2319 South Foothill Drive, Suite 180
Salt Lake City, Utah 84109
Phone: 801.461.0888
Fax: 801.461.0008
saltlakecity@mse-environmental.com

November 16, 2001

Mr. Rusty Wilder
USDA-U.S. Forest Service
RR 2, Box 200 Hwy 385 N.
Custer, SD 57730-9501

Re: EE/CA Technical Memorandum
USDA Forest Service Contract No. 53-84N8-1-009, Activity III
Nemo Work Center, Nemo, South Dakota

Dear Mr. Wilder:

Millennium Science and Engineering (MSE) has a keen interest in moving forward toward resolution of environmental issues associated with EDB contamination impacting the local groundwater aquifer at Nemo. The primary mechanism of achieving this goal is the Engineering Evaluation/Cost Analysis (EE/CA), which we are currently in the process of developing. Prior to completion of the EE/CA, MSE intends to perform several activities to assure all pertinent aspects are properly considered with regard to source identification, potential source removal, site characterization, risk, and options for mitigation. In the course of completing these activities, MSE desires to maintain a high level of communication with the Forest Service. This will assure a mutual understanding of project issues and the course of action MSE intends to follow for developing the EE/CA and achieving project goals. Therefore, MSE is presenting this EE/CA technical memorandum to the Forest Service.

The following sections of this memorandum provide an overview of MSEs intended course of action leading up to submission of the EE/CA. Section 1 provides a tentative schedule for completion of project milestones pending submission of the final EE/CA. A general overview of project and site characteristics are presented in Section 2. Key elements of current and potential risk to human health and the environment are summarized in Section 3. Section 4 provides a preliminary EE/CA overview, including a proposed outline. To assure a solid understanding of the elements of risk at stake associated with this project, a more detailed preliminary risk evaluation is provided as an attachment.

1.0 Tentative Project Schedule

Table 1 Presented below is a tentative schedule developed to provide a means of tracking project milestones and to communicate MSEs intended course of action pending submission of the EE/CA.

MSE - **Millennium Science & Engineering, Inc.**

TABLE 1 - PROJECT SCHEDULE
ENGINEERING EVALUATION/COST ANALYSIS (EE/CA)
USDA Forest Service, Nemo Work Center
Contract No. 53-84N8-1-009, Hazardous Waste Remediation Activity III

ACTIVITY	STAFF	TARGET DATES (Months & Weeks)																																		
		OCTOBER					NOVEMBER					DECEMBER					JANUARY					FEBRUARY					MARCH					APRIL				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Fall 2001 Semiannual Groundwater Sampling Event	RJ	X																																		
Groundwater Data Received	ML/RJ/JC				X																															
Topographic Data Received	KB				X																															
Aerial Photographs Received	KB				X																															
Preliminary Baseline Risk Evaluation (Deliverable)	JC							X																												
Identification of Removal Objectives	ML/DK							X																												
Preparation of Technical Memorandum (Deliverable)	ML/DK							X																												
Evaluation and Screening of Removal Action Technologies	ML/DK/TR								X																											
Description of Removal Action Technologies	ML/TR								X																											
Topographic Overlays with Aerial Photos and Trench Locations	KB								X																											
Identification of Source Survey Lines	ML/KB								X																											
Source Area Tree Removal	?								X																											
Geophysical Source Investigation	ML										X																									
Review of Preliminary Results	ML/DK										X																									
Intrusive Excavation and Confirmation (if anomalies found)	ML										X																									
Preliminary Sparge Pressure Flow Test	ML										X																									
Preliminary Sparge Pressure/Flow Test Evaluation	ML												X																							
Prepare Comprehensive Source Investigation Map	ML/KB												X																							
Preparation of EE/CA Status Memorandum (Deliverable)	ML/JM												X																							
September Groundwater Monitoring Report (Deliverable)	RJ/ML													X																						
Project Status Meeting, 12/17/10, MSE & Forest Service	FS + ML/DK													X																						
Evaluation of Removal Action Alternatives	TR/ML/DK/JM															X																				
Identification of Preferred Alternatives	TR/ML/DK/JM															X																				
Conceptual Design of Preferred Alternatives	TR/ML/DK/JM															X																				
Identification of ARARS	TR/ML															X																				
Submittal of Draft EE/CA Report	ML/DK																				X															
Receive USFS Comments	FS-ML/DK																								X											
Draft Preliminary Design of Preferred Alternative (Deliverable)	TR/ML/DK/JM																												X							
Meet with USFS and Discuss Draft EE/CA and Preliminary Design	FS + ML/DK																														X					
Submit Final EE/CA and Preliminary Design (Deliverable)	ML/DK/JM																																	X		
Spring 2002 Semiannual Groundwater Sampling Event	RJ/ML																																			X

2.0 Overview of Project and Site Characteristics

In the fall of 1996 EnviroSearch International began work at Nemo in an effort to locate and remove containers of the pesticide EDB, supposedly buried onsite. Contamination of the local aquifer by EDB was discovered at this time as well. Since then EnviroSearch, now MSE, has conducted numerous activities to characterize the site, monitor the EDB plume, identify the source of EDB impacting the aquifer, and mitigate it's immediate effect on the local population. These activities include: several geophysical surveys, approximately 30 exploratory excavations, monitoring well installations, aquifer testing, groundwater monitoring, remedial evaluations and the installation a community water system. The source of the EDB impacting the local groundwater aquifer has yet to be identified, however the likely source area has been significantly reduced through these processes, i.e. 65 acres to approximately 4 acres.

Site characterization and groundwater monitoring activities have provided data to develop conclusions with regard to the general characteristics of the EDB contaminant plume over time. There are however some uncertainties remaining with regard to localized hydrogeologic and hydraulic characteristics controlling groundwater flow and contaminant migration within the plume boundary.

Conclusions regarding groundwater contaminant plume characteristics that can be stated at this time include:

- General plume dimensions remain relatively constant; hydraulic and geologic boundaries define major limits.
- There is a recent trend toward increasing EDB concentrations in the source area (MW-1, MW-20, MW-3). The increase in concentrations varies between 3 and over 450 times when compared to the lowest EDB concentrations previously documented for the wells. Concentrations of EDB in MW-1 have increased as much as 284 times over 4 years. MW-3 has exhibited a dramatic increase in EDB concentration to as much as 458 times the previous low concentrations (<MDL) documented in the past 2 years. EDB concentrations in MW-20 are currently at an all time high for any well sampled since the beginning of groundwater monitoring activities at this site.
- The EDB plume source area is not diminishing.
- Concentrations of EDB within the downgradient end of the plume (MW-4, Original Kaberna, Original Weston, MW-12) are variable. EDB concentrations in MW-4 have increased 12 times since the lowest concentration documented in 1998. The Original Kaberna, Original Weston and MW-12 are unstable. Plume boundary shifting (cyclical expansion and contraction) between MW-12 and the Original Weston well is documented.

- The potential for a plume boundary shift toward RW-13 (Weston Supply Well) exists, thus putting Weston drinking water supply at future risk.
- Concentrations of EDB in the N4T well at the northern end of the plume have increased approximately 6 times since the lowest documented concentration in 1999.
- Concentrations of EDB in the majority of other wells in the Nemo area appear relatively constant.

Issues regarding hydrogeology and groundwater contaminant plume characteristics that remain uncertain include:

- A clear definition of all aspects of complex geologic fracture/fault system in the source area;
- A total and complete understanding of all aspects of the hydrogeology and hydrology controlling contaminant flow within the plume boundaries;
- Contaminant transport lag time from the source area to other portions of the contaminant plume;
- Relationship between groundwater elevation and EDB concentration, if any; and
- Description of specific and discrete aquifer characteristics within the plume boundary such as detailed identification of all fault/fracture system flow paths and head pressures.

The general hydrogeologic characteristics of the plume area are known. The uncertainties arise from inability to identify discrete fractures and localized geologic features that provide conduits or barriers for groundwater flow. Although some components of these uncertainties will be resolved by continued evaluation of monitoring and characterization data, it is not technically feasible to define them completely.

Additional documentation of project activities conducted since it was initiated in October 1996 are presented as referenced correspondence and reports provided to the Forest Service previously in Attachment 1.

3.0 Preliminary Risk Overview

Currently, known risk to human health associated with ingestion of EDB in the local water supply aquifer has been mitigated by implementation of the replacement water supply system. Previously impacted residences have been provided with culinary water from wells installed outside the EDB plume. However, inhalation risk and migration of the EDB plume remain potential risks of exposure and compliance liability. Concentrations of EDB present within the aquifer plume remain far above risk based concentrations for residential use. Future installation of new private water wells, or a shift in the contaminant plume configuration represents a potentially significant risk to human health and to the USFS.

Other risk-associated issues of concern include:

- Shallow aquifer continues to be used as primary sanitary water supply; Residential exposure and receptor assumptions apply, particularly near private property.
- Acceptable residential risk based concentrations (i.e., $10E^{-6}$) are very low (0.4 to 0.76 ppt), as are MCL's (50 ppt).
- Residential risks in the source area (MW-20) and the heart of plume (MW-10) are very high (i.e., 2.1×10^{-1} and 4.5×10^{-2} respectively). Existing EDB concentrations in the source area are over 3,200 times allowable levels for drinking water (MCL), and over 200,000 times reported risk based concentrations.
- Residential risks in leading edge near the most threatened drinking water receptor are over 10^{-3} (average of latest data from MW-4, Original Kaberna, & Original Weston = 1050 ppt).
- EDB concentrations in groundwater immediately down gradient of Forest Service property are over 1000 times risk based concentrations for drinking water (Average 2001 data Original Kaberna, & Original Weston = 1,000 ppt).
- Published risk based concentrations (0.4 to 0.75 ppt) are less than method detection limits (20 ppt).
- Inhalation risk is potentially greater than ingestion risk

A more detailed preliminary Risk Evaluation is presented as Attachment 2 to this document.

4.0 Preliminary EE/CA Overview and Outline

Currently, it is understood that our ultimate goal for this project is to mitigate potential risks to human health and the environment posed by the ethylene dibromide (EDB) groundwater plume at Nemo and the surrounding area. The primary tool to realize that goal is the EE/CA. The EE/CA will provide updated site characterization information, and thoroughly evaluated remedial alternatives and recommendations required to implement appropriate corrective action measures.

The EE/CA removal action alternative ultimately chosen will recognize a number of site specific and risk based issues. However, some general concepts must be considered and understood for development of specific alternatives. Evaluation of the contaminated groundwater aquifer, risk mitigation and implementation of a selected removal action alternative will require consideration of the following concepts/issues:

- Groundwater on private lands near the leading edge are preferentially controlled on the upgradient side by geologic features (fault line).

- Significant risk reduction to private landowners and future liabilities to USFS near leading edge can be achieved by eliminating pathway for contaminated groundwater.
- Hydraulic containment upgradient of private lands can be achieved through groundwater recovery and treatment via air stripping or carbon absorption. Freezing conditions will complicate alternatives involving surface treatment or discharge.
- Insitu treatment can potentially be achieved through air sparging if formation accepts air injection and air diffusion within the formation can be safely accomplished. Significant cost savings may be realized through air sparging if effectiveness and safety can be verified.
- Verification of air sparging effectiveness and safety will be required before sparge implementation can be justified. This will likely involve drilling and installation of monitoring points to allow quantification of sparge effectiveness. The generation of EDB vapor at the surface as a result of sparging (vapor fate) will also require evaluation and potential control.
- Pump and treat (air stripping, carbon absorption, sprinkler irrigation) is an effective means of removing EDB from the groundwater. However, there are limitations to pump and treatment technology as a remedial alternative at this site. Many of the wells will not produce enough water to pump continuously. Therefore, a network of wells would likely have to be connected to the system to have any reasonable remedial effect on the aquifer as a whole. Freezing conditions will complicate alternatives involving surface treatment or discharge.
- Risk reduction in Nemo community can be achieved by placing all residents at risk (e.g. Weston, Cooper, Langley) on the community water supply with the others currently on the USFS water supply system.
- Hydraulic containment and plume contraction can potentially be achieved through groundwater injection on north and northeast side of plume.
- Acceleration of site cleanup can be realized if source abatement can be accomplished. Source may be defined by buried EDB containers if they exist and are found, or the heart of the groundwater plume if containers are not found.
- Significant costs and administrative difficulties can be minimized by implementing interim remedial measures.
- Technology exists to remove EDB from water (volatility).

Given the above, the following primary removal action objectives are proposed:

1. Protect public health;
2. Minimize long term risk;
3. Mitigate groundwater contamination on private property; and
4. Provide efficient long-term regulatory compliance.

A preliminary EE/CA outline with additional subsection/discussion topic matter (*Italics*) is provided below. Prior to submission of the draft EE/CA an effort will be made to tighten document structure to provide more concise evaluation and conclusions.

EXECUTIVE SUMMARY

1.0 INTRODUCTION

2.0 SITE CHARACTERIZATION
- 2.1 Site Description and Background
  - *--Site History, Hydrogeology*
- 2.2 Previous Mitigation Activities (Removal Actions, Water Supply System)
- 2.3 Source, Nature, and Extents of Contamination
  - 2.3.1 Ethylene Dibromide (EDB)
    - *--Contaminant Characteristics*
  - 2.3.2 Extent of Contamination
    - *--Plume Characteristics, Source Delineation*
- 2.4 Groundwater Monitoring
  - 2.4.1 Analytical Data, **TABLE 1**
- 2.5 Streamlined Risk Evaluation
  - 2.5.1 Human Health Risk Evaluation
    - *--Hazard Assessment - Identify areas of project Risk & Liability at private wells surrounding the plume & contaminated private lands*
    - *--Exposure Assessment - Develop theoretical baseline risk analysis, well by well risk calculation*
    - *--Toxicity Assessment*
  - 2.5.2 Ecological Risk Assessment

3.0 IDENTIFICATION OF REMOVAL ACTION SCOPE, AND OBJECTIVES
- 3.1 Statutory Limits on Removal Actions
  - *--Evaluation of ARARs*
- 3.2 Removal Action Scope and Objectives (1, 2, 3, 4)
  - *--Scenarios -*
- 3.3 Removal Action Schedule
- 3.4 Planned Remedial Activities

4.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES
- 4.1 Removal Action Scenarios
  - *--No Action*
    - *-Monitor for 20 years*
    - *-Maintain existing water supply system*
    - *-Manage existing risk*
    - *-Administrative and regulatory Interaction*
    - *-Institutional controls on groundwater usage everywhere*
  - *--Upgrade water supply system*
    - *-Connect Weston, Langley, Cooper*

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-Improve storage and distribution system
-Install and connect backup well
-Hookup existing well to individual treatment system
-Monitor only critical wells for protection
-Institutional controls (purchase water rights, deed restrictions) on groundwater usage everywhere - USFS Become sole water utility

--Cleanup Private Properties
-Install EDB cutoff system above Kaberna
Sparging curtain for insitu treatment - Requires Focused Pilot test
Pump and Treat for hydraulic containment
Monitor effectiveness in selected wells
-Pump and Treat for remediation
-Install hydraulic injection system in nemo
-Install sparging system on private lands within plume
-Institutional controls on groundwater usage on USFS lands
-Other?

--Cleanup Entire plume
-Sparge entire plume, Requires Expanded Pilot test
-Pump and Treat
-Combination Sparge & Pump and Treat
-Install hydraulic injection system in nemo
Monitor effectiveness in selected wells
-Source removal
-Institutional controls on groundwater usage
-Other?

4.2 Alternative Technologies Identification and Preliminary Screening

4.2.1 No Action/ Natural Attenuation

4.2.2 *In Situ* Bioremediation
--Screen out - bioremediation at surface (unless soil source is found), etc.

4.2.3 Pump and Treat:
-Activated Carbon Treatment, Sprinkler Irrigation, Air Stripping,
-Nutrient Addition/Re-injection, Fixed Film Bioreactor, UV Oxidation,
-Other?
--Identify benefits of pump and treat, limitations (tight formation, aquifer flow issues)

4.2.4 Air Sparging
--Identify air sparging benefits, limitations (PEL analysis, vapor fate),

4.2.5 Institutional Control

4.2.6 Hydraulic Containment (in combination with other technologies)
--Flush out limitations on hydraulic containment (pore water turnover, pumping limitations, water permeability)

4.2.7 *Other?*

4.3 Removal Action Alternatives Analysis

4.3.1 Evaluation Criteria

4.3.2 Removal Action Technology Evaluation Summary
(Remedial Alternatives Decision Criteria Matrix **TABLE 2)**
--Alternatives 1-6/7
--Effectiveness
--Implementability
--Cost

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5.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES
5.1 Summary & Comparison of Removal Action Alternatives **TABLE 3**
No Action/ Natural Attenuation, *In Situ* Bioremediation, Pump and Treat, Air Sparging, Institutional Control, Other?

6.0 RECOMMENDED REMOVAL ACTION ALTERNATIVES
6.1 Nemo Groundwater Remediation and Potential Exposure Mitigation

7.0 REFERENCES

TABLES 1) EDB Concentrations in Groundwater,
2) Remedial Alternatives Decision Criteria Matrix
- Alternatives 1-6/7, Effectiveness, Implementability, Cost
3) Summary of Removal Action Alternatives

FIGURES 1) Area Map, 2) Site Map,
3) Piezometric Surface Map, 4) EDB Plume Map

APPENDICES 1) List of ARARs, 2) Chemical Data Base, 3) Costs

Millennium Science and Engineering is looking foreword to advancing this project in the direction provided by this document. We desire mutual involvement and agreement on the course of action we have outlined. One issue that we would like to emphasize at this time is the need to conduct tree clearing and the final geophysical source investigation activities as soon as possible. During the performance of those activities, we also propose to perform a preliminary sparge pressure/flow test, which can be completed with relatively little effort and may prove to be of significant value in the future.

A meeting has been tentatively scheduled for December 17, 2001. The primary intent of the meeting is to assure a mutual understanding of aspects of the project for which there may be uncertainty. It will also provide a means of expressing ideas, options, requests and concerns associated with development of the EE/CA.

We appreciate the opportunity to be of assistance to the USFS in this matter and look forward to the process of bringing about a resolution to this most important project. If you should have any questions or comments you may contact me at (801) 461-0888.

Best Regards,

Mark S. Lilly

Mark S. Lilly, P.G.
Project Manager

Cc: Richard Kelsey, P.E.
Technical Director

John K. Mackey, P.E.
Office Manager

Attachments: List of References
Preliminary Risk Evaluation

USFS Nemo EECA Tech Memo 10-16.doc

Attachment 1

USFS Nemo Work Center, Nemo, South Dakota

References to key documentation, letter correspondence and reports provided to the Forest Service previously are provided below:

EnviroSearch, 1996, Letter Correspondence: Groundwater Contamination Associated with the Nemo Work Station, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (October 18, 1996).

EnviroSearch, 1996, Letter Correspondence: Work Plan for Contamination Survey / Hydrogeologic Characterization, Work Order No 3, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (October 29, 1996).

EnviroSearch, 1997, Letter Correspondence: Project Status, November Billing, Geophysical Exploration and Monitoring Well Installation Schedule, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (January 3, 1997).

EnviroSearch, 1997a, Draft Alternative Water Supply Analysis, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (January 23, 1997).

EnviroSearch 1997b, Draft Pesticide Source Investigation, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (March 5, 1997).

EnviroSearch, 1997, Letter Report: Nemo WS, Nemo SD, Preliminary Subsurface Investigation Results, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (April 8, 1997).

EnviroSearch, 1997, Letter Correspondence: Work Order to Perform Aquifer Testing at the Nemo Work Center, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (May 6, 1997).

EnviroSearch, 1997c, Contaminant Survey and Site Characterization Report, Volumes 1, 2, & 3, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (September 3, 1997).

EnviroSearch, 1997d, Letter Report: Groundwater Sampling Results-November 1997, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (December 5, 1997).

EnviroSearch, 1997, Letter Correspondence: Attachment 1-Preliminary Remedial Alternatives Assessment, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (December 5, 1997).

EnviroSearch, 1998, Letter Correspondence: Cost Estimation for Preliminary Remedial Alternatives, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (February 26, 1998).

EnviroSearch, 1998, Letter Correspondence: Preliminary Cost Estimation for Characterization and Remedial Scoping, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (March 20, 1998).

EnviroSearch, 1998, Nemo Domestic Water Supply Systems Construction Report-*Conducted November1997*, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (April 9, 1998).

EnviroSearch, 1998, Proposed Work Order #6 for Additional Remedial Investigation, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (April 17, 1998).

EnviroSearch, 1998, Letter Correspondence: Cost Summary for Preliminary Remedial Alternatives, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (May 20, 1998).

EnviroSearch, 1998, Letter Correspondence: Response to South Dakota DENR Comments for the USFS Nemo Work Center, Nemo, South Dakota, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (July 3, 1998).

EnviroSearch, 1998, April-May 1998 *Quarterly* Groundwater Monitoring & Supplementary Site Characterization Report, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (July 3, 1998).

EnviroSearch, 1998, Groundwater Sampling Results-July 1998, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (August 21,1998).

EnviroSearch, 1998, Groundwater Sampling Results-October 1998, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (November 16, 1998).

EnviroSearch, 1999, April 1999 *Annual* Groundwater Monitoring Report, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (June 30, 1999).

EnviroSearch, 1999, Letter Correspondence: Preliminary Remedial Alternatives assessment, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (May 24, 1999).

EnviroSearch, 1999, Letter Correspondence: EDB Remedial Pilot Testing, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (July 19, 1999).

MSE-EnviroSearch, 1999, September 1999 *Semiannual* Groundwater Monitoring Report, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (December 3, 1999).

MSE, 2000, Letter Correspondence: EDB Remedial Pilot Testing, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (May 4, 2000).

MSE, 2000, April 2000 Groundwater Monitoring Report and EDB Remedial Pilot Test, USDA Forest Service, Nemo Work Center, Nemo, South Dakota, (December 12, 2000).

MSE, 2000, October 2000 Groundwater Monitoring Report, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (December 14, 2000).

MSE, 2001, April 2001 Groundwater Monitoring Report, USDA Forest Service, Nemo Work Center, Nemo, South Dakota (August 30, 2001).

ATTACHMENT 2

PRELIMINARY BASELINE HUMAN HEALTH RISK EVALUATION FOR THE USFS NEMO WORK CENTER NEMO, SOUTH DAKOTA

November 16, 2001

Introduction

This attachment presents a preliminary baseline human health risk evaluation for exposure to groundwater containing EDB at the USFS Nemo Work Center in Nemo, South Dakota. Potential human health risks are evaluated for EDB in groundwater for exposure routes under a residential land use scenario. This risk evaluation uses available groundwater data acquired to date and estimates the risk to human health using the procedures outlined in the following guidance:

- Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual, (Part A), Interim Final (RAGS) (EPA, 1989);
- Exposures Factors Handbook (volumes I, II & III) (EPA 1997);
- Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final (EPA, 1991); and
- Supplemental Guidance to RAGS: Calculating the Concentration Term. (EPA, 1992).

The following sections describe the data used in the risk evaluation, the data reduction and data evaluation methods, potential receptors and exposure pathways and the methods used for quantifying exposure, the toxicological benchmarks for EDB, and the potential for excess risk at the site.

Data Collection and Evaluation

This section describes the data that are used in this risk evaluation. As part of MSE's characterization activities, groundwater samples were collected from 40 locations adjacent to the Nemo Work Center. The last sampling event was completed in October 2001. A summary of the sample locations, the number of groundwater samples collected, the detection frequency, and the minimum and maximum EDB concentrations used in this risk evaluation are provided below in Table 1.

Table 1
Summary of EDB Concentrations in Groundwater (ug/L)

Sample Location	# of Samples	Detection Frequency	Min	Max
Adams	5	5/5	0.73	1.2
Boxelder Creek	5	0/5	0.02	0.02
Cooper	10	1/10	0.005	0.022
Deverman #1	11	0/11	0.01	0.02
Deverman #2	4	0/4	0.01	0.02
Flak	7	0/7	0.02	0.02
Flak Seep	1	1/1	0.069	0.069
Krahn	5	5/5	0.033	0.17
Langley	11	0/11	0.01	0.02
Martin Dan	1	0/1	0.02	0.02
Martin. R	1	0/1	0.01	0.01
MW-1	10	10/10	0.13	37
MW-2	4	0/4	0.02	0.02
MW-3	9	6/9	0.01	8.6
MW-4	7	7/7	0.18	2.3
MW-5	5	1/5	0.01	0.021
MW-6	2	0/2	0.02	0.02
MW-7	4	0/4	0.02	0.02
MW-9	1	0/1	0.02	0.02
MW-10	12	12/12	4	150
MW-11	12	1/12	0.01	0.057
MW-12	12	3/12	0.01	0.55
MW-16	4	0/4	0.02	0.02
MW-17	5	5/5	0.035	0.26
MW-18	2	0/2	0.02	0.02
MW-19	5	5/5	14	17
MW-20	8	8/8	51	160
N4T	4	4/4	0.064	0.53
Nemo Church	14	14/14	0.072	1.55
Original Kaberna	15	15/15	0.47	17
Original Weston	12	12/12	0.023	2.2
Post Office/Fire Dept.	4	4/4	0.023	0.11
Rech	2	0/2	0.02	0.02
RW-13 (Weston Supply) was MW-13	13	0/13	0.02	0.02
RW-15 (Kaberna Supply)	11	0/11	0.02	0.02
RW-8 (Nemo Supply) was MW-8	12	0/12	0.02	0.02
School	5	5/5	0.75	1.12
Spleiss	4	4/4	0.47	3.6
Troxell	11	11/11	0.27	11
Wick/GR	3	0/3	0.02	0.02

For screening purposes, if the analytical results from a particular well were all below laboratory detection limits, the well was dropped from further consideration. However, it should be noted that at the detection limit for EDB (0.01 to 0.02 ug/L), excess human health risk is present (see Section 6). Sampling locations with one or more detections of EDB are summarized in Table 2.

Table 2
Sampling Locations with Detectable EDB

Sample Location	# of Samples	Detection Frequency	Min	Max
Adams	5	5/5	0.73	1.2
Cooper	10	1/10	0.005	0.022
Flak Seep	1	1/1	0.069	0.069
Krahn	5	5/5	0.033	0.17
MW-1	10	10/10	0.13	37
MW-3	9	6/9	0.01	8.6
MW-4	7	7/7	0.18	2.3
MW-5	5	1/5	0.01	0.021
MW-10	12	12/12	4	150
MW-11	12	1/12	0.01	0.057
MW-12	12	3/12	0.01	0.55
MW-17	5	5/5	0.035	0.26
MW-19	5	5/5	14	17
MW-20	8	8/8	51	160
N4T	4	4/4	0.064	0.53
Nemo Church	14	14/14	0.072	1.55
Original Kaberna	15	15/15	0.47	17
Original Weston	12	12/12	0.023	2.2
Post Office/Fire Dept.	4	4/4	0.023	0.11
School	5	5/5	0.75	1.12
Spleiss	4	4/4	0.47	3.6
Troxell	11	11/11	0.27	11

Exposure Assessment

This exposure assessment identifies the receptors that could possibly come in contact with EDB in groundwater at the site, and discusses the assumptions used to calculate the amount of EDB contact to the receptor.

An exposure pathway describes a specific environmental pathway by which a receptor can be exposed to chemicals of concern. To have a complete exposure pathway, the following are typically present:

- A chemical source;
- A method of transport to the medium where contact occurs;

- A point of contact between the contaminated medium and the receptor;
- An exposure route such as ingestion, inhalation, or dermal contact.

Potential receptors at the site include individuals who could come in contact with EDB in groundwater. It is assumed that the complete exposure pathway to groundwater involves a well and that exposure to groundwater via seeps ands springs is not a complete pathway. For preliminary risk evaluation purposes, the most conservative scenario is assumed where all wells are drinking water supply wells in a residential land use. Therefore, the potential receptors evaluated in this baseline risk evaluation include adults in a residential land use scenario. The primary exposure routes in this scenario are: ingestion, dermal contact, and inhalation[1] of EDB in groundwater.

In accordance with EPA guidance, the risk evaluation was conducted using a concentration term "C" for EDB in groundwater. The concentration term "C" was calculated as described in "Supplemental Guidance to RAGS: Calculating the Concentration Term" (EPA, 1992b) on a per well basis. This guidance indicates that, because of the uncertainties associated with estimating the true average concentration, the concentration term should be calculated as the 95% upper confidence limit (UCL) of the arithmetic mean (EPA, 1992b). However, when limited data are available, or there is high variability in the data, the 95% UCL may be greater than the maximum detected value. In this case the true mean may be higher than the maximum value. Therefore, in accordance with EPA guidance for calculating the concentration term (EPA, 1992b), if the 95% UCL exceeds the maximum detected value, the maximum detected value is used as the concentration term. When assessing the concentration term for EDB in groundwater with analytical results at or below the detection limit, a value of one-half the EQL was used.

Prior to calculating the 95% UCL, the sample population distribution was tested using the Shapiro-Wilk test (the W test). For normal distributions, the 95% UCL was calculated using the t-statistic. If the data were lognormally distributed, the 95% UCL was calculated using the H-statistic. The concentration terms for EDB in each well are summarized in Table 3.

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[1] EDB is considered a volatile organic compounds (VOC) by EPA because it has a Henry's Law constant greater than 10-5 atm-m3/mol and its molecular weight is less than 200 g/mole (EDB has a Henry's Law constant 3.2 x 10-4 atm-m3/mol and a molecular weight of 190 g/mole (EPA, 2001)).

Table 3
Concentration Term "C" for EDB in Groundwater

Sample Location	MIN	MAX	Distribution	95% UCL	Conc. Term "C" (ug/L)
Adams	0.73	1.20	Lognormal	1.20	1.20
Cooper	0.01	0.02	neither	0.02	0.02
Flak Seep	0.07	0.07	neither	0.07	0.07
Krahn	0.03	0.17	Lognormal	0.33	0.17
MW-1	0.13	37.00	Normal	22.29	22.29
MW-3	0.01	8.60	neither	8.60	8.60
MW-4	0.18	2.30	Lognormal	3.58	2.30
MW-5	0.01	0.02	neither	0.02	0.02
MW-10	4.00	150.00	Lognormal	87.36	87.36
MW-11	0.01	0.06	neither	0.06	0.06
MW-12	0.01	0.55	neither	0.55	0.55
MW-17	0.04	0.26	Lognormal	0.81	0.26
MW-19	14.00	17.00	Lognormal	16.80	16.80
MW-20	51.00	160.00	Lognormal	129.93	129.93
N4T	0.06	0.53	Normal	0.56	0.53
Nemo Church	0.07	1.55	neither	1.55	1.55
Original Kaberna	0.47	17.00	Normal	10.67	10.67
Original Weston	0.02	2.20	Lognormal	4.62	2.20
Post Office/Fire Dept.	0.02	0.11	Lognormal	0.35	0.11
School	0.75	1.12	neither	1.12	1.12
Spleiss	0.47	3.60	neither	3.60	3.60
Troxell	0.27	11.00	Lognormal	10.69	10.69

The reasonable maximum exposure (RME) is the highest exposure that is reasonably expected to occur. RME values were calculated using the concentration term "C", and EPA default exposure factors (a combination of upper-bound and mid-range exposure factors). Chemical-specific exposure for each complete exposure pathway identified are presented in terms of the mass of chemical in contact with the body per unit body weight per unit time (expressed as mg chemical per kg body weight per day or mg/kg-day). These exposure estimates or "intakes" were calculated using the standard intake equations listed below (EPA, 1989).

Groundwater Ingestion:

Chronic Daily Intake (CDI) (mg/kg-day)= CW x IR-W x EF x ED x 1/BW x 1/AT

where

CW	Chemical Concentration in Water	well specific	mg/L
IR-W	Ingestion Rate of Water	2	L/day
EF	Exposure Frequency	350	days/year
ED	Exposure Duration	30	years
BW	Body Weight	70	kg
AT-C	Averaging Time (Cancer)	25,550	days

Dermal Absorption:

CDI (mg/kg-day)= CW x SA x KP x ET x EF x ED x CF x 1/BW x 1/AT

where

CW	Chemical Concentration in Water	well specific	mg/L
EF	Exposure Frequency	350	days/year
ED	Exposure Duration	30	years
BW	Body Weight	70	kg
AT-C	Averaging Time (Cancer)	25,550	days
KP	Permeability Constant	0.00001	m/hr
ET	Exposure Time	2.6	hr/day
CF	Conversion Factor	0.001	L/cm3
SA	Skin Surface Area Available for Contact	23,000	cm2

Inhalation:

CDI (mg/kg-day)= CW x VF x IRa x EF x ED x 1/BW x 1/AT

where

CW	Chemical Concentration in Water	well specific	mg/L
EF	Exposure Frequency	350	days/year
ED	Exposure Duration	30	years
BW	Body Weight	70	kg
AT-C	Averaging Time (Cancer)	25,550	days
IR	Inhalation Rate	15	m3/day
VF	Volitization Factor	5.0E-01	L/m3

The exposure estimates or "intakes" were calculated on a per well basis and are summarized in Table 4 for the primary exposure routes identified.

Table 4
RME Intake Results (mg/kg-day)

Sample Location	Conc. Term "C" (ug/L)	Ingestion	Dermal	Inhalation
Adams	1.20	1.4E-05	4.2E-09	5.3E-05
Cooper	0.02	2.6E-07	7.7E-11	9.7E-07
Flak Seep	0.07	8.1E-07	2.4E-10	3.0E-06
Krahn	0.17	2.0E-06	6.0E-10	7.5E-06
MW-1	22.29	2.6E-04	7.8E-08	9.8E-04
MW-3	8.60	1.0E-04	3.0E-08	3.8E-04
MW-4	2.30	2.7E-05	8.1E-09	1.0E-04
MW-5	0.02	2.5E-07	7.4E-11	9.2E-07
MW-10	87.36	1.0E-03	3.1E-07	3.8E-03
MW-11	0.06	6.7E-07	2.0E-10	2.5E-06
MW-12	0.55	6.5E-06	1.9E-09	2.4E-05
MW-17	0.26	3.1E-06	9.1E-10	1.1E-05
MW-19	16.80	2.0E-04	5.9E-08	7.4E-04
MW-20	129.93	1.5E-03	4.6E-07	5.7E-03
N4T	0.53	6.2E-06	1.9E-09	2.3E-05
Nemo Church	1.55	1.8E-05	5.4E-09	6.8E-05
Original Kaberna	10.67	1.3E-04	3.7E-08	4.7E-04
Original Weston	2.20	2.6E-05	7.7E-09	9.7E-05
Post Office/Fire Dept.	0.11	1.3E-06	3.9E-10	4.8E-06
School	1.12	1.3E-05	3.9E-09	4.9E-05
Spleiss	3.60	4.2E-05	1.3E-08	1.6E-04
Troxell	10.69	1.3E-04	3.8E-08	4.7E-04

Toxicity Assessment

This section of the baseline risk evaluation provides information on the human health effects of EDB in groundwater. The information presented in this section provides a basis for the dose-response assessment (risk characterization) presented below.

The risks associated with exposure to EDB in groundwater are a function of the toxicity (hazard) of EDB and the exposure dose. Toxicity values were obtained from IRIS. A copy of the most recent toxicity profile from IRIS is attached.

IRIS does not list non-carcinogenic (reference dose - RfD) toxicity values for EDB, while HEAST provides a non-carcinogenic inhalation RfD. This preliminary baseline risk evaluation does not characterize the non-carcinogenic risk due to exposure to EDB; however, it is assumed that the carcinogenic risk will drive the remedy.

The human health risk associated with EDB as a carcinogen is estimated in the risk evaluation. For carcinogens, risks are estimated as the probability of an individual developing cancer over their lifetime as a result of exposure to a carcinogen. Carcinogenic human health risk is expressed as a probability; for example $1x10^{6}$, means one-in-one million chance that an individual will develop an adverse effect.

Studies of carcinogenicity typically to focus on identifying the slope of the linear portion of a curve of dose versus response. The upper-bound value of the slope is called the cancer slope factor (SF). The product of the SF and the exposure dose is an estimate of the risk of developing cancer. In accordance with current scientific policy concerning carcinogens, it is assumed that any dose, no matter how small, has some associated response. This is called a non-threshold effect. In this assessment, the non-threshold effect was applied to all possible, probable, and known human carcinogens.

Identification of chemicals as known, probable, or possible human carcinogens is based on a U.S. EPA weight-of-evidence classification scheme in which chemicals are systematically evaluated for their ability to cause cancer in mammalian species and conclusions are reached about the potential to cause cancer in humans. The U.S. EPA classification (EPA, 1989) contains six classes based on the weight of available evidence, as follows:

- A Known human carcinogen;
- B1 Probable human carcinogen - limited evidence in humans;
- B2 Probable human carcinogen -sufficient evidence in animals and inadequate data in humans;
- C Possible human carcinogen - limited evidence in animals;
- D Inadequate evidence to classify; and
- E Evidence of non-carcinogenicity.

Some chemicals in Class D may have the potential to cause cancer, but adequate data are not currently available to change the classification. In this risk evaluation, evaluations of the likelihood of a carcinogenic effect include chemicals in Classes A, B1, B2, and C. EPA does not assign cancer slope factors to chemicals in Classes D and E (U.S. EPA, 1989). Cancer toxicity data for EDB are listed in Table 5.

Table 5
Cancer Toxicity Data for EDB

Oral Cancer Slope Factor (mg/kg-d)-1	Inhalation Slope Factor (mg/kg-d)-1	Weight of Evidence
8.5E+01	7.7E-01	B2

Risk Characterization

This section characterizes the risks to human health associated with exposure to EDB in groundwater at the site based on the exposure and toxicity assessments. This section begins with a discussion of the methodology, followed by an evaluation of risk for each pathway identified in the exposure assessment.

For carcinogens, risk estimates represent the incremental probability that an individual will develop cancer over a lifetime as a result of exposure to a particular carcinogen or a set of carcinogens (U.S. EPA, 1989). These risks are termed increased lifetime cancer risks and are calculated using the following equation:

Increased Lifetime Cancer Risk = Intake x CSF

where:

Intake = Lifetime Daily Intake (mg/kg-day)
CSF = Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$

A carcinogenic risk is expressed as a probability, such as one additional cancer in an exposed population of one million (which is also expressed as 1×10^{-6}). The lifetime daily intake is the exposure dose averaged over a 70-year lifetime. This is consistent with the concept that there are no threshold doses for carcinogens.

Most regulations require that a site management plan be developed that includes corrective action if the potential cancer risk exceeds one in ten thousand (1×10^{-4}) under current or likely future land use. Cancer risks less than 1×10^{-4} but greater than 1×10^{-6} typically require a site management plan, but closure recommendations can be limited to appropriate management activities. Cancer risks less than 1×10^{-6} are considered de minimis risks.

Table 6 lists the cancer risks for ingestion, dermal absorption, and inhalation of EDB in groundwater by an adult resident. Note that the sampling locations are sorted from highest to lowest cancer risk.

As mentioned under the Data Evaluation section above, excess human health risk is present at the current detection limit for EDB (0.02 ug/L). The groundwater ingestion cancer risk at this detection limit is 2×10^{-5}.

Table 6
Calculation of Cancer Risks

Sample Location	Conc. Term "C" (ug/L)	Cancer Risk			Total Risk
		Ingestion	Dermal	Inhalation	
MW-20	129.93	1.3E-01	3.9E-05	4.4E-03	1.3E-01
MW-10	87.36	8.7E-02	2.6E-05	3.0E-03	9.0E-02
MW-1	22.29	2.2E-02	6.7E-06	7.6E-04	2.3E-02
MW-19	16.80	1.7E-02	5.0E-06	5.7E-04	1.7E-02
Troxell	10.69	1.1E-02	3.2E-06	3.6E-04	1.1E-02
Original Kaberna	10.67	1.1E-02	3.2E-06	3.6E-04	1.1E-02
MW-3	8.60	8.6E-03	2.6E-06	2.9E-04	8.9E-03
Spleiss	3.60	3.6E-03	1.1E-06	1.2E-04	3.7E-03
MW-4	2.30	2.3E-03	6.9E-07	7.8E-05	2.4E-03
Original Weston	2.20	2.2E-03	6.6E-07	7.5E-05	2.3E-03
Nemo Church	1.55	1.5E-03	4.6E-07	5.3E-05	1.6E-03
Adams	1.20	1.2E-03	3.6E-07	4.1E-05	1.2E-03
School	1.12	1.1E-03	3.3E-07	3.8E-05	1.2E-03
MW-12	0.55	5.5E-04	1.6E-07	1.9E-05	5.7E-04
N4T	0.53	5.3E-04	1.6E-07	1.8E-05	5.5E-04
MW-17	0.26	2.6E-04	7.8E-08	8.8E-06	2.7E-04
Krahn	0.17	1.7E-04	5.1E-08	5.8E-06	1.8E-04
Post Office/Fire Dept.	0.11	1.1E-04	3.3E-08	3.7E-06	1.1E-04
Flak Seep	0.07	6.9E-05	2.1E-08	2.3E-06	7.1E-05
MW-11	0.06	5.7E-05	1.7E-08	1.9E-06	5.9E-05
Cooper	0.02	2.2E-05	6.6E-09	7.5E-07	2.3E-05
MW-5	0.02	2.1E-05	6.3E-09	7.1E-07	2.2E-05
Laboratory Detection Limit	0.02	2.0E-05	6.0E-09	6.8E-07	2.1E-05

Conclusions

This preliminary baseline human health risk evaluation indicates that excess human health risk is present due to exposure to EDB in groundwater. However, this preliminary evaluation assumes that all wells are supply wells in a residential scenario.

Residents are currently provided with a culinary water supply from wells (RW-8, -13 & -15) installed outside the EDB plume. Other residences (Cooper, Deverman #1, Flak, Langley, Martin Dan, Martin. R, Rech, and Wick/GR) rely on their existing wells, but are located outside the detectable EDB plume. Groundwater samples collected from all current supply wells are below the laboratory detection limits for EDB, except Cooper where 0.022 ug/L of EDB was detected in 1998.

References

U.S. Environmental Protection Agency, 1989. Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual, (Part A), Interim Final. EPA/540/1-89/002, December 1989.

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U.S. Environmental Protection Agency, 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publication 9285.7-081, May 1992.

U.S. Environmental Protection Agency, 1997. Exposure Factors Handbook, (Volumes I, II & III). Update to Exposure Factors Handbook EPA/600/8-89/043 - May 1989. Office of Research and Development National Center for Environmental Assessment. 20460EPA/600/P-95/002Fa. August 1997

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1,2-Dibromoethane CASRN 106-93-4 (07/01/1997)

MAIN CONTENTS

Reference Dose for Chronic Oral Exposure (RfD)

0361

1,2-Dibromoethane; CASRN 106-93-4 (07/01/1997)

Health assessment information on a chemical substance is included in IRIS only after a comprehensive review of chronic toxicity data by U.S. EPA health scientists from several Program Offices and the Office of Research and Development. The summaries presented in Sections I and II represent a consensus reached in the review process. Background information and explanations of the methods used to derive the values given in IRIS are provided in the Background Documents.

STATUS OF DATA FOR 1,2-Dibromoethane

File First On-Line 09/07/1988

Category (section)	**Status**	**Last Revised**
Oral RfD Assessment (I.A.)	no data	
Inhalation RfC Assessment (I.B.)	no data	12/01/1992
Carcinogenicity Assessment (II.)	on-line	07/01/1997

_I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

_I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name -- 1,2-Dibromoethane
CASRN -- 106-93-4
Primary Synonym -- Ethylene dibromide

Not available at this time.

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_I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name -- 1,2-Dibromoethane
CASRN -- 106-93-4
Primary Synonym -- Ethylene dibromide

Not available at this time.

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_II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name -- 1,2-Dibromoethane
CASRN -- 106-93-4
Primary Synonym -- Ethylene dibromide
Last Revised -- 07/01/1997

_II.A. Evidence for Human Carcinogenicity

__II.A.1. Weight-of-Evidence Characterization

Classification -- B2; probable human carcinogen.

Basis -- Increased incidences of a variety of tumors in rats and mice in both sexes by three routes of administration at both the site of application and at distant sites. EDB is mutagenic in various in vitro and in vivo assays. EDB is structurally similar to DBCP, a probable human carcinogen and to EDC, a probable human carcinogen.

__II.A.2. Human Carcinogenicity Data

Inadequate. Mortality studies of workers occupationally exposed to EDB (Ott et al., 1980) found neither total deaths nor total malignancies of individuals exposed to EDB exceeded the control rate. The studies are inconclusive due to their small cohort size; lack of, or poorly characterized, exposure concentrations; and/or concurrent exposure to other potential or known carcinogens.

__II.A.3. Animal Carcinogenicity Data

Sufficient. EDB has been tested for carcinogenicity by gavage, inhalation, and dermal administration.

The NCI (1978) administered TWA doses of 27 and 29 mg EDB/kg bw/day to male and 26 and 28 mg EDB/kg bw/day to female rats by gavage for 49 and 61 weeks for the low- and high-dose groups, respectively. High treatment-related mortality prompted the early termination of the study (planned for 110 weeks) and alterations of the dosing regimen, resulting in similar TWA dosages for high- and low-treatment groups. Significant increased incidences of squamous cell carcinomas of the stomach (both sexes), hepatocellular carcinomas and neoplastic nodules of the liver (females), and hemangiosarcomas of the circulatory system (males) were observed upon histologic examination. The stomach tumors developed after a short latency period and were observed to metastasize to multiple sites. Male and female B6C3F1 mice received TWA doses of 44 or 77 mg EDB/kg bw/day by gavage for 53 weeks and were observed for their lifetimes (NCI, 1978). The incidence of squamous cell carcinomas and alveolar/bronchiolar adenomas of the lung was significantly increased over the controls in all the mice. As in the rat bioassay, no tumors were observed in the controls, and high treatment-related mortality prompted dosing regimen alterations.

Fischer 344 rats and B6C3F1 mice of both sexes were exposed to EDB vapors at 0, 10, or 40 ppm, 6 hours/day, 5 days/week for their lifespans (NTP, 1982). The incidence of nasal cavity carcinomas and adenocarcinomas in the rats of both sexes and alveolar/bronchiolar carcinomas in female rats and mice of both sexes was significantly increased over the controls. The chronic inhalation of EDB was also associated with circulatory system hemangiosarcomas in both sexes of rats (high-dose only), mammary gland fibroadenomas of female rats, mammary gland adenocarcinomas of female mice, subcutaneous fibrosarcomas of female mice, and tunica vaginalis mesotheliomas of male rats. Stinson et al. (1981), in a chronic inhalation study of experimental design indentical to the NTP study (with B6C3F1 mice only), reported an elevated incidence of nasal cavity carcinomas in the female mice exposed to 40 ppm EDB. Both sexes had dose-related epithelial hyperplastic lesions of the nasal cavity. Histologic and pathologic exams were conducted only on the nasal cavity.

Wong et al. (1982) exposed Sprague-Dawley rats of both sexes by inhalation to 0 or 20 ppm EDB, 7 hours/day, 5 days/week for 18 months. Splenic hemangiosarcomas and adrenal gland tumors of both sexes, subcutaneous mesenchymal tumors in males, and mammary gland tumors in females were significantly increased over the controls. Histologic examination excluded the nasal cavity.

Lifetime dermal application of EDB to female He:ICR Swiss mice caused both skin papillomas at 50 mg and lung papillomas at 25 and 50 mg, a significant increase by comparison to the controls (van Duuren et al., 1979). A single dermal application of EDB followed by thrice weekly treatment with phorbol myristate acetate (PMA) did not result in an increased papilloma incidence.

__II.A.4. Supporting Data for Carcinogenicity

EDB has been studied for mutagenic potential by a variety of in vitro and in vivo test systems. Reverse and forward mutations have been consistently produced in bacterial assays and in in vitro assays using eukaryotic cells. EDB caused an increase in unscheduled DNA synthesis in cultured mammalian cells (Meneghini, 1974; Perocco and Prodi, 1981; Williams et al., 1982) and single-strand DNA breaks in in vitro cultured cells (Sina et al., 1983) and in in vivo rat liver cells (Nachtomi and Sarma, 1977). Direct evidence of interactions with DNA have been provided by the formation of nonextractable radiolabeled DNA following both in vivo and in vitro exposure to radiolabeled EDB.

EDB is structurally similar to 1,2-dibromo-3-chloropropane (DBCP), a probable human carcinogen and to ethylene dichloride (EDC) a probable human carcinogen.

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_II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

__II.B.1. Summary of Risk Estimates

Oral Slope Factor -- 8.5E+1 per (mg/kg)/day

Drinking Water Unit Risk -- 2.5E-3 per (ug/L)

Extrapolation Method -- Modified linearized multistage procedure, extra risk

Drinking Water Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	4E-2 ug/L
E-5 (1 in 100,000)	4E-3 ug/L
E-6 (1 in 1,000,000)	4E-4 ug/L

__II.B.2. Dose-Response Data (Carcinogenicity, Oral Exposure)

Tumor Type -- squamous cell carcinoma of the forestomach
Test animals -- rat/Osborne-Mendel, male
Route -- gavage
Reference -- NCI, 1978

Administered (ppm)	Tumor Incidence
0	0/20
27.4	45/50
29.1	33/50

__II.B.3. Additional Comments (Carcinogenicity, Oral Exposure)

The slope factor was calculated using a model (U.S. EPA, 1985; Thorslund, 1982) that permits consideration of variable partial lifetime exposure. It resembles a model that is multistage in dose and Weibull in time. Surface area corrections were made assuming a 500-g rat and a 70-kg human.

Conversions from gavage to oral/diet were made assuming that the relative potency of ingestion exposure compared to gavage exposure is the same for EDB and dibromochloropropane (DBCP). DBCP is chemically similar to EDB, has been assayed in both an ingestion and a gavage study in male rats and caused the same types of tumors as EDB when administered by gavage. All the human ingestion exposures of EDB are multiplied by 0.59 (relative potency factor for DBCP) when estimating risk based on models derived from EDB animal gavage data in order to correct for potential microexposure differences.

Since the rats were exposed only 5 days out of 7, human equivalent exposure is (mg EDB/day x 1/60-kg human) x 5/7.

The unit risk should not be used if the water concentration exceeds 4.0 ug/L, since above this concentration the unit risk may not be appropriate.

__II.B.4. Discussion of Confidence (Carcinogenicity, Oral Exposure)

The estimate of risk is based upon a study having early mortality which prompted an alteration of dose levels during the experiment, thereby producing essentially only one treatment group.

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_II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

__II.C.1. Summary of Risk Estimates

Inhalation Unit Risk -- 2.2E-4 per (ug/cu.m)

Extrapolation Method -- Linearized multistage procedure, extra risk

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	5E-1 ug/cu.m
E-5 (1 in 100,000)	5E-2 ug/cu.m
E-6 (1 in 1,000,000)	5E-3 ug/cu.m

__II.C.2. Dose-Response Data for Carcinogenicity, Inhalation Exposure

Tumor Type -- nasal cavity (includes adenoma, adenocarcinoma, papillary adenoma, squamous cell carcinoma, and or/papilloma)
Test animals -- rat/Fischer 344, male
Route -- inhalation
Reference -- NTP, 1982

——Dose——		
Administered (ppm)	Human Equivalent (mg/kg/day)	Tumor Incidence
0		0/50
10		39/50
40		41/50

__II.C.3. Additional Comments (Carcinogenicity, Inhalation Exposure)

The unit risk was calculated using a multistage model (Crump and Howe, 1984) that permits consideration of variable partial lifetime exposure. It resembles a model that is multistage for dose and Weibull for time. The model should be used to estimate risk whenever exposure or follow-up is for less than a full lifetime. Equivalent units of exposure for humans and rats in regard to carcinogenic response were assumed (ppm). Since rats were exposed for 6 hours/day, 5 days/week, continuous exposures were determined by multiplying by 5/7 x 6/24. It should be noted that a particularly sensitive subgroup of the general population exists that could be 20 or 30 times more sensitive than these results indicate; namely, alcoholics being treated with Antabuse, a compound demonstrated to increase the inhalation potency of EDB (Wong et al., 1982).

The unit risk should not be used if the air concentration exceeds 5E+1 ug/cu.m, since above this concentration the unit risk may not be appropriate.

__II.C.4. Discussion of Confidence (Carcinogenicity, Inhalation Exposure)

Adequate numbers of animals were observed for their lifetime.

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_II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

__II.D.1. EPA Documentation

Source Document -- U.S. EPA, 1985

The 1986 Drinking Water Criteria Document for Ethylene Dibromide (EDB) has received Agency review.

__II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review -- 04/22/1987, 05/13/1987

Verification Date -- 05/13/1987

__II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

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_III. [reserved]
_IV. [reserved]
_V. [reserved]

_VI. Bibliography

Substance Name -- 1,2-Dibromoethane
CASRN -- 106-93-4
Primary Synonym -- Ethylene dibromide
Last Revised -- 08/01/1991

_VI.A. Oral RfD References

None

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_VI.B. Inhalation RfC References

None

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_VI.C. Carcinogenicity Assessment References

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_VII. Revision History

Substance Name -- 1,2-Dibromoethane
CASRN -- 106-93-4
Primary Synonym -- Ethylene dibromide

Date	Section	Description
09/26/1988	II.	Carcinogen summary on-line
04/01/1989	II.C.	Units corrected
08/01/1989	VI.	Bibliography on-line
05/01/1990	I.B.	Inhalation RfD now under review
09/01/1990	II.	Text edited
09/01/1990	III.A.	Health Advisory added
09/01/1990	VI.D.	Health Advisory references added
01/01/1991	II.	Text edited
01/01/1991	II.C.1.	Inhalation slope factor removed (global change)
08/01/1991	VI.C.	Citations clarified
01/01/1992	IV.	Regulatory Action section on-line
12/01/1992	I.B.	Work group review date added
08/01/1995	I.B.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
07/01/1997	II.C.	Paragraph 1, multiplication factor corrected

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_VIII. Synonyms

106-93-4
dibromoethane
1,2-Dibromoethane
Dibromoethane, 1,2-
alpha,beta-dibromoethane
ethylene bromide
Ethylene dibromide
glycol dibromide
S-dibromoethane

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URL: http://www.epa.gov/iris/subst/0361.htm
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