EnviroSearch
INTERNATIONAL

December 5, 1997

Mr. Bill Schleining
On-Site Coordinator
USFS - Black Hills National Forest
RR 2 Box 200 Highway 385N
Custer, SD 57730-9501

Re: Preliminary Remedial Alternatives Assessment, Nemo Work Station South Dakota

Dear Mr. Schleining;

Please find enclosed Attachment 1, our preliminary assessment of remedial alternatives to be considered for the Nemo, South Dakota site.

If you have any questions concerning this report or the status of the project, please feel free to contact me at your convenience. We appreciate the opportunity to be of continued service to the USFS.

Sincerely,

Richard Kelsey, P.E.
Program Director

RK/dh
Enc.

cc: Byron Shark

C2824.doc

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Attachment 1

Preliminary Remedial Alternatives Assessment

Introduction

The purpose of this Preliminary Remedial Alternatives Assessment is to define the prevailing physical and chemical characteristics of EDB and the site which ultimately affect the feasibility of remediation of groundwater at Nemo, South Dakota. This assessment is not intended to be a formal risk assessment or feasibility study conducted under CERCLA guidelines, however it does address key conditions which need to be factored into managing future site decisions. The objectives of future site management may be to:

- protect public health;
- control further down-gradient migration of EDB on private and public lands;
- reduce EDB concentrations in groundwater; or
- reduce risks to public and private landowners and risks of potential legal exposure.

The specific objectives of further site management need to be established to further define site management goals and future site activities.

Contaminant Characteristics

Ethylene Dibromide (EDB) is a volatile organic compound (VOC) previously utilized by the United States Department of Agriculture Forest Service (USDA-FS) to fend off a bark beetle infestation in the Nemo area. The pesticide was applied as approximately one-half to two percent EDB and Lindane dissolved in a diesel and water mixture (EnviroSearch 1997). Key characteristics of this chemical are summarized in Table 1.

EDB's characteristics can be utilized to predict its environmental fate and transport and to assist in screening of remediation and treatment alternatives. Because its density is greater than water, EDB in pure form is a dense non-aqueous phase liquid (DNAPL). A DNAPL sinks in water and pools at bedrock if present in pure form. Density effects are minimized when a DNAPL is in a dissolved phase. The relatively high water solubility, historic use in a diluted form, and range of concentrations detected indicate that the EDB is more likely to be present in dissolved form. The moderate to high Henry's constant will allow the EDB to readily volatilize from the groundwater in contact with air. A relatively low K_{oc} coefficient indicates EDB will leach from impacted soil in contact with water. EDB is not likely to persist in unsaturated soils nor is it likely to adsorb to bedrock.

Table 1
Key Contaminant Characteristics

Characteristic	Value[1]
Density	2.172 g/cm^3
Melting Point	9.97°C
Boiling Point	131-132°C
Water Solubility	3.4E+03 mg/l
Vapor Pressure	11 mm Hg
Henry's Constant	3.18E-04 atm-m^3/mol
K_{oc}	28
K_{ow}	58
Aerobically Biodegradable	half life 1-2 months[2]
Highest Detected Concentration	18.5 μg/l (MW-12)[3]
EPA MCL	0.05 μg/l

1 Values, except where noted, are from EPA document 540/2-90/011 *Subsurface Contamination Reference Guide*.

2 From Spectrum Laboratories C1x10^{-2}hemical Fact Sheet - Case # 106934.

3 EnviroSearch. Contaminant Survey and Site Characterization Report, USDA Forest Service, Nemo Work Center, Nemo, South Dakota. September 3, 1997.

Site Background

Two EDB plumes have been identified in the vicinity of Nemo. The largest and highest in concentration (Plume A) follows a south-easterly orientation beginning approximately 400 feet up-gradient from MW-3 and terminating near the Flak well. The approximate dimensions are 5700 feet in length and 1200 feet in average width. Concentrations for Plume A range from 20 parts-per-trillion (ppt) to 18,500 ppt. The second and smaller plume (Plume B) begins at a distance 600 feet south-west of the Troxell well and then curves and terminates at a distance 400 feet south of MW-11. Approximate dimensions of Plume B are 3600 feet in total length and 600 feet in average width. Concentrations for Plume B range from 20 ppt to 8,400 ppt. No source for either EDB plume has been located; although, EDB was reportedly disposed of in the vicinity of the Nemo Work Center.

The primary mechanisms which control groundwater movement in the Nemo area include preferential flow paths created by structural and lithologic geologic conditions, groundwater recharge from precipitation on higher slopes surrounding the site and from Boxelder Creek, and groundwater discharge at lower elevations where structural features converge and intersect Boxelder Creek. The primary water bearing zones and groundwater transmission zones in the vicinity of Nemo are located within structurally and lithologically controlled geologic features including: 1) a northwest-southeast trending strike-slip fault west and south of Nemo; 2) a northwest-southeast trending lithologic contact in Nemo and east of the bedrock ridge; and 3) east-west trending normal faults north and through the town site. Most of the groundwater in the Nemo area is under semi-confined conditions created by recharge from the surrounding elevated bedrock. The rate of groundwater movement is estimated at 0.5 to 1.0 feet/day (EnviroSearch 1997).

Plume B is situated in an aquifer beneath the community of Nemo with uncontaminated wells (Deverman, Cooper, and Langley wells) located around the plume. Plume A is located beneath a relatively unpopulated area. To prevent migration of EDB to the aquifer around Plume B, consideration must be given while screening remedial alternatives. Unless controlled, both EDB plumes are expected to continue a migratory path in a south and south-east direction following preferential flow paths associated with regional geologic features.

According to EPA representative Bob Benson, at the October 1996 meeting, the site presents a high risk to public health (greater than $1x10^{-2}$) due to standard risk assessment factors including the usage of the shallow aquifer as a primary drinking water supply, the EDB concentrations present in groundwater, and the low Maximum Contaminant Levels and Risk Based Cleanup levels. A risk of $1x10^{-2}$ means that if one-hundred people were exposed (including ingestion and dermal contact) over a lifetime to the contaminated groundwater, one out of the one-hundred people would be expected to develop cancer. However, practical limitations exist with respect to remedial options that can be applied at the site. These limitations include defining the actual source location, the presence of water supply wells surrounding the plume, freezing conditions in winter months, and the characteristics of the bedrock aquifer. The primary remedial options that have been examined for this site include no action/natural attenuation, groundwater pumping and treatment, air sparging, and *in situ* bioremediation. Vapor extraction has not been evaluated as an appropriate technology at this site since it is primarily applicable with remediation of unsaturated soils. The source of the EDB in groundwater has not been identified thus unsaturated contaminated soils and source removal are not considered in this analysis. For purposes of this analysis, the source is assumed to be associated with dumping of unused pesticide mixtures in areas of thin soils above bedrock (i.e., no buried drums and ongoing leakage of concentrated EDB).

Description of Remedial Alternatives

A general description of the evaluated remedial alternatives follows in the text below with a qualitative examination of the technical effectiveness, implementability, and relative cost presented in Table 2.

<u>Alternative 1: No Action/Natural Attenuation</u>
The no action alternative involves leaving contaminated groundwater in place without corrective action. Degradation of EDB in the groundwater would occur from the natural processes of hydrolysis and/or biodegradation. Both processes are very slow without engineered controls. Periodic groundwater monitoring would be necessary. Further

migration of the impacted plume would be likely; additional monitoring wells may be necessary to monitor this process.

Alternative 2: Pump and Treat

This alternative involves pumping contaminated groundwater from selected impacted wells and/or additional recovery wells, treatment by an appropriate method, and disposal of the treated water by re-injection at selected points or discharge to surface waters. By pumping from wells installed at the down-gradient boundary of the plume the EDB plume can be intercepted and the down-gradient migration of EDB can be prevented. Another positive aspect of this alternative is that if and when the region around the pumping wells is cleaned, new wells can be utilized or installed and pumped from further up-gradient, effectively pushing the front of the plume up-gradient. Re-injection speeds up the process of flushing the contaminated water from the aquifer and provides a consistent source of recharge. Discharge of the treated water to surface water would require an NPDES permit. The re-injection of extracted groundwater can cause disruption of the aquifer and induce EDB migration; a desirable trait if controlled. To minimize migratory effects, it is recommended that the groundwater extracted from the aquifer below the community of Nemo not be re-injected in that area. Instead the water can be injected at Plume A or other acceptable location and Boxelder Creek will likely provide adequate recharge. The following are available treatment options to be applied to the groundwater after extraction:

- Activated Carbon Treatment
- Sprinkler Irrigation
- Air Stripping
- Nutrient Addition/Re-injection
- Fixed Film Bioreactor
- UV Oxidation.

Of the available treatment options three are the most probable for use: activated carbon treatment, sprinkler irrigation, and/or nutrient addition/re-injection. An activated carbon system is already on site and has proven effective, sprinkler irrigation would be effective in the warmer months for applying the water over a large area, and nutrient addition/re-injection would optimize *in situ* bioremediation. The use of an air stripper may also be a feasible treatment option, the cost-effectiveness of its use increases as the necessary volume and rate of water treatment increases. Typical components of the pump and treat alternative include: wells, pumps, buried utilities, a housed treatment system, and a re-injection system.

Alternative 3: Air Sparging

Air sparging involves blowing air directly into the saturated zone through properly constructed wells. The injected air then bubbles up through the contaminated groundwater, volatilizing EDB dissolved in the groundwater and increasing the dissolved oxygen concentration. An increased oxygen concentration increases volatilization and aerobic biodegradation. Typical components of a sparging system include: sparging wells, horizontal air lines, and a blower or compressor. Existing wells can be used for air sparging if properly constructed.

Alternative 4: *In Situ* Bioremediation

Bioremediation is the metabolic breakdown of a contaminant by indigenous or introduced microorganisms to less harmful compounds (for EDB the end products can be either ethene or carbon dioxide). This alternative involves engineered controls to optimize biodegradation of EDB by introducing oxygen and nutrients (phosphorus and nitrogen) into the contaminated groundwater. The oxygen source can be provided by one of the following methods: air sparged into the saturated subsurface, hydrogen peroxide injected into the groundwater, or by soluble magnesium peroxide dosed into the groundwater from filter socks suspended in wells. Typical components of an *in situ* bioremediation system include: existing wells, injection wells, a nutrient mixing facility, and the air sparging components discussed for Alternative 3, if sparging is utilized.

Comparison of Remedial Alternatives

A matrix comparing the considered remedial alternatives on the basis of technical effectiveness, implementability, and relative cost is presented in Table 2.

Table 2
Preliminary Remedial Alternatives

Remedial Alternative	Technical Effectiveness	Implementability	Cost	Advantages/Disadvantages
1) No Action/Natural Attenuation	The natural attenuation of EDB through either hydrolysis or biodegradation is relatively slow and without engineered controls could be non-existent.	Easy, no action necessary.	No implementation cost. Would require periodic ground water monitoring. Potentially high liability cost from long term risk.	No initial cost or implementation necessary. Potential liability from high risk. Won't significantly decrease EDB contamination. Won't address contaminant migration. May be difficult to get regulatory or public acceptance.
2) Pump and Treat	Provides positive gradient control. EDB removal a function of treatment technology selected. Limits to EDB removal efficiency in ground water. Flushes aquifer. Requires long term pumping. Could require long term operation/maintenance.	Moderate. Requires installation of wells and treatment technology setup. Some existing impacted water supply and monitoring wells may be used.	Relatively high cost. Purchase pump, install wells, and purchase treatment technology. Long term O&M cost for maintaining treatment technology and for pumping.	Prevents migration and lowers EDB groundwater concentrations, thereby decreasing liability. High implementation cost and potentially long term O&M cost. Potential for public and regulatory acceptance. Likely not to meet MCL cleanup level if applied independently.
3) Air Sparging	Removes the EDB from water by volatilization. Vapor fate may be unknown. Requires pilot test. Increases the aerobic biodegradation of EDB. Shorter cleanup period than other alternatives if proven effective.	Moderate. Requires installation of wells blower setup.	Moderate cost. Purchase blower and install wells. Long term O&M.	Decreases EDB groundwater concentrations which lowers liability. Moderate implementation cost with potentially long term O&M cost. Doesn't prevent down-gradient migration. May require air permit for EDB emissions to the atmosphere. The injection of air into the aquifer may cause mounding, resulting in increased EDB migration. Potential impact to peripheral wells without gradient control. Migratory issues may inhibit regulatory or public acceptance if not controlled.
4.) *In Situ* Bioremediation	Biodegradation rates not predictable without pilot test. There is potential to meet MCL cleanup level if site conditions are suitable to promote biodegradation.	Moderate. Requires installation or usage of existing wells. Requires design and monitoring of nutrient and oxygen addition requirements.	Moderate cost. Install/maintenance of nutrient and oxygen injection system. Long term O&M costs. Purchase nutrients.	Destroys EDB. Doesn't prevent down-gradient migration. Effectiveness for Nemo site unknown w/o pilot test. Likely to ultimately meet MCL cleanup level if site conditions are suitable.

Summary

Existing remedial technologies can be implemented at the site which would limit further migration of contaminated groundwater and reduce the risk to public health associated with EDB in groundwater beneath Nemo. However, the application of all remedial technologies would likely require long term operation, maintenance and monitoring. The applicability of specific remedial technologies depends upon the specific remedial objectives such as migration control or reduction in plume concentrations and risk to human health. Migration control as a means of plume isolation could include interception of groundwater down-gradient of Boxelder Creek, interception of surface discharge into Boxelder Creek, or interception of contaminated water prior to migration to private land (i.e., Kaberna and Weston, or MW-11) which could ultimately achieve cleanup of groundwater beneath private lands. All forms of migration control could be achieved through groundwater pumping and treatment, augmented with re-injection to allow for bioremediation and induced recharge.

Reduction of EDB concentrations in groundwater could likely be achieved through active pumping and flushing, air sparging, or bioremediation. The applicability and effectiveness of specific remedial technologies is dependent upon the specific definition of risk and cleanup objectives. Because of technical limitations of each alternative, the most effective option would be a combination of two or more of the considered alternatives. Even if it isn't possible to achieve the MCL by utilizing current remedial technologies, the application of a treatment alternative or combination of treatment alternatives, as an interim measure to lower EDB concentrations and/or prevent down-gradient plume migration, may decrease overall risk and liability. EnviroSearch has not defined the specific risk associated with the EDB plume according to State of South Dakota Risk Based cleanup program or established cleanup objectives.

Recommendations

EnviroSearch recommends the USDA-FS identify the acceptable levels of risk to human health and/or regulatory cleanup requirements likely to be imposed by the State of South Dakota. Assuming groundwater containment and/or reduction in risk to human health will be required by the State of South Dakota, EnviroSearch recommends the USDA-FS:

- determine the specific remedial objectives and goals for this site. These may include corrective action to address the areas of unacceptable risk and outstanding regulatory requirements;

- identify interim remedial measures that result in maximum risk reduction and determine effectiveness of remedial options. Interim measures may include air sparging at the center of Plume A near MW-10 and in the Troxell well, nutrient injection at MW-3, and positive gradient control near MW-4, MW-12, and impacted Kaberna and Weston wells.

- perform a more detailed remedial alternatives evaluation directed toward the specific remedial objectives identified for this site. This analysis may include: feasibility analysis and an estimate of the cost of implementing applicable interim and final remedial technologies at this site; and development and evaluation of conceptual groundwater pumping, air sparging, groundwater injection, and biological remediation scenarios;

- conduct an air sparging pilot test to evaluate the applicability of this technology at this site;

- examine the feasibility of utilizing existing impacted water supply wells for site remediation; and

- evaluate the risk to unimpacted water supply wells from implementation of applicable remedial technologies.

In addition, the regulatory requirements associated with specific remedial approaches should be defined, for example vapor emission limitations (for air stripping or sparging) and groundwater injection regulations would need to be defined. In addition, the impacts of source assumptions and site conditions would need to be fully examined and accepted by the regulatory agencies to advance the remedial alternatives analysis. Additional source investigation (soil gas) and additional groundwater characterization downgradient from Boxelder Creek may be necessary depending upon regulatory agency requirements.

References Cited

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

Spectrum Laboratories. Chemical Fact Sheet - Case # 106934.

United States Environmental Protection Agency 1990. Subsurface Contamination Reference Guide, EPA/540/2-90/011 (October 1990).

United States Department of Agriculture | Forest Service | Black Hills National Forest | Highway 385 North
RR 2, Box 200
Custer, SD 57730-9501
605-673-2251
TTY 605-673-4954

File Code: 2160

Date: April 28, 1998

MR AND MRS GORDON WESTON
PO BOX 122
NEMO SD 57759

Dear Mr. and Mrs. Weston:

Enclosed for your records is the final construction report for the new water systems constructed in the Nemo area. Your new water system is included in this report.

If you have any questions about the report or your water system, please feel free to contact me at 605-673-2251.

Thank-you.

Sincerely,

/s/ William G. Schleining

WILLIAM G. SCHLEINING
On-Scene Coordinator

Enclosure

cc:
W.Schleining
D.Murray

MESSAGE SCAN FOR WILLIAM SCHLEINING

To W.Schleining
To D.Murray

From: SO MAILROOM
Postmark: Apr 29,98 8:34 AM Delivered: Apr 29,98 8:34 AM

Subject: 2160 Weston

Comments:
1 page letter no hard copy to follow

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United States Department of Agriculture
Forest Service
Black Hills National Forest
Highway 385 North
RR 2, Box 200
Custer, SD 57730-9501
605-673-2251
TTY 605-673-4954

File Code: 2160

Date: April 28, 1998

MR AND MRS GARY KABERNA
PO BOX 102
NEMO SD 57759

Dear Mr. and Mrs. Kaberna:

Enclosed for your records is the final construction report for the new water systems constructed in the Nemo area. Your new water system is included in this report.

If you have any questions about the report or your new water system, please feel free to contact me at 605-673-2251.

Thank-you.

Sincerely,

/s/ William G. Schleining

WILLIAM G. SCHLEINING
On-Scene-Coordinator

Enclosure

cc:
W.Schleining
D.Murray

MESSAGE SCAN FOR WILLIAM SCHLEINING

To W.Schleining
To D.Murray

From: SO MAILROOM
Postmark: Apr 29,98 8:25 AM Delivered: Apr 29,98 8:25 AM

Subject: 2160 Kaberna

Comments:
1 page letter no hard copy to follow

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