPA, 1992b)
Toluene	Foo et al., 1990; Chronic Neurobehavioral Effects of Toluene	human; 8 hour-TWA inhalation; (occupational exposure)	neurological effects	This cross sectional study generated a LOAEL of 88 ppm (332 mg/cu. m.) for central nervous system (CNS) effects and was used for deriving the RfC. CNS effects are supported by other occupational studies that show effects around 100 ppm.

Notes:
(1) Information provided only for Dataset No. 1 COCs with readily available inhalation RfCs.
(2) Studies not available for alternate RfCs.

Table 5.1-3 **Toxicity Data for Carcinogenic Chemicals of Concern in Data Set No. 1** (1)

Chemical of Concern	EPA weight-of-evidence	Principle Study/ Basis of Unit Risk or Slope Factor	Type of Study	Tumor Type/ Target Organ	Study Synopsis / Source
Acrylonitrile		O'Berg, 1980	human; 9 years; inhalation	respiratory cancer; lung	An exposure of 15 ppm was assumed to be the 8-hour TWA with an average duration of 9 years. The unit risk factor was calculated from a relative risk model adjusted for smoking and based on continuous lifetime equivalent of occupational exposure. (EPA, 1993)
Benzene	A; known human carcinogen	Rinsky et al., 1981; Ott et al., 1979; Wong et al., 1983	human; inhalation; (occupational study)	leukemia; blood	The unit risk factor is based on the geometric mean which employed pooled data from the studies cited. The increases in leukemia were statistically significant and dose-related in one of the studies. (EPA, 1993)
Carbon Tetrachloride	B2; probable human carcinogen	Della Porta et al. 1961; Edwards et al., 1942; NCI 1976-7	hamster; mouse; and rats; oral (gavage) (route-to route extrapolation)	hepatocellular carcinomas / hepatomas; liver	A linearized multi-stage procedure was employed to derive the unit risk factor which was calculated assuming an air intake of 20 cu. m./ day and 40 % absorption rate by humans.
Chloromethane	C; possible human carcinogen (limited evidence of carcinogenicity in humans)	- -	mouse; 24-months; inhalation	tumor; kidneys	(2) (EPA, 1992a)
Chloroform	B2; Probable human carcinogen	NCI 1976	mouse; 78 weeks; oral (gavage) (route-to-route extrapolation)	hepacellular carcinoma/ liver	A linearized multi-stage procedure was used to derive the inhalation unit risk. Inhalation risk estimates were derived from data from an oral study. (EPA, 1993)

Table 5.1-3 (continued)

Toxicity Data for Carcinogenic Chemicals of Concern in Data Set No. 1 (1)

Chemical of Concern	EPA weight-of-evidence	Principle Study/ Basis of Unit Risk or Slope Factor	Type of Study	Tumor Type/ Target Organ	Study Synopsis / Source
1,2-Dibromoethane	B2; probable human carcinogen	Crump and Howe, 1984; NTP, 1982	rat; 88 to 103 weeks; inhalation	papillary adenoma cell carcinoma; nasal cavity	A linearized multi-stage procedure was used to derive the inhalation unit risk. Rats were exposed for 6 hours/day, 5 days/week. Results were extrapolated to humans. (EPA,1993)
1,2-Dichloroethane	B2; probable human carcinogen	Maltoni et al., 1980	rat; 78 weeks; oral (gavage) (route-to-route extrapolation)	sarcoma; circulatory system	A linearized multi-stage procedure was used to derive the inhalation unit risk. The inhalation unit risk factor was calculated from oral data, assuming 100% absorption. Based on the negative inhalation study a 95% upper bound on risk was inferred to be 1E-6/cu. m. (EPA, 1993)
1,1-Dichloroethylene	C; possible human carcinogen (limited evidence of carcinogenicity in humans)	Maltoni et al., 1977 and 1985	mouse; 12 months; inhalation	adenocarcinoma; kidney	The unit risk factor was derived from data from the two studies cited. No statistical significant differences between tumor incidences were observed. (EPA, 1993)
Methylene Chloride	B2; probable human carcinogen	NTP, 1986	mouse; inhalation	combined adenomas and carcinomas;	Inhalation unit risk is based on dose-risk extrapolations which used a pharmacokinetic model. Tumor incidents significantly increased in a dose-dependent fashion. (EPA, 1993)
1,1,2,2-Tetrachloroethane	C; possible human carcinogen	NCI, 1978	mouse; 75 weeks; oral (gavage) (route-to-route extrapolation)	carcinoma; liver	The inhalation unit risk factor was calculated from oral exposure data. A highly significant dose-related increase in the incident of hepatocellular carcinomas was observed in both male and female mice. (EPA, 1993)

Table 5.1-3 (continued) **Toxicity Data for Carcinogenic Chemicals of Concern in Data Set No. 1 (1)**

Chemical of Concern	EPA weight-of-evidence	Principle Study/ Basis of Unit Risk or Slope Factor	Type of Study	Tumor Type/ Target Organ	Study Synopsis / Source
Tetrachloroethylene	B2; probable to possible human carcinogen	Addendum to the Health Assessment Document for Tetrachloroethylene. EPA #600/8.82/005FA.	- -	- -	Currently this chemical is undergoing extensive CRAVE - IRIS verification by the EPA. (ECAO, 1993)
Trichloroethylene	C-B2; probable to possible human carcinogen	Addendum to the Health Assessment Document for Trichloroethylene. EPA #600/8.82/006FA.	- -	- -	Currently this chemical is undergoing extensive CRAVE - IRIS verification by the EPA (ECAO, 1993). EPA withdrew the IRIS carcinogenic file in July 1989 and has not adopted a current position on the weight of evidence. (ECAO, 1993)
Vinyl Chloride	A; known human carcinogen	- -	rat: 1,001 days; inhalation	liver tumors; liver	EPA Office of Health and Environmental Assessment's position is that available toxicity values do not reflect state-of-the-art science for vinyl chloride assessment. (EPA 1992)

Notes:
(1) Toxicity Information provided only for Dataset No. 1 COCs with available inhalation unit risks.
(2) Study synopsis not available.

Section 6
Risk Characterization

Risk characterization involves combining toxicity values for each chemical of concern with exposure estimates for each receptor to derive estimates of total non-carcinogenic and carcinogenic risks (see Table 6.0-1). Toxicity values used in quantifying risk have been developed by the EPA for most, but not all, of the COCs. The potential additive effects of chemicals with similar toxicological endpoints are accounted for by summing the risks from these chemicals to obtain overall risk estimates. Potential synergistic (greater than additive) or antagonistic (less than additive) effects may also be important, hence synergistic effects are qualitatively discussed in Section 7.0, Uncertainty Assessment. The following sections address the methods used to characterize non-carcinogenic and carcinogenic risks.

6.1 Non-Carcinogenic Risks (Chemicals of Concern in Dataset No. 1)

As requested by MPCA, non-carcinogenic risks were estimated by dividing modeled air concentrations of chemicals with inhalation reference concentrations R_fCs. This resulted in the derivation of a hazard quotient. As a conservative risk estimate, chemical-specific hazard quotients were summed to derive a total hazard index (HI) for all chemicals. If the HI exceeds one (1), the HI will be disaggregated by toxic endpoint or target organ (EPA, 1989a).

6.1.1 Non-Carcinogenic Risks for Landfill Workers

Non-carcinogenic risks were estimated for landfill workers potentially exposed to landfill gas chemicals while working at the site. Table 6.1-1 presents the estimated risk for the inhalation route of exposure which was calculated to be 1.1×10^{-2}. This value is well below the EPA hazard index of 1. Thus, based on this assessment, the chemicals at or originating from Freeway Landfill do not pose a hazard with respect to non-carcinogenic effects via the inhalation route of exposure.

6.1.2 Non-Carcinogenic Risks for Nearby Residents

Non-carcinogenic risks were estimated for nearby residents exposed to landfill gas chemicals dispersed into ambient air. Table 6.1-2 presents the estimated risk for the inhalation route of exposure which was calculated as 1.1×10^{-3}. This is a value that is below the EPA hazard index of 1.

6.2 Carcinogenic Risks (Chemicals of Concern in Dataset No. 1)

Cancer risks were estimated by multiplying chemical-specific modeled air concentrations by selected exposure variables and the chemical-specific unit risk value as presented in Table 6.2-1. Cancer risks associated with exposures to all carcinogenic chemicals received via the inhalation pathway were summed to estimate total excess lifetime cancer risk (i.e., the cancer risk or probability, above background cancer, of an individual developing cancer as a result of exposures to COCs of landfill gas origin).

Table 6.0-1 **Equations Used to Estimate Non-Carcinogenic and Carcinogenic Risk Via the Inhalation Route of Exposure - Inhalation of Airborne (Vapor Phase) Chemicals Freeway Landfill Risk Assessment - Burnsville, MN**

NON-CARCINOGENS

Step 1:

$$\frac{Ca\ (mg/m^3)}{RfC\ (mg/m^3)} = HQ$$

Step 2:

$$\Sigma HQ = HI$$

where:

Ca = Modeled Air Concentration of Chemical (mg/m^3)
RfC = Chemical-Specific Reference Concentration (mg/m^3)
HQ = Hazard Quotient (chemical-specific non-carcinogenic risk)
HI = Hazard Index (total non-carcinogenic risk, based on the sum of HQ)

CARCINOGENS

Step 1:

Ca (µg/m^3) * ET (hrs/24 hrs) * AT (yrs/70 yrs) * UR (µg/m^3)^-1 = Chemical-Specific Cancer Risk

Step 2:

ΣChemical-Specific Cancer Risk = Excess Lifetime Cancer Risk

where:

Ca = Modeled Air Concentration of Chemical (µg/m^3)
ET = Exposure Time (hrs/24 hrs)
AT = Averaging Time (yrs/70 yrs) e.g., 70-year lifetime period
UR = Inhalation Unit Risk (µg/m^3)^-1 (chemical-specific)
Excess Lifetime Cancer Risk = Sum of Chemical-Specific Cancer Risk

Source: MPCA. 1993. Comments from MPCA on Deliverable #2 - Freeway Landfill Risk Assessment

Table 6.1-1 **Non-Carcinogenic Risks for Landfill Workers Via Inhalation of Landfill Gas Constituents (RME Occupational Scenario) Freeway Landfill Risk Assessment - Burnsville, MN**

Non-Carcinogenic Chemical	On-Site Exposure Point Concentration (mg/m^3)	Inhalation RfC (mg/m^3)	Hazard Quotient
Acrylonitrile	4.34E-06	2.0E-03	2.2E-03
Chlorobenzene	5.81E-05	2.0E-02	2.9E-03
Chloroethane	3.35E-05	1.0E+01	3.4E-06
Dichlorodifluoromethane	4.05E-04	2.0E-01	2.0E-03
1,1-Dichloroethane	3.21E-05	5.0E-01	6.4E-05
1,2-Dichloropropane	3.47E-06	4.3E-03	8.1E-04
Ethylbenzene	2.76E-04	1.0E+00	2.8E-04
Hexane	1.17E-04	2.0E-01	5.9E-04
Methyl Ethyl Ketone	1.29E-04	1.0E+00	1.3E-04
Methyl Isobutyl Ketone	3.46E-05	8.0E-02	4.3E-04
Methylene Chloride	2.97E-04	3.0E+00	9.9E-05
Toluene	6.84E-04	4.0E-01	1.7E-03
		Hazard Index =	**1.1E-02**

Table 6.1-2 **Non-Carcinogenic Risks for Nearby Residents Via Inhalation of Landfill Gas Constituents (RME Residential Scenario) Freeway Landfill Risk Assessment - Burnsville, MN**

Non-Carcinogenic Chemical	Residential Exposure Point Concentration (mg/m^3)	Inhalation RfC (mg/m^3)	Hazard Quotient
Acrylonitrile	4.34E-07	2.0E-03	2.2E-04
Chlorobenzene	5.81E-06	2.0E-02	2.9E-04
Chloroethane	3.35E-06	1.0E+01	3.4E-07
Dichlorodifluoromethane	4.05E-05	2.0E-01	2.0E-04
1,1-Dichloroethane	3.21E-06	5.0E-01	6.4E-06
1,2-Dichloropropane	3.47E-07	4.3E-03	8.1E-05
Ethylbenzene	2.76E-05	1.0E+00	2.8E-05
Hexane	1.17E-05	2.0E-01	5.9E-05
Methyl Ethyl Ketone	1.29E-05	1.0E+00	1.3E-05
Methyl Isobutyl Ketone	3.46E-06	8.0E-02	4.3E-05
Methylene Chloride	2.97E-05	3.0E+00	9.9E-06
Toluene	6.84E-05	4.0E-01	1.7E-04
		Hazard Index =	**1.1E-03**

Table 6.2-1 **Carcinogenic Risks for Landfill Workers Via Inhalation of Landfill Gas Constituents (RME Occupational Scenario) Freeway Landfill Risk Assessment - Burnsville, MN**

Carcinogenic Chemical	On-Site Exposure Point Concentration (µg/m^3)	Exposure Time (8 hours/24 hours)	Averaging Time (25 yrs/70yrs)	Inhalation Unit Risk (µg/m^3)^-1	Chemical-Specific Cancer Risk
Acrylonitrile	4.34E-03	0.33	0.36	6.8E-05	3.5E-08
Benzene	2.42E-02	0.33	0.36	8.3E-06	2.4E-08
Carbon Tetrachloride	3.92E-05	0.33	0.36	1.5E-05	7.0E-11
Chloromethane	1.78E-02	0.33	0.36	1.8E-06	3.8E-09
Chloroform	9.81E-03	0.33	0.36	2.3E-05	2.7E-08
1,2-Dibromoethane	1.28E-02	0.33	0.36	2.2E-04	3.3E-07
1,2-Dichloroethane	5.57E-03	0.33	0.36	2.6E-05	1.7E-08
1,1-Dichloroethylene	1.71E-03	0.33	0.36	5.0E-05	1.0E-08
Methylene Chloride	2.97E-01	0.33	0.36	4.7E-07	1.7E-08
1,1,2,2-Tetrachloroethane	4.29E-03	0.33	0.36	5.8E-05	3.0E-08
Tetrachloroethylene	1.15E-01	0.33	0.36	5.8E-07	7.9E-09
Trichloroethylene	1.28E-01	0.33	0.36	1.8E-06	2.7E-08
Vinyl Chloride	8.58E-02	0.33	0.36	8.4E-05	8.6E-07

Excess Lifetime Cancer Risk = 1.4E-06

6.2.1 Carcinogenic Risks for Landfill Workers

Carcinogenic risks were estimated for landfill workers potentially exposed to landfill gas chemicals while working at the site. Table 6.2-2 presents the estimated risk via the inhalation route calculated as 1.4×10^{-6}. This value is within the EPA target risk range of 1×10^{-6} and 1×10^{-4}, and below the MPCA cancer risk limit of 1×10^{-5}.

6.2.2 Carcinogenic Risks for Nearby Residents

Carcinogenic risks were estimated for nearby residents exposed to landfill gas chemicals dispersed into ambient air. Table 6.2-2 presents the estimated risk (for the inhalation exposure route) and was calculated as 5×10^{-7}. This value is well below the upper target risk limit of the target risk range of 1×10^{-6} to 1×10^{-4}. In addition, this value is well below the MPCA cancer risk limit of 1×10^{-5}.

6.3 Acute Exposure Hazards (Chemicals of Concern in Dataset No. 2 Only)

A qualitative risk characterization approach was employed to provide an indication of the degree of possible hazards due to hazardous short-term scale-house air conditions. Exposure concentrations in the scale-house were compared to acute occupational guidelines and standards. None of the calculated reasonable maximum exposure levels for any of the chemicals of concern exceed any of the identified acute occupational guidelines or standards.

6.4 Conclusions

As presented in Table 6.4-1, for chronic exposures evaluated quantitatively, risks to landfill workers and nearby residents were below threshold risk limits for non-carcinogens and within the acceptable target risk range for carcinogens. As presented in Table 4.5-1, for acute exposure evaluated semi-quantitatively, exposure point concentrations in the scale-house did not exceed any available occupational guidelines or standards.

Table 6.2-2 **Carcinogenic Risks for Nearby Residents Via Inhalation of Landfill Gas Constituents (RME Residential Scenario) Freeway Landfill Risk Assessment - Burnsville, MN**

Carcinogenic Chemical	Residential Exposure Point Concentration (µg/m^3)	Exposure Time (24 hours/24 hours)	Averaging Time (30 yrs/70yrs)	Inhalation Unit Risk (µg/m^3)^-1	Chemical-Specific Cancer Risk
Acrylonitrile	4.34E-04	1	0.43	6.8E-05	1.3E-08
Benzene	2.42E-03	1	0.43	8.3E-06	8.6E-09
Carbon Tetrachloride	3.93E-06	1	0.43	1.5E-05	2.5E-11
Chloromethane	1.78E-03	1	0.43	1.8E-06	1.4E-09
Chloroform	9.81E-04	1	0.43	2.3E-05	9.7E-09
1,2-Dibromoethane	1.28E-03	1	0.43	2.2E-04	1.2E-07
1,2-Dichloroethane	5.57E-04	1	0.43	2.6E-05	6.2E-09
1,1-Dichloroethylene	1.71E-04	1	0.43	5.0E-05	3.7E-09
Methylene Chloride	2.97E-02	1	0.43	4.7E-07	6.0E-09
1,1,2,2-Tetrachloroethane	4.29E-04	1	0.43	5.8E-05	1.1E-08
Tetrachloroethylene	1.14E-02	1	0.43	5.8E-07	2.8E-09
Trichloroethylene	1.28E-02	1	0.43	1.8E-06	9.9E-09
Vinyl Chloride	8.58E-03	1	0.43	8.4E-05	3.1E-07

Excess Lifetime Cancer Risk = 5.0E-07

Table 6.4-1 Summary of Risks to Human Health
Freeway Landfill Risk Assessment - Burnsville, MN

	Excess Lifetime Cancer Risk	Exceeds Risk Range (1)	Hazard Index	Exceeds Risk Limit (2)
1) ON-SITE LANDFILL WORKERS				
Inhalation	1.4E-06	NO	1.1E-02	NO
2) NEARBY RESIDENTS				
Inhalation	5.0E-07	NO	1.1E-03	NO

Notes:
(1) Cancer Risk Range: 1.0E-06 to 1.0E-04
(2) Non-Cancer Risk Limit: 1.0 Hazard Index

Section 7
Uncertainty Assessment

A discussion of the uncertainties inherent in the methods and assumptions on which risk estimates are based is a critical component of a human health risk assessment. The usefulness of estimates of non-carcinogenic and carcinogenic risk attributed to the Freeway Landfill is dependent on an understanding of the limitations of these estimates and the information and scientific methods used to derive them.

There are uncertainties in the general practice of risk assessment, including species to species (animal to human) and high dose to low dose extrapolations as well as uncertainties in attempting to characterize a site (i.e., the extent of contamination and degree to which the chemicals will be transported from a source to individuals working and/or residing adjacent to the site). In general, the assumptions made throughout the Freeway Landfill HHRA and those involving the standard approach to risk assessment are conservative in that they tend to overestimate, rather than underestimate risk, resulting in an upperbound probability of adverse effects. True health effects resulting from exposure to air contaminants may be lower at the Freeway Landfill site.

Quantitative estimates of uncertainty have been attempted using Monte Carlo simulations, but these estimates also possess a degree of uncertainty in that they are based on statistical distributions of the variance of each input to the risk equation, as well as the co-variance, or interdependence among parameters. While it may be possible to isolate the impact of one variable on the risk equation, such as variances in averaging time, the overall usefulness of this estimate could be limited if the influences of several other variables are not well understood.

This HHRA does not include a quantitative presentation of synergistic interactions for COCs evaluated. Rather, a qualitative discussion is presented. Chemical-specific risks were added to generate a total estimate of non-carcinogenic and carcinogenic risk. This may result in synergistic interactions which might cause over or underestimation of risk. The chemical-specific toxicity of two compounds may result in over magnification of risk estimates which may not occur should chemicals be segregated and evaluated by target organs. For example, carcinogenic agents may be divided into three groups: (1) lung-cancer producers; (2) other target organ cancer producers; and (3) systemic cancer producers.

In Section 2.0, Data Evaluation for HHRA and ERA, and Section 3.0, Selection of Chemicals of Concern in HHRA, there is a degree of uncertainty in the environmental sampling and analysis upon which the risk assessment depends. Uncertainties include potential data collection, and errors in laboratory extraction and analysis. Because data were submitted by individual landfill operators, data collection methods varied and included sampling of the inlet streams to gas flares, wells, or gas probes. There is also uncertainty in the protocol employed to assess contaminants identified as non-detected. While this HHRA focused on MPCA database air contaminants, the use of EPA surrogate landfill gas data for MPCA non-detects may result in uncertainty regarding the assessment of true Freeway Landfill related COCs.

Four specific sources of uncertainties exist in the Data Evaluation and Selection of COCs component of this HHRA:

(1) *Use of EPA concentrations as surrogate landfill gas data for MPCA non-detects* - The EPA database employed as a surrogate source of information is representative of landfill gas concentrations from 46 California landfills. The use of EPA data in the absence of MPCA data may introduce COCs which may not be necessarily related to the Freeway Landfill site. This approach may result in a "medium" or above average potential for overestimation of risk.

(2) *Use of landfill gas data from five Minnesota landfills* - The data on which this HHRA is based was obtained from a total of five Minnesota landfills other than Freeway Landfill. Although there is reasonable agreement on the characteristics of the surrogate landfills used to represent Freeway Landfill (e.g., similar waste composition) the possibility for variability exists. This variability is believed to pose "low" potential for over or underestimation of risk.

(3) *Exclusion of Dataset No. 1 COCs with no chemical-specific inhalation toxicity data from quantitative analysis* - The exclusion of COCs which at this time lack inhalation R_fCs and/or unit risks poses "medium" potential for underestimation of risks, specifically if a chemical is toxic and expected to be present in sufficiently high concentrations.

(4) *Use of Emission and Dispersion Models employed to derive EPCs* - The Industrial Source Complex Short-Term Model was used to predict dispersion of COCs. EPCs derived by this model were based on meteorological conditions over a five-year period, giving the highest (peak year) annual ambient air concentrations thus posing a "medium" potential for overestimation of risk.

Section 4.0, Exposure Assessment, involved the use of assumptions regarding the most likely receptors and their respective exposure scenario. These exposure assumptions are likely to overestimate the "true" exposure to chemicals received by the workers and residents quantitatively assessed in the HHRA.

Four specific sources of uncertainties exist in the exposure assessment component of this HHRA:

(1) *Exposure Variables Employed* - Values for the exposure time and averaging time exposure parameters were obtained from EPA Risk Assessment Guidance (EPA, 1989a, 1989b). The values suggested in these guidance documents are representative of the national upper-bound time spent living or working in a particular setting. There is a "medium" potential for overestimation of risk.

(2) *Exposure to Air Contaminants Remaining Constant Over Exposure Period* - The focus of this HHRA is the evaluation of exposures to air contaminants. Because all the COCs evaluated in this HHRA are volatile in nature, there is tendency for these to undergo degradation in the subsurface portion of the landfill, further decreasing contaminant concentration. This effect results in a "low" potential for overestimation of risk.

(3) *Depiction of Realistic Exposure Scenarios* - Two exposure scenarios are quantitatively evaluated in this risk assessment: the occupational and residential scenario. These scenarios are consistent with current conditions for the Freeway Landfill site. The depiction of these scenarios poses "low" potential for the overestimation of risk.

(4) *Exposure Point Concentration in the Scale-House* - A reasonable maximum methane concentration of 25 percent of the LEL was used to derive toxic non-methane organic compound concentrations in the scale-house. Of over 480 samples collected from January 1991 through November 1992, only 8 samples exceeded 25 percent of the LEL. While relatively infrequent, use of this EPC was deemed appropriate for evaluation of potential acute exposures.

Section 5.0, Toxicity Assessment, involved the estimation of the toxicological effect of COCs on humans usually based upon laboratory animal studies. Two potentially significant sources of uncertainty occur when dose-response relationships in humans are derived from animal to human extrapolation and from high dose to low dose extrapolation. The toxicity values presented in this section, although derived with margins of safety, may contribute an unquantifiable degree of uncertainty.

Four specific sources of uncertainty exist in the toxicity component of this HHRA:

(1) *Extrapolation of Animal Toxicity Data to Humans* - Often times data derived from human studies are not available to assess the magnitude of risk related to chemical exposure. For this reason, animal studies are employed to evaluate these effects which are then extrapolated to humans. While R_fCs and unit risks developed from study results incorporate a margin of safety, there is uncertainty as to the applicability of experimental studies to predict human effects. The use of animal toxicity data to humans poses a "medium" potential for over or underestimation of risk.

(2) *Route-to-Route Extrapolation of Oral Toxicity Values to Evaluate Inhalation Exposures* - There is uncertainty as to route-to-route extrapolation (e.g., oral to inhalation) of toxicity data for various COCs. Toxicity data for some chemicals has been derived from studies which evaluated adverse effects on experimental animals via the oral route of exposure (e.g. gavage). The use of oral data to assess effects via the inhalation route may not be representative of "real" inhalation-specific toxicokinetic effects. The use of toxicity data subject to route-to-route extrapolation poses "medium" potential for overestimation of risk since toxicity values are based on high dose animal concentrations.

(3) *No evaluation of ingestion and dermal exposures* - Ingestion and dermal exposures to chemicals in surface waters, groundwater, and soils at or nearby the Freeway Landfill site are not believed to exist at this time. However, the absence of a "complete" pathway does not affect the validity of the risk estimates generated and poses "low" potential for underestimation.

In Section 6.0, Risk Characterization, uncertainties include the assumption of additive risks from multiple compound exposure and the adequacy of R_fCs and URs to accurately represent the risk of non-carcinogenic and carcinogenic health effects.

Two specific sources of uncertainty exist in the risk characterization component of this HHRA:

(1) *Risk Additivity* - The addition of chemical-specific risks to derive total non-cancer or cancer risks is deemed as standard risk assessment procedure. This may result in "medium" potential for over or underestimation of risk depending on the individual chemical-specific risk contribution to total risk. There is uncertainty as to the addition of risks for chemicals with different target organ effects (e.g., liver versus kidney tumors).

(2) *Use of RME-Approach to estimate risks* - The RME-Approach is intended to represent a conservative exposure scenario (i.e., well above the average case), the highest exposures that are reasonably expected to occur at the site. The use of an RME-Approach to estimate risks poses "medium" potential for the overestimation of risk given the added layers of conservatism that get introduced by using this approach.

Table 7.1-1 presents a discussion, in tabular form, of the uncertainties in the quantitative component of the HHRA and the tendency for each uncertainty to over or underestimate risks. This has been prepared to better understand how limitations in the general practice of risk assessment may affect the estimated risk results for the Freeway Landfill site. The qualitative determinations employed in Table 7.1-1 are based on professional judgment and consider the range of variation for the selected exposure values and information regarding the inherent toxicity of the COCs evaluated.

Table 7.1-1

Sources of Uncertainty in Quantitative HHRA
Freeway Landfill Risk Assessment - Burnsville, MN

ASSUMPTION	*POTENTIAL MAGNITUDE FOR OVERESTIMATION OF RISK*	*POTENTIAL MAGNITUDE FOR UNDERESTIMATION OF RISK*	*POTENTIAL MAGNITUDE FOR OVER OR UNDER ESTIMATION OF RISK*
I. DATA EVALUATION/SELECTION OF COCs			
Representativeness of Data Base			Medium
Use of EPA Concentrations as Surrogate Landfill Gas Data for MPCA Non-Detects	Medium		
Use of Landfill Gas Data from Five MN Landfills other than Freeway Landfill			Low
Exclusion of Dataset No. 1 COCs with no Chemical-Specific Inhalation Toxicity Data from Quantitative Analysis		Medium	
Use of Emission and Dispersion Models Employed to Derive EPCs	Medium		
II. EXPOSURE ASSESSMENT			
Exposure Variables Employed: Exposure Time Averaging Time	 Medium Medium		
Exposure to Air Contaminants Remaining Constant Over Exposure Period	Low		
Depiction of Realistic Exposure Scenarios	Low		
Exposure Point Concentrations in Scale-House (1)	Low		
III. TOXICITY ASSESSMENT			
Extrapolation of Animal Toxicity Data to Humans			Medium
Route to Route Extrapolation of Oral Toxicity Values to Evaluate Inhalation Exposures	Medium		
No Evaluation of Ingestion Exposures		Low	
Use of Upper-Bound Inhalation Unit Risks to Evaluate Cancer Risks	Medium		
IV. RISK CHARACTERIZATION			
Risk Additivity Carcinogens Non-Carcinogens			 Medium Medium
Use of RME-Approach to Estimate Risks	Medium		

Notes:
(1): Evaluated qualitatively. Uncertainty pertains to overestimation of EPCs.

Section 8
Ecological Risk Assessment

The ecological risk assessment (ERA) for the Freeway landfill evaluates risks associated with ecological receptor exposure to landfill contaminants. The Technical Assistannce Work Plan for the ERA states that risks associated with direct ingestion and/or contact with leachate seeps are to be evaluated qualitatively. In addition, risks to aquatic organisms associated with exposure to surface water and groundwater contaminants will also be evaluated qualitatively. Risks associated with ecological receptor exposure to landfill gas were not addressed for reasons discussed in the Technical Assistance Work Plan and Section 8.2.

8.1 Ecological Receptors

8.1.1 General Description

The Freeway Landfill is located within the floodplain of the Minnesota River opposite the Minnesota Valley Wildlife Refuge. The site is located south of the river at approximately River Mile 12 (see Figures 2.1-1 and 2.1-2). Most of the area surrounding the landfill and expansion site is industrial development and quarry property. However, there is undeveloped land north and west of the landfill. Part of this undeveloped land is the Minnesota Valley Wildlife Management Area.

8.1.2 Ecological Conditions and Selection of Species of Concern

The Freeway Landfill and the area surrounding the landfill are characterized mainly by transitional zone vegetation. Tallgrass prairie and maple-basswood forest, as well as oak savannah, are the typical types of vegetated zones found in the area. Elm-willow-cottonwood floodplain forest of the river valley are nearby the site.

Ecological receptors that may be exposed to contaminated media include wildlife, vegetation, and aquatic organisms. Ecological receptors that were evaluated in this ERA are those biota representative of the ecological communities in the study area. The criteria for species selection was based upon the following:

- The food web in the study area
- Exposure pathways leading to humans
- Importance placed by the Minnesota Department of Natural Resources
- Threatened or endangered species.

Ecological communities and sensitive species that could be exposed to the chemicals selected for evaluation are summarized in the following sections. Figure 8.1-1 summarizes potential receptors and pathways for ecological exposure at the Freeway Landfill site. The selection of ecological receptors was based upon key species that could occur in the study area.

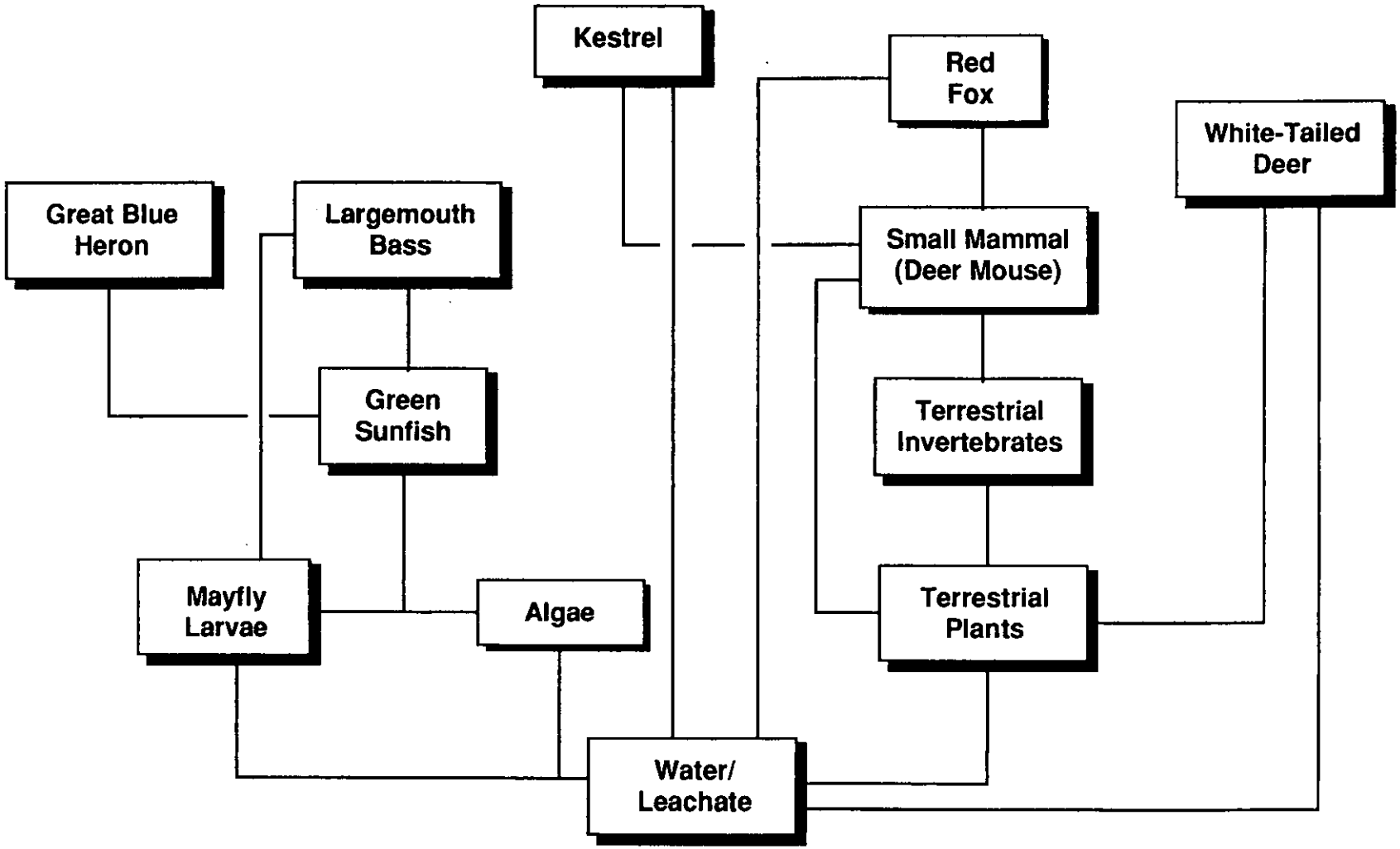

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Figure 8.1-1
Aquatic and Terrestrial Food Web for the Freeway Landfill

8.1.3 Aquatic Habitat

The Minnesota River is located north of the site. The river is classified by the Minnesota Department of Natural Resources (MDNR) as Class 2C, 3B waters from River Mile 22 to its mouth. The Freeway Landfill is located near River mile 12 on the Minnesota River. According to the MDNR, any water listed as Class 2C, 3B is also classified as 3C, 4A, 4B, 5 and 6.

Class 2 waters are for fisheries and recreation. Class 2C waters are regulated so that the quality of this class of surface waters shall be such as to permit the propagation and maintenance of rough fish or species commonly inhabiting waters of the vicinity under natural conditions, maintain the habitat for such fisheries, and be suitable for boating and other forms of aquatic recreation for which the waters may be useable. The standards for Class 2B waters shall apply to these waters with a few exceptions.

Class 3 waters are identified for industrial consumption. The quality of Class 3B waters shall be such as to permit their general use for industrial purposes, except food processing, with only a moderate degree of treatment. The quality of Class 3C waters shall be such as to permit their use for industrial cooling and materials transport without a high degree of treatment being necessary to avoid severe fouling, corrosion, scaling, or other unsatisfactory conditions.

Class 4 waters are for agriculture and wildlife. The quality of Class 4A waters shall be such as to permit their use for irrigation without significant damage or adverse effects upon any crops or vegetation usually grown in the waters or area, including truck garden crops. The quality of Class 4B waters shall be such as to permit their use by livestock and wildlife without inhibition or injurious effect.

Class 5 waters are for aesthetic enjoyment and navigation. The quality of this class of waters shall be such as to be suitable for aesthetic enjoyment of scenery and to avoid any interference with navigation or damaging effects on property. Class 6 waters are for other uses that may be defined more fully at a later date.

Of all these classes, the Class 2C waters contain limits that are the most stringent for potential chemicals of concern detected at the Freeway Landfill site. These limits are the limits which are used in this risk assessment.

The DNR has conducted fishery surveys of the Minnesota River (Barr Engineering, 1990). The surveys were conducted in 1980 and 1982, with a total of 53 species being collected and identified. The two most abundant species identified in the study were both rough fish, i.e., shorthead redhorse (*Moyostoma macrolepidotum*), and the common carp (*Cyprinus carpio*). These two species comprised over 51.8 percent of the total catch for the river (Barr Engineering, 1991). For the segment of the river near the landfill, the study identified gizzard shad (*Dorosoma cepedianum*) and the common carp (*Cyprinus carpio*). These two fish comprised 60.1 and 23.4 percent, respectively, of the catch in this river segment (Barr Engineering, 1991). Green sunfish (*Lepomis cyanellus*) was also observed.

The DNR study also identified the most abundant game fish for the entire river, as well as for different regions of the river (Barr Engineering, 1991). For the entire river, the three most

abundant game fish were walleye (*Stizostedion vitrium*), channel catfish (*Ictalurus puntalus*), and sauger (*Stizostedion canadense*), and they comprised 7.9 percent of the total catch. For lower reaches of the river in the vicinity of the landfill, white bass (*Morone chrysops*) and sauger (*Stizostedion canadense*) were identified as the most abundant game fish (Barr Engineering, 1991).

Studies were conducted for icthyoplankton in 1976 (MPCA, 1985). The studies identified 31 species of fish in the Minnesota River. Gizzard shad (*Dorosoma cepedianum*) and freshwater drum (*Apiodinotus grunniens*) comprised 60.3 and 18.2 percent of the total catch, respectively (Barr Engineering, 1991).

Havlik (1989) studied freshwater mussel communities downstream of the landfill area near the Interstate 35W bridge. The most abundant species identified during the study were the mapleleaf (*Quadruea quadruea*), the giant floater (*Anodonta g. corpulenta*), and the fragile papershell (*Leptodea fragilis*).

The Metropolitan Waste Control Commission (MWCC) has monitored benthic macroinvertebrate communities in the Minnesota River. Studies have been conducted at Fort Snelling (River Mile 3.5) and near Jordan (River Mile 39.4) (MPCA, 1985; Barr Engineering, 1991). The dominant taxa identified were *Chironomidae, Hydropschidae*, and *Oligochaeta* (Barr Engineering, 1991).

MPCA (1985) had concluded that the aquatic biota of the lower Minnesota River near the Burnsville Landfill were indicative of poor water quality. Increased runoff and siltation, low dissolved oxygen concentrations, high turbidity and temperatures, sewerage effluent, and maintenance of a navigational channel were identified as contributors to the poor water quality.

As indicated in Figure 8.1-1, key species include major primary producers (algae), small herbivores (mayfly larvae), and two levels of carnivores (green sunfish and largemouth bass, and the great blue heron). This food web is expected to reasonably represent critical trophic levels of the expected aquatic community. Further, the species selected are thought to be a reasonable representation of other organisms feeding at the same level.

Finally, as noted in Section 1, two different surface waters were sampled at or adjacent to the Freeway landfill. The first is at the Kramer Quarry, which is southwest of the landfill. Operational activities of the quarry cause regional groundwater (i.e., part of the groundwater from under the landfill) to move toward the quarry rather than the Minnesota River, as it would under normal conditions. Studies characterizing the biota in the quarry could not be located. Additionally, time (i.e., only one site visit in February) and budget restricted further study to characterize the biota in the quarry. The second surface water sampled is located in the northeast corner of the landfill. The water level at this location varies seasonally. Again, extensive study of the biota at this location could not be conducted for the same reasons as noted for the quarry.

8.1.4 Terrestrial Habitat

Information on terrestrial habitats were taken from field survey data collected by CDM in February 1992, and from the Burnsville Landfill Supplemental Remedial Investigation (Barr

Engineering, 1991) and Burnsville Landfill Expansion Environmental Impact Statement (CDM, 1991).

The area surrounding the Freeway Landfill has a number of mixed uses. These include the Burnsville Landfill to the southwest and the active Kramer Quarry to the south. Additionally there are areas of undeveloped land as well as industrial/developed land. The undeveloped acres consist of upland prairie, wetlands, mature hardwood forests, and open disturbed areas and brushland. Disturbed areas are either devoid of vegetation or inhabited by weeds. There is an intermittent stream which runs between the landfill and Interstate 35W. Additionally, water elevation in the quarry is maintained between 605 and 610 NGVD (B.A. Leisch Associates, 1991)

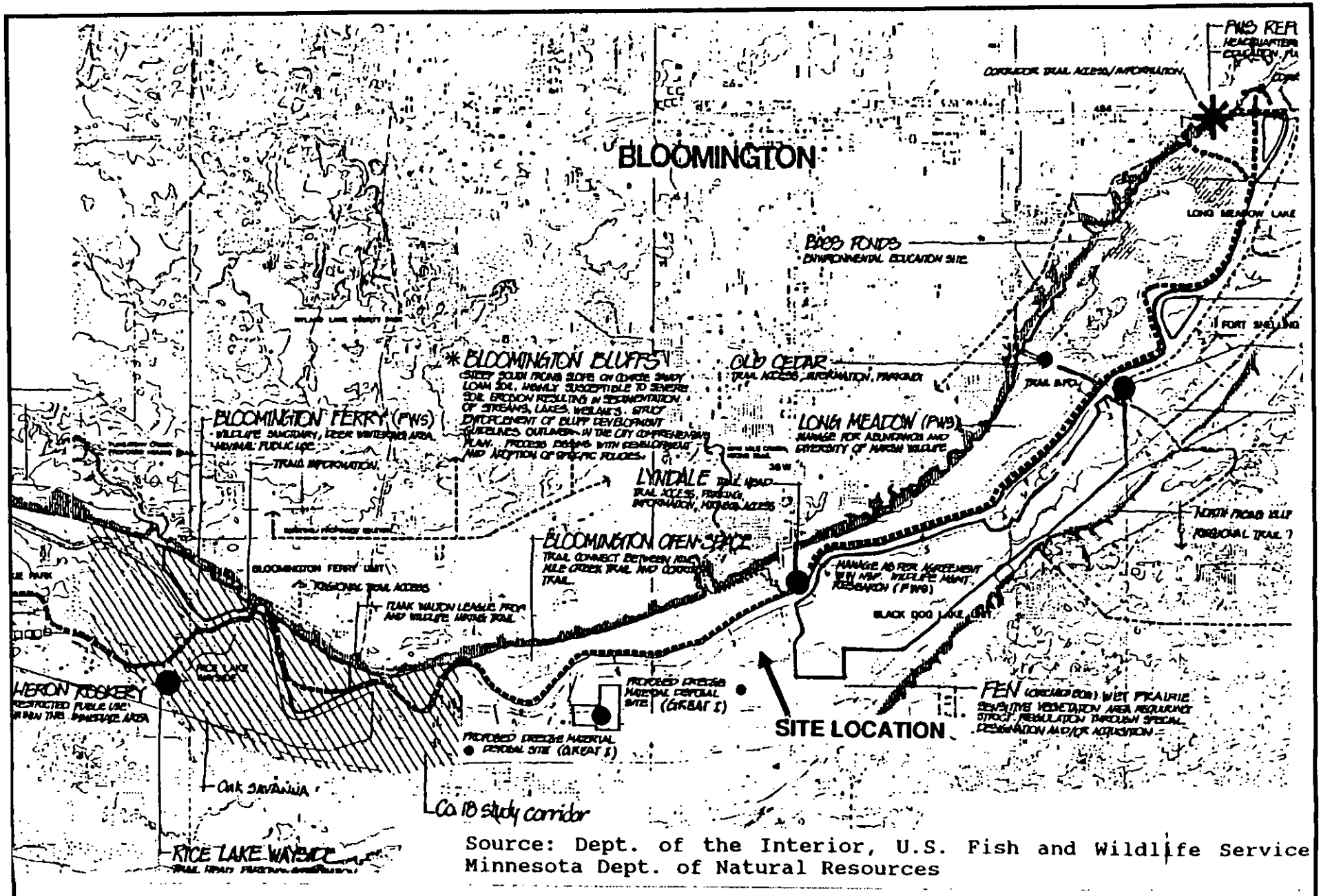
Birds and mammals commonly found in the area include herring gulls (*Larus argentatus*), American robins (*Turdus migratorius*), red-winged blackbirds (*Agelaius phoeniceus*), ring-necked pheasants (*Phasianus colchicus*), killdeer (*Charadrius vociferus*), northern cardinals (*Cardinalis cardinalis*) , American crows (*Corvus brachyrhynchos*), downy woodpeckers (*Picoides pubescens*), American kestrels (*Falco sparverius*), Canada goose (*Branta canadensis*), great blue heron (*Adrea herodias*), wood duck (*Aix sponsa*), eastern cottontail (*Sylvilagus floridanus*), Virginia opossum (*Didelphis virginiana*), woodchucks (*Marmota monax*), gray squirrels (*Sciurus carolinensis*), white-tailed deer (*Odocoileus virginianus*), raccoons (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and red foxes (*Vulpes vulpes*) (CDM, 1991 and Barr Engineering, 1990).

In wetland areas minks (*Mustella vison*), muskrats (*Ondatra zibethicus*), foxes, deer, and woodchucks are the common mammals. Many migratory waterfowl species inhabit the floodplain areas near the landfill. Common species in this area include geese, ducks, and shorebirds (CDM, 1991 and Barr Engineering, 1990).

The intermittent stream which runs between the landfill and Interstate 35W was identified as a wetland area during the 1992 field visit conducted by CDM. Across the Interstate from the landfill is U.S. Fish and Wildlife Service property, including Black Dog Lake, in which a variety of wetland habitats occur. Additionally the Minnesota River is located north of the site.

Although there are no rare, threatened, or endangered mammals, birds, or invertebrates on the landfill site, it is close to the Minnesota River and the Minnesota Valley National Wildlife Refuge (MVNWR) which harbors much wildlife (see Figure 8.1-2). The Minnesota River is a major route for migratory birds and is used extensively for food and shelter during migration. While 121 species nest in the refuge, a total of over 246 species of birds are known to use the refuge throughout the year. It is reasonable to assume that many, though not all, of these species would also depend on surrounding areas such as that of the project site for food, shelter, and nesting sites (CDM, 1991).

Two species found in the MVNWR, the peregrine falcon and piping plover, are federally endangered. However, the piping plover would not be found on the landfill site because it requires wetlands with sandy shores, unlike those on the site. The peregrine falcon prefers cliff edges for nesting and open non-forested areas for hunting. A pair of falcons are reported to be nesting eight miles down river from the landfill (Eliason, 1991).



Source: Dept. of the Interior, U.S. Fish and Wildlife Service
Minnesota Dept. of Natural Resources

Minnesota Pollution Control Agency	**Figure 8.1-2** **Area Wildlife Refuges and Management Areas**
CDM Camp Dresser & McKee Inc.	

Two other bird species found in the refuge, the bald eagle (*Haliaeetus leucocephalus*) and loggerhead shrike (*Lanius ludovicianus*), are threatened. A pair of nesting bald eagles has been reported along the Minnesota River, seven miles downstream from the landfill. Eagles prefer fish, so the landfill site itself may not be used very often for hunting purposes. The loggerhead shrike prefers open country and dry upland prairie where hedgerows, shrubs and small trees occur. It is also found around shelter belts, old orchard pastures, cemeteries, and farmsteads where this type of habitat occurs. Given the disturbance at the landfill site it is unlikely that the loggerhead shrike uses this habitat over less disturbed areas associated with the nearby wildlife refuge (CDM, 1991).

There are no known federal or state designated wildlife refuges, waterbird nesting colonies, trout streams, or fish spawning areas on the project site. There is, however, a colonial waterbird nesting site 7.5 miles downstream of the landfill. In previous years it was used by great blue herons and double-crested cormorants, but has not been used as a nesting site since 1986. It has recently been used as a roost by great blue herons (Barr Engineering, 1991).

Several species were selected as key species for assessment of potential impacts on wildlife. These include the major large game animal found in the area (white-tailed deer) and two major predators (red fox and kestrel). In addition, small rodents were also selected as a key prey species. The species selected illustrate a food web that is expected to reasonably represent critical trophic levels of the expected terrestrial community. Further, the species selected are believed to be a reasonable representation of other organisms feeding at the same level.

8.1.5 Wetland Habitats

Information on wetland habitats were taken from field survey data collected by CDM in February 1992, from the Burnsville Landfill Supplemental Remedial Investigation (Barr Engineering, 1991), and the Burnsville Landfill Expansion Environmental Impact Statement (CDM, 1991). Additional information was taken from the Bloomington, Minnesota National Wetland Inventory (NWI) map. The NWI map (see Figure 8.1-3) shows Palustrine wetlands to the north, south, and east of the site. The NWI maps also notes, that in addition to being Palustrine, the wetlands near the site are also seasonally flooded. During the 1992 site visit by CDM, it was noted that the extent of wetlands actually at the site appeared to be less than that shown on the NWI map. This observation may be attributable to two factors:

(1) The plant community of the wetlands near the site appears to be dominated by emergents. Given that the site visit was conducted in February, few emergents, if any, were visible and contributed to the observation of a lesser extent of wetlands.

(2) The aerial photography used for the NWI map was taken in 1980. Landfill activities or just the continued presence of the landfill may have altered local surface hydrology, thus altering the extent of wetlands.

The actual cause could only be confirmed through additional studies. These studies would include an examination of historical aerials and a contemporary survey/delineation of the wetlands.

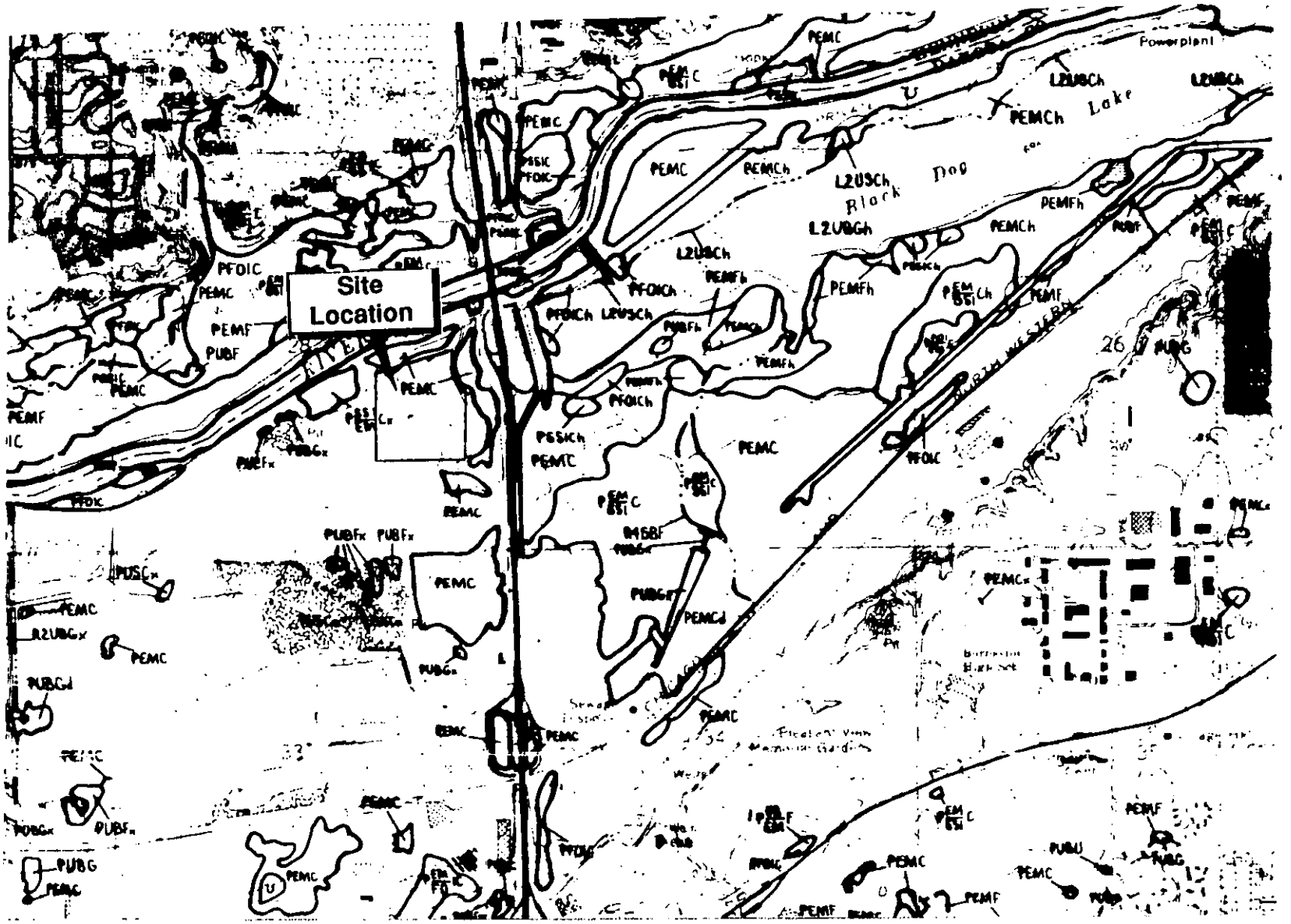


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Figure 8.1-3
Section of National Wetland Inventory Map for Bloomington, Minnesota

8.1.6 Special Status Species

Information from the Minnesota Natural Heritage Program (MNHP) and the U.S. Fish and Wildlife Service (USFWS) regarding threatened and endangered species was collected in 1991 as part of the proposed Burnsville Landfill Expansion EIS (CDM, 1991). While a number of threatened and endangered species are present at the nearby wildlife management area and refuge, none are present at the site. Certain species may use the site for foraging, however, the extent to which individual species may use the site is difficult to quantify. Figure 8.1-4 shows the known habitats for threatened and endangered species in the vicinity of the Freeway Landfill.

8.2 Selection of Chemicals of Concern

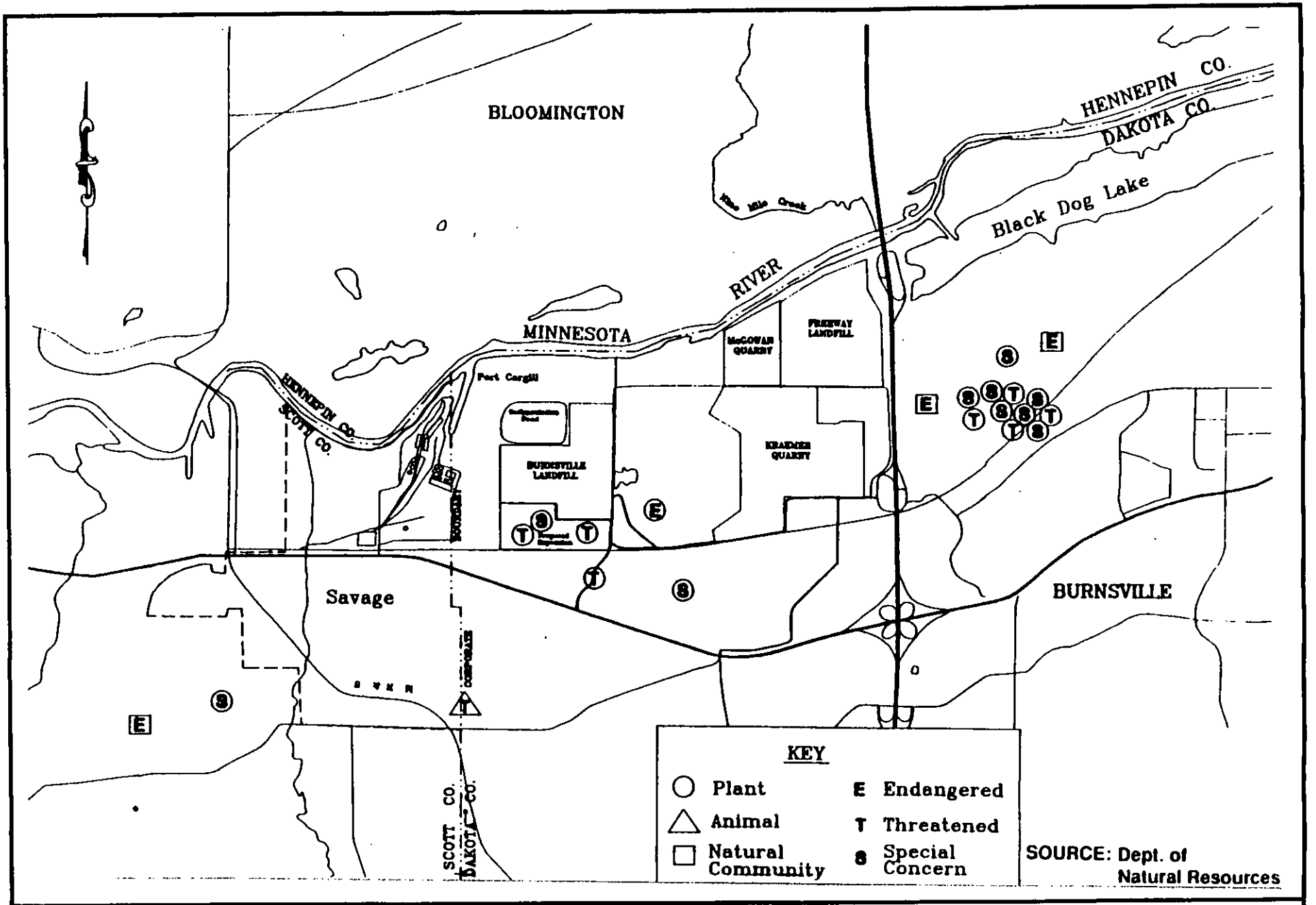
As outlined in the scope of work, data collected as part of the RI activities were summarized and a set of COCs selected from this data. Additional discussions with MPCA staff during preparation of Deliverable #1"Data Summary and Selection of Chemicals of Concern", (CDM, 1992) and subsequent comments provided by MPCA staff resulted in further refinement of how the data from the RI were to be used. Of central concern to the ERA is determining what data are to be used as representative of leachate. Only one location was of sufficient size and regularity to sample as a leachate seep (see Table 2.1-7). In the discussions with MPCA staff noted above, CDM was directed to use data from the monitoring well identified WT-6 for both groundwater and leachate as this sample was drilled in refuse. While this does not affect the process of how COCs were selected it does affect one of the criteria used for selection, specifically frequency of detection. The effect that this use of the data has on this criterion and the subsequent differences seen in selection of COCs for groundwater and leachate are described below. The criteria for selection of COCs are also discussed below.

The scope of work stated that selection of chemicals of concern would be based on:

- Concentrations relative to site background levels;
- Frequency of detection;
- Persistence and mobility;
- Toxicity to ecological receptors; and
- Tendency to bioaccumulate.

For the ERA, chemicals detected in ground water, surface water, and leachate were summarized and a set of COCs was selected. As discussed earlier in Section 2.1, site specific background concentrations for chemicals in these media were not available, thus, chemicals were not selected on this basis.

As discussed in Section 2.1.3, surrogate data are available for chemicals detected in landfill gas. Animals and plants may be exposed to these chemicals, however, these chemicals are readily dispersed in the ambient air. Thus, only burrowing animals and underground portions of plants (*e.g.*, roots and rhizomes) would receive significant exposure to landfill gas. Additionally, there are significant data limitations for assessing risks to animals and plants from landfill gas. These include:



Minnesota Pollution Control Agency

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Figure 8.1-4
Estimated Habitat Areas for Threatened and Endangered Species

- lack of sufficient data on inhalation rates for individual animal species and
- lack of sufficient data on the bioavailability of airborne contaminants for individual animal species.

Both of these factors would hinder the development of and dose estimates for individual species. In addition, MPCA has noted that budgetary constraints would further hinder the estimation of risks to plants and animals from landfill gas. For these reasons, the scope of work eliminated exposure to landfill gas constituents as a pathway of concern for the ERA.

The following discussion summarizes how COCs were selected.

8.2.1 Groundwater

Table 2.1-1 reports the frequency of detection, range of detected concentrations, detection limits, and source of data for chemicals detected in groundwater. The following chemicals were detected in less than five percent of the samples and at relatively low levels:

Mercury	2.3%
Acetone	2.5%
Benzene	4.1%
Chlorobenzene	2.0%
Chloromethane	2.5%
1,4-Dichlorobenzene	2.0%
Vinyl Chloride	4.1%

These chemicals were not selected as COCs based on the low frequency of detection.

Calcium, magnesium, manganese, potassium, and sodium were detected at high frequencies, but did not exceed safe levels. In addition, these chemicals are considered nutrients (a micronutrient in the case of manganese) and were not selected as COCs. All other chemicals detected in groundwater were selected as COCs due to their potential persistence, mobility, and potential toxicity to ecological receptors. Table 8.2-1 summarizes those chemicals selected as COCs for the ecological risk assessment.

8.2.2 Leachate

Table 2.1-7 reports the frequency of detection, range of detected concentrations, detection limits, and sources of data for chemicals detected in leachate. The frequency of detection for all chemicals detected in leachate is greater than five percent. It should be noted that the volatiles selected as COCs for groundwater and leachate differ slightly. This is a result of using data from monitoring well WT-6 as representative of groundwater and leachate. Because there are a greater number of samples for groundwater, some of the volatiles were eliminated as COCs for groundwater. However, there are relatively few samples for leachate, therefore, even one detect in leachate data may warrant inclusion of a chemical as a COC for leachate. This was the case for the following volatiles which were eliminated as COCs for groundwater because of low

Table 8.2-1 **Summary of Selected Chemicals of Concern (COCs)**
Freeway Landfill Risk Assessment - Burnsville, MN

ECOLOGICAL RISK ASSESSMENT:

Media	Chemicals Selected as COCs			
Groundwater	**Inorganics**		**Volatiles**	
	Aluminum	Iron	Dichlorodifluoromethane	Ethyl Ether
	Arsenic	Lead	1,1-Dichloroethane	Tetrahydrofuran
	Barium	Nickel	cis-1,2-Dichloroethylene	1,1,2-Trichloroethylene
	Beryllium	Selenium	trans-1,2-Dichloroethylene	
	Cadmium	Silver		
	Chromium	Thallium		
	Copper	Zinc		

Media	Chemicals Selected as COCs			
Leachate	**Inorganics**		**Volatiles**	
	Aluminum	Iron	Acetone	cis-1,2-Dichloroethylene
	Arsenic	Lead	Chlorobenzene	trans-1,2-Dichloroethylene
	Barium	Nickel	Chloroethane	Ethyl Ether
	Beryllium	Silver	Chloromethane	Tetrahydrofuran
	Cadmium	Thallium	1, 4 - Dichlorobenzene	
	Chromium	Zinc	Dichlorodifluoromethane	
	Copper			

Media	Chemicals Selected as COCs		
Surface Water	**Inorganics**		**Volatiles**
	Aluminum	Iron	Acetone (1)
	Barium	Lead	cis-1,2-Dichloroethylene
	Cadmium	Selenium (2)	trans-1,2-Dichloroethylene (2)
	Chromium	Silver (2)	Ethyl Ether
	Copper	Zinc	

Notes:

(1) Detected in SW - 3 Only
(2) Detected in SW - 6 Only

frequency of detection but should not be eliminated as COCs for leachate: acetone, chlorobenzene, chloroethane, chloromethane, and 1,4-dichlorobenzene.

Calcium, magnesium, manganese, potassium, and sodium were detected at high frequencies in leachate. However, theses chemicals are considered nutrients (a micronutrient in the case of manganese) and were not selected as COCs. All other chemicals detected in leachate were selected as COCs due to their potential persistence and mobility and potential toxicity to ecological receptors. Table 8.2-1 summarizes those chemicals selected as COCs for the ERA.

For the purposes of evaluating ingestion of leachate, all selected COCs presented in Table 8.2-1 were used (see Sections 8.4 and 8.5). For the purposes of evaluating dermal exposure to leachate, only the selected volatiles were evaluated. This was based on similar EPA protocols for evaluating dermal exposure to humans. EPA states that given the low absorption rate of metals, dermal exposure of metals is believed to contribute negligibly to the overall risk. In addition, the toxicity values for the dermal route of exposure have not been derived. EPA has suggested that oral toxicity data should be used as toxicity values when evaluating risks associated with dermal exposures (see Sections 8.4 and 8.5) (EPA, 1989a and EPA, 1992b). However, it is important to note the differences between dermal absorption of species in different functional groups. With respect to human absorption, most other mammals would probably experience less absorption due to greater hair and keratinized skin cover. This is also equally true for birds with feather coverage. Reptiles also tend to have a fairly decent dermal barrier. Amphibians, however, probably experience greater dermal absorption given their thin, permeable dermis. However, the magnitude of the differences described herein cannot be quantified.

8.2.3 Surface Water

Tables 2.1-2 and 2.1-3 report the frequency of detection, range of detected concentrations, range of detection limits and sources of data for the two surface water sampling locations. Given the low number of sampling events, COCs for surface water could not be selected based on frequency of detection. As with other media, calcium, magnesium, manganese, potassium, and sodium were detected, however, given that these chemicals are nutrients, they were not selected as COCs. All other chemicals detected in surface water were selected as COCs due to the potential persistence, mobility and toxicity to ecological receptors. Table 8.2-1 lists all COCs selected for surface water.

8.3 Exposure Scenarios and Pathways to be Evaluated

There are a number of ways in which ecological receptors could be exposed to COCs. The following basic elements will be considered in evaluating potential ecological exposure:

- the environmental transport pathway;
- route of exposure;
- potential exposure points; and
- chemical concentrations at the exposure points;

8.3.1 Environmental Transport Pathway and Routes of Exposures

The environmental transport pathway is the mechanism by which chemicals are transported from a source to an ecological receptor. For a chemical to pose an ecological risk, it must travel through the environmental media to the exposure point and reach receptors in biologically significant concentrations. The exposure pathway must be complete or there is no exposure. The exposure pathways that were considered in this ecological risk assessment are related to exposure to surface water, groundwater (by eventual discharge to surface waters) and leachate (either directly or with discharge to surface water).

Media exposure routes are the final connection between chemical release and the ecological receptor. Potential exposure routes that were evaluated include ingestion of and dermal exposure to contaminated surface water or leachate by wildlife, ingestion of contaminated prey species, and exposure of aquatic organisms to contaminated surface water. In conformance with the scope of work, these were all evaluated qualitatively.

8.3.2 Exposure Point Identification

The exposure points in this ecological risk assessment were locations where ecological receptors could potentially contact contaminated media (surface water or leachate).

Figures 2.1-1 and 2.1-2 show the site on a U.S.G.S Topographic Quadrangle and at a larger scale, respectively. While most of the site is disturbed from previous activities associated with the landfill and has other signs of disturbance such as the highway, railroad tracks, and active adjacent quarry, there are a number of areas where ecological receptors live and could potentially be exposed to COCs from the landfill. For example, terrestrial wildlife which are foraging on the landfill may come into contact with leachate seeps. Therefore, ingestion or dermal exposure could occur to this medium. Furthermore, terrestrial vegetation may also come into contact with leachate seeps. Finally, aquatic organisms could be exposed dermally and through ingestion of surface water.

8.3.3 Exposure Point Concentrations

Exposure point concentrations are derived from the media concentrations analyzed during the Remedial Investigation (RI) process and subsequent monitoring conducted by MPCA. Tables 2.1-1, 2.1-2, 2.1-3, and 2.1-7 presents the range of concentrations detected, the frequency of detection, and the detection limits for compounds analyzed during the aforementioned programs. This information is used here to develop potential exposure point concentrations.

U.S EPA (1992c) states that an estimate of average concentrations is used because average concentrations are most representative of the concentration that would be contacted at a site over time. For example, if you assume that an exposed receptor moves randomly across an exposure area, then the spatially averaged soil concentration can be used to estimate the true average concentration contacted over time (U.S. EPA, 1992c). While an individual may not actually exhibit a truly random pattern of movement across an exposure area, the assumption of equal time spent in different parts of the area is a simple but reasonable approach (U.S. EPA, 1992c).

The choice of the arithmetic mean concentration as the appropriate measure for estimating exposure derives from the need to estimate a receptors long-term average exposure (U.S. EPA, 1992c). Many criteria available are based on long-term average daily doses, which are simply the sum of all daily doses divided by the total number of days in the averaging period (U.S. EPA, 1992c). This is the definition of an arithmetic mean. The arithmetic mean is appropriate regardless of the pattern of daily exposures over time or the type of statistical distribution that might best describe the sampling data (U.S. EPA, 1992c). The geometric mean of a set of sampling results, however, bears no logical connection to the cumulative intake that would result from long-term contact with site contaminants, and it may differ appreciably from - and be much lower than - the arithmetic mean (U.S. EPA, 1992c). Although the geometric mean is a convenient parameter for describing central tendencies of lognormal distributions, it is not an appropriate basis for estimating the concentration term used in Superfund exposure assessments (U.S. EPA, 1992c).

The 95 percent upper confidence level (UCL) provides a conservative estimate of the average (mean) concentration. U.S. EPA (1992c) defines the UCL as a mean value that, when calculated repeatedly for randomly drawn subsets of size data, equals or exceeds the true mean 95 percent of the time. U.S. EPA (1992c) cautions that this should not be confused with a 95th percentile of site concentration data. The 95 percent UCL is used because it accounts for uncertainties due to limited sampling data at Superfund sites and because it is not possible to know the true mean. As sampling data increases, uncertainties decrease, the UCL moves closer to the true mean, and exposure evaluations using either the mean or the UCL produce similar results.

The 95 percent UCL is calculated by the following equation:

$$UCL = x + t(s/n^{1/2})$$

where

UCL	=	upper confidence limit
x	=	mean of the untransformed data
s	=	standard deviation of the untransformed data
t	=	Student-t statistic
n	=	number of samples.

It should be noted that the calculation of a UCL via Student's t-test is not appropriate for only two samples under normal statistical protocols. This calculation may result in an extremely inflated value, in cases where the sample values are significantly different.

Table 8.3-1 presents the arithmetic mean and 95 percent upper confidence level for COCs in groundwater. Non-detects were factored in at half the detection limit. Similarly Tables 8.3-2 and 8.3-3 present the arithmetic means and 95% upper confidence level for COCs in surface water and leachate respectively. Appendix C presents the entire data set for each medium and the calculation listed above. The 95 percent upper confidence level will be used as the exposure point concentration.

Table 8.3-1 **Summary of Groundwater Data**
Freeway Landfill Risk Assessment - Burnsville, MN

Chemical of Concern	Frequency of Detection	Arithmetic Average (µg/L)	Upper Confidence Limit (µg/L)
Metals			
Aluminum	9/9	99	118
Arsenic	7/23	2.9	4.4
Barium	8/9	273	342
Beryllium	4/14	1	1
Cadmium	18/23	0.4	0.7
Chromium	6/23	0.9	1.2
Copper	11/23	6.4	9.2
Iron	9/9	2,220	4,365
Lead	6/23	1.1	1.7
Nickel	15/23	19	25
Selenium	3/23	1.9	2.6
Silver	4/23	2.4	3
Thallium	1/14	22.3	153
Zinc	14/23	67	102
Volatiles			
Dichlorodifluoromethane	1/23	1.1	1.4
1,1-Dichloroethane	2/23	0.1	0.1
cis-1,2-Dichloroethlyene	8/23	0.9	1.3
trans-1,2-Dichlorethylene	8/23	0.4	0.7
Ethyl ether	11/23	3.5	4.6
Tetrahydrofuran	4/23	8	9.6
1,1,2-Trichloroethylene	4/23	0.5	0.6

Table 8.3-2 **Summary of Surface Water Data**
Freeway Landfill Risk Assessment - Burnsville MN

Chemical of Concern	Sample Well SW-3 Arithmetic Average (µg/L)	Sample Well SW-3 Upper Confidence Limit (µg/L)	Sample Well SW-6 Arithmetic Average (µg/L)	Sample Well SW-6 Upper Confidence Limit (µg/L)
Metals				
Aluminum	233	911	98	190
Barium	600	2494	178	423
Cadmium	0.1	0.6	0.21	0.85
Chromium	1.0	3.8	0.6	1.3
Copper	6.0	NA	5.8	22.0
Iron	10,590	68,742	487	1069
Lead	2.8	6.6	2.0	6.2
Selenium			3.5	8.0
Silver			2.2	7.2
Zinc	45	140	14	43
Volatiles (µg/L)				
Acetone	9.3	35		
cis-1,2-Dichloroethylene	1.4	7.3	0.52	0.99
trans-1, 2-Dichloroethylene			0.18	0.30
Ethyl ether	1.7	7.0	0.7	1.2

Table 8.3-3 Summary of Leachate Data
Freeway Landfill Risk Assessment - Burnsville MN

Chemical of Concern	Arithmetic Average (µg/L)	Upper Confidence Limit (µg/L)
Metals		
Aluminum	122	199
Arsenic	12	19
Barium	365	469.0
Beryllium	1	1.0
Cadmium	1.4	3.0
Chromium	3.3	6.1
Copper	13	28
Iron	10,417	21,093
Lead	2.2	5.4
Nickel	86	120
Silver	5.1	6.8
Thallium	12	36
Zinc	108	279
Volatiles		
Acetone	7.7	11
Chlororbenzene	0.2	0.4
Chloroethane	1.5	2.3
Chloromethane	1.2	1.8
1, 4-Dichlorobenzene	0.6	1.1
Dichlorodifluoromethane	1.5	2.1
cis-1,2-Dichloroethylene	0.5	0.6
trans-1, 2-Dichloroethylene	0.2	0.3
Ethyl ether	9.7	16
Tetrahydrofuran	12	26

8.4 Toxicity Reference Values

It was necessary to identify benchmark toxicity reference values for each media for all COCs for comparison to estimated site exposure point concentrations. Toxicity reference values (TRVs) were based upon state and federal water quality criteria for aquatic species. TRVs for terrestrial species were based on best available information from the scientific literature. This information was obtained by using databases such as the Aquatic Information Retrieval Database (AQUIRE) and BIOSYS. Additional information for identifying TRVs was based on comprehensive contaminant hazard reviews for wildlife prepared by Eisler (1985-1993) and summaries prepared by Beyer (1990).

Table 8.4-1 presents Ambient Water Quality Criteria (AWQC) and Minnesota Water Quality Criteria (MWQC) for all chemicals identified as COCs in groundwater and surface water. The Minnesota Water Quality Criteria presented are for Class 2B waters which are applicable to the stretch of Minnesota River in the vicinity of the landfill and the unclassified surface water bodies (intermittent stream and operating quarry). When there were Minnesota Water Quality Criteria for a particular COC, those criteria were used as the TRV in the risk characterization. If Minnesota Water Quality Criteria were not established for a particular COC, then federal Ambient Water Quality Criteria were used as the TRV. In instances where state or federal criteria were not established, a lowest observed adverse effect level (LOAEL) concentration was used. The most stringent LOAELs were taken from information provided in the Ambient Water Quality Criteria documents prepared by EPA or from information available through AQUIRE. There were some compounds for which no information could be obtained and these are noted in Table 8.4-1.

Table 8.4-2 presents TRVs for ingestion of leachate or surface water by terrestrial animals. The toxicity values listed for each compound represent the most stringent value available in the literature. In most cases, a NOAEL (No Observed Adverse Effect Level) or LOAEL (Lowest Observed Adverse Effect Level) value was reported, as indicated in the tables. If water toxicity values were not available, water concentrations were estimated based upon other available toxicity values; i.e., dietary concentrations or doses. The estimated value therefore represents the toxicity value for water consumption only. Therefore, acceptable water concentrations may appear high when the animal's daily intake of water is low. The water concentration wa estimated using the following equation:

$$\text{mg/l in water} = \frac{\text{oral } [R_fD] \text{ (in mg/kg/day) x body weight (kg)}}{\text{ingestion rate (l/day)}}$$

Body weight and ingestion rates used in calculating estimated water concentrations are presented in Table 8.4-3.

In addition, the values presented for volatiles are used as TRVs for dermal exposure to leachate or surface water.

TABLE 8.4-1
Ambient Water Quality Criteria and Minnesota Water Quality Criteria for COCs
Freeway Landfill Risk Assessment - Burnsville, MN

Chemical	AWQC[a] Acute/Chronic (µg/L)	Minnesota Water Quality Standards (µg/L) [b]		
		CS	MS	FAV
Organics				
Acetone	14.2g/L[c]/4.2g/l[c]	NE	NE	NE
Benzene	5,300/NE[c]	114	4,487	8,974
Chlorobenzene	250/50	10	423	846
Chloroethane	120[c]/20[c]	NE	NE	NE
Chloromethane	120[c]/20[c]	NE	NE	NE
1,4-Dichlorobenzene	1,120[d]/763[d]			
1,1-Dichlorobenzene	1,120[d]/763[d]	NE	NE	NE
Dichlorodifloro-methane[h]	NE/NE	NE	NE	NE
1,1-Dichloroethane	118,000[c]/20,000[c]	NE	NE	NE
cis-1,2-Dichloroethylene	150,000[c]	NE	NE	NE
trans-1,2-Dichloroethylene	150,000[c]	NE	NE	NE
Ethyl ether[h]	NE/NE	NE	NE	NE
Tetrahydrofuran[h]	NE/NE	NE	NE	NE
Vinyl chloride	NE/NE	7.6	None	None
Inorganics				
Aluminum	750[e]/87[e]	125	1,072	2,145
Arsenic	360/190	70	360	720
Barium[h]	NE/NE	NE	NE	NE
Beryllium	130/5.3	NE	NE	NE
Cadmium	3.34-12.9[f]/1.01-3.37[f]	1.01-3.37[f]	3.35-5.07[f]	57.0-319[f]
Chromium III	1,546-5,404[f]/184-644[f]	184-644[f]	1,546-5,404[f]	3,089-10,797[f]
Chromium VI	16/11	11	16	32

TABLE 8.4-1 Water Quality Criteria (Cont.)

Chemical	AWQC[a] Acute/Chronic (µg/L)	Minnesota Water Quality Standards (µg/L)[b]		
		CS	MS	FAV
Copper	24.6[f]/16.0[f]	12.2[f]	24.6[f]	49.4[f]
Iron	NE/1,000	NE	NE	NE
Lead	68.2-477[f]/2.65-18.6[f]	2.65-18.6[f]	68.2-477[f]	137-956[f]
Nickel	1,656-5,290[f]/85.8-274[f]	140-213[f]	1,258-4,582[f]	2,156-9,164[f]
Selenium	20/5.0	5.0	20	40
Silver	3.18-44.0[f]/0.92[g]/0.12	1.0	1.59-22.0[f]	3.18-44.0[f]
Thallium	1,400[c]/40[c]	NE	NE	NE
Zinc	286-1,015[f]/47	94-343[f]	104-379[f]	208-758[f]

NE = Not established.
NA = Not Applicable.
[a] AWQC = Ambient Water Quality Criteria. Source: EPA 1986.
[b] Source: Minnesota Pollution Control Agency. 1990.
[c] Insufficient data to establish. Value reported is lowest observed effect level (LOEL).
[d] Values are for dichlorinated benzenes.
[e] Aluminum criteria are pH dependent. These values are for pH between 6.5 and 9.0.
[f] Criteria are hardness dependent. Total hardness (Ca+Mg) ranged from 86.8 to 594 mg/L. As per Minnesota Standards maximum hardness used was 400 mg/L.
[g] Proposed criteria.
[h] No toxicity information available for receptors.

CS = Chronic Standard - the highest water concentration of a toxicant to which organisms can be exposed indefinitely without causing chronic toxicity.

MS = Maximum Standard - the highest concentration of a toxicant in water to which aquatic organisms can be exposed for a brief time with zero to slight mortality. The MS equals the FAV divided by two (2).

FAV = Final Acute Value - an estimate of the concentration of a pllutant corresponding to the cumulative probability of 0.05 in the distribution of all the acute toxicity values for the genera or species from the acceptable acute toxicity tests conducted on a pollutant.

TABLE 8.4-2
Toxicity Reference Values for Ingestion of Leachate
Freeway Landfill Risk Assessment - Burnsville, MN

CHEMICAL	TOXICITY VALUE/DESCRIPTION	EQUIVALENT WATER CONCENTRATION[a]	SPECIES	REFERENCE
Organics				
Acetone	NA	NA	NA	___
Chlorobenzene	1-3 mg/L/LOAEL	-----	cat	Clayton & Clayton 1981-82
Chloroethane	14 mg/L/LOAEL	-----	rodents	Clayton & Clayton 1981-82
Chloromethane	NA	NA	NA	-----
1,4-Dichlorobenzene	18.8 mg/kg-bw/day/NOAEL; fed 5 days/wk for a total of 138 doses	113 mg/L	rat	Clayton & Clayton 1981-82
Dichlorodifluoromethane	160 mg/kg-bw/day/LOAEL; fed 5 days/wk for 18 weeks	1333 mg/L	mouse	ACGIH 1986
cis-1,2-Dichloroethylene	NA	NA	NA	-----
trans-1,2-Dichloroethylene	21 mg/L/LOAEL	-----	mouse	Barnes et al. 1985
Ethyl ether	500 mg/kg-bw/day/NOAEL; gavaged for 13 weeks	3000 mg/L	rat	IRIS 1993
Tetrahydrofuran	NA	NA	NA	-----

TABLE 8.4-2 Toxicity Reference Values (Cont.)

CHEMICAL	TOXICITY VALUE/DESCRIPTION	EQUIVALENT WATER CONCENTRATION[a]	SPECIES	REFERENCE
Inorganics				
Aluminum	1400 mg/kg/LOAEL; proportion in diet	980 mg/L	chicken[b]	Browning 1969
Arsenic	5 mg/L/NOAEL 5 mg/L/LOAEL	----- -----	rat mouse	NAS 1977 NAS 1977
Barium	NA	NA	NA	-----
Beryllium	5 mg/L/NOAEL	-----	rat, mouse	Schroeder & Mitchener 1975a,b
Cadmium	2.5 mg/L/NOAEL 1 mg/L/LOAEL 160 mg/L/LOAEL	----- ----- -----	dog rat rabbit	Awar et al. 1961 Perry et al. 1977 Stove et al. 1972
Chromium	5 mg CrIII/L/NOAEL 5 mg CrVI/L/LOAEL	----- -----	mouse mouse	Schroeder et al. 1964 Schroeder et al. 1964
Copper	100 mg/L/LOAEL	-----	goose	NAS 1980
Iron	NA	NA	NA	-----
Lead	1000 mg/L/NOAEL 1.5 mg/L/LOAEL	----- -----	mouse rat	Eisler 1988 Eisler 1988
Nickel	5 mg/L/NOAEL 5 mg/L/LOAEL	----- -----	rat mouse	Schroeder et al. 1974 Schroeder et al. 1963
Selenium	3 mg/L/NOAEL	-----	mouse	Blakely 1987

TABLE 8.4-2 Toxicity Reference Values (Cont.)

CHEMICAL	TOXICITY VALUE/DESCRIPTION	EQUIVALENT WATER CONCENTRATION[a]	SPECIES	REFERENCE
Silver	NA	NA	NA	-----
Thallium	15 mg/kg-bw/day/lethal oral dose	312.5 mg/L	dog	OHM/TADS 1993
Zinc	100 mg/kg/NOAEL; subchronic feeding study	30 mg/L	rat	Schlicker & Cox 1968

[a] If drinking water toxicity values were not available water concentrations were estimated based upon other available toxicity values i.e. dietary concentrations or doses. Drinking water toxicity values were calculated from these values using animal body weights, food comsumption rates, and daily water consumption rates (USEPA 1986). See Table 8.4-3 for body weights, food consumption rates, and water consumption rates.

[b] Food consumption and water consumption rates for chicken and mallard were obtained from Sax 1984.

TABLE 8.4-3
BODY WEIGHT AND CONSUMPTION RATES FOR SELECTED ANIMALS

SPECIES	BODY WEIGHT (kg)	FOOD CONSUMPTION (kg)	WATER CONSUMPTION (L/day)
Mouse[a]	0.05	0.0065	0.006
Rat[b]	0.15	0.0075	0.025
Dog[c]	11.0	0.275	0.528
Chicken	NA	0.35	0.50
Mallard	NA	0.084	0.42

NA= Not available in the literature

[a] Values are for a medium sized mouse
[b] Values are for a medium sized rat
[c] Values are for a small dog

8.5 Risk Characterization

In accordance with the scope of work, risks will be evaluated qualitatively. As such, risks from direct exposure will be evaluated using the Toxicity Quotient (TQ) method as described by Barnthouse et al. (1986). This method involves comparing the exposure concentration to a toxicity reference value (e.g., State of Minnesota Water Quality Criteria, AWQC, NOAEL, LOAEL, etc.) using the following equation:

TQ = Exposure Point Concentration/Toxicity Reference Value

If the quotient is greater than one, a risk is considered possible; if the quotient is less than one, a risk is considered unlikely.

The method described above will only evaluate potential risks associated with direct exposure. Potential risks to ecological receptors can also occur via food chain effects. The risks associated with food chain effects are discussed qualitatively in addition to any risks which the method described above may identify. This method does not account for potential additive or synergistic effects which could increase overall risks to organisms exposed to mixtures. Identification of assumptions and uncertainties and their impact on estimated risks are described qualitatively.

8.5.1 Groundwater

Table 8.5-1 presents the Toxicity Quotient (TQ) for each of the COCs for groundwater. As a worst case scenario it is assumed that groundwater concentrations would be discharged fully to surface water. Thus the TRVs used for establishing a TQ for each groundwater COC were the appropriate AWQC of Minnesota Water Quality Criteria. Under this worst case scenario the TQ for aluminum (based on a chronic TRV), iron (based on a chronic TRV), silver (based on the proposed acute 0.92 AWQC and the chronic 0.12 TRV), thallium (based on a chronic TRV) and zinc (based on a chronic TRV) would exceed 1. Thus a potential risk exists from aquatic organism exposure to these COCs.

The concentrations reported in groundwater for aluminum, iron, silver, thallium and zinc are either close to or lower than the concentrations detected in surface water for these compounds. Thus, the entire concentration of groundwater COCs is not discharging to surface waters. It should also be noted that the groundwater flow in this area is altered by the influence of pumping activities of the Kramer Quarry. These pumping activities cause groundwater to travel toward the quarry rather than the Minnesota River as would occur naturally if pumping were not occurring. It is highly unlikely that the entire concentration of groundwater COCs would discharge to the Minnesota River. Additionally, given flows in the Minnesota River, concentrations of groundwater COCs would be diluted rapidly. Thus, risks associated with groundwater are considered unlikely based on current conditions and conditions which may occur if pumping activities were to cease at the Kramer Quarry.

8.5.2 Surface Water

As discussed previously, there are two distinct surface water bodies which were sampled as part of previous investigations. The first is the intermittent stream which runs between the landfill and the highway. Surface water samples taken from the intermittent stream occurred at

Table 8.5-1 Toxicity Quotients for Groundwater COCs
Freeway Landfill Risk Assessment - Burnsville, MN

Compound	TRVs (µg/L)	Exposure Concentration (µg/L)	Toxicity Quotient	Is the Toxicity Quotient > 1
Organics				
Dichlorodifluoromethane	NA	1.4	--	--
1, 1-Dichloroethane	1.2E+05	0.1	8.5E-07	no
	2.0E+04	0.1	5.0E-06	no
cis-1,2-Dichloroethylene	1.2E+05	1.3	1.1E-05	no
trans-1, 2-Dichloroethylene	1.2E+05	0.7	6.0E-06	no
Ethyl ether	NA	4.6	--	--
Tetrahydrofuran	NA	9.6	--	--
1,1,2-Trichloroethylene	NA	0.6	--	--
Inorganics				
Aluminum	750	118	0.16	no
	87	118	1.36	yes
Arsenic	70	4.4	6.3E-02	no
	360	4.4	1.2E-02	no
	720	4.4	6.1E-03	no
Barium	NA	342	--	--
Beryllium	130	1.0	7.7E-03	no
	5.3	1.0	1.9E-01	no
Cadmium	3.34 - 12.9	0.7	5.4E-2 - 0.21	no
	1.01 - 3.37	0.7	0.21 - 0.69	no
Chromium (III)	1,546 - 5,404	1.2	2.2E-4 - 7.8E-4	no
	184 - 644	1.2	1.9E-3 - 6.5E-3	no
Chromium (VI)	16	1.2	0.08	no
	11	1.2	0.11	no
Copper	24.6	9.2	0.37	no
	16.0	9.2	0.58	no
Iron	1000	4365	4.37	yes
Lead	68.2 - 477	1.7	3.6E-3 - 2.5E-2	no
	2.65 - 18.6	1.7	9.1E-3 - 0.64	no
Nickel	1,656 - 5,290	25	4.7E-3 - 1.5E-2	no
	85.8 - 274	25	9.0E-2 - 0.29	no
Selenium	20	2.6	0.13	no
	5.0	2.6	0.52	no
Silver	3.18 - 44.0	3.0	6.8E-2 - 0.94	no
	0.92	3.0	3.26	yes
	0.12	3.0	25.00	yes
Thallium	1400	153	0.11	no
	40	153	3.83	yes
Zinc	286 - 1,015	102	0.10 - 0.36	no
	47	102	2.17	yes

Notes:
NA = TRV not available
TRVs are taken from Table 8.4-1
Exposure Concentrations are taken from Table 8.3-2

sampling location SW-3. The second is the quarry south of the landfill. Surface water samples taken from the quarry occurred at sampling location SW-6.

Table 8.5-2 presents the TQ values for each of the COCs selected for each surface water body. The TQ values in SW-6 for aluminum (based on a chronic TRV), copper (based on a chronic TRV), iron (based on a chronic TRV), selenium (based on a chronic TRV), and silver (based on the proposed acute 0.92 AWQC and the chronic 0.12 TRV) were all greater than 1. Thus a potential risk exists from aquatic organism exposure to these COCs. The TQ for lead (based on a chronic TRV range) and for silver (based on an acute TRV range) exceeds a value of 1 in part of the TRV range. Lead and silver water quality criteria values (the TRV used for this exposure) are related to hardness of the water. Therefore, since a range of hardness was reported in the samples, a water quality criteria range was also used. Thus the TQ exceeds one only at certain hardnesses.

The TQ values in SW-3 for aluminum (based on acute and chronic TRVs), iron (based on a chronic TRV), and zinc (based on a chronic TRV) exceed a value of 1. Thus a potential risk exists from aquatic organism exposure to these COCs. The TQ value for lead (based on a chronic TRV range) exceeds one in part of the TRV range. As stated previously, lead water quality criteria values (the TRV used for this exposure) are related to hardness of the water. Therefore, since a range of hardness was reported in the samples, a water quality criteria range was also used. Thus the TQ exceeds one only at certain hardnesses. Thus a potential risk exists from aquatic organism chronic exposures to lead at certain water hardnesses.

8.5.3 Leachate

The scope of work identified direct exposure and ingestion of leachate as the pathway to be evaluated in this ERA. Table 8.5-3 presents TQ values for selected COCs in leachate. As noted previously, for the purposes of evaluating ingestion of leachate, all selected COCs were used. For the purposes of evaluating dermal exposure to leachate, only the selected volatiles were evaluated. Thus the TQ values for organics presented in Table 8.5-3 provide an estimate of risks from leachate associated with ingestion as well as dermal exposure.

None of the TQ values presented in Table 8.5-3 for leachate COCs exceeded one. Therefore, risks associated with dermal exposure and ingestion of leachate are considered unlikely.

8.5.4 Bioaccumulation, Biomagnification, and Food Chain Effects

When predicting risks to ecological receptors it is necessary to determine the relationship between exposure and the resulting tissue concentrations for each contaminant within the organism. Particularly for animals, it may be useful to distinguish between a contaminant which is taken directly from the abiotic environment and that which is "transported" through the food chain. Three terms are commonly used to make these distinctions: bioconcentration, bioaccumulation, and biomagnification.

Bioconcentration is defined as the contaminant concentration found in a species as a direct result of exposure to the contaminant in the species' physical environment, such as fish in contaminated surface water.

Table 8.5-2 Toxicity Quotients for Surface Water COCs (continued)
Freeway Landfill Risk Assessment - Burnsville, MN

Surface Water (SW-3)

Compound	TRVs (µg/L)	Exposure Concentration (µg/L)	Toxicity Quotient	Is the Toxicity Quotient > 1
Organics				
Acetone	1.4E+07	35	2.5E-06	no
cis-1,2-Dichloroethylene	9.0E+06	7.3	8.1E-07	no
Ethyl ether	NA	7.0	- -	- -
Inorganics				
Aluminum	750	911	1.22	yes
	87	911	10.47	yes
Barium	NA	2494	- -	- -
Cadmium	3.34 - 12.9	0.6	4.7E-2 - 0.18	no
	1.01 - 3.37	0.6	0.18 - 0.59	no
Chromium (III)	1,546 - 5,404	3.8	2.5E-3 - 7.0E-4	no
	184 - 644	3.8	5.9E-3 - 2.1E-2	no
Chromium (VI)	16	3.8	0.24	no
	11	3.8	0.35	no
Copper	24.6	6.0	0.24	no
	16.0	6.0	0.38	no
Iron	1000	68,742	68.7	yes
Lead	68.2 - 477	6.6	1.4E-2 - 9.7E-2	no
	2.65 - 18.6	6.6	0.35 - 2.5	yes *
Zinc	286 - 1,015	140	0.14 - 0.49	no
	47	140	2.98	yes

Notes:
* = A segment of the range is above a Toxicity Quotient of 1.0.
NA = TRV not availble
TRVs are taken from Table 8.4-1.
Exposure Concentrations are taken from Table 8.3-2.

Table 8.5-2 Toxicity Quotients for Surface Water COCs
Freeway Landfill Risk Assessment - Burnsville, MN

Surface Water (SW-6)

Compound	TRVs (µg/L)	Exposure Concentration (µg/L)	Toxicity Quotient	Is the Toxicity Quotient > 1
Organics				
cis-1,2-Dichloroethylene	1.5E+05	0.99	6.6E-06	no
trans-1,2-Dichloroethylene	1.5E+05	0.3	2.0E-06	no
Ethyl ether	NA	1.2	- -	- -
Inorganics				
Aluminum	750	190	0.25	no
	87	190	2.18	yes
Barium	NA	423	- -	- -
Cadmium	3.34 - 12.9	0.85	6.6E-2 - 0.25	no
	1.01 - 3.37	0.85	0.25 - 0.84	no
Chromium (III)	1,546 - 5,404	1.3	2.4E-3 - 8.4E-4	no
	184 - 644	1.3	2.0E-3 - 7.0E-3	no
Chromium (VI)	16	1.3	0.08	no
	11	1.3	0.12	no
Copper	24.6	22.0	0.89	no
	16.0	22.0	1.38	yes
Iron	1000	1069	1.07	yes
Lead	68.2 - 477	6.2	1.3E-2 - 9.1E-2	no
	2.65 - 18.6	6.2	0.33 - 2.3	yes *
Selenium	20	8.0	0.40	no
	5.0	8.0	1.60	yes
Silver	3.18 - 44.0	7.2	0.16 - 2.3	yes *
	0.92	7.2	7.83	yes
	0.12	7.2	60.00	yes
Zinc	286 - 1,015	43	4.2E-2 - 0.15	no
	47	43	0.91	no

Table 8.5-3 Toxicity Quotients for Leachate COCs
Freeway Landfill Risk Assessment - Burnsville, MN

Compound	TRVs (µg/L)	Exposure Concentration (µg/L)	Toxicity Quotient	Is the Toxicity Quotient > 1
Organics				
Acetone	NA	11	- -	- -
Chlororbenzene	1,000 - 3,000	0.4	1.3E-4 - 4.0E-4	no
Chloroethane	1.4E+04	2.3	1.6E-04	no
Chloromethane	NA	1.8	- -	- -
1, 4-Dichlorobenzene	1.1E+05	1.1	9.7E-06	no
Dichlorodifluoromethane	1.3E+06	2.1	1.6E-06	no
cis-1,2-Dichloroethylene	NA	0.6	- -	- -
trans-1, 2-Dichloroethylene	2.1E+04	0.3	1.4E-05	no
Ethyl ether	3.0E+06	16	5.3E-06	no
Tetrahydrofuran	NA	26	- -	- -
Inorganics				
Aluminum	9.8E+05	199	2.0E-04	no
Arsenic	5.0E+03	19	3.8E-03	no
Barium	NA	469	- -	- -
Beryllium	5.0E+03	1.0	2.0E-04	no
Cadmium	2.5E+03	3.0	1.2E-03	no
	1.0E+03	3.0	3.0E-03	no
	1.6E+05	3.0	1.9E-05	no
Chromium (III)	5.0E+03	6.1	1.2E-03	no
Chromium (VI)	5.0E+03	6.1	1.2E-03	no
Copper	1.0E+05	28	2.8E-04	no
Iron	NA	21093	- -	- -
Lead	1.0E+06	5.4	5.4E-06	no
	1.5E+03	5.4	3.6E-03	no
Nickel	5.0E+03	120	2.4E-02	no
Silver	NA	6.8	- -	- -
Thallium	3.1E+05	36	1.2E-04	no
Zinc	3.0E+04	279	9.3E-03	no

Notes:
NA = TRV not available
TRVs taken from Table 8.4-2.
Exposure Concentrations taken from Table 8.3-3.

Bioaccumulation is defined as the concentration of contaminant found in a species as a result of exposure to the contaminant in the physical environment (bioconcentration) and through the ingestion of contaminated media. Bioaccumulation is different from other environmental processes because it concentrates rather than diffuses or dilutes contaminants. A bioaccumulation factor (BAF) is expressed as the ratio of the concentration of contaminant in the organism to that in the source medium. Bioaccumulation refers to both uptake of dissolved chemicals in water (bioconcentration) and uptake from ingested food, soil, or sediment residues. Where this ratio exceeds one, bioaccumulation of contaminants can exacerbate exposure to contaminants for those species feeding higher in the food chain.

Finally, biomagnification is defined as the increasing concentration of a contaminant in organisms feeding at progressively higher trophic levels. Biomagnification, as the name implies, is the magnification (increase in concentration of contaminants at successively higher trophic levels.

Bioconcentration, bioaccumulation, and biomagnification are dependent on the specific dynamics of an ecosystem. The impact each has depends largely on the physiological processes of organisms which comprise the ecosystem's food web.

Unfortunately, the specific dynamics of the communities near the Freeway Landfill have not been investigated to the extent necessary to determine the physiological processes unique to organisms in this ecosystem. As such it is difficult to assess the impact that bioconcentration, bioaccumulation, and biomagnification will have to the ecosystem and its individual species at this site. Additionally, bioconcentration factors (BCFs) were not readily available for all compounds selected as COCs at this site. The volatile COCs, however, are not known to bioaccumulate. Limited and highly variable BCFs were available for metals selected as COCs at this site, but none were available for the specific species. Some were available for related species but are highly variable, for example the range of BCFs reported for guppies exposed to zinc was 466.3 to 965.5; for most aquatic species it was 4-24,000. Further quantitative work, (e.g. ecological modelling) and characterization of the ecosystem would have to be done to fully assess food chain effects at this site. However, this was not part of the scope of this assessment and is outside of the ability of a qualitative assessment to evaluate fully.

8.5.5 Uncertainties Associated with Risk Characterization

Ecological risk assessments require the use of many assumptions, each of which has associated uncertainties. The reasons for the use of many assumptions are primarily the lack of reliable toxicity data for all species and chemicals under consideration, and resource and budget constraints that limit the amount of effort that it is reasonable to spend on site-specific ecological investigations. In order to be protective, approaches and assumptions that are known to be likely to overestimate risk are often used in order to compensate for the lack of toxicity information and site-apecific data.

This section summarizes the major assumptions used in this ecological risk assessment and the likely impact of their associated uncertainties on risk characterization. These assumptions are completeness of exposure pathways and frequency of exposure, exposure point concentrations,

bioaccumulation potential, and toxicity values, as discussed in more detail in the following paragraphs:

Completeness of Exposure Pathways and Frequency of Exposure

The surface water and seep locations identified as potential exposure points for ecological receptors are very limited in extent and based on field observations. There is little evidence that the evaluated surface water and seep are actually used by any of the identified potential receptors. Although numerous deer tracks were observed on and around the landfill and near these water resources, it is unlikely that these are the only water resources used by deer in the area. Nevertheless, the ecological risk assessment assumes that numerous species of organisms are not only exposed to these water sources but that exposure is continuous over a long period of time.

In addition, although much of the ecological information presented regarding to local species is related to the Minnesota River, there is no evidence that this river has been or will be impacted by the minimal water resources identifed at the site.

Therefore, the assumptions regarding completeness of exposure pathways and frequency of exposure can only be interpreted as conservative and likely to overestimate risk.

Exposure Point Concentrations

Risk calculations assume that organisms are continuously exposed at the estimated exposure point concentrations. Procedures for estimating exposure point concentrations are conservative and will derive higher, rather than lower, estimates if there is variance in the data set, as discussed in Section 8.3.3. In addition, exposure to groundwater was also evaluated even though groundwater concentrations are higher than surface water concentrations and organisms are not exposed directly to groundwater.

The concentrations reported for groundwater COCs are either close to, or higher than, the concentrations detected in surface water for these compounds. Thus, the entire concentration of groundwater COCs is not discharging to surface waters. It should also be noted that the groundwater flow in this area is altered by the influence of pumping activities of the Kramer Quarry. These pumping activities cause groundwater to travel toward the quarry rather than the Minnesota River as would occur naturally if pumping were not occurring. It is highly unlikely that the entire concentration of groundwater COCs would discharge to the Minnesota River. Additionally, given flows in the Minnesota River, concentrations of groundwater COCs would be diluted rapidly. Thus, risks associated with groundwater are considered unlikely based on current conditions and conditions which may occur if pumping activities were to cease at the Kramer Quarry. However, the assumption that the entire concentration of a COC detected in groundwater would discharge to any surface water body is a worst case scenario and overestimates the exposure concentration to which aquatic organisms would be exposed. This overestimation of the exposure concentration leads to an over estimation of the TQ and thus the potential risk.

Also, the use of UCL values as the exposure concentration tends to overestimate the exposure concentration, particularly when there is a low number of samples, as was the case with surface water and leachate. Again, this procedure tends to overestimate risk.

Bioaccumulation Potential

The organic COCs at this site are all volatiles and are not known to bioaccumulate. Although some of the inorganic COCs (metals) are known to bioaccumulate in aquatic species, there are no higher trophic level species such as fish or fish eating birds on the site that could be sampled to evaluate the extent to which bioaccumulation might occur at the COC concentrations in water at the site.

The lack of quantitative estimation or sampling to evaluate bioaccumulation may underestimate theoretical risk but is not likely to underestimate actual risk because complete exposure pathways appear to be lacking.

Toxicity Values

Toxicity values for ecological receptors are limited because of the variety of species involved and because no systematic effort has been undertaken to develop a wide range of generally agreed upon chemical-specific and species-specific values. Currently, ecological risk assessors must rely on searching toxicological data bases and using guidelines such as AWQC developed under the Clean Water Act. In this ecological risk assessment, the most stringent values available for each chemical and for related species were used for comparison to estimated exposures. This method attempts to overestimate rather than underestimate risk.

An alternative to searching for appropriate toxicity values is to perform site-specifc bioassays with contaminated site media. Generally, however, the resources and effort necessay to perform these tests must be weighed against the likelihood of exposure and whether or not critical species or habitats are potentially at risk.

Section 9
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APPENDIX A

LANDFILL GAS DATA

LANDFILL GAS AIR TOXICS DATA - MINNESOTA

LANDFILL GAS DATA - PPM BASIS																			
				Version Date - 1/13/93															
By: Libbie Henderson, MPCA/AQD																			
TEST	PPM Test Data:			Chloro-		cis-1,2-Dichloro		Methylene		trans-1,2-Dichloro		1,1-Dichloro		1,1-Dichloro		1,1,1-Trichlor-			
Location-Date	CMPD:	Vinyl Chloride		ethane		ethene		Chloride		ethene		ethane		ethene		oethane		Benzne	
	CAS #:	75-1-4		75-00-3		156-59-2		75-9-2		156-60-5		75-34-3		75-35-4		71-55-6		71-43-2	
	MW:	62.5		63.6		96.9		84.9		96.9		99		96.9		130.7		78	
Pine Bend - Total Collected Gas																			
3/90		4.5		0.75	*		*?0.3	19		0.6	*	4.1			?3.9	0.3		2.1	
6/90		3		0.5	*		*?0.2	12		0.4	*	2.2			?2.2	0.2	*	1.3	
9/90		3.4		0.5	*	2.3		10		0.4	*	2.2		0.2	*	0.2	*	1.3	
12/90		2.2		0.3	*	1.9		6.2		0.2	*	1.5		0.1	*	0.2		1.0	
10/91		2.5		0.333	*	1.7		5.9		0.2	*	1.6		0.1	*	0.133	*	1.0	
3/92		2.2			BDL	2.0		3.73			BDL	1.09			*	0.29		1.2	
5/92		2.27			BDL	1.8		6.93			BDL	1.87			*		*	1.2	
Flying Cloud - Total Collected Gas																			
3/90		5.5		0.75	*		*?0.3	6.6		0.6	*	1.6			?6.1	0.3	*	1.0	
6/90		3.3		0.5	*		*?0.2	4.1		0.4	*	0.9			?3.2	0.2	*	0.6	
9/90		2.5		0.5	*	2.7		3.7		0.4	*	0.25	*	0.2	*	0.2	*	0.3	*
12/90		2.8		0.25	*	2.4		2.8		0.2	*	0.7		0.1	*	0.1	*	0.4	
10/91		2.8		0.25	*	2.1		1.5		0.2		0.5		0.1	*	0.1	*	0.4	
Hopkins Well Tests																			
G-3 9/90		3.76						0.7	*										
G-5 9/90			BDL					2.3											
G-8 9/90								13.3											
G-8 DUP 9/90								3.7											
G-13 9/90								26											
G-5-PCA 9/90						60.4		42.1				1.8			BDL	0.48			BDL
G-13-PCA 9/90						19.7		11.2				0.73			BDL	1.43			BDL
G-3 1/90								0.29	*							0.09	*	1.1	
G-5 1/90								72								0.09	*	2.7	
G-8 1/90								42								1.7		2.7	
G-13 1/90								3.5								0.09	*	2.2	
Bemidji Landfill Gas Vent Samples***																			
Vent 1 - 8/92		0.43				0.023	(3)	0.0066								0.0052		0.018	
Vent 6 - 8/92		0.036				1.46	(3)	0.012				0.10		0.0013		0.030		0.27	
Vent 8 - 8/92						0.31	(3)	0.097				1.4				4.4		0.20	
Vent 15 - 8/92		0.0095				0.65	(3)	0.025				0.44		0.0011		0.26		0.79	
Vent 16 - 8/92		0.0039				1.0	(3)	0.01				0.63				0.026		0.39	
Vent 23 - 8/92		0.012				1.4	(3)	0.36				0.15				0.29		2.4	
Vent 1 - 10/92		0.0068				0.376	(3)	0.0029				0.007				0.0012		0.887	
Vent 6 - 10/92		0.05				0.005	(3)	0.0011				0.0004		0.0002		0.001		0.011	
Vent 8 - 10/92		0.15				0.077	(3)	0.016				0.15		0.0012		0.225		0.02	
Vent 11 - 10/92		0.053				4.2	(3)	0.01				0.012				0.012		0.99	
Vent 16 - 10/92		0.005				0.0046	(3)	0.00026								0.00075		0.0015	
Vent 23 - 10/92		0.014				0.005	(3)	0.0035				0.00082		0.00033		0.0017		0.0023	
Olmsted County - 9/91																			
Vent 01		20				2.8		0.2	*	0.2	*	0.26		0.1	*	0.1	*	0.62	
Vent 0581		26				21		2.1		0.2	*	0.34		0.3		0.1	*	0.8	
Vent 0241		0.00125	*			0.016		0.002	*	0.002	*	0.00125	*	0.001	*	0.001	*	0.0015	*
Gas Probe 003		0.0025	*			0.0081		0.004	*	0.004	*	0.0025	*	0.002	*	0.002	*	0.003	*
Gas Probe 004		1.8				0.26		0.33		0.02	*	0.0125	*	0.01	*	0.01	*	0.15	
CALCULATIONS USING ALL DATA POINTS:																			

LANDFILL GAS AIR TOXICS DATA - MINNESOTA

OVERALL AVERAGE(2)		3.08		0.46		4.84		7.57		0.27		0.85		0.08		0.34		0.85
Pine Bend Average		2.87		0.48		1.94		9.11		0.36		2.08		0.13		0.22		1.30
Flying Cloud Average		3.38		0.45		2.40		3.74		0.36		0.79		0.13		0.18		0.54
Hopkins Well Test Average		3.76				40.05		19.74				1.27				0.65		2.18
Bemidji Vent Average		0.070				0.79		0.045				0.29		0.00083		0.44		0.50
Olmsted County Average		9.56				4.82		0.53		0.085		0.12		0.08		0.043		0.31
Overall Avg as ug/m3 **		7855.73		1202.69		19130.20		26226.33		1061.55		3420.27		300.87		1815.18		2706.54
Std Deviation		5.81		0.18		12.27		14.56		0.19		0.96		0.09		0.80		0.80
Number of Values		29		10		27		40		15		29		16		34		33
95% UCL		5.19		0.58		9.46		12.08		0.37		1.20		0.12		0.61		1.12
# of 1/2 DL		2		all		0		5		14		4		10		16		3
CALCULATIONS WITHOUT 1/2 DL DATA:																		
OVERALL AVERAGE(2)		3.31		NO		SAME		8.62		0.20		0.97		0.051		0.54		0.92
Pine Bend Average		2.87		DATA		AS		9.11				2.08				0.26		1.30
Flying Cloud Average		3.38				ABOVE		3.74		0.20		0.93						0.60
Hopkins Well Test Average		3.76						24.01				1.27				1.20		2.18
Bemidji Vent Average		0.070						0.045				0.289		0.00083		0.438		0.498
Olmsted County Average		15.93						1.22				0.30		0.30				0.52
Overall Avg as ug/m3 **		8437.28						29854.54		791.02		3924.48		200.48		2660.83		2944.88
Std Deviation		5.96						15.30		NA		0.98		0.122		1.08		0.80
Number of Values		27						35		1		25		6		18		30
95% UCL		5.56						13.68		NA		1.36		0.148		1.03		1.21
Chemical Name		Vinyl Chloride		Chloro ethane		cis-1,2-dichloro-ethene		Methylene Chloride		trans-1,2-Dichloro-ethene		1,1-Dichloro-ethane		1,1-Dichloro-ethene		1,1,1-Trichloro-ethane		Benzene

* value used = 1/2 detection level

** ug/m3 = (overall average*MW*1000)/24.5

***data by MPCA

? It is possible that these data (for cis-1,2-dichloroethene and 1,1-dichloroethene) were reversed in test results submittals.
Therefore, this data is not recommended for use in further analysis.

(1) Bemidji data for m&o xylene only - added together (MW equal).

(2) Averages include only those data with values in the column. Blanks are not treated as zero values

(3) Reported as "1,2 dichloroethylene".

LANDFILL GAS AIR TOXICS DATA - MINNESOTA

LANDFILL GAS DATA - I																					
By: Libbie Henderson, I																					
TEST	PPM Test Dat	Trichloro		1,2-Dichloro				Tetrachloro		Ethyl		Total		1,2-Dichloro		Chloro-		Carbon		Chloro-
Location-Date	CMPD:	ethene		propane		Toluene		ethene		benzenes		Xylenes		ethane		benzene		Tetrachloride		form
	CAS #:	71-01-6		78-87-5		108-88-3		127-18-4		100-41-4		1330-20-7		107-06-2		108-90-7		56-23-5		67-66-3
	MW:	131.5		111.2		92.1		165.8		106.2		106.2		97.1		111.6		153.8		119.4
Pine Bend - Total Collected Gas																					
3/90		4.6		1.1	*	66		5.5		15		36									
6/90		2.6		0.8	*	41		3.3		9.1		23									
9/90		3.2		0.8	*	44		4.1		11		27									
12/90		2.5		0.4	*	37		3.1		9.2		23									
10/91		1.4		0.533	*	35.3		2.1		8.5		21.7									
3/92		2.13			*	44		2.3		12		30.7									
5/92		2.1			*	44.3		2.5		11.6		29.3									
Flying Cloud - Total Collected Ga																					
3/90		2.3		1.1	*	47		5.8		17		35									
6/90		1.2		0.8	*	26		3.3		8.9		19									
9/90		1.3		0.8	*	25		3.7		10		22									
12/90		1.0		0.4	*	19		3.1		8.4		18									
10/91		0.6		0.4	*	14.3		1.9		7.4		16									
Hopkins Well Tests																					
G-3 9/90		0.45	*			8.1		0.35	*	3.2											
G-5 9/90		0.45	*			1.6		0.35	*	0.55	*										
G-8 9/90		7.5				29		3.5		7.6											
G-8 DUP 9/90		2.2				8.4		1		2.3											
G-13 9/90		0.45	*			4.4		0.7		0.55	*										
G-5-PCA 9/90			P			42.9		10.9		58.5	*	28		0.55		0.013			BDL		
G-13-PCA 9/90			P			32.2		0.95		12.4		25.8		0.73		0.009			BDL		
G-3 1/90		0.1	*			15		0.08	*	6											
G-5 1/90		3				45		0.75		23											
G-8 1/90		9.9				110		2.4		31											
G-13 1/90		3				37		0.08	*	29											
Bemidji Landfill Gas Vent Sample																					
Vent 1 - 8/92						0.041		0.0067		0.15		0.14	(1)								
Vent 6 - 8/92						0.14		0.24		0.18		0.44	(1)	0.018		0.11		0.00012		0.010	
Vent 8 - 8/92						0.18		0.092		0.14		0.18	(1)			0.058		0.00088		1.33	
Vent 15 - 8/92						1.9		0.20		7.1		5.6	(1)			0.14				0.017	
Vent 16 - 8/92						1.2		0.50		1.6		4.8	(1)	0.024		0.15		0.0033		0.0056	
Vent 23 - 8/92						28		0.23		9.0		12.6	(1)	0.081		9.3				0.038	
Vent 1 - 10/92						2.4		0.11		12		2.9	(1)	0.022		0.14		0.000032		0.029	
Vent 6 - 10/92						0.048		0.00029		0.097		0.089	(1)			0.0046		0.00038		0.0002	
Vent 8 - 10/92						0.044		0.71		0.0035		0.0061	(1)	0.0049		0.0076		0.000604		0.055	
Vent 11 - 10/92						14.2		0.99		0.99		10	(1)	0.017		0.18				0.099	
Vent 16 - 10/92						0.01		0.00		0.008		16	(1)	0.000049		0.00047		0.00037		0.00016	
Vent 23 - 10/92						0.031		0.0016		0.011		36	(1)	0.000049		0.0073		0.00032		0.0001	
Olmsted County - 9/91																					
Vent 01		0.125	*			30		0.15	*	4.9				0.1	*			0.1	*	0.1	
Vent 0581		1.6				16		3.8		4.1				0.1	*			0.1	*	0.1	
Vent 0241		0.00125	*			0.13		0.0087		0.055				0.001	*			0.001	*	0.001	
Gas Probe 003		0.0025	*			0.094		0.02		0.078				0.002	*			0.002	*	0.002	
Gas Probe 004		0.12				1.1		0.083		0.36				0.01	*			0.01	*	0.024	
CALCULATIONS USING ALL D																					

LANDFILL GAS AIR TOXICS DATA - MINNESOTA

OVERALL AVERAGE(2)	2.07	0.71	21.80	1.72	8.57	17.05	0.111	0.78	0.0168	0.11
Pine Bend Average	2.65	0.73	44.51	3.27	10.91	27.24				
Flying Cloud Average	1.28	0.70	26.26	3.56	10.34	22.00				
Hopkins Well Test Average	3.01		30.33	1.91	15.83	26.90	0.64	0.011		
Bemidji Vent Average			4.02	0.26	2.61	7.40	0.021	0.92	0.00075	0.14
Olmsted County Average	0.37		9.46	0.81	1.90		0.043		0.043	0.045
Overall Avg as ug/m3 **	11112.21	3237.51	81951.90	11657.31	37167.02	73899.04	438.60	3545.96	105.76	551.63
Std Deviation	2.31	0.27	23.37	2.22	11.16	12.28	0.22	2.56	0.04	0.33
Number of Values	26	10	40	40	40	26	15	13	13	16
95% UCL	2.96	0.88	29.04	2.41	12.03	21.77	0.22	2.1708	0.0370	0.27
# of 1/2 DL	7	all	0	5	3	0	5	0	5	4
CALCULATIONS WITHOUT 1/2										
OVERALL AVERAGE(2)	2.75	NO	SAME	1.94	7.66	SAME	0.145	SAME	0.00075	0.13401
Pine Bend Average	2.65	DATA	AS	3.27	10.91	AS		AS		
Flying Cloud Average	1.28		ABOVE	3.56	10.34	ABOVE		ABOVE		
Hopkins Well Test Average	5.12			2.89	14.31		0.64			
Bemidji Vent Average				0.257	2.607		0.021		0.00075	0.14401
Olmsted County Average	0.86			0.98	1.90					0.024
Overall Avg as ug/m3 **	14760.20			13127.36	33198.19		573.48		4.71	653.07
Std Deviation	2.37			2.30	7.82		0.27		0.0011	0.3777
Number of Values	19			35	37		10		8	12
95% UCL	3.82			2.70	10.18		0.31		0.0015	0.3477
Chemical Name	Trichloro-ethene	1,2-Dichloro-propane	Toluene	Tetrachloro-ethene	Ethylbenzenes	Total Xylenes	1,2-Dichloro-ethane	Chloro-benzene	Carbon Tetrachloride	Chloroform

LANDFILL GAS AIR TOXICS DATA - MINNESOTA

LANDFILL GAS DATA - I																			
By: Libbie Henderson, I																			
TEST	PPM Test Dat		1,2-Dibromo				o-Dichloro-		m-Dichloro-		Methyl		Chloro-				Methyl Ethyl		Methyl Iso-
Location-Date	CMPD:		ethane		Styrene		benzene		benzene		Mercaptan		methane		Acetone		Ketone		butyl Ketone
	CAS #:		106-93-4		100-42-5		95-50-1		541-73-1		74-93-1		74-87-3		76-64-1		78-93-3		108-10-1
	MW:		187.8		104.1		145.2		145.2		48.1		50.5		58		72		100
Pine Bend - Total Collected Gas																			
3/90																			
6/90																			
9/90																			
12/90																			
10/91																			
3/92																			
5/92																			
Flying Cloud - Total Collected Ga																			
3/90																			
6/90																			
9/90																			
12/90																			
10/91																			
Hopkins Well Tests																			
G-3 9/90																			
G-5 9/90																			
G-8 9/90																			
G-8 DUP 9/90																			
G-13 9/90																			
G-5-PCA 9/90		BDL		BDL		P		BDL											
G-13-PCA 9/90		BDL		BDL		P		BDL											
G-3 1/90											0.13 *								
G-5 1/90											23								
G-8 1/90											13								
G-13 1/90											0.13 *								
Bemidji Landfill Gas Vent Sampl																			
Vent 1 - 8/92									0.020										
Vent 6 - 8/92			0.13						0.40										
Vent 8 - 8/92			0.050						0.25										
Vent 15 - 8/92			0.27						0.57										
Vent 16 - 8/92			0.30						0.77										
Vent 23 - 8/92			0.27						8.4										
Vent 1 - 10/92			0.36						0.710										
Vent 6 - 10/92			0.00091						0.0046										
Vent 8 - 10/92			0.011						0.023										
Vent 11 - 10/92			0.55						0.42										
Vent 16 - 10/92									0.00099										
Vent 23 - 10/92			0.0001						0.16										
Olmsted County - 9/91																			
Vent 01		*	0.1	*									0.125 *		0.5 *		0.71		0.15 *
Vent 0581		*	0.1	*									0.125 *		3.6		9.3		0.15 *
Vent 0241		*	0.001	*									0.00125 *		0.019		0.0015 *		0.001 *
Gas Probe 003		*	0.002	*									0.0025 *		0.044		0.023		0.003 *
Gas Probe 004			0.01	*									0.094		0.05 *		0.13		0.015 *
CALCULATIONS USING ALL D																			

LANDFILL GAS AIR TOXICS DATA - MINNESOTA

OVERALL AVERAGE(2)		0.14						0.98		9.07		0.070		0.84		2.03		0.064
Pine Bend Average																		
Flying Cloud Average																		
Hopkins Well Test Average										9.07								
Bemidji Vent Average		0.19						0.98										
Olmsted County Average		0.043										0.070		0.84		2.03		0.064
Overall Avg as ug/m3 **		1101.25						5792.49		17797.00		143.36		1994.73		5974.24		260.41
Std Deviation		0.17						2.35		11.10		0.063		1.55		4.07		0.079
Number of Values		15						12		4		5		5		5		5
95% UCL		0.23						2.31		19.94		0.12		2.21		5.60		0.13
# of 1/2 DL		5						0		2		4		2		1		5
CALCULATIONS WITHOUT 1/2																		
OVERALL AVERAGE(2)		0.19420						SAME		18.00		0.094		1.22		2.54		NO
Pine Bend Average								AS										DATA
Flying Cloud Average								ABOVE										
Hopkins Well Test Average										18.00								
Bemidji Vent Average		0.19420																
Olmsted County Average												0.094		1.22		2.54		
Overall Avg as ug/m3 **		1488.61								35338.78		193.76		2890.53		7466.69		
Std Deviation		0.1857								7.07		NA		2.06		4.52		
Number of Values		10								2		1		3		4		
95% UCL		0.3093								27.80		NA		3.55		6.97		
Chemical Name		1,2-Dibromo-ethane		Styrene		o-Dichloro-benzene		m-Dichloro-benzene		Methyl mercaptan		Chloro-methane		Acetone		MEK		MIBK

LANDFILL GAS AIR TOXICS DATA - MINNESOTA

LANDFILL GAS DATA -											
By: Libbie Henderson,											
					these are repeated to be able to calc stdev w/o 1/2 dl						
TEST	PPM Test Dat	Methane			Methylene		Tetrachloro		Ethyl		
Location-Date	CMPD:	as noted			Chloride		ethene		benzenes		
	CAS #:	74-82-8			75-9-2		127-18-4		100-41-4		
	MW:	16.00			84.9		165.8		106.2		
Pine Bend - Total Collected Gas											
3/90		49.30	%v/vdry		19		5.5		15		
6/90		41.30	%v/vdry		12		3.3		9.1		
9/90		46.40	%v/vdry		10		4.1		11		
12/90		49.70	%v/vdry		6.2		3.1		9.2		
10/91		52.10	%v/vdry		5.9		2.1		8.5		
3/92		57.40	%v/vdry		3.73		2.3		12		
5/92		45.50	%v/vdry		6.93		2.5		11.6		
Flying Cloud - Total Collected Ga											
3/90		43.30	%v/vdry		6.6		5.8		17		
6/90		37.30	%v/vdry		4.1		3.3		8.9		
9/90		46.70	%v/vdry		3.7		3.7		10		
12/90		36.20	%v/vdry		2.8		3.1		8.4		
10/91		47.30	%v/vdry		1.5		1.9		7.4		
Hopkins Well Tests											
G-3 9/90						*		*	3.2		
G-5 9/90					2.3			*		*	
G-8 9/90					13.3		3.5		7.6		
G-8 DUP 9/90					3.7		1		2.3		
G-13 9/90					26		0.7			*	
G-5-PCA 9/90					42.1		10.9			*	
G-13-PCA 9/90					11.2		0.95		12.4		
G-3 1/90						*		*	6		
G-5 1/90					72		0.75		23		
G-8 1/90					42		2.4		31		
G-13 1/90					3.5			*	29		
Bemidji Landfill Gas Vent Sampl											
Vent 1 - 8/92					0.0066		0.0067		0.15		
Vent 6 - 8/92					0.012		0.24		0.18		
Vent 8 - 8/92					0.097		0.092		0.14		
Vent 15 - 8/92					0.025		0.20		7.1		
Vent 16 - 8/92					0.01		0.50		1.6		
Vent 23 - 8/92					0.36		0.23		9.0		
Vent 1 - 10/92					0.0029		0.11		12		
Vent 6 - 10/92					0.0011		0.00029		0.097		
Vent 8 - 10/92					0.016		0.71		0.0035		
Vent 11 - 10/92					0.01		0.99		0.99		
Vent 16 - 10/92					0.00026		0.00		0.008		
Vent 23 - 10/92					0.0035		0.0016		0.011		
Olmsted County - 9/91											
Vent 01		570000.00	ppm			*		*	4.9		
Vent 0581		560000.00	ppm		2.1		3.8		4.1		
Vent 0241		7.50	ppm			*	0.0087		0.055		
Gas Probe 003		510.00	ppm			*	0.02		0.078		
Gas Probe 004		260000.00	ppm		0.33		0.083		0.36		
CALCULATIONS USING ALL D											

LANDFILL GAS AIR TOXICS DATA - MINNESOTA

OVERALL AVERAGE(2)					8.62		1.94		7.66		
Pine Bend Average					9.11		3.27		10.91		
Flying Cloud Average					3.74		3.56		10.34		
Hopkins Well Test Average					24.01		2.89		14.31		
Bemidji Vent Average					0.045		0.257		2.607		
Olmsted County Average					1.22		0.98		1.90		
Overall Avg as ug/m3 **					29854.54		13127.36		33198.19		
Std Deviation					15.30		2.30		7.82		
Number of Values					35		35		37		
95% UCL					13.68		2.70		10.18		
# of 1/2 DL					5		5		5		
CALCULATIONS WITHOUT 1/2											
OVERALL AVERAGE(2)											
Pine Bend Average											
Flying Cloud Average											
Hopkins Well Test Average											
Bemidji Vent Average											
Olmsted County Average											
Overall Avg as ug/m3 **											
Std Deviation											
Number of Values											
95% UCL											
Chemical Name		methane			Methylene Chloride		Tetrachloro-ethene		Ethylbenzenes		

Cynthia Hibbard

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-90-011a
March 1991

Air

EPA

Air Emissions from Municipal Solid Waste Landfills - Background Information for Proposed Standards and Guidelines

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TABLE 3-6. SUMMARY OF NONMETHANE ORGANIC COMPOUNDS FOUND IN LANDFILL GAS[a]

CHEMICAL NAME	No. of Times Quantified	Average Conc. ppm	Average Conc. Detected ppm	Highest Conc. ppm	Lowest Conc. ppm
ETHANE	26	142.79	252.63	1780	0
TOLUENE	40	51.60	59.34	758	0.2
METHYLENE CHLORIDE	37	19.70	24.5	174	0
HYDROGEN SULFIDE	3	16.50	252.97	700	11
ETHYLBENZENE	31	14.64	21.73	428	0.15
XYLENE	2	14.52	333.85	664	3.7
1,2 - DIMETHYL BENZENE	1	12.78	588	588	588
LIMONENE	1	10.22	470	470	470
TOTAL XYLENE ISOMERS	27	10.04	17.11	70.9	0
α-PINENE	1	9.70	446	446	446
DICHLORODIFLUOROMETHANE	31	8.83	13.1	43.99	0
ETHYLESTER BUTANOIC ACID	1	8.65	398	398	398
PROPANE	26	7.68	13.59	86.5	0
TETRACHLOROETHENE	39	7.15	8.43	77	0
VINYL CHLORIDE	42	7.04	7.71	48.1	0
METHYLESTER BUTANOIC ACID	1	6.63	305	305	305
ETHYLESTER ACETIC ACID	1	6.13	282	282	282
PROPYLESTER BUTANOIC ACID	1	5.50	253	253	253
1,2 - DICHLOROETHENE	37	5.09	6.33	84.7	0
METHYL ETHYL KETONE	27	4.80	8.17	57.5	0
THIOBISMETHANE	1	4.57	210	210	210
METHLYCYCLOHEXANE	2	4.33	99.7	197	2.4
TRICHLOROETHENE	44	3.80	3.98	34	0.01
NONANE	1	3.63	167	167	167
BENZENE	45	3.52	3.6	52.2	0
ETHANOL	1	3.41	157	157	157
ACETONE	26	3.36	5.94	32	0
2 - BUTANOL	1	3.30	152	152	152
OCTANE	1	3.30	152	152	152

(continued)

TABLE 3-6. (Continued)

CHEMICAL NAME	No. of Times Quantified	Average Conc. ppm	Average Conc. Detected ppm	Highest Conc. ppm	Lowest Conc. ppm
PENTANE	26	3.19	5.64	46.53	0
HEXANE	26	3.01	5.33	25	0
METHYLESTER ACETIC ACID	1	2.96	136	136	136
1 - METHOXY - 2 - METHYL PROPANE	1	2.96	136	136	136
2 - BUTANONE	1	2.80	129	129	129
1,1 - DICHLOROETHANE	33	2.52	3.51	19.5	0
1 - BUTANOL	1	2.17	100	100	100
BUTANE	26	2.08	3.68	32	0
4 - METHYL - 2 - PENTANONE	1	1.93	89	89	89
2 - METHYL PROPANE	1	1.83	84	84	84
1 - METHYLETHYLESTER BUTANOIC ACID	1	1.50	69	69	69
2 - METHYL, METHYLESTER PROPANOIC ACID	1	1.50	69	69	69
CARBON TETRACHLORIDE	37	1.49	1.85	68.3	0
CHLOROETHANE	29	1.28	2.03	9.2	0
1,1,3 TRIMETHYL CYCLOHEXANE	1	1.24	57	57	57
2 - METHYL - 1 - PROPANOL	1	1.11	51	51	51
1,2 - DICHLOROETHANE	37	1.05	1.3	30.1	0
TRICHLOROFLUOROMETHANE	46	0.99	0.99	11.9	0
CHLOROMETHANE	30	0.90	1.38	10.22	0
2,5 DIMETHYL FURAN	1	0.89	41	41	41
2 - METHYL FURAN	1	0.87	40	40	40
CHLORODIFLUOROMETHANE	27	0.79	1.35	12.58	0
PROPENE	1	0.78	36	36	36
METHYL ISOBUTYL KETONE	26	0.78	1.38	11.5	0
ETHYL MERCAPTAN	3	0.78	11.93	23.8	1
DICHLOROFLUOROMETHANE	28	0.73	1.2	26.11	0
1,1,1 - TRICHLOROETHANE	38	0.69	0.84	9	0
TETRAHYDROFURAN	1	0.65	30	30	30
ETHYLESTER PROPANOIC ACID	1	0.57	26	26	26

(continued)

TABLE 3-6. (Continued)

CHEMICAL NAME	No. of Times Quantified	Average Conc. ppm	Average Conc. Detected ppm	Highest Conc. ppm	Lowest Conc. ppm
BROMODICHLOROMETHANE	29	0.45	0.71	7.85	0
ETHYL ACETATE	1	0.43	20	20	20
3 - METHYLHEXANE	1	0.43	20	20	20
C10H16 UNSATURATED HYDROCARBON	1	0.33	15	15	15
METHYLPROPANE	1	0.26	12	12	12
CHLOROBENZENE	29	0.24	0.38	10	0
ACRYLONITRILE	26	0.18	0.32	7.4	0
METHYLETHYLPROPANOATE	1	0.16	7.3	7.3	7.3
1,1 - DICHLOROETHENE	32	0.16	0.23	3.1	0
METHYL MERCAPTAN	3	0.12	1.87	3.3	1
1,2 - DICHLOROPROPANE	28	0.07	0.12	1.8	0
i - PROPYL MERCAPTAN	2	0.07	1.55	2.1	1
CHLOROFORM	36	0.06	0.08	1.56	0
1,1,2,2 - TETRACHLOROETHANE	28	0.06	0.1	2.35	0
1,1,2,2 - TETRACHLOROETHENE	2	0.06	1.33	2.6	0.05
2 - CHLOROETHYLVINYL ETHER	28	0.05	0.08	2.25	0
t - BUTYL MERCAPTAN	2	0.03	0.64	1	0.28
DIMETHYL SULFIDE	2	0.02	0.55	1	0.1
DICHLOROTETRAFLUOROETHANE	1	0.02	1.1	1.1	1.1
DIMETHYL DISULFIDE	2	0.02	0.55	1	0.1
CARBONYL SULFIDE	1	0.02	1	1	1
1,1,2-TRICHLORO 1,2,2-TRIFLUOROETHANE	1	0.01	0.5	0.5	0.5
METHYL ETHYL SULFIDE	1	0.01	0.32	0.32	0
1,1,2 - TRICHLOROETHANE	28	0.00	0	0.1	0
1,3 - BROMOCHLOROPROPANE	1	0.00	0.01	0.01	0.01
1,2 - DIBROMOETHANE	2	0.00	0	0	0
C-1,3 - DICHLOROPROPENE	2	0.00	0	0	0
t-1,3 - DICHLOROPROPENE	2	0.00	0	0	0
ACROLEIN	26	0.00	0	0	0

(continued)

TABLE 3-6. (Continued)

CHEMICAL NAME	No. of Times Quantified	Average Conc. ppm	Average Conc. Detected ppm	Highest Conc. ppm	Lowest Conc. ppm
1,4 -DICHLOROBENZENE	28	0.00	0	0	0
BROMOFORM	28	0.00	0	0	0
1,3 - DICHLOROPROPANE	26	0.00	0	0	0
1,2 - DICHLOROBENZENE	29	0.00	0	0	0
1,3 - DICHLORBENZENE	29	0.00	0	0	0
DIBROMOCHLOROMETHANE	28	0.00	0	0	0
BROMOMETHANE	28	0.00	0	0	0

[a]References 75-81.

APPENDIX B

AIR QUALITY EMISSIONS AND DISPERSION MODELING

LANDFILL 2 OUTPUT 2/2/93

Model Parameters

Lo : 8120.000000 ft^3 / Mg
k : 0.020000 1/yr

NMOC : 8000.000000 ppmv
Methane : 46.040000 % volume ***** Note : Default value not used ****
Carbon Dioxide : 53.960000 % volume

Air Toxics Parameters

Chemical Name	Molecular Wt	Concentration
Benzene	78.120	1.210
Carbon Tetrachloride	153.810	0.002
Chloroform	119.380	0.348
Ethylene Dichloride	98.960	1.750
Methylene Chloride	84.930	13.680
Perchloroethene	165.830	3.700
Trichloroethene	131.290	3.821
Vinyl Chloride	62.500	3.900
1,1-Dichloroethylene	96.940	0.148

Revised w/specific concentrations

Landfill Parameters

Year Opened : 1970 Current Year : 1993 Year Closed: 1990
Capacity : 1550767.000000 Mg
Average Acceptance Rate : 67424.652174 Mg/year
Average Acceptance Rate Required from
Current Year to Closure Year : 0.000000 Mg/year

Model Parameters

Year	Refuse In Place (Mg)	Methane Emission Rate (Mg/yr)	Methane Emission Rate (Cubic Ft/yr)
1971	7.754E+004	2.379E+002	1.259E+007
1972	1.551E+005	4.711E+002	2.494E+007
1973	2.326E+005	6.996E+002	3.703E+007
1974	3.102E+005	9.237E+002	4.889E+007
1975	3.877E+005	1.143E+003	6.052E+007
1976	4.652E+005	1.359E+003	7.191E+007
1977	5.428E+005	1.569E+003	8.308E+007
1978	6.203E+005	1.776E+003	9.403E+007
1979	6.978E+005	1.979E+003	1.048E+008
1980	7.754E+005	2.178E+003	1.153E+008
1981	8.529E+005	2.372E+003	1.256E+008
1982	9.305E+005	2.563E+003	1.357E+008
1983	1.008E+006	2.751E+003	1.456E+008
1984	1.086E+006	2.934E+003	1.553E+008
1985	1.163E+006	3.114E+003	1.648E+008
1986	1.241E+006	3.290E+003	1.741E+008
1987	1.318E+006	3.463E+003	1.833E+008
1988	1.396E+006	3.632E+003	1.923E+008
1989	1.473E+006	3.798E+003	2.010E+008
1990	1.551E+006	3.961E+003	2.097E+008
1991	1.551E+006	3.882E+003	2.055E+008
1992	1.551E+006	3.805E+003	2.014E+008
1993	1.551E+006	3.730E+003	1.974E+008
1994	1.551E+006	3.656E+003	1.935E+008
1995	1.551E+006	3.584E+003	1.897E+008

1996	1.551E+006	3.513E+003	1.859E+008
1997	1.551E+006	3.443E+003	1.823E+008
1998	1.551E+006	3.375E+003	1.787E+008
1999	1.551E+006	3.308E+003	1.751E+008
2000	1.551E+006	3.243E+003	1.716E+008
2001	1.551E+006	3.179E+003	1.683E+008
2002	1.551E+006	3.116E+003	1.649E+008
2003	1.551E+006	3.054E+003	1.617E+008
2004	1.551E+006	2.993E+003	1.585E+008
2005	1.551E+006	2.934E+003	1.553E+008
2006	1.551E+006	2.876E+003	1.522E+008
2007	1.551E+006	2.819E+003	1.492E+008
2008	1.551E+006	2.763E+003	1.463E+008
2009	1.551E+006	2.709E+003	1.434E+008
2010	1.551E+006	2.655E+003	1.405E+008
2011	1.551E+006	2.602E+003	1.378E+008
2012	1.551E+006	2.551E+003	1.350E+008
2013	1.551E+006	2.500E+003	1.324E+008
2014	1.551E+006	2.451E+003	1.297E+008
2015	1.551E+006	2.402E+003	1.272E+008
2016	1.551E+006	2.355E+003	1.246E+008
2017	1.551E+006	2.308E+003	1.222E+008
2018	1.551E+006	2.262E+003	1.198E+008
2019	1.551E+006	2.218E+003	1.174E+008
2020	1.551E+006	2.174E+003	1.151E+008
2021	1.551E+006	2.131E+003	1.128E+008
2022	1.551E+006	2.088E+003	1.105E+008
2023	1.551E+006	2.047E+003	1.084E+008
2024	1.551E+006	2.007E+003	1.062E+008
2025	1.551E+006	1.967E+003	1.041E+008
2026	1.551E+006	1.928E+003	1.020E+008
2027	1.551E+006	1.890E+003	1.000E+008
2028	1.551E+006	1.852E+003	9.805E+007
2029	1.551E+006	1.816E+003	9.611E+007
2030	1.551E+006	1.780E+003	9.420E+007
2031	1.551E+006	1.744E+003	9.234E+007
2032	1.551E+006	1.710E+003	9.051E+007
2033	1.551E+006	1.676E+003	8.872E+007
2034	1.551E+006	1.643E+003	8.696E+007
2035	1.551E+006	1.610E+003	8.524E+007
2036	1.551E+006	1.578E+003	8.355E+007
2037	1.551E+006	1.547E+003	8.190E+007
2038	1.551E+006	1.517E+003	8.027E+007
2039	1.551E+006	1.486E+003	7.869E+007
2040	1.551E+006	1.457E+003	7.713E+007

Year	Refuse In Place (Mg)	Carbon Dioxide Emission Rate (Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	7.650E+002	1.476E+007
1972	1.551E+005	1.515E+003	2.922E+007
1973	2.326E+005	2.250E+003	4.340E+007
1974	3.102E+005	2.970E+003	5.730E+007
1975	3.877E+005	3.676E+003	7.093E+007
1976	4.652E+005	4.369E+003	8.428E+007
1977	5.428E+005	5.047E+003	9.737E+007
1978	6.203E+005	5.712E+003	1.102E+008
1979	6.978E+005	6.364E+003	1.228E+008
1980	7.754E+005	7.003E+003	1.351E+008
1981	8.529E+005	7.629E+003	1.472E+008

1982	9.305E+005	8.243E+003	1.590E+008
1983	1.008E+006	8.845E+003	1.706E+008
1984	1.086E+006	9.435E+003	1.820E+008
1985	1.163E+006	1.001E+004	1.932E+008
1986	1.241E+006	1.058E+004	2.041E+008
1987	1.318E+006	1.114E+004	2.148E+008
1988	1.396E+006	1.168E+004	2.253E+008
1989	1.473E+006	1.221E+004	2.356E+008
1990	1.551E+006	1.274E+004	2.457E+008
1991	1.551E+006	1.248E+004	2.409E+008
1992	1.551E+006	1.224E+004	2.361E+008
1993	1.551E+006	1.199E+004	2.314E+008
1994	1.551E+006	1.176E+004	2.268E+008
1995	1.551E+006	1.152E+004	2.223E+008
1996	1.551E+006	1.130E+004	2.179E+008
1997	1.551E+006	1.107E+004	2.136E+008
1998	1.551E+006	1.085E+004	2.094E+008
1999	1.551E+006	1.064E+004	2.052E+008
2000	1.551E+006	1.043E+004	2.012E+008
2001	1.551E+006	1.022E+004	1.972E+008
2002	1.551E+006	1.002E+004	1.933E+008
2003	1.551E+006	9.821E+003	1.895E+008
2004	1.551E+006	9.626E+003	1.857E+008
2005	1.551E+006	9.435E+003	1.820E+008
2006	1.551E+006	9.249E+003	1.784E+008
2007	1.551E+006	9.065E+003	1.749E+008
2008	1.551E+006	8.886E+003	1.714E+008
2009	1.551E+006	8.710E+003	1.680E+008
2010	1.551E+006	8.538E+003	1.647E+008
2011	1.551E+006	8.369E+003	1.614E+008
2012	1.551E+006	8.203E+003	1.583E+008
2013	1.551E+006	8.040E+003	1.551E+008
2014	1.551E+006	7.881E+003	1.520E+008
2015	1.551E+006	7.725E+003	1.490E+008
2016	1.551E+006	7.572E+003	1.461E+008
2017	1.551E+006	7.422E+003	1.432E+008
2018	1.551E+006	7.275E+003	1.404E+008
2019	1.551E+006	7.131E+003	1.376E+008
2020	1.551E+006	6.990E+003	1.349E+008
2021	1.551E+006	6.852E+003	1.322E+008
2022	1.551E+006	6.716E+003	1.296E+008
2023	1.551E+006	6.583E+003	1.270E+008
2024	1.551E+006	6.453E+003	1.245E+008
2025	1.551E+006	6.325E+003	1.220E+008
2026	1.551E+006	6.200E+003	1.196E+008
2027	1.551E+006	6.077E+003	1.172E+008
2028	1.551E+006	5.956E+003	1.149E+008
2029	1.551E+006	5.839E+003	1.126E+008
2030	1.551E+006	5.723E+003	1.104E+008
2031	1.551E+006	5.610E+003	1.082E+008
2032	1.551E+006	5.499E+003	1.061E+008
2033	1.551E+006	5.390E+003	1.040E+008
2034	1.551E+006	5.283E+003	1.019E+008
2035	1.551E+006	5.178E+003	9.990E+007
2036	1.551E+006	5.076E+003	9.792E+007
2037	1.551E+006	4.975E+003	9.598E+007
2038	1.551E+006	4.877E+003	9.408E+007
2039	1.551E+006	4.780E+003	9.222E+007
2040	1.551E+006	4.686E+003	9.039E+007

Year	Refuse In Place (Mg)	NMOC Emission Rate (as Hexane) (Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	2.221E+001	2.188E+005
1972	1.551E+005	4.398E+001	4.333E+005
1973	2.326E+005	6.532E+001	6.435E+005
1974	3.102E+005	8.623E+001	8.496E+005
1975	3.877E+005	1.067E+002	1.052E+006
1976	4.652E+005	1.268E+002	1.250E+006
1977	5.428E+005	1.465E+002	1.444E+006
1978	6.203E+005	1.658E+002	1.634E+006
1979	6.978E+005	1.848E+002	1.820E+006
1980	7.754E+005	2.033E+002	2.003E+006
1981	8.529E+005	2.215E+002	2.182E+006
1982	9.305E+005	2.393E+002	2.358E+006
1983	1.008E+006	2.568E+002	2.530E+006
1984	1.086E+006	2.739E+002	2.699E+006
1985	1.163E+006	2.907E+002	2.864E+006
1986	1.241E+006	3.071E+002	3.026E+006
1987	1.318E+006	3.233E+002	3.185E+006
1988	1.396E+006	3.391E+002	3.341E+006
1989	1.473E+006	3.546E+002	3.493E+006
1990	1.551E+006	3.698E+002	3.643E+006
1991	1.551E+006	3.624E+002	3.571E+006
1992	1.551E+006	3.553E+002	3.500E+006
1993	1.551E+006	3.482E+002	3.431E+006
1994	1.551E+006	3.413E+002	3.363E+006
1995	1.551E+006	3.346E+002	3.296E+006
1996	1.551E+006	3.280E+002	3.231E+006
1997	1.551E+006	3.215E+002	3.167E+006
1998	1.551E+006	3.151E+002	3.104E+006
1999	1.551E+006	3.089E+002	3.043E+006
2000	1.551E+006	3.027E+002	2.983E+006
2001	1.551E+006	2.967E+002	2.924E+006
2002	1.551E+006	2.909E+002	2.866E+006
2003	1.551E+006	2.851E+002	2.809E+006
2004	1.551E+006	2.795E+002	2.753E+006
2005	1.551E+006	2.739E+002	2.699E+006
2006	1.551E+006	2.685E+002	2.645E+006
2007	1.551E+006	2.632E+002	2.593E+006
2008	1.551E+006	2.580E+002	2.542E+006
2009	1.551E+006	2.529E+002	2.491E+006
2010	1.551E+006	2.479E+002	2.442E+006
2011	1.551E+006	2.430E+002	2.394E+006
2012	1.551E+006	2.381E+002	2.346E+006
2013	1.551E+006	2.334E+002	2.300E+006
2014	1.551E+006	2.288E+002	2.254E+006
2015	1.551E+006	2.243E+002	2.210E+006
2016	1.551E+006	2.198E+002	2.166E+006
2017	1.551E+006	2.155E+002	2.123E+006
2018	1.551E+006	2.112E+002	2.081E+006
2019	1.551E+006	2.070E+002	2.040E+006
2020	1.551E+006	2.029E+002	1.999E+006
2021	1.551E+006	1.989E+002	1.960E+006
2022	1.551E+006	1.950E+002	1.921E+006
2023	1.551E+006	1.911E+002	1.883E+006
2024	1.551E+006	1.873E+002	1.846E+006
2025	1.551E+006	1.836E+002	1.809E+006
2026	1.551E+006	1.800E+002	1.773E+006
2027	1.551E+006	1.764E+002	1.738E+006

2028	1.551E+006	1.729E+002	1.704E+006
2029	1.551E+006	1.695E+002	1.670E+006
2030	1.551E+006	1.661E+002	1.637E+006
2031	1.551E+006	1.629E+002	1.604E+006
2032	1.551E+006	1.596E+002	1.573E+006
2033	1.551E+006	1.565E+002	1.542E+006
2034	1.551E+006	1.534E+002	1.511E+006
2035	1.551E+006	1.503E+002	1.481E+006
2036	1.551E+006	1.474E+002	1.452E+006
2037	1.551E+006	1.444E+002	1.423E+006
2038	1.551E+006	1.416E+002	1.395E+006
2039	1.551E+006	1.388E+002	1.367E+006
2040	1.551E+006	1.360E+002	1.340E+006

Selected Air Toxic: Benzene

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	3.045E-003	3.309E+001
1972	1.551E+005	6.030E-003	6.553E+001
1973	2.326E+005	8.955E-003	9.733E+001
1974	3.102E+005	1.182E-002	1.285E+002
1975	3.877E+005	1.463E-002	1.590E+002
1976	4.652E+005	1.739E-002	1.890E+002
1977	5.428E+005	2.009E-002	2.183E+002
1978	6.203E+005	2.274E-002	2.471E+002
1979	6.978E+005	2.533E-002	2.753E+002
1980	7.754E+005	2.787E-002	3.030E+002
1981	8.529E+005	3.037E-002	3.301E+002
1982	9.305E+005	3.281E-002	3.566E+002
1983	1.008E+006	3.521E-002	3.826E+002
1984	1.086E+006	3.755E-002	4.082E+002
1985	1.163E+006	3.986E-002	4.332E+002
1986	1.241E+006	4.211E-002	4.577E+002
1987	1.318E+006	4.432E-002	4.817E+002
1988	1.396E+006	4.649E-002	5.053E+002
1989	1.473E+006	4.861E-002	5.284E+002
1990	1.551E+006	5.070E-002	5.510E+002
1991	1.551E+006	4.969E-002	5.401E+002
1992	1.551E+006	4.871E-002	5.294E+002
1993	1.551E+006	4.774E-002	5.189E+002
1994	1.551E+006	4.680E-002	5.086E+002
1995	1.551E+006	4.587E-002	4.986E+002
1996	1.551E+006	4.496E-002	4.887E+002
1997	1.551E+006	4.407E-002	4.790E+002
1998	1.551E+006	4.320E-002	4.695E+002
1999	1.551E+006	4.235E-002	4.602E+002
2000	1.551E+006	4.151E-002	4.511E+002
2001	1.551E+006	4.068E-002	4.422E+002
2002	1.551E+006	3.988E-002	4.334E+002
2003	1.551E+006	3.909E-002	4.248E+002
2004	1.551E+006	3.832E-002	4.164E+002
2005	1.551E+006	3.756E-002	4.082E+002
2006	1.551E+006	3.681E-002	4.001E+002
2007	1.551E+006	3.608E-002	3.922E+002
2008	1.551E+006	3.537E-002	3.844E+002
2009	1.551E+006	3.467E-002	3.768E+002
2010	1.551E+006	3.398E-002	3.693E+002
2011	1.551E+006	3.331E-002	3.620E+002
2012	1.551E+006	3.265E-002	3.549E+002

2013	1.551E+006	3.200E-002	3.478E+002
2014	1.551E+006	3.137E-002	3.409E+002
2015	1.551E+006	3.075E-002	3.342E+002
2016	1.551E+006	3.014E-002	3.276E+002
2017	1.551E+006	2.954E-002	3.211E+002
2018	1.551E+006	2.896E-002	3.147E+002
2019	1.551E+006	2.838E-002	3.085E+002
2020	1.551E+006	2.782E-002	3.024E+002
2021	1.551E+006	2.727E-002	2.964E+002
2022	1.551E+006	2.673E-002	2.905E+002
2023	1.551E+006	2.620E-002	2.848E+002
2024	1.551E+006	2.568E-002	2.791E+002
2025	1.551E+006	2.518E-002	2.736E+002
2026	1.551E+006	2.468E-002	2.682E+002
2027	1.551E+006	2.419E-002	2.629E+002
2028	1.551E+006	2.371E-002	2.577E+002
2029	1.551E+006	2.324E-002	2.526E+002
2030	1.551E+006	2.278E-002	2.476E+002
2031	1.551E+006	2.233E-002	2.427E+002
2032	1.551E+006	2.189E-002	2.379E+002
2033	1.551E+006	2.145E-002	2.332E+002
2034	1.551E+006	2.103E-002	2.285E+002
2035	1.551E+006	2.061E-002	2.240E+002
2036	1.551E+006	2.020E-002	2.196E+002
2037	1.551E+006	1.980E-002	2.152E+002
2038	1.551E+006	1.941E-002	2.110E+002
2039	1.551E+006	1.903E-002	2.068E+002
2040	1.551E+006	1.865E-002	2.027E+002

Selected Air Toxic: Carbon Tetrachloride

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	7.432E-006	4.103E-002
1972	1.551E+005	1.472E-005	8.124E-002
1973	2.326E+005	2.186E-005	1.207E-001
1974	3.102E+005	2.886E-005	1.593E-001
1975	3.877E+005	3.572E-005	1.972E-001
1976	4.652E+005	4.244E-005	2.343E-001
1977	5.428E+005	4.903E-005	2.707E-001
1978	6.203E+005	5.549E-005	3.063E-001
1979	6.978E+005	6.183E-005	3.413E-001
1980	7.754E+005	6.804E-005	3.756E-001
1981	8.529E+005	7.412E-005	4.092E-001
1982	9.305E+005	8.008E-005	4.421E-001
1983	1.008E+006	8.593E-005	4.744E-001
1984	1.086E+006	9.166E-005	5.060E-001
1985	1.163E+006	9.728E-005	5.370E-001
1986	1.241E+006	1.028E-004	5.674E-001
1987	1.318E+006	1.082E-004	5.972E-001
1988	1.396E+006	1.135E-004	6.264E-001
1989	1.473E+006	1.187E-004	6.550E-001
1990	1.551E+006	1.237E-004	6.831E-001
1991	1.551E+006	1.213E-004	6.695E-001
1992	1.551E+006	1.189E-004	6.563E-001
1993	1.551E+006	1.165E-004	6.433E-001
1994	1.551E+006	1.142E-004	6.305E-001
1995	1.551E+006	1.120E-004	6.181E-001
1996	1.551E+006	1.097E-004	6.058E-001
1997	1.551E+006	1.076E-004	5.938E-001

1998	1.551E+006	1.054E-004	5.821E-001
1999	1.551E+006	1.034E-004	5.705E-001
2000	1.551E+006	1.013E-004	5.592E-001
2001	1.551E+006	9.930E-005	5.482E-001
2002	1.551E+006	9.734E-005	5.373E-001
2003	1.551E+006	9.541E-005	5.267E-001
2004	1.551E+006	9.352E-005	5.162E-001
2005	1.551E+006	9.167E-005	5.060E-001
2006	1.551E+006	8.985E-005	4.960E-001
2007	1.551E+006	8.807E-005	4.862E-001
2008	1.551E+006	8.633E-005	4.766E-001
2009	1.551E+006	8.462E-005	4.671E-001
2010	1.551E+006	8.294E-005	4.579E-001
2011	1.551E+006	8.130E-005	4.488E-001
2012	1.551E+006	7.969E-005	4.399E-001
2013	1.551E+006	7.811E-005	4.312E-001
2014	1.551E+006	7.657E-005	4.227E-001
2015	1.551E+006	7.505E-005	4.143E-001
2016	1.551E+006	7.356E-005	4.061E-001
2017	1.551E+006	7.211E-005	3.981E-001
2018	1.551E+006	7.068E-005	3.902E-001
2019	1.551E+006	6.928E-005	3.824E-001
2020	1.551E+006	6.791E-005	3.749E-001
2021	1.551E+006	6.656E-005	3.674E-001
2022	1.551E+006	6.525E-005	3.602E-001
2023	1.551E+006	6.395E-005	3.530E-001
2024	1.551E+006	6.269E-005	3.460E-001
2025	1.551E+006	6.145E-005	3.392E-001
2026	1.551E+006	6.023E-005	3.325E-001
2027	1.551E+006	5.904E-005	3.259E-001
2028	1.551E+006	5.787E-005	3.194E-001
2029	1.551E+006	5.672E-005	3.131E-001
2030	1.551E+006	5.560E-005	3.069E-001
2031	1.551E+006	5.450E-005	3.008E-001
2032	1.551E+006	5.342E-005	2.949E-001
2033	1.551E+006	5.236E-005	2.890E-001
2034	1.551E+006	5.132E-005	2.833E-001
2035	1.551E+006	5.031E-005	2.777E-001
2036	1.551E+006	4.931E-005	2.722E-001
2037	1.551E+006	4.834E-005	2.668E-001
2038	1.551E+006	4.738E-005	2.615E-001
2039	1.551E+006	4.644E-005	2.564E-001
2040	1.551E+006	4.552E-005	2.513E-001

Selected Air Toxic: Chloroform

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	1.338E-003	9.518E+000
1972	1.551E+005	2.650E-003	1.885E+001
1973	2.326E+005	3.936E-003	2.799E+001
1974	3.102E+005	5.196E-003	3.696E+001
1975	3.877E+005	6.432E-003	4.574E+001
1976	4.652E+005	7.642E-003	5.435E+001
1977	5.428E+005	8.829E-003	6.280E+001
1978	6.203E+005	9.993E-003	7.107E+001
1979	6.978E+005	1.113E-002	7.918E+001
1980	7.754E+005	1.225E-002	8.713E+001
1981	8.529E+005	1.335E-002	9.492E+001
1982	9.305E+005	1.442E-002	1.026E+002

1983	1.008E+006	1.547E-002	1.100E+002
1984	1.086E+006	1.651E-002	1.174E+002
1985	1.163E+006	1.752E-002	1.246E+002
1986	1.241E+006	1.851E-002	1.316E+002
1987	1.318E+006	1.948E-002	1.385E+002
1988	1.396E+006	2.043E-002	1.453E+002
1989	1.473E+006	2.137E-002	1.520E+002
1990	1.551E+006	2.228E-002	1.585E+002
1991	1.551E+006	2.184E-002	1.553E+002
1992	1.551E+006	2.141E-002	1.523E+002
1993	1.551E+006	2.098E-002	1.492E+002
1994	1.551E+006	2.057E-002	1.463E+002
1995	1.551E+006	2.016E-002	1.434E+002
1996	1.551E+006	1.976E-002	1.405E+002
1997	1.551E+006	1.937E-002	1.378E+002
1998	1.551E+006	1.899E-002	1.350E+002
1999	1.551E+006	1.861E-002	1.324E+002
2000	1.551E+006	1.824E-002	1.297E+002
2001	1.551E+006	1.788E-002	1.272E+002
2002	1.551E+006	1.753E-002	1.247E+002
2003	1.551E+006	1.718E-002	1.222E+002
2004	1.551E+006	1.684E-002	1.198E+002
2005	1.551E+006	1.651E-002	1.174E+002
2006	1.551E+006	1.618E-002	1.151E+002
2007	1.551E+006	1.586E-002	1.128E+002
2008	1.551E+006	1.555E-002	1.106E+002
2009	1.551E+006	1.524E-002	1.084E+002
2010	1.551E+006	1.494E-002	1.062E+002
2011	1.551E+006	1.464E-002	1.041E+002
2012	1.551E+006	1.435E-002	1.021E+002
2013	1.551E+006	1.407E-002	1.000E+002
2014	1.551E+006	1.379E-002	9.806E+001
2015	1.551E+006	1.351E-002	9.612E+001
2016	1.551E+006	1.325E-002	9.421E+001
2017	1.551E+006	1.298E-002	9.235E+001
2018	1.551E+006	1.273E-002	9.052E+001
2019	1.551E+006	1.248E-002	8.873E+001
2020	1.551E+006	1.223E-002	8.697E+001
2021	1.551E+006	1.199E-002	8.525E+001
2022	1.551E+006	1.175E-002	8.356E+001
2023	1.551E+006	1.152E-002	8.190E+001
2024	1.551E+006	1.129E-002	8.028E+001
2025	1.551E+006	1.106E-002	7.869E+001
2026	1.551E+006	1.085E-002	7.714E+001
2027	1.551E+006	1.063E-002	7.561E+001
2028	1.551E+006	1.042E-002	7.411E+001
2029	1.551E+006	1.021E-002	7.264E+001
2030	1.551E+006	1.001E-002	7.120E+001
2031	1.551E+006	9.813E-003	6.979E+001
2032	1.551E+006	9.619E-003	6.841E+001
2033	1.551E+006	9.429E-003	6.706E+001
2034	1.551E+006	9.242E-003	6.573E+001
2035	1.551E+006	9.059E-003	6.443E+001
2036	1.551E+006	8.879E-003	6.315E+001
2037	1.551E+006	8.704E-003	6.190E+001
2038	1.551E+006	8.531E-003	6.068E+001
2039	1.551E+006	8.362E-003	5.948E+001
2040	1.551E+006	8.197E-003	5.830E+001

Selected Air Toxic: Ethylene Dichloride

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	5.579E-003	4.786E+001
1972	1.551E+005	1.105E-002	9.478E+001
1973	2.326E+005	1.641E-002	1.408E+002
1974	3.102E+005	2.166E-002	1.858E+002
1975	3.877E+005	2.681E-002	2.300E+002
1976	4.652E+005	3.186E-002	2.733E+002
1977	5.428E+005	3.681E-002	3.158E+002
1978	6.203E+005	4.166E-002	3.574E+002
1979	6.978E+005	4.641E-002	3.982E+002
1980	7.754E+005	5.107E-002	4.382E+002
1981	8.529E+005	5.564E-002	4.773E+002
1982	9.305E+005	6.011E-002	5.158E+002
1983	1.008E+006	6.450E-002	5.534E+002
1984	1.086E+006	6.880E-002	5.903E+002
1985	1.163E+006	7.302E-002	6.265E+002
1986	1.241E+006	7.715E-002	6.620E+002
1987	1.318E+006	8.120E-002	6.967E+002
1988	1.396E+006	8.517E-002	7.308E+002
1989	1.473E+006	8.907E-002	7.642E+002
1990	1.551E+006	9.288E-002	7.969E+002
1991	1.551E+006	9.104E-002	7.811E+002
1992	1.551E+006	8.924E-002	7.657E+002
1993	1.551E+006	8.747E-002	7.505E+002
1994	1.551E+006	8.574E-002	7.356E+002
1995	1.551E+006	8.404E-002	7.211E+002
1996	1.551E+006	8.238E-002	7.068E+002
1997	1.551E+006	8.075E-002	6.928E+002
1998	1.551E+006	7.915E-002	6.791E+002
1999	1.551E+006	7.758E-002	6.656E+002
2000	1.551E+006	7.604E-002	6.524E+002
2001	1.551E+006	7.454E-002	6.395E+002
2002	1.551E+006	7.306E-002	6.269E+002
2003	1.551E+006	7.162E-002	6.145E+002
2004	1.551E+006	7.020E-002	6.023E+002
2005	1.551E+006	6.881E-002	5.904E+002
2006	1.551E+006	6.745E-002	5.787E+002
2007	1.551E+006	6.611E-002	5.672E+002
2008	1.551E+006	6.480E-002	5.560E+002
2009	1.551E+006	6.352E-002	5.450E+002
2010	1.551E+006	6.226E-002	5.342E+002
2011	1.551E+006	6.103E-002	5.236E+002
2012	1.551E+006	5.982E-002	5.132E+002
2013	1.551E+006	5.863E-002	5.031E+002
2014	1.551E+006	5.747E-002	4.931E+002
2015	1.551E+006	5.634E-002	4.833E+002
2016	1.551E+006	5.522E-002	4.738E+002
2017	1.551E+006	5.413E-002	4.644E+002
2018	1.551E+006	5.305E-002	4.552E+002
2019	1.551E+006	5.200E-002	4.462E+002
2020	1.551E+006	5.097E-002	4.373E+002
2021	1.551E+006	4.996E-002	4.287E+002
2022	1.551E+006	4.898E-002	4.202E+002
2023	1.551E+006	4.801E-002	4.119E+002
2024	1.551E+006	4.706E-002	4.037E+002
2025	1.551E+006	4.612E-002	3.957E+002
2026	1.551E+006	4.521E-002	3.879E+002
2027	1.551E+006	4.431E-002	3.802E+002

2028	1.551E+006	4.344E-002	3.727E+002
2029	1.551E+006	4.258E-002	3.653E+002
2030	1.551E+006	4.173E-002	3.581E+002
2031	1.551E+006	4.091E-002	3.510E+002
2032	1.551E+006	4.010E-002	3.440E+002
2033	1.551E+006	3.930E-002	3.372E+002
2034	1.551E+006	3.853E-002	3.305E+002
2035	1.551E+006	3.776E-002	3.240E+002
2036	1.551E+006	3.701E-002	3.176E+002
2037	1.551E+006	3.628E-002	3.113E+002
2038	1.551E+006	3.556E-002	3.051E+002
2039	1.551E+006	3.486E-002	2.991E+002
2040	1.551E+006	3.417E-002	2.932E+002

Selected Air Toxic: Methylene Chloride

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	3.743E-002	3.742E+002
1972	1.551E+005	7.411E-002	7.409E+002
1973	2.326E+005	1.101E-001	1.100E+003
1974	3.102E+005	1.453E-001	1.453E+003
1975	3.877E+005	1.799E-001	1.798E+003
1976	4.652E+005	2.137E-001	2.137E+003
1977	5.428E+005	2.469E-001	2.469E+003
1978	6.203E+005	2.795E-001	2.794E+003
1979	6.978E+005	3.114E-001	3.113E+003
1980	7.754E+005	3.426E-001	3.425E+003
1981	8.529E+005	3.733E-001	3.732E+003
1982	9.305E+005	4.033E-001	4.032E+003
1983	1.008E+006	4.327E-001	4.326E+003
1984	1.086E+006	4.616E-001	4.615E+003
1985	1.163E+006	4.899E-001	4.897E+003
1986	1.241E+006	5.176E-001	5.175E+003
1987	1.318E+006	5.448E-001	5.446E+003
1988	1.396E+006	5.714E-001	5.713E+003
1989	1.473E+006	5.975E-001	5.974E+003
1990	1.551E+006	6.231E-001	6.229E+003
1991	1.551E+006	6.108E-001	6.106E+003
1992	1.551E+006	5.987E-001	5.985E+003
1993	1.551E+006	5.868E-001	5.867E+003
1994	1.551E+006	5.752E-001	5.751E+003
1995	1.551E+006	5.638E-001	5.637E+003
1996	1.551E+006	5.527E-001	5.525E+003
1997	1.551E+006	5.417E-001	5.416E+003
1998	1.551E+006	5.310E-001	5.308E+003
1999	1.551E+006	5.205E-001	5.203E+003
2000	1.551E+006	5.102E-001	5.100E+003
2001	1.551E+006	5.001E-001	4.999E+003
2002	1.551E+006	4.902E-001	4.900E+003
2003	1.551E+006	4.805E-001	4.803E+003
2004	1.551E+006	4.709E-001	4.708E+003
2005	1.551E+006	4.616E-001	4.615E+003
2006	1.551E+006	4.525E-001	4.524E+003
2007	1.551E+006	4.435E-001	4.434E+003
2008	1.551E+006	4.347E-001	4.346E+003
2009	1.551E+006	4.261E-001	4.260E+003
2010	1.551E+006	4.177E-001	4.176E+003
2011	1.551E+006	4.094E-001	4.093E+003
2012	1.551E+006	4.013E-001	4.012E+003

2013	1.551E+006	3.934E-001	3.933E+003
2014	1.551E+006	3.856E-001	3.855E+003
2015	1.551E+006	3.779E-001	3.778E+003
2016	1.551E+006	3.705E-001	3.704E+003
2017	1.551E+006	3.631E-001	3.630E+003
2018	1.551E+006	3.559E-001	3.558E+003
2019	1.551E+006	3.489E-001	3.488E+003
2020	1.551E+006	3.420E-001	3.419E+003
2021	1.551E+006	3.352E-001	3.351E+003
2022	1.551E+006	3.286E-001	3.285E+003
2023	1.551E+006	3.221E-001	3.220E+003
2024	1.551E+006	3.157E-001	3.156E+003
2025	1.551E+006	3.094E-001	3.093E+003
2026	1.551E+006	3.033E-001	3.032E+003
2027	1.551E+006	2.973E-001	2.972E+003
2028	1.551E+006	2.914E-001	2.913E+003
2029	1.551E+006	2.856E-001	2.856E+003
2030	1.551E+006	2.800E-001	2.799E+003
2031	1.551E+006	2.744E-001	2.744E+003
2032	1.551E+006	2.690E-001	2.689E+003
2033	1.551E+006	2.637E-001	2.636E+003
2034	1.551E+006	2.585E-001	2.584E+003
2035	1.551E+006	2.533E-001	2.533E+003
2036	1.551E+006	2.483E-001	2.483E+003
2037	1.551E+006	2.434E-001	2.433E+003
2038	1.551E+006	2.386E-001	2.385E+003
2039	1.551E+006	2.339E-001	2.338E+003
2040	1.551E+006	2.292E-001	2.292E+003

Selected Air Toxic: Perchloroethene

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	1.976E-002	1.012E+002
1972	1.551E+005	3.914E-002	2.004E+002
1973	2.326E+005	5.813E-002	2.976E+002
1974	3.102E+005	7.674E-002	3.929E+002
1975	3.877E+005	9.499E-002	4.863E+002
1976	4.652E+005	1.129E-001	5.779E+002
1977	5.428E+005	1.304E-001	6.677E+002
1978	6.203E+005	1.476E-001	7.556E+002
1979	6.978E+005	1.644E-001	8.419E+002
1980	7.754E+005	1.809E-001	9.264E+002
1981	8.529E+005	1.971E-001	1.009E+003
1982	9.305E+005	2.130E-001	1.090E+003
1983	1.008E+006	2.285E-001	1.170E+003
1984	1.086E+006	2.438E-001	1.248E+003
1985	1.163E+006	2.587E-001	1.325E+003
1986	1.241E+006	2.733E-001	1.400E+003
1987	1.318E+006	2.877E-001	1.473E+003
1988	1.396E+006	3.018E-001	1.545E+003
1989	1.473E+006	3.156E-001	1.616E+003
1990	1.551E+006	3.291E-001	1.685E+003
1991	1.551E+006	3.226E-001	1.652E+003
1992	1.551E+006	3.162E-001	1.619E+003
1993	1.551E+006	3.099E-001	1.587E+003
1994	1.551E+006	3.038E-001	1.555E+003
1995	1.551E+006	2.978E-001	1.525E+003
1996	1.551E+006	2.919E-001	1.494E+003
1997	1.551E+006	2.861E-001	1.465E+003

1998	1.551E+006	2.804E-001	1.436E+003
1999	1.551E+006	2.749E-001	1.407E+003
2000	1.551E+006	2.694E-001	1.379E+003
2001	1.551E+006	2.641E-001	1.352E+003
2002	1.551E+006	2.589E-001	1.325E+003
2003	1.551E+006	2.537E-001	1.299E+003
2004	1.551E+006	2.487E-001	1.273E+003
2005	1.551E+006	2.438E-001	1.248E+003
2006	1.551E+006	2.390E-001	1.223E+003
2007	1.551E+006	2.342E-001	1.199E+003
2008	1.551E+006	2.296E-001	1.175E+003
2009	1.551E+006	2.250E-001	1.152E+003
2010	1.551E+006	2.206E-001	1.129E+003
2011	1.551E+006	2.162E-001	1.107E+003
2012	1.551E+006	2.119E-001	1.085E+003
2013	1.551E+006	2.077E-001	1.064E+003
2014	1.551E+006	2.036E-001	1.043E+003
2015	1.551E+006	1.996E-001	1.022E+003
2016	1.551E+006	1.956E-001	1.002E+003
2017	1.551E+006	1.918E-001	9.819E+002
2018	1.551E+006	1.880E-001	9.624E+002
2019	1.551E+006	1.842E-001	9.434E+002
2020	1.551E+006	1.806E-001	9.247E+002
2021	1.551E+006	1.770E-001	9.064E+002
2022	1.551E+006	1.735E-001	8.884E+002
2023	1.551E+006	1.701E-001	8.708E+002
2024	1.551E+006	1.667E-001	8.536E+002
2025	1.551E+006	1.634E-001	8.367E+002
2026	1.551E+006	1.602E-001	8.201E+002
2027	1.551E+006	1.570E-001	8.039E+002
2028	1.551E+006	1.539E-001	7.880E+002
2029	1.551E+006	1.508E-001	7.724E+002
2030	1.551E+006	1.479E-001	7.571E+002
2031	1.551E+006	1.449E-001	7.421E+002
2032	1.551E+006	1.421E-001	7.274E+002
2033	1.551E+006	1.393E-001	7.130E+002
2034	1.551E+006	1.365E-001	6.989E+002
2035	1.551E+006	1.338E-001	6.850E+002
2036	1.551E+006	1.311E-001	6.715E+002
2037	1.551E+006	1.285E-001	6.582E+002
2038	1.551E+006	1.260E-001	6.451E+002
2039	1.551E+006	1.235E-001	6.324E+002
2040	1.551E+006	1.211E-001	6.198E+002

Selected Air Toxic: Trichloroethene

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	1.616E-002	1.045E+002
1972	1.551E+005	3.200E-002	2.069E+002
1973	2.326E+005	4.753E-002	3.074E+002
1974	3.102E+005	6.274E-002	4.058E+002
1975	3.877E+005	7.766E-002	5.022E+002
1976	4.652E+005	9.228E-002	5.968E+002
1977	5.428E+005	1.066E-001	6.895E+002
1978	6.203E+005	1.207E-001	7.804E+002
1979	6.978E+005	1.344E-001	8.694E+002
1980	7.754E+005	1.479E-001	9.567E+002
1981	8.529E+005	1.612E-001	1.042E+003
1982	9.305E+005	1.741E-001	1.126E+003

1983	1.008E+006	1.868E-001	1.208E+003
1984	1.086E+006	1.993E-001	1.289E+003
1985	1.163E+006	2.115E-001	1.368E+003
1986	1.241E+006	2.235E-001	1.445E+003
1987	1.318E+006	2.352E-001	1.521E+003
1988	1.396E+006	2.467E-001	1.596E+003
1989	1.473E+006	2.580E-001	1.669E+003
1990	1.551E+006	2.691E-001	1.740E+003
1991	1.551E+006	2.637E-001	1.706E+003
1992	1.551E+006	2.585E-001	1.672E+003
1993	1.551E+006	2.534E-001	1.639E+003
1994	1.551E+006	2.484E-001	1.606E+003
1995	1.551E+006	2.434E-001	1.574E+003
1996	1.551E+006	2.386E-001	1.543E+003
1997	1.551E+006	2.339E-001	1.513E+003
1998	1.551E+006	2.293E-001	1.483E+003
1999	1.551E+006	2.247E-001	1.453E+003
2000	1.551E+006	2.203E-001	1.425E+003
2001	1.551E+006	2.159E-001	1.396E+003
2002	1.551E+006	2.116E-001	1.369E+003
2003	1.551E+006	2.075E-001	1.342E+003
2004	1.551E+006	2.033E-001	1.315E+003
2005	1.551E+006	1.993E-001	1.289E+003
2006	1.551E+006	1.954E-001	1.263E+003
2007	1.551E+006	1.915E-001	1.238E+003
2008	1.551E+006	1.877E-001	1.214E+003
2009	1.551E+006	1.840E-001	1.190E+003
2010	1.551E+006	1.804E-001	1.166E+003
2011	1.551E+006	1.768E-001	1.143E+003
2012	1.551E+006	1.733E-001	1.121E+003
2013	1.551E+006	1.698E-001	1.098E+003
2014	1.551E+006	1.665E-001	1.077E+003
2015	1.551E+006	1.632E-001	1.055E+003
2016	1.551E+006	1.600E-001	1.034E+003
2017	1.551E+006	1.568E-001	1.014E+003
2018	1.551E+006	1.537E-001	9.939E+002
2019	1.551E+006	1.506E-001	9.742E+002
2020	1.551E+006	1.477E-001	9.549E+002
2021	1.551E+006	1.447E-001	9.360E+002
2022	1.551E+006	1.419E-001	9.175E+002
2023	1.551E+006	1.391E-001	8.993E+002
2024	1.551E+006	1.363E-001	8.815E+002
2025	1.551E+006	1.336E-001	8.640E+002
2026	1.551E+006	1.310E-001	8.469E+002
2027	1.551E+006	1.284E-001	8.302E+002
2028	1.551E+006	1.258E-001	8.137E+002
2029	1.551E+006	1.233E-001	7.976E+002
2030	1.551E+006	1.209E-001	7.818E+002
2031	1.551E+006	1.185E-001	7.663E+002
2032	1.551E+006	1.162E-001	7.512E+002
2033	1.551E+006	1.139E-001	7.363E+002
2034	1.551E+006	1.116E-001	7.217E+002
2035	1.551E+006	1.094E-001	7.074E+002
2036	1.551E+006	1.072E-001	6.934E+002
2037	1.551E+006	1.051E-001	6.797E+002
2038	1.551E+006	1.030E-001	6.662E+002
2039	1.551E+006	1.010E-001	6.530E+002
2040	1.551E+006	9.898E-002	6.401E+002

Selected Air Toxic: Vinyl Chloride

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	7.852E-003	1.067E+002
1972	1.551E+005	1.555E-002	2.112E+002
1973	2.326E+005	2.309E-002	3.137E+002
1974	3.102E+005	3.049E-002	4.142E+002
1975	3.877E+005	3.774E-002	5.126E+002
1976	4.652E+005	4.484E-002	6.091E+002
1977	5.428E+005	5.180E-002	7.038E+002
1978	6.203E+005	5.863E-002	7.965E+002
1979	6.978E+005	6.532E-002	8.874E+002
1980	7.754E+005	7.188E-002	9.765E+002
1981	8.529E+005	7.831E-002	1.064E+003
1982	9.305E+005	8.461E-002	1.149E+003
1983	1.008E+006	9.079E-002	1.233E+003
1984	1.086E+006	9.684E-002	1.316E+003
1985	1.163E+006	1.028E-001	1.396E+003
1986	1.241E+006	1.086E-001	1.475E+003
1987	1.318E+006	1.143E-001	1.553E+003
1988	1.396E+006	1.199E-001	1.629E+003
1989	1.473E+006	1.254E-001	1.703E+003
1990	1.551E+006	1.307E-001	1.776E+003
1991	1.551E+006	1.281E-001	1.741E+003
1992	1.551E+006	1.256E-001	1.706E+003
1993	1.551E+006	1.231E-001	1.673E+003
1994	1.551E+006	1.207E-001	1.639E+003
1995	1.551E+006	1.183E-001	1.607E+003
1996	1.551E+006	1.159E-001	1.575E+003
1997	1.551E+006	1.137E-001	1.544E+003
1998	1.551E+006	1.114E-001	1.513E+003
1999	1.551E+006	1.092E-001	1.483E+003
2000	1.551E+006	1.070E-001	1.454E+003
2001	1.551E+006	1.049E-001	1.425E+003
2002	1.551E+006	1.028E-001	1.397E+003
2003	1.551E+006	1.008E-001	1.369E+003
2004	1.551E+006	9.880E-002	1.342E+003
2005	1.551E+006	9.685E-002	1.316E+003
2006	1.551E+006	9.493E-002	1.290E+003
2007	1.551E+006	9.305E-002	1.264E+003
2008	1.551E+006	9.121E-002	1.239E+003
2009	1.551E+006	8.940E-002	1.215E+003
2010	1.551E+006	8.763E-002	1.190E+003
2011	1.551E+006	8.590E-002	1.167E+003
2012	1.551E+006	8.419E-002	1.144E+003
2013	1.551E+006	8.253E-002	1.121E+003
2014	1.551E+006	8.089E-002	1.099E+003
2015	1.551E+006	7.929E-002	1.077E+003
2016	1.551E+006	7.772E-002	1.056E+003
2017	1.551E+006	7.618E-002	1.035E+003
2018	1.551E+006	7.467E-002	1.014E+003
2019	1.551E+006	7.320E-002	9.944E+002
2020	1.551E+006	7.175E-002	9.747E+002
2021	1.551E+006	7.033E-002	9.554E+002
2022	1.551E+006	6.893E-002	9.364E+002
2023	1.551E+006	6.757E-002	9.179E+002
2024	1.551E+006	6.623E-002	8.997E+002
2025	1.551E+006	6.492E-002	8.819E+002
2026	1.551E+006	6.363E-002	8.644E+002
2027	1.551E+006	6.237E-002	8.473E+002

2028	1.551E+006	6.114E-002	8.306E+002
2029	1.551E+006	5.993E-002	8.141E+002
2030	1.551E+006	5.874E-002	7.980E+002
2031	1.551E+006	5.758E-002	7.822E+002
2032	1.551E+006	5.644E-002	7.667E+002
2033	1.551E+006	5.532E-002	7.515E+002
2034	1.551E+006	5.422E-002	7.366E+002
2035	1.551E+006	5.315E-002	7.220E+002
2036	1.551E+006	5.210E-002	7.077E+002
2037	1.551E+006	5.107E-002	6.937E+002
2038	1.551E+006	5.006E-002	6.800E+002
2039	1.551E+006	4.906E-002	6.665E+002
2040	1.551E+006	4.809E-002	6.533E+002

Selected Air Toxic: 1,1-Dichloroethylene

Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic Ft/yr)
1971	7.754E+004	4.622E-004	4.048E+000
1972	1.551E+005	9.152E-004	8.016E+000
1973	2.326E+005	1.359E-003	1.190E+001
1974	3.102E+005	1.794E-003	1.572E+001
1975	3.877E+005	2.221E-003	1.945E+001
1976	4.652E+005	2.639E-003	2.312E+001
1977	5.428E+005	3.049E-003	2.671E+001
1978	6.203E+005	3.451E-003	3.023E+001
1979	6.978E+005	3.845E-003	3.367E+001
1980	7.754E+005	4.231E-003	3.706E+001
1981	8.529E+005	4.609E-003	4.037E+001
1982	9.305E+005	4.980E-003	4.362E+001
1983	1.008E+006	5.344E-003	4.680E+001
1984	1.086E+006	5.700E-003	4.992E+001
1985	1.163E+006	6.049E-003	5.298E+001
1986	1.241E+006	6.392E-003	5.598E+001
1987	1.318E+006	6.727E-003	5.892E+001
1988	1.396E+006	7.056E-003	6.180E+001
1989	1.473E+006	7.379E-003	6.463E+001
1990	1.551E+006	7.695E-003	6.739E+001
1991	1.551E+006	7.542E-003	6.606E+001
1992	1.551E+006	7.393E-003	6.475E+001
1993	1.551E+006	7.247E-003	6.347E+001
1994	1.551E+006	7.103E-003	6.221E+001
1995	1.551E+006	6.962E-003	6.098E+001
1996	1.551E+006	6.825E-003	5.977E+001
1997	1.551E+006	6.689E-003	5.859E+001
1998	1.551E+006	6.557E-003	5.743E+001
1999	1.551E+006	6.427E-003	5.629E+001
2000	1.551E+006	6.300E-003	5.518E+001
2001	1.551E+006	6.175E-003	5.409E+001
2002	1.551E+006	6.053E-003	5.301E+001
2003	1.551E+006	5.933E-003	5.196E+001
2004	1.551E+006	5.816E-003	5.094E+001
2005	1.551E+006	5.700E-003	4.993E+001
2006	1.551E+006	5.588E-003	4.894E+001
2007	1.551E+006	5.477E-003	4.797E+001
2008	1.551E+006	5.368E-003	4.702E+001
2009	1.551E+006	5.262E-003	4.609E+001
2010	1.551E+006	5.158E-003	4.518E+001
2011	1.551E+006	5.056E-003	4.428E+001
2012	1.551E+006	4.956E-003	4.340E+001

Freeway Landfill Human Health Risk Assessment					Prepared by:	CSH/MCW		
Landfill Gas Dispersion Modeling Results					Date:	3/9/93		
					Checked by:	CSH		
					Date:	3/9/93		
Input Information:								
Surface Area of Fill:	610000	square meters						
		Highest Normalized Concentrations						
	Highest Annual Average - Read Directly from ISCLT2 Printout							
	(Based on 0.001 g/m2/s Emission Rate)							
		Results by Year of Meteorological Data				*Highest*		
Case	*1982*	*1983*	*1984*	*1985*	*1986*	*Year*		
On-Site (Worker)	8738.102	8495.305	8134.717	9172.209	8951.572	**9172.209**		
Off-Site	7604.310	6571.576	6549.360	9047.286	6869.797	**9047.286**		
Resident	763.939	717.241	810.174	633.080	917.128	**917.128**		
	LANDFILL 2 Model NMOC Emission Rates							
NMOC concentration in landfill gas is		8000	ppmdv expressed as hexane with MW of:			86.18		
Equivalent mass/volume conc. is:		28176621.6	ug/m3	[ug/m3 = (ppm)40.87(MW)]				
	Emission Rate	*Emission Rate*		*Peak Year*	*Highest 25-yr*	*Highest 30-yr*		
Year	*(Mg/yr)*	*(g/s)*		*(g/s)*	*Avg. (g/s)*	*Avg. (g/s)*		
1971	2.22E+01	0.70427448		**11.7262811**	9.43125317	9.54697277		
1972	4.40E+01	1.39459665			9.24809741	9.54570438		
1973	6.53E+01	2.07128361			9.5825723	9.52424742		
1974	8.62E+01	2.73433536			9.70268899			
1975	1.07E+02	3.3834348			9.79223744	**9.54697277**		
1976	1.27E+02	4.02080162			9.85185185			
1977	1.47E+02	4.64548453			9.88216641			
1978	1.66E+02	5.25748351			9.88368848			
1979	1.85E+02	5.85996956			9.85705226			
1980	2.03E+02	6.44660071						
1981	2.22E+02	7.02371892			**9.88368848**			

1982	2.39E+02	7.58815322						
1983	2.57E+02	8.14307458						
1984	2.74E+02	8.68531202						
1985	2.91E+02	9.21803653						
1986	3.07E+02	9.73807712						
1987	3.23E+02	10.2517757						
1988	3.39E+02	10.7527905						
1989	3.55E+02	11.2442922						
1990	3.70E+02	**11.7262811**						
1991	3.62E+02	11.4916286						
1992	3.55E+02	11.2664891						
1993	3.48E+02	11.0413496						
1994	3.41E+02	10.822552						
1995	3.35E+02	10.6100964						
1996	3.28E+02	10.4008118						
1997	3.22E+02	10.1946981						
1998	3.15E+02	9.99175545						
1999	3.09E+02	9.79515474						
2000	3.03E+02	9.59855403						
2001	2.97E+02	9.40829528						
2002	2.91E+02	9.22437849						
2003	2.85E+02	9.04046169						
2004	2.80E+02	8.86288686						
2005	2.74E+02	8.68531202						
2006	2.69E+02	8.51407915						
2007	2.63E+02	8.34601725						
2008	2.58E+02	8.18112633						
2009	2.53E+02	8.01940639						
2010	2.48E+02	7.86085743						
2011	2.43E+02	7.70547945						
2012	2.38E+02	7.55010147						
2013	2.33E+02	7.40106545						
2014	2.29E+02	7.25520041						
2015	2.24E+02	7.11250634						
2016	2.20E+02	6.96981228						
2017	2.16E+02	6.83346017						
2018	2.11E+02	6.69710807						
2019	2.07E+02	6.56392694						
2020	2.03E+02	6.43391679						
2021	1.99E+02	6.30707763						
2022	1.95E+02	6.18340944						

2023	1.91E+02	6.05974125						
2024	1.87E+02	5.93924404						
2025	1.84E+02	5.82191781						
2026	1.80E+02	5.70776256						
2027	1.76E+02	5.59360731						
2028	1.73E+02	5.48262303						
2029	1.70E+02	5.37480974						
2030	1.66E+02	5.26699645						
2031	1.63E+02	5.16552511						
2032	1.60E+02	5.0608828						
2033	1.57E+02	4.96258245						
2034	1.53E+02	4.86428209						
2035	1.50E+02	4.76598174						
2036	1.47E+02	4.67402334						
2037	1.44E+02	4.57889396						
2038	1.42E+02	4.49010654						
2039	1.39E+02	4.40131913						
2040	1.36E+02	4.31253171						

Individual Carcinogenic VOC Emisson Rates and Predicted Ambient Concentrations								
Compound	CAS #	MW	Concentration in Landfill Gas (ppmdv)	Concentration in Landfill Gas (ug/m3)	Ratio of VOC to NMOC conc. in Landfill Gas	Peak-Year Emssion Rate (g/m2/s)	25-Year Emssion Rate (g/m2/s)	30-Year Emssion Rate (g/m2/s)
Acetone	67-64-1	58.08	3.55	8426.74008	2.99E-04	5.75E-09	4.85E-09	4.68E-09
Benzene	71-43-2	78.12	1.21	3863.24492	1.37E-04	2.64E-09	2.22E-09	2.15E-09
Carbon Tetrachloride	56-23-5	153.81	0.001	6.2862147	2.23E-07	4.29E-12	3.61E-12	3.49E-12
Chlorobenzene	108-90-7	112.56	2.017	9278.85996	3.29E-04	6.33E-09	5.34E-09	5.15E-09
Chloroethane	75-00-3	64.52	2.03	5352.97277	1.90E-04	3.65E-09	3.08E-09	2.97E-09
Chloromethane	74-87-3	50.49	1.38	2847.66629	1.01E-04	1.94E-09	1.64E-09	1.58E-09
Chloroform	67-66-3	119.38	0.3213	1567.64217	5.56E-05	1.07E-09	9.01E-10	8.71E-10
1,2-Dibromoethane	106-93-4	187.8	0.266	2041.65268	7.25E-05	1.39E-09	1.17E-09	1.13E-09
m-Dichlorobenzene	541-73-1	147.01	2.31	13879.17	4.93E-04	9.47E-09	7.98E-09	7.71E-09
1,1-Dichloroethane	75-34-3	98.96	1.27	5136.5089	1.82E-04	3.50E-09	2.95E-09	2.85E-09
1,2-Dichloroethane	107-6-2	98.96	0.22	889.788944	3.16E-05	6.07E-10	5.12E-10	4.94E-10
1,1-Dichloroethylene	75-34-4	96.94	0.069	273.373708	9.70E-06	1.87E-10	1.57E-10	1.52E-10
cis-1,2 Dichlorotheylene	156-59-2	96.94	9.46	37479.9316	1.33E-03	2.56E-08	2.16E-08	2.08E-08
trans-1,2 Dichlorotheylene	156-60-5	96.94	0.2	792.38756	2.81E-05	5.41E-10	4.56E-10	4.40E-10
1,2 Dichloropropane	78-87-5	112.99	0.12	554.148156	1.97E-05	3.78E-10	3.19E-10	3.08E-10
Ethyl Benzene	100-41-4	106.17	10.18	44172.7292	1.57E-03	3.01E-08	2.54E-08	2.45E-08
Methyl Ethyl Ketone	78-93-3	72.11	6.97	20541.5358	7.29E-04	1.40E-08	1.18E-08	1.14E-08
Methyl Isobutyl Ketone	108-10-1	98.15	1.38	5535.71889	1.96E-04	3.78E-09	3.18E-09	3.07E-09
Methyl Mercaptan	74-93-1	48.11	27.8	54661.9085	1.94E-03	3.73E-08	3.14E-08	3.04E-08
Methylene Chloride	75-9-2	84.93	13.68	47484.4989	1.69E-03	3.24E-08	2.73E-08	2.64E-08
Tetrachloroethylene	127-18-4	165.83	1.33	9014.03789	3.20E-04	6.15E-09	5.18E-09	5.01E-09
Toluene	108-88-3	92.14	29.04	109357.723	3.88E-03	7.46E-08	6.29E-08	6.07E-08
Total Xylenes	1330-20-7	106.17	21.77	94463.6852	3.35E-03	6.44E-08	5.43E-08	5.25E-08
1,1,1-Trichloroethane	71-55-6	130.7	1.03	5501.96027	1.95E-04	3.75E-09	3.16E-09	3.06E-09
Trichloroethylene	71-01-6	131.39	3.82	20513.0535	7.28E-04	1.40E-08	1.18E-08	1.14E-08
Vinyl Chloride	75-1-4	62.5	5.37	13716.9937	4.87E-04	9.36E-09	7.89E-09	7.62E-09

	Peak-Year Predicted Ambient Concentration (ug/m3)			Long-Term Predicted Ambient Concentration (ug/m3)				
Compound	On-Site	Off-Site	Residence	On-Site (25)	Off-Site (25)	Residence (30)		
Acetone	5.27E-02	5.20E-02	5.27E-03	4.44E-02	4.38E-02	4.29E-03		
Benzene	2.42E-02	2.38E-02	2.42E-03	2.04E-02	2.01E-02	1.97E-03		
Carbon Tetrachloride	3.93E-05	3.88E-05	3.93E-06	3.32E-05	3.27E-05	3.20E-06		
Chlorobenzene	5.81E-02	5.73E-02	5.81E-03	4.89E-02	4.83E-02	4.73E-03		
Chloroethane	3.35E-02	3.30E-02	3.35E-03	2.82E-02	2.78E-02	2.73E-03		
Chloromethane	1.78E-02	1.76E-02	1.78E-03	1.50E-02	1.48E-02	1.45E-03		
Chloroform	9.81E-03	9.68E-03	9.81E-04	8.27E-03	8.16E-03	7.99E-04		
1,2-Dibromoethane	1.28E-02	1.26E-02	1.28E-03	1.08E-02	1.06E-02	1.04E-03		
m-Dichlorobenzene	8.69E-02	8.57E-02	8.68E-03	7.32E-02	7.22E-02	7.07E-03		
1,1-Dichloroethane	3.21E-02	3.17E-02	3.21E-03	2.71E-02	2.67E-02	2.62E-03		
1,2-Dichloroethane	5.57E-03	5.49E-03	5.57E-04	4.69E-03	4.63E-03	4.53E-04		
1,1-Dichloroethylene	1.71E-03	1.69E-03	1.71E-04	1.44E-03	1.42E-03	1.39E-04		
cis-1,2 Dichlorotheylene	2.35E-01	2.31E-01	2.35E-02	1.98E-01	1.95E-01	1.91E-02		
trans-1,2 Dichlorotheylene	4.96E-03	4.89E-03	4.96E-04	4.18E-03	4.12E-03	4.04E-04		
1,2 Dichloropropane	3.47E-03	3.42E-03	3.47E-04	2.92E-03	2.88E-03	2.82E-04		
Ethyl Benzene	2.76E-01	2.73E-01	2.76E-02	2.33E-01	2.30E-01	2.25E-02		
Methyl Ethyl Ketone	1.29E-01	1.27E-01	1.29E-02	1.08E-01	1.07E-01	1.05E-02		
Methyl Isobutyl Ketone	3.46E-02	3.42E-02	3.46E-03	2.92E-02	2.88E-02	2.82E-03		
Methyl Mercaptan	3.42E-01	3.37E-01	3.42E-02	2.88E-01	2.84E-01	2.78E-02		
Methylene Chloride	2.97E-01	2.93E-01	2.97E-02	2.50E-01	2.47E-01	2.42E-02		
Tetrachloroethylene	5.64E-02	5.56E-02	5.64E-03	4.75E-02	4.69E-02	4.59E-03		
Toluene	6.84E-01	6.75E-01	6.84E-02	5.77E-01	5.69E-01	5.57E-02		
Total Xylenes	5.91E-01	5.83E-01	5.91E-02	4.98E-01	4.91E-01	4.81E-02		
1,1,1-Trichloroethane	3.44E-02	3.40E-02	3.44E-03	2.90E-02	2.86E-02	2.80E-03		
Trichloroethylene	1.28E-01	1.27E-01	1.28E-02	1.08E-01	1.07E-01	1.04E-02		
Vinyl Chloride	8.58E-02	8.47E-02	8.58E-03	7.23E-02	7.14E-02	6.99E-03		

Freeway Landfill Human Health Risk Assessment				Prepared by:	CSH
Landfill Gas Compound Concentrations in the Scale House				Date:	
Methane Conc. in Scale House:		12500	ppmdv		
Methane Conc. in Landfill Gas:		460400	ppmdv		
Dilution Ratio:		0.0271503			
	Concentration		*Concentration*		
	in Landfill Gas		*in Scale House*		
Compound	*(ppmdv)*		*(ppmdv)*		
1-Butanol	100		2.72E+00		
Acetone	3.6		9.77E-02		
Acrylonitrile	0.32		8.69E-03		
Benzene	1.2		3.26E-02		
Butane	3.68		9.99E-02		
Carbon Tetrachloride	0.001		2.72E-05		
Chlorobenzene	2		5.43E-02		
Chlorodifluoromethane	1.35		3.67E-02		
Chloroethane	2.03		5.51E-02		
Chloroform	0.3		8.15E-03		
1,2-Dibromoethane	0.3		8.15E-03		
1,2-Dichloroethane	1.27		3.45E-02		
1,2-Dichloroethene	6.33		1.72E-01		
Dichlorodifluoromethane	43.99		1.19E+00		
1,1-Dichloroethane	3.51		9.53E-02		
1,1-Dichloroethene	0.07		1.90E-03		
Dichlorofluoromethane	1.2		3.26E-02		
Dichlorotetrafluoroethane	1.1		2.99E-02		
1,2-Dichloropropane	0.12		3.26E-03		
1,2-Dimethyl Benzene	588		1.60E+01		
Ethane	252.63		6.86E+00		
Ethanol	157		4.26E+00		
Ethyl Acetate	20		5.43E-01		
Ethyl Mercaptan	11.93		3.24E-01		
Ethylbenzene	10.2		2.77E-01		
Hexane	5.33		1.45E-01		
Hydrogen Sulfide	252.97		6.87E+00		
Limonene	470		1.28E+01		
Methyl Isobutyl Ketone	1.38		3.75E-02		
Methyl Mercaptan	1.55		4.21E-02		
4-Methyl 2-Pentanone	89		2.42E+00		
Methyl Ethyl Ketone	7		1.90E-01		
Methylcyclohexane	99.7		2.71E+00		

Nonane	167		4.53E+00		
Octane	152		4.13E+00		
Pentane	5.64		1.53E-01		
Propane	13.59		3.69E-01		
Propene	36		9.77E-01		
t-Butyl Mercaptan	0.64		1.74E-02		
1,1,2,2-Tetrachloroethane	0.1		2.72E-03		
Tetrachloroethene	2.7		7.33E-02		
Tetrahydrofuran	30		8.15E-01		
Toluene	29		7.87E-01		
Total Xylene Isomers	21.8		5.92E-01		
1,1,1-Trichloroethane	0.84		2.28E-02		
Trichloroethene	3.8		1.03E-01		
Trichlorofluoromethane	0.99		2.69E-02		
Vinyl Chloride	5.4		1.47E-01		
Xylene	333.85		9.06E+00		

APPENDIX C

ECOLOGICAL RISK ASSESSMENT BACKUP DATA

The 95 percent upper confidence level (UCL) provides a conservative estimate of the average (mean) concentration. U.S. EPA (1992) defines the UCL as a mean value that, when calculated repeatedly for randomly drawn subsets of size data, equals or exceeds the true mean 95 percent of the time. U.S. EPA (1992) cautions that this should not be confused with a 95th percentile of site concentration data. The 95 percent UCL is used because it accounts for uncertainties due to limited sampling data at Superfund sites and because it is not possible to know the true mean. As sampling data increases, uncertainties decrease, the UCL moves closer to the true mean, and exposure evaluations using either the mean or the UCL produce similar results.

The 95 percent UCL is calculated by the following equation:

$$UCL = x + t(s/n1/2)$$

where

UCL	=	upper confidence limit
x	=	mean of the untransformed data
s	=	standard deviation of the untransformed data
t	=	Student-t statistic
n	=	number of samples.

Tables C-1, C-2, and C-3, which follow, present the data for groundwater, surface water, and leachate, respectively, used for calculating the UCL by the method described above. The data used is the sampling data for groundwater, surface water, and leachate provided to CDM by MPCA. The data sources are the same as those listed in Tables 2.1-1, 2.1-2, 2.1-3, and 2.1-7. When a non-detect was reported, one-half the detection limit was used to for the purposes of calculating the arithmetic average. Values for Student's t-statistic were taken from *Introduction to the Practice of Statistics*. 1989. D.S. Moore and G.P. McCabe. W.H. Freeman and Company, NY. 839 pp.

Table C-1

GROUNDWATER DATA

SAMPLE IDENTIFICATION

PARAMETER	US Salt	WT-6	WT-9	WT-10	J-13	WT-13	WT-11B	J-14	WT-14	WT-12B	US Salt	WT-6	WT-9	WT-10
METALS (µg/L)														
Aluminum	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)	290	ND(250)	ND(250)
Arsenic	ND(2.0)	25.2	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	9.8	ND(2.0)	2.4
Barium	100	180	ND(100)	390	ND(100)	ND(100)	380	ND(100)	350	600	300	380	ND(100)	420
Beryllium														
Cadmium	0.14	0.12	0.1	ND(0.1)	ND(0.1)	0.12	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)	0.2	ND(0.1)	ND(0.1)	ND(0.1)
Chromium	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.3	ND(1.0)	ND(1.0)	ND(1.0)
Copper	24	8	1.7	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	16.9	ND(20)				
Iron	580	16,600	5	5,020	5	21	410	350	190	6	810	280	40	1880
Lead	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(2.0)	2.4	ND(1.0)	ND(1.0)	ND(1.0)
Nickel	ND(40)	100	ND(40)	ND(40)	ND(40)	ND(40)	ND(40)	ND(40)	ND(40)	ND(40)	ND(40)	80	ND(40)	ND(40)
Selenium	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.48
Silver	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)
Thallium														
Zinc	140	20	ND(10)	10	ND(10)	ND(10)	ND(10)	ND(10)	10	10	350	10	ND(10)	ND(10)
VOLATILES (µg/L)														
Dichlorodifluoromethane	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	2.9	ND(2.0)	ND(2.0)
1, 1-Dichloroethane	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)
cis-1,2-Dichloroethylene	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	1.7	ND(0.8)	ND(0.8)	1	ND(0.8)	ND(0.8)
trans-1, 2-Dichloroethylene	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)
Ethyl ether	ND(1.6)	4.5	ND(1.6)	ND(1.6)	ND(1.6)	ND(1.6)	ND(1.6)	ND(1.6)	2.4	8.1	ND(1.6)	7.5	ND(1.6)	ND(1.6)
Tetrahydrofuran	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	20.4	19.8	19.8	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)
1,1,2-Trichloroethylene	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	1	1	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)

Table C-1

GROUNDWATER DATA	SAMPLE IDENTIFICATION												
PARAMETER	J-13	WT-13	WT-11B	J-14	WT-14	WT-12B	US Salt	WT-6	WT-9	WT-10	WT-13	WT-14	WT-6
METALS (µg/L)													
Aluminum	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)	ND(250)							33.7
Arsenic	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)							15.1
Barium	ND(100)	210	320	ND(100)	480	470							266
Beryllium													
Cadmium	ND(0.1)	0.1	ND(0.1)	ND(0.1)	ND(0.1)	ND(0.1)							0.1
Chromium	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)							ND(1.0)
Copper													ND(4.0)
Iron	60	40	450	8	28	19							33400
Lead	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.04	ND(1.0)							ND(1.0)
Nickel	ND(40)	ND(40)	ND(40)	ND(40)	ND(40)	ND(40)							41.3
Selenium	ND(1.0)	1.93	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)							ND (3.0)
Silver	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)							ND(0.2)
Thallium													
Zinc	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)	ND(10)							20
VOLATILES (µg/L)													
Dichlorodifluoromethane	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	7	ND(2.0)
1, 1-Dichloroethane	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	0.4	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)
cis-1,2-Dichloroethylene	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	4.2	1.1	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	1	ND(0.8)
trans-1, 2-Dichloroethylene	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	0.6	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)
Ethyl ether	ND(1.6)	ND(1.6)	ND(1.6)	ND(1.6)	6.3	4.7	ND(3.0)	7.7	ND(3.0)	ND(3.0)	5.1	6.2	ND(3.0)
Tetrahydrofuran	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)
1,1,2-Trichloroethylene	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	1.8	0.9	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)

Table C-1

GROUNDWATER DATA	SAMPLE IDENTIFICATION												
PARAMETER	WT-9	WT-10	J-13	WT-13	WT-11B	J-14	WT-14	WT-12B	WT-6	WT-9	WT-10	WT-11B (Shallow)	WT-11B (Deep)
METALS (µg/L)													
Aluminum	12.2	21.8	27.8	16.2	18.6	14.0	18.6	34.6					
Arsenic	ND(2.0)	3.1	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	2	ND(1.0)	ND(1.0)	2	1
Barium	67.6	761	ND(2.0)	223	433	18.9	643	584					
Beryllium									ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)
Cadmium	0.3	1.6	0.3	0.1	0.1	ND(0.1)	0.5	0.5	4.5	0.3	0.2	0.2	ND(0.1)
Chromium	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)
Copper	1.8	ND(4.0)	1.6	1.5	3.6	ND(4.0)	4.5	2.1	5	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)
Iron	3.8	3540	30.5	160	310	80	12.6	28.3					
Lead	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.1	ND(1.0)	1.1	ND(1.0)	2	ND(1.0)	ND(1.0)	2
Nickel	ND(1.0)	6.1	1.3	1.8	4	ND(1.0)	22	20.5	6	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)
Selenium	ND(2.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	3	ND(3.0)	ND(3.0)
Silver	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	0.6	ND(0.2)	0.2	0.2	ND(0.2)
Thallium									ND(3.0)				
Zinc	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	ND(20)	40	ND(10)	10	140	130
VOLATILES (µg/L)													
Dichlorodifluoromethane	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	3.7	ND(2.0)	ND(2.0)	ND(1.5)	ND(1.5)	ND(1.5)	ND(1.5)	ND(1.5)
1, 1-Dichloroethane	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)
cis-1,2-Dichloroethylene	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	10	ND(0.8)	ND(0.8)	0.4	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)
trans-1, 2-Dichloroethylene	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	1.8	ND(0.3)	ND(0.3)	0.4	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)
Ethyl ether	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	11.2	11.3	10.4	2.1	ND(0.3)	ND(0.3)	1.1	ND(0.3)
Tetrahydrofuran	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)	26.2	29.3	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)
1,1,2-Trichloroethylene	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	ND(0.4)	1.9	0.8	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)

Table C-1

GROUNDWATER DATA	SAMPLE IDENTIFICATION												
PARAMETER	WT-12B (Shallow)	WT-12B (Deep)	WT-6	WT-9	WT-10	WT-11 (Shallow)	WT-11 (Deep)	WT-12B (Shallow)	WT-12B (Deep)	Degrees of Freedom	t Statistic	Arithmetic Average	Upper Confidence Limit
METALS (µg/L)													
Aluminum										28	1.701	99	118
Arsenic	ND(1.0)	ND(1.0)	28	ND(1.0)	2	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	42	1.684	2.9	4.4
Barium										28	1.701	273	342
Beryllium	ND(0.2)	ND(0.2)	1.2	ND(0.2)	1.6	ND(0.2)	ND(0.2)	1.3	0.4	13	1.771	0.4	0.6
Cadmium	0.2	0.2	6.1	0.2	ND(0.1)	ND(0.1)	ND(0.1)	0.1	0.2	42	1.684	0.4	0.7
Chromium	ND(1.0)	ND(1.0)	9	ND(1.0)	ND(1.0)	2	1	3	2	42	1.684	0.9	1.2
Copper	ND(4.0)	ND(4.0)	50	ND(4.0)	ND(4.0)	ND(4.0)	ND(4.0)	9	2	32	1.697	6.4	9.2
Iron										28	1.701	2,220	4,365
Lead	3	4	14	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	42	1.684	1.1	1.7
Nickel	9	8	100	ND(2.0)	2	4	ND(2.0)	16	12	42	1.684	18.8	24.6
Selenium	19	3	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	ND(3.0)	42	1.684	1.9	2.6
Silver	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	0.4	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	42	1.684	2.4	3.0
Thallium			43							1	6.314	22.3	153
Zinc	280	320	740	10	ND(10)	50	30	210	190	42	1.684	66.9	102
VOLATILES (µg/L)													
Dichlorodifluoromethane	ND(1.5)	ND(1.5)	ND(1.5)	ND(1.5)	ND(1.5)	ND(1.5)	ND(1.5)	ND(1.5)	ND(1.5)	48	1.684	1.1	1.4
1, 1-Dichloroethane	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	ND(0.2)	48	1.684	0.1	0.1
cis-1,2-Dichloroethylene	1.5	0.9	0.6	ND(0.5)	ND(0.5)	0.4	ND(0.5)	5.8	3.1	48	1.684	0.9	1.3
trans-1, 2-Dichloroethylene	1.5	0.9	0.6	ND(0.3)	ND(0.3)	0.4	ND(0.3)	5.8	3.1	48	1.684	0.4	0.7
Ethyl ether	13	6.9	3.5	ND(0.3)	ND(0.3)	2.6	ND(0.3)	19	13	48	1.684	3.5	4.6
Tetrahydrofuran	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)	ND(15)	25	15	48	1.684	8.0	9.6
1,1,2-Trichloroethylene	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)	1.8	1.3	48	1.684	0.5	0.6

Table C-2

SURFACE WATER DATA	SAMPLE IDENTIFICATION					
PARAMETER	SW-3	SW-3	Degrees of Freedom	t Statistic	Arithmetic Average	Upper Confidence Limit
METALS (µg/L)						
Aluminum	340	ND(250)	1	6.314	232.5	911.3
Barium	900	300	1	6.314	600	2494.2
Cadmium	0.19	ND(0.1)	1	6.314	0.1	0.6
Chromium	1.4	ND(1.0)	1	6.314	1.0	3.8
Copper	ND(12)		0	NA	6.0	NA
Iron	19,800	1,380	1	6.314	10,590	68741.9
Lead	3.4	2.2	1	6.314	2.8	6.6
Selenium	ND(2.0)	ND(2.0)				
Silver	ND(10)	ND(10)				
Zinc	60	30	1	6.314	45.0	139.7
VOLATILES (µg/L)						
Acetone	ND(10.4)	13.4	1	6.314	9.3	35.2
cis-1,2-Dichloroethylene	2.3	ND(0.8)	1	6.314	1.4	7.3
trans-1, 2-Dichloroethylene	ND(0.3)	ND(0.3)				
Ethyl ether	2.5	ND(1.6)	1	6.314	1.7	7.0

Table C-2

SURFACE WATER DATA

SAMPLE IDENTIFICATION

PARAMETER	SW-6	SW-6	SW-6	SW-6	SW-6	SW-6	Degrees of Freedom	t Statistic	Arithmetic Average	Upper Confidence Limit
METALS (µg/L)										
Aluminum	ND(250)	ND(250)		43.3			2	2.92	98	190
Barium	ND(100)	300		184			2	2.92	178	423
Cadmium	ND(0.1)	0.79		0.1	ND(0.1)	ND(0.1)	4	2.132	0.21	0.85
Chromium	ND(1.0)	1.2		ND(1.0)	ND(1.0)	ND(1.0)	4	2.132	0.6	1.3
Copper	18.1			2.7	ND(4.0)	ND(1.0)	3	2.353	5.8	22.0
Iron	740	560		160			2	2.92	487	1069
Lead	4	4.7		ND(1.0)	ND(1.0)	ND(1.0)	4	2.132	2.0	6.2
Selenium	3.7	7.2		3.5	ND(3.0)	ND(3.0)	4	2.132	3.5	8.0
Silver	ND(10)	ND(10)		ND(0.2)	0.2	ND(1.0)	4	2.132	2.2	7.2
Zinc	10	40		ND(20)	ND(10)	ND(10)	4	2.132	14	43
VOLATILES (µg/L)										
Acetone	ND(10.4)	ND(10.4)	ND(10.4)	ND(10.4)	ND(40)	ND(40)				
cis-1,2-Dichloroethylene	ND(0.8)	ND(0.8)	ND(0.8)	ND(0.8)	0.5	1	5		0.52	0.99
trans-1, 2-Dichloroethylene	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	0.3	ND(0.3)	5		0.18	0.30
Ethyl ether	ND(1.6)	ND(1.6)	ND(1.6)	ND(1.6)	0.7	ND(0.3)	5		0.7	1.2

Table C-3

LEACHATE DATA

PARAMETER	SAMPLE IDENTIFICATION WT-6	Seep Leachate	WT-6	Seep Leachate	WT-6	Seep Leachate	WT-6	WT-6	Seep Leachate	WT-6	Degrees of Freedom	t Statistic	Arithmetic Average	Upper Confidence Limit
METALS (µg/L)														
Aluminum	ND(250)	ND(250)	290	ND(250)					32.2	33.7	5	2.015	121.8	199.1
Arsenic	25.2	3.44	9.8	7.32			2	28	4.9	15.1	7	1.895	12.0	18.6
Barium	180	500	380	500					361	266	5	2.015	365	469.0
Beryllium							ND(0.2)	1.2	ND(0.2)	ND(0.2)	3	2.353	0.5	1.0
Cadmium	0.12	0.11	ND(0.1)	ND(0.1)			4.5	6.1	0.1	0.1	7	1.895	1.4	3.0
Chromium	ND(1.0)	10.8	ND(1.0)	ND(1.0)			1	9	3.3	ND(1.0)	7	1.895	3.3	6.1
Copper	ND(12)	ND(12)					5	50	2	ND(1.0)	5	2.015	12.5	27.7
Iron	16,600	80	280	9,840					2300	33,400	5	2.015	10417	21093
Lead	ND(1.0)	ND(1.0)	ND(1.0)	ND(1.0)			ND(1.0)	14	ND(1.0)	ND(1.0)	7	1.895	2.2	5.4
Nickel	100	140	80	160			6	100	63.5	41.3	7	1.895	86.4	120.1
Silver	ND(10)	ND(10)	ND(10)	10			0.6	ND(0.2)	ND(10)	ND(0.2)	7	1.895	5.1	6.8
Thallium							ND(3)	43	ND(3)	ND(3)	3	2.353	11.9	36.3
Zinc	20	10	10	20			40	740	ND(10)	20	7	1.895	108.1	279.3
VOLATILES (µg/L)														
Acetone	ND(10.4)	ND(10.4)	20.6	ND(10.4)	ND(10.4)	ND(10.4)	ND(40)	ND(40)	ND(10.4)	ND(10.4)	9	1.833	7.7	10.6
Chlororbenzene	ND(0.3)	ND(0.3)	ND(0.3)	0.9	ND(0.3)	ND(0.3)	ND(0.3)	ND(1.0)	ND(0.3)	ND(0.3)	9	1.833	0.2	0.4
Chloroethane	ND(2.0)	ND(2.0)	2.1	ND(2.0)	ND(2.0)	ND(2.0)	ND(1.0)	ND(1.0)	ND(2.0)	5.5	9	1.833	1.5	2.3
Chloromethane	ND(2.0)	ND(2.0)	ND(2.0)	ND(2.0)	4.2	ND(2.0)	ND(1.0)	ND(1.0)	ND(2.0)	ND(2.0)	9	1.833	1.2	1.8
1, 4-Dichlorobenzene	ND(0.2)	ND(0.2)	ND(0.2)	1.2	ND(0.2)	ND(0.2)	ND(4.0)	ND(4.0)	ND(0.2)	ND(0.2)	9	1.833	0.6	1.1
Dichlorodifluoromethane	3.8	ND(2.0)	2.9	ND(2.0)	ND(2.0)	ND(2.0)	ND(1.5)	ND(1.5)	ND(2.0)	ND(2.0)	9	1.833	1.5	2.1
cis-1,2-Dichloroethylene	ND(0.8)	ND(0.8)	1	ND(0.8)	ND(0.8)	ND(0.8)	0.4	0.6	ND(0.8)	ND(0.8)	9	1.833	0.5	0.6
trans-1, 2-Dichloroethylene	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	ND(0.3)	0.4	0.6	ND(0.3)	ND(0.3)	9	1.833	0.2	0.3
Ethyl ether	4.5	2.2	7.5	36.5	7.7	8.3	2.1	3.5	14.1	10.4	9	1.833	9.7	15.6
Tetrahydrofuran	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	ND(6.0)	21.6	ND(6.0)	ND(15)	78.9	ND(15)	9	1.833	12.5	26.4