Health Consultation

Groundwater Discharge to Lake Michigan

BENDIX CORPORATION/ALLIED AUTOMOTIVE

LINCOLN TOWNSHIP, BERRIEN COUNTY, MICHIGAN

EPA FACILITY ID: MID005107222

DECEMBER 22, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Acronyms

1,1-DCA:	1,1-Dichloroethane
1,2-DCA:	1,2-Dichloroethane
1,1-DCE:	1,1-Dichloroethylene
1,1,2-TCA:	1,1,2-trichloroethane
ATSDR:	Agency for Toxic Substances and Disease Registry
c-1,2-DCE:	cis-1,2-Dichloroethylene
CERCLIS:	Comprehensive Environmental Response, Compensation and Liability Information System
U.S. EPA:	United States Environmental Protection Agency
MDCH:	Michigan Department of Community Health
MDEQ:	Michigan Department of Environmental Quality
RME:	Reasonable maximum exposure
MRL:	Minimal risk level
NT:	Not analyzed for
NA:	Not applicable
ND:	Not detected
RfD:	Reference dose
t-1,2-DCE:	trans-1,2-dichloroethylene
TCE:	tetrachloroethylene
UCL:	Upper confidence limit
VOC:	Volatile organic chemical

Summary

The Bendix Corporation/Allied Automotive site is located in Lincoln Township, Berrien County, Michigan, south of the city of St. Joseph. Between 1953 and the mid-1970's Bendix Corporation, a division of Allied-Signal, Inc., used a series of lagoons at this site for the disposal of waste water containing chlorinated organic solvents. The shallow aquifer beneath the site has been impacted by volatile organic compounds (VOCs) from the lagoons or from other sources. A contaminant plume has migrated off-site, and is discharging through lake sediments into Lake Michigan.

The Michigan Department of Environmental Quality (MDEQ) has identified an affected area of lake sediment extending approximately 150 feet along the Lake Michigan shoreline. The plume begins approximately 20 feet off the shoreline and ends 50 feet offshore. The plume has apparently shifted south between 1999 and 2004, and currently exists off of a sandy beach. This beach is being used for recreational purposes, as evidenced by chairs and toys observed on the beach during the Michigan Department of Community Health (MDCH) site visit on July 19, 2001 (Appendix 2, Figure 1).

The sampling results indicate that there are significant concentrations of VOCs in the pore water of lake sediments, which represents a source of contamination to the surface water. Vinyl chloride, a carcinogen, is the main chemical of concern. The limited surface water data shows sporadic detections of VOCs at low levels. The pattern of VOC diffusion into the lake is not defined, making estimation of an exposure point concentration not possible. In general, children swimming or wading in the lake may ingest or have dermal contact with vinyl chloride. The most likely persistent exposure maybe to children playing in shallow water sediments which have high vinyl chloride pore water concentrations in the top 5 to12 inches. Given the high level of uncertainty in determining potential exposures to vinyl chloride, the MDCH finds the contaminated area represents an indeterminate public health hazard. Although the actual concentrations that waders and swimmers may be exposed to cannot be known with certainty, the MDCH believes that it is prudent for the public, particularly children, to avoid or limit activities in the affected area. The MDCH recommends that annual written notification be provided to near-by residents to make them aware of the potential risks of exposure to contaminants found in the pore water of the lake sediments.

Background

The MDEQ has asked the MDCH to evaluate the health risk associated with the discharge of contaminants from the Bendix Corporation/Allied Automotive Superfund Site to groundwater and ultimately into Lake Michigan. The site was placed on the United States Environmental Protection Agency (U.S. EPA) National Priorities List (NPL) (also called the Superfund list) on February 21, 1990.

The Bendix Corporation/Allied Automotive NPL site is located in Lincoln Township, Berrien County, Michigan, south of the city of St. Joseph, on a 36-acre lot at 3737 Red Arrow Highway/South Lakeshore Drive. Since 1981, sampling of monitoring wells around the property has revealed high concentrations of various VOCs in the groundwater on the property and in plumes extending to the northeast as far as Hickory Creek and northwest as far as Lake Michigan. The contamination has been traced to closed lagoons in the southeast corner of the property, a loading dock area, and a secondary source beneath a parking lot north of the property. The lagoons were used from 1965 to 1975 for the disposal of waste water containing chlorinated organic solvents, cutting oils, paints, chromium, and lead. The site owners drained the lagoons and filled them with soil in August 1978. Soil samples collected from the lagoon area in 1982, 1984, and 1994 contained several VOCs. During the Remedial Investigation of the site in 1994, Bosch Braking Systems, current owner of the site, found elevated concentrations of VOCs in groundwater samples collected from temporary monitoring wells located at the lagoons and at a parking lot across Maiden Lane north of the former Bendix building. The western groundwater plume extends under residential areas between South Lakeshore Drive and Lake Michigan north of Lake Bluff Terrace Road (W & C, 1997).

On February 14, 1992, the Michigan Department of Public Health (MDPH)[1], working under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR), issued an Interim Preliminary Health Assessment (IPrHA) for the site. The recommendations in the IPrHA included continued groundwater monitoring to follow the plume migration and to detect when nearby private wells might become threatened. It also recommended sampling of vulnerable private wells on a yearly basis (MDPH, 1992). On September 23, 1998, the MDCH issued a Health Consultation addressing the question of private wells down gradient from the site. The consultation recommended sampling, then abandonment of any private wells in the affected area (MDCH, 1998). Subsequent to this, all potentially affected properties have been connected to municipal water and those private drinking water wells were properly abandoned.

The present MDCH Health Consultation focuses on the potential public health hazard associated with the discharge of contaminants from the Bendix Corporation/Allied Automotive Superfund Site to groundwater and ultimately into Lake Michigan.

Discussion

Environmental Contamination

The MDEQ collected pore water samples from within the area of sediments affected by the contaminated groundwater plume discharging to Lake Michigan (MDEQ, 2006). Pore water is water that occupies spaces between grains of sand and other material that are present in the lake bottom sediments. These samples were collected to further define the area where groundwater is discharging to Lake Michigan. Within a larger area of affected shoreline, the MDEQ has identified a

[1] On April 1, 1996, the MDPH Division of Health Risk Assessment (DHRA) was reorganized into the MDCH as the Environmental Epidemiology Division. The site history and background section of this document uses the departmental identifiers in effect at the time of the events.

groundwater plume discharge area where the majority of contaminants are venting through the sediments and into the lake.

Due to the lack of source characterization, the location of the source area is inferred to be on the Bendix Corporation/Allied Automotive NPL site. Because of the lack of source characterization, the quantity and chemical composition of the source, the physical dimensions of the source, and the variability in the rate at which these chemicals are being released from the source and entering Lake Michigan are unknown. Therefore, the MDEQ and MDCH cannot be certain that increased chemical releases into the groundwater and swimming area will not occur.

The MDEQ collected 166 pore water samples from the groundwater discharge area during June 1999, September 1999, March 2000, February 2001, July 2001, June 2003, October 2004, November 2004, October 2005, and November 2005 (Appendix 3). All MDEQ pore water samples were collected from within the lake sediments at depths ranging from approximately 5 to 24 inches into the sandy lake bottom. The MDEQ has described, in detail, the sampling and analytical procedures elsewhere (MDEQ 2006). Based on the sampling results, the MDEQ concluded that the plume discharge continuously enters Lake Michigan, is not stable, and can shift north and south along the shoreline.

Prior to discharge into the lake, MDEQ has also observed upward and downward vertical gradients within the groundwater, which may result in some mixing of the plume. The depth of the groundwater plume is approximately 50 feet from the top of the plume to the bottom. The chemical contamination resides in the lower 30 feet of the plume with approximately 20 feet of uncontaminated groundwater above the 30 feet of contaminated groundwater. The depth from

Uncertainties in Estimating Exposure Point Concentrations for Human Risk Screening Analysis

1. Lack of source characterization (MDEQ 2006) prevents identification of the:
   a. Quantity of source chemicals.
   b. Types of chemical at the source.
   c. Physical dimensions of the source.
   d. Variability in the rate and location of release of the chemicals from the source to the lake.

2. Unknown pattern and rate of diffusion of the VOCs from the pore water into the surface water.

3. Limited surface water data that does not characterize temporal or spatial patterns of VOCs in the water column.

4. Lack of activity based exposure point sampling that is suitable for dermal or ingestion exposure estimates.

5. Insufficient ground water monitoring wells in the center of the plume (MDEQ 2006).

6. Unexplained movement of the plume from north to south, suggesting the plume is not stable (MDEQ 2006).

7. Lack of knowledge about the upward and downward vertical gradients within the groundwater (MDEQ 2006).

land surface to the groundwater is approximately 40 feet (Appendix 2, Figure 2).

The MDEQ has concluded that the groundwater plume travels horizontally from the uncharacterized pollutant source until the groundwater reaches Lake Michigan. The MDEQ has concluded that when the groundwater reaches Lake Michigan, the 50-foot vertical groundwater plume flows toward the lake and becomes a horizontal discharge plume entering the near-shore lake water (i.e., starting at the shoreline out to 50 feet offshore) (Appendix 2, Figure 2). This near-shore lake water constitutes a recreational swimming area with a conjoining sandy beach. The depth of water in the swimming area reaches a maximum of approximately 4 to 5 feet of water at 50 feet offshore. The majority of the first 50 feet offshore is between a few inches and 3.5 feet of water. The first 20 feet from the shoreline receives what was once the top 20 vertical feet of the groundwater plume, and as such, the pore water samples reflect relatively little chemical contamination in the first 20 feet of lake bottom from the shoreline. The next 30 feet of surface water (i.e., 20 – 50 feet offshore) receives what was the bottom 30 vertical feet of contaminated groundwater, and the MDEQ has found the pore water within this region to have significantly elevated chemical contaminant concentrations.

Surface water sampling during the spring, summer, or fall has been limited to about one sampling event per year between 1999 and 2005 with the exception of 2002 during which no surface water samples were collected. The surface water sampling conducted to date does not adequately reflect varying water conditions at the beach (i.e., multiple consecutive days of calm water or windy, rough conditions) or the influence of human activity.

MDEQ collected one surface water sample in September 1999, two surface water samples from the discharge area in March 2000, and ten surface water samples from the discharge area in November 2005. Samples were collected from either the middle or near the bottom (within 1 inch) of the water column. In September 1999 and 2001, June 2003, and November and December 2004, a contractor for the current site owner collected surface water samples from many of the locations where they had collected pore water samples. At some locations samples were collected both in the middle and at the surface of the lake water column. Generally, samples closer to the shoreline (0 - 50 ft) were more likely to have VOC detections. Individual sample results are presented in Appendix 4.

MDCH finds the current surface water VOC data of limited use for human health assessments because these data have not been collected in a manner that characterizes the range of possible environmental conditions or changes in plume discharge that may occur at this beach. In addition, the uncertainties related to source characterization, potential plume instability, and limited surface water data, led the MDCH to conclude that using the current surface water VOC data as the sole data source could not characterize the potential risks to public health.

MDCH finds that the pore water data for most exposure point concentrations would likely over estimate the dose a person would receive. In situations in which a child may sit on or partially bury their legs in the sediment, the pore water measurements may be an accurate exposure point concentration for dermal estimates. MDCH believes activity based sampling would be required to determine appropriate exposure point concentrations. Currently, no activity based sampling exists that would represent the above scenario. MDEQ has collected one activity-based sample that may represent the effect of disturbing the sediments (i.e. wading) on surface water concentrations. The sample, taken from the bottom of the water column, had slightly higher VOC concentrations compared to the water concentration prior to disturbing the sediments.

Human Exposure Pathways

The MDCH evaluated past, present, and future human exposure pathways (Table 1). An exposure pathway contains five elements: (1) a source of contamination, (2) contaminant transport through an environmental medium, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. An exposure pathway is considered *complete* if there is evidence that all five of these elements are, have been, or will be present at the property. More simply stated, an exposure pathway is considered complete when it is highly likely people are being exposed to the chemicals of potential concern (COPC). It is considered a *potential* exposure pathway if at least one of the elements is missing but could be found present at some point. An *incomplete* pathway exists if at least one element is missing and will never be present.

Table 1. Potential exposure pathways in the near-shore Lake Michigan discharge plume.

Source	**Chemical Transport**	**COPC**	**Exposure Point**	**Exposure Route**	**Potentially Exposed Population**	**Time**	**Status**
Uncontained, buried chemicals at the Bendix Corporation/Allied Automotive Superfund Site	Groundwater flowing into Lake Michigan	Table 2	Swimming, wading, recreating at beach (Summer)	Dermal contact, Incidental Ingestion of water	People wading/playing in water at beach	Past	Complete
						Present	Complete
						Future	Complete
	Volatilization from near-shore lake water	Table 2	Swimming, wading, recreating at beach (Summer)	Inhalation of VOCs	People using the beach	Past	Potential (lack of data to quantify exposure)
						Present	
						Future	
	Vapor migration into interior spaces.	Table 2	Indoor air of homes	Inhalation of VOCs	Residents of homes	Past	Incomplete
						Present	Potential (lack of data to quantify exposure
						Future	
	Volatilization of VOCs from water	Table 2	Ice fish Shelters	Inhalation of VOCs	Ice Fishers (unknown if ever present)	Past	Incomplete
						Present	Incomplete
						Future	Incomplete

The MDCH finds that plausible exposure pathways to VOCs at this location exist for the past, present, and future at the beach, and potentially in the future for homeowners. Currently, MDEQ has not found any evidence of VOCs migrating into homes. However, further investigations into fugitive VOC emissions from the groundwater into the surface soil are yet to be undertaken. MDEQ observations based on the hydrology and groundwater data that the plume is not stable and may experience vertical mixing is enough information to cause MDCH to identify a potential future exposure to homeowners from vapor intrusion. Without further source and plume characterization, MDCH cannot further evaluate this potential future exposure pathway.

Inhalation exposure outdoors may exist given that the COPC are volatile; however, no air concentration measurements have been made. Volatilization of these chemicals will likely be dispersed and not reach air concentrations of concern to human health.

Surface water or groundwater from this location is not used as drinking water or for household purposes. Past residential use of groundwater was addressed in the earlier MDCH health consultation (MDCH 1998). Residences in the area are now connected to the St. Joseph municipal water system, which takes its water supply from Lake Michigan, approximately three miles north of the Bendix Corporation/Allied Automotive site. Routine monitoring of the municipal water system ensures no deviations outside U.S. EPA and MDEQ standards.

Swimming, wading, and playing in the near-shore lake water at the beach constitutes a completed exposure pathway. Such recreational activities may occur from the end of May to the end of September. In 2004, the plume existed offshore of the northern portion of the sandy beach and extends onto a portion of the beach covered by rip-rap (i.e., rocks and construction rubble). The observations made during the MDEQ sampling event that was completed in October and November of 2005 indicate that the riprap that extended out into the lake was almost completely covered with sand, thereby making it indistinguishable from the “swimming beach”. From 2001 to 2004, the discharge plume had apparently moved south directly offshore of the sandy beach. During the site visit, MDCH staff observed beach chairs (Appendix 2, Figure 1) and children's toys including swimming goggles, wave board, sand pails and shovels. Depending on the air temperature, shallow lake water is generally warmer than water found at depth. At the time of the MDCH site visit on July 19, 2001, the lake temperature in the plume discharge area was 22°C (71.6°F). Surface water depths between one and four feet exist over the plume. These shallow depths would allow young children to immerse portions of their bodies in the water and flocculent sediments without needing to be able to swim.

Toxicological Evaluation

The potential for adverse health effects that might result from exposure to contaminated media is evaluated by estimating a dose of each contaminant of concern. These doses are calculated for scenarios in which individuals might come into contact with the contaminated environmental media. In order to calculate these doses, assumptions are made about the way people behave, the amount of contaminated media they may ingest, inhale, or make skin contact with, and how long and how frequently they may make contact with the contaminated media. These calculated doses are used along with chemical-specific toxicological information to evaluate the risk of noncancer and cancer health effects.

Currently, MDCH does not find it possible to conduct a definitive human health screening analysis. A definitive screening analysis cannot be conducted because MDCH finds it is not possible to estimate an accurate dosage range due to the lack of adequate exposure point concentration measurements. With the VOC data that are available, the MDCH finds that the estimated dose may likely either grossly underestimate (e.g. current surface water data) or overestimate (e.g. pore water data) the potential human risk. Using the existing available VOC data, MDCH provides an interim screening analysis of a potential dermal and ingestion exposure pathway to a child and adolescent scenario. MDCH considers this interim screening analysis to have a high degree of uncertainty due to the lack of adequate exposure point concentrations.

Interim Screening Analysis

MDCH evaluated an interim dermal exposure to pore water and an interim incidental ingestion exposure to surface water for child (under 7 years old) and adolescent (7 to 14 year olds) scenarios. Dermal exposure point concentrations (i.e., chemical concentration that will contact the skin) were based on the median pore water concentrations (Table 2) within the discharge plume as depicted by the map of vinyl chloride concentration (Appendix 2, Figures 3 and 4) relative to the direct contact criteria calculated by MDCH (Appendix 1). Dermal contact was calculated using U.S. EPA methods (EPA 2004). Incidental ingestion concentrations were based on the maximum surface water concentration detected in the near-shore water (Table 3). The frequency with which a child or adolescent might swim, wade, or play in the plume discharge area were evaluated for a low-end exposure scenario and reasonable maximum exposure (RME). MDCH used a low-end exposure that has a child or adolescent swim/wade seven events per year. MDCH used an RME scenario that evaluates 36 swim/wade events per year. Each exposure event was estimated to be 1 hour in length. Dermal exposure was estimated based on half the body surface area being in contacted with contaminated water. MDCH assumed 50 ml incidental ingestion of contaminated water per event.

Table 2. Range of pore water contaminant concentrations and interim dermal exposure point concentrations (median) within the groundwater plume discharge area.

Contaminant	**Years of Sampling**	**Number of Samples**	**Detected Pore Water Concentrations**	**Interim Dermal Exposure Point Concentration**[a]
	Range	**Detections/ Total Samples**	**Range ppb**	**Median ppb**
Benzene	1999-2004	8/56	0.7-5	1.3
1,1-DCA	1999-2004	20/56	4.6-95	20.5
1,2-DCA	1999-2004	13/56	1.1-15	3.5
1,1-DCE	1999-2004	33/56	3.1-610	120
c-1,2-DCE	1999-2004	56/56	14-40,000	6,400
t-1,2-DCE	1999-2004	49/56	5.2-1,800	610
1,1,2-TCA	1999-2004	4/56	0.7-7.3	2
TCE	1999-2004	42/56	22-15,000	3,000
Vinyl chloride	1999-2004	55/56	9-9,100	4,100

[a]Median value of detections was used instead of a UCL of the mean because some data sets had great than 50% of the samples as non-detections and a single quantification method was considered more desirable for this interim assessment.

Table 3. Range of surface water contaminant concentrations and interim ingestion exposure point concentrations (maximum) for all surface water samples collected at the site.

Contaminant	**Years of Sampling**	**Number of Samples**	**Detected Surface Water Concentration**	**Interim Ingestion Exposure Point Concentration**
	Range	**Detections/ Total Samples**	**Range ppb**	**Maximum ppb**
Benzene	1999-2005	NT	NA	NA
1,1-DCA	1999-2005	1/66	NA	10
1,2-DCA	1999-2005	3/66	6.1-13	13
1,1-DCE	1999-2005	0/66	ND	NA
c-1,2-DCE	1999-2005	33/66	0.9-51	51
t-1,2-DCE	1999-2005	6/66	0.09-3.1	3.1
1,1,1-TCA	1999-2005	4/66	1.3-8.5	8.5
1,1,2-TCA	1999-2005	NT	NA	NA
TCE	1999-2005	17/66	0.5-40	40
Vinyl chloride	1999-2005	18/66	0.1-47	47

NT: not analyzed for; NA: not applicable; ND: not detected

Noncancer Hazard
In order to assess the potential for noncancer health effects, the estimated interim dose for each contaminant under each scenario is compared to ATSDR's minimal risk level (MRL) or the U.S. Environmental Protection Agency's (EPA's) oral reference dose (RfD). MRLs and RfDs are doses below which noncancer adverse health effects are not expected to occur. They are derived from toxic effect levels obtained from human population and/or occupational studies, and laboratory animal studies. Toxic effect levels identified from these studies may be either a no observed adverse effect level (NOAEL) or the lowest observed adverse effect level (LOAEL). Since the NOAEL is the highest dose that **does not** result in **any** adverse health effects, this effect level is preferred as the basis for an MRL or an RfD. The LOAEL is the lowest dose at which adverse health effects are seen, and is used when a NOAEL cannot be identified.

Because there is uncertainty in both human and animal studies, NOAELs and LOAELs are divided by "uncertainty factors" to derive the more protective RfD or MRL. These uncertainty factors are generally in multiples of ten, but may sometimes be less depending on the quality of the study or the seriousness of the observed adverse effect. An additional uncertainty factor is applied when an RfD or MRL is based on a LOAEL.

Given the level of uncertainty in the development of RfDs and MRLs, they should not be considered a strict line between a safe and an unsafe dose of a contaminant. If a calculated dose exceeds either the RfD or the MRL, it is important to consider the magnitude of the exceedance as well as the uncertainty surrounding the calculated dose before determining if noncancer health effects are likely.

The chemicals of health concern found in the pore water of the sediments of Lake Michigan in the groundwater plume discharge area associated with this site are benzene, 1,1-dichloroethane, 1,2-dichloroethane**,** 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, trichloroethylene, and vinyl chloride. These chemicals are VOCs and are readily absorbed when ingested. Dermal absorption kinetics are dependent on physical properties of the chemical, particularly the oil/water partitioning coefficient and molecular size. The liver and kidneys are the primary targets for the adverse health effects that may result from exposure to these compounds (ATSDR 1990, 1994, 1996, 1997a, 1997b, 1997c, 1999). Given that these chemicals have similar toxicological properties or endpoints, their individual interim hazard estimates were combined to determine cumulative risk from exposure to multiple chemicals via both dermal contact and ingestion pathways.

The estimated interim dose of these compounds received by a child or adolescent wading or swimming in the discharge area of the groundwater plume did not exceed their respective ATSDR MRLs or EPA RfDs. The combined interim estimated hazard of these compounds for the child scenario also did not exceed their respective ATSDR MRLs or EPA RfDs (Table 4 and Appendix 6). MDCH's interim finding is that the additive dose of these chemicals are unlikely to cause adverse non-cancer health effects.

Table 4. Noncancer hazard index for combined exposure to the plume discharge chemicals from both dermal contact and oral ingestion.

Exposure Pathway	Swimming/Wading Events per year in Plume Sediments	Hazard Index	
		Child 6 yr	Adolescent 8 yr
Average Exposure Scenario			
Dermal Contact	7	0.12	0.08
Oral Ingestion	7	1.5E-03	5.3E-04
Summed Hazard Quotients	7	0.12	0.08
RME Scenario			
Dermal Contact	36	0.6	0.41
Oral Ingestion	36	7.5E-03	2.7E-03
Summed Hazard Quotients	36	0.6	0.41

Cancer Risk

Cancer risk is estimated by calculating a dose and multiplying it by a cancer potency factor, known as the cancer slope factor. Some cancer slope factors are derived from human populations. Human studies typically involve occupational exposures to higher dose not found in the general public.

When no human data are available, cancer slope factors are calculated from data obtained from animal studies in laboratories. The dose of contaminant to which animals are exposed in the laboratory is generally far higher than would result from environmental exposures. Use of animal data introduces additional uncertainty into the cancer slope factor due to differences in metabolism, life span, and body size between test animals and humans.

For most cancer causing chemicals (carcinogens), it is generally thought that an increasingly lower dose will result in a proportionally lower cancer risk. The cancer slope factor quantitatively defines this relationship between the dose and the risk of developing cancer. In order to calculate the slope factor, it is necessary to extrapolate high doses from either human or animal studies to lower, more realistic levels of exposure. Extrapolation below the observed dose level introduces uncertainty into the cancer slope factor. Cancer risk estimates are, therefore, measures of the chance of developing cancer as a result of exposure to an estimated dose. Cancer risk estimates are generally expressed as the number of individuals in a larger population that may develop cancer. Note that these estimates are for excess cancers. Excess cancers are the theoretical additional cancers in an exposed population that theoretically might occur above the expected number of cancers in an unexposed population. Because cancer is a common illness caused by many factors, a population with no known chemical exposure could be expected to have a substantial number of cancer cases.

Vinyl chloride, trichloroethylene, benzene, 1,1,2-trichloroethane, and 1,2-dichloroethane have been detected in the discharge area of the groundwater plume. These compounds are believed to be capable of causing cancer. The EPA has determined that vinyl chloride is a known human carcinogen because vinyl chloride exposure has resulted in liver cancer in people (EPA 2001).The EPA provides two cancer slope factors for vinyl chloride: one for use when considering the risk of exposure during adulthood only and another for use when considering the risk to children. Separate slope factors are provided for adults and children because the risk of developing cancer is believed to be greater when exposure occurs during childhood. The slope factor provided by the EPA for exposure during childhood is used in this assessment.

The combined estimated increased risk of theoretically developing cancer over a lifetime as a result of exposure to contaminants at this site are almost completely (99%) attributable to the increased risk associated with dermal contact to vinyl chloride. Exposure to the levels of vinyl chloride detected in the venting groundwater plume may result in a low to moderate increased risk of developing cancer over a lifetime of exposure, depending on the frequency of exposure (Table 5 and Appendix 5). Based on this interim screening analysis, MDCH would estimate that as few as eight exposure events could result in an incremental increase in lifetime cancer risk of greater than or equal to 1 additional cancer per 100,000 exposed individuals.

Table 5. Theoretical incremental cancer risk estimates ($x10^{-5}$) from combined exposure to the potential or known carcinogens in the plume discharge from both dermal contact and oral ingestion. (Boxes in grey exceed $1x10^{-5}$ risk estimate)

Exposure Pathway		**Child**		**Adolescent**	
	Swimming/Wading Events per year in Plume Sediments	**Number of years of exposure**			
		1 yr	**6 yr**	**1 yr**	**8 yr**
		Incremental Increase in Cancer Risk ($x10^{-5}$)			
Average Exposure Scenario					
Dermal Contact	7	0.4	2.3	0.3	2.1
Oral Ingestion	7	0.007	0.03	0.002	0.02
Summed Incremental Risk	7	0.4	2.3	0.3	2.1
RME Scenario					
Dermal Contact	36	2.0	12	1.4	11
Oral Ingestion	36	0.03	0.2	0.01	0.1
Summed Incremental Risk	36	2.0	12	1.4	11

Child Health Initiative

Children may be at greater risk than adults from certain kinds of exposure to hazardous substances at sites of environmental contamination. They engage in activities such as playing outdoors and hand-to-mouth behaviors that increase their exposure to hazardous substances. They are shorter than adults, which means they breathe dust, soil, and vapors close to the ground. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of children can sustain permanent damage if toxic exposures are high enough during critical growth stages. Prenatal exposures (before children are born) and those that occur in the first few years of life are more likely to cause permanent damage (ATSDR 1999).

Vinyl chloride has been detected at high concentrations in the groundwater plume originating from the Bendix Corporation/Allied Automotive Superfund Site and discharging through the sediments into Lake Michigan. The EPA has determined that childhood exposure to vinyl chloride results in a greater increased risk of developing cancer than would be expected if the exposure had occurred only during adulthood (EPA 2001). The MDCH has, therefore, used the cancer slope factor for vinyl chloride recommended by the EPA when assessing the risks of childhood exposure to this contaminant.

Conclusions

Contaminated groundwater emanating from the Bendix Corporation/Allied Automotive Superfund Site is discharging through lake sediments and into Lake Michigan. The area of highest VOC concentrations in groundwater in lake sediments is located approximately 20 to 50 feet from the shore in one to four feet of water. The discharging plume has apparently shifted south along the shoreline to a sandy beach area that is generally accessible to small children, adolescents or older individuals wading, fishing, and swimming in the lake. The beach is currently being used for recreational purposes as evidenced by chairs and toys observed on the beach during the MDCH site visit (Appendix, Figure 2).

MDCH does not find it possible to currently conduct a definitive human health screening analysis at this site given the lack of accurate exposure point concentration data. The MDCH interim screening analysis suggests that the concentration of vinyl chloride in the pore water may result in elevated incremental cancer risk. MDCH believes that the collection of activity-based VOC sampling for ingestion and dermal contact exposure pathways would make a definitive screening analysis possible.

Because an accurate dose and thus risk cannot be currently determined, MDCH finds this site to be an indeterminate public health hazard. Until a definitive screening analysis can be conducted, the MDCH suggests the public, particularly children, avoid or limit activities in the affected area.

Recommendations

The MDEQ is considering remedial options to better characterize and reduce the levels of groundwater contaminants discharging into Lake Michigan. Preference should be given to options that reduce contaminants to levels that do not pose public health hazards to recreational users of the lake.

Until action can be taken to reduce the levels of contaminants, the following measures should be taken to limit exposure to contaminants in the groundwater plume:

- The MDCH recommends that written notification be provided annually to near-by residents to make them aware of the presence of the contaminants found in the pore water of the lake sediments and that MDCH recommends limiting or avoiding contact with those sediments.

- The MDCH recommends the continued monitoring of the groundwater plume to ensure that any changes in the location or concentration of the plume discharge area can be identified.

- The MDCH recommends the development and implementation of an activity based sampling design that will provide VOC data form lake water that represents exposure point concentrations for dermal and ingestion pathways.

New environmental data or information concerning the future use of this property may require future health consultations.

Public Health Action Plan

The MDCH will be available to consult on the appropriateness and efficacy of future remedial actions.

The MDCH will assist the MDEQ in the development of written notification to provide near-by residents with information concerning the contaminants venting to the lake, the potential health risks, and ways to limit exposure. Notification will be provided to all homeowners in the residential development who have access to the affected beach area.

The MDCH will discuss with MDEQ the feasibility of developing and implementing an activity based sampling design for VOCs in lake water that would be more representative of exposure point concentrations.

If any citizen has additional information or health concerns regarding the groundwater contamination plume from the Bendix Corporation/Allied Automotive NPL site, please contact the Michigan Department of Community Health, Division of Environmental and Occupational Epidemiology, at 1-800-648-6942.

Certification

This **Bendix Corporation/Allied Automotive, Groundwater Discharge to Lake Michigan** Health Consultation was prepared by the Michigan Department of Community Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the cooperative agreement partner.

Technical Project Officer, CAT, CAPEB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.

Team Lead, CAT, CAPEB, DHAC, ATSDR

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Appendix 1: Dermal Contact Screening Value for Vinyl Chloride in Pore Water.

Using the Michigan Department of Environmental Quality's (DEQ) *Part 201 Generic Groundwater Contact Criteria: Technical Support Document (January 5, 2001)*, MDCH calculated a dermal contact vinyl chloride screening value based on carcinogenicity for a child (640 ppb) and an adolescent (710 ppb) scenario. The screening values were used to define the geographic area within the lake to which this health consultation applies. The equation used to calculate the contact criteria is:

$$DCC = \frac{BW \text{ x } AT \text{ x } TR \text{ x } CF_1}{SF \text{ x } SA \text{ x } SP \text{ x } EV \text{ x } EF \text{ x } ED \text{ x } CF_2} \qquad \text{Eq. 1}$$

where,

	Units	Child	Adolescent
Body Weight (BW)	kg	15	41
Averaging time (AT)	days	25550	25550
Target Cancer Risk (TR)		1×10^{-5}	1×10^{-5}
Cancer slope factor (SF)	$(mg/kg\text{-}day)^{-1}$	1.5	1.5
Skin surface area (SA)[1]	cm^2	3300	6100
Skin penetration (SP)[2]	cm/event	0.0056	0.0056
Exposure frequency (EF)	days/year	36	36
Exposure duration (ED)	years	6	8
Event frequency (EV)	event/day	1	1
Conversion factor 1 (CF_1)	µg/mg	1000	1000
Conversion factor 2 (CF_2)	L/cm^3	0.001	0.001
Dermal Screening Value (DCC) for Vinyl Chloride	ppb	**640**	**710**

[1] Surface area is half of the body surface area for a child or adolescent.
[2] Skin penetration has the exposure event time set at 1 hour.

Equation 1 (Eq. 1) is a back-calculation of the following cancer risk equation based on the U.S. EPA document *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*:

$$\text{Cancer Risk} = \left(\frac{DA_{event} \text{ x } EV \text{ x } EF \text{ x } ED \text{ x } SA}{BW \text{ x } AT} \right) \times SF \qquad \text{Eq. 2}$$

where, DA_{event} is the absorbed dose per event (mg/cm^2-event) and is equal to concentration in the water (C_w) multiplied by the skin penetration value (SP) ($DA_{event} = C_w * SP$). C_w in Eq. 2 is replaced by dermal screening value (DCC) in Eq. 1. Cancer risk is the estimated incremental increase in risk of the occurrence of cancer. The cancer risk estimate in Eq. 2 is replaced by the target cancer risk (TR) in Eq. 1.

Appendix 2. Figures

Figure 1. Lake Michigan Beach near the Plume Discharge Area (July 19, 2001).

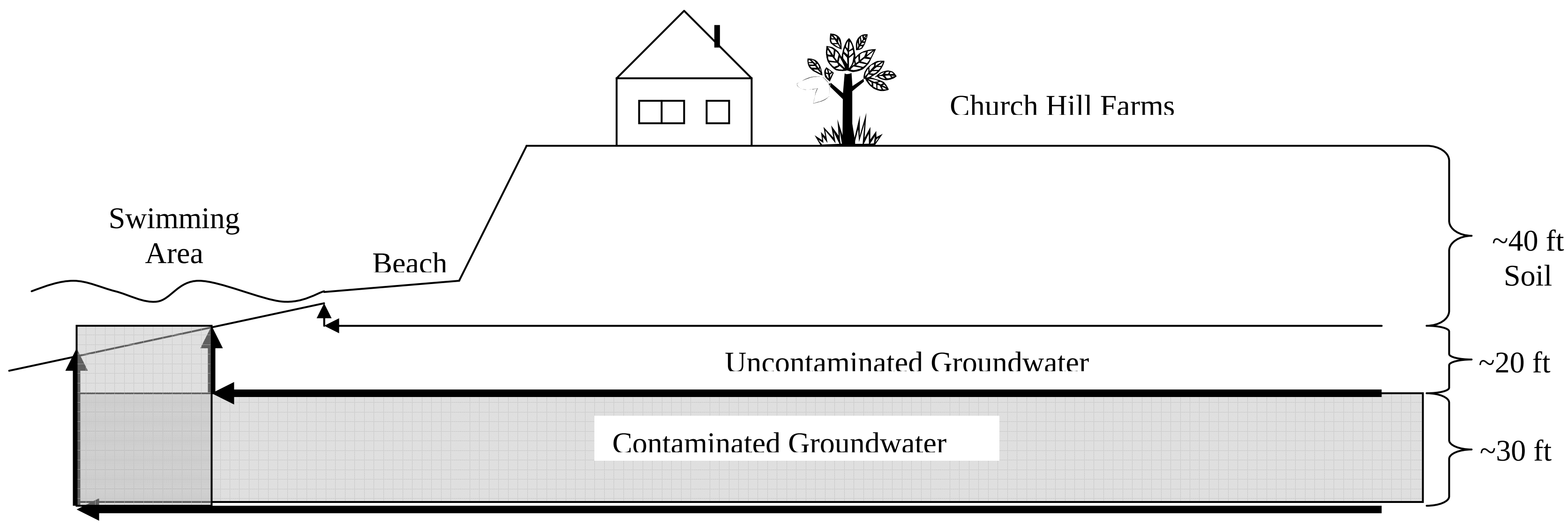

Figure 2. Cross-sectional conceptual depiction of the flow of contaminated and uncontaminated groundwater under the Church Hill Farms residential area and into the near-shore water of Lake Michigan.

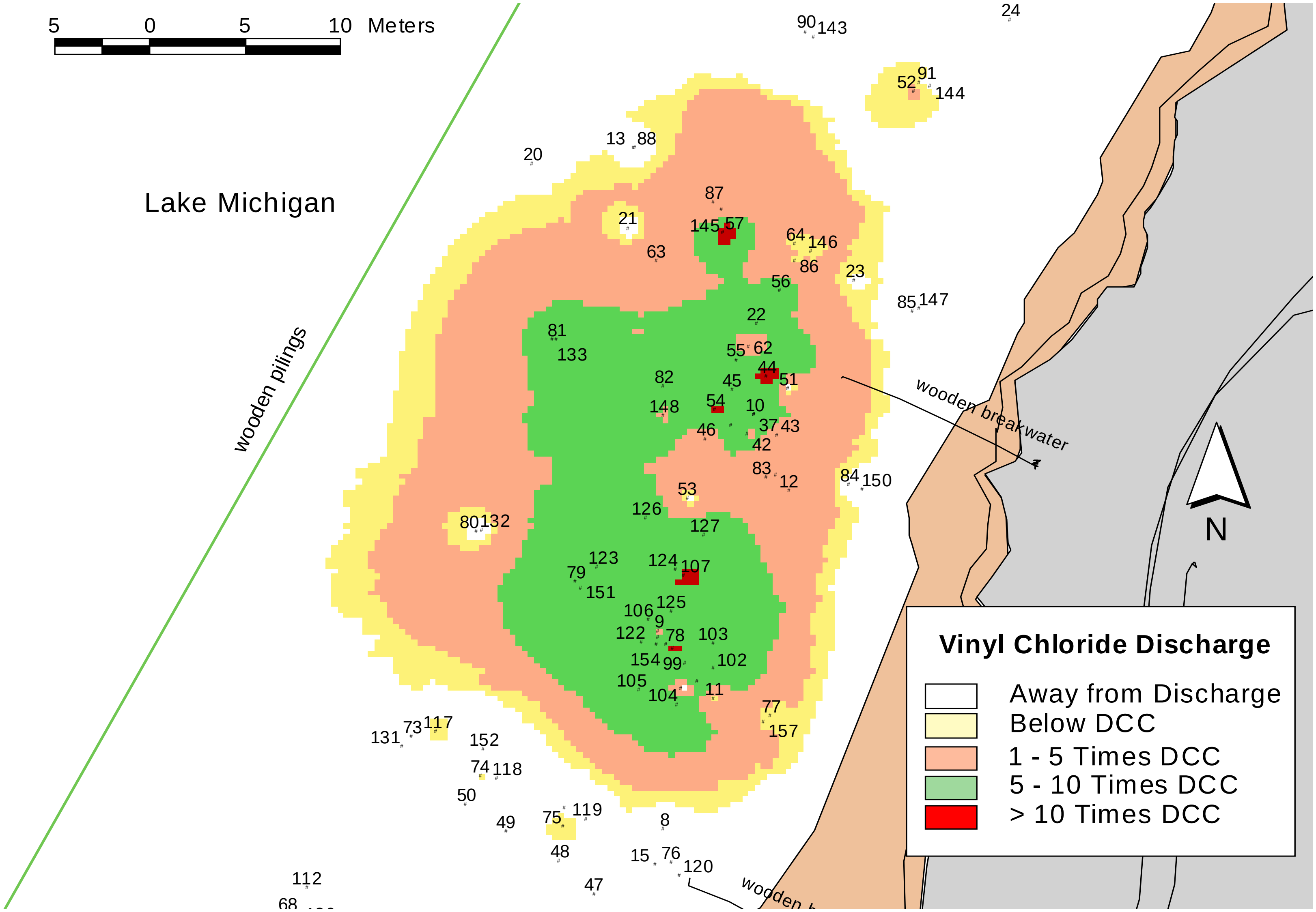

Figure 3. Graphical depiction of the plume sampling locations (numbered black dots) and the vinyl chloride discharge concentrations relative to a dermal contract screening criteria (DCC) as calculated by MDCH in Appendix 1.

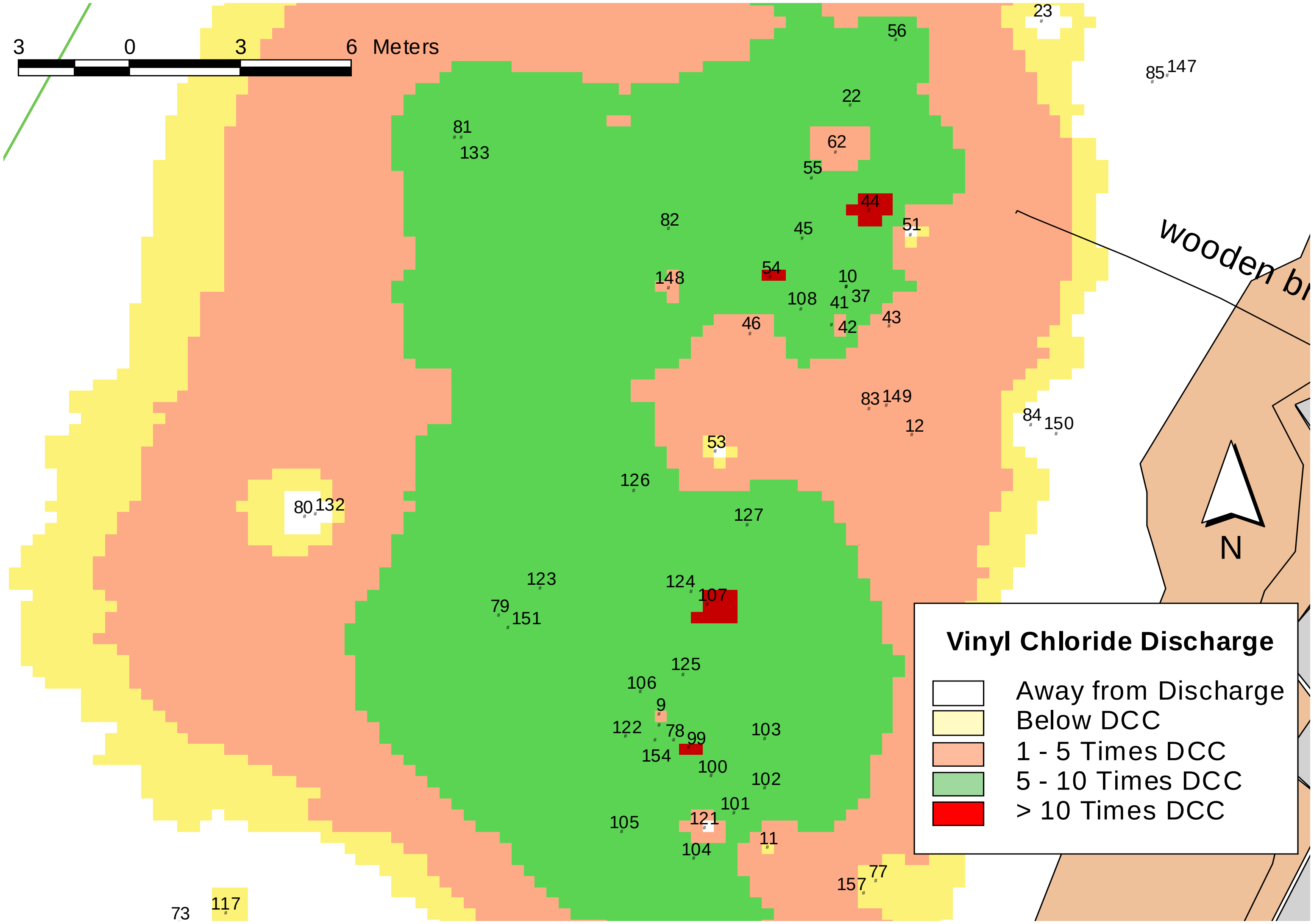

Figure 4. Graphical depiction of the center of plume sampling locations (numbered black dots) and the vinyl chloride discharge concentrations relative to a dermal contact screening criteria (DCC) as calculated by MDCH in Appendix 1.

Table for Figures 3 and 4. Vinyl chloride pore water data associated with the numbered points.

Label	Year	Vinyl Chloride ppb	Label	Year	Vinyl Chloride ppb
1	1999	5	41	2000	5300
2	1999	nd	42	2000	3000
3	1999	2	43	2000	1800
4	1999	nd	44	2000	9100
5	1999	37	45	2000	4600
6	1999	2	46	2000	1700
7	1999	19	47	2000	nd
8	1999	41	48	2000	25
9	1999	2300	49	2000	35
10	1999	6200	50	2000	nd
11	1999	390	51	2001	9
12	1999	2350	52	2001	960
13	1999	0	53	2001	150
14	1999	0	54	2001	7000
15	1999	0	55	2001	4300
16	1999	0	56	2001	4600
17	1999	0	57	2001	8300
18	1999	0	58	2001	130
19	1999	0	59	2003	nd
20	1999	0	60	2003	6
21	1999	0	61	2003	nd
22	1999	4100	62	2003	960
23	1999	170	63	2003	1400
24	1999	7	64	2003	350
25	1999	nd	65	2003	nd
26	1999	nd	66	2003	nd
27	1999	nd	67	2003	22
28	1999	nd	68	2003	90
29	1999	nd	69	2003	14
30	1999	nd	70	2003	57
31	1999	nd	71	2003	15
32	1999	nd	72	2003	4
33	1999	nd	73	2003	200
34	1999	nd	74	2003	260
35	1999	nd	75	2003	480
36	1999	nd	76	2003	19
37	2000	4600	77	2003	285
38	2000	nd	78	2003	6000
39	2000	nd	79	2003	6300
40	2000	nd	80	2003	15

Table for Figures 3 and 4. Continued.

Label	Year	Vinyl Chloride ppb	Label	Year	Vinyl Chloride ppb
81	2003	5500	122	2004	5000
82	2003	3300	123	2004	4800
83	2003	1650	124	2005	4200
84	2003	2	125	2005	3700
85	2003	nd	126	2005	4600
86	2003	560	127	2005	5100
87	2003	1800	128	2005	8
88	2003	130	129	2005	39
89	2003	160	130	2005	38
90	2003	30	131	2005	76
91	2003	190	132	2005	nd
92	2003	nd	133	2005	2200
93	2003	14	134	2005	23
94	2003	140	135	2005	nd
95	2003	13	136	2005	35
96	2003	4	137	2005	2
97	2003	13	138	2005	nd
98	2003	nd	139	2005	4
99	2004	7300	140	2005	6
100	2004	6100	141	2005	nd
101	2004	5600	142	2005	nd
102	2004	6500	143	2005	140
103	2004	5500	144	2005	110
104	2004	6100	145	2005	700
105	2004	4200	146	2005	460
106	2004	5500	147	2005	nd
107	2004	8200	148	2005	3100
108	2004	5200	149	2005	1300
109	2004	nd	150	2005	nd
110	2004	11	151	2005	3150
111	2004	5	152	2005	50
112	2004	43	153	2005	9
113	2004	55	154	2005	3300
114	2004	nd	155	2005	170
115	2004	7	156	2005	nd
116	2004	2	157	2005	nd
117	2004	310	158	2005	nd
118	2004	5	159	2005	4
119	2004	63	160	2005	50
120	2004	10	161	2005	3500
121	2004	75	162	2005	nd

Appendix 3. Concentrations of chlorinated hydrocarbons found in pore water samples from the sediment in and near the discharge area of the groundwater contaminant plume from the Bendix facility. All concentrations expressed in ug/l (ppb).[A]

Date	Location	Water Depth	Water Temperature	Depth into sediments	Benzene	1,1DCA	1,2DCA	1,1DCE	cis-1,2DCE	trans-1,2DCE	TCE	VC	1,1,1TCA	1,1,2 TCA
		Feet	C°	Feet	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
6/8/1999	PB 01	NA	NA	NA	ND	1.9	ND	ND	89	1.6	1.9	4.9	ND	ND
6/8/1999	PB 02	NA	NA	NA	ND	1	ND	ND	31	ND	ND	ND	ND	ND
6/8/1999	PB 03	NA	NA	NA	ND	3.8	ND	ND	71	5.7	ND	1.8	ND	ND
6/8/1999	PB 04	NA	NA	NA	ND	6.4	ND	ND	75	7.5	ND	ND	ND	ND
6/8/1999	PB 05	NA	NA	NA	ND	3	ND	ND	57	7.9	1.7	37	ND	ND
6/8/1999	PB 06	NA	NA	NA	ND	ND	ND	ND	24	1.9	38	2.3	ND	ND
6/8/1999	PB 07	NA	NA	NA	ND	3.4	ND	1.4	49	1.4	140	19	ND	ND
6/8/1999	PB 08	NA	NA	NA	ND	ND	ND	ND	79	ND	8.3	41	ND	ND
6/8/1999	PB 09	NA	NA	NA	ND	ND	ND	53	3600	740	ND	2300	ND	ND
6/8/1999	PB 10	NA	NA	NA	ND	ND	ND	320	22000	880	5700	6200	ND	ND
9/2/1999	PB 11	2	19.6	1	ND	ND	ND	ND	15	ND	ND	390	ND	ND
9/2/1999	PB 12 (avg)	2	20	0.83	ND	4.85	2	50	3800	140	ND	2350	ND	ND
9/2/1999	LS-02	6.8	18.8	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	LS-03	5.8	18.8	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	LS-04	5.6	19.8	1.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	LS-05	6.8	NA	1.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	LS-06	9.9	18.9	1.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	LS-07	NA	18.9	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	LS-08	5.8	19.0	1	ND	ND	ND	ND	1	ND	ND	ND	ND	ND
9/2/1999	LS-09	5	19.5	1.5	ND	ND	ND	ND	3	ND	ND	ND	ND	ND
9/2/1999	LS-10	2.5	20.5	1	ND	19	3.4	48	6300	50	27	4100	ND	ND
9/2/1999	PB 13	NA	NA	NA	ND	12	ND	26	4300	180	2300	170	ND	2.1
9/2/1999	PB 14	NA	NA	0.75	ND	69	ND	5.4	640	9	250	7	ND	ND
9/2/1999	PB 15	NA	NA	0.5	ND	1.3	ND	ND	14	ND	ND	ND	ND	ND

Date	Location	Water Depth	Water Temperature	Depth into sediments	Benzene	1,1DCA	1,2DCA	1,1DCE	cis-1,2DCE	trans-1,2DCE	TCE	VC	1,1,1TCA	1,1,2 TCA
		Feet	C°	Feet	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
9/2/1999	PB 16	NA	NA	0.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 17	NA	NA	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 18	NA	NA	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 19	NA	NA	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 20	NA	NA	0.58	ND	ND	ND	ND	ND	ND	ND	ND	1.9	ND
9/2/1999	PB 21	NA	NA	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 22	NA	NA	0.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 23	NA	NA	0.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 24	NA	NA	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 25	NA	NA	0.42	ND	2.9	ND	ND	ND	ND	ND	ND	ND	ND
9/2/1999	PB 26	NA	NA	0.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12/15/2000	PB 30[B]	NA	NA	NA	ND	ND	ND	130	14000	620	3800	4600	ND	ND
3/22/2000	PB 40	2	7.9	0.83	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/22/2000	PB 41	2	8.8	0.67	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/22/2000	PB 42	2	8.0	0.67	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/22/2000	LS 20	2	8.9	0.6	ND	ND	ND	130	5200	360	4800	5300	ND	ND
3/22/2000	LS 22	1.5	8.9	0.75	ND	ND	ND	ND	1500	110	800	3000	ND	ND
3/22/2000	LS 23	1.5	9.5	0.5	ND	ND	ND	89	3300	240	6400	1800	ND	ND
3/22/2000	LS 24	2	9.6	0.67	ND	62	ND	190	19000	810	370	9100	ND	ND
3/22/2000	LS 25A	1.8	9.3	1.1	ND	ND	ND	70	3700	200	630	4600	ND	ND
3/22/2000	LS 26	2	9.0	1	ND	ND	ND	85	3500	340	1400	1700	ND	ND
3/22/2000	LS 27	1	9.8	0.9	ND	ND	ND	ND	1.5	ND	8.4	ND	ND	ND
3/22/2000	LS 28	2	9.0	0.8	ND	10	ND	2.2	80	1.2	180	25	ND	ND
3/22/2000	LS 29	NA	NA	NA	ND	2.8	ND	ND	110	1.35	7.95	34.5	ND	ND
3/22/2000	LS 30	3	7.9	1.5	ND	ND	ND	ND	4.4	ND	3.7	ND	ND	ND
2/21/2001	LS 50 (avg)	0.25	NA	1.6	ND	4.6	ND	ND	58	5.15	82.5	9.05	ND	0.7

Date	Location	Water Depth	Water Temperature	Depth into sediments	Benzene	1,1DCA	1,2DCA	1,1DCE	cis-1,2DCE	trans-1,2DCE	TCE	VC	1,1,1TCA	1,1,2TCA
		Feet	Cº	Feet	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
2/21/2001	LS 51	1.1	1.5	0.9	1.4	43	ND	33	2600	76	980	960	ND	ND
2/21/2001	LS 52	0.25	1.0	0.7	ND	21	3.5	4.8	1300	53	36	150	ND	7.3
7/19/2001	LS 55	3.5	21.8	0.85	1.2	55	7.8	260	15000	390	2900	7000	ND	ND
7/19/2001	LS 56	3.5	22.1	0.85	ND	ND	3.5	65	6400	100	27	4300	ND	ND
7/19/2001	LS 57	4	21.9	1	1.3	ND	2.2	150	13000	940	2400	4600	ND	ND
7/19/2001	LS 58	3	21.9	1	ND	16	1.7	ND	1100	7.1	ND	8300	ND	ND
7/19/2001	LS 59	2.5	22.4	1	ND	2.8	ND	ND	18	ND	ND	130	ND	ND
9/24/2001	DEQ-P12-12	NA	16.7	1	ND	50	ND	280	17000	550	2600	4700	ND	ND
9/24/2001	DEQ-P2-2	NA	16.8	NA	ND	ND	ND	ND	35	1.3	9.4	4.6	ND	ND
9/24/2001	DEQ-P2-3	NA	19.6	NA	ND	ND	ND	ND	200	ND	38	110	ND	ND
9/24/2001	DEQ-P3-3	NA	19.8	0.5	ND	ND	ND	ND	110	ND	ND	3500	ND	ND
2/27/2003	Hole 1	2	4.1	1	ND	ND	ND	ND	14	ND	96	ND	ND	ND
2/27/2003	Hole 2	3.67	2.5	0.83	ND	2.5	ND	ND	54	4.9	1.3	6.4	ND	ND
2/27/2003	Hole 3	3.83	2.5	0.75	ND	ND	ND	ND	12	1.1	82	ND	ND	ND
2/27/2003	Hole 4	2.67	3.0	0.83	ND	ND	ND	ND	2700	98	4400	960	ND	ND
2/27/2003	Hole 5	2.5	2.5	1	ND	ND	ND	ND	2500	ND		1400	ND	ND
2/27/2003	Hole 6	1.5	5.0	1.17	ND	55	ND	68	2000	91	3500	350	ND	1.7
6/5/2003	BPW #1	1.17	13.4	0.83	ND	ND	ND	ND	ND	ND	5	ND	ND	ND
6/5/2003	BPW #2	0.67	13.7	0.67	ND	ND	ND	ND	ND	ND	1.6	ND	ND	ND
6/5/2003	BPW #3	2	13.4	1	ND	13	ND	3.2	120	1.9	79	22	ND	ND
6/5/2003	BPW #4	3.5	13.1	1.67	ND	4.3	ND	3.5	59	1.2	62	90	ND	ND
6/5/2003	BPW #5	3.5	13.3	1	ND	ND	ND	ND	10	ND	ND	14	ND	ND
6/5/2003	BPW #6	3.5	13.4	1	ND	ND	ND	ND	7.1	ND	ND	57	ND	ND
6/5/2003	BPW #7	2	13.2	2	ND	ND	ND	ND	30	2.3	ND	15	ND	ND
6/5/2003	BPW #8	1.17	13.3	0.75	ND	ND	ND	ND	6.8	1.3	4.3	3.9	ND	ND
6/5/2003	BPW #9	3.2	13.0	0.83	ND	ND	1.5	ND	3.7	ND	ND	200	ND	ND
6/6/2003	BPW #10	2.5	13.4	1	ND	ND	ND	ND	90	1.5	2	260	ND	ND
6/6/2003	BPW #11	1.5	13.3	0.83	ND	16	ND	1.7	350	6	5.2	480	ND	ND

Date	Location	Water Depth	Water Temperature	Depth into sediments	Benzene	1,1DCA	1,2DCA	1,1DCE	cis-1,2DCE	trans-1,2DCE	TCE	VC	1,1,1TCA	1,1,2 TCA
		Feet	C°	Feet	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
6/6/2003	BPW #12	1	13.4	1	ND	8.6	ND	ND	34	2.9	9.7	19	ND	ND
6/6/2003	BPW #13 (avg)	1.5	13.4	1	0.65	32	1.05	3.05	805	87.5	22	285	ND	1.9
6/6/2003	BPW #14	2	13.7	1	1.9	73	5.8	260	36000	1600	11000	6000	ND	ND
6/6/2003	BPW #15	2.5	13.4	1.5	ND	95	5.7	270	34000	1100	54	6300	ND	ND
6/6/2003	BPW #16	4	13.8	0.83	ND	ND	ND	ND	ND	ND	ND	15	ND	ND
6/6/2003	BPW #17	4	13.0	0.83	ND	11	ND	55	4600	270	ND	5500	ND	ND
6/6/2003	BPW #18	2.8	13.5	1	ND	11	ND	120	6400	220	3300	3300	ND	ND
6/6/2003	BPW #19 (avg)	2.5	13.8	0.67	ND	ND	ND	610	8050	ND	4350	1650	ND	ND
6/6/2003	BPW #20	1.17	13.9	1.5	ND		ND	ND	39	1.4	26	1.5	ND	ND
6/6/2003	BPW #21	1	13.5	0.75	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6/2003	BPW #22	2	13.4	1.08	ND	ND	ND	ND	3800	ND	1000	560	ND	ND
6/6/2003	BPW #23	3.2	13.3	1.25	ND	ND	ND	ND	2000	ND	ND	1800	ND	ND
6/6/2003	BPW #24	4.3	13.3	1.08	ND	ND	ND	ND	ND	ND	ND	130	ND	ND
6/6/2003	BPW #25	4	13.2	1.17	ND	ND	ND	ND	ND	ND	ND	160	ND	ND
6/6/2003	BPW #26	3	13.3	1.17	ND	3	ND	ND	ND	ND	1.1	30	ND	ND
6/6/2003	BPW #27	3	13.7	0.67	ND	ND	ND	ND	1800	ND	690	190	ND	ND
6/6/2003	BPW #28	2.5	13.8	0.58	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/6/2003	BPW #29	2	13.6	1	ND	37	ND	5.6	280	ND	180	14	ND	ND
6/6/2003	BPW #30	3.5	13.3	1.08	ND	ND	ND	ND	82	ND	ND	140	ND	ND
6/6/2003	BPW #31	3.5	12.8	1.5	ND	ND	ND	ND	57	1.1	ND	13	ND	ND
6/6/2003	BPW #32 (avg)	2.3	13.2	1.17	ND	3.3	ND	ND	51	1.65	ND	4.4	ND	ND
6/6/2003	BPW #33	2	14.0	0.58	ND	ND	ND	ND	ND	ND	1.1	13	ND	ND
6/6/2003	BPW #34	2.5	13.6	0.83	ND	ND	ND	ND	1.9	ND	ND	ND	ND	ND
10/13/2004	BPW #60	2	15.1	0.83	1.3	33	15	210	25000	1800	11000	7300	ND	ND
10/13/2004	BPW #61	2	15.1	0.83	1	32	13	190	30000	1600	9300	6100	ND	ND

Date	Location	Water Depth	Water Temperature	Depth into sediments	Benzene	1,1DCA	1,2DCA	1,1DCE	cis-1,2DCE	trans-1,2DCE	TCE	VC	1,1,1TCA	1,1,2 TCA
		Feet	Cº	Feet	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
10/13/2004	BPW #62	2	15.1	0.67	ND	ND	ND	ND	22000	1400	5300	5600	ND	ND
10/13/2004	BPW #63	2	15.1	0.83	ND	ND	ND	ND	39000	1800	12000	6500	ND	ND
10/13/2004	BPW #64	2	15.1	0.75	ND	ND	ND	ND	36000	1600	13000	5500	ND	ND
10/13/2004	BPW #65	2	15.1	0.83	ND	ND	ND	ND	15000	1100	ND	6100	ND	ND
10/13/2004	BPW #66	2	15.1	0.83	5	20	3.8	71	7100	750	92	4200	ND	ND
10/13/2004	BPW #67	2.2	15.1	0.83	ND	ND	ND	ND	22000	1100	5700	5500	ND	ND
10/13/2004	BPW #68	2.5	15.0	0.75	ND	ND	ND	ND	40000	1600	15000	8200	ND	ND
11/3/2004	BPW-1-04	1.2	12.3	0.83	ND	ND	ND	ND	2.1	ND	15	ND	ND	ND
11/3/2004	BPW-2-04	3.2	12.6	1	ND	12	ND	2.5	33	ND	260	11	ND	ND
11/3/2004	BPW-3-04 (avg)	4	12.1	0.67	ND	7.35	ND	2.15	30	ND	170	4.8	ND	ND
11/3/2004	BPW-4-04	4.9	12.3	0.67	ND	7.1	ND	ND	4.9	ND	ND	43	ND	ND
11/3/2004	BPW-5-04	5.2	12.3	0.5	ND	ND	ND	ND	16	ND	ND	55	ND	ND
11/3/2004	BPW-6-04	5	12.3	1	ND	ND	ND	ND	110	3.4	ND	ND	ND	ND
11/3/2004	BPW-7-04	4.5	12.2	0.58	ND	ND	ND	ND	3.1	ND	1.6	6.8	ND	ND
11/3/2004	BPW-8-04	3	12.2	0.58	ND	ND	ND	ND	41	5.1	6.3	1.6	ND	ND
11/3/2004	BPW-9-04	4.7	11.5	0.83	ND	ND	ND	ND	60	ND	ND	310	ND	ND
11/3/2004	BPW-10-04	4.5	11.9	1	ND	ND	ND	ND	11	ND	1.6	5.2	ND	ND
11/3/2004	BPW-11-04	3.2	11.7	0.67	ND	ND	ND	8.6	180	ND	13	63	ND	ND
11/3/2004	BPW-12-04	2.5	12.3	1.17	ND	1.9	ND	2	300	16	30	10	ND	ND
11/4/2004	BPW-13-04	2.9	11.3	0.83	ND	15	ND	22	3700	140	2400	75	ND	ND
11/4/2004	BPW-14-04	3.5	11.0	0.83	ND	ND	ND	200	24000	1600	3100	5000	ND	ND
11/4/2004	BPW-15-04	4.8	11.1	0.58	ND	ND	ND	120	16000	1000	180	4800	ND	ND
11/4/2004	BPW #71	3	11.4	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/4/2004	BPW #72	4	11.0	1	ND	ND	ND	160	17000	420	4000	5200	ND	ND

Date	Location	Water Depth	Water Temperature	Depth into Sediments	Benzene	1,1DCA	1,2DCA	1,1DCE	cis-1,2DCE	Trans-1,2DCE	TCE	VC	1,1,1 TCA	1,1,2 TCA
		Feet	Cº	Feet	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
10/4/2005	BPW091	3.5	13.5	1.00	ND	ND	ND	ND	35,000	1,900	12,000	4,200	ND	ND
10/4/2005	BPW095	3	18.7	1.08	ND	ND	ND	ND	33,000	1,900	3,600	3,700	ND	ND
10/4/2005	BPW099	4	19.2	1.00	ND	ND	ND	ND	29,000	1,500	8,300	4,600	ND	ND
10/4/2005	BPW102	3	18.7	1.17	ND	ND	ND	ND	29,000	1,800	14,000	5,100	ND	ND
11/8/2005	BPW110	NA	NA	NA	ND	ND	ND	ND	46.0	ND	ND	8.3	ND	ND
11/8/2005	BPW111	NA	NA	NA	ND	ND	ND	ND	17.0	ND	ND	39.0	ND	ND
11/8/2005	BPW112	NA	NA	NA	ND	12.0	ND	ND	4.3	ND	ND	38.0	ND	ND
11/8/2005	BPW113	NA	NA	NA	ND	ND	ND	ND	170	ND	ND	76.0	ND	ND
11/8/2005	BPW114	NA	NA	NA	ND	ND	1.0	ND	400	3.0	ND	ND	ND	ND
11/8/2005	BPW115	NA	NA	NA	ND	ND	ND	100	8,300	480	ND	2,200	ND	ND
11/8/2005	BPW116	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND	23.0	ND	ND
11/8/2005	BPW117	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/8/2005	BPW118	NA	NA	NA	ND	ND	ND	ND	62.0	ND	ND	35.0	ND	ND
11/8/2005	BPW119	NA	NA	NA	ND	ND	ND	ND	49.0	ND	ND	2.4	ND	ND
11/8/2005	BPW120	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/8/2005	BPW121	NA	NA	NA	ND	ND	ND	ND	17.0	ND	ND	3.9	ND	ND
11/8/2005	BPW122 (avg)	NA	NA	NA	ND	6.6	ND	1.6	120	1.2	16.0	5.8	ND	ND
11/8/2005	BPW123	NA	NA	NA	ND	ND	ND	ND	2.0	ND	ND	ND	ND	ND
11/8/2005	BPW124	NA	NA	NA	ND	ND	ND	ND	ND	ND	28.0	ND	ND	ND
11/8/2005	BPW125	NA	NA	NA	ND	7.4	ND	ND	150	ND	ND	140	ND	ND
11/8/2005	BPW126	NA	NA	NA	ND	18.0	ND	2.0	310	3.0	ND	110	ND	ND
11/8/2005	BPW127	NA	NA	NA	ND	ND	ND	ND	720	45.0	ND	700	ND	ND
11/8/2005	BPW128	NA	NA	NA	ND	ND	ND	ND	1,500	ND	ND	460	ND	ND

Date	Location	Water Depth	Water Temperature	Depth into Sediments	Benzene	1,1DCA	1,2DCA	1,1DCE	cis-1,2DCE	trans-1,2DCE	TCE	VC	1,1,1 TCA	1,1,2 TCA
		Feet	C°	Feet	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
11/8/2005	BPW129	NA	NA	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11/8/2005	BPW130	NA	NA	NA	ND	ND	ND	ND	5,400	280	4,100	3,100	ND	ND
11/8/2005	BPW131	NA	NA	NA	ND	54.0	ND	ND	3,400	240	920	1,300	ND	ND
11/8/2005	BPW132	NA	NA	NA	ND	ND	ND	ND	15.0	ND	7.0	ND	ND	ND
11/8/2005	BPW133 (avg)	NA	NA	NA	ND	ND	ND	ND	6,250	610	ND	3,150	ND	ND
11/8/2005	BPW134	NA	NA	NA	ND	ND	ND	ND	7.3	ND	ND	50.0	ND	ND
11/8/2005	BPW135	NA	NA	NA	ND	10	ND	3.0	38.0	1.3	86.0	8.9	ND	ND
11/8/2005	BPW136	NA	NA	NA	ND	ND	ND	150	23,000	1,700	ND	3,300	ND	ND
11/8/2005	BPW137	NA	NA	NA	ND	ND	ND	ND	30.0	1.0	ND	170	ND	ND
11/8/2005	BPW138	NA	NA	NA	ND	ND	ND	ND	1.1	ND	52.0	ND	ND	ND
11/8/2005	BPW139	NA	NA	NA	ND	ND	ND	ND	5.8	ND	3.5	ND	ND	ND
11/9/2005	BPW140	NA	NA	NA	ND	3.3	ND	ND	56.0	4.1	11.0	ND	ND	ND
11/9/2005	BPW141	NA	NA	NA	ND	ND	ND	ND	29.0	1.4	ND	4.2	ND	ND
11/9/2005	BPW142	NA	NA	NA	ND	6.2	ND	2.1	45.0	5.1	12.0	50.0	ND	ND
11/9/2005	BPW143	NA	NA	NA	ND	ND	ND	180	31,000	1,900	ND	3,500	ND	ND
11/9/2005	BPW144	NA	NA	NA	ND	ND	ND	ND	1.7	ND	ND	ND	ND	ND

[A] Shaded results were used in the interim risk estimates and fall within the central plume discharge area as shown in Appendix 2, Figure 3.
[B] Sample collected at PB10 Location during stormy seas
ND: not detectable NA: not available

Appendix 4. Concentrations of chlorinated hydrocarbons in surface water samples collected from Lake in and near the discharge area of the groundwater contaminant plume. All concentrations are expressed in ug/l (ppb).

Location	Year	VC	1,1DCE	t 1,2DCE	1,1DCA	c 1,2DCE	1,2DCA	TCE	1,1,1TCA
SW-N-S1-7A	1999	ND	ND	ND	ND	**1.4**	ND	**1.2**	**1.3**
SW-N-S1-9A	1999	ND	ND	ND	ND	ND	ND	ND	ND
SW-N-S1-11A	1999	ND	ND	ND	ND	ND	ND	ND	ND
SW-N-S1-1A	1999	ND	ND	ND	ND	ND	ND	ND	ND
SW-N-S1-3A	1999	ND	ND	ND	ND	**1.3**	ND	**1**	ND
SW-N-S1-5A	1999	ND	ND	ND	ND	**2.2**	ND	**1.4**	ND
SW-N-S2-10AD	1999	ND	ND	ND	ND	ND	ND	ND	ND
SW-N-S2-10AS	1999	ND	ND	ND	ND	ND	ND	ND	ND
SW-N-S2-2AD	1999	ND	ND	ND	ND	ND	ND	ND	ND
SW-N-S2-4AD	1999	**2.1**	ND	ND	ND	**8**	**6.1**	ND	ND
SW-N-S2-6AD	1999	ND	ND	ND	ND	**1.4**	ND	ND	ND
SW-N-S2-6AS	1999	ND	ND	ND	ND	**2**	ND	**1.1**	ND
SW-N-S2-8AD	1999	ND	ND	ND	ND	ND	ND	ND	ND
SW-N-S2-8AS	1999	ND	ND	ND	ND	ND	ND	ND	ND
SW-N-S2-SAS	1999	ND	ND	ND	ND	ND	ND	ND	ND
LW 02	1999	**7.8**	ND	**1.1**	ND	**14**	ND	ND	**2.3**
LS 01	1999	ND	ND	ND	ND	ND	ND	ND	ND
LS 21	2000	**4.8**	ND	ND	ND	ND	**13**	ND	**8.5**
LS 25D	2000	**2.6**	ND	ND	ND	ND	**6.5**	ND	**4.5**
P1-1-DSW&dup	2001	ND	ND	ND	ND	ND	ND	ND	ND
P1-1-SSW	2001	**2**	ND	ND	ND	**1.6**	ND	**1**	ND
P1-2-DSW	2001	ND	ND	ND	ND	ND	ND	**2.1**	ND
P1-3-DSW	2001	ND	ND	ND	ND	**1.7**	ND	ND	ND
P1-4-DSW	2001	**13**	ND	**3.1**	ND	**51**	ND	**40**	ND
P2-2-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
P2-4-DSW&dup	2001	ND	ND	ND	ND	**1.9**	ND	ND	ND

Location	Year	VC	1,1DCE	t 1,2DCE	1,1DCA	c 1,2DCE	1,2DCA	TCE	1,1,1TCA
P2-4-SSW	2001	ND	ND	ND	ND	**2.7**	ND	ND	ND
P2-5-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
P3-1-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
P3-2-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
P3-3-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
P3-4-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
P4-2-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
P4-3-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
P4-4-DSW	2001	ND	ND	ND	ND	ND	ND	ND	ND
SSW-1	2001	ND	ND	ND	ND	ND	ND	ND	ND
SSW-2	2001	ND	ND	ND	ND	ND	ND	ND	ND
SSW-3	2001	ND	ND	ND	ND	ND	ND	ND	ND
SSW-4	2001	ND	ND	ND	ND	ND	ND	ND	ND
SSW-5	2001	ND	ND	ND	ND	ND	ND	ND	ND
SSW-6	2001	ND	ND	ND	ND	ND	ND	ND	ND
SSW-7	2001	**47**	ND	ND	**10**	**48**	ND	ND	ND
SSW-8	2001	ND	ND	ND	ND	ND	ND	ND	ND
SW-1	2003	ND	ND	ND	ND	**0.9**	ND	**0.5**	ND
SW-2	2003	ND	ND	ND	ND	**0.9**	ND	ND	ND
SW-3	2003	**0.2**	ND	ND	ND	**2**	ND	ND	ND
SW-4	2003	ND	ND	ND	ND	**1**	ND	ND	ND
SW-5	2003	**0.1**	ND	ND	ND	**1**	ND	ND	ND
SW-6&dup	2003	ND	ND	ND	ND	ND	ND	ND	ND
SW7	2003	ND	ND	ND	ND	ND	ND	ND	ND

Location	Year	VC	1,1DCE	t 1,2DCE	1,1DCA	c 1,2DCE	1,2DCA	TCE	1,1,1TCA
SW-1	2004	**2.9**	ND	ND	ND	**11.3**	ND	**5.7**	ND
SW-1&dup [4]	2004	**2**	ND	**0.95**	ND	**15.5**	ND	**4**	ND
SW-2	2004	ND	ND	ND	ND	ND	ND	ND	ND
SW-2 [4]	2004	**1.5**	ND	**0.09**	ND	**12**	ND	**3**	ND
SW-3	2004	**0.85**	ND	ND	ND	ND	ND	ND	ND
SW-3[4]	2004	ND	ND	**0.6**	ND	**2.5**	ND	**2**	ND
BPW090	2005	**1.5**	ND	ND	ND	**13.0**	ND	**2.2**	ND
BPW094	2005	**1.1**	ND	ND	ND	**10.0**	ND	**1.1**	ND
BPW098	2005	ND	ND	ND	ND	**4.5**	ND	ND	ND
BPW101	2005	ND	ND	ND	ND	**2.8**	ND	ND	ND
BPW092	2005	**1.4**	ND	ND	ND	**12.0**	ND	**1.8**	ND
BPW093	2005	ND	ND	ND	ND	**3.7**	ND	ND	ND
BPW096	2005	**1.6**	ND	ND	ND	**18.0**	ND	**1.8**	ND
BPW097	2005	**4.5**	ND	**1.7**	ND	**42.0**	ND	**8.2**	ND
BPW100	2005	ND	ND	ND	ND	**4.5**	ND	ND	ND
BPW103	2005	ND	ND	ND	ND	**5.6**	ND	ND	ND
BPW103 Dup.	2005	ND	ND	ND	ND	**5.3**	ND	ND	ND

Appendix 5. Chemical and Scenario Specific Estimates of Incremental Cancer Risk.

Dermal Exposure

Scenario (age range)		**Child (1 to 6 yrs old)**				**Adolescent (7 to 14 yr old)**			
No. years of exposure		**1 year**		**6 years**		**1 year**		**8 years**	
No. exposure events/year		**7 Events**	**36 Events**	**7 Events**	**36 Events**	**7 Events**	**36 Events**	**7 Events**	**36 Events**
Chemical	EPC (ppb)								
Benzene	1.3	1.0E-10	5.3E-10	6.2E-10	6.7E-09	7.0E-11	3.6E-10	5.4E-10	2.9E-09
1,2-Dichloroethane	3.5	9.3E-11	4.8E-10	5.6E-10	5.8E-09	6.3E-11	3.2E-10	5.0E-10	2.6E-09
1,1,2-Trichloroethane	2	1.0E-10	5.2E-10	6.0E-10	5.8E-09	6.8E-11	3.5E-10	5.4E-10	2.8E-09
Trichloroethylene	3,000	2.8E-08	1.5E-07	1.7E-07	1.6E-06	1.9E-08	9.9E-08	1.5E-07	7.9E-07
Vinyl chloride	4,100	3.9E-06	2.0E-05	2.3E-05	2.6E-04	2.6E-06	1.3E-05	2.1E-05	1.1E-04
Total Dermal Risk	NA	3.9E-06	2.0E-05	2.3E-05	1.2E-04	2.6E-06	1.4E-05	2.1E-05	1.1E-04

Ingestion Exposure

Benzene	NT	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethane	13	6.9E-10	3.5E-09	4.1E-09	2.1E-08	2.5E-10	1.3E-9	2.0E-9	1.0E-08
1,1,2-Trichloroethane	ND	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethylene	40	2.2E-10	1.1E-09	1.3E-09	6.8E-09	8.0E-11	4.1E-10	6.4E-10	3.3E-09
Vinyl chloride	47	6.4E-08	3.3E-07	3.9E-07	2.0E-06	2.4E-08	1.2E-07	1.9E-07	9.7E-07
Total Ingestion Risk	NA	6.5E-08	3.4E-07	3.9E-07	2.0E-06	2.4E-08	1.2E-07	1.9E-07	9.8E-07

NA: Not applicable

NT: No analytical analyses conducted for this chemical in surface water.

ND: Analyzed for but not detected.

Appendix 6. Chemical and Scenario Specific Estimates of Noncancer Hazard Quotients.

Dermal Exposure

Scenario (age range)		**Child (1 to 6 yrs old)**				**Adolescent (7 to 14 yr old)**			
No. years of exposure		**1 year**		**6 years**		**1 year**		**8 years**	
No. exposure events/year		**7 Events**	**36 Events**	**7 Events**	**36 Events**	**7 Events**	**36 Events**	**7 Events**	**36 Events**
Chemical	EPC (ppb)								
Benzene	1.3	5.5E-06	2.8E-05	3.3E-05	1.7E-04	2.8E-06	1.4E-05	2.2E-05	1.1E-04
1,1-Dichloroethane	20.5	1.5E-06	7.7E-06	9.0E-06	4.6E-05	7.6E-07	3.9E-06	6.1E-06	3.1E-05
1,2-Dichloroethane	3.5	NA	NA	NA	NA	NA	NA	NA	NA
1,1-Dichloroethylene	120	2.0E-04	1.0E-03	1.2E-03	6.1E-03	1.0E-04	5.1E-04	8.0E-04	4.1E-03
cis-1,2-Dichloroethylene	6,400	5.7E-03	2.9E-02	3.4E-02	1.7E-01	2.9E-03	1.5E-02	2.3E-02	1.2E-01
trans-1,2-Dichloroethylene	610	5.0E-04	2.6E-03	3.0E-03	1.5E-02	2.5E-04	1.3E-03	2.0E-03	1.0E-02
1,1,1-Trichloroethane	ND	NA	NA	NA	NA	NA	NA	NA	NA
1,1,2-Trichloroethane	2	5.1E-06	2.6E-05	3.1E-05	1.6E-04	2.6E-06	1.3E-05	2.1E-05	1.0E-04
Trichloroethylene	3,000	3.1E-03	1.6E-02	1.8E-02	9.5E-02	1.6E-03	8.0E-03	1.2E-02	6.4E-02
Vinyl chloride	4,100	1.0E-02	5.2E-02	6.0E-02	3.1E-01	5.1E-03	2.6E-02	4.1E-02	2.1E-01
Summed Dermal Hazard		1.9E-02	1.0E-01	1.2E-01	6.0E-01	9.9E-03	5.1E-02	7.9E-02	4.1E-01

Ingestion Exposure

Benzene	NT	NA	NA	NA	NA	NA	NA	NA	NA
1,1-Dichloroethane	10	8.9E-07	4.6E-06	5.3E-06	2.7E-05	2.4E-07	1.3E-06	1.9E-06	1.0E-05
1,2-Dichloroethane	13	NA	NA	NA	NA	NA	NA	NA	NA
1,1-Dichloroethylene	ND	NA	NA	NA	NA	NA	NA	NA	NA
cis-1,2-Dichloroethylene	51	4.9E-05	2.5E-04	3.0E-04	1.5E-03	1.4E-05	7.0E-05	1.1E-04	5.6E-04
trans-1,2-Dichloroethylene	3.1	1.9E-06	1.0E-05	1.2E-05	6.0E-05	5.3E-07	2.7E-06	4.3E-06	2.2E-05
1,1,1-Trichloroethane	8.5	4.1E-08	2.1E-07	2.5E-07	1.3E-06	1.1E-08	5.8E-08	9.0E-08	4.6E-07
1,1,2-Trichloroethane	ND	NA	NA	NA	NA	NA	NA	NA	NA
Trichloroethylene	40	2.4E-05	1.2E-04	1.4E-04	7.3E-04	6.5E-06	3.3E-05	5.2E-05	2.7E-04
Vinyl chloride	47	1.7E-04	8.6E-04	1.0E-03	5.2E-03	4.6E-05	2.4E-04	3.7E-04	1.9E-03
Summed Ingestion Hazard		2.4E-04	1.2E-03	1.5E-03	7.5E-03	6.7E-05	3.4E-04	5.3E-04	2.7E-03

NA: Not applicable.
NT: No analytical analyses conducted for this chemical in surface water.
ND: Analyzed for but not detected.