Public Health Assessment

Initial/Public Comment Release

Kalamazoo River/Enbridge Spill: Evaluation of crude oil release to Talmadge Creek and Kalamazoo River on residential drinking water wells in nearby communities (Calhoun and Kalamazoo Counties, Michigan).

Prepared by
Michigan Department of Community Health

COMMENT PERIOD ENDS: JULY 25, 2012

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Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
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THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR 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. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR's Cooperative Agreement Partner will utilize this document to determine if follow-up health actions are appropriate at this time.

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Prepared by:

Michigan Department of Community Health
Under a Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Foreword

The Michigan Department of Community Health (MDCH) conducted this evaluation under a cooperative agreement with federal Agency for Toxic Substances and Disease Registry (ATSDR). 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 recommends 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.

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www.michigan.gov/mdch-toxics

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Acronyms and Abbreviations

µg/L	micrograms per liter
ATSDR	Agency for Toxic Substances and Disease Registry
DRO	diesel range organics
EPA	United States Environmental Protection Agency
FDA	United States Food and Drug Administration
GRO	gasoline range organics
HSDB	Hazardous Substance Data Bank
IOM	Institute of Medicine
IPCS	International Programme on Chemical Safety
kg	Kilogram
MCL	Maximum Contaminant Level
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
mg/L	milligrams per liter
MRL	minimal risk level
NA	not available
NAS	National Academy of Sciences
NLM	U.S. National Library of Medicine
NRC	National Response Center
ORO	oil range organics
RDWC	Residential Drinking Water Criteria
RfD	reference dose
UL	tolerable upper limit
WHO	World Health Organization

Summary

The private drinking water well sampling program has been on-going since the first week of the Enbridge oil spill into the Kalamazoo River in July 2010. Samples have been analyzed for both oil-related chemicals and for non-oil-related chemicals, such as arsenic and lead. Oil-related chemicals were those identified in the heavy crude oil that spilled. More than 150 wells have been sampled resulting in over 600 individual sample analyses as part of the drinking water well sampling program. The Michigan Department of Community Health (MDCH) has been reviewing well water data since the program began. This public health assessment summarizes the results of that program from the start of the testing until August 2011. The program is still on-going and is expected to continue for several years.

MDCH has reached the following conclusions about chemical levels in private drinking water wells along stretches of Talmadge Creek and the Kalamazoo River impacted by the heavy crude oil spill:

1. *Only two oil-related inorganic chemicals, nickel and iron, were found in private drinking water wells. The levels of nickel and iron found will not harm people's health. No oil-related organic chemicals were found in people's water.* Most of the oil-related inorganic chemical (metals) levels were below health-based screening levels. Two metals, iron and nickel, were detected above health-based screening levels in some samples from a few wells. However, iron and nickel were previously detected from wells in Calhoun and Kalamazoo Counties and are likely naturally occurring metals.

   Next steps: MDCH, Calhoun County Health Department, and Kalamazoo County's Health and Community Services Department will continue to review new data from the drinking water well sampling program.

2. *Arsenic and lead, two metals not present in the crude oil, are present at levels that may harm people's health.* Arsenic and lead levels were higher than the health-based screening levels in multiple samples. Arsenic is a naturally occurring metal in the area and lead could be naturally occurring or be present in people's plumbing. Chronic (long-term) exposure to levels of arsenic and lead detected in these samples may cause health effects.

   Next steps: The local health departments (Calhoun County Health Department and Kalamazoo County's Health and Community Services Department) and state agencies (Michigan Department of Environmental Quality [MDEQ] and MDCH) are available to discuss water sampling results and ways to reduce exposure to these chemicals. People may want to consider installing a water treatment system in their home to reduce levels of arsenic and lead if samples repeatedly have arsenic and lead levels above the screening levels.

Purpose and Health Issues

Within a few days of the heavy crude oil spill in July 2010, local health departments sampled private drinking water wells. Contractors for Enbridge developed a drinking water well sampling

program, with local, state, and federal agency oversight, and included wells that were within 200 feet of the high water mark from the July 2010 flood event. Samples collected from the wells were analyzed for crude oil-related and other chemicals. Local health departments received the results of the sampling as Enbridge Energy Partners, LLP and their contractors provided homeowners with the results. This public health assessment discusses the chemical levels present in the drinking water well samples and whether any chemicals are present at levels that could harm people's health.

Background

In July 2010, more than 800,000 gallons of crude oil flowed into Talmadge Creek, which is a tributary of the Kalamazoo River. The oil was from a 30-inch pipeline near the city of Marshall, Calhoun County, Michigan operated by Enbridge Energy Partners, LLP (Enbridge). Enbridge reported the spill to the National Response Center (NRC), which notified the United States Environmental Protection Agency (EPA), among other agencies.

The EPA was the lead agency for response to this spill and on July 27, the federal On-Scene Coordinator issued the EPA Removal Order. Using guidelines of the Incident Command System[1], a Unified Command was established later that week. Members of the Unified Command included federal, state and local agencies, along with Enbridge representatives. At the request of the EPA Incident Commander, MDCH staff deployed to the Command Center to provide public health support.

The spilled oil was eventually contained at Morrow Lake, which was more than 30 miles downstream from the spill (MDEQ 2010a). See Figure 1 for the extent of the oil spill. At the time of the spill, Talmadge Creek and the Kalamazoo River were between 25- and 50-year flood levels due to the rain that had fallen during the previous days. Because the river and creek were at high water levels, oil flowed into overbank areas, wetlands, and floodplains.

The Calhoun County Health Department issued a precautionary Bottled Water Advisory on July 29, 2010. At the time of the advisory, there was no evidence to suggest that groundwater contamination had occurred from the oil spill. The advisory was issued as a precaution and to allow time for well water samples to be collected and analyzed. The Bottled Water Advisory was in effect from July 29 to November 8, 2010.

Two different types of data were collected before the precautionary bottled water advisory was lifted. One was data from the drinking water well sampling program. The other type of data was information on how the groundwater flows around the stretch of the Kalamazoo River affected by the oil spill. These are described below.

Drinking water well sampling program

During the initial response to the spill, any residents with wells along the areas of Talmadge Creek and the Kalamazoo River, either Calhoun or Kalamazoo County, could have their well water tested. Wells eligible for the drinking water well sampling program had to be located

[1] The Incident Command System is a management system for incidents of all sizes and types. This system is used when one agency is responding to an incident and can be scaled up for when many agencies are responding to an incident.

within 200 feet of the high water mark from the July 27 (in 2010) flood event. Wells located further than 200 feet from high water mark are not expected to be at risk of contamination from the heavy crude oil that spilled.

Many municipal wells in the area are located more than 200 feet from the high water mark. These wells are not expected to be at risk of contamination by the heavy crude oil that spilled. The Village of Augusta and City of Kalamazoo municipal wells are being tested for oil-related chemicals. These wells are being tested either due to their location (within 200 feet of the high water mark) or at the request of the local government (H. Nicholas, Kalamazoo County Health and Community Services Department, personal communication, 2011).

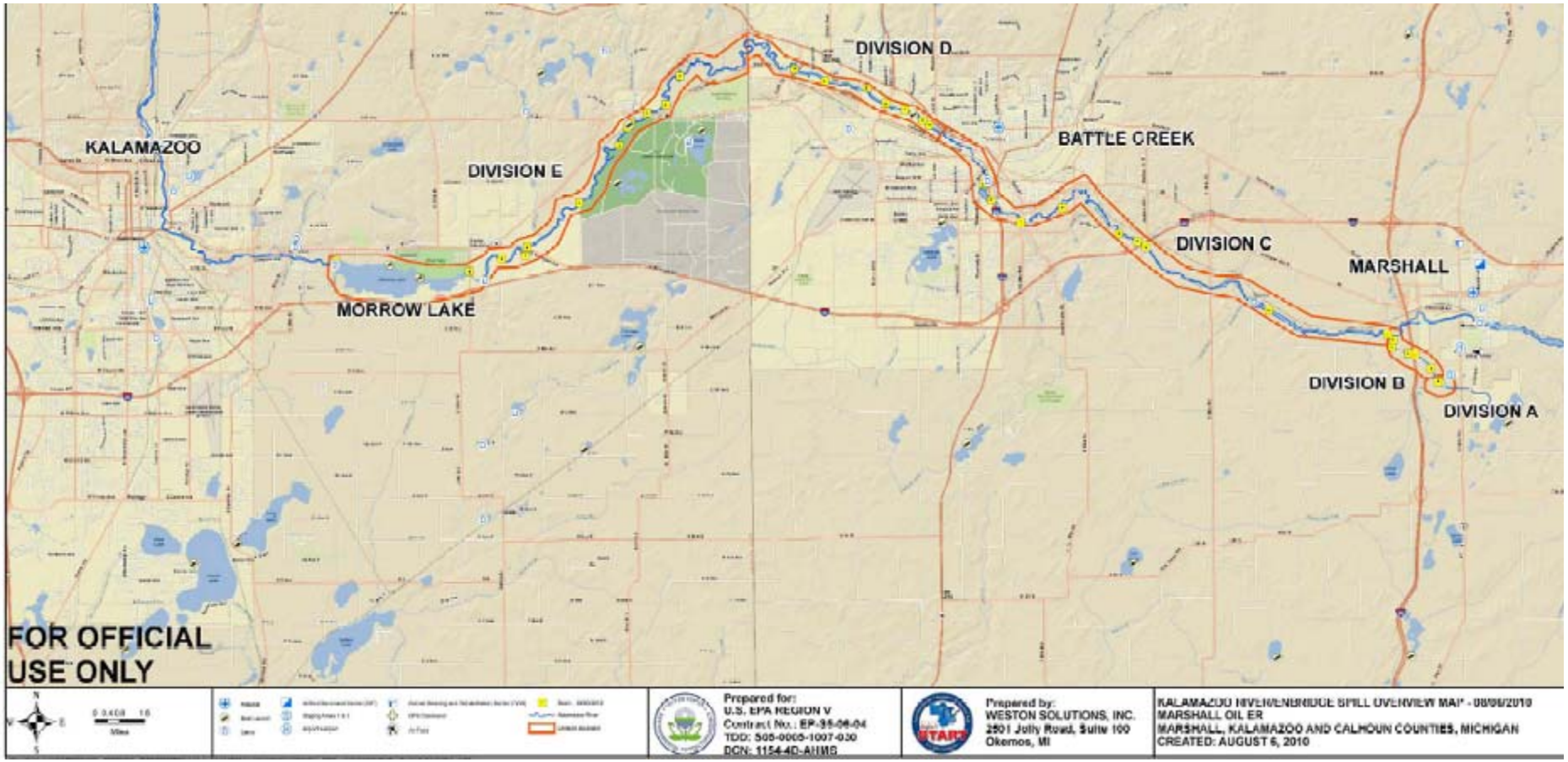
The purpose of the drinking water well sampling program is to check drinking water wells for oil-related chemicals. The drinking water well sampling program was started in August 2010 and is still currently on-going (as of April 2012). Property owners and the local health departments receive the results of each sampling.

Chemicals detected in the MDEQ's analysis of the crude oil were identified and analyzed in the drinking water samples (Enbridge 2010a). These chemicals were:

Inorganic chemicals (metals)[2]	Organic chemicals
Beryllium	1,2,3-Trimethylbenzene
Iron[3]	1,2,4-Trimethylbenzene
Mercury	1,3,5-Trimethylbenzene
Molybdenum	2-Methylnapthalene
Nickel[4]	Benzene
Titanium	Cyclohexane
Vanadium	Ethylbenzene
	Isopropylbenzene
	Naphthalene
	n-Propylbenzene
	Phenanthrene
	p-Isopropyltoluene
	sec-Butylbenzene
	Toluene
	Xylenes, Total

[2] Aluminum, arsenic, barium, cadmium, chromium, cobalt, copper, lead, lithium, manganese, and zinc were not detected in samples of the crude oil (MDEQ 2010b).
[3] Although iron was detected in the crude oil and is included in the drinking water well sampling program, iron has previously been measured in wells from Calhoun and Kalamazoo Counties at levels higher than the screening level (2.0 mg/L). These iron levels range from 0.01 to 94 mg/L, with a majority of the 3,383 samples less 2.0 mg/L (MDEQ 2010c).
[4] Nickel, while also detected in the crude oil, has been previously found in wells in Calhoun and Kalamazoo Counties. Nickel levels range from 0 to 0.05 mg/L. All 81 samples are below the screening level (MDEQ 2010c).

Figure 1: Overview of the areas of Talmadge Creek and the Kalamazoo River impacted by the July 2011 oil spill (Calhoun and Kalamazoo Counties, Michigan). Division A through E were arbitrary divisions created to assist with the response to the spill. Map was taken from the EPA's Response to the Enbridge Oil Spill website (http://www.epa.gov/enbridgespill/images/enbridge_overview_map_20100806.pdf).



Wells were sampled every other week until October 31, 2010 or until there were two sampling events with no detections of crude oil-related chemicals other than iron or nickel, which are naturally occurring in wells in Calhoun and Kalamazoo counties. Monthly sampling occurred for three months, then the wells were sampled quarterly. As of August 2011, Enbridge identified 167 private wells that were eligible for sampling. Quarterly sampling is on-going (November 2011) and the sampling program will continue for several years. The complete sampling plan can be found at: http://www.epa.gov/enbridgespill/pdfs/enbridgespill-workplan-201010-drinking-water-well.pdf.

Hydrogeological study

As river levels went down after the oil spill, the crude oil was deposited in areas near drinking water wells. The hydrogeological report gathered information on whether the Kalamazoo River was a gaining or losing stream (Enbridge 2010b). Gaining streams are those with groundwater flowing into the stream. For losing streams, groundwater flows away from, and out of the stream (Alley et al.1999).

Eight areas, representing different sections of the Kalamazoo River, were targeted during this study. These areas were at locations with oil remaining in the floodplain or river banks, the Ceresco Dam, locations with submerged oil, sharp bends in the river, and the Morrow Lake delta. For most of the locations, the Kalamazoo River is a gaining stream (groundwater flows to the river). Two locations were identified as areas where the Kalamazoo River was a losing stream. One was at the Ceresco Dam and the other was in a low-lying floodplain. The low-lying floodplain area had no nearby drinking water wells. In areas with sharp bends, groundwater may flow under the bend toward the river channel. Overall, since most areas of the Kalamazoo River are a gaining stream, groundwater that people use for drinking water in these areas is not expected to be impacted by any remaining oil. The area around the Ceresco Dam will continue to be be monitored for groundwater flow and the presence of any oil-related chemicals. The complete report can be found at:
http://www.epa.gov/enbridgespill/pdfs/enbridge_hydrogeological_evaluation_final.pdf.

Discussion

Results from the drinking water samples were compared to drinking water screening levels. All drinking water screening levels are protective for a lifetime of exposure to the chemical. Screening levels were from the following sources:

- First selected were the Michigan Department of Environmental Quality's Part 201 Generic Residential Drinking Water Criteria[5] (RDWC) (MDEQ 2011a). In some cases the RDWC were set based on aesthetic issues, such as taste or color of the water. Health-based RDWC were used here instead of the aesthetic values (MDEQ 2011b).
- If RDWC were unavailable, the MDEQ's Rule 57 human drinking water value (MDEQ 2011c) was selected.
- If none of the above were available, the EPA's drinking water lifetime health advisory (EPA 2011a) was selected.

[5] The RDWC are the EPA Maximum Contaminant Level (MCL), if one is available. Chemical levels must be lower than the MCLs in publicly supplied drinking water.

Environmental Contamination

The wells sampled have been separated into seven sections, as they are along about 40 miles of Talmadge Creek and the Kalamazoo River. Descriptions of the sections are in Table 1. See Appendix A for maps of these areas.

Table 1: Wells sampled after the oil spill in the Kalamazoo River (Calhoun and Kalamazoo Counties, Michigan). The number of wells in each section and the locations of those sections (a description and the mile post numbers) are included.

Section	Location	Mile Post[a]	Number of wells
1	Talmadge Creek near source area to 15 Mile Road at the Kalamazoo River	0.0 to about 2.25	14
2	West of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood	About 2.25 to 3.25[b]	19
3	Approximately a half mile upstream (east) of the Ceresco Dam to just over a half mile downstream (west) of the Ceresco Dam	5.25[b] to 6.5	30
4	Just over a half mile downstream (west) of the Ceresco Dam to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River	6.5 to 13.25	28
5	About a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River to east of Battle Creek, near 20th Street North at the Kalamazoo River	13.25 to 18.0	32
6	West of Battle Creek, near 20th Street North at the Kalamazoo River to the Calhoun County/Kalamazoo County border	18.0 to the Calhoun/Kalamazoo County border (near 24.0)	37
7	Kalamazoo County (Kalamazoo River west of the Kalamazoo County/Calhoun County border to Morrow Lake)	Calhoun/Kalamazoo County border (near 24.0) through Morrow Lake (39.75)	56

a = Mile post number indicate the number of miles downstream from the entry of the oil spill in Talmadge Creek.
b = No wells are between mile post 3.25 and 5.25.

The sampling results discussed below are primarily from drinking water samples taken from July 2010 to February 2011. Sampling has continued, and sampling results from February to August 2011 are, for the most part, within the same range reported in the tables. Sampling results that are different than those presented in Tables 2 to 15 are discussed in the Sampling Results from February to August 2011 section. All sampling results are recorded in the EPA's Scribe data base and data were compiled from there.

All chemicals measured in the drinking water samples, whether or not they were identified as an oil-related chemical, were evaluated. If chemicals were not detected in the sample, the lowest and highest values in the tables are the range of reporting limits. Reporting limits are the lowest value that could be accurately measured in the sample. They vary because of differences between samples and because different laboratories analyzed different samples. See the tables in Appendix B for more detailed information.

Section 1 –Talmadge Creek near source area to 15 Mile Road at the Kalamazoo River

Fourteen wells are located in this section. Results from all of the inorganic and organic chemicals measured in these samples can be found in Appendix B. The number of samples varies for each chemical because wells sampled after the oil spill but before the drinking water sampling program was started in August were included as long as appropriate drinking water analytical methods were used for the sample.

Table 2 presents the inorganic chemicals, in milligrams per liter (mg/L) that were either detected above or had no drinking water screening level in Section 1. Table 3 present the organic chemicals, in micrograms/L (µg/L) that had no drinking water screening levels. No oil-related organic chemicals were detected above their screening levels. Organic chemicals are those that have carbon atoms in their structure, while inorganic chemicals do not. Results from all of the inorganic and organic chemicals measured in samples from wells in this section can be found in Appendix B.

Table 2: Inorganic chemicals (in milligrams per liter [mg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 14 wells located between the oil spill source area next to Talmadge Creek and 15 Mile Road, Marshall, Michigan (Calhoun County).

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences[b]	Number of samples
Arsenic	0.01	0.002	**0.015**	9 (2 wells)	48
Iron	2.0[c]	0.016	**7**	18 (4 wells)	76
Titanium	NA[d]	0.00023	0.02	NA	28

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

The maximum values for arsenic and iron are greater than the screening levels in several samples. The iron exceedences are from four wells and the arsenic exceedences are from two wells. They will be discussed later in the Toxicological Evaluation. Titanium, which was not detected in any sample (values in Table 2 are the lowest and highest reporting limit), will be discussed later in the Chemicals with No Screening Levels Evaluation.

None of the chemicals in Table 3 have screening levels. These chemicals were not detected in any samples. They will be discussed in the Chemicals with no Screening Levels section.

Table 3: Organic chemicals (in micrograms per liter [µg/L]) with no drinking water screening level in samples collected between July 2010 and February 2011 from 14 wells located between the oil spill source area next to Talmadge Creek and 15 Mile Road, Marshall, Michigan (Calhoun County).

Organic chemical	Lowest value (µg/L)	Highest value (µg/L)	Number of samples
1,1-Dichloropropene	0.5	0.5	48
1,3-Dichloropropane	0.5	0.5	48
2,2-Dichloropropane	0.5	0.5	48
Butachlor	0.2	0.54	48
Cyclohexane	0.5	1	28
DRO (C10-C20)	100	100	54
GRO (C6-C10)	100	200	55
ORO (C20-C34)	100	100	53
p-Isopropyltoluene	0.5	0.5	76

DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics

Section 2 – West of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood (Mile Post 3.25)

Nineteen wells are located along this section of the Kalamazoo River. The number of samples varies for each chemical because wells sampled before the drinking water sampling program was started were included as long as appropriate drinking water analytical methods were used for the sample.

Table 4 presents the inorganic chemicals, in mg/L, detected in the drinking water samples that either were above or had no screening levels. Table 5 presents the organic chemicals, in µg/L, detected above or with no screening levels. Results from all of the inorganic and organic chemicals measured in samples from wells in this section can be found in Appendix B.

Table 4: Inorganic chemicals (in milligrams per liter [mg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 19 wells located west of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood, Marshall, Michigan (Calhoun County).

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences[b]	Number of samples
Calcium	NA[c]	76	76	NA	1
Iron	2.0[d]	0.011	**3.65**	9 (3 wells)	123
Lead	0.004	0.000078	**0.015**	5 (4 wells)	74
Titanium	NA	0.0007	0.02	NA	49

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = No screening level was available (NA = not available).
d = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.

The analytical results from drinking water samples were over the screening levels for iron and lead. Three wells out of 19 had iron exceedences and four wells had lead exceedences. Iron and lead will be discussed in the Toxicological Evaluation. Calcium and titanium will be discussed later in the Chemicals with No Screening Levels Evaluation.

Table 5: Organic chemicals (in micrograms per liter [µg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 19 wells located west of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood, Marshall, Michigan (Calhoun County).

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences[b]	Number of samples
1,1-Dichloropropene	NA[c]	0.5	0.5	NA	74
1,3-Dichloropropane	NA	0.5	0.5	NA	74
2,2-Dichloropropane	NA	0.5	1	NA	74
Bis(2-ethylhexyl)phthalate	6	0.5	**15**	1 (1 well)	75
Butachlor	NA	0.2	0.55	NA	75
Cyclohexane	NA	0.5	1	NA	59
DRO (C10-C20)	NA	100	100	NA	78
GRO (C6-C10)	NA	200	200	NA	78
ORO (C20-C34)	NA	100	100	NA	77
p-Isopropyltoluene	NA	0.5	0.5	NA	123

Bold values are those over the screening level.
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = No screening level was available (NA = not available).

Only one organic chemical, bis(2ethylhexyl)phthalate, was detected in the drinking water samples. This chemical was higher than the screening level in one sample. It will be discussed later in the Toxicological Evaluation. All other chemicals in Table 5 have no screening levels and will be discussed later in the Chemicals with No Screening Levels Evaluation.

Section 3 – Approximately a half mile upstream (east) of the Ceresco Dam (Mile Post 5.25) to just over a half mile downstream (west) of the Ceresco Dam (Mile Post 6.5)

Thirty wells are located along this section of the Kalamazoo River. The number of samples varies for each chemical because wells sampled before the drinking water sampling program was

started were included as long as appropriate drinking water analytical methods were used for the sample.

Table 6 presents the inorganic chemicals, in mg/L, and Table 7 presents the organic chemicals, in µg/L, detected above or with no drinking water screening levels. No organic chemicals were detected above the screening levels. Results from all of the inorganic and organic chemicals measured in samples from wells in this section can be found in Appendix B.

Table 6: Inorganic chemicals (in milligrams per liter [mg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 26 wells located approximately a half mile upstream (east) of the Ceresco Dam to just over a half mile downstream (west) of the Ceresco Dam, Ceresco, Michigan (Calhoun County).

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences[b]	Number of samples
Iron	2.0[c]	0.013	**4.41**	10 (5 wells)	143
Lead	0.004	0.00014	**0.035**	6 (3 wells)	88
Titanium	NA[d]	0.0006	0.02	NA	55

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Results for drinking water samples from five wells, out of 26 wells total, were over the screening level for iron and samples from three wells were over the lead screening level. Iron and lead will be discussed later in the Toxicological Evaluation. Titanium was not detected in any sample and will be discussed later in the Chemicals with No Screening Levels Evaluation.

Table 7: Organic chemicals (in micrograms per liter [µg/L]) with no drinking water screening level in samples collected between July 2010 to February 2011 from 30 wells located approximately a half mile upstream (east) of the Ceresco Dam to just over a half mile downstream (west) of the Ceresco Dam, Ceresco, Michigan (Calhoun County).

Organic chemical	Lowest value (µg/L)	Highest value (µg/L)	Number of samples
1,1-Dichloropropene	0.5	0.5	88
1,3-Dichloropropane	0.5	0.5	88
2,2-Dichloropropane	0.5	1	88
Butachlor	0.2	0.55	88
Cyclohexane	0.5	1	60
DRO (C10-C20)	100	100	94
GRO (C6-C10)	200	200	94
ORO (C20-C34)	100	100	94
p-Isopropyltoluene	0.5	0.5	143

DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics

None of the organic chemicals in Table 7 were detected in any of the samples. Even though these chemicals were not detected, they have no screening levels. They will all be discussed later in the Chemicals with No Screening Levels Evaluation.

Section 4 – Just over a half mile downstream (west) of the Ceresco Dam (Mile Post 6.5) to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River (Mile Post 13.25)

Twenty-eight wells are located along this section of the Kalamazoo River. The number of samples varies for each chemical because wells sampled before the drinking water sampling program was started were included as long as appropriate drinking water analytical methods were used for the sample.

Table 8 presents the inorganic chemicals, in mg/L, and Table 9 presents the organic chemicals, in µg/L, detected above or with no drinking water screening levels. No organic chemicals were detected above the screening levels. Results from all of the inorganic and organic chemicals measured in samples from wells in this section can be found in Appendix B.

Table 8: Inorganic chemicals (in milligrams per liter [mg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 24 wells located just over a half mile downstream (west) of the Ceresco Dam to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River, between Ceresco and Battle Creek, Michigan (Calhoun County).

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences[b]	Number of samples
Antimony	0.006	0.00054	**0.0073**	1 (1 well)	83
Arsenic	0.01	0.00037	**0.015**	3 (1 well)	83
Calcium	NA[c]	68	86	NA	3
Iron	2.0[d]	0.0085	**3.7**	4 (3 wells)	100
Lead	0.004	0.000076	**0.089**	5 (4 wells)	83
Titanium	NA	0.001	0.02	NA	17

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = No screening level was available (NA = not available).
d = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.

Levels of antimony, arsenic, iron, and lead were higher than the screening level in at least one sample. Arsenic levels were higher than the screening level in samples from one well. Iron levels were higher than the screening level in samples from three wells and lead levels in samples from four wells were higher than the screening level. These four chemicals will be discussed later in

the Toxicological Evaluation. Calcium and titanium will be discussed later in the Chemicals with No Screening Levels Evaluation.

Table 9: Organic chemicals (in micrograms per liter [µg/L]) with no drinking water screening level in samples collected between July 2010 and February 2011 from 28 wells located just over a half mile downstream (west) of the Ceresco Dam to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River, between Ceresco and Battle Creek, Michigan (Calhoun County).

Organic chemical	Lowest value (µg/L)	Highest value (µg/L)	Number of samples
1,1-Dichloropropene	0.5	0.5	83
1,3-Dichloropropane	0.5	0.5	83
2,2-Dichloropropane	0.5	1	83
Butachlor	0.1	0.54	83
Cyclohexane	0.5	1	33
DRO (C10-C20)	24	100	89
GRO (C6-C10)	100	200	89
ORO (C20-C34)	100	500	89
p-Isopropyltoluene	0.5	0.5	100

DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics

The only organic chemical from Table 9 that was detected in drinking water well samples from this area was DRO (24 µg/L). All chemicals in this table will be discussed later in the Chemicals with No Screening Levels Evaluation.

Section 5 – About a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River (Mile Post 13.25) to east of Battle Creek, near 20th Street North at the Kalamazoo River (Mile Post 18.0)

Thirty-two wells are located along this section of the Kalamazoo River. The number of samples varies for each chemical because wells sampled before the drinking water sampling program was started were included as long as appropriate drinking water analytical methods were used for the sample.

Table 10 presents the inorganic chemicals, in mg/L, and Table 11 presents the organic chemicals, in µg/L, detected above or with no screening levels. Results from all of the inorganic and organic chemicals measured in samples from wells in this section can be found in Appendix B.

Table 10: Inorganic chemicals (in milligrams per liter [mg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 26 wells located about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River to east of Battle Creek, near 20th Street North at the Kalamazoo River (Calhoun County, Michigan).

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences[b]	Number of samples
Arsenic	0.01	0.0013	**0.048**	81 (14 wells)	120
Iron	2.0[c]	0.012	**6.95**	64 (12 wells)	189
Lead	0.004	0.00032	**0.115**	3 (2 wells)	120
Titanium	NA[d]	0.00086	0.02	NA	69

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Levels of arsenic, iron, and lead were higher than the screening levels in samples from 14 wells (for arsenic), 12 wells (for iron), and two wells (for lead). These three chemicals will be discussed later in the Toxicological Evaluation. Titanium will be discussed later in the Chemicals with No Screening Levels Evaluation.

Table 11: Organic chemicals (in micrograms per liter [µg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 32 wells located about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River to east of Battle Creek, near 20th Street North at the Kalamazoo River (Calhoun County, Michigan).

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences[b]	Number of samples
1,1-Dichloropropene	NA[c]	0.5	0.5	NA	120
1,3-Dichloropropane	NA	0.5	0.5	NA	120
2,2-Dichloropropane	NA	0.5	1	NA	120
Bis(2-ethylhexyl)phthalate	6	0.5	**11**	2 (2 wells)	120
Butachlor	NA	0.2	0.55	NA	120
Cyclohexane	NA	0.5	1	NA	71
DRO (C10-C20)	NA	100	100	NA	132
GRO (C6-C10)	NA	200	200	NA	132
ORO (C20-C34)	NA	100	100	NA	132
p-Isopropyltoluene	NA	0.5	0.5	NA	189

Bold values are those over the screening level.
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = No screening level was available (NA = not available).

Bis(2-ethylhexyl)phthalate was found at concentrations above the screening level in samples from two wells. It will be discussed later in the Toxicological Evaluation. All other chemicals in Table 11 will be discussed later in the Chemicals with No Screening Levels Evaluation.

Section 6 – West of Battle Creek, near 20th Street North at the Kalamazoo River (Mile Post 18.0) to the Calhoun County/Kalamazoo County border

Thirty-three wells are located along this stretch of the Kalamazoo River. The number of samples varies for each chemical because wells sampled before the drinking water sampling program was started were included as long as appropriate drinking water analytical methods were used for the sample.

Table 12 presents the inorganic chemicals, in mg/L, and Table 13 presents the organic chemicals, in µg/L, detected above or with no screening levels. Results from all of the inorganic and organic chemicals measured in samples from wells in this section can be found in Appendix B.

Table 12: Inorganic chemicals (in milligrams per liter [mg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 30 wells located west of Battle Creek, near 20th Street North at the Kalamazoo River (Mile Post 18.0) to the Calhoun County/Kalamazoo County border (Calhoun County, Michigan).

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences[b]	Number of samples
Arsenic	0.01	0.0006	**0.025**	1 (1 well)	119
Iron	2.0[c]	0.01	**7.01**	19 (6 wells)	169
Lead	0.004	0.000096	**0.052**	7 (4 wells)	119
Titanium	NA[d]	0.00081	0.02	NA	50

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

A drinking water sample from one well contained arsenic above its screening level. Iron levels in samples from six wells were higher than the screening level. Samples from four wells had lead levels over the screening level. These chemicals will be discussed later in the Toxicological

Evaluation. Titanium will be discussed later in the Chemicals with No Screening Levels Evaluation.

Table 13: Organic chemicals (in micrograms per liter [µg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 37 wells located west of Battle Creek, near 20th Street North at the Kalamazoo River (Mile Post 18.0) to the Calhoun County/Kalamazoo County border (Calhoun County, Michigan).

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences[b]	Number of samples
1,1-Dichloropropene	NA[c]	0.5	0.5	NA	119
1,3-Dichloropropane	NA	0.5	0.5	NA	119
2,2-Dichloropropane	NA	0.5	1	NA	119
Bis(2-ethylhexyl)phthalate	6	0.5	**18**	3 (2 wells)	118
Butachlor	NA	0.2	0.55	NA	118
Cyclohexane	NA	0.5	1	NA	58
DRO (C10-C20)	NA	100	100	NA	141
GRO (C6-C10)	NA	200	200	NA	141
ORO (C20-C34)	NA	100	190	NA	137
p-Isopropyltoluene	NA	0.5	0.5	NA	169
Vinyl chloride	2	0.5	**3**	2 (1 well)	119

Bold values are those over the screening level.
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = No screening level was available (NA = not available).

Three chemicals (bis[2-ethylhexyl]phthalate, ORO, and vinyl chloride) were detected in drinking water samples from this area along the Kalamazoo River. Samples from two wells were over the screening level for bis(2-ethylhexate)phthalate. Vinyl chloride levels in samples from one well were over the screening level. These two chemicals (bis[2-ethylhexate]phthalate and vinyl chloride) will be discussed later in the Toxicological Evaluation. All other chemicals from Table 13 will be discussed later in the Chemicals with No Screening Levels Evaluation.

Section 7 – Kalamazoo County (Kalamazoo River west of the Kalamazoo County/Calhoun County border to Morrow Lake)

Fifty-six wells are located along this stretch of the Kalamazoo River. The number of samples varies for each chemical because wells sampled before the drinking water sampling program was started were included as long as appropriate drinking water analytical methods were used for the sample.

Table 14 presents the inorganic chemicals, in mg/L, and Table 15 presents the organic chemicals, in µg/L, detected above or with no screening level in wells along the Kalamazoo River in

Kalamazoo County. Results from all of the inorganic and organic chemicals measured in samples from wells in this section can be found in Appendix B.

Table 14: Inorganic chemicals (in milligrams per liter [mg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 51 wells located along the Kalamazoo River in Kalamazoo County, Michigan.

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences[b]	Number of samples
Iron	2.0[c]	0.008	**6.6**	3 (2 wells)	242
Lead	0.004	0.000076	**0.024**	7 (6 wells)	156
Manganese	0.86[c]	0.005	**2.46**	1 (1 well)	156
Titanium	NA[d]	0.00083	0.02	NA	86

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Samples from two wells were above the screening levels for iron. Lead levels in samples from six wells were over the screening level. One well had manganese levels higher than the screening level. These chemicals will be discussed later in the Toxicological Evaluation. Titanium will be discussed later in the Chemicals with No Screening Levels Evaluation.

Table 15: Organic chemicals (in micrograms per liter [µg/L]) detected above or with no drinking water screening level in samples collected between July 2010 and February 2011 from 56 wells located along the Kalamazoo River in Kalamazoo County, Michigan.

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences[b]	Number of samples
1,1-Dichloropropene	NA[c]	0.5	0.5	NA	156
1,3-Dichloropropane	NA	0.5	0.5	NA	156
2,2-Dichloropropane	NA	0.5	1	NA	156
Bis(2-ethylhexyl)phthalate	6	0.19	**18**	2 (1 well)	156
Butachlor	NA	0.048	0.56	NA	156
Cyclohexane	NA	0.5	1	NA	92
DRO (C10-C20)	NA	100	100	NA	166
GRO (C6-C10)	NA	200	200	NA	166
ORO (C20-C34)	NA	100	100	NA	166
p-Isopropyltoluene	NA	0.5	0.5	NA	242

Bold values are those over the screening level.
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = No screening level was available (NA = not available).

Drinking water samples from two wells had bis(2-ethylhexyl)phthalate higher than the screening level. This chemical will be discussed later in the Toxicological Evaluation. All other chemicals in Table 15 will be discussed later in the Chemicals with No Screening Levels Evaluation.

Sampling results from February to August 2011

Approximately 125 wells along the Kalamazoo River were sampled between February and August 2011. Many of the inorganic chemicals were detected in these samples. Several of the inorganic chemicals (iron, nickel, and titanium) were detected at higher levels than from the samples taken before February 2011. Table 16 contains the highest value of these chemicals detected in drinking water well samples from along the Kalamazoo River.

Table 16: Inorganic chemicals (in milligrams per liter [mg/L]) detected above the screening levels in drinking water well samples from 125 wells taken from February to August 2011 from wells along the Kalamazoo River (Calhoun and Kalamazoo Counties, Michigan).

Inorganic chemicals	Screening level[a] (mg/L)	Highest value (mg/L)	Number of exceedences[b]	Number of samples
Iron	2.0[c]	**13**	43 (21 wells)	382
Nickel	0.1	**0.15**	3 (3 wells)	268
Titanium	NA[d]	0.039	NA	252

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = Number of samples with chemicals detected higher than the screening level. The number of wells these samples were from is in parentheses.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Iron levels in samples from 21 wells were above the screening level. Samples from three wells had nickel levels higher than the screening level. Iron and nickel will be discussed later in the Toxicological Evaluation. Titanium will be discussed later in the Chemicals with No Screening Levels Evaluation.

Only two organic chemicals, bis(2-ethylhexyl)phthalate and toluene, were detected in the samples taken from February to August 2011. All of the organic chemicals, including the two detected, were below screening levels or within the range presented in the above tables (Tables 3, 5, 7, 9, 11, 13, and 15).

Exposure Pathways Analysis

There are five things to consider when deciding if a person may be exposed to a chemical, also known as an *exposure pathway*: (1) where is the chemical coming from (source), (2) what in a person's environment has been contaminated (environmental medium), (3) is there a way a person might come into contact with the chemical (exposure point), (4) how they might come into contact with the chemical (exposure route), and (5) who might be exposed to it (exposed population). An exposure pathway is complete if it is expected or there is proof that all five elements are present. Table 17 describes the exposure pathway for residents and visitors to potential chemicals from the Enbridge pipeline release or naturally present in private drinking water wells along the Kalamazoo River (Calhoun and Kalamazoo Counties), Michigan.

Table 17: Exposure pathway for residents and visitors using private drinking water wells in the areas of the Kalamazoo River and Morrow Lake (Calhoun and Kalamazoo Counties), Michigan, impacted by the July 2010 Enbridge pipeline release of heavy crude oil.

Source	Environmental Medium	Exposure Point	Exposure Route	Exposed Population	Time Frame	Exposure
Heavy crude oil (crude oil-related chemicals)	Groundwater with potential impact from chemicals in the crude oil	Private well water	Ingestion, dermal contact, and inhalation	Residents and visitors who use private well water	Past Present Future	Incomplete Incomplete Potential
Natural sources or contaminated areas (non-oil-related chemicals)	Groundwater from areas with mineral deposits or contamination sources (not oil spill related)	Private well water	Ingestion and dermal contact	Residents and visitors who use private well water	Past Present Future	Potential Completed Potential

Before the crude oil spill, iron and nickel were detectable in drinking water wells from Calhoun and Kalamazoo counties. A majority of the iron detections were below the screening level of 2.0 mg/L. The range of iron levels from the Drinking Water Sampling Program were similar to the previously measured iron levels, which ranged from 0.01 to 94 mg/L (MDEQ 2010c). The range of nickel previously measured, 0 to 0.05 mg/L (MDEQ 2010c), is also similar to the nickel results from the drinking water sampling program.

Although some of the non-oil-related contaminants are above screening levels, no more than 14% of all samples had chemical levels higher than the screening levels. These samples were from 65 wells, which represent about 30% of the wells sampled. The most common chemicals that were higher than the screening levels were arsenic, iron, and lead. These chemicals, and others, will be discussed in the Toxicological Evaluation section.

People's wells may not have levels of chemicals consistently above the screening levels. Groundwater chemicals levels are variable, depending on the depth of the water; the chemicals naturally present in the layers of rock and soil surrounding the groundwater; and groundwater flow (Hem 1985). There could also be a difference between the chemicals in the water samples and the chemicals that people may be drinking. The samples could have been taken from an

outside faucet not connected to any potential water treatment systems in place on inside faucets used for drinking water.

Toxicological Evaluation

Maximum amounts of each chemical over the screening level were calculated for adults and children. These calculations are protective, and result in a higher amount of chemicals than people would be expected to be exposed to from drinking the water.

Oil-related chemicals

Iron and nickel were previously found in drinking water wells in Calhoun and Kalamazoo Counties sampled before the crude oil spill. Iron and nickel levels measured in samples from the Drinking Water Well Sampling Program since the spill are similar to previous measurements.

Iron

People need iron in their bodies. Iron is part of hemoglobin, a protein in red blood cells that carries oxygen throughout the body. People get iron from foods, such as meats, spinach, beans, and iron-fortified products (cereals and breads) (ODS 2007). Iron is naturally occurring in drinking water.

A tolerable upper limit (UL) of 40 mg/day has been established for infants and children under 13 years of age. A UL of 45 mg/day has been established for children 14 and older and adults. The UL was established by the National Academy of Sciences and is the amount of iron that can be ingested per day that is not expected to cause any harmful effects (IOM 2001).

Drinking water well samples had up to 13 mg/L of iron (in samples taken through August 2011), which is over the health-based screening level of 2.0 mg/L. People drinking water with this much iron would ingest up to 35 mg of iron per day.[6] The maximum amount of iron that people may be drinking is below the ULs of 40 and 45 mg/day. Total intake of iron (from this drinking water and diet, using the range of 8 to 18 mg/day) is right around or a little over the UL for adults[7]. A child's total intake is less than the UL, using a dietary intake of 11 mg/day and 13 mg/day from drinking water with 13/L. Most (about 88% of the 1,424 samples) of the drinking water samples analyzed for iron were below the screening level, therefore, people are not expected to consistently be drinking water with 13 mg iron/L. People are not expected to be ingesting levels of iron that would harm their health.[8] Aesthetic issues, such as taste or color of the water, may be present and may limit the amount of water people drink. Water treatment systems can be installed in people's houses to reduce the iron levels.

[6] Adults drinking 2.7 L of water per day (EPA 2011b) with 13 mg iron/L would drink 35 mg iron/day. Children drinking 1 L of water per day (EPA 2008) with 13 mg iron/L would drink 13 mg iron/day. This calculation uses the maximum amount of iron measured in a drinking water sample. Average levels of iron, which people are expected to be exposed to, would be lower than 13 mg/L.

[7] Using the highest amount of iron that adults (80 kg body weight) are calculated to ingest (53 mg) results in a dose equivalent to the EPA's provisional RfD of 0.7 mg/kg-day (http://hhpprtv.ornl.gov/issue_papers/IronandCompounds.pdf).

[8] Individuals with genetic diseases that interfere with iron metabolism should bring their drinking water test results to the attention of their medical doctor.

Nickel

Three samples, out of 1,309, had nickel levels over the screening level (0.1 mg/L). These three samples were from three separate wells. The highest nickel levels measured in the drinking water samples over the screening level was 0.15 mg/L. Adults and children drinking water with this level of nickel would be ingesting up to 0.4 mg nickel/day with a dose as high as 0.02 mg/kg/day.[9] The EPA's RfD for nickel is 0.02 mg/kg/day (EPA 1996b). The dose (0.02 mg/kg/day) that an adult or child may be drinking from with the highest level of nickel (0.15 mg/L) is equal to the RfD and would not be expected to cause any health effects.

Chemicals not found in the crude oil

Antimony

Antimony is naturally-occurring chemical that people ingest (eat) daily. People's average daily intake of antimony is about 0.005 mg from foods, including meats, seafood, and vegetables, and water (ATSDR 1992).

One drinking water sample, out of 688 samples from wells along the Kalamazoo River, was over the antimony screening level of 0.006 mg/L. That sample had 0.0073 mg/L of antimony in the water. Conservatively, adults and children drinking this water would ingest up to 0.02 mg per day, resulting in a dose as high as 0.0007 mg/kilogram (kg)/day.[10] The EPA's reference dose (RfD) of 0.0004 mg/kg/day is a level considered safe for long-term exposure (EPA 1991a). The RfD is less than half of the amount of antimony people may have ingested in water with 0.0073 mg/L. Although one sample, out of 688, was over the screening level, the antimony levels were not consistently higher than the screening level. No samples collected from February to August had antimony levels higher than the screening level. As antimony levels were not consistently above the screening level, people are not expected to drink water with antimony levels that would harm their health.

Arsenic

People ingest small amounts of arsenic in food and water (ATSDR 2007a). Although there is currently no known function for arsenic in humans, animal studies have shown that arsenic is necessary in the diet (IOM 2001). U.S. dietary inorganic arsenic intake ranges from 0.0002 to 1.3 mg/day with a mean of 0.05 mg/day for women and a mean of 0.06 mg/day for men. 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 (IOM 2001). Arsenic compounds can dissolve in water, and natural levels of arsenic in surface and groundwater are usually 0.001 mg/L (ATSDR 2007a).

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[9] Adults drinking 2.7 L of water per day (EPA 2011b) with 0.15 mg nickel/L would drink 0.4 mg nickel/day. An 80 kg (EPA 2011b) adult would have a dose of 0.005 mg/kg/day. Children drinking 1 L of water per day (EPA 2008) with 0.15 mg nickel/L would drink 0.15 mg nickel/day. A 10 kg (EPA 2008) child would have a dose of 0.02 mg/kg/day.

[10] Adults drinking 2.7 L of water per day (EPA 2011b) with 0.0073 mg antimony/L would drink 0.02 mg antimony/day. An 80 kg (EPA 2011b) adult would have a dose of 0.0002 mg/kg/day. Children drinking 1 L of water per day (EPA 2008) with 0.0073 mg antimony/L would drink 0.0073 mg antimony/day. A 10 kg (EPA 2008) child would have a dose of 0.0007 mg/kg/day.

The highest level of arsenic measured in a drinking water sample was 0.048 mg/L. Ninety-four samples, out of a total of 688, were over the screening level of 0.01 mg/L. These 94 samples were taken from 18 wells. Adults and children could be ingesting up to 0.13 mg of arsenic per day, resulting in an arsenic dose up to 0.005 mg/kg-day. [11] This is 17 times higher than the ATSDR chronic oral minimal risk level (MRL) of 0.0003 mg/kg-day (ATSDR 2007a). The chronic oral MRL is the amount of arsenic that, even if adults and children ingest for a lifetime, will not result in health effects. People could develop health effects from levels of arsenic measured in their drinking water wells if the arsenic levels are consistently higher than the screening levels.

Low levels of ingestion can result in nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to the blood vessels and sensation of pins and needles in hands and feet. Chronic oral exposures of 0.05-0.1 mg/kg/day are associated with neurological or hematological signs of arsenic toxicity. Both children and adults can have vomiting, respiratory, cardiovascular, dermal, and neurological effects from arsenic exposure. Even with the highest level of arsenic, the calculated dose is lower than those associated with most of the above health effects. However, reduced numbers of red and white blood cells and skin lesions have occurred in humans exposed to more than 0.0012 mg arsenic/kg/day (two to four times lower than the arsenic dose from water with 0.048 mg/L). Arsenic is a carcinogen and long-term exposure has been linked to skin, bladder, liver, and lung cancer (ATSDR 2007a).[12]

People with wells that have consistently elevated arsenic levels may want to consider using water treatment systems to remove arsenic from their water. It should be noted that these water samples, while from potable wells, could have been taken from an outside faucet and water treatment systems could be in place on inside faucets used for drinking water.

Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate, also called di(2ethylhexyl)phthalate, is a chemical used in plastic products, such as shower curtains, footwear, food packaging, and children's toys (NLM 2002a). In some drinking water samples, bis(2-ethylhexyl)phthalate was identified as a laboratory contaminant, probably from gloves or a plastic container used in the lab.

Nine samples, out of 688, were higher than the screening level. These 9 samples were collected from 6 wells. Although all nine were not identified as laboratory contaminants, samples from the same well did not have levels of bis(2ethylhexyl)phthalate consistently over the screening level. The highest level measured was 18 µg/L. Adults and children drinking this water could have ingested up to 48.6 µg, resulting in a dose of up to 1.8 µg/kg/day.[13] ATSDR's chronic oral MRL

[11] Adults drinking 2.7 L of water per day (EPA 2011b) with 0.048 mg arsenic/L would drink 0.13 mg arsenic/day. An 80 kg (EPA 2011b) adult would have a dose of 0.002 mg/kg/day. Children drinking 1 L of water per day (EPA 2008) with 0.048 mg arsenic/L would drink 0.048 mg arsenic/day. A 10 kg (EPA 2008) child would have a dose of 0.005 mg/kg/day.

[12] The theoretical cancer risk drinking water with 0.048 mg/L is two excess cases in 1,000 people, using the drinking water unit risk of $5x10^{-5}$ per µg/L (EPA 1998). This may overestimate the cancer risk as arsenic levels in water samples were not consistently at 0.048 mg/L.

[13] Adults drinking 2.7 L of water per day (EPA 2011b) with 18 µg bis(2ethylhexyl) phthalate/L would drink 49 µg bis(2ethylhexyl) phthalate/day. An 80 kg (EPA 2011b) adult would have a dose of 0.6 µg/kg/day. Children drinking

for bis(2-ethylhexyl)phthalate is 60 µg/kg/day (ATSDR 2002a). As the highest level measured in a drinking water sample results in a dose lower than the chronic oral MRL, people are not expected to have health effects from the levels of bis(2-ethylhexyl)phthalate measured in the drinking water samples. Although bis(2ethylhexyl)phthalate may cause cancer in humans, the levels in the drinking water are not expected to increase people's risk of cancer.[14]

Lead

Lead is a naturally occurring element. It had been used paints, ceramic products, caulking, and pipe solder. Older houses, those built before 1978, may still have paint containing lead. Lead can be present in plumbing and may be in people's drinking water. People have an average dietary intake, from food and water, of 0.001 mg/kg/day. Almost all (99%) of the publicly supplied drinking water has less than 0.005 mg/L lead. Lead in food ranges from less than 0.4 to 523.4 mg lead/g food (ATSDR 2007b). Lead was not found in the heavy crude oil that spilled in the Kalamazoo River.

The highest levels of lead detected in drinking water samples ranged from 0.015 to 0.115 mg/L. Thirty-three samples, out of a total of 688, were over the screening level. These 33 samples were collected from 23 wells. Children, 0 to 7 years of age, drinking water with 0.115 mg lead/L could have an average blood lead level of 10.4 µg/deciliter (dL).[15] Although blood lead levels of at least 10 µg/dL are considered elevated, health effects have occurred at lower blood lead levels (ATSDR 2007b).

If samples from one well are consistently higher than the screening level, adults and children may be consistently drinking enough lead to develop health effects. If only one sample from a well is over the screening level, lead may not be in the groundwater but may be from plumbing in the house (i.e., from lead solder).[16] It should be noted that these water samples, while from potable wells, could have been taken from an outside faucet and water treatment systems could be in place on inside faucets used for drinking water. If this was the case, people would be exposed to smaller amounts of lead than what was measured in the drinking water samples.

Children are more vulnerable to lead poisoning as compared to adults. Children absorb, on average, 50% of lead that was ingested while adults absorb between 6-80% of ingested lead depending on recent food consumption. In both adults and children, the main target is the nervous system, but lead will affect every organ system. Large amounts of lead can cause anemia, kidney damage, colic, muscle weakness, and brain damage. Small amounts of lead can

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1 L of water per day (EPA 2008) with 18 µg bis(2ethylhexyl) phthalate /L would drink 18 µg bis(2ethylhexyl) phthalate /day. A 10 kg (EPA 2008) child would have a dose of 1.8 µg/kg/day.

[14] The highest level of bis(2ethylhexyl)phthalate detected in a drinking water sample (18 µg/L) would not result in increased cancer risk. (Assuming people are consistently drinking water with 18 µg/L and using the drinking water unit risk of $4x10^{-7}$ per µg/L [EPA 1997], the theoretical cancer risk is one excess case in 100,000 people. This overestimates the cancer risk as levels of bis[2-ethylhexal]phthalate were not consistently higher than the screening level.)

[15] Using the EPA's Integrated Exposure Uptake Biokinetic Model for Lead and Children Version 1.0, Build 264 (http://www.epa.gov/superfund/lead/products.htm), a geometric mean blood lead level of 10.4 µg/deciliter (dL) was predicted for children ages 0 to 7 years old. The model parameters used were the default values, except for the water level, which was set at 0.115 mg/L.

[16] Water should be allowed to run for 15 minutes before the sample is collected to clear any particles that may have settled in the plumbing.

also cause effects on blood, development, and behavior. Even at low blood lead levels, adverse effects may include delays or impairments in development. Alterations in immune function or any cognitive defects that occur during childhood from lead exposure can be detected as an adult (ATSDR 2007b).

Adults older than 60 years and postmenopausal women are vulnerable to specific effects of lead, which include cognitive deficiency, hypertension, and depressed glomerular filtration rate (kidney function). There is a significant association of an increase in systolic blood pressure with an increase of blood lead levels (ATSDR 2007b).

Manganese

One sample, out of 688, had a manganese level (2.46 mg/L) higher than the screening level (0.86 mg/L). Adults and children drinking water with this level of manganese could be drinking up to 6.6 mg/day with a dose as high as 0.25 mg/kg/day.[17] The EPA RfD for manganese is 0.14 mg/kg/day (EPA 1996a). Although the ingested amount (0.25 mg/kg/day) of manganese from the drinking water sample with 2.46 mg/L is higher than the RfD, manganese levels from all other samples of water, including other samples from the same well, would result in an ingested amount lower than the RfD. Since the manganese levels from the one well? were not repeatedly over the screening level, people are not expected to be drinking water with levels of manganese that would harm their health.

Vinyl chloride

Vinyl chloride levels were over the screening level only for two samples taken from a well at a business. The highest level was 3.0 µg/L. Workers at the business use this water for industrial processes and do not use it for drinking. People's health will not be harmed by the vinyl chloride as no one drinks this water.

Contaminants with No Screening Levels Evaluation

Many of the organic chemicals discussed below are not oil-related chemicals or were not detected in the sample. If chemicals were not detected, the highest and lowest values were the reporting limits[18] for the samples. In some cases the highest and lowest values were the same, indicating that there was one reporting limit for all samples and in other cases chemicals had different reporting limits. Reasons for different reporting limits include different laboratories performing the analysis or different analytical methods (the instrument and steps taken to measure the chemical) being used for the same chemical.

[17] Adults drinking 2.7 L of water per day (EPA 2011b) with 2.46 mg manganese/L would drink 6.6 mg manganese/day. An 80 kg (EPA 2011b) adult would have a dose of 0.08 mg/kg/day. Children drinking 1 L of water per day (EPA 2008) with 2.46 mg manganese/L would drink 2.5 mg manganese/day. A 10 kg (EPA 2008) child would have a dose of 0.25 mg/kg/day.

[18] Reporting limits are the lowest levels that can accurately be measured in a sample. Chemicals may be detected lower than the reporting limits, but only as an estimation of the amount present.

Oil-related chemicals

Cyclohexane

Cyclohexane was not detected above the reporting limit, which ranged from 0.5 to 1.0 µg/L, in all 461 samples. Cyclohexane was found in the crude oil. There is not enough information to determine levels that could harm people's health. Cyclohexane is not expected to be dissolved in water. If oil spilled or soaked into the ground near a well, cyclohexane would be expected to remain bound to the soil material (NLM 2005).

DRO (C10-C20)

DRO (diesel range organics) are chemicals with 10 to 20 carbons in the structure. This is a generic designation for many specific chemicals present in petroleum products. Of the 754 samples analyzed, DRO was detected in only one sample (24 µg/L). The detection was below the reporting limits[18], which was 100 µg/L. DRO data are most useful in identifying whether petroleum products are present in the samples, not to assess any potential health concerns. The results from the drinking water samples do not indicate that petroleum products are present in the groundwater.

GRO (C6-C10)

GRO (gasoline range organic) are chemicals with six to ten carbons in the structure. Similar to DRO, this is a generic designation. GRO was not detected in any of the 755 samples analyzed and the reporting limit ranged from 100 to 200 µg/L. GRO data are most useful in identifying whether petroleum products are present in the samples, not to assess any potential health concerns. The results from the drinking water samples do not indicate that petroleum products are present in the groundwater.

ORO (C20-C34)

ORO (oil range organics) are chemicals with 20 to 34 carbons in the structure. As with DRO and GRO, any chemicals with the correct number of carbons will be measured. There was only one detection in the 748 samples analyzed for ORO. The detection was 190 µg/L, which was within the range of the reporting limits (100 to 500 µg/L). ORO data are most useful in identifying whether petroleum products are present in the samples, not to assess any potential health concerns. The results from the drinking water samples do not indicate that petroleum products are present in the groundwater.

p-Isopropyltoluene

Over 1,000 samples (1,042 samples) were analyzed for p-isopropyltoluene, also called p-cymene. It was not detected in any of the samples. The reporting limit for all samples was 0.5 µg/L. The United States Food and Drug Administration (FDA) allows this chemical to be added to foods as a flavoring (NLM 2010b). This chemical is not expected to harm people's health.

Titanium

People ingest titanium in food, such as milled grains, butter, corn oil, and lettuce (IPCS 1982). There is not enough information available on titanium to determine levels that could cause harm to people's health. However, titanium is used in a variety of medical devices, such as knee or hip joint replacements and dental implants and there is no evidence of toxicity from these implants

(IPCS 1982). One form of titanium, titanium dioxide, is FDA-approved for use as a color additive in food (NLM 2009). Titanium was measured in 462 samples, including the samples taken from February to August 2011, and had a range of 0.00023 to 0.039 mg/L. People's bodies will not absorb a majority of the titanium in the water. Even if adults and children were consistently drinking water with the highest level of titanium, they would ingest about one-third of the average titanium amount in the typical U.S. diet (NLM 2002).

Non-oil-related chemicals

1,1-Dichloropropene

This chemical was not detected in any of the 688 samples above the reporting limit (0.5 µg/L) and is not expected to be in the crude oil that spilled in Talmadge Creek and the Kalamazoo River. There is not enough information to determine levels that could cause harm to people's health. However, this chemical is not expected to be in these drinking water wells.

1,3-Dichloropropane

There were no detections of 1,3-dichloropropane in any of the 688 samples. The reporting limit for all samples was 0.5 µg/L. There is no evidence that this compound is produced or used in the United States (NLM 2002). That being the case, this chemical is not expected to be in these drinking water wells.

2,2-Dichloropropane

In the 688 samples analyzed for 2,2-dichloropropane, there were no detections. The reporting limit ranged from 0.5 to 1.0 µg/L. There is not enough information to determine levels that could cause harm to people's health. However, this chemical is not expected to be in these drinking water wells.

Butachlor

Butachlor was tested in 688 samples, but was not detected in any sample. The reporting limit ranged from 0.048 to 0.56 µg/L. Butachlor is a pesticide that is no longer used in the United States and is not expected to remain in the soil or water from any potential earlier use (NLM 2005). This chemical is not expected to be in people's drinking water, even at levels below the reporting limits.

Calcium

Calcium is required for teeth and bone formation, along with muscle contracting and blood clotting. People can obtain calcium from eating milk, cheese, yogurt, corn tortillas, Chinese cabbage, broccoli, kale, calcium-set tofu, and calcium-fortified foods. Adequate intakes are 210 mg/day or higher for people, including infants. The UL is 1,000 mg/day for people, including infants (IOM 2011).

Calcium was only measured in four drinking water samples. The highest level was 86 mg/L. Even an infant, drinking 1 L of water per day (EPA 2008), would have more than ten times less (86 mg/day) than the UL and about half of the adequate calcium intake (210 mg/day). People are not expected to have any health effects from drinking water with 86 mg/L calcium.

Children's Health Considerations

Children may be at greater risk than adults when exposed to certain hazardous substances. A child's lower body weight and higher intake rate result in a greater dose of hazardous chemicals compared to their weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children may be damaged. Drinking too much of some of the chemicals, such as lead, may be more damaging for children and fetuses than adults. Doses calculated for children were included in the Toxicological Evaluation.

Community Health Concerns

Community members have expressed concerns regarding possible contamination of their drinking water. Individuals have asked questions about the chemicals tested, if any chemical was above health-based drinking water screening values, and if variation present in results had any trend indicating potential contamination of the groundwater. These questions were addressed at several public meetings and by email responses to the questioner. This public health assessment should aid in answering people's questions about the drinking water sampling program and provide a summary of the results (to February 2011).[19]

Conclusions

Only two oil-related inorganic chemicals, nickel and iron, were found in private drinking water wells. The levels of nickel and iron found will not harm people's health. No oil-related organic chemicals were found in people's water. Most of the oil-related inorganic chemical (metals) levels were below the screening levels as well. Two metals, iron and nickel, were detected above the screening levels in some samples. However, iron and nickel were previously detected from wells in Calhoun and Kalamazoo Counties and are likely naturally occurring metals.

Arsenic and lead, two metals not present in the crude oil, are present at levels that may harm people's health. Arsenic and lead levels were higher than the screening levels in multiple samples. Chronic (long-term) exposure to levels of arsenic and lead detected in these samples may cause health effects.

Recommendations

People may want to consider use of a water treatment system to reduce the levels of arsenic and lead in their drinking water, if arsenic and lead levels were repeatedly over the screening levels. Contact your local health department to discuss arsenic and lead results and ways to reduce your exposure to these chemicals.

[19] There is no way to determine the number of individuals that may be exposed to arsenic or lead from private drinking water wells. There are no laws in Michigan requiring testing of all residential drinking water wells. Because of this, reviewing health outcome data, such as information from national disease tracking systems, would not be useful for this exposure.

Public Health Action Plan

Local (Calhoun County Health Department and Kalamazoo County's Health and Community Services Department) and state agencies (MDEQ and MDCH) will continue to follow the Drinking Water Well Sampling Program and review results from the sampling.

- Local health departments and property owners receive letters with the results of each sampling. Local and state agencies will answer questions regarding the drinking water sampling results.
- Local health departments have addressed the residential wells with arsenic and lead levels over the screening levels in their pre-existing programs.

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: Figures from drinking water sampling results

Drinking water wells have been divided into sections as described in Table A-1. Each section is depicted in the figures in this appendix. The blue line of the figures represents the approximate location of 200 feet beyond the high water mark from the July 2010 flooding. Wells are included in the Drinking Water Well Sampling Program if they are in this boundary.

Table A-1: Wells sampled after the oil spill in the Kalamazoo River (Calhoun and Kalamazoo Counties, Michigan). The number of wells in each section and the locations of those sections (a description and the mile post numbers) are included.

Section	Location	Mile Posts[a]	Number of wells
1	Talmadge Creek near source area to 15 Mile Road at the Kalamazoo River	0.0 to about 2.25	14
2	West of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood	About 2.25 to 3.25[b]	19
3	Approximately a half mile upstream (east) of the Ceresco Dam to just over a half mile downstream (west) of the Ceresco Dam	5.25 to 6.5	30
4	Just over a half mile downstream (west) of the Ceresco Dam to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River	6.5 to 13.25	28
5	About a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River to east of Battle Creek, near 20th Street North at the Kalamazoo River	13.25 to 18.0	32
6	West of Battle Creek, near 20th Street North at the Kalamazoo River to the Calhoun County/Kalamazoo County border	18.0 to the Calhoun/Kalamazoo County border (near 24.0)	37
7	Kalamazoo County (Kalamazoo River west of the Kalamazoo County/Calhoun County border to Morrow Lake)	Calhoun/Kalamazoo County border (near 24.0) through Morrow Lake (39.75)	56

a = Mile post number indicate the number of miles downstream from the entry of the oil spill in Talmadge Creek.
b = No wells are between mile post 3.25 and 5.25.

Figure A-1: The drinking water well sampling area boundary along Talmadge Creek near the source area to 15 Mile Road at the Kalamazoo River (Section 1) for drinking water well data, Calhoun County, Michigan.

Figure A-2: The drinking water well sampling area boundary west of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood (Section 2) for drinking water well data, Calhoun County, Michigan.

Figure A-3: The drinking water well sampling area boundary from approximately a half mile upstream (east) of the Ceresco Dam to just over a half mile downstream (west) of the Ceresco Dam (Section 3) for drinking water well data, Calhoun County, Michigan.

Figure A-4: The drinking water well sampling area boundary from just over a half mile downstream (west) of the Ceresco Dam to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River (Section 4) for drinking water well data, Calhoun County, Michigan.

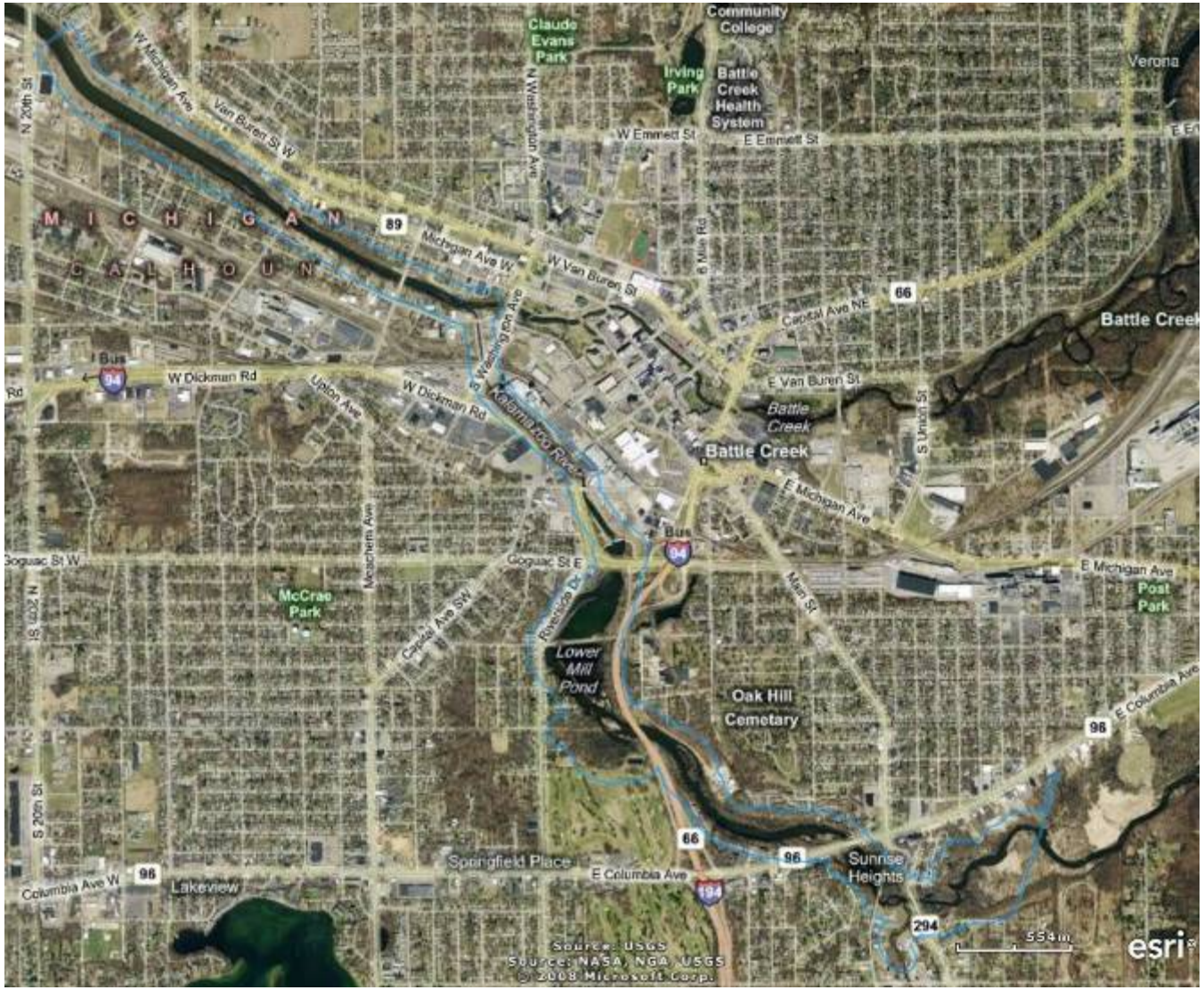

Figure A-5: The drinking water well sampling area boundary from about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River to east of Battle Creek, near 20th Street North at the Kalamazoo River (Section 5) for drinking water well data, Calhoun County, Michigan.

Figure A-6: The drinking water well sampling area boundary west of Battle Creek, near 20th Street North at the Kalamazoo River to the Calhoun County/Kalamazoo County border (Section 6) for drinking water well data, Calhoun County, Michigan.

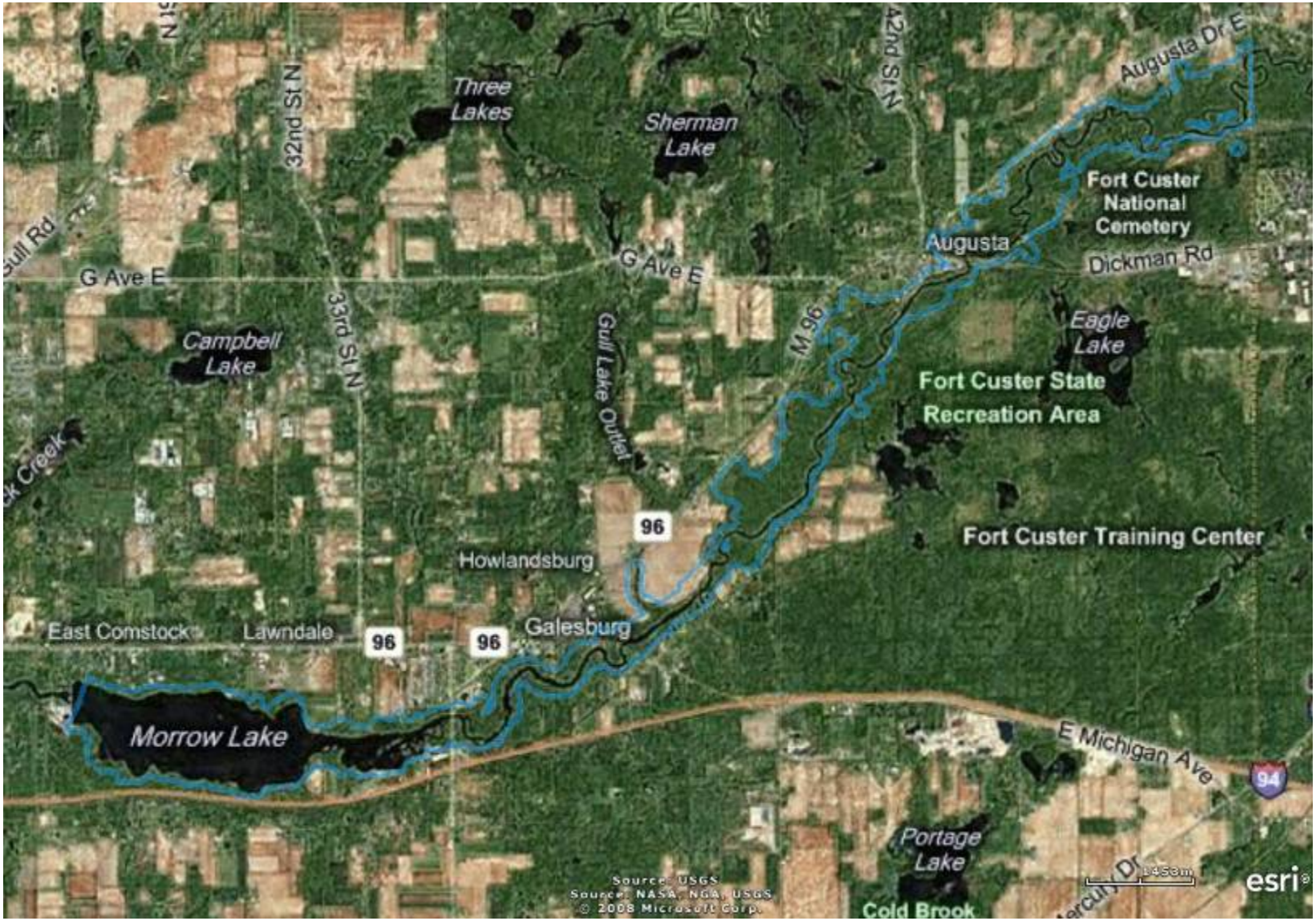

Figure A-7: The drinking water well sampling area boundary for Kalamazoo County (Kalamazoo River west of the Kalamazoo County/Calhoun County border to Morrow Lake) (Section 7) for drinking water well data, Kalamazoo County, Michigan.

Appendix B: Expanded drinking water well sampling results from wells along Talmadge Creek and the Kalamazoo River

Results from the drinking water samples were compared to drinking water screening levels. All drinking water screening levels are protective for a lifetime of exposure to the chemical. Screening levels were from the following sources:

- First selected were the Michigan Department of Environmental Quality's Part 201 Generic Residential Drinking Water Criteria[20] (RDWC) (MDEQ 2011a). In some cases the RDWC were set based on aesthetic issues, such as taste or color of the water. Health-based RDWC were used instead of the aesthetic values (MDEQ 2011b).
- If RDWC were unavailable, the MDEQ's Rule 57 human drinking water value (MDEQ 2011c) was selected.
- If none of the above were available, the EPA's drinking water lifetime health advisory (EPA 2011a) was selected.

If the chemicals were not detected in the sample, the lowest and highest values were the range of reporting limits (also called detection limits). Different laboratories and different methods were used for the samples and, for some chemicals, the reporting limits varied. Several of the organic chemicals had reporting limits over the screening levels. These chemicals are discussed at the end of the appendix.

Chemicals that were detected were noted in the tables. It was also noted if the number of exceedences (number of samples that had chemical levels over a particular screening level) were for chemicals that were not detected. This means that the reporting levels were over the screening levels.

Section 1 –Talmadge Creek near source area to 15 Mile Road at the Kalamazoo River

Table B-1: Inorganic chemicals (in milligrams per liter [mg/L]) analyzed in samples collected between July 2010 and February 2011 from 14 wells located between the oil spill source area next to Talmadge Creek and 15 Mile Road (Section 1), Marshall, Michigan (Calhoun County).

Inorganic chemical	Screening level (mg/L)[a]	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Aluminum	0.05	0.005	0.009	0	12
Antimony	0.006	0.001	0.005	0	48
Arsenic[b]	0.01	0.002	**0.015**	9 (2 wells)	48
Barium	2	0.005	0.45	0	48
Beryllium	0.004	0.000079	0.001	0	76
Cadmium[b]	0.005	0.0005	0.0005	0	48
Chromium[b]	0.1	0.001	0.005	0	48
Cobalt[b]	0.04	0.005	0.005	0	48
Copper	1	0.001	0.022	0	48
Iron[b]	2.0[c]	0.016	**7**	18 (4 wells)	76

[20] The RDWC are the EPA Maximum Contaminant Level (MCL), if one is available. Chemical levels must be lower than the MCL in publicly supplied drinking water.

Table B-1 continued					
Inorganic chemical	Screening level (mg/L)[a]	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Lead	0.004	0.001	0.004	0	48
Manganese	0.86 [c]	0.005	0.739	0	48
Mercury	0.002	0.0001	0.0002	0	77
Molybdenum	0.073	0.00026	0.005	0	64
Nickel	0.1	0.00016	0.005	0	75
Selenium[b]	0.05	0.001	0.005	0	48
Silver[b]	0.034	0.0005	0.0005	0	48
Thallium[b]	0.002	0.0004	0.001	0	48
Titanium	NA[d]	0.00023	0.02	NA	28
Vanadium	0.0045	0.00017	0.004	0	76
Zinc	2.4	0.005	0.16	0	48

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = The chemical was detected in at least one sample.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Table B-2: Organic chemicals (in micrograms per liter [µg/L]) analyzed in samples collected between July 2010 and February 2011 from 14 wells located between the oil spill source area next to Talmadge Creek and 15 Mile Road (Section 1), Marshall, Michigan (Calhoun County).

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
1,1,1,2-Tetrachloroethane	77	0.5	0.5	0	48
1,1,1-Trichloroethane	200	0.5	0.5	0	48
1,1,2,2-Tetrachloroethane	8.5	0.5	0.5	0	48
1,1,2-Trichloroethane	5	0.5	0.5	0	48
1,1-Dichloroethane	880	0.5	0.5	0	48
1,1-Dichloroethene	7	0.5	0.5	0	48
1,1-Dichloropropene	NA[b]	0.5	0.5	NA	48
1,2,3-Trichlorobenzene	55[c]	0.5	0.5	0	48
1,2,3-Trichloropropane	42	0.5	0.5	0	48
1,2,3-Trimethylbenzene	290 [c]	0.5	0.5	0	28
1,2,4-Trichlorobenzene	70	0.5	0.5	0	48
1,2,4-Trimethylbenzene	63	0.5	0.5	0	76
1,2-Dibromoethane	5	0.5	0.5	0	48
1,2-Dichlorobenzene	600	0.5	0.5	0	48
1,2-Dichloroethane	5	0.5	0.5	0	48
1,2-Dichloropropane	5	0.5	0.5	0	48
1,3,5-Trimethylbenzene	72	0.5	0.5	0	76
1,3-Dichlorobenzene	6.6	0.5	0.5	0	48
1,3-Dichloropropane	NA	0.5	0.5	NA	48
1,4-Dichlorobenzene	75	0.5	0.5	0	48

Table B-2 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
2,2-Dichloropropane	NA	0.5	0.5	NA	48
2-Chlorotoluene	150	0.5	0.5	0	48
2-Methylnaphthalene	260	0.5	0.5	0	28
4-Chlorotoluene	100[d]	0.5	0.5	0	48
Alachlor	2	0.19	0.22	0	48
Aldrin[e]	0.098	0.071	**0.22**	47[f]	48
Atrazine	3	0.19	0.22	0	48
Benzene	5	0.5	0.5	0	76
Benzo[a]pyrene	5	0.19	0.22	0	48
Bis(2-ethylhexyl)phthalate[e]	6	0.5	3.1	0	48
Bromobenzene	18	0.5	0.5	0	48
Bromochloromethane	1,000[c]	0.5	0.5	0	48
Bromodichloromethane	80	0.5	0.5	0	48
Bromoform	80	0.5	0.5	0	48
Bromomethane	10	0.5	0.5	0	48
Butachlor	NA	0.2	0.54	NA	48
Carbon tetrachloride	5	0.5	0.5	0	48
Chlordane (technical)	2	0.24	0.26	0	35
Chlorobenzene	100	0.5	0.5	0	48
Chloroethane	430	0.5	0.5	0	48
Chloroform	80	0.5	0.5	0	48
Chloromethane	260	0.5	0.5	0	48
cis-1,2-Dichloroethene	70	0.5	0.5	0	48
cis-1,3-Dichloropropene	3.3[c]	0.5	0.5	0	48
Cyclohexane	NA	0.5	1	NA	28
Di(2-ethylhexyl) adipate	400	0.2	1.6	0	48
Dibromochloromethane	80	0.5	0.5	0	48
Dibromomethane	80	0.5	0.5	0	48
Dichlorodifluoromethane	1700	0.5	0.5	0	48
Dieldrin[e]	0.11	0.051	**0.54**	46[f]	48
DRO (C10-C20)	NA	100	100	NA	54
Endrin	2	0.2	0.54	0	48
Ethylbenzene	74	0.5	0.5	0	76
gamma-BHC (Lindane)	0.2	0.19	**0.22**	5[f]	48
GRO (C6-C10)	NA	100	200	NA	55
Heptachlor	0.4	0.19	0.22	0	48
Heptachlor epoxide[e]	0.2	0.2	**0.69**	36[g]	48
Hexachlorobenzene	1	0.19	0.22	0	48
Hexachlorobutadiene	15	0.5	0.5	0	48
Hexachlorocyclopentadiene	50	0.2	2.2	0	48
Isopropylbenzene	800	0.5	0.5	0	76
m,p-Xylenes	280	1	1	0	76
Methoxychlor	40	0.2	0.54	0	48
Methylene chloride	5	0.5	0.5	0	48
Metolachlor[e]	240	0.025	0.22	0	48

Table B-2 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
Metribuzin	180	0.19	0.22	0	48
Naphthalene	520	0.5	0.5	0	76
n-Butylbenzene	80	0.5	0.5	0	48
n-Propylbenzene	80	0.5	0.5	0	76
ORO (C20-C34)	NA	100	100	NA	53
o-Xylene	280	0.5	0.5	0	48
PCB, Total	0.5	0.47	**0.52**	2[f]	47
PCB-1016	NA	0.47	0.52	NA	35
PCB-1221	NA	0.47	0.52	NA	35
PCB-1232	NA	0.47	0.52	NA	35
PCB-1242	NA	0.47	0.52	NA	35
PCB-1248	NA	0.47	0.52	NA	35
PCB-1254	NA	0.47	0.52	NA	35
PCB-1260	NA	0.47	0.52	NA	35
Phenanthrene	52	0.19	0.22	0	27
p-Isopropyltoluene	NA	0.5	0.5	NA	76
Propachlor	95	0.19	0.22	0	48
sec-Butylbenzene	80	0.5	0.5	0	76
Simazine	4	0.2	0.54	0	48
Styrene[e]	100	0.2	0.5	0	48
tert-Butylbenzene	80	0.5	0.5	0	48
Tetrachloroethene	5	0.5	0.5	0	48
Toluene	790	0.5	0.5	0	76
Toxaphene	3	2.4	2.6	0	35
trans-1,2-Dichloroethene	100	0.5	0.5	0	48
trans-1,3-Dichloropropene	3.3[c]	0.5	0.5	0	48
Trichloroethene	5	0.5	0.5	0	48
Trichlorofluoromethane	2,600	0.5	0.5	0	48
Vinyl chloride	2	0.5	0.5	0	48

Bold values are those over the screening level.
BHC = Benzene hexachloride
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
PCB = Polychlorinated biphenyl
a = Screening levels are the Michigan Department of Environmental Quality (MDEQ) Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = No screening level was available (NA = not available).
c = The screening level is the MDEQ's Rule 57 human health value (MDEQ 2011c).
d = The screening level is the EPA's drinking water lifetime health advisory (EPA 2011a).
e = The chemical was detected in at least one sample.
f = None of the values over the screening level were detections. Check for a footnote next to the chemical name to determine if the chemical was detected in any sample.
g = Of the 36 results only two were detections. The two detections were from two different wells. Other samples from those wells did not detect heptachlor epoxide.

Section 2 – West of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood (Mile Post 3.25)

Table B-3: Inorganic chemicals (in milligrams per liter [mg/L]) analyzed in samples collected between July 2010 and February 2011 from 19 wells located west of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood (Section 2), Marshall, Michigan (Calhoun County).

Inorganic chemical[a]	Screening level[b] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Aluminum	0.05	0.005	0.012	0	20
Antimony	0.006	0.00018	0.005	0	74
Arsenic	0.01	0.0013	0.007	0	74
Barium	2	0.00019	0.291	0	74
Beryllium	0.004	0.000033	0.001	0	123
Cadmium	0.005	0.00002	0.0005	0	74
Calcium	NA[c]	76	76	NA	1
Chromium	0.1	0.000063	0.005	0	74
Cobalt	0.04	0.000028	0.005	0	74
Copper	1	0.00099	0.18	0	74
Iron	2.0[d]	0.011	**3.65**	9 (3 wells)	123
Lead	0.004	0.000078	**0.015**	5 (4 wells)	74
Magnesium	400	21	21	0	1
Manganese	0.86[d]	0.0003	0.108	0	74
Mercury	0.002	0.0001	0.00024	0	123
Molybdenum	0.073	0.00048	0.005	0	103
Nickel	0.1	0.00015	0.031	0	123
Selenium	0.05	0.00063	0.005	0	74
Silver	0.034	0.00002	0.0005	0	74
Thallium	0.002	0.00012	0.001	0	74
Titanium	NA	0.0007	0.02	NA	49
Vanadium	0.0045	0.0007	0.004	0	123
Zinc	2.4	0.0013	0.521	0	74

Bold values are those over the screening level.
a = All chemicals were detected in at least one sample.
b = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
c = No screening level was available (NA = not available).
d = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.

Table B-4: Organic chemicals (in micrograms per liter [µg/L]) analyzed in samples collected between July 2010 and February 2011 from 19 wells located west of 15 Mile Road at the Kalamazoo River to the Squaw Creek neighborhood (Section 2), Marshall, Michigan (Calhoun County).

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
1,1,1,2-Tetrachloroethane	77	0.5	0.5	0	74
1,1,1-Trichloroethane	200	0.5	0.5	0	74
1,1,2,2-Tetrachloroethane	8.5	0.5	0.5	0	74
1,1,2-Trichloroethane	5	0.5	0.5	0	74
1,1-Dichloroethane	880	0.5	0.5	0	74
1,1-Dichloroethene	7	0.5	0.5	0	74
1,1-Dichloropropene	NA[b]	0.5	0.5	NA	74
1,2,3-Trichlorobenzene	55[c]	0.5	1	0	74
1,2,3-Trichloropropane	42	0.5	1	0	74
1,2,3-Trimethylbenzene	290[c]	0.5	0.5	0	59
1,2,4-Trichlorobenzene	70	0.5	0.5	0	74
1,2,4-Trimethylbenzene	63	0.5	0.5	0	123
1,2-Dibromoethane	5	0.5	0.5	0	74
1,2-Dichlorobenzene	600	0.5	0.5	0	74
1,2-Dichloroethane	5	0.5	0.5	0	74
1,2-Dichloropropane	5	0.5	0.5	0	74
1,3,5-Trimethylbenzene	72	0.5	0.5	0	123
1,3-Dichlorobenzene	6.6	0.5	0.5	0	74
1,3-Dichloropropane	NA	0.5	0.5	NA	74
1,4-Dichlorobenzene	75	0.5	0.5	0	74
2,2-Dichloropropane	NA	0.5	1	NA	74
2-Chlorotoluene	150	0.5	0.5	0	74
2-Methylnaphthalene	260	0.5	2	0	59
4-Chlorotoluene	100[d]	0.5	0.5	0	74
Alachlor	2	0.19	0.22	0	75
Aldrin	0.098	**0.19**	**0.22**	75[f]	75
Atrazine	3	0.19	0.22	0	75
Benzene	5	0.5	0.5	0	123
Benzo[a]pyrene	5	0.19	0.22	0	75
Bis(2-ethylhexyl)phthalate[e]	6	0.5	**15**	1 (1 well)	75
Bromobenzene	18	0.5	0.5	0	74
Bromochloromethane	1000[c]	0.5	0.5	0	74
Bromodichloromethane	80	0.5	0.5	0	74
Bromoform	80	0.5	0.5	0	74
Bromomethane	10	0.5	1	0	74
Butachlor	NA	0.2	0.55	NA	75
Carbon tetrachloride	5	0.5	0.5	0	74
Chlordane (technical)	2	0.24	0.25	0	54
Chlorobenzene	100	0.5	0.5	0	74
Chloroethane	430	0.5	1	0	74
Chloroform	80	0.5	0.5	0	74
Chloromethane	260	0.5	1	0	74

Table B-4 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
cis-1,2-Dichloroethene	70	0.5	0.5	0	74
cis-1,3-Dichloropropene	3.3[c]	0.5	0.5	0	74
Cyclohexane	NA	0.5	1	NA	59
Di(2-ethylhexyl) adipate	400	0.2	1.6	0	75
Dibromochloromethane	80	0.5	0.5	0	74
Dibromomethane	80	0.5	0.5	0	74
Dichlorodifluoromethane	1700	0.5	1	0	74
Dieldrin	0.11	**0.2**	**0.55**	75[f]	75
DRO (C10-C20)	NA	100	100	NA	78
Endrin	2	0.2	0.55	0	75
Ethylbenzene	74	0.5	0.5	0	123
gamma-BHC (Lindane)	0.2	0.19	**0.22**	9[f]	75
GRO (C6-C10)	NA	200	200	NA	78
Heptachlor	0.4	0.19	0.22	0	75
Heptachlor epoxide	0.2	0.2	**0.44**	55[f]	75
Hexachlorobenzene	1	0.19	0.22	0	75
Hexachlorobutadiene	15	0.5	1	0	74
Hexachlorocyclopentadiene	50	0.2	2.2	0	75
Isopropylbenzene	800	0.5	0.5	0	123
m,p-Xylenes	280	1	1	0	123
Methoxychlor	40	0.2	0.55	0	75
Methylene chloride	5	0.5	1	0	74
Metolachlor	240	0.19	0.22	0	75
Metribuzin	180	0.19	0.22	0	75
Naphthalene	520	0.5	0.5	0	123
n-Butylbenzene	80	0.5	0.5	0	74
n-Propylbenzene	80	0.5	0.5	0	123
ORO (C20-C34)	NA	100	100	NA	77
o-Xylene	280	0.5	0.5	0	123
PCB, Total	0.5	0.47	**0.51**	1[f]	74
PCB-1016	NA	0.47	0.51	NA	54
PCB-1221	NA	0.47	0.51	NA	54
PCB-1232	NA	0.47	0.51	NA	54
PCB-1242	NA	0.47	0.51	NA	54
PCB-1248	NA	0.47	0.51	NA	54
PCB-1254	NA	0.47	0.51	NA	54
PCB-1260[e]	NA	0.065	0.51	NA	54
Phenanthrene	52	0.19	0.22	0	48
p-Isopropyltoluene	NA	0.5	0.5	NA	123
Propachlor	95	0.19	0.22	0	75
sec-Butylbenzene	80	0.5	0.5	0	123
Simazine	4	0.2	0.55	0	75
Styrene	100	0.5	0.5	0	74
tert-Butylbenzene	80	0.5	1	0	74
Tetrachloroethene	5	0.5	0.5	0	74
Toluene	790	0.5	0.5	0	123

Table B-4 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
Toxaphene	3	2.4	2.5	0	54
trans-1,2-Dichloroethene	100	0.5	0.5	0	74
trans-1,3-Dichloropropene	3.3[c]	0.5	0.5	0	74
Trichloroethene[e]	5	0.09	0.5	0	74
Trichlorofluoromethane	2600	0.5	0.5	0	74
Vinyl chloride	2	0.5	1	0	74
Xylenes, Total	280	1	1	0	4

Bold values are those over the screening level.
BHC = Benzene hexachloride
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
PCB = Polychlorinated biphenyl
a = Screening levels are the Michigan Department of Environmental Quality (MDEQ) Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = No screening level was available (NA = not available).
c = The screening level is the MDEQ's Rule 57 human health value (MDEQ 2011c).
d = The screening level is the EPA's drinking water lifetime health advisory (EPA 2011a).
e = The chemical was detected in at least one sample.
f = None of the values over the screening level were detections.

Section 3 – Approximately a half mile upstream (east) of the Ceresco Dam (Mile Post 5.25) to just over a half mile downstream (west) of the Ceresco Dam (Mile Post 6.5)

Table B-5: Inorganic chemicals (in milligrams per liter [mg/L]) analyzed in samples collected between July 2010 and February 2011 from 26 wells located approximately a half mile upstream (east) of the Ceresco Dam to just over a half mile downstream (west) of the Ceresco Dam (Section 3), Ceresco, Michigan (Calhoun County).

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Aluminum	0.05	0.005	0.005	0	19
Antimony[b]	0.006	0.001	0.005	0	88
Arsenic[b]	0.01	0.00053	0.002	0	88
Barium[b]	2	0.001	0.363	0	8
Beryllium[b]	0.004	0.000031	0.0012	0	143
Cadmium	0.005	0.0005	0.0005	0	88
Chromium[b]	0.1	0.00017	0.005	0	88
Cobalt[b]	0.04	0.00029	0.005	0	88
Copper[b]	1	0.001	0.577	0	88
Iron[b]	2.0[c]	0.013	**4.41**	10 (5 wells)	143
Lead[b]	0.004	0.00014	**0.035**	6 (3 wells)	88
Manganese[b]	0.86[c]	0.005	0.258	0	88
Mercury[b]	0.002	0.000092	0.0002	0	143
Molybdenum[b]	0.073	0.00011	0.005	0	124
Nickel[b]	0.1	0.00013	0.05	0	143

Table B-5 continued					
Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Selenium[b]	0.05	0.0008	0.005	0	88
Silver[b]	0.034	0.000016	0.0005	0	88
Thallium	0.002	0.0004	0.001	0	88
Titanium[b]	NA[d]	0.0006	0.02	NA	55
Vanadium[b]	0.0045	0.00012	0.004	0	143
Zinc[b]	2.4	0.0021	0.73	0	88

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = The chemical was detected in at least one sample.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Table B-6: Organic chemicals (in micrograms per liter [µg/L]) analyzed in samples collected between July 2010 and February 2011 from 30 wells located approximately a half mile upstream (east) of the Ceresco Dam to just over a half mile downstream (west) of the Ceresco Dam (Section 3), Ceresco, Michigan (Calhoun County).

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
1,1,1,2-Tetrachloroethane	77	0.5	0.5	0	88
1,1,1-Trichloroethane	200	0.5	0.5	0	88
1,1,2,2-Tetrachloroethane	8.5	0.5	0.5	0	88
1,1,2-Trichloroethane	5	0.5	0.5	0	88
1,1-Dichloroethane[b]	880	0.08	0.5	0	88
1,1-Dichloroethene	7	0.5	0.5	0	88
1,1-Dichloropropene	NA[c]	0.5	0.5	NA	88
1,2,3-Trichlorobenzene	55[d]	0.5	1	0	88
1,2,3-Trichloropropane	42	0.5	1	0	88
1,2,3-Trimethylbenzene	290[d]	0.5	0.5	0	60
1,2,4-Trichlorobenzene	70	0.5	0.5	0	179
1,2,4-Trimethylbenzene	63	0.5	0.5	0	52
1,2-Dibromoethane	5	0.5	0.5	0	88
1,2-Dichlorobenzene	600	0.5	0.5	0	88
1,2-Dichloroethane	5	0.5	0.5	0	88
1,2-Dichloropropane	5	0.5	0.5	0	88
1,3,5-Trimethylbenzene	72	0.5	0.5	0	143
1,3-Dichlorobenzene	6.6	0.5	0.5	0	88
1,3-Dichloropropane	NA	0.5	0.5	NA	88
1,4-Dichlorobenzene	75	0.5	0.5	0	88
2,2-Dichloropropane	NA	0.5	1	NA	88
2-Chlorotoluene[b]	150	0.2	0.5	0	88
2-Methylnaphthalene	260	0.5	2	0	60
4-Chlorotoluene[b]	100[e]	0.1	0.5	0	88
Alachlor	2	0.19	0.22	0	88

Table B-6 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
Aldrin	0.098	**0.19**	**0.22**	88[f]	88
Atrazine	3	0.19	0.22	0	88
Benzene	5	0.5	0.5	0	143
Benzo[a]pyrene	5	0.19	0.22	0	88
Bis(2-ethylhexyl)phthalate[b]	6	0.5	5.6	0	88
Bromobenzene	18	0.5	0.5	0	88
Bromochloromethane	1000[d]	0.5	0.5	0	88
Bromodichloromethane[b]	80	0.1	8.1	0	88
Bromoform[b]	80	0.2	1	0	88
Bromomethane	10	0.5	1	0	88
Butachlor	NA	0.2	0.55	NA	88
Carbon tetrachloride[b]	5	0.1	0.5	0	88
Chlordane (technical)	2	0.24	0.25	0	69
Chlorobenzene	100	0.5	0.5	0	88
Chloroethane	430	0.5	1	0	88
Chloroform[b]	80	0.05	40.7	0	88
Chloromethane[b]	260	0.2	1	0	88
cis-1,2-Dichloroethene	70	0.5	0.5	0	88
cis-1,3-Dichloropropene	3.3[d]	0.5	0.5	0	88
Cyclohexane	NA	0.5	1	NA	60
Di(2-ethylhexyl) adipate[b]	400	0.2	1.6	0	88
Dibromochloromethane[b]	80	0.4	1.9	0	88
Dibromomethane	80	0.5	0.5	0	88
Dichlorodifluoromethane[b]	1700	0.5	1	0	88
Dieldrin	0.11	**0.2**	**0.55**	88[f]	88
DRO (C10-C20)	NA	100	100	NA	94
Endrin	2	0.2	0.55	0	88
Ethylbenzene[b]	74	0.2	0.5	0	143
gamma-BHC (Lindane)	0.2	0.19	**0.22**	11[f]	88
GRO (C6-C10)	NA	200	200	NA	94
Heptachlor	0.4	0.19	0.22	0	88
Heptachlor epoxide	0.2	0.2	**0.44**	69[f]	88
Hexachlorobenzene	1	0.19	0.22	0	88
Hexachlorobutadiene	15	0.5	1	0	88
Hexachlorocyclopentadiene	50	0.2	2.2	0	88
Isopropylbenzene	800	0.5	0.5	0	143
m,p-Xylenes	280	1	1	0	143
Methoxychlor	40	0.2	0.55	0	88
Methylene chloride	5	0.5	1	0	88
Metolachlor	240	0.19	0.22	0	88
Metribuzin	180	0.19	0.22	0	88
Naphthalene	520	0.5	0.5	0	143
n-Butylbenzene	80	0.5	0.5	0	88
n-Propylbenzene	80	0.5	0.5	0	143
ORO (C20-C34)	NA	100	100	NA	94

Table B-6 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
o-Xylene	280	0.5	0.5	0	143
PCB, Total	0.5	0.47	0.5	0	88
PCB-1016	NA	0.47	0.5	NA	69
PCB-1221	NA	0.47	0.5	NA	69
PCB-1232	NA	0.47	0.5	NA	69
PCB-1242	NA	0.47	0.5	NA	69
PCB-1248	NA	0.47	0.5	NA	69
PCB-1254	NA	0.47	0.5	NA	69
PCB-1260	NA	0.47	0.5	NA	69
Phenanthrene	52	0.19	0.22	0	55
p-Isopropyltoluene	NA	0.5	0.5	NA	143
Propachlor	95	0.19	0.22	0	88
sec-Butylbenzene	80	0.5	0.5	0	143
Simazine	4	0.2	0.55	0	88
Styrene[b]	100	0.5	0.9	0	88
tert-Butylbenzene	80	0.5	1	0	88
Tetrachloroethene	5	0.5	0.5	0	88
Toluene[b]	790	0.5	13.8	0	143
Toxaphene	3	2.4	2.5	0	69
trans-1,2-Dichloroethene	100	0.5	0.5	0	88
trans-1,3-Dichloropropene	3.3[d]	0.5	0.5	0	88
Trichloroethene	5	0.5	0.5	0	88
Trichlorofluoromethane	2600	0.5	0.5	0	88
Vinyl chloride	2	0.5	1	0	88
Xylenes, Total	280	1	1	0	3

Bold values are those over the screening level.
BHC = Benzene hexachloride
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
PCB = Polychlorinated biphenyl
a = Screening levels are the Michigan Department of Environmental Quality (MDEQ) Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = The chemical was detected in at least one sample.
c = No screening level was available (NA = not available).
d = The screening level is the MDEQ's Rule 57 human health value (MDEQ 2011c).
e = The screening level is the EPA's drinking water lifetime health advisory (EPA 2011a).
f = None of the values over the screening level were detections.

Section 4 – Just over a half mile downstream (west) of the Ceresco Dam (Mile Post 6.5) to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River (Mile Post 13.25)

Table B-7: Inorganic chemicals (in milligrams per liter [mg/L]) analyzed in samples collected between July 2010 and February 2011 from 24 wells located just over a half mile downstream (west) of the Ceresco Dam to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River (Section 4), between Ceresco and Battle Creek, Michigan (Calhoun County).

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Aluminum	0.05	0.005	0.005	0	22
Antimony[b]	0.006	0.00054	**0.0073**	1 (1 well)	83
Arsenic[b]	0.01	0.00037	**0.015**	3 (1 well)	83
Barium[b]	2	0.041	0.294	0	83
Beryllium[b]	0.004	0.000054	0.001	0	100
Cadmium[b]	0.005	0.00004	0.0018	0	83
Calcium[b]	NA[c]	68	86	NA	3
Chromium[b]	0.1	0.000053	0.005	0	83
Cobalt[b]	0.04	0.00015	0.005	0	83
Copper[b]	1	0.00051	0.554	0	83
Iron[b]	2.0[d]	0.0085	**3.7**	4 (3 wells)	100
Lead[b]	0.004	0.000076	**0.089**	5 (4 wells)	83
Magnesium[b]	400	18	20	0	3
Manganese[b]	0.86[d]	0.005	0.278	0	83
Mercury	0.002	0.0001	0.0002	0	100
Molybdenum[b]	0.073	0.00026	0.005	0	78
Nickel[b]	0.1	0.00015	0.056	0	100
Selenium[b]	0.05	0.00076	0.005	0	83
Silver[b]	0.034	0.000019	0.0005	0	83
Thallium[b]	0.002	0.00013	0.001	0	83
Titanium[b]	NA	0.001	0.02	NA	17
Vanadium[b]	0.0045	0.00014	0.004	0	100
Zinc[b]	2.4	0.0016	0.567	0	83

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = The chemical was detected in at least one sample.
c = No screening level was available (NA = not available).
d = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.

A sole drinking water sample was analyzed for 1,2-dibromo-3-chloropropane, 2-butanone, 2-hexanone, 4-methyl-2-pentanone, acetone, acrylonitrile, carbon disulfide, diethyl ether, ethyl methacrylate, hexachloroethane, methyl iodide, methyl tert-butyl ether, tetrahydrofuran, and trans-1,4-dichloro-2-butene. None of these chemicals were detected in the sample.

Table B-8: Organic chemicals (in micrograms per liter [µg/L]) analyzed in samples collected between July 2010 and February 2011 from 28 wells located just over a half mile downstream (west) of the Ceresco Dam to about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River (Section 4), between Ceresco and Battle Creek, Michigan (Calhoun County).

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
1,1,1,2-Tetrachloroethane	77	0.5	0.5	0	83
1,1,1-Trichloroethane	200	0.5	0.5	0	83
1,1,2,2-Tetrachloroethane	8.5	0.5	0.5	0	83
1,1,2-Trichloroethane	5	0.5	0.5	0	83
1,1-Dichloroethane	880	0.5	0.5	0	83
1,1-Dichloroethene	7	0.5	0.5	0	83
1,1-Dichloropropene	NA[b]	0.5	0.5	NA	83
1,2,3-Trichlorobenzene	55[c]	0.5	1	0	83
1,2,3-Trichloropropane	42	0.5	1	0	83
1,2,3-Trimethylbenzene	290[c]	0.5	0.5	0	33
1,2,4-Trichlorobenzene	70	0.5	0.5	0	83
1,2,4-Trimethylbenzene	63	0.5	0.5	0	100
1,2-Dibromoethane	5	0.5	0.5	0	83
1,2-Dichlorobenzene	600	0.5	0.5	0	83
1,2-Dichloroethane	5	0.5	0.5	0	83
1,2-Dichloropropane	5	0.5	0.5	0	83
1,3,5-Trimethylbenzene	72	0.5	0.5	0	100
1,3-Dichlorobenzene	6.6	0.5	0.5	0	83
1,3-Dichloropropane	NA	0.5	0.5	NA	83
1,4-Dichlorobenzene	75	0.5	0.5	0	83
2,2-Dichloropropane	NA	0.5	1	NA	83
2-Chlorotoluene	150	0.5	0.5	0	83
2-Methylnaphthalene	260	0.5	2	0	33
4-Chlorotoluene	100[d]	0.5	0.5	0	83
Alachlor	2	0.1	0.22	0	83
Aldrin	0.098	**0.1**	**0.22**	83[f]	83
Atrazine	3	0.1	0.22	0	83
Benzene	5	0.5	0.5	0	100
Benzo[a]pyrene	5	0.02	0.22	0	83
Bis(2-ethylhexyl)phthalate[e]	6	0.5	3.9	0	83
Bromobenzene	18	0.5	0.5	0	83
Bromochloromethane	1000[c]	0.5	0.5	0	83
Bromodichloromethane	80	0.5	0.5	0	83
Bromoform	80	0.5	0.5	0	83
Bromomethane	10	0.5	1	0	83
Butachlor	NA	0.1	0.54	NA	83
Carbon tetrachloride	5	0.5	0.5	0	83
Chlordane (technical)	2	0.1	0.25	0	59
Chlorobenzene	100	0.5	0.5	0	83
Chloroethane	430	0.5	1	0	83
Chloroform	80	0.5	0.5	0	83

Table B-8 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
Chloromethane[e]	260	0.2	1	0	83
cis-1,2-Dichloroethene	70	0.5	0.5	0	83
cis-1,3-Dichloropropene	3.3[c]	0.5	0.5	0	83
Cyclohexane	NA	0.5	1	NA	33
Di(2-ethylhexyl) adipate[e]	400	0.2	1.6	0	83
Dibromochloromethane	80	0.5	0.5	0	83
Dibromomethane	80	0.5	0.5	0	83
Dichlorodifluoromethane	1700	0.5	1	0	83
Dieldrin	0.11	0.1	**0.54**	82[f]	83
DRO (C10-C20)[e]	NA	24	100	NA	89
Endrin	2	0.01	0.54	0	83
Ethylbenzene	74	0.5	0.5	0	100
gamma-BHC (Lindane)	0.2	0.02	**0.22**	8[f]	83
GRO (C6-C10)	NA	100	200	NA	89
Heptachlor	0.4	0.04	0.22	0	83
Heptachlor epoxide	0.2	0.02	**0.43**	58[f]	83
Hexachlorobenzene	1	0.1	0.22	0	83
Hexachlorobutadiene	15	0.5	1	0	83
Hexachlorocyclopentadiene	50	0.1	2.2	0	83
Isopropylbenzene	800	0.5	0.5	0	100
m,p-Xylene	280	1	1	0	100
Methoxychlor	40	0.0002	0.54	0	83
Methylene chloride	5	0.5	1	0	83
Metolachlor	240	0.1	0.22	0	83
Metribuzin	180	0.1	0.22	0	83
Naphthalene[e]	520	0.1	0.5	0	100
n-Butylbenzene	80	0.5	0.5	0	83
n-Propylbenzene	80	0.5	0.5	0	100
ORO (C20-C34)	NA	100	500	NA	89
o-Xylene	280	0.5	0.5	0	100
PCB, Total	0.5	0.0005	0.5	0	83
PCB-1016	NA	0.08	0.5	NA	59
PCB-1221	NA	0.19	0.5	NA	59
PCB-1232	NA	0.23	0.5	NA	59
PCB-1242	NA	0.26	0.5	NA	59
PCB-1248	NA	0.1	0.5	NA	59
PCB-1254	NA	0.1	0.5	NA	59
PCB-1260	NA	0.2	0.5	NA	59
Phenanthrene	52	0.19	0.22	0	17
p-Isopropyltoluene	NA	0.5	0.5	NA	100
Propachlor	95	0.1	0.22	0	83
sec-Butylbenzene	80	0.5	0.5	0	100
Simazine	4	0.07	0.54	0	83
Styrene	100	0.5	0.5	0	83
tert-Butylbenzene	80	0.5	1	0	83

Table B-8 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
Tetrachloroethene	5	0.5	0.5	0	83
Toluene[e]	790	0.2	2.3	0	100
Toxaphene	3	1	2.5	0	59
trans-1,2-Dichloroethene	100	0.5	0.5	0	83
trans-1,3-Dichloropropene	3.3[c]	0.5	0.5	0	83
Trichloroethene	5	0.5	0.5	0	83
Trichlorofluoromethane	2600	0.5	0.5	0	83
Vinyl chloride	2	0.5	1	0	83
Xylenes, Total	280	1	1	0	4

Bold values are those over the screening level.
BHC = Benzene hexachloride
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
PCB = Polychlorinated biphenyl
a = Screening levels are the Michigan Department of Environmental Quality (MDEQ) Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = No screening level was available (NA = not available).
c = The screening level is the MDEQ's Rule 57 human health value (MDEQ 2011c).
d = The screening level is the EPA's drinking water lifetime health advisory (EPA 2011a).
e = The chemical was detected in at least one sample.
f = None of the values over the screening level were detections.

Section 5 – About a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River (Mile Post 13.25) to east of Battle Creek, near 20th Street North at the Kalamazoo River (Mile Post 18.0)

Table B-9: Inorganic chemicals (in milligrams per liter [mg/L]) analyzed in samples collected between July 2010 and February 2011 from 26 wells located about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River to east of Battle Creek, near 20th Street North at the Kalamazoo River (Section 5), Calhoun County, Michigan.

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Aluminum[b]	0.05	0.005	0.006	0	24
Antimony	0.006	0.001	0.005	0	120
Arsenic[b]	0.01	0.0013	**0.048**	81 (14 wells)	120
Barium[b]	2	0.001	0.356	0	120
Beryllium[b]	0.004	0.000035	0.001	0	189
Cadmium	0.005	0.0005	0.0005	0	120
Chromium[b]	0.1	0.00087	0.007	0	120
Cobalt[b]	0.04	0.00015	0.005	0	120
Copper[b]	1	0.001	0.457	0	120
Iron[b]	2.0[c]	0.012	**6.95**	64 (12 wells)	189
Lead[b]	0.004	0.00032	**0.115**	3 (2 wells)	120
Manganese[b]	0.86[c]	0.005	0.725	0	120
Mercury[b]	0.002	0.0001	0.00034	0	189
Molybdenum[b]	0.073	0.00039	0.005	0	165
Nickel[b]	0.1	0.00014	0.007	0	189
Selenium	0.05	0.001	0.005	0	120
Silver	0.034	0.0005	0.0005	0	120
Thallium	0.002	0.0004	0.001	0	120
Titanium[b]	NA[d]	0.00086	0.02	NA	69
Vanadium[b]	0.0045	0.00016	0.004	0	189
Zinc[b]	2.4	0.003	0.615	0	120

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = The chemical was detected in at least one sample.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Table B-10: Organic chemicals (in micrograms per liter [µg/L]) analyzed in samples collected between July 2010 and February 2011 from 32 wells located about a half mile upstream (east) of Beadle Lake Road at the Kalamazoo River to east of Battle Creek, near 20th Street North at the Kalamazoo River (Section 5), Calhoun County, Michigan.

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
1,1,1,2-Tetrachloroethane	77	0.5	0.5	0	120
1,1,1-Trichloroethane	200	0.5	0.5	0	120
1,1,2,2-Tetrachloroethane	8.5	0.5	0.5	0	120
1,1,2-Trichloroethane	5	0.5	0.5	0	120
1,1-Dichloroethane	880	0.5	0.5	0	120
1,1-Dichloroethene	7	0.5	0.5	0	120
1,1-Dichloropropene	NA[b]	0.5	0.5	NA	120
1,2,3-Trichlorobenzene	55[c]	0.5	1	0	120
1,2,3-Trichloropropane	42	0.5	1	0	120
1,2,3-Trimethylbenzene	290[c]	0.5	0.5	0	71
1,2,4-Trichlorobenzene	70	0.5	0.5	0	120
1,2,4-Trimethylbenzene	63	0.5	0.5	0	189
1,2-Dibromoethane	5	0.5	0.5	0	120
1,2-Dichlorobenzene[d]	600	0.2	0.5	0	120
1,2-Dichloroethane	5	0.5	0.5	0	120
1,2-Dichloropropane	5	0.5	0.5	0	120
1,3,5-Trimethylbenzene	72	0.5	0.5	0	189
1,3-Dichlorobenzene	6.6	0.5	0.5	0	120
1,3-Dichloropropane	NA	0.5	0.5	NA	120
1,4-Dichlorobenzene	75	0.5	0.5	0	120
2,2-Dichloropropane	NA	0.5	1	NA	120
2-Chlorotoluene	150	0.5	0.5	0	120
2-Methylnaphthalene	260	0.5	2	0	71
4-Chlorotoluene	100[e]	0.5	0.5	0	120
Alachlor	2	0.19	0.22	0	120
Aldrin	0.098	**0.19**	**0.22**	120[f]	120
Atrazine	3	0.19	0.22	0	120
Benzene	5	0.5	0.5	0	189
Benzo[a]pyrene	5	0.19	0.22	0	120
Bis(2-ethylhexyl)phthalate[d]	6	0.5	**11**	2 (2 wells)	120
Bromobenzene	18	0.5	0.5	0	120
Bromochloromethane	1000[c]	0.5	0.5	0	120
Bromodichloromethane	80	0.5	0.5	0	120
Bromoform	80	0.5	0.5	0	120
Bromomethane	10	0.5	1	0	120
Butachlor	NA	0.2	0.55	NA	120
Carbon tetrachloride	5	0.5	0.5	0	120
Chlordane (technical)	2	0.24	0.25	0	93
Chlorobenzene	100	0.3	0.5	0	120
Chloroethane[d]	430	0.5	1	0	120
Chloroform[d]	80	0.2	1.5	0	120

Table B-10 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
Chloromethane	260	0.5	1	0	120
cis-1,2-Dichloroethene[d]	70	0.3	0.5	0	120
cis-1,3-Dichloropropene	3.3[c]	0.5	0.5	0	120
Cyclohexane	NA	0.5	1	NA	71
Di(2-ethylhexyl) adipate	400	0.2	1.6	0	120
Dibromochloromethane	80	0.5	0.5	0	120
Dibromomethane	80	0.5	0.5	0	120
Dichlorodifluoromethane	1700	0.5	1	0	120
Dieldrin	0.11	**0.2**	**0.55**	120[f]	120
DRO (C10-C20)	NA	0.1	100	NA	132
Endrin	2	0.2	0.55	0	120
Ethylbenzene	74	0.5	0.6	0	189
gamma-BHC (Lindane)	0.2	0.19	**0.22**	18[f]	120
GRO (C6-C10)	NA	200	200	NA	132
Heptachlor	0.4	0.19	0.22	0	120
Heptachlor epoxide	0.2	0.2	**0.44**	93[f]	120
Hexachlorobenzene	1	0.19	0.22	0	120
Hexachlorobutadiene	15	0.5	1	0	120
Hexachlorocyclopentadiene	50	0.0002	2.2	0	120
Isopropylbenzene	800	0.5	0.5	0	189
m,p-Xylenes[d]	280	0.2	2	0	189
Methoxychlor	40	0.0002	0.55	0	121
Methylene chloride	5	0.5	1	0	120
Metolachlor	240	0.19	0.22	0	120
Metribuzin	180	0.19	0.22	0	120
Naphthalene	520	0.5	0.5	0	189
n-Butylbenzene	80	0.5	0.5	0	120
n-Propylbenzene	80	0.5	0.5	0	189
ORO (C20-C34)	NA	100	100	NA	132
o-Xylene[d]	280	0.5	0.6	0	189
PCB, Total	0.5	0.0005	0.5	0	120
PCB-1016	NA	0.47	0.5	NA	93
PCB-1221	NA	0.47	0.5	NA	93
PCB-1232	NA	0.47	0.5	NA	93
PCB-1242	NA	0.47	0.5	NA	93
PCB-1248	NA	0.47	0.5	NA	93
PCB-1254	NA	0.47	0.5	NA	93
PCB-1260	NA	0.47	0.5	NA	93
Phenanthrene	52	0.19	0.22	0	69
p-Isopropyltoluene	NA	0.5	0.5	NA	189
Propachlor	95	0.19	0.22	0	120
sec-Butylbenzene	80	0.5	0.5	0	189
Simazine	4	0.2	0.55	0	120
Styrene[d]	100	0.2	0.5	0	120
tert-Butylbenzene	80	0.5	1	0	120

Table B-10 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
Tetrachloroethene	5	0.5	0.5	0	120
Toluene[d]	790	0.5	0.9	0	189
Toxaphene	3	2.4	2.5	0	93
trans-1,2-Dichloroethene	100	0.5	0.5	0	120
trans-1,3-Dichloropropene	3.3[c]	0.5	0.5	0	120
Trichloroethene	5	0.5	0.5	0	120
Trichlorofluoromethane	2600	0.5	0.5	0	120
Vinyl chloride[d]	2	0.5	1.6	0	120
Xylenes, Total	280	1	1	0	1

Bold values are those over the screening level.
BHC = Benzene hexachloride
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
PCB = Polychlorinated biphenyl
a = Screening levels are the Michigan Department of Environmental Quality (MDEQ) Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = No screening level was available (NA = not available).
c = The screening level is the MDEQ's Rule 57 human health value (MDEQ 2011c).
d = The chemical was detected in at least one sample.
e = The screening level is the EPA's drinking water lifetime health advisory (EPA 2011a).
f = None of the values over the screening level were detections.

Section 6 – West of Battle Creek, near 20th Street North at the Kalamazoo River (Mile Post 18.0) to the Calhoun County/Kalamazoo County border

Table B-11: Inorganic chemicals (in milligrams per liter [mg/L]) analyzed in samples collected between July 2010 and February 2011 from 30 wells located west of Battle Creek, near 20th Street North at the Kalamazoo River (Mile Post 18.0) to the Calhoun County/Kalamazoo County border (Section 6), Calhoun County, Michigan.

Inorganic chemical[a]	Screening level[b] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Aluminum	0.05	0.005	0.013	0	27
Antimony	0.006	0.00014	0.005	0	119
Arsenic	0.01	0.0006	**0.025**	1 (1 well)	119
Barium	2	0.005	0.499	0	119
Beryllium	0.004	0.00013	0.001	0	169
Cadmium	0.005	0.00013	0.0006	0	119
Chromium	0.1	0.000066	0.005	0	119
Cobalt	0.04	0.0001	0.005	0	119
Copper	1	0.001	0.32	0	119
Iron	2.0[c]	0.01	**7.01**	19 (6 wells)	169
Lead	0.004	0.000096	**0.052**	7 (4 wells)	119
Manganese	0.86[c]	0.00023	0.33	0	119
Mercury	0.002	0.0001	0.0002	0	170

Table B-11 continued					
Inorganic chemical[a]	Screening level[b] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Molybdenum	0.073	0.00037	0.005	0	142
Nickel	0.1	0.00015	0.043	0	169
Selenium	0.05	0.001	0.005	0	119
Silver	0.034	0.00013	0.0005	0	119
Thallium	0.002	0.0004	0.001	0	119
Titanium	NA[d]	0.00081	0.02	NA	50
Vanadium	0.0045	0.00014	0.004	0	169
Zinc	2.4	0.0029	0.792	0	119

Bold values are those over the screening level.
a = All chemicals were detected in at least one sample.
b = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Table B-12: Organic chemicals (in micrograms per liter [µg/L]) analyzed in samples collected between July 2010 and February 2011 from 37 wells located west of Battle Creek, near 20th Street North at the Kalamazoo River (Mile Post 18.0) to the Calhoun County/Kalamazoo County border (Section 6), Calhoun County, Michigan.

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
1,1,1,2-Tetrachloroethane	77	0.5	0.5	0	119
1,1,1-Trichloroethane[b]	200	0.04	0.5	0	119
1,1,2,2-Tetrachloroethane	8.5	0.5	0.5	0	119
1,1,2-Trichloroethane	5	0.5	0.5	0	119
1,1-Dichloroethane[b]	880	0.5	2.5	0	119
1,1-Dichloroethene[b]	7	0.4	0.7	0	119
1,1-Dichloropropene	NA[c]	0.5	0.5	NA	119
1,2,3-Trichlorobenzene	55[d]	0.5	1	0	119
1,2,3-Trichloropropane	42	0.5	1	0	119
1,2,3-Trimethylbenzene	290[d]	0.5	0.5	0	58
1,2,4-Trichlorobenzene	70	0.5	0.5	0	119
1,2,4-Trimethylbenzene	63	0.5	0.5	0	169
1,2-Dibromoethane	5	0.5	0.5	0	119
1,2-Dichlorobenzene	600	0.5	0.5	0	119
1,2-Dichloroethane[b]	5	0.1	0.5	0	119
1,2-Dichloropropane	5	0.5	0.5	0	119
1,3,5-Trimethylbenzene	72	0.5	0.5	0	169
1,3-Dichlorobenzene	6.6	0.5	0.5	0	119
1,3-Dichloropropane	NA	0.5	0.5	NA	119
1,4-Dichlorobenzene	75	0.5	0.5	0	119
2,2-Dichloropropane	NA	0.5	1	NA	119
2-Chlorotoluene	150	0.5	0.5	0	119

Table B-12 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
2-Methylnaphthalene	260	0.5	2	0	58
4-Chlorotoluene	100[e]	0.5	0.5	0	119
Alachlor	2	0.19	0.22	0	118
Aldrin	0.098	**0.19**	**0.22**	118[f]	118
Atrazine	3	0.19	0.22	0	118
Benzene	5	0.5	0.5	0	169
Benzo[a]pyrene[b]	5	0.19	0.3	0	118
Bis(2-ethylhexyl)phthalate[b]	6	0.5	**18**	3 (2 wells)	118
Bromobenzene	18	0.5	0.5	0	119
Bromochloromethane	1000[d]	0.5	0.5	0	119
Bromodichloromethane[b]	80	0.2	0.5	0	119
Bromoform	80	0.5	0.5	0	119
Bromomethane	10	0.5	1	0	119
Butachlor	NA	0.2	0.55	NA	118
Carbon tetrachloride	5	0.5	0.5	0	119
Chlordane (technical)	2	0.24	0.26	0	91
Chlorobenzene	100	0.5	0.5	0	119
Chloroethane	430	0.5	1	0	119
Chloroform[b]	80	0.18	2.2	0	119
Chloromethane	260	0.5	1	0	119
cis-1,2-Dichloroethene[b]	70	0.5	4.5	0	119
cis-1,3-Dichloropropene	3.3[d]	0.5	0.5	0	119
Cyclohexane	NA	0.5	1	NA	58
Di(2-ethylhexyl) adipate[b]	400	0.2	1.6	0	118
Dibromochloromethane[b]	80	0.09	0.5	0	119
Dibromomethane	80	0.5	0.5	0	119
Dichlorodifluoromethane	1700	0.5	1	0	119
Dieldrin	0.11	**0.2**	**0.55**	118[f]	118
DRO (C10-C20)	NA	100	100	NA	141
Endrin	2	0.2	0.55	0	119
Ethylbenzene	74	0.5	0.5	0	169
gamma-BHC (Lindane)	0.2	0.19	**0.22**	8[f]	118
GRO (C6-C10)	NA	200	200	NA	141
Heptachlor	0.4	0.19	0.22	0	118
Heptachlor epoxide	0.2	0.2	**0.44**	91[g]	118
Hexachlorobenzene	1	0.19	0.22	0	118
Hexachlorobutadiene	15	0.5	1	0	119
Hexachlorocyclopentadiene	50	0.0002	2.2	0	118
Isopropylbenzene	800	0.5	0.5	0	169
m,p-Xylenes	280	1	1	0	169
Methoxychlor	40	0.0002	0.55	0	118
Methylene chloride	5	0.5	1	0	119
Metolachlor	240	0.19	0.22	0	118
Metribuzin	180	0.19	0.22	0	118
Naphthalene	520	0.5	0.5	0	169

Table B-12 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
n-Butylbenzene	80	0.5	0.5	0	119
n-Propylbenzene	80	0.5	0.5	0	169
ORO (C20-C34) [b]	NA	100	190	NA	137
o-Xylene	280	0.5	0.5	0	169
PCB, Total	0.5	0.47	**0.51**	1[f]	118
PCB-1016	NA	0.47	0.51	NA	91
PCB-1221	NA	0.47	0.51	NA	91
PCB-1232	NA	0.47	0.51	NA	91
PCB-1242	NA	0.47	0.51	NA	91
PCB-1248	NA	0.47	0.51	NA	91
PCB-1254	NA	0.47	0.51	NA	91
PCB-1260	NA	0.47	0.51	NA	91
Phenanthrene	52	0.19	0.24	0	52
p-Isopropyltoluene	NA	0.5	0.5	NA	169
Propachlor	95	0.19	0.22	0	118
sec-Butylbenzene	80	0.5	0.5	0	169
Simazine	4	0.2	0.55	0	118
Styrene	100	0.5	0.5	0	119
tert-Butylbenzene	80	0.5	1	0	119
Tetrachloroethene	5	0.5	0.5	0	119
Toluene	790	0.5	0.5	0	169
Toxaphene	3	2.4	2.6	0	91
trans-1,2-Dichloroethene	100	0.5	0.5	0	119
trans-1,3-Dichloropropene	3.3[d]	0.5	0.5	0	119
Trichloroethene	5	0.5	0.5	0	119
Trichlorofluoromethane	2600	0.5	0.5	0	119
Vinyl chloride[b]	2	0.5	**3**	2 (1 well)	119
Xylenes, Total	280	1	1	0	2

Bold values are those over the screening level.
BHC = Benzene hexachloride
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
PCB = Polychlorinated biphenyl
a = Screening levels are the Michigan Department of Environmental Quality (MDEQ) Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = The chemical was detected in at least one sample.
c = No screening level was available (NA = not available).
d = The screening level is the MDEQ's Rule 57 human health value (MDEQ 2011c).
e = The screening level is the EPA's drinking water lifetime health advisory (EPA 2011a).
f = None of the values over the screening level were detections.
g = Heptachlor epoxide was not detected, but the reporting levels in samples from 28 wells were above the screening level.

Section 7 – Kalamazoo County (Kalamazoo River west of the Kalamazoo County/Calhoun County border to Morrow Lake)

Table B-13: Inorganic chemicals (in milligrams per liter [mg/L]) analyzed in samples collected between July 2010 and February 2011 from 51 wells located along the Kalamazoo River in Kalamazoo County (Section 7), Michigan.

Inorganic chemical	Screening level[a] (mg/L)	Lowest value (mg/L)	Highest value (mg/L)	Number of exceedences	Number of samples
Aluminum[b]	0.05	0.005	0.013	0	29
Antimony[b]	0.006	0.00014	0.005	0	156
Arsenic[b]	0.01	0.00061	0.009	0	156
Barium[b]	2	0.001	0.291	0	156
Beryllium[b]	0.004	0.000045	0.001	0	242
Cadmium	0.005	0.0005	0.001	0	156
Chromium[b]	0.1	0.000062	0.005	0	156
Cobalt[b]	0.04	0.00013	0.005	0	156
Copper[b]	1	0.00087	0.99	0	156
Iron[b]	2.0[c]	0.008	**6.6**	3 (2 wells)	242
Lead[b]	0.004	0.000076	**0.024**	7 (6 wells)	156
Manganese[b]	0.86[c]	0.005	**2.46**	1 (1 well)	156
Mercury	0.002	0.0001	0.0002	0	243
Molybdenum[b]	0.073	0.00029	0.005	0	213
Nickel[b]	0.1	0.00013	0.014	0	242
Selenium[b]	0.05	0.00081	0.005	0	156
Silver[b]	0.034	0.00002	0.0005	0	156
Thallium[b]	0.002	0.0004	0.001	0	156
Titanium[b]	NA[d]	0.00083	0.02	NA	86
Vanadium[b]	0.0045	0.00014	0.004	0	242
Zinc[b]	2.4	0.005	0.863	0	156

Bold values are those over the screening level.
a = Screening levels are the Michigan Department of Environmental Quality Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = The chemical was detected in at least one sample.
c = Residential health-based drinking water value (MDEQ 2011b). Aesthetic impacts, to the color and taste of the water, can be present.
d = No screening level was available (NA = not available).

Table B-14: Organic chemicals (in micrograms per liter [µg/L]) analyzed in samples collected between July 2010 and February 2011 from 56 wells located along the Kalamazoo River in Kalamazoo County (Section 7), Michigan.

Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
1,1,1,2-Tetrachloroethane	77	0.5	0.5	0	156
1,1,1-Trichloroethane[b]	200	0.07	1.1	0	156
1,1,2,2-Tetrachloroethane	8.5	0.5	0.5	0	156
1,1,2-Trichloroethane	5	0.5	0.5	0	156
1,1-Dichloroethane[b]	880	0.2	0.5	0	156
1,1-Dichloroethene	7	0.5	0.5	0	156
1,1-Dichloropropene	NA[c]	0.5	0.5	NA	156
1,2,3-Trichlorobenzene	55[d]	0.5	1	0	156
1,2,3-Trichloropropane	42	0.5	1	0	156
1,2,3-Trimethylbenzene	290[d]	0.5	0.5	0	92
1,2,4-Trichlorobenzene	70	0.5	0.5	0	156
1,2,4-Trimethylbenzene	63	0.5	0.5	0	242
1,2-Dibromoethane	5	0.5	0.5	0	156
1,2-Dichlorobenzene	600	0.5	0.5	0	156
1,2-Dichloroethane	5	0.5	0.5	0	156
1,2-Dichloropropane	5	0.5	0.5	0	156
1,3,5-Trimethylbenzene	72	0.5	0.5	0	242
1,3-Dichlorobenzene	6.6	0.5	0.5	0	156
1,3-Dichloropropane	NA	0.5	0.5	NA	156
1,4-Dichlorobenzene	75	0.5	0.5	0	156
2,2-Dichloropropane	NA	0.5	1	NA	156
2-Chlorotoluene	150	0.5	0.5	0	156
2-Methylnaphthalene	260	0.5	2	0	92
4-Chlorotoluene	100[e]	0.5	0.5	0	156
Alachlor	2	0.019	0.22	0	156
Aldrin	0.098	0.019	**0.22**	155[f]	156
Atrazine	3	0.019	0.22	0	156
Benzene	5	0.5	0.5	0	242
Benzo[a]pyrene	5	0.019	0.22	0	156
Bis(2-ethylhexyl)phthalate[b]	6	0.19	**18**	2 (1 well)	156
Bromobenzene	18	0.5	0.5	0	156
Bromochloromethane	1000[d]	0.5	0.5	0	156
Bromodichloromethane[b]	80	0.1	0.5	0	156
Bromoform	80	0.4	0.5	0	156
Bromomethane	10	0.5	1	0	156
Butachlor	NA	0.048	0.56	NA	156
Carbon tetrachloride	5	0.5	0.5	0	156
Chlordane (technical)	2	0.24	0.27	0	125
Chlorobenzene	100	0.5	0.5	0	156
Chloroethane	430	0.5	1	0	156
Chloroform[b]	80	0.05	0.5	0	156
Chloromethane	260	0.5	1	0	156
cis-1,2-Dichloroethene	70	0.5	0.5	0	156

Table B-14 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
cis-1,3-Dichloropropene	3.3[d]	0.5	0.5	0	156
Cyclohexane	NA	0.5	1	NA	92
Di(2-ethylhexyl) adipate[b]	400	0.14	1.7	0	156
Dibromochloromethane[b]	80	0.2	0.5	0	156
Dibromomethane	80	0.5	0.5	0	156
Dichlorodifluoromethane	1700	0.5	1	0	156
Dieldrin	0.11	0.048	**0.56**	155[f]	156
DRO (C10-C20)	NA	100	100	NA	166
Endrin	2	0.048	0.56	0	156
Ethylbenzene	74	0.5	0.5	0	242
gamma-BHC (Lindane)	0.2	0.019	**0.22**	18[f]	156
GRO (C6-C10)	NA	200	200	NA	166
Heptachlor	0.4	0.019	0.22	0	156
Heptachlor epoxide	0.2	0.038	**0.44**	124[f]	156
Hexachlorobenzene	1	0.019	0.22	0	156
Hexachlorobutadiene	15	0.5	1	0	156
Hexachlorocyclopentadiene	50	0.0002	2.2	0	156
Isopropylbenzene	800	0.5	0.5	0	242
m,p-Xylenes	280	1	1	0	242
Methoxychlor	40	0.0002	0.56	0	156
Methylene chloride	5	0.5	1	0	156
Metolachlor	240	0.019	0.22	0	156
Metribuzin	180	0.019	0.22	0	156
Naphthalene	520	0.5	0.5	0	242
n-Butylbenzene	80	0.5	0.5	0	156
n-Propylbenzene	80	0.5	0.5	0	242
ORO (C20-C34)	NA	100	100	NA	166
o-Xylene	280	0.5	0.5	0	242
PCB, Total	0.5	0.0005	**0.53**	2[f]	156
PCB-1016	NA	0.47	0.53	NA	125
PCB-1221	NA	0.47	0.53	NA	125
PCB-1232	NA	0.47	0.53	NA	125
PCB-1242	NA	0.47	0.53	NA	125
PCB-1248	NA	0.47	0.53	NA	125
PCB-1254	NA	0.47	0.53	NA	125
PCB-1260	NA	0.47	0.53	NA	125
Phenanthrene[b]	52	0.032	0.21	0	86
p-Isopropyltoluene	NA	0.5	0.5	NA	242
Propachlor	95	0.019	0.22	0	156
sec-Butylbenzene	80	0.5	0.5	0	242
Simazine	4	0.048	0.56	0	156
Styrene	100	0.5	0.5	0	156
tert-Butylbenzene	80	0.5	1	0	156
Tetrachloroethene	5	0.5	0.5	0	156
Toluene	790	0.5	0.5	0	242
Toxaphene	3	2.4	2.7	0	125

Table B-14 continued					
Organic chemical	Screening Level[a] (µg/L)	Lowest value (µg/L)	Highest value (µg/L)	Number of exceedences	Number of samples
trans-1,2-Dichloroethene	100	0.5	0.5	0	156
trans-1,3-Dichloropropene	3.3[d]	0.5	0.5	0	156
Trichloroethene[b]	5	0.2	0.5	0	156
Trichlorofluoromethane	2600	0.5	0.5	0	156
Vinyl chloride	2	0.5	1	0	156
Xylenes, Total	280	1	1	0	4

Bold values are those over the screening level.
BHC = Benzene hexachloride
DRO = Diesel Range Organics
GRO = Gasoline Range Organics
ORO = Oil Range Organics
PCB = Polychlorinated biphenyl
a = Screening levels are the Michigan Department of Environmental Quality (MDEQ) Residential Drinking Water Criteria unless otherwise noted (MDEQ 2011a).
b = The chemical was detected in at least one sample.
c = No screening level was available (NA = not available).
d = The screening level is the MDEQ's Rule 57 human health value (MDEQ 2011c).
e = The screening level is the EPA's drinking water lifetime health advisory (EPA 2011a).
f = None of the values over the screening level were detections.

Organic chemicals with reporting limits above the screening levels[21]

Five chemicals had reporting limits that were over the screening levels in many of the sections. These chemicals were aldrin, dieldrin, gamma-BHC (Lindane), heptachlor epoxide, and total PCBs. The crude oil did not have detectable levels of PCBs, and as the other chemicals listed are pesticides they are not expected to be in the oil. If chemicals are not detected above the reporting limit, the exact concentration of the chemical is unknown. As the chemicals are below the reporting limit and are not expected to be present, the EPA recommends use of one-half of the reporting limit to represent the actual levels of the chemical (EPA 1989). People can contact their local health department to discuss appropriate testing to confirm whether or not these chemicals are present in their drinking water wells.

Aldrin was not detected in any of the samples, although the reporting limit ranged up to 0.22 µg/L. The one-half of the maximum reporting limit for all of the samples was 0.11 µg/L, which was over the screening level of 0.098 µg/L. If adults and children were to drink water with 0.11 µg aldrin/L, they would ingest up to 0.3 µg/day with a highest dose of aldrin that a person would drink being 0.01 µg/kg/day.[22] This dose is below ATSDR's oral chronic MRL of 0.03 µg/kg/day (ATSDR 2002b). People's health would not be harmed by these levels of aldrin.

Dieldrin was not detected in any of the samples, but the maximum reporting limit was 0.56 µg/L. One-half of that reporting limit, 0.28 µg/L, was above the screening level of 0.11 µg/L. If adults

[21] This discussion pertains to data from wells in both Calhoun and Kalamazoo Counties.
[22] Adults drinking 2.7 L of water per day (EPA 2011b) with 0.11 µg aldrin/L would drink 0.3 µg aldrin/day. An 80 kg (EPA 2011b) adult would have a dose of 0.004 µg/kg/day. Children drinking 1 L of water per day (EPA 2008) with 0.11 µg aldrin/L would drink 0.11 µg aldrin/day. A 10 kg (EPA 2008) child would have a dose of 0.01 µg/kg/day.

and children were drinking water with 0.11 µg/L, a person could drink up to 0.8 µg/day. The highest dose of dieldrin that a person would ingest would be 0.03 µg/kg/day.[23] ATSDR's oral chronic MRL for dieldrin is 0.05 mg/kg/day (ATSDR 2002b), which is higher than the highest amount people could ingest. People's health would not be harmed by these levels of dieldrin.

The maximum reporting limit for gamma-BHC (Lindane) was 0.22 µg/L. This chemical was not detected in any of the samples. One-half of the reporting limit, 0.11 µg/L, is below the screening level of 0.2 µg/L. People's health would not be harmed by these levels, if gamma-BHC (Lindane) was present in the water.

Heptachlor epoxide was detected in two samples from two different wells. These wells are over one mile apart. In one of the samples (0.69 µg/L), a duplicate sample collected on the same did not detect heptachlor epoxide (the reporting limit was 0.39 µg/L). In the sample from the other well, heptachlor epoxide was detected at 0.44 µg/L. A sample taken 10 days earlier did not detect heptachlor epoxide (the reporting limit was 0.38 µg/L). If the groundwater for these two drinking water wells has heptachlor epoxide, the levels are close to or below the reporting limits.

The rest of the samples did not have any detections of heptachlor epoxide, but the maximum reporting limit was 0.43 µg/L, which was above the screening level of 0.2 µg/L. One-half of the maximum reporting limit is 0.22 µg/L. Adults and children drinking water with 0.22 µg/L, would drink up to 0.6 µg/day and the highest dose of that people would be exposed to would be 0.02 µg/kg/day.[24] The EPA RfD for heptachlor epoxide is 0.000013 µg/kg/day (EPA 1991b). The RfD is lower than the highest dose of heptachlor epoxide people may be exposed to (0.02 µg/kg/day). Health effects are possible if heptachlor epoxide is detected at these levels in people's water. If people's drinking water well sample results are consistently above the screening level, people may want to consider testing to confirm whether heptachlor epoxide is present or not.

Total PCBs were not detected in any of the samples. The maximum reporting limit was 0.53 µg/L. On-half of that limit was 0.27 µg/L, which is below the screening level of 0.5 µg/L. People's health would not be harmed by these levels if PCBs were present in the water.

[23] Adults drinking 2.7 L of water per day (EPA 2011b) with 0.28 µg dieldrin/L would drink 0.8 µg dieldrin/day. An 80 kg (EPA 2011b) adult would have a dose of 0.009 µg/kg/day. Children drinking 1 L of water per day (EPA 2008) with 0.28 µg dieldrin/L would drink 0.28 µg dieldrin/day. A 10 kg (EPA 2008) child would have a dose of 0.03 µg/kg/day.

[24] Adults drinking 2.7 L of water per day (EPA 2011b) with 0.22 µg heptachlor epoxide/L would drink 0.6 µg heptachlor epoxide/day. An 80 kg (EPA 2011b) adult would have a dose of 0.007 µg/kg/day. Children drinking 1 L of water per day (EPA 2008) with 0.22 µg heptachlor epoxide/L would drink 0.22 µg heptachlor epoxide/day. A 10 kg (EPA 2008) child would have a dose of 0.02 µg/kg/day.