

Health Consultation

BREWER BROTHERS PETROLEUM BULK PLANT

CARDWELL, DUNKLIN COUNTY, MISSOURI

SEPTEMBER 30, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

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Agency for Toxic Substances and Disease Registry

Division of Health Assessment and Consultation

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Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

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

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HEALTH CONSULTATION

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CARDWELL, DUNKLIN COUNTY, MISSOURI

Prepared by:

Missouri Department of Health and Senior Services
Division of Community and Public Health
Section for Disease Control and Environmental Epidemiology
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

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STATEMENT OF ISSUES AND BACKGROUND

Statement of Issues

The Missouri Department of Natural Resources (MDNR) has requested the Missouri Department of Health and Senior Services (DHSS), in conjunction with the federal Agency for Toxic Substances and Disease Registry (ATSDR), to complete a health consultation regarding environmental investigations in Cardwell, Dunklin County, Missouri. This health consultation focuses on residents' exposure to potentially contaminated soil, groundwater, and drinking water within the City of Cardwell.

Background

Cardwell, Missouri, is a small rural town (approximately 790 residents) located in the southwest corner Missouri's boot heel. It is situated among large agricultural fields, mostly used for growing cotton and rice. The landscape changes seasonally from the crop growth and harvest and the aerial application of pesticides and herbicides. At one time, Cardwell was a thriving community; however, it has not continued to grow in recent years. Several commercial businesses located within the city are no longer operating, including three service stations and a petroleum bulk plant.

The City of Cardwell's water is drawn from a deep aquifer well (approximately 1760 feet) and serves the entire town with a system of subsurface water lines. Although it is unknown when the original water system was installed, it is known that it was built with asbestos concrete pipes and lead joints. In 1998, new polyvinyl chloride (PVC) water lines were installed to service the public drinking water system. The lines were installed throughout town, including along the edge of the former Brewer Brothers petroleum bulk plant and along the residential neighborhood defined by Hall, Pool, Brewer, and Mulberry streets. The workmen encountered strong gasoline odors while working in the line trench along the former Brewer Brothers petroleum bulk plant. However, no soil samples were collected at that time and the plastic line was laid into potentially contaminated soil.

MDNR began receiving complaints from Cardwell residents as early as 1996. The residents typically complained that their drinking water had a foul odor, taste, or coloring. Some residents stated that they believed that petroleum contaminated soil was present in town. Others believed that residents of Cardwell experienced unusual health problems due to specific factors that existed in the town.

In 2004, MDNR received complaints from a number of Cardwell residents specifically about the quality of the city's public drinking water. Residents referred to potential petroleum soil contamination within the city and the possibility of it adversely impacting their water. Some residents also stated that at times their water was discolored and had a foul taste and odor. MDNR's Southeast Regional Office (SERO) and the Environmental Services Program (ESP) investigated the complaints and found petroleum contaminated soil and groundwater on the Brewers Brothers property at the intersection of Poole and Decatur streets. A drinking water

sample was collected from a residence across the street from the Brewer Brothers property and analyzed for petroleum products. The sampling results did not show any petroleum related contaminants above detection levels.

MDNR tested the quality of Cardwell's public drinking water several times and found it to be in compliance with all applicable regulations. However, there have been times over the past few years that the City of Cardwell received notices of violation (NOVs) from MDNR concerning their public drinking water system. These NOVs typically cited public drinking water supply system operation deficiencies. The city has had problems maintaining the proper chlorine residual in their system. They have also been cited for incompetent supervision and operation of the system, and for not maintaining a proper schedule for flushing the system. MDNR has provided the city's public drinking water supply operator with technical assistance to resolve the operational problems.

In March 2004, MDNR conducted an expedited site assessment at the former Brewer Brothers Bulk Plant. The assessment identified directional plumes of petroleum in the subsurface and confirmed the presence of free-phase petroleum. The sampling results showed petroleum contamination in the soil and groundwater.

Shifrin & Associates conducted an investigation of the Brewer Brothers Bulk Plant site and, in October 2005, submitted a report of their findings along with a risk assessment to MDNR. The initial risk assessment was based on incomplete data and did not assess the risk posed by petroleum contamination proximate to the PVC water line. In November 2005, MDNR responded to Shifrin & Associates requesting an additional site investigation be completed to define the extent of soil and groundwater contamination. A revised risk assessment will be required thereafter.

MDNR investigated four sites within the town of Cardwell and the Cardwell public water distribution system (figure 1). The four sites are the former Martin Oil Service Station, the former Brewer Brothers Petroleum Bulk Plant, the Rick Watkins Service Station, and Tri-State Delta Chemicals, an agrichemical warehouse. At the four sites, subsurface soil, groundwater, and drinking water samples were taken when possible.

The former Martin Oil Service Station (Martin Oil) is an alleged petroleum bulk plant that may have distributed gasoline, diesel fuel, and kerosene. This business has not operated for at least 20 years.

The former Brewers Brothers Plant is an abandoned former gasoline bulk plant and filling station. Reportedly, there were above-ground gasoline and diesel storage tanks located in the southeast corner of the property. It is unknown if the underground storage tanks are still located on the site, west of the former loading dock/rack. There is still a concrete slab on-site from a building formerly utilized on the site and a one-story office building, the interior of which has been destroyed by fire (1).

The former Watkin's Service Station is a recently operated service station that reportedly had above-ground storage tanks used to hold the gasoline, diesel fuel, and kerosene.

Tri-State Delta Chemicals (TSDC) agrichemical warehouse is an active warehouse that sells and distributes agrichemicals. It is not known how many years this business has been in operation. It has been reported that previous owners of this facility allowed rinsate from the agrichemical containers to be spilled out onto the ground.

Although several contaminants were detected in the sampling results (2), not all were above health-based comparison values. At the former Brewer Brothers Bulk Plant (north of Pool Street), four contaminants found in the subsurface soil samples were above health-based comparison values for residential use (2 – methylnaphthalene, total petroleum hydrocarbons-gasoline related organics (TPH-GRO), 1,2,4 – trimethylbenzene, 1,3,5 – trimethylbenzene) (Table 1).

In the drinking water samples, lead and tetrahydrofuran were detected at levels above health-based comparison values (Table 2). The elevated lead level was found in the first draw sample taken from a residence. This sample was collected immediately upon turning on the tap. Lead was detected at a significantly lower concentration in the second draw (after two minutes) and was non-detect in the third (after six minutes). This indicates that the lead is most likely leaching from the residential plumbing when water sits stagnant in the pipes overnight or for several hours. The elevated levels of tetrahydrofuran were found in the samples collected from two different residences. The tetrahydrofuran was detected in the first draw sample from both of these residences and was non-detect in the second and third draw samples. This also indicated that it could be leaching from the residential plumbing when water sits stagnant in the pipes overnight or for several hours, especially in PVC pipes.

In the groundwater samples, several contaminants (arsenic, benzene, bis (2-Ethylhexyl) phthalate, lead, naphthalene, nitrate + nitrite as N, 1,2,4 – trimethylbenzene, 1,3,5 – trimethylbenzene, o-xylene) were detected at several locations above health-based comparison values (Table 3).

Because of the type of contaminants that were found in the soil and groundwater samples and their tendency to be volatile, DHSS and MDNR were concerned that vapors of these chemicals could be entering residential homes. Contaminated soil can give off gas vapors that can rise through the subsurface soil and enter buildings through cracks in the foundation or sub-floor and potentially cause health problems. Therefore, MDNR decided to conduct soil gas sampling and surface soil sampling to determine if there was a further potential health hazard from contaminated soil.

In May of 2006, MDNR collected additional groundwater, soil, drinking water, and soil gas samples at various locations in Cardwell (3). At the Former Brewer Brothers North site (north of Pool Street), groundwater samples were found to have elevated levels of benzene, total xylenes, bis (2-ethylhexyl) phthalate and total petroleum hydrocarbons (Table 4). The soil samples collected at that site contained 1,2,4-trimethylbenzene, naphthalene and arsenic at elevated levels (Table 5).

Arsenic and lead were detected in the groundwater samples collected at the former Brewer Brothers South site (Table 6). Soil samples were also collected at the Former Brewer Brothers South site. Arsenic and dieldrin were detected but were below comparison levels (Table 7). One surface soil sample collected at the Tri State Delta Chemical site had an elevated level of dieldrin (Table 8). Soil and groundwater samples from the Watkins service station site contained several petroleum related contaminants, see Tables 9 and 10 for a listing of the sample results.

Water samples were collected from several residences in Cardwell. Elevated levels of bromodichloromethane, chloroform, dibromochloromethane and bis (2-ethylhexyl) phthalate were detected in some of these samples (Table 11). The residential drinking water samples were collected as soon as the faucet was turned on (first draw), after the water had been running for three minutes, and again after six minutes. The levels of dibromochloromethane stayed consistent throughout the samples, it was not dependent on draw time.

Two soil gas samples were collected near two residences. When analyzed, several chemicals were detected (see Table 12). Eight contaminants were found at levels that exceeded health based comparison values for residential use.

Dibromochloromethane, chloroform and bromodichloromethane are common byproducts when chlorine is added to water supply systems. The levels detected exceed the US Environmental Protection Agency's Region 9 Preliminary Remediation Goals (PRGs) and ATSDR's Cancer Risk Evaluation Guide (CREG). However, the levels are significantly below EPA's Maximum Contaminant Level (MCL), which is the enforceable standard that is applicable to all public drinking water systems.

Around the same time that the environmental investigations were beginning (September 2005), a Cardwell resident petitioned DHSS' Cancer Inquiry Program to determine if an abnormal rate of cancer cases or deaths exists in Cardwell. In response to the petition, the cancer inquiry program examined the incidence and mortality rates of cancers in Cardwell and their possible relationship to petroleum and crop-dusting chemical concentrations. The final inquiry report concluded that the cancer rate during 1998-2002 and mortality rates during 1996-2004 in Cardwell were not significantly higher than that in Dunklin County and the State of Missouri during the same time period (4). Therefore, no evidence could be found to support the idea that suspected environmental hazards are causing an increase in cancer in Cardwell. Also, a 2003 county-level study showed that the prevalence of behavioral risk factors (smoking, physical inactivity, and lack of cancer screening) among residents in Dunklin County was significantly higher than the prevalence in the State of Missouri (4). The report recommended public health education on cancer control and the reduction of risk behaviors that are associated with cancer. DHSS' cancer inquiry program will continue to monitor the leukemia incidence and mortality in Cardwell.

DISCUSSION

There are many areas within the city of Cardwell where contamination is present. Elevated levels of contaminants were detected in soil, groundwater, and soil gas samples.

Contaminated soil was found within the City of Cardwell at all four sites. Fortunately, at this time, the contamination is not affecting the residents of Cardwell. MDNR and the potentially responsible parties will be evaluating the extent of the contamination.

Because of the nature of the soil contamination and the type of piping, there is concern about the potential for the contamination in the soil to infiltrate the existing public drinking water supply lines. The current pipes are PVC, which could be permeable to contaminants over time. If that were to occur, the residents could potentially receive drinking water that contained petroleum related constituents. To eliminate the potential for infiltration, a permanent solution should be reached. The contaminated soil should be remediated, the lines could be relocated to an area without contamination or could be replaced with impermeable pipes.

The shallow groundwater sampled in the City of Cardwell was found to contain several contaminants, some of which are petroleum related. Contaminants were found at levels that exceeded recommended drinking water levels. This groundwater should not be used for residential consumption. Because the city's public drinking water source is a deep aquifer well and not impacted by the shallow groundwater, residents are not being exposed to contaminated groundwater.

Lead and tetrahydrofuran were detected in the February sampling in first draw samples. This sample is collected right after the faucet is turned on after the water has been sitting in the pipes in the house. The lead and tetrahydrofuran most likely came from the piping inside the residence and is not site related. The next two samples, taken after the water had been running for two and five minutes, did not contain these contaminants at levels of concern. If the tap water is allowed to run for several minutes before using, it will not present a health hazard.

During the May sampling event, more contaminants were detected in the drinking water at levels that exceeded health-based comparison values. Bromodichloromethane, chloroform, and dibromochloromethane were detected at one or more residence. The majority of the detected levels were below the applicable MCLs. A few of the values exceeded ATSDR's Cancer Risk Evaluation Guides for excess cancer risk. The contaminants are common byproducts of the chlorination process. It is likely that these contaminants were present because the city of Cardwell is having problems regulating the chlorine residual in the system.

Because of the type of contaminants, there was concern about the potential for volatilization to occur in the soil (liquid turning into a vapor). Soil gas vapors rise and if the contamination is near the surface, some of it is likely to be released at the surface. Many factors can influence that process, including the type and concentration of contamination, the make-up of the soil, and the presence of uncontaminated water near the surface. Organisms such as bacteria may break down the contaminants, particularly petroleum products, as they approach the surface. This process is called biodegradation. Surface structures, including buildings and pavement, can influence the quantity and rate of vapor movement, by affecting both biodegradation and by creating updrafts that pull the contamination up (5). MDNR collected two soil gas samples in the contaminated area and did find that contaminants had volatilized in the soil. When the extent of the contamination is determined, this possible pathway of human exposure should be evaluated to ensure that residents are not being exposed to vapors.

Pathway Analysis

To determine whether residents of the area have been or are being exposed to contaminants from the Cardwell site, DHSS evaluated the environmental and human components that lead to an exposure pathway. Completed exposure pathways exist when all five elements of a pathway link the contaminant source to a receptor population. Potential exposure pathways exist if at least one of the five elements is missing or uncertain, but could exist. An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present. Completed and potential exposure pathways could have been present in the past, could be present currently, or could be present in the future.

1. **Contaminant source** – contaminated soil and groundwater.
2. **Environmental medium and transport** – contaminated soil and groundwater.
3. **Point of exposure** – soil
4. **Route of exposure** – ingestion and inhalation.
5. **Receptor population** – residents.

Completed Exposure Pathways

Past:

There is no indication that residents were exposed to contaminants in the past. Past water sampling results did not detect contamination in the residents' drinking water samples.

Present:

At this time, the contamination found at the sites in Cardwell is not directly impacting the residents or the residential areas. Although the subsurface soil is contaminated at levels above health-based comparison values for residential land use scenarios, because it is in the subsurface, residents of Cardwell are not being directly exposed to the contamination. In addition, because the city's public drinking water source is a deep aquifer well and not impacted by the contaminated shallow groundwater, residents are not being exposed to contaminated groundwater.

Potential Exposure Pathways:

Because of the type of contaminants, there was concern about the potential for volatilization to occur in the soil (liquid turning into a vapor). Soil gas vapors rise and if the contamination is near the surface, some of it is likely to be released at the surface. When the extent of the contamination is determined, this possible pathway of human exposure should be evaluated to ensure that residents are not being exposed to vapors.

CONCLUSIONS

Because of the potential for penetration of the city's residential drinking water system supply lines by contamination and the lack of information as to the extent of subsurface soil contamination, the City of Cardwell is considered to be an *Indeterminate Health Hazard* for present and future residential exposure. This category applies to sites where information is lacking to support a judgment regarding the level of public health hazard. Sites where exposure to site-related contaminants might have occurred in the past or is still occurring, but the exposures are not likely to cause adverse health. Although the extent of contamination has not been defined, the contamination found at the sites in Cardwell is not directly impacting the residents or the residential areas at this time. The subsurface soil within the City of Cardwell is contaminated at levels above health-based comparison values for residential land use scenarios. Because it is in the subsurface, residents of Cardwell are not being directly exposed to the contamination. However, there could be a small potential for petroleum contamination to infiltrate PVC drinking water supply lines and possibly infiltrate residences from volatilization.

Three first-draw drinking water samples were found to have lead or tetrahydrofuran at levels that are not considered safe for consumption, but do not appear to be contaminant related. This will not be a hazard for residents if they allow their drinking water to run for several minutes before using. Residents could also install home filtration systems that would remove the chemicals from their water. Byproducts of the chlorination process were found in residential drinking water samples at levels that were significantly below EPA's MCLs.

Shallow groundwater within the City of Cardwell is contaminated with petroleum-related products at levels above health-based comparison values for drinking water. However, the drinking water provided by the City of Cardwell is drawn from a deep-well aquifer and has not tested positive for contamination at any time.

RECOMMENDATIONS

1. Residents should avoid the contaminated sites.
2. The contaminated soil should be remediated. If remediation does not occur, public drinking water supply lines should be relocated away from petroleum contaminated soil or replaced with impermeable pipes to prevent the potential infiltration of the lines by contamination.
3. MDNR or potentially responsible parties should determine the extent of soil contamination and the potential for vapor intrusion; then determine the appropriate course of action for remediation.
4. Digging in contaminated subsurface soil is not recommended due to the potential for exposure to soil gas vapors.
5. Stagnant water should be flushed from pipes before the water is used for consumption.

6. The shallow groundwater present in the area should not be used as a drinking water source.
7. DHSS' Cancer Inquiry program should provide public health education on cancer control and the reduction of risk behaviors that are associated with cancer.

PUBLIC HEALTH ACTION PLAN

This Public Health Action Plan (PHAP) for the Cardwell, Missouri site contains an explanation of the actions to be taken by the Missouri Department of Health and Senior Services (DHSS), the Agency for Toxic Substances and Disease Registry (ATSDR), and other stakeholders. The purpose of the PHAP is to ensure that this public health consultation not only identifies public health hazards, but provides an action plan to mitigate and prevent adverse human health effects resulting from past, present, and future exposures to hazardous substances at or near the site. Below is a list of commitments of public health actions to be implemented by DHSS, ATSDR, or other stakeholders at the site:

1. DHSS/ATSDR will assist other agencies in addressing community health concerns and questions as they arise.
2. DHSS/ATSDR will review additional sampling data as it becomes available.
3. DHSS/ATSDR will coordinate with the appropriate agencies or stakeholders to implement the recommendations in this public health consultation.
4. DHSS/ATSDR has provided and will continue to provide the community with health education at public meetings that have been and will be held in Cardwell.

Preparers of the Report: Kristi Campbell, Missouri Department of Health and Senior Services

CERTIFICATION

The Missouri Department of Health and Senior Services (DHSS) prepared this Cardwell, Dunklin County, Missouri Public Health Consultation under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with the approved methodologies and procedures existing at the time the health consultation were initiated. The Cooperative Agreement partner completed the editorial review.

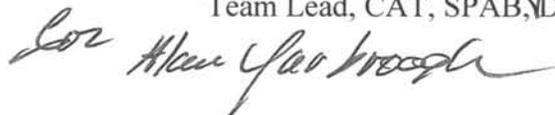


Technical Project Officer, CAT, SPAB, DHAC

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this health consultation and concurs with its findings.



Team Lead, CAT, SPAB, DHAC, ATSDR


For Allen Yao

REFERENCES

1. Shifrin & Associates, Inc. Missouri Risk-Based Corrective Action Tier 1 Assessment Report, Former Brewer Brothers Bulk Plant. 2005 October 17.
2. Missouri Department of Natural Resources, Environmental Services Program, Sampling Results. 2006 February 16
3. Missouri Department of Natural Resources, Environmental Services Program, Sampling Results. 2005 May 22.
4. Candido, Janette and Ferhmann Warren, Victoria. Cancer Inquiry CI05-002 – Cardwell, Missouri located in Dunklin County. Final Report, July 19, 2006.
5. Siegel, Lenny. 2005. Brownfields Brief, Brownfields and Vapor Intrusion. Mountain View, CA: Center for Public Environmental Oversight. <http://www.cpeo.org>

Figure 1. Map of Cardwell, Missouri



**Table 1. Selected Analytical Subsurface Soil Sampling Results February 2006 Sampling Event,
Cardwell, Missouri (Former Brewer Brothers North Site)**

Sample #	Contaminant	Sampling Result	MRBCA DTL*	ATSDR Comparison Value†
060217004-3	TPH-GRO	5190	346	NA
060217004-3	1,2,4 – Trimethylbenzene	373	3.93	NA
060217004-3	1,3,5 – Trimethylbenzene	90.5	0.882	NA
060217004-8	2 – Methylanthalene	13.4	7.55	3,000/40,000 Chronic EMEG

All values in milligrams per kilogram (mg/kg).

NA = Not available

*Missouri Risk Based Corrective Action Default Target Level.

†ATSDR Comparison Value (adult/child) RMEG-Reference Dose Media Evaluation Guide

**Table 2. Selected Analytical Water Sampling Results February 2006 Sampling Event,
Cardwell, Missouri (near Martin Oil)**

Sample #	Contaminant	Sampling Result	MRBCA DTL*	EPA
060215014-01 (Potable, 1 st draw)	Tetrahydrofuran	2.4	20.3	1.6 (PRG)
060215014-04 (Potable, 1 st draw)	Tetrahydrofuran	9.9	20.3	1.6 (PRG)
060216042-02 (Potable, 1 st draw)	Lead	16.5	15	15 (MCL Action Level)
0602473 (groundwater)	Arsenic	3.21 (e)	10	3/10 Chronic EMEG
	Lead	182.0		15 (MCL Action Level)
0602475 (groundwater)	Arsenic	4.4 (e)	10	3/10 Chronic EMEG
	Lead	19.9		15 (MCL Action Level)
0602478 (groundwater)	Arsenic	5.58 (e)	10	3/10 Chronic EMEG
	Lead	78.8		15 (MCL Action Level)
0602480 (groundwater)	Arsenic	10.3	10	3/10 Chronic EMEG
	Lead	162.0		15 (MCL Action Level)

All values in micrograms per liter (µg/L).

e=estimated level, detected below Practical Quantitation Limits.

EPA PRG – Preliminary Remediation Goal.

*Missouri Risk Based Corrective Action Default Target Level.

Table 3. Selected Analytical Ground Water Sampling Results February 2006 Sampling Event, Cardwell, Missouri (Brewer Brothers, Tri-State Delta Chemical and Martin Oil)

Sample #	Contaminant	Sampling Result	MRBC A DTL*	ATSDR† or EPA‡ Comparison Value
0602482	Arsenic	28.3	10	0.02 CREG
	Lead	42.2	15	15 (EPA MCL action level)
	1,2,4 - Trimethylbenzene	437	7.1	12 (EPA PRG)
	1,3,5 – Trimethylbenzene	89.2	7.1	12 (EPA PRG)
	1,2 – Dichloroethane	15.8		5 (EPA MCL)
	Benzene	546	5	0.6 CREG
	o - Xylene	417	10,000	210 (EPA PRG)
060217004-05	Arsenic	24.8	10	3/10 Chronic EMEG
	Lead	140	15	15 (EPA MCL action level)
060217004-07	Arsenic	43.9	10	0.02 CREG
	Naphthalene	471	1.1	200/700 RMEG
	Lead	165	15	15 (EPA MCL action level)
	1,2,4 – Trimethylbenzene	774	7.1	12 (EPA PRG)
	1,3,5 – Trimethylbenzene	55	7.1	12 (EPA PRG)
	Benzene	59	5	0.6 CREG
060216035-02	Nitrate + Nitrite as N	134 (mg/L)		10 mg/L (MCL)
060216035-09	Nitrate + Nitrite as N	110 (mg/L)		10 mg/L (MCL)
060216035-15	Arsenic	45.5	10	0.02 CREG
	Lead	176	15	15 (EPA MCL action level)
060216035-20	Nitrate + Nitrite as N	10.4 (mg/L)		10 mg/L (MCL)
060216035-22	Nitrate + Nitrite as N	32.7 (mg/L)		10 mg/L (MCL)
060215004-03 (bkgd)	Arsenic	6.45	10	0.02 CREG
	bis(2-ethylhexyl)phthalate	14.5	6	3 CREG
	Lead	26.5	15	15 (EPA MCL action level)
060215004-07	Nitrate + Nitrite as N	39.2 (mg/L)		10 mg/L (MCL)
060221001-02	Arsenic	3.45	10	0.02 CREG
	Lead	25.3	15	15 (EPA MCL action level)

All samples in micrograms per liter (µg/L) unless noted otherwise. Indicated samples are in milligrams per liter (mg/L).

* Missouri Risk Based Corrective Action Default Target Level.

†ATSDR Environmental Media Evaluation Guide (EMEG) or Reference Dose Media Evaluation Guide (RMEG)

Chronic-exposure that lasts for more than one year.

‡EPA Preliminary Remediation Goal (PRG) or Maximum Contaminant Level (MCL)

**Table 4. Selected Analytical Ground Water Sampling Results May 2006 Sampling Event, Cardwell, Missouri
(Former Brewer Brothers (North) Site)**

Sample #	Contaminant	Sampling Result	MRBCA DTL*	ATSDR Comparison Value†
0600763	Benzene	14.8	5	0.6 CREG
	Total Xylenes	2.86	10,000	210 (EPA PRG)
	TPH-DRO	1280	32,400	NA
0600767	Benzene	82.5	5	0.6 CREG
	Total Xylenes	461.0	10,000	210 (EPA PRG)
	2-Methylnaphthalene	392	11.7	NA
	TPH-DRO	28,000	32,400	NA
	TPH-GRO	11,000	10,500	NA

All samples in micrograms per liter (µg/L) unless noted otherwise.

TPH-DRO = Total Petroleum Hydrocarbons – Diesel Range Organics

TPH-GRO = Total Petroleum Hydrocarbons – Gasoline Range Organics

*Missouri Risk Based Corrective Action Default Target Level.

†ATSDR Environmental Media Evaluation Guide (EMEG) or Reference Dose Media Evaluation Guide (RMEG)

**Table 5. Selected Analytical Soil Sampling Results May 2006 Sampling Event, Cardwell, Missouri
(Former Brewer Brothers (North) Site)**

Sample #	Contaminant	Sampling Result	MRBCA DTL*	ATSDR Comparison Value†
0600762	Arsenic	2.91	3.89	20/200 (Chronic EMEG)
0600766	Arsenic	2.41 (e)	3.89	20/200 (Chronic EMEG)
	1,2,4 – Trimethylbenzene	115.0	3.93	NA
	1,3,5 - Trimethylbenzene	41.5	0.882	NA
	Ethylbenzene	16.5	39.9	5,000/70,000 (RMEG)
	Naphthalene	46.7 (e)	0.325	30,000/40,000 (Intermediate, EMEG)
0600768	Arsenic	3.74	3.89	20/200 (Chronic EMEG)
0600769	Arsenic	0.599 (e)	3.89	20/200 (Chronic EMEG)
060770	Arsenic	7.21	3.89	20/200 (Chronic EMEG)

All values in milligrams per kilogram (mg/kg).

e=estimated level, detected below Practical Quantitation Limits.

*Missouri Risk Based Corrective Action Default Target Level.

†ATSDR Environmental Media Evaluation Guide (EMEG) or Reference Dose Media Evaluation Guide (RMEG). Child/Adult values.

Chronic exposure is defined as occurring for more than one year.

Intermediate exposure is defined as occurring for more than 14 days but less than 365 days.

**Table 6. Selected Analytical Ground Water Sampling Results May 2006 Sampling Event, Cardwell, Missouri
(Former Brewer Brothers (South) Site)**

Sample #	Contaminant	Sampling Result	MRBCA DTL*	ATSDR Comparison Value†
0602534	Arsenic	24.5		0.02 (CREG)
	Lead	31.5	15	15 (EPA Action Level)
0602535	Arsenic	23.4		0.02 (CREG)
	Lead	19.0	15	15 (EPA Action Level)

All samples in micrograms per liter (µg/L) unless noted otherwise.

*Missouri Risk Based Corrective Action Default Target Level.

†ATSDR Comparison Value CMEG-Cancer Risk Media Evaluation Guide (1×10^{-6} excess cancer risk).

**Table 7. Selected Analytical Soil Sampling Results May 2006 Sampling Event, Cardwell, Missouri
(Former Brewer Brothers (South) Site)**

Sample #	Contaminant	Sampling Result	MRBCA DTL*	ATSDR Comparison Value†
0602498	Arsenic	2.34 (e)	3.89	20/200 (Chronic EMEG)
	Dieldrin	0.0251	0.0936	3/40 (Chronic EMEG)
0602499	Arsenic	1.16 (e)	3.89	20/200 (Chronic EMEG)
0602500	Arsenic	2.75	3.89	20/200 (Chronic EMEG)
0602531	Arsenic	1.1 (e)	3.89	20/200 (Chronic EMEG)
0602532	Arsenic	2.56 (e)	3.89	20/200 (Chronic EMEG)
0602533	Arsenic	2.22 (e)	3.89	20/200 (Chronic EMEG)

All values in milligrams per kilogram (mg/kg).

*Missouri Risk Based Corrective Action Default Target Level.

†ATSDR Environmental Media Evaluation Guide (EMEG) or Reference Dose Media Evaluation Guide (RMEG). Child/Adult values.

Chronic exposure is defined as occurring for more than one year.

Intermediate exposure is defined as occurring for more than 14 days but less than 365 days.

**Table 8. Selected Analytical Soil Sampling Results, May 2006 Sampling Event,
Cardwell, Missouri (Tri-State Delta Chemical Site)**

Sample #	Contaminant	Sampling Result	EPA PRG† Residential	ATSDR Comparison Value‡
0602501*	Dieldrin	0.121	0.03	3/40 (Chronic EMEG)

All values in milligrams per kilogram (mg/kg).

*This sample was collected in the top 0-3 feet of soil.

†Missouri Risk Based Corrective Action Default Target Level.

‡ATSDR Environmental Media Evaluation Guide (EMEG) or Reference Dose Media Evaluation Guide (RMEG). Child/Adult values.

Chronic exposure is defined as occurring for more than one year.

**Table 9. Selected Analytical Groundwater Sampling Results, May 2006 Sampling Event,
Cardwell, Missouri (Watkins Service Station Site)**

Sample #	Contaminant	Sampling Result	MRBCA DTL*	ATSDR Comparison Value†
0602523	1,2,4 – Trimethylbenzene	4,810	7.06	NA
	1,3,5 - Trimethylbenzene	1,310	7.05	NA
	Benzene	47,400	5	0.6 CREG
	Ethylbenzene	4,650	700	1,000/4,000 (RMEG)
	MTBE	13,800	128	3,000/10,000 (Intermediate, EMEG)
	n-Butylbenzene	253	98.9	NA
	n-Propylbenzene	719	115	NA
	Naphthalene	1420	1.09	6,000/20,000 (Intermediate, EMEG)
	Styrene	204	100	2,000/7,000 (Intermediate, EMEG)
	Toluene	145,000	1,000	200/700 (Intermediate, EMEG)
	Total Xylenes	16,200	10,000	2,000/7,000 (Intermediate, EMEG)
	2,6 – Dinitrotoluene	5.2	0.964	40/100 (Intermediate, EMEG)
	TPH – DRO	38,500	32,400	NA
	TPH - GRO	150,000	10,500	NA
0602525	1,2,4 – Trimethylbenzene	526	7.06	NA
	1,3,5 - Trimethylbenzene	106	7.05	NA
	Benzene	6.75	5	0.6 CREG
	Naphthalene	147	1.09	6,000/20,000 (Intermediate, EMEG)
	TPH-GRO	3,440	10,500	NA

All values in milligrams per kilogram (mg/kg).

MTBE = Methyl –tert-butyl-ether

TPH- DRO = Total Petroleum Hydrocarbons – Diesel Range Organics

TPH – GRO = Total Petroleum Hydrocarbons – Gasoline Range Organics

NA = Not available

*Missouri Risk Based Corrective Action Default Target Level.

†ATSDR Environmental Media Evaluation Guide (EMEG) or Reference Dose Media Evaluation Guide (RMEG). Child/Adult values.

ATSDR Comparison Value CMEG-Cancer Risk Media Evaluation Guide (1×10^{-6} excess cancer risk

Chronic exposure is defined as occurring for more than one year.

Intermediate exposure is defined as occurring for more than 14 days but less than 365 days.

**Table 10. Selected Analytical Subsurface Soil Sampling Results, May 2006 Sampling Event,
Cardwell, Missouri (Watkins Service Station Site)**

Sample #	Contaminant	Sampling Result	EPA PRG Residential	ATSDR Comparison Value
0602522	1,2,4- Trimethylbenzene	447.0	52	NA
	1.3.5- Trimethylbenzene	146.0	21	NA
	Benzene	72.9	0.64	10 (CREG)
	Ethylbenzene	169.0	400	5,000 child /70,000 (RMEG)
	MTBE	2.72 (e)	32	20,000 / 200,000 (Inter, EMEG)
	n-Propylbenzene	92.0	240	NA
	Napthalene	68.6	56	1,000/10,000 (RMEG)
	n-Isopropyltoluene	19.9		NA
	sec-Butylbenzene	9.27	220	NA
	Toluene	523.0	520	1,000 /10,000 (Inter, EMEG)
	Total Xylenes	680.0	270	10,000/100,000 (Inter, EMEG)
	TPH - DRO	52.3	125,000 (MRBCA DTL)*	NA
	TPH - GRO	10,600.0	346 (MRBCA DTL)*	NA

All values in milligrams per kilogram (mg/kg).

NA = Not available

MTBE = Methyl-tert-butyl-ether

TPH- DRO = Total Petroleum Hydrocarbons – Diesel Range Organics

TPH – GRO = Total Petroleum Hydrocarbons – Gasoline Range Organics

*Missouri Risk Based Corrective Action Default Target Level.

ATSDR Environmental Media Evaluation Guide (EMEG) or Reference Dose Media Evaluation Guide (RMEG). Child/Adult values.

Chronic exposure is defined as occurring for more than one year.

Intermediate exposure is defined as occurring for more than 14 days but less than 365 days.

Table 11. Selected Analytical Drinking Water Sampling Results May 2006 Sampling Event, Cardwell, Missouri (Cardwell Residential Wells)

Sample #	Contaminant	Sampling Result	EPA MCL	ATSDR Comparison Value
0600759	Bromodichloromethane	<0.5	80	0.6 (CREG)
	Chloroform	0.64 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.19	80	0.4 (CREG)
0600760	Bromodichloromethane	<0.5	80	0.6 (CREG)
	Chloroform	0.61 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.33	80	0.4 (CREG)
0600761	Bromodichloromethane	0.57 (e)	80	0.6 (CREG)
	Chloroform	0.65 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.25	80	0.4 (CREG)
0602514	Bromodichloromethane	<0.5	80	0.6 (CREG)
	Chloroform	0.57 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.16	80	0.4 (CREG)
0602515	Bromodichloromethane	0.55 (e)	80	0.6 (CREG))
	Chloroform	0.51 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.21	80	0.4 (CREG)
0602516	Bromodichloromethane	<0.5	80	0.6 (CREG)
	Chloroform	0.55 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.21	80	0.4 (CREG)
0602517	Bromodichloromethane	0.56 (e)	80	0.6 (CREG)
	Chloroform	0.6 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.33	80	0.4 (CREG)
0602518	Bromodichloromethane	0.53 (e)	80	0.6 (CREG)
	Chloroform	0.61 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.52	80	0.4 (CREG)
0602519	Bromodichloromethane	0.55 (e)	80	0.6 (CREG)
	Chloroform	0.53 (e)	80	100/400 (Chronic, EMEG)
	Dibromochloromethane	1.53	80	0.4 (CREG)

All samples in micrograms per liter (µg/L) unless noted otherwise.

(i)=PQL elevated due to sample dilution.

(e) = Estimated value, detected below PQL

EPA Preliminary Remediation Goal (PRG) or Maximum Contaminant Level (MCL)

Indicated samples are in milligrams per liter (mg/L)

ATSDR Environmental Media Evaluation Guide (EMEG) or Reference Dose Media Evaluation Guide (RMEG). Child/Adult values.

Chronic exposure is defined as occurring for more than one year.

Table 12. Selected Analytical Soil Gas Sampling Results May 2006 Sampling Event, Cardwell, Missouri

Sample #	Contaminant	Sampling Result	EPA Region 9 PRG	ATSDR Comparison Value†
00600757	1,3 – Butadiene	14	0.061	0.03 (CREG)
	Acetone	43	3300	30,880 (Chronic EMEG)
	Carbon Disulfide	4.2	730	700 (RfC)
	Hexane	290	210	200 (RfC)
	2-Butanone	15	5100	5000 (RfC)
	Cyclohexane	8.1	6200	6000 (RfC)
	2,2,4 – Trimethylpentane	40	NA	NA
	Benzene	9.8	0.25	0.1 (CREG)
	Heptane	37	NA	NA
	Toluene	28	400	301 (Chronic EMEG)
	Ethyl Benzene	12	1100	1000 (RfC)
	m,p - Xylene	35	110	436 (Chronic EMEG)
	o - Xylene	12	110	436 (Chronic EMEG)
	Propylbenzene	5.4	150	NA
	4-Ethyltoluene	20	NA	NA
	1,3,5 – Trimethylbenzene	8.1	6.2	NA
	1,2,4 - Trimethylbenzene	21	6.2	NA
00600758	1,3 – Butadiene	19	0.061	0.03 (CREG)
	Acetone	70	3300	30,880 (Chronic EMEG)
	Carbon Disulfide	13	730	700 (RfC)
	Hexane	1200	210	200 (RfC)
	2-Butanone	20	5100	5000 (RfC)
	Cyclohexane	180	6200	6000 (RfC)
	2,2,4 – Trimethylpentane	1200	NA	NA
	Benzene	160	0.25	0.1 (CREG)
	Heptane	770	NA	NA
	Toluene	1100	400	301 (Chronic EMEG)
	Ethyl Benzene	410	1100	1000 (RfC)
	m,p - Xylene	1500	110	436 (Chronic EMEG)
	o - Xylene	510	110	436 (Chronic EMEG)
	Cumene	41	150	400 (RfC)
	Propylbenzene	41	150	NA
	4-Ethyltoluene	620	NA	NA
	1,3,5 – Trimethylbenzene	250	6.2	NA
	1,2,4 - Trimethylbenzene	630	6.2	NA

All samples in micrograms per meter cubed ($\mu\text{g}/\text{m}^3$).

*EPA Region 9 Preliminary Remediation Goals.

†ATSDR Environmental Media Evaluation Guide (EMEG); Reference Dose Media Evaluation Guide (RMEG); Reference Dose Concentration (RfC); Cancer Risk Evaluation Guide (1×10^{-6} excess cancer risk). Chronic-exposure that lasts for more than one year.