Health Consultation

PLAQUEMINE AREA VINYL CHLORIDE GROUNDWATER PLUME

IBERVILLE PARISH, LOUISIANA

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

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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IBERVILLE PARISH, LOUISIANA

Prepared by:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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List of Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CEL	cancer effect level
CREG	cancer risk evaluation guide
CV	comparison value
DBP	disinfection byproducts
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
kg	kilogram
L	liter
LDEQ	Louisiana Department of Environmental Quality
LDHH	Louisiana Department of Health and Hospitals
LOAEL	lowest-observed-adverse-effect-level
µg	microgram
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg	milligram
MGTP	Myrtle Grove Trailer Park
MRL	minimal risk level
ND	not detected
NOAEL	no-observed-adverse-effect-level
PCE	perchloroethylene
PHAP	public health action plan
ppb	parts per billion
ppm	parts per million
QA/QC	quality assurance/quality control
RMEG	reference dose media evaluation guide
SMCL	secondary maximum contaminant level
THM	trihalomethanes
TOC	total organic carbon
VOC	volatile organic compound

1.0 Summary

In 2001, the Louisiana Department of Health and Hospitals (LDHH) detected vinyl chloride-contaminated groundwater in a well system in Iberville Parish, Plaquemine, Louisiana. Following this detection, the Louisiana Department of Environmental Quality (LDEQ) coordinated efforts with the U.S. Environmental Protection Agency (EPA) to characterize the vinyl chloride plume and determine its source. While LDEQ and EPA focused on these efforts, the local community requested that the Agency for Toxic Substances and Disease Registry (ATSDR) determine whether current exposures to the contaminated groundwater could result in harmful health effects to area residents.

Within the contamination plume area, LDEQ identified 24 active wells. Homeowners use Well G for domestic (drinking water) purposes, while other homeowners use their wells for irrigating family gardens. Some residents and local businesses use the wells to supply water for ponds. A few local businesses use them for sanitary purposes (e.g., toilets, sinks, and emergency showers), for emergency fire systems, and for industrial processing purposes. ATSDR collected available groundwater sampling data for these 24 active wells. Of them, 13 had detectable levels of chemicals, including arsenic and vinyl chloride. Although the other 11 wells are active, no contamination was detected in them.

After its review of available groundwater data, ATSDR focused its evaluation on those 13 active wells containing detectable levels of chemicals. For each well, ATSDR evaluated the exposure pathway factors and the available chemical data. The evaluation then concentrated on levels of those detected chemicals known to cause harmful health effects in animals and humans. The goal was to determine whether harmful health effects are likely. Overall, ATSDR concludes that exposure to the water from these 13 active wells is unlikely to result in harmful health effects, including arsenic exposures.

Although the detected arsenic levels are not likely to result in harmful health effects, uncertainties do surround the toxicity of arsenic at low doses, and only limited groundwater data are available. Because Well G is a current source of drinking water, prudent public health practice calls for the Well G homeowners to reduce arsenic exposures by limiting ingestion of water from this well or by adding a treatment system to remove the arsenic. ATSDR also recommends against using the water from the other active wells as a source of drinking water in the future unless retesting shows arsenic levels are below regulatory drinking water standards.

ATSDR considers that

- investigating and planning for the continued protection of the City of Plaquemine's water supply from Plaquemine aquifer contaminants,
- monitoring performance of the Plaquemine aquifer, and
- performing a remediation study

are all protective of public health.

2.0 Background and Statement of Issues

In February 2001, during routine testing of the Myrtle Grove Trailer Park (MGTP) well system in Iberville Parish, Plaquemine, Louisiana, LDHH detected vinyl chloride at 8.45 parts per billion (ppb) and 11.2 ppb in groundwater samples it collected. Those levels were above EPA's maximum contaminant level (MCL) of 2 ppb. In March 2001, park residents were placed on city-supplied water (ATSDR 2001). LDHH then performed a records review for the MGTP well system and found that in November 1997 and September 1998, vinyl chloride levels were also above the MCL. In August 2001, ATSDR received a petition requesting evaluation of whether exposures to the vinyl chloride levels detected in the MGTP well system water posed a public health hazard to park residents (Petition Letter 2001).

Specifically, MGTP residents asked ATSDR if their health ailments could be the result of drinking, showering, bathing, cooking, washing dishes, or swimming in contaminated water. In May 2004, ATSDR released in final form the Myrtle Grove Trailer Park Health Consultation, which evaluated the available data and information about the MGTP well system. ATSDR found that the reported health concerns are not likely to be related to exposure to vinyl chloride, to any other contaminant—or to a combination of contaminants—detected in the MGTP well water.

At the time of the MGTP health consultation's release, however, the source of the vinyl chloride-contaminated groundwater plume had not been determined. As a result, ATSDR recommended continued groundwater monitoring to better characterize the vinyl chloride plume and to determine its source. From 2001 to 2004, in an effort to characterize the plume more fully, LDEQ and EPA collected samples from wells located in areas surrounding the trailer park. In October 2004, EPA released the results of its investigation of groundwater flow directions and its contaminant-source-area evaluation for the Plaquemine aquifer (see Section 2.2 for further details).

In its earlier health consultation, ATSDR also recommended a broader public health evaluation of exposures to vinyl chloride-contaminated groundwater. To address Plaquemine area residents' health concerns, ATSDR suggested extending the evaluation to areas surrounding the MGTP. In this health consultation, ATSDR follows through on that suggestion. Here ATSDR focuses on whether current exposures to contaminated groundwater in areas surrounding the MGTP could result in adverse health effects in area residents.

2.1 Plaquemine Aquifer

As part of its investigation, EPA focused on determining the directions of groundwater flow in the Plaquemine aquifer upper sand unit and on understanding how the Mississippi River and pumping wells affect groundwater flow. EPA reviewed published information on the Plaquemine aquifer from agencies such as the U.S. Geological Survey, reviewed the well measurements collected during the vinyl chloride groundwater plume investigation, and used groundwater models to simulate the direction of net groundwater flow under site conditions (EPA 2004e).

Overall, the depth of the freshwater-bearing part of the Plaquemine aquifer in the plume area extends to approximately 560 feet below land surface. The aquifer itself is divided into an upper sand unit and lower sands, which are separated by a silt or clay layer extending from approximately 200 to 250 feet below land surface. EPA logs indicate the top of the Plaquemine aquifer upper sand unit to be approximately 100 to 110 feet below land surface (EPA 2004e).

Typically, groundwater flow adjacent to streams is perpendicular to stream flow. During dry periods, the groundwater discharges from aquifers into streams. During periods of high stream stage, groundwater moves a short distance from streams into an aquifer.

The Mississippi River and Plaquemine aquifer appear to follow this pattern. Numerous river stage measurements show considerable variability over time, with low river stages occurring in late summer and fall and high river stages occurring in the winter and spring. During these periods, river stage measurements between high and low river stages vary as much as 30 feet. Data also show significant groundwater level fluctuations in the Plaquemine aquifer that are generally consistent with the time of river stage rise or fall. Moreover, the Mississippi is in direct contact with the upper sand unit of the Plaquemine aquifer (EPA 2004e).

The modeling results show that the net flow direction, both with and without well pumpage, is primarily to the west. This is consistent with previously published information from the U.S. Geological Survey that found a westerly direction of groundwater flow in the plume area (EPA 2004e).

2.2 Plaquemine Groundwater Plume Investigation

Through discussions with long-time residents, door-to-door visits, public meetings, and calls to a LDEQ toll-free line, LDEQ identified numerous private wells in the Plaquemine area. To better characterize the plume, LDEQ began in April 2001 to collect water samples from area wells surrounding the MGTP. In June 2001, LDEQ requested assistance from EPA. Since then, at numerous locations LDEQ and EPA have identified and sampled groundwater. Between 2001 and 2004, about 85 locations—including private wells, monitoring wells, and City of Plaquemine sentinel wells—were sampled at least once (EPA 2004a). See Figure 1, Appendix A, for a well location map.

Most of the wells are located in the upper sand unit at depths of 200 feet or less. Several active wells are, however, located in the lower sand unit, such as Wells WW-1 through WW-10. Of the four City of Plaquemine sentinel wells, two are in the upper sand unit and are less than 200 feet in depth, and two are in the lower sand unit at about 250 feet in depth. The City of Plaquemine installed these sentinel monitoring wells to serve as advance warning if contaminants were detected in the area near the city's backup water supply wells.

LDEQ and EPA analyzed all groundwater samples for vinyl chloride and other volatile organic compounds (VOCs). In some instances, LDEQ and EPA analyzed the samples for several other groundwater parameters including metals (arsenic and manganese), selected anions (chloride, nitrate, nitrite, and sulfate), total organic carbon (TOC), and alkalinity. In addition, EPA analyzed samples for natural groundwater attenuation parameters (i.e., ethane, ethene, and methane). These parameters were monitored to assist with groundwater plume characterization and source identification.

Additionally, at the EPA National Risk Management Research Laboratory, EPA coordinated reviews of the well data with hydrologists and other scientists. In October 2004, EPA released the results of its investigation of groundwater flow directions and contaminant-source-area evaluation for the Plaquemine aquifer. EPA based its investigation on groundwater flow modeling, including observations about local geology, hydrogeology, and river hydrology combined with information about known chemical releases and LDEQ's previous investigation of potential source areas and releases (EPA 2004e).

As stated in its October 2004 report, EPA identified only one geographic area as a likely source for the Plaquemine aquifer contamination (EPA 2004e). This area is near the northeastern edge of the contamination plume and along the western side of the Mississippi River. Historical information indicates that many years ago perchloroethylene (PCE)—also known as tetrachloroethene—was discharged to the Mississippi River at this location (EPA 2004e). During the groundwater investigation, common breakdown products of PCE, including vinyl chloride and cis-1,2-dichloroethene, were detected in Plaquemine area groundwater. EPA concluded that at this likely source area, surface contamination of PCE was scoured, eroded, and transported southward by the river, causing the original source area to become enlarged (EPA 2004e). As stated, the river is in contact with the Plaquemine aquifer. Thus any contamination reaching the Plaquemine aquifer upper sand unit would have been transported and dispersed from the river in a westerly direction, moving underneath the MGTP well system as well as other affected locations in the Plaquemine area (EPA 2004e).

2.3 Dow Chemical

Dow Chemical is one of the largest petrochemical facilities in the state. It has 23 units producing more than 50 different basic and specialty chemical products that it ships worldwide (Dow Chemical 2004). Dow Chemical products amount to more than 19.5 billion pounds of production annually (EPA 2003a). Following the discovery of a vinyl chloride plume near its Plaquemine facility, Dow Chemical began conducting its own investigation into the possibility that its operations resulted in the groundwater contamination.

Dow Chemical's investigation concluded that its manufacturing site is not a source of any contaminants detected in the Plaquemine aquifer (EPA 2004f). Nevertheless, to assist the community, Dow Chemical entered into a Cooperative Agreement with EPA and LDEQ to

a. investigate and plan for the continued protection of the City of Plaquemine's water supply from contaminants in the Plaquemine aquifer,
b. conduct monitoring of the Plaquemine aquifer, and
c. conduct a remediation study to assess the long-term need for remediation and, if necessary, to evaluate options for remediation (EPA 2004f).

In April and November 2005, as part of the Cooperative Agreement, Dow Chemical participated in groundwater sampling and analysis. Groundwater samples were collected and analyzed for arsenic, VOCs, selected anions, TOC, and alkalinity. ATSDR includes data from the April and November 2005 sampling events in this health consultation (see Table 3, Appendix B).

2.4 Data Quality

ATSDR relies on information provided in the referenced documents and databases. Consequently, the analyses, conclusions, and recommendations contained in this health consultation are valid only if the referenced documents are complete and reliable. LDEQ and

EPA provided groundwater data to ATDSR in electronic form, which includes the 2005 Dow Chemical data (EPA 2004b, EPA 2004c, EPA 2004d, LDEQ 2005, LDEQ 2006). A third party contractor validated the LDEQ analytical data and, from the laboratory validation sheets, LDEQ staff entered that data into an Excel spreadsheet. As the data were entered, LDEQ performed data entry checks (LDEQ 2004). EPA conducted sampling in accordance with a quality assurance project plan (EPA 2003a). Although ATSDR staff did not review quality assurance/quality control (QA/QC) information, adequate QA/QC measures appear to have been followed regarding chain-of-custody, laboratory procedures, and data reporting. As such, ATSDR considers these data adequate for public health evaluation purposes.

2.5 Data Results

LDEQ identified 24 currently active wells that residents and local businesses use and that are within the contamination plume. ATSDR reviewed the available groundwater sampling data for these 24 currently active private wells. See Table 1, Appendix B, for information on these wells.

With regard to the 24 wells listed in Table 1, Appendix B, arsenic was detected in 13 (Wells A, B, D, G, H, N, P, S, T, V, EE, LL, and QQ). Vinyl chloride was detected in five (Wells A, H, N, V, and LL). Several other VOCs were detected in seven wells (Wells A, H, N, P, V, LL, and QQ). Of note, 17 of these wells (Wells B, D, E, G, S, T, EE, and WW-1 through WW-10) showed no VOC contamination, including no vinyl chloride. Table 3, Appendix A, provides the detected levels of these chemicals and, when available, the detected levels of other chemicals and groundwater parameters.

2.6 Exposure Pathway Information

To determine whether people are being exposed to contaminants, ATSDR examines the path between a contaminant and a person or group of people who could be exposed. Completed exposure pathways have five required elements. ATSDR evaluates each possible pathway to determine whether all five factors exist and whether people are being exposed. These five factors or elements must exist for a person to be exposed to a contaminant:

1. a source of contamination,
2. transport through an environmental medium,
3. a point of exposure,
4. a route of human exposure, and
5. an exposed population.

ATSDR classifies exposure pathways in one of the following three categories.

- *Completed Exposure Pathway*. ATSDR identifies a pathway as “complete” if it is certain that people are exposed to contaminated media. Completed pathways require the presence of the five elements and accordingly indicate that exposure to the contaminant is occurring.

- *Potential Exposure Pathway.* Potential pathways are those in which at least one of the five elements is missing, but could exist. Potential pathways indicate that exposure to a contaminant could be occurring.

- *Eliminated Exposure Pathway*. In an eliminated exposure pathway, at least one of the five elements is missing. From a human health perspective, pathways can be eliminated from further consideration if ATSDR can show that (a) an environmental medium is not contaminated or that (b) no one is exposed to contaminated media.

Approximately 85 locations within the Plaquemine area were sampled at least once (see Figure 1, Appendix A). For many of these locations, however, no known point of human exposure is currently present. Specifically, the groundwater samples from inactive domestic wells, inactive business wells, inactive irrigation wells, monitoring wells, soil borings, piezometers, and City of Plaquemine sentinel wells were collected only for the purpose of delineating the contamination plume. Table 2, Appendix B, lists these wells, which are not used for residential or industrial purposes. Thus because of the absence of any human exposure point, these locations represent eliminated exposure pathways. Because ATSDR's evaluation focuses on current human exposure to groundwater, ATSDR did not review the chemical data collected for the wells listed in Table 2, Appendix B.

Of the approximately 85 locations, LDEQ identified 24 active wells within the contamination plume currently used by residents and local businesses. Contamination, however, was not detected in 11 of these wells (Well E and Wells WW-1 through WW-10). The following provides further information on the noncontaminated wells.

- Well E supplies water for a bathroom and an outdoor baptismal pool at a local church. Parishioners and church personnel contact the water during bathroom use, such as hand washing activities, and as they wade in the outdoor pool during baptismal ceremonies. Although this well is active, testing of the water in August 2001 did not show contamination. Thus exposure to the well water represents an eliminated exposure pathway. Levels of contamination are not expected to rise in the future because Well E is not located near the likely contamination source: a PCE spill in the Mississippi river that occurred many years ago. In addition, compared to the other wells in the study, Well E is one of the farthest south and farthest west of the likely source area.
- A business uses Wells WW-1 through WW-10 for its emergency fire system and to supply process water to its industrial facility. The water from these wells does not supply drinking water fountains, bathrooms, or emergency showers. Although these wells are active, exposure to the water from them represents an eliminated exposure pathway—testing of the water in July 2001 did not show any contamination. Levels of contamination are not expected to rise in the future because these wells are all located in the lower sand unit at depths greater than 400 feet, not in the contaminated Plaquemine aquifer upper sand unit.

Again, of the 24 active wells, 13 contain detectable levels of chemicals. For each of the 13 wells, ATSDR carefully evaluated the exposure pathway elements:

- Homeowners use Well G for domestic water. They contact the well water daily during activities such as drinking, showering, bathing, cooking, and washing dishes. Routes of exposure for this completed exposure pathway are ingestion (drinking), inhalation of vapors (breathing), and dermal contact (skin contact).

- Homeowners use Wells H and N to maintain water in their residential ponds. They occasionally contact pond waters during wading and fishing as well as during cleaning of the ponds. Routes of exposure for this completed exposure pathway are dermal contact and inhalation of vapors.
- Homeowners use Wells D, H, and LL to irrigate their home gardens. These homeowners contact the irrigation hose water during gardening activities. Routes of exposure for this completed exposure pathway are dermal contact and inhalation of vapors.
- Wells A, P, and V supply water to golf course ponds. Golf course employees contact the water and golfers occasionally contact the water when retrieving golf balls hit into the ponds. Routes of exposure for this completed exposure pathway are dermal contact and inhalation of vapors.
- Local business owners use Wells B and QQ to supply water to bathrooms in their facilities. Employees and customers of these businesses contact the water during bathroom use, such as hand washing activities. Routes of exposure for this completed exposure pathway are dermal contact and inhalation of vapors.
- A local business uses Wells S and T to supply water for emergency showers. Employees occasionally contact the water during showering activities. Routes of exposure for this completed exposure pathway are dermal contact and inhalation of vapors.
- A business uses Well EE to supply water to bathroom facilities and safety showers. The facility is inside a locked fence, is not permanently staffed, and is used only infrequently. Consequently, employees infrequently contact the water during hand washing and showering activities. Routes of exposure for this completed exposure pathway are dermal contact and inhalation of vapors.

3.0 Discussion

Following its review of exposure pathways and available groundwater data, ATSDR focused on the levels of chemicals detected in 13 active wells (Wells A, B, D, G, H, N, P, S, T, V, EE, LL and QQ).

ATSDR now addresses the question of whether exposure to the levels of chemicals detected in these 13 Plaquemine area wells could result in harmful health effects. While the relative toxicity of a chemical is important, in assessing these health effects the human body's response to a chemical exposure is determined by several additional factors, including

- the concentration (how much) of the chemical to which the person was exposed,
- the amount of time the person was exposed (how long), and
- the way the person was exposed (through breathing, eating, drinking, or direct contact with something containing the chemical).

Lifestyle factors (e.g., occupation and personal habits) have a major impact on the likelihood, magnitude, and duration of exposure. Individual characteristics such as age, sex, nutritional status, overall health, and genetic constitution affect how the human body absorbs, distributes, metabolizes, and eliminates a contaminant. A unique combination of all these factors will determine an individual's physiologic response to a chemical contaminant and any harmful health effects the individual could suffer as a result of the chemical exposure.

Additionally, ATSDR reviewed the groundwater data presented in Table 3 to determine whether the maximum detected chemical concentrations are above ATSDR's health-based comparison values (CVs). Health-based CVs are estimates of daily human exposure to a chemical that are not likely to result in adverse health effects over a specified duration of exposure. These values are developed for specific media (e.g., air, water, and soil) and for specific durations of exposure (i.e., acute, intermediate, and chronic). ATSDR's review also identified those chemicals with no relevant CV.

Some of the CVs and health guidelines used by ATSDR scientists include ATSDR's minimal risk levels (MRLs), environmental media evaluation guides (EMEGs), reference dose media evaluation guides (RMEGs), and cancer risk evaluation guides (CREGs). These ATSDR CVs and health guidelines represent conservative levels of safety—they are not thresholds of toxicity. Although concentrations at or below a CV may reasonably be considered safe, concentrations above a CV will not necessarily be harmful. To ensure that they will protect even the most sensitive populations (such as children or the elderly), ATSDR CVs are intentionally designed to be much lower, usually by two or three orders of magnitude, than the corresponding no-observed-adverse-effect-levels (NOAELs) or lowest-observed-adverse-effect-levels (LOAELs) on which the CVs were based. Most NOAELs and LOAELs are established in laboratory animals; relatively few are derived from epidemiological (i.e., chiefly occupational) studies. Note too that ATSDR health-based CVs are nonenforceable.

Specifically, ATSDR's MRLs are estimates of daily human exposure to a chemical that are unlikely to be associated with any appreciable risk of noncancer effects over a specified duration of exposure. MRLs are calculated using data from human and animal studies and are reported for acute (≤ 14 days), intermediate (15–364 days), and chronic (≥ 365 days) exposures. MRLs for specific chemicals are published in ATSDR's toxicological profiles. ATSDR's EMEGs are contaminant concentrations calculated from ATSDR's MRLs by factoring in default body weights and ingestion rates. ATSDR's RMEGs are contaminant concentrations calculated from EPA's reference doses and default exposure assumptions. ATSDR's CREGs are estimated contaminant concentrations expected to cause no more than one excess cancer in a million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors, or cancer potency factors, using default values for exposure rates. As stated previously, concentrations above these ATSDR CVs and health guidelines will not necessarily be harmful.

When reviewing the Plaquemine area groundwater data, ATSDR also screened the chemical data using EPA's maximum contaminant levels (MCLs), maximum contaminant level goals (MCLGs), and secondary maximum contaminant levels (SMCLs). The MCL is a legally enforceable drinking water standard set by EPA to control the level of a contaminant in the nation's municipal (i.e., public) drinking water. Of note, EPA's MCL standards are not solely based on human exposure and the risk of adverse health effects. Other factors play a role, such as the contaminant's occurrence in the environment, analytical methods of detection, technical feasibility, and impact of specific regulations on water systems (EPA 2005a).

EPA's MCLG is the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur. When determining an MCLG, EPA considers a sensitive subpopulation's (e.g., infants, children, the elderly, and those with compromised immune systems) risk of experiencing a variety of adverse health effects. Unlike MCLs, MCLGs are nonenforceable public health goals. Because MCLGs consider only public health and not the limits of detection and treatment technology, they are sometimes set at a level that water systems cannot meet (EPA 2005a).

EPA's SMCLs are also nonenforceable federal guidelines regarding cosmetic drinking water effects such as tooth or skin discoloration or aesthetic effects such as taste, odor, or color. These water quality standards pertain to 15 contaminants not considered risks to human health at the SMCL (EPA 2002, EPA 2005b).

For each chemical, ATSDR's initial review determines whether

a. its maximum concentration exceeds a CV, or

b. no CV is listed for it.

ATSDR reviews levels of each chemical known to cause harmful health effects in animals and humans. Then, by reviewing the exposure durations, routes of exposure, maximum chemical levels, and available chemical data, ATSDR determines whether health effects are likely.

3.1 Metals

Arsenic and manganese were analyzed for in several well water samples. The following describes ATSDR's public health evaluation of these metals.

Arsenic

Arsenic occurs naturally in soil and minerals. In the environment, arsenic usually combines with other elements such as oxygen, chlorine, and sulfur. Arsenic in this form is known as inorganic arsenic. Arsenic combined with carbon and hydrogen is organic arsenic. The organic forms of arsenic are usually less harmful than the inorganic forms. That said, analytical methods used by scientists to determine the levels of arsenic in the environment generally do not determine the specific form of arsenic present. Most inorganic and organic arsenic compounds are white or colorless powders that do not evaporate. They have no smell, and most have no special taste. People normally take in small amounts of arsenic in the air, water, soil and food. Of these, food is usually the largest source of arsenic (ATSDR 2005a).

As reported in ATSDR's *Toxicological Profile on Arsenic* (ATSDR 2005a), drinking water generally contains an average of 2 micrograms per liter (µg/L) (or 2 ppb) of arsenic. For arsenic in drinking water, the primary exposure of concern is ingestion (oral exposure). Neither skin contact nor inhalation of vapors is expected to pose harm—arsenic is not readily absorbed through the skin, nor is it volatile (ATSDR 2005a).

Current understanding of arsenic's toxicology suggests that at low-level exposures, arsenic compounds detoxify, that is, they change into less harmful forms, then excrete in the urine. At higher exposures, the body's capacity to detoxify arsenic can be exceeded. When this happens, blood levels of arsenic increase and harmful health effects might occur. Saturation of the body's detoxification mechanism might explain why arsenic adverse health effects appear to exhibit a threshold—a minimal effective dose that might result in health effects (ATSDR 2005a).

For the 13 wells in the Plaquemine area with completed exposure pathways, arsenic was detected in all 13. Still, only one of these wells (Well G) is used for domestic purposes, which includes oral (ingestion) exposures. On April 25 and June 1, 2001, LDEQ collected and analyzed water samples from Well G and detected arsenic at levels of 13.7 ppb and 18 ppb. These arsenic concentrations exceed ATSDR's chronic child EMEG of 3 ppb, chronic adult EMEG of 10 ppb, and CREG of 0.02 ppb. Concentrations in Well G met EPA's former MCL of 50 ppb. But EPA has since adopted a new 10-ppb MCL standard, and public water systems must now (since January 23, 2006) comply with this new standard. Although Well G is a private (i.e., not public) well, both detections exceed the new EPA standard.

The data for Well G are limited; ATSDR nonetheless assumed the two levels found in 2001 are representative of ongoing exposures and thus derived exposure doses for adults and children (see Appendix C). Exposure doses help to determine the extent to which ingesting water every day containing the maximum detected concentration of arsenic in this well (18 ppb) might be associated with harmful health effects. ATSDR assumed adult exposures would occur for 70 years (a lifetime) and child exposures would occur for 6 years. ATSDR found that an adult ingesting water containing the highest concentration of arsenic detected in Well G is likely to be exposed to 0.0005 milligrams per kilogram per day (mg/kg/day) of arsenic. A child is likely to be exposed to 0.001 mg/kg/day. (Appendix C describes the equation and assumptions used to estimate arsenic exposure doses from drinking water from Well G.)

ATSDR developed a provisional acute oral MRL for arsenic of 0.005 mg/kg/day (ATSDR 2005a). Acute exposure to arsenic can cause irritation to the stomach and intestines, with symptoms such as pain, nausea, vomiting, and diarrhea. When an estimated acute dose of arsenic is below 0.005 mg/kg/day, these noncancerous harmful effects are unlikely. Both the estimated arsenic adult dose (0.0005 mg/kg/day) and child dose (0.001 mg/kg/day) are below the acute oral MRL. Therefore, acute exposures (≤ 14 days) are unlikely to result in noncancerous harmful effects.

Both the estimated arsenic adult and child doses in Well G exceeded ATSDR's chronic oral MRL of 0.0003 mg/kg/day. ATSDR considers its MRL accurate, given that it is supported by a number of well-conducted epidemiological studies that identify reliable NOAELs and LOAELs for dermal effects (ATSDR 2005a). As stated previously, concentrations above health guidelines such as the MRL are not necessarily harmful. Thus ATSDR reviewed the scientific literature on arsenic to evaluate whether noncancer harmful health effects would be likely to occur at the estimated doses. ATSDR based its chronic oral MRL on one of the most common and characteristic effects of arsenic ingestion: a pattern of skin changes that include hyperpigmentation and hyperkeratosis. These dermal effects have been noted in a majority of human studies involving repeated arsenic ingestion. Collectively, the studies indicate that the threshold dose for hyperpigmentation and hyperkeratosis is approximately 0.002 mg/kg/day (ATSDR 2005a). Well G's estimated arsenic doses for adults and children are below this noncancer threshold dose. Therefore, available data suggest that daily ingestion exposures to the arsenic levels in Well G are unlikely to result in noncancer harmful health effects.

With regard to cancer, arsenic is classified as a human carcinogen. Several foreign epidemiological studies (including Taiwan and Chile) have reported chronic ingestion of water containing several hundred parts per billion can increase the risk of cancer in the skin, liver, bladder, kidneys, prostate, and lungs (ATSDR 2005a). Studies in U.S. populations exposed to arsenic in drinking water have not yielded the cancer incidences noted in these other countries.

For example, U.S. studies have not detected an increased frequency of skin cancer in small populations ingesting water containing arsenic at levels of around 100–200 ppb (ATSDR 2005a). Daily ingestion exposures to the arsenic levels in Well G (13.7 ppb and 18 ppb) are below the levels reported in these U.S studies, suggesting that cancerous harmful health effects are unlikely.

Yet whether this difference is due to smaller U.S. study populations or to potential differences in nutritional or socioeconomic conditions of these other countries is currently unknown. In addition, little information is available to address arsenic cancer risk in the low parts-per-billion range, such as at the levels found in Well G water. Consequently, Well G homeowners could be exposed to levels of arsenic that may increase their risk of cancer. The actual risk cannot be determined—the toxicity of arsenic at low doses is uncertain—and only limited Well G groundwater data are available. In addition, the arsenic concentrations in Well G are above EPA's MCL regulatory standard. Prudent public health practice calls for Well G homeowners to reduce their drinking water exposures. They can accomplish this by limiting their ingestion of water from this well (such as by drinking bottled water) or by adding a treatment system to remove the arsenic (such as by reverse osmosis).

In addition to Well G, 12 other wells contained arsenic detections. Well QQ, which is used for bathroom activities such as hand washing in an automobile repair garage, had the highest arsenic detection (217 ppb). Arsenic was also detected at a maximum concentration of 12 ppb in Well B, 5 ppb in Well S, 5 ppb in Well T, and 19 ppb in Well EE. These wells are used for bathroom activities such as hand washing or emergency showering. In addition, arsenic was detected in Well A (15–27 ppb), Well D (6–16 ppb), Well H (10–27 ppb), Well N (51.2–64 ppb), Well P (15.4–26 ppb), Well V (18.5–43 ppb), and Well LL (6.4 ppb). These wells supply water to fill ponds or to irrigate gardens.

The arsenic detections from these 12 wells are above some of ATSDR's comparison values. Ten wells showed arsenic detections above EPA's MCL regulatory standard as well. Of note, ATSDR's comparison values and EPA's MCLs are based on ingesting 2 liters of water every day for life. The exposures associated with the water from these 12 wells do not include drinking the water (oral exposure). The exposures are limited to dermal contact and inhalation of vapors. As stated previously, neither skin contact nor inhalation of vapors is expected to pose harm—arsenic is not readily absorbed through the skin, nor is it volatile. Therefore, harmful health effects are unlikely to occur from contact with the arsenic levels detected in the water from these 12 Plaquemine area wells. As a prudent public health measure, however, ATSDR recommends the water from Wells A, B, D, H, P, N, V, EE, LL, and QQ not be used as drinking water in the future unless retesting of the well water shows arsenic levels below EPA's MCL.

Manganese

Manganese is a naturally occurring substance found in many types of rock. Manganese does not have a special taste or smell. In nature, manganese occurs as a solid, forming mixtures with oxygen, carbon, and silica. These manganese compounds are mined and refined to yield manganese metal, which is primarily used in the steel industry. Manganese metal is also used in dietary supplements and as an ingredient in ceramics, fertilizers, and pesticides (ATSDR 2000).

Manganese is an essential trace element necessary for good health. Diets deficient in manganese can result in serious illness, leading to problems with blood clotting, skin disorders, and metabolic disorders, as well as interfering with normal growth, bone formation, and reproduction. Manganese appears in several food items, including grains and cereals. Food is usually the most important route of exposure for humans and typical daily intakes range from 1–5 mg/day (ATSDR 2000).

Some manganese compounds dissolve in water. A 1962 survey of public drinking water supplies in 100 large U.S. cities reported 97% contained less than 100 ppb of manganese. A 1969 survey of 969 systems reported 91% contained less than 50 ppb, with a mean concentration of 22 ppb. Several other studies reported similar manganese concentrations, with mean values ranging from 4–32 ppb. As with arsenic, the primary exposure route of concern for manganese in groundwater is ingestion (oral exposure). Neither skin contact nor inhalation of vapors is expected to pose harm—manganese does not penetrate the skin readily, nor is it volatile (ATSDR 2000).

Manganese was detected in eight active wells. The highest concentration was detected in Well QQ (353 ppb), which is used for bathroom activities such as hand washing. Manganese was detected at a maximum concentration of 188 ppb in Well A, 172 ppb in Well B, 183 ppb in Well H, 173 ppb in Well N, 178 ppb in Well P, 100 ppb in Well V, and 166 ppb in Well EE. These wells are used for a variety of purposes, including pond supply, garden irrigation, and sanitary supply.

Manganese levels in these eight active wells are above EPA's SMCL of 50 ppb. Although considered safe to drink, EPA found that manganese levels above 50 ppb may stain clothes or plumbing fixtures. From a health perspective, these manganese levels are below ATSDR's drinking water RMEGs for child exposure (500 ppb) and adult exposure (2,000 ppb). In summary, because

a. very little manganese is absorbed through the skin,
b. manganese is not volatile,
c. the residents are not drinking the well water, and
d. manganese levels are below ATSDR's health-based drinking water comparison values,

site-specific exposures to manganese are unlikely to result in harmful health effects.

3.2 Volatile Organic Compounds

Vinyl chloride— the chemical that initiated the groundwater plume investigation in the Plaquemine area—was detected in groundwater along with several other volatile organic compounds (VOCs). These VOCs are bromodichloromethane, bromoform, carbon disulfide, chloroform, dibromochloromethane, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, methylene chloride, PCE, and *m,p*-xylene. The following describes ATSDR's public health evaluation of these volatile chemicals.

Vinyl Chloride

At normal temperatures vinyl chloride is a colorless, flammable gas with a mild, sweet odor. It is a manufactured chemical, used to make a common plastic product called polyvinyl chloride (PVC). PVC appears in a variety of plastic products, including pipes, wire and cable coatings, and furniture and automobile upholstery. Vinyl chloride also results from the breakdown of other chemicals, such as PCE.

If it is near the surface, vinyl chloride in water and soil evaporates rapidly, and vinyl chloride in the air breaks down in a few days. Vinyl chloride is unlikely to build up in plants or animals that one might eat (ATSDR 2004a). If vinyl chloride gas contacts the skin, a small amount may pass through the skin and enter a person's body. Vinyl chloride is however more likely to enter a person's body when that person breathes air or drinks water containing it (ATSDR 2004a).

Vinyl chloride was detected in five active private wells (Wells A, H, N, V and LL). All five wells showed vinyl chloride levels below ATSDR's noncancer EMEGs of 30 ppb for children and 100 ppb for adults. Because vinyl chloride was detected below ATSDR's noncancer CVs, noncancer harmful health effects are unlikely to occur.

That said, all five wells did show detections of vinyl chloride above ATSDR's CREG of 0.03 ppb. Vinyl chloride was also detected in Well N (4.8 and 7.3 ppb) and Well LL (2.4 ppb) at levels above EPA's MCL of 2 ppb. These drinking water values (ATSDR's CREG and EPA's MCL) are based on ingesting 2 liters of water every day for life. In the area under investigation here vinyl chloride was detected in five wells currently used to maintain the water level in ponds or to irrigate home gardens. The five wells are not used as drinking water sources. Therefore, the routes of exposure are dermal contact and inhalation of vapors, not ingestion. Exposure would be expected to occur frequently during warmer months, but only sporadically during colder months.

Most of the vinyl chloride in the pond water and hose water is released into the air almost immediately, thereby decreasing the levels of vinyl chloride in the water. Because only small amounts of vinyl chloride pass through the skin and most of the vinyl chloride is released to the air, dermal contact with vinyl chloride-contaminated water from these five Plaquemine area wells is unlikely to cause harm.

Vinyl chloride has been consistently associated with elevated incidences of rare angiosarcomas of the liver. These elevated incidences occurred in workers exposed repeatedly to high indoor air concentrations of vinyl chloride (Zocchetti 2001). At the five Plaquemine area wells vinyl chloride air exposures occur outdoors. In addition, the low levels of vinyl chloride released to the open air from the well water would be expected to dissipate quickly. The levels of vinyl chloride detected in these five Plaquemine area wells are not expected to harm currently exposed residents because

a. the residents are not drinking the well water,
b. only the most protective vinyl chloride CVs for drinking water were exceeded, and
c. the vinyl chloride outdoor air levels are expected to be much lower than the vinyl chloride indoor air levels associated with angiosarcomas of the liver in workers.[1]

[1] In the MGTP health consultation, ATSDR determined domestic use (including drinking and showering) of well water with the maximum vinyl chloride level of 13.8 ppb would not be expected to result in adverse health effects (ATSDR 2004b). Of note, the maximum vinyl chloride detection in the wells evaluated in this health consultation (7.3 ppb in Well N) is less than the maximum detected concentration in the MGTP well system.

Trihalomethanes

Trihalomethanes (THM) are a group of four chemicals formed along with other disinfection byproducts when chlorine, used to control microbial contaminants in drinking water, reacts in water with naturally occurring organic and inorganic matter. Bromodichloromethane, bromoform, dibromochloromethane, and chloroform are collectively referred to as THMs. EPA set the MCL for total THMs at 80 ppb. ATSDR has no CVs for total THMs.

Chloroform was detected in Well V at 3 ppb. The other THMs (bromodichloromethane, bromoform, and dibromochloromethane) were not detected in this well. The chloroform level is below EPA's total THM MCL of 80 ppb and below chloroform's ATSDR chronic EMEGs for child exposure (100 ppb) and adult exposure (400 ppb) (ATSDR 1997). Well V supplies water for a golf course pond; therefore, in addition to chloroform being below the THM MCL and chloroform's EMEGs for drinking water exposures, exposure is limited to occasional dermal contact and inhalation of vapors. Therefore, harmful health effects are unlikely.

THMs were also detected in Well H. In April 2001, LDEQ detected all four THMs in Well H at a combined total of 128 ppb, which is above the EPA total THM MCL. In October 2002 and June 2003, however, EPA did not detect any of these chemicals in Well H (detection limit was 1 ppb). In April 2001, bromodichloromethane, bromoform, and dibromochloromethane were also above their respective ATSDR CREGs (ATSDR 1989, ATSDR 2005b). All four chemicals were detected below their respective ATSDR EMEGs for child and adult exposures. As stated previously, ATSDR and EPA base their drinking water comparison values and standards on the assumption that a person ingests 2 liters of water every day for life. Well H is used for pond supply and garden irrigation, which results in dermal contact and inhalation of vapors, not daily oral exposure. Also, additional testing of this well in 2002 and 2003 did not detect these chemicals, which indicates chronic exposure is not occurring at the levels detected in April 2001. Therefore, harmful health effects are unlikely to result from current site-specific exposures to this well water.

Other VOCs

Although several other VOCs were detected in Plaquemine area groundwater, they were all below ATSDR's health-based comparison values or EPA's MCLs. Carbon disulfide was detected at 2 ppb in Well P, which is below its ATSDR RMEGs for child exposure (1,000 ppb) and adult exposure (4,000 ppb). *Cis*-1,2-dichloroethene was detected in 5 of the 13 wells with completed exposure pathways. All levels (ranging from 0.245 ppb to 5 ppb) are below ATSDR's intermediate EMEGs for child exposure (3,000 ppb) and adult exposure (10,000 ppb), as well as EPA's MCL of 70 ppb. Although *trans*-1,2-dichloroethene was detected in Well V at a maximum concentration of 0.44 ppb, this is below EPA's MCL of 100 ppb and ATSDR's intermediate EMEGs for child exposure (2,000 ppb) and adult exposure (7,000 ppb). In April 2005, Dow Chemical detected in Well V methylene chloride at 4.3 ppb and PCE at 0.6 ppb. These detections are below ATSDR's comparison values and below EPA's MCLs. The one detection (0.7 ppb) of *m,p*-xylene in Well QQ is below ATSDR's chronic EMEGs for child exposure (6,000 ppb) and adult exposure (20,000 ppb), as well as EPA's MCL of 10,000 ppb. These wells are used for a variety of purposes, including pond supply, garden irrigation, and sanitary supply. Exposure results in dermal contact and inhalation of vapors. As stated previously, because these VOCs are below comparison values for drinking water exposures, harmful health effects are unlikely.

3.3 Total Organic Carbon and Alkalinity

Total organic carbon (TOC) analysis is a commonly used methodology that measures the carbon content of dissolved and particulate organic matter present in water. Drinking water is disinfected to kill disease-causing microorganisms such as bacteria and viruses and parasites. But the chemical disinfectants also react with naturally occurring disinfection byproduct precursors to form disinfection byproducts (DBPs) (EPA 2001a). Some of the DBPs, such as the THMs mentioned previously, can be of health concern (EPA 2001b). TOC values are a direct reflection of naturally occurring materials in water that have the potential to form these DBPs.

Alkalinity is a measure of the capacity of the water to neutralize a strong acid, that is, the measure of how much acid can be added to water without causing a significant change in pH. Alkalinity is related to the amount of dissolved calcium, magnesium, and other compounds in the water and as such, alkalinity tends to be higher in so-called harder water. Alkalinity can result from naturally occurring materials such as carbonate and bicarbonate. Naturally occurring maximum alkalinity levels up to approximately 400 mg/L (or 400,000 ppb) as calcium carbonate are not considered a risk to human health (EPA 1986).

Drinking water systems that use conventional filtration treatment are required to remove specified percentages of TOC that may react with chemical disinfectants to form DBPs. Removal (e.g., when TOC levels are above 2 mg/L or 2,000 ppb) is achieved through a treatment technique such as enhanced coagulation or enhanced softening, unless a system meets alternative criteria (EPA 1999). TOC removal percentages are dependent on alkalinity, as TOC removal is generally more difficult in higher alkalinity waters.

TOC and alkalinity were analyzed for in nine active private wells (Wells A, B, H, N, P, V, EE, LL and QQ). TOC was detected in Well A (2,160–9,600 ppb), Well B (7,400 ppb), Well H (1,800–6,100 ppb), Well N (9,000 ppb), Well P (870–16,600 ppb), Well V (1,980–10,100 ppb), Well EE (480–10,900 ppb), Well LL (2,200 ppb) and Well QQ (7,400 ppb). Alkalinity was detected at a maximum concentration of 256,000 ppb in Well A, 166,000 ppb in Well B, 166,000 ppb in Well H, 168,000 ppb in Well N, 206,000 ppb in Well P, 186,000 ppb in Well V, 250,000 ppb in Well EE, 167,000 ppb in Well LL and 177,000 ppb in Well QQ. Had the water supplied a municipal drinking water system, these TOC and alkalinity levels would have required treatment. Of note, because these private wells are not so used, treatment is not required and DBPs will not be created. Also of note, the alkalinity concentrations are all below 400,000 ppb and, therefore, unlikely to harm human health.

3.4 Selected Anions

EPA and LDEQ analyzed some groundwater samples for the anions chloride, nitrate, nitrite, and sulfate. ATSDR does not have CVs for these anions. The following describes ATSDR's public health evaluation of these select anions.

Chloride

Chloride is a salt consisting of two elements, one of which is chlorine. Chloride makes up about 0.15% of a person's body weight. Chloride is essential in the maintenance of the body's acid-base and fluid balance. It is also an essential component of the gastric (digestive) juices. Chloride has no recommended dietary allowance, but it is readily available in the food supply, mainly from table salt. It is also found in many vegetables (Medline Plus® 2004). Chloride in water may impart a salty taste (Symons 2001).

The maximum levels of chloride in Well A (19,400 ppb), Well B (7,900 ppb), Well H (18,000 ppb), Well N (18,500 pbb), Well P (16,500 pbb), Well V (20,700 ppb), Well EE (7,730 ppb), Well LL (26,100 ppb) and Well QQ (19,100 pbb) are below EPA's SMCL for chloride in public drinking water systems of 250 mg/L (or 250,000 ppb). Levels at or below the SMCL are not considered a risk to human health for ingestion exposures. The wells identified here are used for a variety of purposes, including pond supply, garden irrigation, and sanitary supply. The exposures from these wells are not only below the SMCL—in the Plaquemine area they are limited to dermal contact and inhalation of vapors. Therefore, under site-specific exposure scenarios the levels of chloride detected in these six Plaquemine area wells are unlikely to cause harmful health effects.

Nitrate and Nitrite

Nitrates and nitrites are nitrogen-oxygen chemical units. They combine with various organic and inorganic compounds. The most extensive use of nitrates is in fertilizer (EPA 2005d).

In the bloodstream nitrates can convert into nitrites and react with hemoglobin to form methemoglobin. High levels of nitrates in drinking water pose a health hazard to bottle-fed infants because of the potential risk of methemoglobinemia, or so-called blue baby syndrome. To protect public health, EPA set the MCL for nitrates at 10 parts per million (ppm) (or 10,000 ppb) and nitrites at 1 ppm (or 1,000 ppb). The maximum levels of nitrates in Well A (40 ppb), Well P (39 pbb), Well V (176 ppb), and Well EE (80 ppb) are below the EPA MCL for nitrate. Nitrite levels in Well A (4 ppb), Well P (3 ppb), and Well EE (5 ppb) are below its EPA MCL. Furthermore, because Wells A, P, and V only supply water to local golf course ponds, no infants are bottle-fed with it. Well EE is used by a facility that is inside a locked fence, is not permanently staffed, and is used only infrequently by adult employees during bathroom activities. Therefore, under site-specific exposure scenarios the levels of nitrates and nitrites detected in these Plaquemine area wells are unlikely to result in harmful health effects.

Sulfate

Sulfates are naturally occurring substances found in minerals, soil, and rocks. They are present in ambient air, groundwater, plants, and food. The principal commercial use of sulfate is in the chemical industry. Sulfates are discharged into water in industrial wastes and through atmospheric deposition (EPA 2003b). Sulfates in drinking water may cause a bitter taste (Symons 2001).

The maximum sulfate levels in Well A (20,500 ppb), Well H (16,000 ppb), Well N (22,600 ppb), Well V (30,500 ppb), Well LL (34,500 ppb) and Well QQ (7,000 ppb) are below the EPA SMCL of 250 mg/L (or 250,000 ppb). Levels at or below the SMCL are considered as posing no risk to human health for ingestion exposures. The wells under investigation here are used for a variety of purposes, including pond supply, garden irrigation, and sanitary supply. In addition to containing sulfate levels below the SMCL, the exposures from these Plaquemine area wells are limited to occasional dermal contact and vapor inhalation. Therefore, the levels of sulfates detected in these four Plaquemine area wells are, under site-specific exposure scenarios, unlikely to harm exposed residents.

3.5 Natural Attenuation Parameters

Natural groundwater attenuation includes a variety of processes which, under favorable conditions, can act without human intervention to reduce the concentration of contaminants in groundwater. At sites containing PCE contamination, the existence of *cis*-1,2-dichloroethene and vinyl chloride gives the first indication that natural attenuation is occurring or has occurred. In addition to analyzing for these chemicals, measuring natural attenuation parameters, such as ethane, ethene, and methane, can assist EPA with groundwater plume characterization and source identification.

EPA analyzed for ethane and ethene as dissolved gases in some wells, but detected them only in one well at 1 ppb and 2 ppb, respectively. ATSDR has no CVs for ethane and ethene. These nontoxic chemicals were detected in Well A, which supplies water to a golf course pond. The levels of these highly volatile gases would be expected to disperse rapidly in the air during activities such as filling a pond (HSDB 2005). As such, the levels detected in Well A would be unlikely to harm people who come in contact with the water and who breathe vapors.

Methane was detected as a dissolved gas in Well A (910–1,900 ppb), Well B (2,300 ppb), Well H (240–930 ppb), Well N (170 ppb), Well V (52–64 ppb), Well EE (2,200–4,410 ppb), Well LL (210 ppb) and Well QQ (140 ppb). These wells are used for a variety of purposes, including pond supply, garden irrigation, and sanitary supply. Although methane is essentially nontoxic at low concentrations, it can accumulate in the air in confined spaces and can become a fire and asphyxiation hazard (HSDB 2005). That said, the levels of this volatile gas would be expected to disperse rapidly in the open air during activities such as filling a pond or watering a garden. Although methane could potentially accumulate in bathrooms, air exchange from people entering and leaving the bathrooms should disperse this volatile gas. Consequently, the methane levels detected in these Plaquemine area active wells would be unlikely to harm people who contact the water and who breathe in methane gas.

4.0 Community Concerns

During the groundwater plume investigation, Plaquemine area residents expressed several concerns to ATSDR or LDEQ staff regarding their well water. The concerns are addressed in the following text:

- *Could current exposures to contaminated well water result in hair loss, learning problems in school-age children, and skin rashes?*

ATSDR is not aware of any studies documenting that the chemical levels detected in the 13 active wells could be associated with hair loss.

Some studies show exposure to high levels of chemicals such as arsenic and manganese may affect children’s learning ability—that is, children may do more poorly on tests (ATSDR 2000, ATSDR 2005a). As stated in Section 3, however, under site-specific conditions of exposure the levels of arsenic and manganese detected in active Plaquemine area wells are unlikely to result in harmful health effects, including learning problems.

Although several chemicals are associated with harmful dermal health effects, these effects are not seen at the levels found in the active private wells. For example, skin contact with inorganic arsenic can cause redness and swelling (ATSDR 2005a), but only at levels much higher than the site-specific detected levels. Overall, given the limited data available for review, ATSDR finds it unlikely that exposure to water from the 13 active wells would result in harmful health effects.

- *Can children safely play in sprinklers that rely on water from active private wells within the contamination plume?*

A review of the available data for the 24 active wells shows that children who occasionally play in sprinklers supplied by that well water are unlikely to be harmed. Of the 24 active wells, 11 did not show detectable levels of chemicals. Although in 13 of the 24 active wells a few chemicals exceed protective health-based guidance values, these guidance values are based on ingesting 2 liters of that well water every day for life. Occasional dermal and inhalation exposures when playing in a sprinkler would not be expected to result in harmful health effects in children (see Section 3).

- *Several wells supply water to ornamental ponds. The ponds support fish such as bass, brim, and sunfish. Are fish from these ponds safe to eat?*

ATSDR does not have data on chemical levels in fish from Plaquemine area ponds. Of the chemicals detected in active wells used to supply water for these ponds, arsenic and manganese can bioaccumulate in fish. The arsenic in fish is, however, usually present as organic arsenic, which does not appear to be harmful to humans (ATSDR 2005a). And manganese can bioaccumulate in lower organisms (e.g., phytoplankton, algae, mollusks, and some fish), but biomagnification in food-chains is not expected to be significant (ATSDR 2000). Therefore, the chemical levels detected in groundwater from wells that supply Plaquemine area ponds (Wells A, H, N, P, and V) would not be expected to bioaccumulate in pond fish at levels of health concern for residents who occasionally eat fish taken from those ponds.

- *Several wells in the contamination plume supply irrigation water to family gardens. Is produce grown in these gardens safe to eat?*

Residents report eating produce grown in their home gardens. No data exist regarding potential levels of chemicals in their garden produce. Still, the chemicals detected in well water used for gardening (Wells D, H, and LL) are not likely to build up. For example, vinyl chloride is unlikely to build up in edible plants (ATSDR 2004a). Thus for residents who eat homegrown produce, the chemical levels detected in groundwater from Wells D, H, and LL would not be expected to accumulate in that produce at levels of health concern.

- *One well supplied a heat pump unit at a building supply business. Water from the heat pump was discharged directly to a nearby drainage ditch. Would past exposures to the discharged water or drainage ditch soils be of health concern?*

Until May 2001, Well L supplied water for a heat pump. On one occasion, LDEQ tested for and detected arsenic in this well at a concentration of 21 ppb, which is within the range of arsenic concentrations previously evaluated in this health consultation. LDEQ detected *cis*-1,2-dichloroethene at a maximum concentration of 1 ppb, which is also within the range of *cis*-1,2-dichloroethene concentrations previously evaluated in this health consultation. Routes of potential exposure to these chemicals were dermal contact with the discharged water and inhalation of vapors. As stated previously, at these levels neither skin contact with well water nor inhalation of vapors would be expected to pose a risk of harm (see Section 3 for further information).

LDEQ also detected vinyl chloride in Well L at a maximum concentration of 58 ppb, which is greater than the maximum concentrations evaluated thus far in this health consultation. Routes of potential exposure to vinyl chloride from this well were dermal contact with the discharged water and inhalation of vapors. Still, most of the vinyl chloride would be released into the open air almost immediately, thereby decreasing the levels of vinyl chloride in the discharged water. The vinyl chloride released to the open air from this discharged water would be expected to dissipate quickly. As such, potential intermittent dermal and inhalation exposures to vinyl chloride levels in discharged water and open air would not be expected to result in harm.

Occasional dermal contact with the drainage ditch soil is a potential exposure pathway, but no data exist for the ditch soil. In general, the chemical levels detected in groundwater from Well L would not be expected to accumulate in soil at levels of health concern for residents who occasionally contact the soil in this area.

- *One resident has an inactive well that overflows during high river stages. This resident is concerned about the safety of taking sips of water from the overflowing well. This resident also reports that the fruits from his Satsuma, Lemon, Lime, and Grapefruit trees are turning odd colors.*

Inactive wells are not usually maintained properly. As such, ATSDR does not recommend drinking water from overflowing inactive wells in the Plaquemine area.

Regarding this resident's specific inactive well, in 2001 vinyl chloride was detected at 8.1 ppb, 8 ppb, and 7 ppb. Nearby monitoring wells showed vinyl chloride as high as 97 ppb. Although the vinyl chloride levels in this inactive well (about 8 ppb) exceed EPA's MCL regulatory standard (2 ppb), this standard is based on ingesting 2 liters of water from that well every day for life. Occasional sips of water containing about 8 ppb vinyl chloride are unlikely to cause harm. As stated previously, however, ATSDR does not recommend drinking water from overflowing inactive wells in the Plaquemine area.

In June 2001, in a water sample from this same resident's well, LDEQ detected arsenic at 453 ppb. Whether this sample is representative of arsenic concentrations in the well water, or whether the elevated arsenic concentration is an anomaly, is unknown. Studies conducted in other countries found harmful health effects (e.g., cancer and skin effects in persons who regularly for many years drank water containing arsenic) in the hundreds of parts per billion. Because of the high arsenic level detected in this well, ATSDR recommends against using the water from this well for any purpose until the water is retested and demonstrated to be within federal drinking water standards.

Regarding the fruit trees, roots from trees generally do not extend below the tree height, and most fruit trees are 30 feet tall or less at maturity. The top of the upper Plaquemine aquifer is approximately 100 to 110 feet below the ground surface. Therefore, the fruit trees are most likely not in contact with the upper Plaquemine aquifer. While groundwater contamination is most likely not responsible for the odd-colored fruit, ATSDR notes that the odd colors may be due to many other factors, including lack of fertilizer, wrong pH in the soil, over watering, diseases, or pests.

5.0 Child Health Considerations

In communities faced with air, water, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than are adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dust, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus adults need as much information as possible to make informed decisions regarding their children's health.

Thirteen active wells in the Plaquemine area contain detectable levels of chemicals. Current well water exposures while wading in ponds and washing hands in bathrooms are unlikely to harm children. ATSDR recommends, however, that as a prudent public health measure children reduce their drinking water exposures to Well G water unless and until retesting shows arsenic levels are below federal drinking water standards.

6.0 Conclusions

ATSDR evaluated the exposure pathways and maximum chemical levels detected in 24 active wells in the Plaquemine area. Contamination was not detected in 11 of them. For the other 13 wells, residents are exposed to detectable levels of chemicals, including arsenic and vinyl chloride. The 13 wells are used for a variety of purposes, such as for drinking water, irrigation water, and bathroom water. For each chemical detected in the 13 wells, ATSDR reviewed the exposure durations, routes of exposure, maximum detected chemical levels, and available chemical data on levels known to cause harmful health effects in animals and humans to determine whether harmful health effects are likely. Under site-specific exposure conditions, ATSDR concludes that exposure to the water from the 13 active Plaquemine area wells is unlikely to result in harmful health effects.

Although the detected arsenic levels are not likely to result in harmful health effects, uncertainties do surround the toxicity of arsenic at low doses, and only limited groundwater data are available. Because Well G is a current source of drinking water, prudent public health practice calls for the Well G homeowners to reduce their arsenic exposures. ATSDR also considers that other measures taken to prevent future contaminant exposures and safeguard the Plaquemine area water supply would be protective of public health.

7.0 Recommendations

1. Well G homeowners should reduce their drinking water exposures by limiting ingestion of their well water (such as drinking bottled water) or by adding a treatment system to remove the arsenic (such as by reverse osmosis).
2. Wells A, B, D, H, P, N, V, EE, LL, and QQ should not be used as a source of drinking water in the future unless retesting of the well water shows arsenic levels below regulatory drinking water standards.

3. Actions to safeguard the Plaquemine area water supply should continue, such as monitoring the performance of the aquifer and performing a remediation study.

8 .0 Public Health Action Plan

The purpose of the public health action plan (PHAP) is to ensure that this evaluation not only identifies potential and ongoing public health hazards, but the PHAP also provides a plan of action designed to mitigate and to prevent harmful human health effects resulting from exposure to hazardous substances in the environment. The public health actions that are completed, ongoing and planned are listed below.

Completed Actions

- From 2001 to 2004, LDEQ and EPA collected water samples from Plaquemine area wells.
- In May 2004, ATSDR released in final form the Myrtle Grove Trailer Park Health Consultation.
- In October 2004, EPA released the results of its investigation of groundwater flow directions and contaminant source area evaluation for the Plaquemine aquifer.
- In 2004, Dow Chemical, EPA and LDEQ entered into a Cooperative Agreement to evaluate plume conditions and ensure protection of the City of Plaquemine's drinking water supply.

Ongoing Actions

LDEQ, EPA, and Dow Chemical perform semiannual monitoring of 15 Plaquemine area wells and quarterly monitoring of the Plaquemine sentinel monitoring wells.

Planned Actions

Through the Cooperative Agreement, Dow Chemical, EPA and LDEQ will perform a remediation study to assess the long-term need for remediation and, if necessary, evaluate options for remediation (EPA 2004f).

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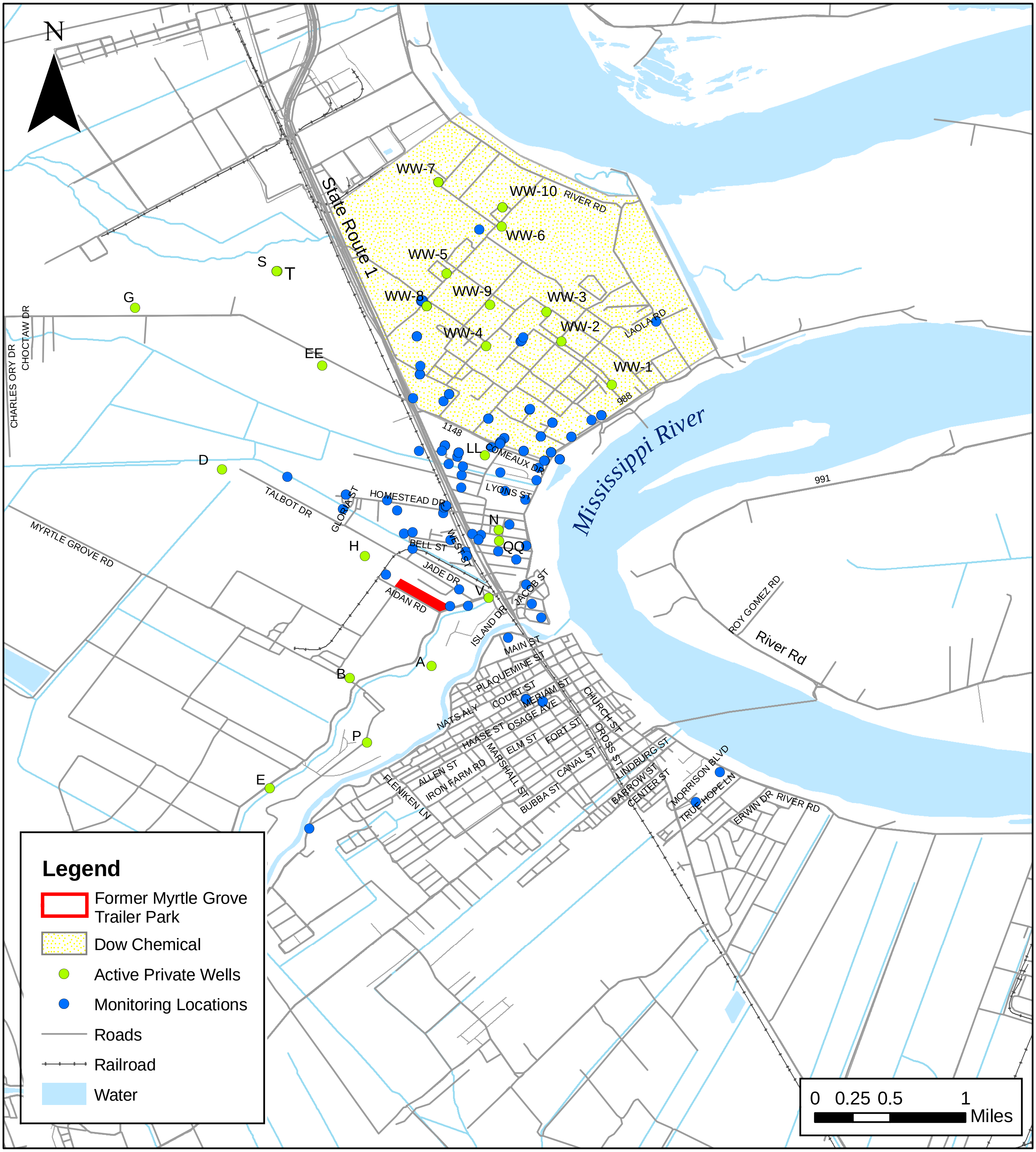
Appendix A: Figure



Plaquemine Area Groundwater

Monitoring Locations

Plaquemine, Louisiana

Base Map Source: 1995 TIGER/LINE FILES

JVA022106

Figure 1

GRASP
GEOSPATIAL RESEARCH, ANALYSIS & SERVICES PROGRAM

Appendix B: Tables

Table 1: Active Private Well Information

Well Owner	Well Use	Well ID	Year Installed	Depth (feet)	Sample Dates
Resident	Domestic supply	G	Unknown	150	4/2001; 6/2001
Resident	Residential pond supply and garden irrigation	H	1995	180	4/2001; 5/2001; 12/2001
Resident	Residential pond supply	N	Unknown	~120	5/2001; 12/2001
Resident	Garden irrigation	D	Unknown	168	4/2001; 6/2001
Resident	Garden irrigation	LL	~1970	~170	5/2001
Business (golf course)	Ornamental pond supply	A	2000	180	4/2001; 5/2001; 12/2001; 12/2003; 7/2004; 4/2005; 11/2005
		P	2000	175	5/2001; 7/2001; 12/2001; 12/2003; 7/2004; 4/2005; 11/2005
		V	2002	180	2/2002; 12/2003; 7/2004; 4/2005; 11/2005
Church	Sanitary supply and Baptismal pool	E	Unknown	Unknown	8/2001
Business (antiques)	Sanitary supply	B	Unknown	~100	4/2001; 5/2001; 12/2001
Business (automobile repair garage)	Sanitary supply	QQ	~1980	145	6/2001; 12/2001
Business (manufacturer)	Emergency shower supply	S	2000	186	9/2001
		T	2000	189	9/2001
Business (manufacturer)	Sanitary supply and emergency shower supply	EE	~1994	~170	6/2001; 2/2002; 12/2003; 7/2004; 4/2005; 11/2005
Business (manufacturer)	Emergency fire system and process water supply	WW-1	1964	480	7/2001
		WW-2	1963	445	7/2001
		WW-3	1963	445	7/2001
		WW-4	1974	460	7/2001
		WW-5	1977	409	7/2001
		WW-6	1976	430	7/2001
		WW-7	1976	410	7/2001
		WW-8	1979	454	7/2001
		WW-9	1979	440	7/2001
		WW-10	1996	420	7/2001

Source: [LDEQ] Louisiana Department of Environment Quality. 2004. May 7 email from Steve Chustz, LDEQ, to Danielle Langmann, ATSDR, with attached LDEQ Plaquemine groundwater results and well information (file names: Plaq Summary LDEQ.xls and Plaquemine Well Depths.xls). Baton Rouge, LA.

Table 2: Other Groundwater Information

Well ID	*Well Use*	*Comments*
F, L, CC, II	Business supply	Wells are inactive.
C, FF, PP, TT	Irrigation supply	Wells are inactive.
I, J, K, M, Q, R, U, W, AA, BB, DD, HH, JJ, KK, MM, NN, RR, SS, UU, VV	Domestic Supply	Wells are inactive.
EPA-1, EPA-2, EPA-3, EPA-4, EPA-5	Monitoring Well	EPA installed five wells. Monitoring wells are all active.
SW-1, SW-2, SW-3, SW-4	Sentinel Well	Wells installed by the City of Plaquemine. Sentinel wells are all active.
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19	Soil Borings	Dow Chemical drilled soil borings. For each soil boring location, water samples were collected at various depths. Soil borings are currently plugged.
PZ-27, PZ-29, PZ-30, PZ-31, PZ-32, PZ-33, PZ-34, PZ-35, PZ-36, PZ-37, PZ-38, PZ-39, PZ-40, PZ-41, PZ-42, PZ-43, PZ-44, PZ-45, PZ-46, PZ-47, PZ-48, PZ-49, PZ-50, PZ-51, PZ-52, PZ-53, PZ-54, PZ-55, PZ-56	Piezometers	Dow Chemical installed piezometers. Piezometers are all active. PZ-34 is also know as location GG (a former agricultural supply well).

Source: [LDEQ] Louisiana Department of Environment Quality. 2004. May 7 email from Steve Chustz, LDEQ, to Danielle Langmann, ATSDR, with attached LDEQ Plaquemine groundwater results and well information (file names: Plaq Summary LDEQ.xls and Plaquemine Well Depths.xls). Baton Rouge, LA.

Table 3: Groundwater Monitoring Data (page 1 of 3)

Well ID	*Chemical*	*Concentration Range (ppb)*
A	Arsenic	15 – 27
	Manganese	178 – 188
	cis-1,2-Dichloroethene	ND – 0.245 J
	Vinyl Chloride	ND – 0.9
	TOC	ND – 9,600
	Alkalinity	217,000 – 256,000
	Chloride	16,400 – 19,400
	Nitrate	40
	Nitrite	4
	Sulfate	ND – 20,500
	Ethane	ND – 1
	Ethene	ND – 2 J
	Methane	910 – 1,900*
B	Arsenic	7 – 12
	Manganese	164 – 172
	TOC	7,400
	Alkalinity	166,000
	Chloride	7,900
	Methane	2,300*
D	Arsenic	6 – 16
G	Arsenic	13.7 – 18
H	Arsenic	10 – 27
	Manganese	182 – 183
	Bromodichloromethane	ND – 23
	Bromoform	ND – 44
	Chloroform	ND – 9
	Dibromochloromethane	ND – 52
	Vinyl Chloride	0.11 – 0.12 J
	TOC	1,800 – 6,100
	Alkalinity	163,000 – 166,000
	Chloride	15,100 – 18,000
	Sulfate	10,800 – 16,000
	Methane	240 – 930*

* Identifies compounds whose concentrations exceeded the calibration range; therefore the sample was diluted and reanalyzed.
J estimated value
ND not detected
ppb parts per billion
TOC total organic carbon

Table 3 continued (page 2 of 3).

Well ID	*Chemical*	*Concentration Range (ppb)*
N	Arsenic	51.2 – 64
	Manganese	170 – 173
	cis-1,2-Dichloroethene	1 – 4
	Vinyl Chloride	1 – 7.3
	TOC	9,000
	Alkalinity	168,000
	Chloride	18,500
	Sulfate	22,600
	Methane	170*
P	Arsenic	15.4 – 26
	Manganese	172 – 178
	Carbon disulfide	2
	cis-1,2-Dichloroethene	1
	TOC	870 – 16,600
	Alkalinity	192,000 – 206,000
	Chloride	11,400 – 16,500
	Nitrate	39
	Nitrite	3
	Methane	1,800 – 4,000*
S	Arsenic	5
T	Arsenic	5
V	Arsenic	18.5 – 43
	Manganese	96.9 – 100
	Chloroform	ND – 3
	cis-1,2-Dichloroethene	3.1 J – 5
	trans-1,2-Dichloroethene	0.34 J – 0.44 J
	Methylene Chloride	4.3 J
	Tetrachloroethene	0.6 J
	Vinyl Chloride	0.8 J – 2
	TOC	ND – 10,100
	Alkalinity	145,000 – 186,000
	Chloride	18,700 – 20,700
	Nitrate	176
	Sulfate	13,000 – 30,500
	Methane	52* – 64

* Identifies compounds whose concentrations exceeded the calibration range; therefore the sample was diluted and reanalyzed.
J estimated value
ND not detected
ppb parts per billion
TOC total organic carbon

Table 3 continued (page 3 of 3).

Well ID	*Chemical*	*Concentration Range (ppb)*
EE	Arsenic	12 – 19
	Manganese	158 – 166
	TOC	480 – 10,900
	Alkalinity	232,000 – 250,000
	Chloride	5,500 – 7,730
	Nitrate	ND – 80
	Nitrite	5
	Methane	2,200 – 4,410
LL	Arsenic	6.4
	cis-1,2-Dichloroethene	2.5 – 3.1
	Vinyl Chloride	ND – 2.4
	TOC	2,200
	Alkalinity	167,000
	Chloride	26,100
	Sulfate	34,500
	Methane	210
QQ	Arsenic	133 – 217
	Manganese	321 – 353
	m,p-Xylenes	0.7 J
	TOC	7,400
	Alkalinity	177,000
	Chloride	19,100
	Sulfate	7,000
	Methane	140*

Sources: [EPA] US Environmental Protection Agency. 2004b. May 6 email from Nancy Fagan, EPA, to Danielle Langmann, ATSDR, with attached Plaquemine combination table of groundwater results (file name: Plaquemine Combination Table1.xls). Environmental Protection Agency Region 6, Dallas, Texas.

[EPA] US Environmental Protection Agency. 2004c. May 6 email from Nancy Fagan, EPA, to Danielle Langmann, ATSDR, with attached Plaquemine November 2002 groundwater results (file name: Nov_2002_Results.xls). Environmental Protection Agency Region 6, Dallas, Texas.

[EPA] US Environmental Protection Agency. 2004d. May 6 email from Nancy Fagan, EPA, to Danielle Langmann, ATSDR, with attached Plaquemine June 2003 groundwater results (file name: Jun_2003_Results-rev.xls). Environmental Protection Agency Region 6, Dallas, Texas.

[LDEQ] Louisiana Department of Environment Quality. 2005. November 30 email from Steve Chustz, LDEQ, to Danielle Langmann, ATSDR, with attached LDEQ and Dow Chemical Plaquemine groundwater results (file names: PLAQ SUMMARY.xls and DOW CA SUMMARY.xls). Baton Rouge, LA.

* Identifies compounds whose concentrations exceeded the calibration range; therefore the sample was diluted and reanalyzed.

J estimated value

ND not detected

ppb parts per billion

TOC total organic carbon

Appendix C: Derivation of Arsenic Exposure Doses

In April and June 2001, the Louisiana Department of Environmental Quality (LDEQ) detected arsenic in a private drinking water well (Well G) in the Plaquemine area. Sampling data indicated arsenic levels at 13.7 and 18 parts per billion (ppb). To evaluate the likelihood that arsenic in this private well might be associated with harmful health effects, ATSDR calculated arsenic exposure doses. An exposure dose is an estimate of how much of the contaminant a person may contact based on their actions and habits. Estimating an exposure dose requires identifying how much, how often, and how long a person may come in contact with some concentration of the contaminant in a specific medium. The following text describes the equation and assumptions used to estimate exposure doses from drinking arsenic-contaminated water from Well G in Plaquemine, Louisiana.

Exposure Dose Equation for Drinking Water Exposures

$$D = \frac{C \times IR \times AF \times EF}{BW}$$

where

D	=	arsenic exposure dose in milligrams per kilogram per day (mg/kg/day)
C	=	arsenic concentration in milligrams per liter (mg/L)
IR	=	ingestion rate in liters per day (L/day)
AF	=	bioavailability factor (unitless)
EF	=	exposure factor (unitless)
BW	=	body weight in kilograms (kg)

In the absence of complete exposure-specific information, ATSDR applied several conservative exposure assumptions to define site-specific exposures as accurately as possible. Specifically, ATSDR derived arsenic exposure doses using the following assumptions about a person's use of this private well water as a primary drinking water source:

- The maximum detected concentration of arsenic (18 ppb or 0.018 mg/L) was assumed to be representative of ongoing arsenic levels in this private well.
- For the ingestion rate, ATSDR estimated that an adult drinks 2 liters and a child drinks 1 liter of water a day and that all drinking water comes from this private well.
- The assumed bioavailability factor was 1—that is, all of arsenic to which a person ingested is assumed to enter the bloodstream.
- The assumed exposure factor was 1, representing daily exposure to the contaminant.
- The body weight of an adult was assumed to be 70 kg and a child was 10 kg.

Using these conservative assumptions, ATSDR found that an adult ingesting drinking water containing the highest concentration of arsenic detected in Well G was likely to be exposed to 0.0005 mg/kg/day of arsenic. A child was likely to be exposed to 0.001 mg/kg/day.