Public Health Assessment

Final Release

VELSICOL BURN PIT
(a/k/a FORMER BURN AREA)
ST. LOUIS, GRATIOT COUNTY, MICHGAN

EPA FACILITY ID: MIN000510389

Prepared by the
Michigan Department of Community Health

MARCH 27, 2013

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR's Cooperative Agreement Partner pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 45-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

Velsicol Burn Pit (also known as the Former Burn Area), St Louis (Gratiot County), Michigan
(EPA ID# MIN000510389)

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Foreword

The Michigan Department of Community Health (MDCH) conducted this evaluation for the federal Agency for Toxic Substances and Disease Registry (ATSDR) under a cooperative agreement. ATSDR conducts public health activities (assessments/consultations, advisories, education) at sites of environmental contamination. The purpose of this document is to identify potentially harmful exposures and recommend actions that would minimize those exposures. This is not a regulatory document and does not evaluate or confirm compliance with laws. This is a publicly available document and is provided to the appropriate regulatory agencies for their consideration.

The following steps are necessary to conduct public health assessments/consultations:

- Evaluating exposure: MDCH toxicologists begin by reviewing available information about environmental conditions at the site: how much contamination is present, where it is found on the site, and how people might be exposed to it. This process requires the measurement of chemicals in air, water, soil, or animals. Usually, MDCH does not collect its own environmental sampling data. We rely on information provided by the Michigan Department of Environmental Quality (MDEQ), U.S. Environmental Protection Agency (EPA), and other government agencies, businesses, and the general public.

- Evaluating health effects: If there is evidence that people are being exposed – or could be exposed – to hazardous substances, MDCH toxicologists then determine whether that exposure could be harmful to human health, using existing scientific information. The report focuses on public health – the health impact on the community as a whole.

- Developing recommendations: In its report, MDCH outlines conclusions regarding any potential health threat posed by a site, and offers recommendations for reducing or eliminating human exposure to contaminants. If there is an immediate health threat, MDCH will issue a public health advisory warning people of the danger, and will work with the appropriate agencies to resolve the problem.

- Soliciting community input: The evaluation process is interactive. MDCH solicits and considers information from various government agencies, parties responsible for the site, and the community. If you have any questions or comments about this report, we encourage you to contact us.

Please write to: Toxicology and Response Section
Division of Environmental Health
Michigan Department of Community Health
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Or call us at: 1-800-648-6942 (toll free)

For more information, please visit:
www.michigan.gov/mdch-toxics

Table of Contents

List of Tables

List of Figures

List of Appendices

Acronyms and Abbreviations

µg/L	micrograms per liter
1,2-DCA	1,2-dichloroethane
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BHC	benzene hexachloride
DBCP	1,2-dibromo-3-chloropropane
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
EPA	United States Environmental Protection Agency
VBP	Velsicol Burn Pit
HBB	Hexabromobenzene
HEM	n-hexane extractable material
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MDNRE	Michigan Department of Natural Resources and the Environment
NAPL	non-aqueous phase liquid
NPL	National Priorities List
PBB	polybrominated biphenyls
PCB	polychlorinated biphenyls
pCBSA	para-chlorobenzene sulfonic acid
RDWC	Residential Drinking Water Criteria
SVOC	semivolatile organic chemicals
TRIS	tris(2,3-dibromopropyl) phosphate
VAS	vertical aquifer sampling
VOCs	volatile organic chemicals

Summary

The Velsicol Burn Pit (VBP), also called the Former Burn Area, was proposed to the National Priorities List (NPL) in September 2009 and was added to the NPL in March 2010. The site is located partially in an out-of-bounds area on the Hidden Oaks Golf Course and partially off of the Hidden Oaks Golf Course property. It is the former waste burning and disposal site for the Velsicol Chemical Plant and its predecessor, Michigan Chemical Corporation. A variety of chemicals were disposed of and burned with solid waste from the plant at this site from the 1950s to 1970. Contaminants might have migrated or be migrating into groundwater below the site and may, in the future, migrate into groundwater under nearby residential areas. The Michigan Department of Community Health (MDCH) assesses the human health risk present at all NPL (also called Superfund) sites in Michigan under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). The purpose of this document is to identify potentially harmful human exposures to contaminants from the VBP, and does not include discussion of contaminated material in the Pine River or at the Velsicol Chemical Corporation plant site in St Louis, Michigan.

MDCH's conclusions regarding contaminants from the VBP are as follows:

Contaminants present in the soil at the site will not harm people's health. Levels of contaminants present in the soil are, for almost all samples, below the applicable screening levels. Visitors, including golfers, to the golf course around the VBP are expected to have little to no contact with the VBP soil as it is not on the golf course, and it has vegetation growing on it that could prevent soil from being blown onto the golf course. Workers at the golf course are not expected to have contact with the soil.

Next steps: No additional public health activities are necessary at this time.

Not enough information is available to determine if the contaminants present in the ash piles at the VBP could harm worker's and visitor's health. Only one sample was taken from the surface of each ash pile. Levels of arsenic and lead in both ash piles were higher than the health-based screening levels. Workers and visitors to the golf course are not expected to have contact with the ash piles; the VBP is not on the active golf course. However, it is not known how large the ash piles are, if contaminant levels are consistent throughout the pile, or if existing vegetation would prevent ash from being blown on to the golf course. Currently, there is no fence around the ash piles or the rest of the VBP that would limit people's access.

Next steps: MDCH recommends that ash piles be further characterized. Additional characterization of ash pile contaminants is necessary.

Levels of contaminants in the soil from the residential area downwind of the VBP are not expected to harm resident's health. Overall, contaminant levels in the downwind residential area were below applicable health-based screening levels.

Next steps: No additional public health activities are necessary at this time.

Contaminants from the VBP may be migrating into groundwater; however, current levels of contaminants in the groundwater at the site are not expected to harm visitor's or worker's health because people have little to no contact with groundwater at the VBP. Contaminants that migrate into the groundwater from the contaminated soil or the non-aqueous phase liquid (NAPL) could, in the future, reach residential private wells or municipal drinking water if the migration continues.

> Next steps: Further contaminant migration should be prevented and groundwater contaminant levels should be evaluated in the future.

Levels of contaminants in the three drinking water wells, one from the Hidden Oaks Golf Course and two from the neighborhood near the site, are not expected to harm people's health. Because contaminants may continue to migrate into the groundwater, contamination levels in monitoring wells surrounding the site should continue to be monitored in the future. Thirty-two monitoring wells have been installed in the VBP or nearby areas to identify the extent that chemicals from the VBP have spread into the groundwater.

> Next steps: Sampling of monitoring wells should continue around the VBP to monitor potential contaminants in the groundwater if contaminated soil is not removed. MDCH will review future water testing results as needed.

Contaminants in the surface water and sediment in the drainage ditch, a county drain, near the site are not expected to harm people's health. People are expected to have limited, if any, contact with water and sediment in this ditch.

Next steps: No additional public health activities are necessary at this time.

Purpose and Health Issues

The Michigan Department of Environmental Quality (MDEQ), then the Michigan Department of Natural Resources and Environment[1], and U.S. Environmental Protection Agency (EPA) proposed the addition of the Velsicol Burn Pit site to the EPA National Priorities List (NPL) in September 2009 and finalized addition to the list in March 2010. The Michigan Department of Community Health (MDCH) assesses the human health risk present at NPL (also called Superfund) sites in Michigan under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). The site is the former waste burning and disposal site for the Velsicol Chemical Corporation plant. A variety of chemicals were disposed of and burned with solid waste from the plant at this site from the 1950s to 1970. The purpose of this document is to identify potentially harmful human exposures to contaminants from the Velsicol Burn Pit NPL site and does not include discussion of contaminated material from the Velsicol Chemical Corporation plant site or the Pine River. This document addresses human health concerns from contaminants and does not include any ecological assessments, such as discussion of impacts to wildlife or the environment.

[1] In January 2010, the Michigan Department of Environmental Quality (MDEQ) merged with the Michigan Department of Natural Resources (MDNR) and became the Michigan Department of Natural Resources and Environment (MDNRE). In March 2011, the MDNRE was once again split into the MDEQ and MDNR.

Background

The Velsicol Burn Pit (VBP) (also known as the Former Burn Area) covers about five acres surrounded by the east side of the Hidden Oaks Golf Course[2] on Monroe Road in St Louis, Michigan (EPA 2010). It is across the Pine River from the former Velsicol Chemical Corporation manufacturing plant. The site includes an inactive waste burning and disposal site (Dames & Moore 1980), consisting of an open dump, burn pit, brine well, and brine pond (Lockheed 1982). The site is surrounded by a golf course and, to the east, a residential area (Weston 2009). See Figure 1.

The VBP was a disposal site for solid and liquid waste from the former plant site and solid waste from the city of St Louis (Weston 2006). The Velsicol Chemical Corporation manufacturing plant burned waste liquids weekly, from approximately 1956 to 1970 (EPA 2010). In 1963, the site expanded northwest of the original site, and the area used in the 1950s was covered in vegetation (Lockheed 1982).

The dumpsite for the plant was used for disposal of polybrominated biphenyls (PBB), tris(2,3-dibromopropyl)phosphate (TRIS), dichlorodiphenyl trichloroethane (DDT), and filter cakes from bromide operations (Lockheed 1982). Records were not available on all materials burned or disposed of at this site. Additional materials that may have been disposed of include: magnesium oxide wastes, sodium chloride wastes, DDT waste, TRIS and other hydrocarbon wastes, and heavy metal residues (such as copper, cobalt, and zinc) (Dames & Moore 1980).

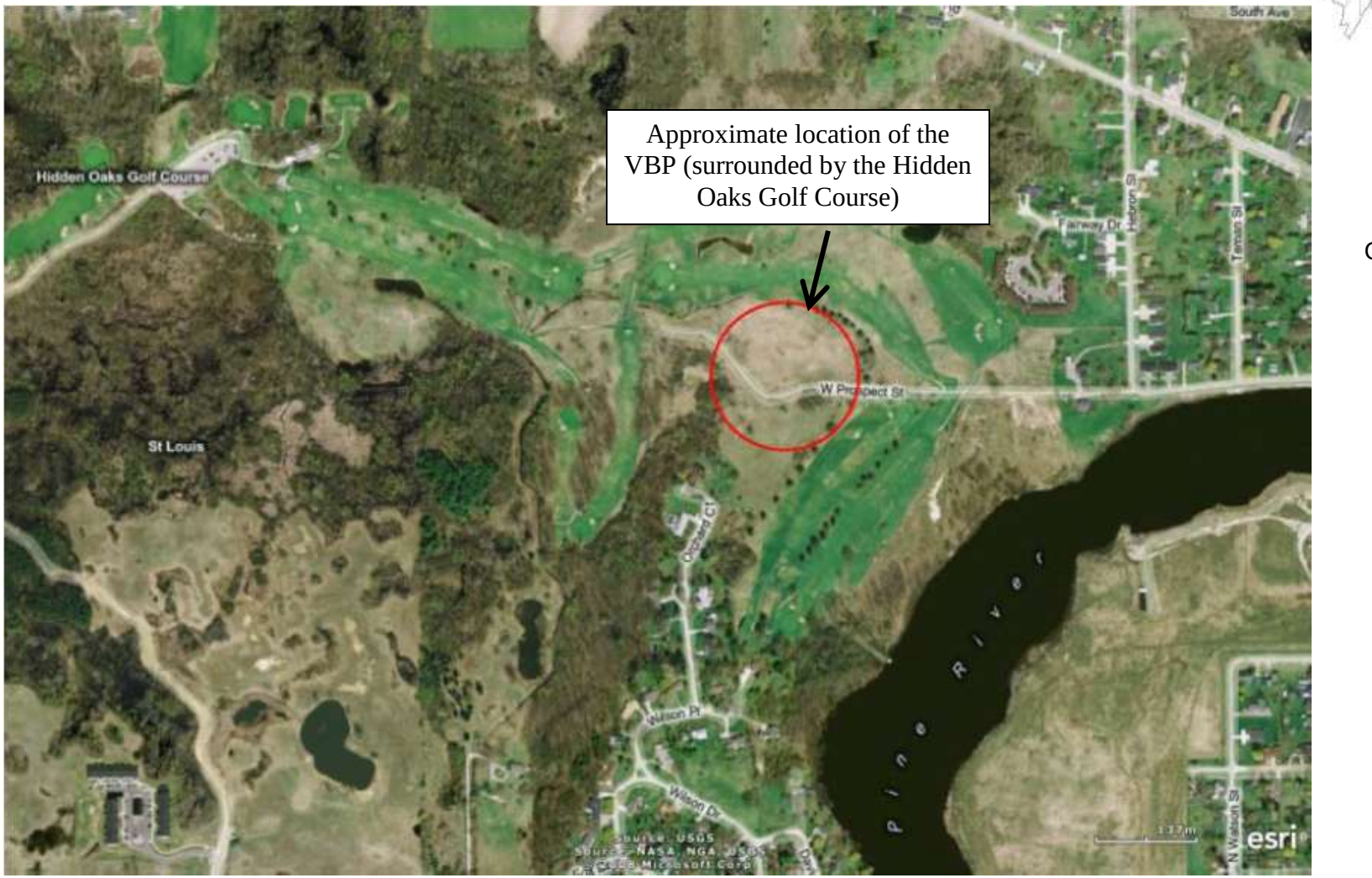
A gravel pit, east of the VBP, was formerly used for disposal of general refuse and municipal materials, and possibility some general refuse and waste materials from the plant. Another pit was identified south of the VBP. That pit was used in the 1940s to 1950s for storage of calcium chloride brine for the chemical plant (Dames & Moore 1980).

The VBP, originally a gravel pit approximately 100 feet long and 30 feet wide (Dames and Moore Aug 1980), was sold in 1970. A 9-hole golf course (Edgewood Farms Golf Course) was constructed in 1972 around the VBP and is currently part of the Hidden Oaks Golf Course. As part of the construction activities, the gravel pit was filled and graded after the 1970 purchase and was re-graded in 1978 (Dames & Moore 1980).

This area was originally proposed to the NPL in 1982[3], but not added to the final list before deletion (EPA 2010). In 1983, the responsible party excavated the contaminated soil to different depths depending on the extent of the contamination. The MDEQ[4] monitored contaminant levels and requested additional excavation for an area with elevated levels of DDT. After removal of an additional 300 cubic yards, no detectable DDT was present. The excavated areas were filled with material from adjacent land, covered with six inches of topsoil, seeded, and mulched (CRA 1982).

[2] A 9- hole golf course was originally built around the FBA. Later another nine holes were added to the west and all 18 holes are now the Hidden Oaks Golf Course.
[3] The site was identified with an identification number of MID980794531 and was also called Edgewood Farms Golf Course Site when proposed to the NPL in 1982.
[4] At the time of this work, the MDEQ was the Michigan Department of Natural Resources (MDNR).

Figure 1: Map of the Velsicol Burn Pit (VBP) (also known as the Former Burn Area) National Priorities List (NPL) site (EPA ID# MIN000510389). The VBP boundary is approximate.



Gratiot County

All excavated material was disposed of at the Velsicol plant site located across the river. Among the material removed was domestic refuse and industrial waste, plastic sample bags (containing magnesium oxide), 25 empty drums, and 14 drums containing material such as silica gel, hypo crystals (sodium thiosulfate), magnesium oxide, and filter cakes (CRA 1982). Groundwater (1.2474 million gallons) was also collected and disposed of by deep well injection on the Velsicol plant site. Levels of contaminants in groundwater were measured in three samples and one duplicate. PBB was not detected, but hexabromobenzene (HBB), DDT, and TRIS were detected in the samples (CRA 1982). The excavation and groundwater collection activities resulted in deletion of the site from the NPL in 1983.

Soil and groundwater contamination at the VBP was identified in 2006 and the site was again proposed to the NPL in September 2009 and placed on the NPL in March 2010. Two ash piles, identified during the work in 2006, are present at the site along with an estimated 345,606 square feet of contaminated soil. Municipal and private residential wells, water supplies for about 20,000 residents, are located within three miles of this site (EPA 2010).

Discussion

Environmental contaminant data were compared to soil, sediment, soil gas, and water screening levels. See Appendix A for description of the screening levels.

If maximum contaminant levels were above the screening level, averages and 95% upper confidence levels (95% UCL) of the averages were calculated by the EPA's ProUCL (version 4.00.05)[5]. The reporting limit, the lower limit that could be accurately measured, was used if the contaminant was not detected in the sample. Contaminants with averages or 95% UCLs above the screening levels are discussed in the Exposure Pathways section. Contaminants without screening levels are discussed in the Contaminants without Screening Levels section.

Environmental Contamination

Since the previous work at the site, there have been two investigations into contaminants present at the VBP. The first investigation, in 2004-2005, identified contamination remaining at the site from the disposal activities decades earlier (Weston 2006). Appendix A contains tables of all chemicals detected, at a minimum of one sampling location, during this investigation. A more recent investigation, in 2007-2008, further characterized contamination of the VBP and identified offsite migration of the contaminants (Weston 2009). Appendix B contains tables of all chemicals detected, at a minimum of one sampling location, during the more recent investigation.

Site Geology

Three units of unconsolidated material are below the site, the shallow outwash, till, and lower outwash units. The shallow outwash unit is the layer extending 20 to 30 feet below ground surface (bgs) and is composed of fill (from the excavation), alluvium (material deposited by running water), and lacustrine (material formed in lakes) deposits. The till unit is below the shallow outwash unit, and is composed of sandy silt (sand, gravel, and cobbles). It is 30 to 80

[5] The EPA's ProUCL (version 4.00.05) can be downloaded for free at http://www.epa.gov/osp/hstl/tsc/softwaredocs.htm.

feet thick, with an average of 40 to 45 feet. The lower outwash unit extends from the base of the till unit (around 80 feet bgs) to the top of the bedrock (approximately 280 feet bgs). This unit is composed of sand, gravel, silt, and clay (Weston 2009).

Velsicol Burn Pit (VBP) Soil Sampling

Soil samples, from borings, were taken in October 2004 from random intervals in the soil cores and from visibly contaminated soil, when present. Non-aqueous phase liquid (NAPL) was identified in one of the soil borings. NAPL are liquids that do not dissolve in water and remain separate from the water. Additional discussion of the NAPL is in the Groundwater Sampling section. Soil samples were tested for volatile organic chemicals (VOCs), specialty chemicals, inorganic chemicals, semivolatile organic chemicals (SVOCs), pesticides, and polychlorinated biphenyls (PCBs) (Weston 2006). Specialty chemicals were HBB, PBB, TRIS, chlordane (technical), 2,4'-DDT, and para-chlorobenzenesulfonic acid (pCBSA). Table 1 presents the contaminants that were higher than or had no screening levels.

Table 1: Maximum value (in milligrams per kilograms [mg/kg]) of contaminants that were higher than or had no screening levels in 17 soil samples from the 2004 soil borings (Weston 2006).

Analyte	Screening level[a] (mg/kg)	Maximum value in VBP soil (mg/kg)
2,4-DDT	NA[b]	0.023
arsenic, total	7.6	**10.4**
calcium, total	NA	87,000
delta-BHC	NA	0.043[c]
methyl acetate	NA	0.99
potassium, total	NA	1,200

Bold values are higher than the screening level.
DDT = dichlorodiphenyl trichloroethane
BHC = benzenehexachloride
a = Unless otherwise noted, the screening level is the MDEQ Residential Direct Contact Criteria. Details on the screening level are in Appendix A.
b = NA, "not available" indicates that no screening levels are available.
c = This value is an estimated result.

Arsenic levels in two of 17 samples were higher than the screening level. One sample was from a depth of seven to nine feet bgs and the other sample was from soil one to three feet bgs. The average of the five soil samples collected at less than three feet deep was 4.6 milligrams per kilogram (mg/kg).[6] The average[7] is below the arsenic screening level of 7.6 mg/kg. Other contaminants are discussed in the Contaminants without Screening Levels section.

[6] The average of the soil arsenic values, a total of 17 from all depths, was 4.6 mg/kg and the 95% upper confidence limit of the average (UCL) was 5.6 mg/kg. The 95% UCL is a value that would be higher than the true average contaminant level 95% of the time. It is used as a conservative value to make sure that, even if there were limited samples, higher levels of contaminants that may be present at the site are accounted for.
[7] The 95% UCL could not be calculated, as there were only five values in this group.

Additional soil borings were done in 2007, and seventy surface and vadose zone soil samples were taken. Surface soil was collected from zero to 0.5 feet bgs. The vadose zone is the soil between the land surface and the water table, including the capillary fringe (a zone above the water table that is saturated with water). Vadose zone samples, at least one per boring, were collected at random intervals above the capillary fringe if no contamination was identified[8] (Weston 2009).

Soil samples were tested for VOCs, pesticides, inorganic chemicals, and specialty chemicals. Select samples were also tested for pCBSA, dioxins, and furans. Dioxin and furan levels are in Table B-8 in Appendix B. They were not detected above applicable screening levels. NAPL was not identified in any of the soil borings from this sampling (Weston 2009). Table 2 presents the maximum value of contaminants in soil samples that were higher than or had no screening levels.

Table 2: Maximum value (in milligrams per kilograms [mg/kg]) of contaminants that were higher than or had no screening levels in 66 soil samples from the 2007 sampling (Weston 2009).

Analyte	Screening level[a] (mg/kg)	Maximum levels in all soil depths (mg/kg)
2,4-DDT	NA[b]	0.64[c]
arsenic, total	7.6	**21**
calcium, total	NA	103,000[c]
lead, total	400	**810**
PBB	1.2	**5.4**[d]
potassium, total	NA	1,510[c]

Bold values are those higher than the screening level.
DDT = dichlorodiphenyl trichloroethane
PBB = polybrominated biphenyls
a = Unless otherwise noted, the screening level is the MDEQ Residential Direct Contact Criteria. Details on the screening level are in Appendix A.
b = NA, "not available," indicates that no screening levels are available.
c = The value is an estimated result.
d = The value is the reporting limit.

Three out of 70 soil samples were higher than the arsenic screening level. These 3 samples were from depths of zero to 0.5 feet bgs, two to three feet bgs, and 13 to 14 feet bgs. Thirty-three samples were collected from soil less than 0.5 feet deep. People are most likely to come into contact with soil closest to the ground surface. The average arsenic value for the 33 samples collected from soil less than 0.5 feet deep was 3.0 mg/kg, and the 95% UCL was 3.5 mg/kg[9]. The three samples higher than the PBB screening level were all from zero to 0.5 feet bgs, and the one sample above the lead screening level was from 13 to 14 feet bgs. The average PBB level, for the 33 samples collected from less than 0.5 feet deep was 0.39 mg/kg and the 95% UCL was 1.2 mg/kg[10]. The soil lead levels, for the 33 samples collected from less than 0.5 feet deep averaged 11.2 mg/kg and the 95% UCL was 13.3 mg/kg[11]. All averages and 95% UCLs were below or

[8] Contamination was identified visually or with a photoionization detector (a machine to detect organic chemicals).
[9] For all 70 samples, the average arsenic value was 3.6 mg/kg and the 95% UCL was 4.0 mg/kg.
[10] The average PBB value for all 70 samples was 0.22 mg/kg and the 95% UCL was 0.79 mg/kg.
[11] The average lead level, for all samples, was 19.6 mg/kg and the 95% UCL was 69.6 mg/kg.

equal to the applicable screening levels. Contaminants with no screening levels are discussed in later sections.

Residential Area Soil Sampling

Thirty-two surface soil samples (all from 0 to 0.5 feet bgs) were taken from the residential area east and northeast (downwind) of the VBP in December 2007. Samples were tested for SVOCs, pesticides, inorganic, and specialty chemicals (Weston 2009). Table 3 presents the maximum value of contaminants that were higher than or had no screening levels.

One of the samples, of the two higher than the screening level for arsenic, was in an area adjacent to the golf course and the other was two streets to the east of the golf course. The maximum value, 35 mg/kg, was determined to be an outlier (S. Cornelius, MDEQ, personal communication, 2011). With that value removed, the average soil arsenic level was 4.4 mg/kg and the 95% UCL was 4.8 mg/kg. Both the average and 95% UCL were below the arsenic screening level. Contaminants with no screening levels will be discussed in later sections.

Table 3: Maximum value (in milligrams per kilograms [mg/kg]) of contaminants that were higher than or had no screening levels in 32 downwind residential soil samples (0 to 0.5 feet deep) from the 2007 sampling (Weston 2009).

Analyte	Screening level[a] (mg/kg)	Maximum levels in surface soil (mg/kg)
2,4-DDT	NA[b]	0.054[c]
arsenic, total	7.6	**8.0**
calcium, total	NA	68,000
potassium, total	NA	1,290[c]

Bold values are those higher than the screening levels.
DDT = dichlorodiphenyl trichloroethane
a = Unless otherwise noted, the screening level is the MDEQ Residential Direct Contact Criteria. Details on the screening level are in Appendix A.
b = NA, "not available," indicates that no screening levels are available.
c = The value is an estimated result.

Ash Pile Sampling

Two ash piles are located in a wooded area that, while not on golf course property, could be considered to be in the rough (areas outside of the fairway or green with taller or thicker grass) or out of bounds (a non-playable area) for the golf course. These piles are visible through the vegetation growing on them, which may not prevent ash from blowing onto the golf course. One sample from each of the two ash piles (two samples total) on site were analyzed for VOCs, SVOCs, PCB/pesticides, inorganic chemicals, and specialty chemicals in 2005 (Weston 2006). The ash piles were not sampled in the second investigation. Table 4 presents the contaminants in the ash piles that were higher than or had no screening levels.

The two samples from the ash piles were both higher than the screening levels for arsenic and lead. Since only two samples were taken from the surface of the pile, the size of the piles and the

range of contaminant concentrations are unknown. Arsenic and lead are discussed in the Exposure Pathways section.

Table 4: Maximum value (in milligrams per kilograms [mg/kg]) of contaminants that were higher than or had no screening levels in two ash samples collected in 2005 (Weston 2006).

Analyte	Screening level[a] (mg/kg)	Maximum value in ash samples (mg/kg)
arsenic, total	7.6	**62.4**
calcium, total	NA[b]	25,000
dibenzofuran	NA	0.54[c]
lead, total	400	**670**
methyl acetate	NA	0.19[d]

Bold values are higher than the screening level.
a = Unless otherwise noted, the screening level is the MDEQ Residential Direct Contact Criteria. Details on the screening level are in Appendix A.
b = NA, "not available," indicates that no screening levels are available.
c = The value is the reporting limit.
d = The value is an estimated result.

Soil Gas Sampling

Nine soil gas samples were taken in the VBP from various depths (all between 1.0 and 24.3 feet bgs) in October 2005. Soil gas samples were analyzed at an on-site mobile laboratory. One sample, from the location where on-site analysis found the highest contaminant concentrations, was sent to an off-site laboratory for analysis (Weston 2006). It should be noted that there are no buildings in this area. Soil gas levels that are elevated above screening levels may indicate that if any buildings are built on the site,[12] they might have soil contaminants seeping into indoor air that could be harmful to human health. If no buildings are present at the location, no indoor air contamination is possible.

Results were compared to shallow and deep soil gas screening levels (MDEQ 2009); however, soil gas samples from less than five feet deep may not be informative. Soil gas levels taken from less than five feet deep can be influenced by the ambient air (Amy Salisbury, MDEQ, personal communication, 2010) and be a reflection of chemicals present in the aboveground air while the samples are being collected. Soil gas levels were higher than the screening levels for twelve analytes, and five analytes do not have screening levels. See Table A-3, in Appendix A, for the levels of the analytes and the screening levels.

Hydrogeology

Groundwater for the shallow outwash and till units flows southeast toward the Pine River from the eastern portion of the site, and west and southwest from the western part of the VBP. Based on information from four monitoring locations, groundwater in the lower outwash unit flows southeast, toward the Pine River (Weston 2006).

[12] There are no plans at this time to build any buildings on the VBP.

Groundwater Sampling

Groundwater samples were taken during the October 2004 soil investigation at the VBP. As contaminants were identified in the samples, monitoring wells were installed in the VBP. Shallow monitoring wells were installed in the shallow outwash unit between October 2004 and March 2005. NAPL was present in one of the shallow wells. NAPL had been observed in two monitoring wells during installation. The NAPL was sampled from one well, and identified as 1,2-dichloroethane and benzene. The NAPL was estimated to be 18 inches thick. NAPL, composed of the above or other chemicals, might be present at other locations (Weston 2006). Monitoring wells are present in shallow, intermediate, and deep units of groundwater and would be able to identify NAPL in shallower or deeper groundwater.

Vertical aquifer sampling (VAS) was done to determine the extent of contamination in the lower outwash unit groundwater. Select samples were measured for VOCs; SVOCs; PCBs, pesticides, and specialty chemicals; and inorganic chemicals (Weston 2006). Table 5 presents the maximum value of contaminants from the VAS that exceeded or had no screening levels.

Table 5: Maximum value (in milligrams per liter [mg/L]) of contaminants that either had no screening level or exceeded the screening levels in 17 groundwater samples from soil borings (vertical aquifer sampling) sampled in 2004 (Weston 2006).

Analyte	Screening level[a] (mg/L)	Maximum value (mg/L)
benzene	11	**14**
calcium, dissolved	NA[b]	186
calcium, total	NA	314
potassium, dissolved	NA	11.9
potassium, total	NA	5.41[c]

Bold values are higher than the screening level.
a = Unless otherwise noted, the screening level was the MDEQ's Groundwater Contact Criteria. Details on the screening level are in Appendix A.
b = NA, "not available," indicates that no screening level was available.
c = The value is an estimated result.

Only benzene, in one sample, was above the screening levels. This sample was taken from 24 to 26 feet bgs. Benzene is discussed in the Exposure Pathways section. Calcium and potassium are discussed in the Contaminants without Screening Levels section.

Two of the 22 monitoring wells sampled in October 2005 had detectable levels of pCBSA (Weston 2006). This chemical has since been detected in all six of the municipal wells (S. Cornelius, MDEQ, personal communication, 2011). Levels of pCBSA in municipal wells are below levels considered to be protective of human health[13] (M. Joseph, MDEQ, personal communication, 2011). Detailed municipal well data are not included as none of the wells are located on the VBP. Several of the municipal wells are located to the east of the VBP and the others are located across the Pine River near the Velsicol Chemical Corp. Superfund site. Table

[13] The MDEQ has a Residential Drinking Water Criterion of 7.3 mg/L for pCBSA.

A-6 presents the maximum pCBSA level from monitoring wells tested in 2005. Levels of pCBSA in the groundwater samples were below the applicable screening level.

In May to June 2005, monitoring wells were sampled for VOCs; SVOCs; pesticides, PCBs, specialty chemicals; and total or dissolved inorganic chemicals. Samples from the monitoring wells were taken again in October 2005 and analyzed for the same contaminants (Weston 2006). Table A-5 presents the results of those sampling events. These wells were sampled again along with additional monitoring wells installed between fall of 2007 and spring of 2008.

The new wells were screened in the shallow outwash (shallow), till (intermediate), and lower outwash (deep) units (three in each unit). The horizontal and vertical extent (VAS) of the contamination was assessed at the three locations. Two intermediate depth wells were installed in the till unit, in the downwind residential area, in fall 2007. They were screened between 39 to 60.5 feet bgs. Two deep wells were also installed in the downwind residential area. (Weston 2009). Table B-3 presents the maximum level of contaminants from the VAS. None of the contaminants were above the applicable screening levels.[14]

Groundwater samples from monitoring wells, screened in various depths below the ground surface, were collected in 2008. Samples were analyzed for VOCs, SVOCs, pesticides, specialty chemicals, and total inorganic chemicals. Select samples were analyzed for pCBSA, PCBs, dissolved inorganic chemicals, and hexavalent chromium (Weston 2009).

Tables 6 through 9 presents maximum values of contaminants found in the monitoring wells that were higher than or had no screening levels. No compounds from upper or lower till unit monitoring wells were detected above screening levels; however, several analytes did not have screening levels.

Benzene was detected above the screening level in three monitoring wells (Table 6). The wells were screened from six to 11 feet (shallow outwash unit), 33 to 38 feet (till unit), and 43.5 to 48.5 feet (till unit) bgs. Elevated levels of benzene were previously detected in two of the three wells. The maximum arsenic level was also higher than the screening level. The other analytes that were higher than the screening level were estimated below the detection limit. These analytes are discussed in the Exposure Pathways section.

[14] There was no screening level for total trihalomethanes, which is a group of chemicals with one carbon and three halogens, such as bromine or chlorine. Although there is no screening level for total trihalomethanes, individual screening levels are available for many of the chemicals included in this group, such as chloroform, bromoform, and bromodichloromethane.

Table 6: Maximum value (in milligrams per liter [mg/L]) of compounds that either exceeded their respective screening value or had no screening levels in the Velsicol Burn Pit (VBP) 17 groundwater samples from the shallow outwash unit monitor wells sampled in 2008 (Weston 2009).

Analyte	Screening level[a] (mg/L)	Maximum value (mg/L)
1,2,3-trichlorobenzene	0.073[b]	5[c]
1,2,3-trimethylbenzene	0.65[b]	1[c]
1,2-dibromo-3-chloropropane	0.390	**5**[c]
2,4-DDT	NA	0.001[c]
aldrin	0.00034	**0.001**[c]
anthracene	0.043	**0.5**[c]
arsenic, total	4.3	**10**[e]
benzene	11	**99**
calcium, dissolved	NA	3,590[e]
calcium, total	NA	5,180[e]
cyclohexane	NA	5[c]
delta-BHC	NA	0.002[c]
fluoranthene	0.21	**0.5**[c]
pentachlorophenol	0.2	**10**[c]
potassium, dissolved	NA	110[e]
potassium, total	NA	120[e]
pyrene	0.14	**0.5** [c]
trihalomethane (total)	NA	3.2

Bold values are higher than the screening level.
DDT = dichlorodiphenyl trichloroethane
BHC = benzenehexachloride
a = The screening level was the MDEQ's Groundwater Contact Criteria. Details on the screening level are in Appendix A.
b = The screening level is MDEQ's Rule 57 non-drinking water value set for human health. Details on the screening level are in Appendix A.
c = The value is the reporting limit.
d = NA indicates that no screening levels are available.
e = The value is an estimated result.

None of the chemicals measured from the upper or lower till monitoring wells (Table 7 and Table 8) with screening levels were detected above their respective screening levels. Monitoring wells installed in the lower outwash unit access groundwater from the same groundwater unit that residential drinking water wells would access. However, since no drinking water wells are located in the VBP and analytes were not measured using drinking water analytical methods, the analyte values from these wells were only compared to screening levels protective for workers coming into contact with the groundwater. Although there are no drinking water wells installed in the VBP, drinking water wells are in the vicinity of the VBP, and there are no restrictions on the installation of drinking water wells in this area.

Table 7: Maximum value (in milligrams per liter [mg/L]) of compounds with no screening levels in the Velsicol Burn Pit (VBP) seven groundwater samples from the upper till unit monitor wells sampled in 2008 (Weston 2009).

Analyte	Screening Level (mg/L)	Maximum value (mg/L)
2,4-DDT	NA[a]	0.0049
calcium, dissolved	NA	8,250[b]
calcium, total	NA	17,400[b]
potassium, dissolved	NA	53[b]
potassium, total	NA	77[b]

a = NA indicates that no screening levels are available.
b = The value is an estimated result.

Table 8: Maximum value (in milligrams per liter [mg/L]) of compounds with no screening levels in the Velsicol Burn Pit (VBP) two groundwater samples from the lower till unit monitor wells sampled in 2008 (Weston 2009).

Analyte	Screening Level (mg/L)	Maximum value (mg/L)
2,4-DDT	NA[a]	0.00001[b]
calcium, dissolved	NA	321[c]
calcium, total	NA	309[c]
potassium, dissolved	NA	4.5
potassium, total	NA	4.6

DDT = dichlorodiphenyl trichloroethane
a = NA indicates that no screening levels are available.
b = The value is the reporting limit.
c = The value is an estimated result within the accurate range of the analytical method.

Table 9 presents the analytes in the lower outwash unit monitoring wells that have no screening levels. No concentrations of compounds exceeded screening levels.

Table 9: Maximum value (in milligrams per liter [mg/L]) of compounds with no screening levels in the Velsicol Burn Pit (VBP) eight groundwater samples from the lower outwash unit monitor wells sampled in 2008 (Weston 2009).

Analyte	Screening Level (mg/L)	Maximum value (mg/L)
2,4-DDT	NA[a]	0.000051
calcium, dissolved	NA	618[a]
calcium, total	NA	674[a]
cyclohexane	NA	0.005[b]
potassium, dissolved	NA	6.6[a]
potassium, total	NA	6.4[a]

DDT = dichlorodiphenyl trichloroethane
a = NA indicates that no screening levels are available.
b = The value is an estimated result within the accurate range of the analytical method.
The value is estimated below the level which the analytical method can accurately detect.

Residential Well Sampling

Two residential wells on Prospect Street and one on the Hidden Oaks Golf Course were tested for VOCs, SVOCs, pesticides, PCBs, specialty chemicals, inorganic chemicals, and water quality parameters in 2002[15] (Weston 2006). The Hidden Oaks Golf Course well is also used for irrigation at the golf course. Table 10 presents the contaminants present that were higher than or had no screening levels.

The maximum arsenic and chloride levels in wells on Prospect Street were above drinking water screening levels. The concentrations of several analytes were estimated values higher than the screening levels (2,4-DDT, bis(2-ethylhexyl)phthalate, and n-nitroso-di-n-propylamine). Arsenic, chloride, 2,4-DDT, bis(2-ethylhexyl)phthalate, and n-nitroso-di-n-propylamine are discussed in the Exposure Pathways section.

Another residential well was sampled on Orchard Court, which is adjacent to the VBP, and tested for pCBSA. This contaminant was not detected (Weston 2009).

Table 10: Maximum value (in milligrams per kilogram [mg/kg]) of contaminants that were higher than or had no screening levels in three drinking water wells sampled in 2002 (Weston 2006).

Analyte	Drinking water screening levels[a] (mg/L)	Hidden Oaks Golf Course well values (mg/L)	Maximum value from two residential wells on Prospect St (mg/L)
2,4-DDT	NA[b]	0.00002[c]	0.00002[c]
arsenic, total	0.01	0.0032[d]	**0.0234**
bis(2-ethylhexyl)phthalate	0.006	**0.013**[d]	**0.01**[d]
calcium, total	NA	53.1	143
chloride	250	15	**345**
HEM, oil and grease	NA	5[d]	5[d]
n-nitroso-di-n-propylamine	0.005	**0.013**[d]	**0.01**[d]
potassium, total	NA	1.04	2.98

Bold values are those that exceed the drinking water screening level.
DDT = dichlorodiphenyl trichloroethane
HEM = n-hexane extractable material
a = Unless otherwise noted, the screening level is the MDEQ Part 201 Residential Drinking Water Criteria. Details on the screening level are in Appendix A.
b = NA, "not available," indicates that no screening levels are available.
c = The value is an estimated reporting limit.
d = This value is the reporting limit.

Surface Water and Sediment Sampling

Five surface water and seven sediment samples were taken from a drainage ditch next to the VBP in January 2008. They were tested for VOCs, SVOCs, pesticides, specialty chemicals,

[15] A well on State Street was also sampled. However, not all analytes were measured in the sample, so it was not included here. The analytes measured were similar to the values in Table 10 and Table A-7.

including pCBSA, inorganic chemicals, and general water chemistry[16] (Weston 2009). No concentrations exceeded screening levels. Table 11 presents the contaminants in surface water samples that had no screening levels. These analytes are discussed in the Contaminants without Screening Levels section.

Table 11: Maximum levels (in milligrams per liter [mg/L]) of compounds with no screening levels in five surface water samples from a drainage ditch adjacent to the Velsicol Burn Pit (VBP) sampled in 2008 (Weston 2009).

Analyte	Maximum value (mg/L)
2,4-DDT	0.00001[a]
calcium, total	134[b]
chloride	124[b]
oil and grease	11[a]
potassium, total	5.9[b]
sulfate	100[b]

DDT = dichlorodiphenyl trichloroethane
a = The value is estimated reporting limit.
b = The value is an estimated result.

Sediment cores were collected from the drainage ditch, to a depth of one to three feet. The sediment cores were homogenized (mixed) before testing. They were analyzed for VOCs, SVOCs, pesticides, total organic carbon, specialty, and inorganic chemicals. Two of the sediment samples were analyzed for pCBSA (Weston 2009). No compounds had levels higher than screening levels. Table 12 presents the maximum level of contaminants that had no screening levels. These are discussed in the Contaminants without Screening Levels section.

Table 12: Maximum levels (in milligrams per kilograms [mg/kg]) of compounds with no screening levels in seven sediment samples from a drainage ditch adjacent to the Velsicol Burn Pit (VBP) sampled in 2008 (Weston 2009).

Analyte	Maximum levels (mg/kg)
2,4-DDT	0.14[a]
calcium, total	82,200[b]
potassium, total	700[b]

DDT = dichlorodiphenyl trichloroethane
a = The value is the reporting limit.
b = The value is an estimated result.

Exposure Pathways Analysis

An exposure pathway contains five elements: (1) the contaminant source, (2) contamination of environmental media, (3) an exposure point, (4) a human exposure route, and (5) potentially exposed populations. An exposure pathway is complete if there is a high probability or evidence

[16] Except for the oil and grease analysis, these analytes are not included in Table 11. These often do not have screening levels and do not directly affect human health.

that all five elements are present. Table 13 describes human exposure pathways to contaminants at the Gratiot County Golf Course, St Louis (Gratiot County), Michigan.

Table 13: Exposure pathway for contaminants present at the Velsicol Burn Pit (VBP) at the Gratiot County Golf Course National Priorities List Site, St Louis (Gratiot County), Michigan.

Source	Environmental Medium	Exposure Point	Exposure Route	Exposed Population	Time Frame	Exposure
Materials burned and disposed of at the VBP	Groundwater	Groundwater wells for irrigation	Dermal contact and inhalation	People who work at or visit the golf course (adjacent to the VBP)	Past Present Future	Potential
Materials burned and disposed of at the VBP	Soil	Soil	Incidental ingestion and dermal contact	People who work or visit the golf course (adjacent to the VBP)	Past Present Future	Potential
Materials burned and disposed of at the VBP	Air	Air downwind of the VBP	Inhalation	People who live or visit the downwind residential area	Past	Potential
					Present Future	Eliminated
Materials burned and disposed of at the VBP	Suspended dust or soil in the air	Soil in the downwind residential area	Incidental ingestion and dermal contact	People who live or visit the downwind residential area	Past Present Future	Potential
Materials burned and disposed of at the VBP	Groundwater	Drinking water wells	Ingestion	People who live, work, or visit areas near the VBP	Past Present Future	Potential

Soil and ash samples from the VBP

Soil samples at the site exceeded the screening levels for arsenic, lead, and PBB. Arsenic exceedences represented about 6% of the total soil samples tested from the VBP for the two investigations combined (Weston 2006, 2009). The arsenic levels ranged up to a maximum of about three times (21 mg/kg) the arsenic screening level. The average and 95% UCL levels for the two soil investigations were below the screening level of 7.6 mg/kg. Although certain spots on the site have elevated arsenic levels, they are not consistently elevated across the site. The soil sample depths for all samples ranges from zero to 14 feet bgs. It is not expected that people will come into contact with soil deep below the ground surface. The average arsenic level for soil samples collected less than 0.5 feet bgs was 3.0 mg/kg and the 95% UCL was 3.5 mg/kg, both below the screening level of 7.6 mg/kg.

Estimated results of three soil samples, collected in the second investigation (Weston 2009), were higher than the PBB screening level and had an estimated maximum of 5.4 mg/kg. These samples were collected from zero to 0.5 feet bgs. The results are an estimated reporting limit. However, the estimated reporting limit was higher than the screening level and so these values were included in the average and 95% UCL. The average PBB level for the soil samples

collected from less than 0.5 feet deep was 0.39 mg/kg, and the 95% UCL was 1.2 mg/kg. Overall, the PBB levels in the soil samples were below or equal to the screening level of 1.2 mg/kg.

Only one soil lead level, 810 mg/kg, collected from 13 to 14 feet bgs, was higher than the screening level. The soil lead levels for the soil samples collected from less than 0.5 feet deep averaged 11.2 mg/kg, and the 95% UCL was 13.3 mg/kg. Both are below the lead screening level of 400 mg/kg.

One ash sample was collected for each of the two ash piles[17]. Both ash piles samples exceeded the lead and arsenic screening levels. The ash piles have vegetation growing on them, but still are visible.

Visitors to the area adjacent to the VBP, such as golfers, are expected to have little or no contact with contaminants from soil or ash piles. The VBP is not part of the golf course property and is considered "out of bounds" for the golf course. However, there are no fences or signs that would prevent golfers or other visitors from walking into the VBP.

Golf course rules require the use of soft spikes (Hidden Oaks Golf Course, Rules and Regulations[18]), which are plastic cleats that minimize damage to the turf grass. The use of these plastic cleats will result in little or no soil exposure for golfers from their golf shoes. The averages and 95% UCLs for arsenic, PBB, and lead levels in the soil are below the screening levels. People are expected to have little to no contact with the soil; people's health is not expected to be harmed by the levels of these contaminants.

Workers at the golf course may have dermal contact with soil or the ash piles. Although the soil and ash piles are not part of the golf course, workers may enter the VBP at times. No fences are present to prevent people from going into the VBP. Although levels of arsenic, lead, and PBB in several soil samples are higher than the screening levels, averages and 95% UCLs are below the screening levels. It is not expected that workers at the golf course will be exposed to levels of contaminants in the soil that will cause health effects.

Although workers or visitors to the golf course are not expected to spend much time in the VBP, levels of arsenic and lead are elevated in the two ash samples. Further characterization of the ash piles is necessary to determine the size of the ash piles and the uniformity of the contamination present. Ash piles were identified during monitoring well installation and the size of the ash piles are unknown. Arsenic and lead will be discussed in the Toxicological Evaluation section.

Soil samples from a residential area near the VBP

Soil samples were taken in the downwind residential area, a neighborhood east of the VBP on the same side of the Pine River. Two of the downwind residential soil samples (35 total) were higher than the arsenic screening level. The soil samples were taken from zero to 0.5 feet bgs. The maximum arsenic level in the samples was 8.0 mg/kg, but the average level and the 95%

[17] As only one sample was collected from each ash pile, averages and 95% UCL could not be calculated.
[18] The Hidden Oaks Golf Course Rules and Regulations can be found at: http://www.hiddenoaksgolf.com/node/3 (accessed March 2011).

UCL were below the screening level of 7.6 mg/kg. It is not expected that resident's health would be affected by the arsenic levels as they are not consistently elevated in the soil of the residential area.

Groundwater samples from the VBP

The three shallow outwash unit wells (the ones closest to the ground surface) were higher than the screening levels for arsenic, aldrin, pyrene, pentachlorophenol, fluoranthene, benzene, anthracene, and 1,2-dibromo-3-chloropropane (DBCP). One well detected benzene above screening level values; a second well contained DBCP, benzene and arsenic above screening values; and a third well had arsenic, aldrin, pyrene, pentachlorophenol, fluoranthene, benzene, and anthracene above screening values. Several of the chemicals, aldrin, pyrene, pentachlorophenol, fluoranthene, anthrancene, and DBCP, had estimated values as the values were below the detection levels. These detection levels were higher than the screening levels. All groundwater samples with contaminants higher than the screening levels were from wells screened at least six to 11 feet bgs. The golf course workers are expected to have little to no contact with water from more than six feet bgs. However, since contaminants higher than the screening levels were only found in the shallow wells, soil contaminants may be migrating (leaching) into the groundwater.

Although some contaminant levels were above the screening levels, golfers or other visitors to the site are not expected to have contact with the groundwater. The Hidden Oaks Golf Course well is used for irrigation, but possible levels of analytes (bis(2-ethylhexyl)phthalate at 0.013 mg/L and n-nitroso-di-n-propylamine at 0.013 mg/L) in the water are not expected to harm people's health if they happen to have contact with the water. Furthermore, people are only expected to have occasional exposure to irrigation or other groundwater as watering would typically be occurring during the beginning or end of the day. It is not expected that people visiting or golfing on this site will be exposed to levels of chemicals that will cause health effects.

Workers contacting groundwater, either pumped to the surface or when digging underground, could possibility inhale benzene. The maximum levels found from the two investigations were 120 mg/L (Weston 2006) and 99 mg/L (Weston 2009). These values are above the MDEQ's Acute Inhalation Screening Level (AISL) of 67 mg/L for benzene. The AISL is a level of a contaminant in groundwater that is not expected to harm a worker's health if the worker is breathing in the contaminant for a short amount of time.[19] However, since the water with the elevated benzene levels is from at least six to 11 feet bgs under the VBP, workers are not expected to encounter groundwater during typical maintenance activities. Benzene was not detected in the Hidden Oaks Golf Course well (used for drinking water and irrigation), but it was sampled in 2004. Additional sampling of these wells is necessary to determine if contaminants have migrated into the groundwater.

Drinking water well samples located near the VBP

Water samples from two residential wells and one at the Hidden Oaks were analyzed for many contaminants. However, it is not known if concentrations of analytes (bis[2-ethylhexyl]phthalate,

[19] This screening level does not take the place of any of the Michigan Occupational Safety and Health Administration's (MIOSHA) standards or guidance.

n-nitroso-di-n-propylamine) actually exceeded the screening levels. The values for these chemicals were estimated below the accurate range that could be measured. 2,4-DDT is discussed in the Contaminants without Screening Levels section.

Chloride (345 mg/L) and arsenic (0.0234 mg/L) were higher than the applicable screening levels, 250 mg/L for chloride and 0.01 mg/L for arsenic, in one of the two residential wells samples. The EPA notified the residents of these findings. Arsenic is naturally occurring and can be found in drinking water wells throughout Michigan. Arsenic and chloride will be discussed in the Toxicological Evaluation section.

Toxicological Evaluation

Arsenic and lead were higher than the screening levels in the two ash pile samples (one from each pile). Although it is not expected that people will be repeatedly exposed to these chemical in the VBP, the size of the ash piles are unknown, therefore arsenic and lead are briefly discussed.

Chloride and arsenic were higher than the screening levels for drinking water in one of the residential well samples.

Arsenic

Arsenic is commonly present in the Earth's crust. People ingest small amounts of arsenic in food and water. Typical levels of arsenic in food are 0.02-0.14 mg/kg (ATSDR 2007a). Foods that contain arsenic, mainly in the form of organic arsenic, are dairy products, meat, poultry, fish, grains, and cereal (NAS 2001). Both children and adults can have vomiting, respiratory, cardiovascular, dermal, and neurological effects from exposure to high levels of arsenic. Dermal exposure to arsenic can result in direct irritation of skin (ATSDR 2007a).

Arsenic can be found in private drinking water wells throughout Michigan. Arsenic has been found in Gratiot County drinking water at levels as high as 0.05 mg/L.[20] One residential well sample had an arsenic level that was over the screening level (0.0234 mg/L). Residents with private drinking wells should have their water tested for arsenic.

Arsenic was found in both of the ash pile samples. The size of the ash piles are not known. Arsenic levels may be uniform throughout the pile or may be higher or lower in different parts of the ash piles.

Lead

Lead has been removed from many paints, ceramic products, caulking, pipe solder, and gasoline. Houses built before the late 1970's may still have paint containing lead. Children are often exposed to lead from ingesting paint chips or dust. Although sources of lead have been reduced people still encounter lead in their daily lives. Almost all (99%) of the publicly supplied drinking water have less than 5.0 µg lead /L. Lead in food ranged from less than 0.0004 to 0.5234 µg/g. People have an average dietary intake of 1.0 µg/kg/day (ATSDR 2007).

[20] A map of Gratiot County and the arsenic levels in the water can be found at http://www.michigan.gov/documents/deq/deq-wd-gws-ciu-counties21-30-as_270825_7.pdf.

Compared to adults, children are more vulnerable to lead poisoning. Children absorb, on average, 50% of the lead they ingest, while adults absorb between 6-80% depending on recent food consumption. Although lead can be absorbed through the skin, absorption of inorganic lead from dermal (skin) exposure appears to be less efficient than absorption from ingestion or inhalation. In studies measuring the amount of lead absorbed after dermal exposure, people's absorption ranged from less than or equal to 0.3% to possibly as high as 30% of the applied dose (ATSDR 2007).

After absorption by ingestion, inhalation, or dermal exposure, lead is distributed throughout the body similarly. Because of this and the fact that there is little information on people's health effects due to dermal exposure to lead, effects from ingestion are discussed. In both adults and children, the main target is the nervous system, but lead will affect every organ system (ATSDR 2007).

Lead was found in both of the ash pile samples. As previously stated, the size of the ash piles are not known. Lead levels may be uniform throughout the pile or may be higher or lower in different parts of the ash piles. The ash piles are part of the VBP and are not part of the golf course property. That area is considered "out of bounds" for the golf course. However, there are no fences or signs that would prevent golfers, workers, or other visitors from walking into the VBP.

Chloride

One residential well had a chloride level (345 mg/L) higher than the drinking water screening level (250 mg/L). People frequently eat chloride in table salt (sodium chloride) (NAS 2004). People's bodies typically regulate the levels of chloride they have. Drinking water or coming into contact with water that has elevated levels of chloride will not harm people's health, although eating a lot of salt can contribute to high blood pressure (NAS 2004). Although it will not harm people's health, drinking water with elevated chloride may be unpleasant, as it could have a salty taste. People with most types of water softeners will have higher levels of chloride in their water.

<u>Contaminants without Screening Levels</u>

Calcium, potassium, 2,4-DDT, and delta-BHC were detected in the soil and groundwater samples from the VBP. 2,4-DDT may also be present in the sediment and surface water from a nearby county drain.

Both calcium and potassium are required elements in people. Calcium is required for teeth and bone formation, along with muscle contracting and blood clotting. Recommended intakes are 1,000 mg/day or higher for people over 9 years of age. The upper limit on the daily intake is 2,500 mg/day for people older than 1 year old. People can obtain calcium from eating milk, cheese, yogurt, corn tortillas, Chinese cabbage, broccoli, kale, calcium-set tofu (NAS 2001), and calcium-fortified foods (like orange juice).

Potassium is necessary for the normal functioning of people's cells. People obtain potassium by eating fruits, vegetables, meat, and nuts. There is no upper limit on the daily intake set for potassium because there is no evidence chronic excess intakes of potassium can occur in

apparently healthy individuals (NAS 2004). Most people's bodies will remove the extra or unnecessary calcium and potassium.

About 15-21% of technical grade DDT was 2,4-DDT. It is less toxic than 4,4-DDT, but 2,4-DDT can act similar to the hormone estrogen. Laboratory experiments have shown that, 2,4-DDT was about 100,000 times less effective than estrogen hormones in producing an effect on reproductive systems (ATSDR 2002). Levels of 2,4-DDT range from 0.023 to 0.64 mg/kg in soil (from the VBP) and sediment (in a county drain near the VBP), and from 0.00001 to 0.0049 mg/L in surface (in a county drain near the VBP) and groundwater (under the VBP). Adults or children are not expected to be exposed to levels of 2,4-DDT that would harm their health.[21]

Delta-BHC is one of the isomers of the pesticide lindane. Technical grade BHC contained about 6 to 10% of the delta-BHC (ATSDR 2005). It was found in the soil at and in the groundwater under the VBP. Soil had a maximum amount of delta-BHC of 0.043 mg/kg (estimated value) and delta-BHC may have been present in the groundwater, but below the detection limit for the samples (0.002 mg/L). People are expected to have little to no contact with the soil at the VBP and the groundwater under the VBP.

Methyl acetate and dibenzofuran may have been present in the ash piles and methyl acetate was detected in the soil on the VBP Since people are expected to have limited or no contact with the soil and ash piles on the VBP, it is not expected that these chemicals will harm people's health.

1,2,3-Trichlorobenzene, trihalomethane (total), and cyclohexane may be present in groundwater samples taken from monitoring wells on the VBP. Trichlorobenzenes have been used, in industry, as solvents, chemical intermediates, and dye carriers. However, trichlorobenzenes can also be degradation products from other chemicals, such as lindane (ATSDR 2010). 1,2,3-Trichlorobenzene may have been present below the reported sample quantitation limit (5 mg/L) in shallow outwash unit monitor wells at the VBP. People are expected to have limited to no contact with the groundwater under this site, and people's health is not expected to be harmed from contact with water containing this level of 1,2,3-trichlorobenzene.

Total trihalomethane was found up to 3.2 mg/L in groundwater under the VBP. Total trihalomethane refers to chemicals that have three halogens, such as bromine and chlorine, attached to a carbon. Many chemicals, such as bromoform and chloroform are included in this group. While there is no screening level for total trihalomethane, the screening levels exist for the individual chemicals that are included in this group. The individual chemicals included in this group were not above the screening levels. Although people are not expected to have contact with the groundwater, levels of total trihalomethanes present in the water will not harm people's health.

[21] If adults or children happened to inhale airborne dust with the maximum level of 2,4-DDT (0.64 mg/kg) from the FBA daily, the amount of 2,4-DDT ingested would be about 40 to 300 times lower than 0.3 mg/kg/day (a dose given to rats for two generations with no effect). This assumes adults (70 kg) and children (15 kg) swallow 0.2 kg of soil daily with 0.64 mg/kg of 2,4-DDT. If adults (70 kg) or children (15 kg) drink water (2 L/day) with 0.0049 2,4-DDT, the amount of ingested 2,4-DDT would be 459 to 2,142 times lower than the 2,4-DDT amount given to rats for two generations without an effect (0.3 mg/kg/day). DDT is not absorbed well through the skin, so skin contact with the water or soil would not add to people's exposure. The levels present in soil, water, or sediment would not harm people's health.

Cyclohexane may have also been present in VBP groundwater samples at levels below the lower level that could be accurately measured. People are expected to have little to no contact with groundwater from the VBP and so will not come into contact with this chemical.

Sulfate was found in the surface water of the county drain near the VBP with a maximum value of 100 mg/L. The level of sulfate in the water was below the screening level for drinking water (250 mg/L). People's health will not be affected by coming into contact with water containing sulfate. Even if used for drinking water, the sulfate levels would not harm people's health.

Oil and grease may have been present in surface water and in a drinking water sample; however both were at levels below a level that could be accurately measured by the analytical method used. The oil and grease could have been from normal levels of oil and grease from natural sources, such as fats from plant material.

Children's Health Considerations

Compared to adults, children could be at greater risk from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Certain contaminants of concern at these locations, such as lead, produce greater adverse effects in children as compared to adults. Children may have both increased absorption and increased susceptibility to these contaminants.

The VBP is located adjacent to a golf course, in an area that could be considered in the rough (an untended area). As it is not part of the golf course, children visiting the golf course are not expected to have much contact with the soil or ash piles. As the VBP is surrounded by a golf course, young children are not expected to encounter contaminants at this site. Older children and teenagers could make their way onto the VBP, but the vegetation and the depth of contaminated groundwater and soil would limit the exposure.

Contamination might have migrated off the site, either during the use of the site or from areas that into the downwind residential areas. Children may encounter contaminants from the site in their own yards. However, children are not expected to be harmed from the current levels of contamination present in soil in the residential areas.

Conclusions

Contaminants present in the soil at the VBP will not harm people's health. Visitors, including golfers, to the golf course around the VBP are expected to have little to no contact with the soil as it is not on the golf course, and is covered by vegetation. Golf course workers are not expected to have contact with the soil.

Not enough information is available to determine if the contaminants present in the ash piles at the VBP could harm people's health as only one sample was taken from the surface of each ash

pile. Levels of arsenic and lead in both ash piles were higher than the screening levels. Workers and visitors to the golf course are not expected to have contact with the ash piles; the VBP is not on the golf course. Currently, however, there is no fence around the ash piles or the VBP that would limit people's access. If people appear to have more contact with the ash piles, such as if the vegetation does not completely cover the pile and people often visit the VBP or ash repeatedly blows onto the golf course, contaminant levels should be better characterized.

Levels of contaminants in the soil of the downwind residential area are not expected to harm resident's health. Contaminants are not expected to migrate from the VBP, based on the current vegetation present.

Levels of contaminants in the groundwater at the VBP are not expected to harm people's health; however, contaminants in soil appear to be migrating into the groundwater. Contaminants that migrate into the groundwater have the potential to reach residential or municipal drinking water. Groundwater at and around the VBP should continue to be monitored to determine if contaminants are migrating.

Levels of contaminants in the two residential wells near the site are not expected to harm people's health. Contaminants from the VBP should be measured in the monitoring wells. If the contaminants migrate into the deeper monitoring wells, residential wells should be tested.

Contaminants in the surface water and sediment in the drainage ditch near the site are not expected to harm people's health. This area is a county drain and people will have limited contact with the surface water and sediments.

Recommendations

Characterize the extent of contamination in the ash piles, and the potential for contaminant migration.

Consider restricting public access to the ash piles.

Continue monitoring contaminants in the groundwater at the VBP and prevent further migration of contaminants.

Public Health Action Plan

MDCH will evaluate any relevant new data.

Preparers of Report

This Public Health Assessment was prepared by the Michigan Department of Community Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database, and the approving agency reviewers are listed below.

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Appendix A: Contaminants measured during the 2006 Remedial Investigation (Weston 2006).

This appendix contains tables of contaminants at or above the reported quantitation limit from the first investigation (Weston 2006). Screening levels are included in each table.

MDEQ Part 201 Generic Cleanup Criteria (MDEQ 2006a, 2006b) values were selected for screening levels if they were available. Screening levels for soil and sediment were the MDEQ Part 201 Residential and Commercial I Direct Contact Criteria (DCC). The DCC are soil concentrations of contaminants that are not expected to harm people's health after long-term (30 years) ingestion and dermal contact typical of residential use, which includes activities such as gardening. If no DCC were available, an ATSDR soil comparison value was selected. ATSDR soil comparison values do not include a dermal exposure route, which is expected to be the most relevant route for golfers (handling and cleaning golf equipment). If contaminant concentrations were below the screening levels, either the DCC or ATSDR soil comparison values, the contaminants are not expected to harm people's health. The DCC were also used as screening levels to evaluate exposure to sediments, such as when people step into the water.

For groundwater, the MDEQ Part 201 Groundwater Contact Criteria (GCC) were used as screening levels. The GCC is a protective value for workers coming into contact with groundwater contaminants (for 21 years) and was also used as a screening value to evaluate contact with surface water. Since the VBP is located within a working golf course, workers would be the group most expected to have dermal contact with groundwater. ATSDR has no comparison values for dermal contact with water. The Part 201 MDEQ Residential Drinking Water Criteria (RDWC) were used as screening levels for wells that are used for drinking water. If the RDWC was not health-based, the human health-based drinking water value (MDEQ 2010) for was selected as the screening level. ATSDR drinking water comparison values were added to Table A-7 if they were lower than the MDEQ value.

Screening levels for soil gas were from the MDEQ Part 201 Program Redesign 2009 Draft Proposed Residential Soil Gas Criteria (MDEQ 2009). The Residential Soil Gas Criteria are calculated from the Residential Indoor Air Criteria, levels of chemicals that people can breathe in their home that are not expected to cause health effects. These levels are only meaningful if a building is present on the location. If buildings are built on the VBP in the future, the possibility of soil gas phase contaminant migration into the buildings (vapor intrusion) should be evaluated. ATSDR has no soil gas comparison values.

Soil sampling results

Table A-1: Maximum value (in milligrams per kilogram [mg/kg]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit (VBP) soil from soil borings (17 samples) (Weston 2006).

Analyte	Screening level[a] (mg/kg)	Maximum value in VBP soil (mg/kg)
1,1-dichloroethane	890	0.071 J[b]
1,2-dichloroethane	91	33
2,4-DDT	NA[c]	0.023
2,6-dinitrotoluene	200[d]	1.1 U[e]
2-methylnaphthalene	8,100	0.47 UJ[f]
4,4-DDD	95	0.38 J
4,4-DDE	45	0.2
4,4-DDT	57	0.041 U
acetone	23,000	3.3 UJ
alpha-BHC	2.6	0.14 J
aluminum, total	50,000	7,800J
anthracene	230,000	1.1 U
antimony, total	180	3.9
arsenic, total	7.6	**10.4**
barium, total	37,000	52
benzene	180	6.2
beryllium, total	410	0.60 J
beta-BHC	5.4	0.023 J
bromomethane	320	0.29 J
cadmium, total	550	3.3 U
calcium, total	NA	87,000
chlordane, total	31	0.083 J
chlorobenzene	260	0.076 J
chloroform	1,200	0.24
chromium, hexavalent	2,500	0.65
chromium, total	2,500[g]	14
chromium, trivalent	790,000	13.35
cobalt, total	2,600	6.4
copper, total	20,000	15
delta-BHC	NA	0.043 J
diethylphthalate	740	1.1 U
endosulfan II	1,400[h]	0.15 J
endosulfan, total	1,400	0.15 J
endrin aldehyde	65[i]	0.96 DJ[j]
endrin ketone	65[i]	0.041 U
ethylbenzene	140	0.22 U
gamma-BHC (lindane)	8.3	1.5 DJ
gamma-chlordane	31[k]	0.083 J
hexabromobenzene	1,100	0.10 U
iron, total	160,000	21,000J
lead, total	400	100J

Table A-1 continued		
Analyte	Screening level[a] (mg/kg)	Maximum value in VBP soil (mg/kg)
magnesium, total	1,000,000	34,000
manganese, total	25,000	420J
mercury, total	160	0.42 J
methyl acetate	NA	0.99
methylene chloride	1,300	0.29 U
naphthalene	16,000	0.47 UJ
nickel, total	40,000	15J
n-nitroso-di-n-propylamine	1.2	1.1 U
PBB	1.2	0.05 UJ
phenanthrene	1,600	0.47 UJ
phenol	12,000	1.3
potassium, total	NA	1,200
selenium, total	2,600	1.6 U
silver, total	2,500	2.4 U
sodium, total	1,000,000	460
thallium, total	35	2.0 U
toluene	250	0.25
trans-1,3-dichloropropene	10	1.3
vanadium, total	750	23
xylene (total)	150	0.67 U
zinc, total	170,000	41

Bold values are higher than the criteria.
a = Unless otherwise noted, the screening level is the MDEQ Residential DCC.
b = The "J" indicates that the value is an estimated result.
c = The "NA" indicates that no screening level is available.
d = The screening level is ATSDR's intermediate Environmental Media Evaluation Guide value.
e = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
f = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.
g = The screening level is the MDEQ Residential DCC for hexavalent chromium.
h = The screening level is the MDEQ Residential DCC for total endosulfan isomers.
i = The screening level is the MDEQ Residential DCC for endrin.
j = The "DJ" indicates that the sample was diluted and the value is an estimated result.
k = The screening level is the MDEQ Residential DCC for total chlordane isomers.

Ash sampling results

Table A-2: Maximum value (in milligrams per kilogram [mg/kg]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit (VBP) ash samples (two samples) (Weston 2006).

Analyte	Screening level[a] (mg/kg)	Maximum value in ash samples (mg/kg)
2-methylnaphthalene	8,100	0.54 U
4,4-DDD	95	0.0013
4,4-DDE	45	0.061
4,4-DDT	57	0.030
acetone	23,000	0.32 U
aluminum, total	50,000	14,000
anthracene	230,000	0.54 U
antimony, total	180	36
arsenic, total	7.6	**62.4**
barium, total	37,000	840
benzo(a)anthracene	20	0.54 U
benzo(a)pyrene	2	0.54 U
benzo(b)fluoranthene	20	0.3 J
benzo(k)fluoranthene	200	0.54 U
beryllium, total	410	5.8
butylbenzylphthalate	310	0.54 U
cadmium, total	550	1.9 J
calcium, total	NA	25,000
chromium, hexavalent,	2,500	0.6 U
chromium, total	2,500 d	26
chromium, trivalent	790,000	25.4
chrysene	2,000	0.41 J
cobalt, total	2,600	41
copper, total	20,000	95
cyanide, total	12	1.0
dibenzofuran	NA	0.54 U
diethylphthalate	740	0.065 J
endrin ketone	65 (endrin)	0.01
fluoranthene	46,000	0.5 J
heptachlor epoxide	3.1	0.007 U
hexabromobenzene	1,100	0.1 U
indeno(1,2,3-cd)pyrene	20	0.54 U
iron, total	160,000	62,000
lead, total	400	**670**
magnesium, total	1,000,000	2,800
manganese, total	25,000	620
mercury, total	160	0.145
methoxychlor	1,900	0.007 U
methyl acetate	NA	0.19 J
naphthalene	16,000	0.54 U
nickel, total	40,000	38
PBB	1.2	0.0012 J

Table A-2 continued		
Analyte	Screening level[a] (mg/kg)	Maximum value in ash samples (mg/kg)
phenanthrene	1,600	0.58 J
phenol	12,000	0.54 U
pyrene	29,000	0.25 J

Bold values are higher than the criteria.
a = Unless otherwise noted, the screening level is the MDEQ Residential Direct Contact Criteria (DCC).
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
c = The "J" indicates that the value is an estimated result.
d = The "NA" indicates that no screening level is available.
e = The screening level is the MDEQ Residential DCC for hexavalent chromium.
f = The screening level is the MDEQ Residential DCC for endrin.

Soil gas sampling

Table A-3: Maximum value (in milligrams per cubic meter [mg/m^3]) of soil gas levels in the Velsicol Burn Pit (VBP) (Weston 2006).

Analyte	Shallow screening level (sub-slab)[a]	Maximum levels from samples less than five feet deep	Deep screening level (deep 5')[b]	Maximum levels from samples over five feet deep
1,1,1-trichloroethane	310	<0.04[c]	3,100	<5
1,1,2-trichloroethane	0.076	<0.04[c]	0.76	<5
1,1-dichloroethane	26	0.13[c]	260	5.8
1,1-dichloroethene	10	<0.04[c]	100	<5
1,2,4-trichlorobenzene	21,000	<0.04[c]	21,000	<5
1,2,4-trimethylbenzene	11	<0.04[c]	110	ND[d]
1,2-dibromoethane	NA[e]	<0.04[c]	NA	0.43
1,2-dichlorobenzene	16	<0.04[c]	160	<10
1,2-dichloroethane	0.047	**>4.0**[c]	0.47	**22**
1,2-dichloroethene, cis-	1.8	<0.04[c]	18	<5
1,2-dichloroethene, trans-	3.7	<0.04[c]	37	<5
1,2-dichloropropane	0.21	0.058[c]	2.10	**<5**
1,3,5-trimethylbenzene	11	<0.04[c]	110	ND
1,3-dichlorobenzene	0.16	<0.04[c]	1.60	**<10**
1,4-dichlorobenzene	0.18	<0.04[c]	1.80	**<10**
1-2 dibromo-3-chloropropane	0.01	**<0.1**[c]	0.10	**<25**
2-butanone (MEK)	260	<0.04[c]	2,600	<50
2-hexanone	2.1	<0.04[c]	21	**<50**
4-methyl-2-pentanone (MIBK)	160	0.085[c]	1,600	<50
acetone	310	<0.48[c]	3,100	<50
benzene	0.15	**>3.2**[c]	1.50	**160**
carbon disulfide	37	<0.04[c]	370	<50
carbon tetrachloride	0.081	<0.04[c]	0.81	**<5**
chlorobenzene	37	<0.04[c]	37	0.49
chloroethane	520	<0.1[c]	5,200	<25
chloroform	0.51	<0.22[c]	5.10	<5
cyclohexane	310	<0.04[c]	3,100	<50
dichlorodiflouromethane	2,600	<0.1[c]	26,000	<25
ethanol	NA	<0.04[c]	NA	ND

Table A-3 continued				
Analyte	Shallow screening level (sub-slab)[a]	Maximum levels from samples less than five feet deep	Deep screening level (deep 5')[b]	Maximum levels from samples over five feet deep
ethyl benzene	3.9	<0.04[c]	39	<5
heptane	180	<0.04[c]	1,800	ND
hexane, n-	37	<0.2[c]	370	ND
isopropylbenzene	21	<2	210	<10
methyl acetate	NA	<0.1[c]	NA	<50
methylcyclohexane	NA	<0.1[c]	NA	<50
methylene chloride	2.60	1.3[c]	26	<25
propylene	NA	>1.7[c]	NA	ND
styrene	2.10	<0.04[c]	21	<5
tetrachloroethene	2.10	<0.04[c]	21	<5
toluene	260	0.15[c]	2,600	<5
trichloroethene	7.20	<0.04[c]	7.20	<5
trichlorofluoromethane	2,900	<0.1[c]	29,000	<25
vinyl chloride	0.140	<0.04[c]	1.40	**<10**
xylene, m,p	5.20	<0.08[c]	52	<10
xylene, o-	5.20	<0.04[c]	52	<5
Table A-3 continued				

Bold values are higher than the criteria.
a = The screening levels are MDEQ's Draft Proposed Sub-Slab Residential Soil Gas Criteria (MDEQ 2009).
b = The screening levels are MDEQ's Draft Proposed Deep 5' Residential Soil Gas Criteria (MDEQ 2009).
c = The sample was collected in a Summa canister and analyzed offsite
d = The "ND" indicates that the sample was not analyzed for this analyte.
e = The "NA" indicates that no screening level is available.

Groundwater sampling results from soil borings

Table A-4: Maximum value (in milligrams per liter [mg/L]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit (VBP) groundwater samples (17 samples) from vertical aquifer sampling (Weston 2006).

Analyte	Screening level[a] (mg/L)	Maximum value (mg/L)
1,2-dichloroethane	19	16
1,3-dichlorobenzene	2	0.005 U[b]
2-chlorophenol	94	0.005 U
4-methylphenol	810[c]	0.0092
acetone	31,000	10 UJ[d]
aluminum, dissolved	64,000	0.2 U
aluminum, total	64,000	10.8
antimony, dissolved	68	0.0059 J[e]
arsenic, dissolved	4.3	0.0588
arsenic, total	4.3	0.0133 J
barium, dissolved	14,000	0.705
barium, total	14,000	0.254
benzene	11	**14**
beryllium, total	290	0.005 U

Table A-4 continued		
Analyte	Screening level[a] (mg/L)	Maximum value (mg/L)
bis(2-ethylhexyl)phthalate	0.32	0.028
cadmium, dissolved	190	0.005 U
calcium, dissolved	NA[f]	186
calcium, total	NA	314
carbon disulfide	1,200	0.5 U
chloroform	150	0.14 J
chromium, dissolved	460[g]	0.01 U
chromium, total	460[g]	0.0841
cis-1,2-dichloroethane	19	0.2 U
cobalt, dissolved	2,400	0.0102
copper, total	7,400	0.0495 J
diethylphthalate	1,100	0.005 U
iron, dissolved	58,000	33.2
iron, total	58,000	27.1
lead, total	0.19[h]	0.0101 J
magnesium, dissolved	1,000,000	44
magnesium, total	1,000,000	81.5
manganese, dissolved	9,100	0.11
manganese, total	9,100	0.604
nickel, dissolved	74,000	0.0474
nickel, total	74,000	0.0449
phenol	29,000	0.02
potassium, dissolved	NA	11.9
potassium, total	NA	5.41 J
selenium, dissolved	970	0.035 U
sodium, dissolved	1,000,000	483
sodium, total	1,000,000	75
tetrachloroethane	4.7[i]	0.2 U
thallium, dissolved	13	0.025 U
toluene	530	0.2 U
trichloroethane	21[j]	0.2 U
vanadium, dissolved	970	0.05 U
vinyl chloride	1.0	0.2 U
zinc, dissolved	110,000	0.0345
zinc, total	110,000	0.222

Table A-4 continued
Bold values are higher than the criteria.
a = Unless otherwise noted, the screening levels is the MDEQ Groundwater Contact Criteria (GCC).
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
c = The screening level is the MDEQ GCC for total methylphenols.
d = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.
e = The "J" indicates that the value is an estimated result.
f = The "NA" indicates that no screening level is available.
g = The screening level is the MDEQ GCC for hexavalent chromium.
h = The value is the MDEQ's Rule 57 non-drinking water value set for human health.
i = The screening level is the MDEQ GCC for 1,1,2,2- tetrachloroethane.
j = The screening level is the MDEQ GCC for 1,1,2- trichloroethane.

Groundwater sampling results from monitor wells

Table A-5: Maximum value (in milligrams per liter [mg/L]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit (VBP) groundwater samples (52 samples) from monitor wells sampled in 2005 (Weston 2006).

Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
1,1,1-trichloroethane	1,300	0.340 J[b]
1,1-biphenyl	0.69[c]	0.00072 J
1,1-dichloroethane	2,400	1.8
1,2-dichloroethane	19	**700 D[d]**
1,2-dichloropropane	16	0.88
2,2-oxybis(1-chloropropane)	NA[e]	0.6 UJ[f]
2,4-DDT	NA	0.000094 UJ
2,4-dichlorophenol	48	0.6 UJ
2-chlorophenol	94	0.024
2-methylnaphthalene	25	0.014 J
2-methylphenol	810[g]	0.25 J
4,4-DDD	0.044	0.0022 UJ
4,4-DDE	0.027	0.0022 UJ
4,4-DDT	0.013	0.0022 UJ
4-methyl-2-pentanone	13,000	50
4-methylphenol	810	0.6 U[h]
acetone	31,000	50 U
acetophenone	6,100	0.6 U
aldrin	0.00034	**0.0035 J**
alpha-BHC	0.06	0.001 U
alpha-chlordane	0.015[i]	0.001 U
aluminum, total	64,000	2.83
antimony, dissolved	68	0.06 U
antimony, total	68	0.06 U
arsenic, dissolved	4.3	0.035
arsenic, total	4.3	0.118
barium, dissolved	14,000	1.14

Table A-5 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
barium, total	14,000	1.99 J
benzene	11	**120 E**[j]
beryllium, dissolved	290	0.005 J
beryllium, total	290	0.005 J
beta-BHC	0.12	0.001 U
bis(2-chloroethyl)ether	5.7	0.16 J
bis(2-ethylhexyl)phthalate	0.32	**0.6 U**
cadmium, total	190	0.005 U
calcium, dissolved	NA	3,420
calcium, total	NA	3,920
carbon disulfide	1,200	50 U
chlordane, (total)	0.015	**0.017 J**
chlorobenzene	86	50 U
chloroform	150	50 U
chromium, dissolved	460[k]	0.01 U
chromium, total	460[k]	0.049
cis-1,2-dichloroethene	20	50U
cobalt, dissolved	2,400	0.050 U
cobalt, total	2,400	0.050 U
copper, dissolved	7,400	0.025 U
copper, total	7,400	0.025 U
cyanide, total	57	0.0103
cyclohexane	NA	50 U
endosulfan II	0.51	0.001 U
endosulfan sulfate	0.51	0.001 U
endosulfan, (total)	0.51	0.00011 J
endrin	0.16	0.001 U
endrin ketone	0.16	0.001 U
fluorene	2.0	0.6 U
gamma-BHC (Lindane)	0.19	0.041 D
gamma-chlordane	0.015[h]	**0.017 J**
heptachlor	0.0029	0.001 U
heptachlor epoxide	0.009	0.001 U
iron, dissolved	58,000	279 J
iron, total	58,000	281 J
lead, dissolved	0.19[m]	0.0328
lead, total	0.19 [m]	0.0292
magnesium, dissolved	1,000,000	675
magnesium, total	1,000,000	687.999 J
manganese, dissolved	9,100	5.62
manganese, total	9,100	5.65 J
mercury, dissolved	0.056	0.0034
mercury, total	0.056	0.0036
methoxychlor	0.045	0.011 EJ[j]

Table A-5 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
methylcyclohexane	NA	50 U
methylene chloride	220	16
methylphenol, (total)	810	0.342 J
naphthalene	31	0.6 UJ
nickel, dissolved	74,000	0.57 J
nickel, total	74,000	0.574 J
PCBs - Aroclor-1242	0.0033[n]	**0.005 UJ**
p-chloro-m-cresol	79	0.6 UJ
phenol	29,000	2.7
potassium, dissolved	NA	174.999 J
potassium, total	NA	171 J
pyrene	0.14	**0.6 U**
selenium, dissolved	970	0.035 U
selenium, total	970	0.035 U
sodium, dissolved	1,000,000	726.999 J
sodium, total	1,000,000	1,140 J
toluene	530	50 U
trichloroethene	22	**50 U**
tris (2,3-dibromopropyl) phosphate	2.1	0.01 U
vanadium, dissolved	970	0.05 UJ
vanadium, total	970	0.05 U
zinc, dissolved	110,000	0.0686 J
zinc, total	110,000	0.063 J

Bold values are higher than the criteria.
a = Unless otherwise noted, the screening levels is the MDEQ Groundwater Contact Criteria (GCC).
b = The "J" indicates that the value is an estimated result.
c = The screening level is the MDEQ's Rule 57 non-drinking water value set for human health.
d = The "D" indicates that the sample was diluted for analysis.
e = The "NA" indicates that no screening level is available.
f = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.
g = The screening level is the MDEQ GCC for total methylphenols.
h = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
i = The screening level is the MDEQ GCC for total chlordane isomers.
j = The "E" or "EJ" indicates that the value exceeded the instrument's calibration range for the analytical method and the result is estimated.
k = The screening level is the MDEQ GCC for hexavalent chromium.
l = The screening level is the MDEQ GCC for total endosulfan isomers.
m = The screening level is the MDEQ's Rule 57 non-drinking water value set for human health.
n = The screening level is the MDEQ GCC for total PCBs.

Table A-6: Maximum value (in milligrams per liter [mg/L]) of para-Chlorobenzenesulfonic acid (pCBSA) in the Velsicol Burn Pit (VBP) groundwater samples from monitor wells sampled in 2005 (Weston 2006).

Wells	Number of wells	Screening level[a] (mg/L)	Maximum level pCBSA (mg/L)
Shallow depth wells	8	2,200	0.015
Intermediate depth wells	7	2,200	0.001 U[b]
Deep wells	4	2,200	0.0018

a = The screening level is the MDEQ's Rule 57 non-drinking water value set for human health.
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.

Residential and Hidden Oaks Golf Course well sampling results

Table A-7: Maximum value (in milligrams per liter [mg/L]) of compounds at or above the reported quantitation limit in the Hidden Oaks Golf Course and two residential wells sampled in 2004 (Weston 2006).

Analyte	Screening level[a] (mg/L)	Maximum values from Hidden Oaks Golf Course well (mg/L)	Maximum values from two residential wells (mg/L)
1,1-biphenyl	0.46[b]	0.013 U[c]	0.01 U
2,4-DDT	NA[d]	**0.00002 UJ[e]**	**0.00002 UJ**
aluminum, total	0.3[f]	0.0536 U	0.0311 J[g]
arsenic, total	0.010[h]	0.0032 U	**0.0234**
barium, total	2	0.053	0.277
beryllium, total	0.004	0.0002 U	0.00085 J
bis(2-ethylhexyl)phthalate	0.006	**0.013 U**	**0.01 U**
butylbenzylphthalate	1.2	0.013 U	0.01 U
calcium, total	NA	53.1	143
chloride	250	15	**345**
chlorobenzene	0.1	0.01 U	0.01 U
chromium, total	0.1	0.0011 U	0.0006 U
copper, total	1[i]	0.0011 UJ	0.0123
cyanide, total	0.200[j]	0.003 UJ	0.0062 J
di-n-butylphthalate	0.88	0.013 U	0.01 U
HEM, oil & grease	NA	5 U	5 U
hexabromobenzene	0.00017	0.00002UJ	0.0000067 J
iron, total	2.0[f]	0.161	0.989
lead, total	0.004	0.0026 U	0.0023
magnesium, total	400	17.1	56.3
manganese, total	0.86[f, k]	0.0743	0.133
nitrogen, ammonia	10	0.53	0.46
nitrogen, nitrate+nitrite	1[l]	0.02	0.11
n-nitroso-di-n-propylamine	0.005	**0.013 U**	**0.01 U**
potassium, total	NA	1.04	2.98
selenium, total	0.05	0.0032 U	0.0025 U
sodium, total	120	83.4 J	79.1 J

Table A-7 continued			
Analyte	Screening level[a] (mg/L)	Maximum values from Hidden Oaks Golf Course well (mg/L)	Maximum values from two residential wells (mg/L)
sulfate	250	107	20
vanadium, total	0.0045	0.001 U	0.0015 U
zinc, total	2.4	0.0551	0.342

Bold values are higher than the criteria.
a = Unless otherwise noted, the screening levels is the MDEQ Residential Drinking Water Criteria (RDWC).
b = The screening level is the MDEQ's Rule 57 drinking water value set for human health.
c = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
d = The "NA" indicates that no screening level is available.
e = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.
f = The screening level is the MDEQ's Residential health based drinking water value in the Footnotes (MDEQ 2005).
g = The "J" indicates that the value is an estimated result.
h = ATSDR's arsenic drinking water comparison value for children is 0.003 mg/L. The value in the Hidden Oaks Golf Course well (0.0032 mg/L) is considered equivalent to this value.
i = ATSDR's copper drinking water comparison value for children is 0.1 mg/L. Measured levels were below this value.
j = ATSDR's cyanide drinking water comparison value for children is 0.006 mg/L. This was equivalent to the maximum level measured from the two residential wells.
k = The EPA's lifetime health advisory for manganese is 0.3 mg/L. Measured levels were below this value.
l = The screening level is the MDEQ's RDWC for nitrite.

Appendix B: Contaminants measured during the 2009 Remedial Investigation (Weston 2009).

This appendix contains tables of contaminants at or above the reported quantitation limit from the second investigation (Weston 2006). Descriptions of the screening levels included in the tables are on page A-1.

Soil sampling results from the VBP

Table B-1: Maximum value (in milligrams per kilogram [mg/kg]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit (VBP) soil sampled (66 samples) in 2007 (Weston 2009).

Analyte	Screening level[a] (mg/kg)	Maximum levels in all soil depths (mg/kg)
1,2-dichloroethane	91	1.7
2,4-DDT	NA[b]	0.64 J[c]
4,4-DDD	95	0.42
4,4-DDE	45	2.2
4,4-DDT	57	2.3
aldrin	1.0	0.18 U[d]
alpha-BHC	2.6	0.18 U
alpha-chlordane	31[e]	0.22
aluminum, total	50,000	10,000
antimony, total	180	1.7
arsenic, total	7.6	**21**
barium, total	37,000	140
benzene	180	2.8
beryllium, total	410	1.2
cadmium, total	550	2.2
calcium, total	NA	103,000 J
chlordane (total)	31	0.37
chlorobenzene	260	0.13 U
chromium, hexavalent	2,500	6.6
chromium, total	2,500[f]	23
cobalt, total	2,600	8.1
copper, total	20,000	120
cyanide, total	12	0.32
endosulfan (total)	1,400	0.0014
endosulfan I	1,400	0.18 U
gamma-BHC (lindane)	8.3	0.18 U
gamma-chlordane	31[e]	0.15 J
HBB	1,100	11U
iron, total	160,000	29,000 J
lead, total	400	**810**
magnesium, total	1,000,000	37,400 J
manganese, total	25,000	630
mercury, total	160	0.16
molybdenum, total	2,600	1.8

Table B-1 continued		
Analyte	Screening level[a] (mg/kg)	Maximum levels in all soil depths (mg/kg)
nickel, total	40,000	22
PBB	1.2	**5.4 UJ**[g]
pCBSA	230,000	0.011
potassium, total	NA	1,510 J
selenium, total	2,600	7.6
silver, total	2,500	0.25
sodium, total	1,000,000	1,540
thallium, total	35	0.5 U
vanadium, total	750	84
zinc, total	170,000	520

Bold values are higher than the criteria.
a = Unless otherwise noted, the screening level is the MDEQ Residential Direct Contact Criteria (DCC).
b = The "NA" indicates that no screening level is available.
c = The "J" indicates that the value is an estimated result.
d = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
e = The screening level is the MDEQ Residential DCC for total chlordane isomers.
f = The screening level is the MDEQ Residential DCC for hexavalent chromium.
g = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.

Soil sampling results from the downwind residential area

Table B-2: Maximum value (in milligrams per kilogram [mg/kg]) of compounds at or above the reported quantitation limit in the downwind residential area soil (0 to 0.5 feet deep, 32 samples) sampled in 2007 (Weston 2009).

Analyte	Screening level[a] (mg/kg)	Maximum levels in surface soil (mg/kg)
2,4-DDT	NA[b]	0.054 J[c]
4,4-DDD	95	39 UJ[d]
4,4-DDE	45	0.61
4,4-DDT	57	0.28
aluminum, total	50,000	12,000
antimony, total	180	0.31
arsenic, total	7.6	**35**
barium, total	37,000	72
benzo(a)anthracene	20	0.14 U[e]
benzo(b)fluoranthene	20	0.28 U
beryllium, total	410	0.52
cadmium, total	550	0.58
calcium, total	NA	68,000
chromium, hexavalent	2,500	2.7 UJ
chromium, total	2,500[f]	18
chrysene	2,000	0.14 U
cobalt, total	2,600	8
copper, total	20,000	22
cyanide, total	12	0.22
fluoranthene	46,000	0.24

Table B-2 continued		
Analyte	Screening level[a] (mg/kg)	Maximum levels in surface soil (mg/kg)
gamma-BHC (lindane)	8.3	0.038 UJ
HBB	1,100	2.2 U
heptachlor	5.6	0.038 UJ
iron, total	160,000	22,000 J
lead, total	400	100
magnesium, total	1,000,000	18,200 J
manganese, total	25,000	350
mercury, total	160	0.16
molybdenum, total	2,600	2.4
nickel, total	40,000	19
PBB	1.2	1.1 UJ
phenanthrene	1,600	0.14 U
potassium, total	NA	1,290 J
pyrene	29,000	0.21
selenium, total	2,600	1.2
silver, total	2,500	0.18
sodium, total	1,000,000	140
vanadium, total	750	27 J
zinc, total	170,000	140

Bold values are higher than the criteria.
a = Unless otherwise noted, the screening level is the MDEQ Residential Direct Contact Criteria (DCC)..
b = The "NA" indicates that no screening level is available.
c = The "J" indicates that the value is an estimated result.
d = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.
e = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
f = The screening level is the MDEQ Residential DCC for hexavalent chromium.

Groundwater sampling results from vertical aquifer sampling

Table B-3: Maximum levels (in milligrams per liter [mg/L]) of contaminants at or above the reported quantitation limit from vertical aquifer sampling (15 samples) (Weston 2009).

Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
1,1,1,2-tetrachloroethane	30	0.001 U[b]
1,1-dichloroethane	2,400	0.001 U
1,2-dichlorobenzene	160	0.001 U
1,2-trichloroethane	19	0.001 U
1,3-dichlorobenzene	2	0.001 U
1,4-dichlorobenzene	6.4	0.001 U
acetone	31,000	0.02 U
benzene	11	0.001 U
bromobenzene	12	0.001 U
bromodichloromethane	14	0.001 U
bromoform	140	0.001 U
carbon disulfide	1,200	0.001 U

Table B-3 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
chlorobenzene	86	0.001 U
chloroethane	440	0.005 U
chloroform	150	0.0021
cis-1,2-dichloroethene	200	0.001 U
ethyl ester	64,000	0.005 U
pCBSA	2,200[c]	0.001 U
styrene	9.7	0.001 U
toluene	530	0.001 U
trans-1,2-dichloroethene	220	0.001 U
trichloroethane	21[d]	0.001 U
trihalomethane (total)	NA[e]	0.0021
vinyl chloride	1	0.001 U

a = Unless otherwise noted, the screening levels is the MDEQ Groundwater Contact Criteria (GCC).
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
c = The screening level is the MDEQ's Rule 57 non-drinking water value set for human health.
d = The screening level is the MDEQ GCC for 1,1,2- trichloroethane.
e = The "NA" indicates that no screening level is available.

Groundwater sampling results from monitor wells

Table B-4: Maximum value (in milligrams per liter [mg/L]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit (VBP) groundwater samples from the shallow outwash unit monitor wells (17 samples) (Weston 2009).

Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
1,1,1-trichloroethane	1,300	1 U[b]
1,1,2,2-tetrachloroethane	4.7	1 U
1,1,2-trichloroethane	21	1 U
1,1-dichloroethane	2,400	1.3
1,1-dichloroethene	11	1 U
1,2,3-trichlorobenzene	0.073[c]	**5U**
1,2,3-trimethylbenzene	0.65[d]	**1 U**
1,2,4-trichlorobenzene	19	5U
1,2,4-trimethylbenzene	56	1 U
1,2-dibromo-3-chloropropane	0.39	**5U**
1,2-dibromoethane	530	1 U
1,2-dichlorobenzene	160	1 U
1,2-dichloroethane	19	1 U
1,2-dichloropropane	16	1 U
1,3-dichlorobenzene	2	1 U
1,4-dichlorobenzene	6.4	1 U
2,4-DDT	NA[e]	0.001 U
2,4-dichlorophenol	48	5U
2-butanone	240,000	5 U

Table B-4 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
2-chlorophenol	94	5U
2-methylnaphthalene	25	2.5 U
3 and 4-methylphenol	810[f]	1 U
4,4-DDD	0.044	0.002 U
4,4-DDE	0.027	0.002 U
4,4-DDT	0.013	0.002 U
acenaphthene	4.2	0.5 U
acetone	31,000	20U
aldrin	0.00034	0.001 U
alpha-BHC	0.06	0.002 U
aluminum, dissolved	64,000	0.05 U
aluminum, total	64,000	0.05 U
anthracene	0.043	0.5 U
antimony, dissolved	68	0.001 U
antimony, total	68	0.01 U
arsenic, dissolved	4.3	0.3
arsenic, total	4.3	**10 J**[g]
barium, dissolved	14,000	0.14
barium, total	14,000	1.8 J
benzene	11	**99**
beryllium, dissolved	290	0.001 U
beryllium, total	290	0.01 U
beta-BHC	0.12	0.02 U
bis(2-chloroethyl)ether	5.7	0.5 U
bromobenzene	12	1 U
bromochloromethane	59[h]	1 U
bromodichloromethane	14	1 U
bromoform	140	1 U
bromomethane	70	5U
cadmium, dissolved	190	0.002 U
cadmium, total	190	0.02 U
calcium, dissolved	NA	3,590 J
calcium, total	NA	5,180 J
carbon disulfide	1,200	1 U
carbon tetrachloride	4.6	1 U
chlorobenzene	86	1 U
chloroethane	440	5U
chloroform	150	3.2
chloromethane	490	5U
chromium, dissolved	460[i]	0.001 U
chromium, hexavalent	460	0.01 U
chromium, total	460[i]	0.59
cis-1,2-dichloroethene	200	1 U
cobalt, dissolved	2,400	0.015 U
cobalt, total	2,400	0.052
copper, dissolved	7,400	0.0017

Table B-4 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
copper, total	7,400	0.012
cyclohexane	NA	5U
delta-BHC	0.12	0.002 U
dibromochloromethane	18	1 U
dibromomethane	530	1 U
ethyl ether	1,000[j]	5U
ethylbenzene	170	1 U
fluoranthene	0.210	**0.5 U**
fluorene	2	0.5 U
gamma-BHC	0.19	0.1 U
iron, dissolved	58,000	54J
iron, total	58,000	310J
isopropylbenzene	56	1 U
lead, dissolved	0.19[k]	0.001 U
lead, total	0.19[k]	0.01 U
magnesium, dissolved	1,000,000	680J
magnesium, total	1,000,000	1,120 J
manganese, dissolved	9.1	0.025
manganese, total	9.1	8.6 J
mercury, dissolved	0.056	0.0002 U
mercury, total	0.056	0.0002 U
methylene chloride	220	13
methylphenol, total	810	0.091
naphthalene	31	5U
nickel, dissolved	74,000	0.017
nickel, total	74,000	0.38
n-propylbenzene	15	1 U
pCBSA	2,200	0.036
pentachlorophenol	0.2	**10 U**
phenanthrene	1	0.5 U
phenol	29,000	2.5 U
potassium, dissolved	NA	110J
potassium, total	NA	120J
Pyrene	0.14	0.5 U
pyridine	94	10U
sec-butylbenzene	4.4	1 U
selenium, dissolved	970	0.001 U
selenium, total	970	0.1 U
silver, dissolved	1,500	0.0002 UJ
silver, total	1,500	0.00025[l]
sodium, dissolved	1,000,000	1,810J
sodium, total	1,000,000	3,170J
tertiary butyl alcohol	79,000	50 U
tetrachloroethene	12	1 U
toluene	530	1.5
trans-1,2-dichloroethene	220	1 U

Table B-4 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels (mg/L)
trans-1,3-dichloropropane	3.3[m]	1 U
trichloroethene	22	1 U
trihalomethane, total	NA	3.2
TRIS	2.1	0.1 U
vanadium, dissolved	970	0.002 U
vanadium, total	970	0.031
vinyl chloride	1	1 U
xylene, meta & para	190	2 U
xylene, o-	190	1 U
xylenes (total)	190	0.028
zinc, dissolved	110,000	0.01 U
zinc, total	110,000	0.13

Bold values are higher than the criteria.
a = Unless otherwise noted, the screening levels is the MDEQ Groundwater Contact Criteria (GCC).
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
c = The value is the MDEQ's Rule 57 non-drinking water value set for human health.
d = The value is the MDEQ's Rule 57 non-drinking water value set for human health.
e = The "NA" indicates that no screening level is available.
f = The screening level is the MDEQ GCC for total methylphenols.
g = The "J" indicates that the value is an estimated result.
h = The value is the MDEQ's Rule 57 non-drinking water value set for human health.
i = The screening level is the MDEQ GCC for hexavalent chromium.
j = The value is the MDEQ's Rule 57 non-drinking water value set for human health.
k = The value is the MDEQ's Rule 57 non-drinking water value set for human health.
l = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.
m = The value is the dermal tapwater screening level from the EPA Regional Screening Levels.

Table B-5: Maximum value (in milligrams per liter [mg/L]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit (VBP) groundwater samples from the upper till unit monitor wells (seven samples) (Weston 2009).

Analyte	Screening level[a] (mg/L)	Maximum levels from upper till monitor wells (mg/L)
1,1-dichloroethane	2,400	0.001 U[b]
1,2-dichloroethane	19	0.001 U
1,2-dichloropropane	16	0.001 U
2,4-DDT	NA[c]	0.0049
2-butanone	240,000	0.005 U
4,4-DDD	0.044	0.0003
4,4-DDE	0.027	0.000054
4,4-DDT	0.013	0.0061
4-methyl-2-pentanone	13,000	0.005 U
acetone	31,000	0.027
aluminum, dissolved	64,000	0.05 U

Table B-5 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels from upper till monitor wells (mg/L)
aluminum, total	64,000	6.9 J[d]
arsenic, dissolved	4.3	0.01 U
arsenic, total	4.3	0.19
barium, dissolved	14,000	10J
barium, total	14,000	80J
benzene	11	0.0072
bis(2-ethylhexyl)phthalate	0.32	0.0089
bromobenzene	12	0.001 U
bromochloromethane	1[e]	0.001 U
calcium, dissolved	NA	8,250 J
calcium, total	NA	17,400 J
chlorobenzene	86	0.001 U
chloroform	150	0.001 U
chromium, dissolved	460[f]	0.023
chromium, total	460 [f]	0.055
cis-1,2-dichloroethene	0.07	0.001 U
cobalt, dissolved	2,400	0.028
cobalt, total	2,400	0.045
copper, dissolved	7,400	0.012
copper, total	7,400	0.034
dibromomethane	530	0.001 U
ethyl ether	0.01	0.005 U
iron, dissolved	58,000	16
iron, total	58,000	100J
lead, dissolved	0.19[g]	0.01 U
lead, total	0.19[g]	0.02 U
magnesium, dissolved	1,000,000	2,640 J
magnesium, total	1,000,000	2,880 J
manganese, dissolved	9,100	2.3 J
manganese, total	9,100	4.4 J
methylene chloride	220	0.005 U
molybdenum, dissolved	970	0.027
molybdenum, total	970	0.026
nickel, dissolved	74,000	0.25
nickel, total	74,000	0.66
pCBSA	2,200[h]	0.001 U
potassium, dissolved	NA	53 J
potassium, total	NA	77 J
selenium, dissolved	970	0.01 U
selenium, total	970	0.02 U
sodium, dissolved	1,000,000	2,180 J
sodium, total	1,000,000	10,900 J
toluene	530	0.001 U
vanadium, dissolved	970	0.01 U
vanadium, total	970	0.02 U
vinyl chloride	1	0.07

Table B-5 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels from upper till monitor wells (mg/L)
zinc, dissolved	110,000	0.021
zinc, total	110,000	0.042

a = Unless otherwise noted, the screening levels is the MDEQ Groundwater Contact Criteria (GCC).
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
c = The "NA" indicates that no screening level is available.
d = The "J" indicates that the value is an estimated result.
e = The value is the MDEQ's Rule 57 non-drinking water value set for human health.
f = The screening level is the MDEQ GCC for hexavalent chromium.
g = The value is the MDEQ's Rule 57 non-drinking water value set for human health.
h = The value is the MDEQ's Rule 57 non-drinking water value set for human health.

Table B-6: Maximum value (in milligrams per liter [mg/L]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit(VBP) groundwater samples from the lower till unit monitor wells (two samples) (Weston 2009).

Analyte	Screening level[a] (mg/L)	Maximum levels from lower till monitor wells (mg/L)
1,1,1,2-tetrachloroethane	30	0.001 U[b]
1,1,2,2-tetrachloroethane	4.7	0.001 U
1,1-dichloroethane	2,400	0.001 U
1,2,4-trichlorobenzene	19	0.005 U
1,2,4-trimethylbenzene	56	0.001 U
1,2-dichlorobenzene	160	0.001 U
1,2-dichloroethane	19	0.001 U
1,3-dichlorobenzene	2	0.001 U
1,4-dichlorobenzene	6.4	0.001 U
2,4-DDT	NA[c]	0.00001 U
2-butanone	240,000	0.005 U
2-chlorophenol	94	0.01 U
4,4-DDD	0.044	0.00002 U
4,4-DDE	0.027	0.00002 U
4,4-DDT	0.013	0.00002 U
aluminum, dissolved	64,000	0.05 U
aluminum, total	64,000	0.38
antimony, dissolved	68	0.001 U
antimony, total	68	0.001 U
arsenic, dissolved	4.3	0.076
arsenic, total	4.3	0.077
barium, dissolved	14,000	1.2 J[d]
barium, total	14,000	1.2 J
benzene	11	0.17
beta-BHC	0.12	0.00002 U
bis(2-chloroethyl)ether	5.7	0.001 U
bis(2-ethylhexyl)phthalate	0.32	0.016
bromobenzene	12	0.014

Table B-6 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels from lower till monitor wells (mg/L)
bromochloromethane	NA	0.001 U
cadmium, dissolved	190	0.0002 U
cadmium, total	190	0.0002 U
calcium, dissolved	NA	321 J
calcium, total	NA	309 J
carbon disulfide	1,200	0.001 U
chloroethane	440	0.005 U
chloroform	150	0.001 U
chromium, dissolved	460[e]	0.001 U
chromium, hexavalent	460	0.005 U
chromium, total	460[e]	0.026
cis-1,2-dichloroethene	200	0.001 U
cobalt, dissolved	2,400	0.015 U
cobalt, total	2,400	0.015 U
copper, dissolved	7,400	0.001 U
copper, total	7,400	0.0028
dibromomethane	530	0.001 U
ethyl ether	35,000	0.005 U
gamma-BHC	0.19	0.00002 U
iron, dissolved	58,000	3.2
iron, total	58,000	3.9
lead, dissolved	0.19	0.001 U
lead, total	0.19	0.001 U
magnesium, dissolved	1,000,000	160 J
magnesium, total	1,000,000	160 J
manganese, dissolved	9,100	0.13
manganese, total	9,100	0.17
methylene chloride	220	0.005 U
molybdenum, dissolved	970	0.025 U
molybdenum, total	970	0.025 U
nickel, dissolved	74,000	0.018
nickel, total	74,000	0.023
pCBSA	2,200	0.001 U
phenol	29,000	0.0051 U
potassium, dissolved	NA	4.5
potassium, total	NA	4.6
selenium, dissolved	970	0.001 U
selenium, total	970	0.001 U
sodium, dissolved	1,000,000	168 J
sodium, total	1,000,000	171 J
toluene	530	0.001 U
trans-1,2-dichloroethene	200	0.001 U
trichloroethene	NA	0.001 U
TRIS	2.1	0.01 U
vanadium, dissolved	970	0.002 U
vanadium, total	970	0.002 U

Table B-6 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels from lower till monitor wells (mg/L)
zinc, dissolved	110,000	0.01 U
zinc, total	110,000	0.014

a = Unless otherwise noted, the screening levels is the MDEQ Groundwater Contact Criteria (GCC).
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
c = The "NA" indicates that no screening level is available.
d = The "J" indicates that the value is an estimated result.
e = The screening level is the MDEQ GCC for hexavalent chromium.

Table B-7: Maximum value (in milligrams per liter [mg/L]) of compounds at or above the reported quantitation limit in the Velsicol Burn Pit(VBP) groundwater samples from the lower outwash unit monitor wells (eight samples) (Weston 2009).

Analyte	Screening level[a] (mg/L)	Maximum levels from lower outwash monitor wells (mg/L)
1,1,2,2-tetrachloroethane	30	0.001 U[b]
1,1-dichloroethane	2,400	0.001 U
1,2,4-trichlorobenzene	19	0.0021 U
1,2-dichlorobenzene	160	0.001 U
1,2-dichloroethane	19	0.001 U
1,2-dichloropropane	16	0.001 U
1,4-dichlorobenzene	6.4	0.001 U
2,4-DDT	NA[c]	0.00005
2-chlorophenol	94	0.01 U
4,4-DDD	0.044	0.00002 U
4,4-DDE	0.027	0.00002 U
4,4-DDT	0.013	0.00021
aluminum, dissolved	64,000	0.05 U
aluminum, total	64,000	2.1 J[d]
antimony, total	68	0.001 U
arsenic, dissolved	4.3	0.087
arsenic, total	4.3	0.092
barium, dissolved	14,000	1.1 J
barium, total	14,000	1.1 J
benzene	11	0.001 U
bis(2-ethylhexyl)phthalate	0.32	0.0051 U
bromobenzene	12	0.001 U
cadmium, total	190	0.0002 U
calcium, dissolved	NA	618 J
calcium, total	NA	674 J
chlorobenzene	86	0.001 U
chromium, dissolved	460[e]	0.0047
chromium, total	460 [e]	0.16
cis-1,2-dichloroethene	200	0.001 U
cobalt, total	2,400	0.015 U
copper, dissolved	7,400	0.0068
copper, total	7,400	0.024

Table B-7 continued		
Analyte	Screening level[a] (mg/L)	Maximum levels from lower outwash monitor wells (mg/L)
cyclohexane	NA	0.005 U
fluorene	2	0.001 U
iron, dissolved	58,000	4.3
iron, total	58,000	9.0
lead, total	0.19	0.0019
magnesium, dissolved	1,000,000	17 J
magnesium, total	1,000,000	18 J
manganese, dissolved	9,100	0.4
manganese, total	9,100	0.46
mercury, total	0.056	0.0002 U
methylene chloride	220	0.005 U
molybdenum, dissolved	970	0.025 U
molybdenum, total	970	0.025 U
nickel, dissolved	74,000	0.041
nickel, total	74,000	0.052
pCBSA	2,200 [f]	0.001 U
phenol	29,000	0.005 U
potassium, dissolved	NA	6.6 J
potassium, total	NA	6.4 J
selenium, dissolved	970	0.001 U
selenium, total	970	0.001 U
silver, total	1,500	0.0002 U
sodium, dissolved	1,000,000	233 J
sodium, total	1,000,000	231 J
tetrachloroethene	12	0.001 U
tetrahydrofuran	1,600	0.005 U
toluene	530	0.001 U
trichloroethene	22	0.001 U
vanadium, total	970	0.0036
xylene, o-	190	0.001 U
zinc, dissolved	110,000	0.013
zinc, total	110,000	0.037

a = Unless otherwise noted, the screening levels is the MDEQ Groundwater Contact Criteria (GCC).
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
c = The "NA" indicates that no screening level is available.
d = The "J" indicates that the value is an estimated result.
e = The screening level is the MDEQ GCC for hexavalent chromium.
f = The value is the MDEQ's Rule 57 non-drinking water value set for human health.

Soil and groundwater dioxin levels from the VBP samples

Table B-8: Dioxin levels in soil (in nanograms per kilogram [ng/kg], 11 samples) and groundwater (in picograms per liter [pg/L], five samples) Velsicol Burn Pit(VBP) samples (Weston 2009).

Analyte	Soil screening level (ng/kg)	Soil (ng/kg)	Water screening level (pg/L)	Water (pg/L)
2378-TCDF	NA[a]	12 U[b]	NA	12 U
2378-TCDD	NA	1.1 U	NA	12 U
12378-PeCDF	NA	190 E[c]	NA	59 U
23478-PeCDF	NA	12	NA	59 U
12378-PeCDD	NA	6.8 U	NA	59 U
123478-HxCDF	NA	15	NA	59 U
123678-HxCDF	NA	9.5	NA	59 U
234678-HxCDF	NA	6.8 U	NA	59 U
123789-HxCDF	NA	6.8 U	NA	59 U
123478-HxCDD	NA	6.8 U	NA	59 U
123678-HxCDD	NA	6.8 U	NA	59 U
123789-HxCDD	NA	6.8 U	NA	59 U
1234678-HpCDF	NA	24	NA	59 U
1234789-HpCDF	NA	10	NA	59 U
1234678-HpCDD	NA	48	NA	59 U
OCDF	NA	53	NA	120 U
OCDD	NA	410	NA	120 U
Total TEQ in parts per trillion (ppt)	90[d]	7.9	10[e]	0

a = The "NA" indicates that no screening level is available.
b = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
c = The "E" indicates that the value is the estimated maximum possible concentration.
d = The screening level is the MDEQ Residential Direct Contact Criteria for total dioxins based on Toxic Equivalency (TEQ) in parts per trillion (ppt).
e = The screening level is the MDEQ Groundwater Contact Criteria for total dioxins based on Toxic Equivalency (TEQ) in parts per trillion (ppt).

Surface water sampling results

Table B-9: Maximum levels (in milligrams per liter [mg/L]) of compounds at or above the reported quantitation limit in surface water (five samples) from a drainage ditch adjacent to the Velsicol Burn Pit (VBP) (Weston 2009).

Analyte	Screening level[a] (mg/L)	Maximum level in surface water (mg/L)
2,4-DDT	NA[b]	0.00001 UJ[c]
aluminum, total	64,000	0.71
ammonia	10[d]	0.53
arsenic, total	4.3	0.0073
barium, total	14,000	0.092
calcium, total	NA	134 J[e]

Table B-9 continued		
Analyte	Screening level[a] (mg/L)	Maximum level in surface water (mg/L)
chloride	NA	124 J
chromium, total	460[f]	0.0018
copper, total	7,400	0.0036
iron, total	58,000	9.2
lead, total	0.19[g]	0.0019
magnesium, total	1,000,000	30
manganese, total	9,100	0.86
nickel, total	74,000	0.0063
nitrate + nitrite	310,000[h]	0.66
oil and grease	NA	11 U
potassium, total	NA	5.9 J
sodium, total	1,000,000	49.5
sulfate	NA	100 J
vanadium, total	970	0.004
zinc, total	110,000	0.025

a = Unless otherwise noted, the screening levels is the MDEQ Groundwater Contact Criteria (GCC).
b = The "NA" indicates that no screening level is available.
c = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.
d = The screening levels is the MDEQ's RDWC for ammonia.
e = The "J" indicates that the value is an estimated result.
f = The screening level is the MDEQ GCC for hexavalent chromium.
g = The screening level is the MDEQ's Rule 57 non-drinking water value set for human health.
h = The screening level is the MDEQ GCC for nitrate.

Sediment sampling results

Table B-10: Maximum levels (in milligrams per kilograms [mg/kg]) of compounds at or above the reported quantitation limit in sediment (seven samples) from a drainage ditch adjacent to the Velsicol Burn Pit(VBP) (Weston 2009).

Analyte	Screening level[a] (mg/kg)	Maximum levels (mg/kg)
2,4-DDT	NA[b]	0.14 U[c]
4,4-DDD	95	0.2
4,4-DDE	45	0.05
4,4-DDT	57	0.027 U
alpha-chlordane	31[d]	0.013 J[e]
aluminum, total	50,000	5,200
antimony, total	180	0.55
arsenic, total	7.6	7.2
barium, total	37,000	58
beryllium, total	410	0.26
cadmium, total	550	0.52
calcium, total	NA	82,200 J
carbon, total organic	NA	87,000 J

Table B-10 continued		
Analyte	Screening level[a] (mg/kg)	Maximum levels (mg/kg)
chromium, total	2,500[f]	11
chrysene	2,000	0.590 U
cobalt, total	2,600	5
copper, total	20,000	18
endosulfan I	1,400	0.014 U
fluoranthene	46,000	0.59 U
gamma-chlordane	31[d]	0.013 UJ[g]
HBB	1,100	0.27 U
iron, total	160,000	21,000 J
lead, total	400	19
magnesium, total	1,000,000	24,800 J
manganese, total	25,000	1,000
mercury, total	160	0.15 U
molybdenum, total	16,000	4.5
nickel, total	40,000	14
pCBSA	230,000	0.01 U
phenanthrene	1,600	0.59 U
PBB	1.2	0.13 U
potassium, total	NA	700 J
pyrene	29,000	0.59 U
selenium, total	2,600	0.87
silver, total	2,500	0.1 U
sodium, total	1,000,000	140
toluene	250	0.23
vanadium, total	750	14
zinc, total	170,000	130

a = Unless otherwise noted, the screening level is the MDEQ Residential Direct Contact Criteria (DCC).
b = The "NA" indicates that no screening level is available.
c = The "U" indicates that the analyte was not detected above the reported sample quantitation limit.
d = The screening level is the MDEQ Residential DCC for total chlordane isomers.
e = The "J" indicates that the value is an estimated result.
f = The screening level is the MDEQ Residential DCC for hexavalent chromium.
g = The "UJ" indicates that the analyte was not detected and the reporting limit is estimated.

Appendix C: Responses to comments received during the Public Comment Period.

Several individuals and groups provided comments on this Public Health Assessment (PHA). Thank you to all who submitted comments and questions. Comments and questions were paraphrased and combined if similar. Responses to comments and questions are below. If comments and questions prompted changes to the PHA, the page number was noted.

General comments:

1. Two comments requested removal of all soil, either soil that had levels of chemicals above applicable screening levels or soil containing certain site-related chemicals, and any dense non-aqueous phase liquid (DNAPL) at the site.

Response: Although individual locations may have had chemical levels above applicable screening levels, people would be exposed to soil in multiple locations. Either average chemical levels or the 95% upper confidence limit of the mean (95% UCL) would more accurately represent people's exposure to soil rather than maximum levels. These comments have been sent to the EPA and MDEQ project managers for the VBP, as those regulatory agencies are ultimately responsible for the removal decisions.

2. One comment requested an investigative long-term study of the area and its inhabitants in relation to the prevalence of depression and irritability, to benefit not only the community but also add to the scientific knowledge regarding the connection between DDT and metabolites and depression/irritability.

Response: This PHA deals solely with the VBP, which was no longer used after about 1970. It is not possible to determine the exposure that individuals may have had during the active burning. The VBP was used as a disposal site and various amounts and types of material would have been burned. Without knowing people's exposure, it is not possible to link the exposure to health effects. Carrying out this type of study is beyond the purpose of this PHA.

3. One comment suggested additional public health activities (no specifics provided) to reduce the chemical levels in the soil of residential area downwind of the VBP.

Response: No health concerns were identified from contact with the soil of the downwind residential area and, therefore, this PHA does not contain any recommendations for further activities for that area. (See page 15 and 24-25 for a discussion of the chemical levels in soil at the downwind residential area.)

Specific comments:

4. It was requested that MDCH require a fence be placed around the ash piles in the VBP.

Response: MDCH cannot require fencing of the ash piles in the VBP. However, a recommendation to restrict access to those ash piles is already in the PHA (see page 30).

5. Prevent migration of DDT from the water in the drainage ditch to the air by removing the contaminated material.

Response: The DDT (2,4'-DDT) in the drainage ditch was detected in two of the six surface water samples. While some very small amount of 2,4'-DDT may be present in the surface water of the drainage ditch, and some volatilization may be occurring, this isomer of DDT was not detected in the sediment in the drainage ditch. This may indicate that the DDT is not from the drainage ditch and is migrating to the surface water in the ditch from another location. Furthermore, the levels that were measured in those two surface water samples were not expected to cause health effects. Other isomers of DDT were not detected in the surface water. (See pages 22 and 28 for levels of DDT in the drainage ditch and discussion of potential health effects.) The MDEQ and EPA project managers were provided with this comment.

6. Regarding further monitoring of groundwater, provide a schedule of activities and actions that will take place to prevent further migration of chemicals into the groundwater.

Response: Groundwater monitoring was recommended in the PHA (see page 9). However, MDCH does not conduct this monitoring and, as such, cannot provide a schedule of activities or actions. The MDEQ and EPA project managers were provided with this comment.

7. Clarify the location of the burn area (see page 8, first and third paragraphs).

Response: The VBP is located partly in an out-of-bounds area in an operating golf course. It is not part of the active golf course (on a hole). This is clarified on page 8 and 10.

8. Page 13, Table 1 (and many of the other tables), why are only these compounds listed in the table? There are other compounds that do not have criteria besides the ones in the table, in addition, why are the concentrations of contaminants in this table only compared to direct contact criteria? There are additional MDEQ Part 201 criteria that are lower and applicable.

Response: Compounds in the tables in the main body of the PHA are only listed if there were no screening levels or if the levels (detected levels or reporting/quantitation limits) were above the screening levels. For the VBP soil and ash samples, the most likely way people could be exposed to chemicals in the soil or ash is by direct contact. Other criteria are relevant for regulatory purposes, but the purpose of the PHA is to discuss people's on-going or potential exposure and any health concerns from that exposure.

9. Several comments were made on the qualifiers noted in the tables and the inclusion of the reporting or quantitation limits for chemicals that were not detected.

Response: Qualifiers were checked in each table and were corrected as needed. Even if chemicals are not detected, when reporting or quantitation limits are above the screening level those chemicals are addressed as if they are present at that level. Those reporting or quantitation limits were included in the 95% UCL calculation. This is health-protective approach to chemicals that were not detected.

10. Page 15, the elevated concentration of arsenic was actually determined to be an anomaly or outlier not a lab error and the ash piles were actually sampled in 2005, not 2004

Response: Both of these were corrected on page 15.

11. For Table 6, why was groundwater contact criteria (GCC) selected as the only criteria compared to on this table? Other criteria should also be considered, such as the Residential Drinking Water Criteria (RDWC).

Response: The GCC was selected as this reflects the way that people are most likely to be exposed to the groundwater at the VBP. The RDWC, while another possibility as drinking water wells are in the area, was not used for these samples as the methods used were not drinking water analytical methods. Drinking water analytical methods need to be used when comparing to drinking water screening levels to ensure the quantitation limits are below the screening levels. Language describing this is present on page 19 and in the conclusion language on pages 9 and 30.

12. Page 21, first paragraph, there were actually two residential wells sampled on Prospect Street, as well as one on State Street along with the golf course well.

Response: The State Street well was not included as there was only are partial list of analytes that were tested in this sample. Additional clarification was added to page 21 regarding the residential wells.

13. The conclusions seem to be focused on the ash piles and saying they are the major health risks, but groundwater contamination and to some extent soil contamination are issues too, they don't even discuss the NAPL that was found at the site either.

Response: Migration of chemicals into the groundwater from the soil is an issue at the site and should be addressed (and language is already present in the document). However, the levels present in the soil or groundwater are not currently harmful to human health as people have no contact with the soil or water below the surface. Soil and groundwater contamination was addressed through multiple statements regarding the possibility for contaminants to continue to migrate into the groundwater. NAPL was found during the sampling done in 2006, but not in 2009. This was stated on page 13 and 17 of the document. As the NAPL was identified in a well screened around 4.5 to 8 feet below the ground surface, the NAPL is concerning for future contaminant migration, but people would not have direct contact with the NAPL.