

Health Consultation

Review of Groundwater Sampling Results from the
Myrtle Grove Trailer Park Well System

MYRTLE GROVE TRAILER PARK

PLAQUEMINE, IBERVILLE PARISH, LOUISIANA

EPA FACILITY ID:

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

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 document has previously been released for a 30 day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The health consultation has now been reissued. 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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1 Summary

In August 2001, the Agency for Toxic Substances and Disease Registry (ATSDR) was petitioned for a public health assessment of the Myrtle Grove Trailer Park (MGTP) site in Iberville Parish, Plaquemine, Louisiana (Petition Letter 2001). Myrtle Grove residents are concerned about their past exposure to vinyl chloride-contaminated water. The purpose of this evaluation is to determine whether the residents' health ailments could be the result of drinking, showering, bathing, cooking, washing dishes, and swimming in contaminated water.

ATSDR reviewed available information on the MGTP water supply, summarized environmental sampling results, evaluated human exposures, and addressed community concerns. Until March 31, 2001, a well system supplied the 58 mobile homes on the site with drinking water from the Plaquemine aquifer. A review of available water sampling data indicated that between 1997 and 2001 vinyl chloride concentrations had been above the US Environmental Protection Agency's (EPA's) maximum contaminant level (MCL) of 2 parts per billion (ppb). However, the vinyl chloride (4.9 ppb to 13.8 ppb) detected in the well system would not be expected to produce adverse health effects in residents (either adults or children) who used the water for household (i.e., drinking, showering, bathing, etc.) and outdoor purposes. Other contaminants detected in the well system were below levels of public health concern. The reported health concerns are not likely to be related to exposure to vinyl chloride or any other contaminant—or a combination of contaminants—detected in the MGTP well water.

ATSDR recommends continued monitoring of the vinyl chloride to better characterize the plume and determine its source. Since March 2001, the EPA and the Louisiana Department of Environment Quality (LDEQ) have collected samples from area wells surrounding the trailer park.

ATSDR is evaluating the additional data for public health significance and will report the results of the evaluation in a separate health consultation.

2 Background and Statement of Issues

In August 2001, ATSDR was petitioned for a public health assessment of the Myrtle Grove Trailer Park (MGTP) site in Plaquemine, Louisiana. MGTP residents are concerned about their past exposure to vinyl chloride-contaminated water. The purpose of this evaluation is to determine whether the residents' health ailments could be the result of drinking contaminated water (oral exposure) and showering, bathing, cooking, washing dishes, and swimming in contaminated water (inhalation and dermal exposure).

2.1 History

Prior to the development of the MGTP, the land was used for sugarcane production. The site is bounded by sugarcane fields to the west and north. The Green Acres housing addition abuts the site along the eastern border. To the south is Bayou Jacob Road and the Island Country Club community. The MGTP residents are concerned that two facilities involved in vinyl chloride operations, Dow Chemical and Shintech Incorporated, are located within two miles of the trailer park. At this time, however, the source of the vinyl chloride contamination is unknown. Figure 1, Appendix A, provides a site location map, and Figure 2, Appendix A, provides demographic statistics for the area.

MGTP was developed in the early 1980s. The well system that originally provided water to the park was located on the south side of the site just west of the first mobile home. It consisted of a fenced concrete slab containing two well heads. Water was drawn from the Plaquemine aquifer about 180 feet below ground surface. A 55-gallon drum containing chlorine (with an automatic feed system) was located at each well head before the water entered two large pressure tanks. The tanks fed a common distribution pipe providing water to the 58 trailer park residences (ATSDR 2001a).

The Louisiana Department of Health and Hospitals (LDHH) is required to conduct tests every 2 to 3 years on any drinking water well system that has more than 15 connections. In February 2001, during routine testing, vinyl chloride (8.45 ppb and 11.2 ppb) was detected in the MGTP well system above the US Environmental Protection Agency's maximum contaminant level (MCL) of 2 ppb. Park residents were placed on city-supplied water (ATSDR 2001a). Subsequently, LDHH performed a records review for the MGTP well system. Vinyl chloride levels were above the MCL in November 1997 and September 1998 (see Table 2, Appendix B).

Since becoming aware of the vinyl chloride groundwater plume, the Louisiana Department of Environmental Quality (LDEQ) has taken actions to assure that no one is drinking water from the contaminated aquifer. LDEQ identified numerous private wells in the Plaquemine area through discussions with long-time residents, door-to-door visits, public meetings, and calls to a LDEQ toll-free line. Although some private wells still exist, none are currently used as a primary drinking water source. However, several wells within the contamination plume have been used

or are being used by local businesses. Some wells are used for sanitary purposes (as water supply for toilets and sinks); some wells supply water to ponds; some wells are used for irrigating small gardens; and one well supplied a heat pump unit at a building supply business. Because this document focuses solely on the MGTP well system, ATSDR will evaluate the Plaquemine area well data for public health significance in a separate health consultation.

Although many groundwater samples were collected and analyzed, the source of the vinyl chloride is unknown. LDEQ and EPA are gathering information and well data to understand area groundwater flow.

2.2 ATSDR Activities

On August 21, 2001, ATSDR staff members had one-on-one visits with three Myrtle Grove homeowners. During these meetings, the homeowners expressed numerous health concerns including mild headaches, skin rashes and irritation, changes in skin pigment, numbness, high blood pressure, nose bleeds, stomach problems, nausea, asthma, miscarriages, behavior problems and learning disabilities in school-age children, and breast cancer. An open house meeting was held later that evening at the Louisiana Environmental Action Network (LEAN) office in Plaquemine, Louisiana. Approximately 40 area residents, several lawyers, and several reporters attended the meeting.

During a conference call held in early December 2001 with MGTP representatives and representatives of LEAN, ATSDR was asked about available health care programs. ATSDR staff members outlined both state and federal health care programs potentially available for park residents. An outline of the available programs is provided in Appendix G. The available programs are also discussed in the Community Concerns Evaluation section of this document.

Exposure from the MGTP well water system stopped in March 2001. Park residents want to know whether their current health problems could be caused by past vinyl chloride exposure. In late December 2001, residents reported health problems that included developing lumps covering the body, severe coughing leading to nose bleeds, vomiting blood, blood in stool, and liver cancer.

On March 11, 2002, ATSDR staff visited the MGTP site to meet with the residents, tour the area, and gather data. During one-on-one meetings, residents again expressed concerns about skin rashes, liver cancer, and stomach problems. The residents also wanted information on “how vinyl chloride moves through the body”. They questioned whether vinyl chloride could cause genetic damage and lupus, whether arsenic was detected in the water, and whether the contamination could be responsible for rust-colored water that smells like sewage. During an MGTP organizational meeting held that evening at the LEAN office in Plaquemine, residents expressed concern about the effects of vinyl chloride exposure in combination with common household cleaning products. The residents also wanted to know if there were any studies on exposure to vinyl chloride in drinking water and whether park residents could be added to an

ATSDR disease registry for vinyl chloride. LEAN wanted information on other communities with similar groundwater exposure to vinyl chloride. They also expressed concerns about past and present vinyl chloride-contaminated groundwater exposures in other areas of Iberville Parish, specifically the bayou and rural River Road areas.

ATSDR's Division of Health Education and Promotion assisted in coordinating health care provider training for the Myrtle Grove area. On April 5, 2002, the LDHH sponsored the health care provider training. Experts from Tulane University School of Public Health and Meharry Medical College provided training in general environmental and occupational medicine. In addition, the training covered the potential health effects of exposure to vinyl chloride. Continuing medical education credits were offered to the physicians. ATSDR information cards "Environmental Exposure History" and "Evaluating Environmental Exposures" were also given to those attending.

A public meeting was held in Plaquemine the day after the health care provider training. Community members received information about ATSDR, were provided with a shortened version of the training given to the health care providers, asked questions, and provided input on future health education activities.

On July 23, 2002, ATSDR staff held a public meeting to discuss the results of the draft health consultation with MGTP residents and other concerned individuals. ATSDR staff addressed questions revolving around topics such as medical monitoring, lack of data (both environmental samples and human samples), EPA's safe drinking water standard for vinyl chloride, and the properties of vinyl chloride. There was an open discussion about strategies for improved communication between the agency and concerned individuals.

At the request of the petitioner, ATSDR held a Community Stress Train-the-Responder course to increase the level of understanding in the community about stress and living near hazardous waste sites. On August 15, 2002, a public meeting was held to determine the level of community interest in offering stress training to health and social services staff and local physicians. A one-day course on community stress was given on August 26, 2002. The complete two-day course was given on September 23 and 24, 2002. This course was offered to local government representatives, mental health and social services staff members, local physicians, business representatives, and interested community representatives. The interaction between the health and social service providers and the government, business, and community representatives resulted in building the group's capacity to act as a resource for stress and environmental health issues in the community (ATSDR 2002).

3 Discussion

In this section, ATSDR addresses the question of whether exposure to contaminants at the maximum concentrations detected at MGTP could result in adverse health effects. ATSDR methodology is discussed in Appendix C.

A completed exposure pathway to groundwater existed for MGTP residents from sometime after April 1994 through March 2001. The residents reported that approximately 600 people were exposed. Routes of past exposure were ingestion (eating or drinking), inhalation (breathing), and dermal contact (skin contact). Since March 2001, park residents have been using water supplied by the city of Plaquemine distribution system. Currently, residents are no longer using the MGTP well system water. Table 1, Appendix B, provides information on the exposure pathways.

Samples collected from the MGTP well system were tested for water quality parameters including volatile organic compounds (VOCs). With the exception of three samples, data quality control and assurance procedures were adequate. And, although ATSDR reported the three sample concentrations in our tables, these data were not used in our public health evaluation because there were issues related to the precision of the reported concentrations.

In April 1994, sampling and analysis of the well system did not detect vinyl chloride or any other VOCs. Sampling of the well system in 1997, 1998, and 2001 indicated vinyl chloride levels ranging from 4.9 parts per billion (ppb) to 13.8 ppb. Results of the analysis of the vinyl chloride sampling are provided in Table 2, Appendix B.

Several other VOCs were detected in the well system. Bromodichloromethane, bromoform, chlorodibromomethane, and chloroform were detected in the distribution pipe water. These four chemicals are by-products of the chlorination process. Although trichloroethylene (TCE) and tetrachloroethylene (PCE) were not detected, a common breakdown product of these chemicals, cis-1,2-dichloroethylene, was detected. Table 3 of Appendix B provides the sampling results for all the VOCs detected.

The available data are limited because water samples were not collected from the MGTP well system before April 1994. ATSDR staff members reviewed the available data. Information on the chemicals detected is provided in the following text.

3.1 Vinyl Chloride

Vinyl chloride is a colorless, flammable gas at normal temperatures, with a mild, sweet odor. It is a manufactured chemical that is used to make a common plastic product called polyvinyl chloride (PVC). PVC is used to make 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 trichloroethylene, tetrachloroethylene, and cis-1,2-dichloroethylene. MGTP residents were exposed to water contaminated with vinyl chloride by drinking the water (oral exposure) and by showering, bathing, cooking, washing dishes, and swimming in contaminated water (inhalation and dermal exposure).

3.1.1 Oral Exposure

The maximum concentration of vinyl chloride recorded in drinking water at MGTP was 13.8 ppb. This would correspond to maximum doses of 1.38 micrograms per kilogram per day ($\mu\text{g}/\text{kg}/\text{day}$) for a 10-kilogram (kg) child drinking 1 liter of water per day (L/day) and 0.39 $\mu\text{g}/\text{kg}/\text{day}$ for a 70-kg adult drinking 2 L/day. Due to the volatility of vinyl chloride (a gas), high concentrations are not sustainable in water. For that reason, there have been no drinking water studies of vinyl chloride toxicity performed in either animals or humans.

Using a chronic rat feeding and a model for improved extrapolation to equivalent human doses, EPA derived a chronic oral reference dose (RfD) of 3 $\mu\text{g}/\text{kg}/\text{day}$. A reference dose is an estimate of daily exposure to a contaminant unlikely to cause noncancer adverse health effects. The doses received by adults and children drinking water provided by the MGTP well system are less than half of EPA's reference dose. Therefore, noncancer adverse health effects are not likely at the vinyl chloride levels detected at MGTP.

Vinyl chloride is a known human carcinogen under certain circumstances. Vinyl chloride has been consistently associated with elevated incidences of rare angiosarcomas of the liver in humans, but only by inhalation and only at the extremely high worker exposures that were once associated with certain job categories that no longer exist (Zocchetti 2001). This same form of liver cancer has also been produced experimentally in rats administered chronic oral doses of 300 $\mu\text{g}/\text{kg}/\text{day}$ by gavage¹ in oil. In humans, this dose would be numerically (if not biologically) equivalent to 10,500 ppb in drinking water for an adult drinking 2 L/day or 3,000 ppb for a child drinking 1 L/day, for several decades. These levels are over 650 times higher than the maximum recorded level of vinyl chloride in the MGTP well system. Using EPA's oral slope factor, the oral exposure route would be associated with a lifetime excess cancer risk of about 5.52×10^{-5} (see Appendix F). In qualitative terms, this represents a very low risk of cancer.

Detectable vinyl chloride exposures may well have been limited to less than 7 years (that is, from sometime after April 1994 to March 2001) because vinyl chloride was not detected during

¹The term "gavage" refers to the administration of a test substance directly into the animal's stomach via a tube inserted down its throat. Because rats cannot vomit, this practice enables investigators to know exactly how much of the substance the animals received.

the April 1994 sampling event. Also, daily fluid intake for the residents probably consisted of more than just the water from the tap at home. The fluid intake would have included water from other sources (for example, water consumed while at school or at work). These considerations would tend to further reduce estimated exposures.

Based on the available data, it is unlikely that the highest level of vinyl chloride detected in drinking water at MGTP would have resulted in adverse health effects in exposed residents (see Appendices D and F for further details). Nevertheless, because EPA's federal safe drinking water standards are legally enforceable, residents of MGTP were provided with an alternative source of drinking water as a prudent (that is, conservative) public health measure.

3.1.2 Inhalation and Dermal Exposures

Residents inhaled vinyl chloride vapors and their skin was exposed to vinyl chloride when showering, bathing, cooking, and washing dishes with water provided by the MGTP well system, as well as swimming in water provided by the well system. However, air data are not available for the kitchen and bathroom areas, nor for the outdoor area near where an above-ground pool had been located. ATSDR used a one-compartment model to predict the residents' inhalation and dermal exposures from showering with the maximum detected level of vinyl chloride in their water. Based on a maximum water concentration of about 14 ppb, the estimated maximum concentration of vinyl chloride in air during showering would be 40 ppb (see Appendix E). Bathing, cooking, dishwashing, and swimming would result in additional, but much lower, exposures to vinyl chloride than would showering (see Appendix E). Therefore, throughout the comparisons discussed in the following text, 40 ppb is used as the maximum site-specific concentration of vinyl chloride in air.

Vinyl chloride has neurotoxic properties at greater than 4,000 ppm (or 4,000,000 ppb) in air (ATSDR 1997b). The lowest known noncancer effect level for vinyl chloride in air is 10,000 ppb for increased relative liver weight in rats exposed 6 hours per day (hrs/day), 6 days per week (days/wk), for 6 months. The lowest known cancer effect level (CEL) for vinyl chloride in air is 5,000 ppb for mammary gland cancer in rats exposed 4 hrs/day, 5 days/wk for 1 year (ATSDR 1997b). The maximum estimated inhalation exposures at MGTP (40 ppb) were 250 and 125 times lower, respectively, than the lowest known effect levels in rats for noncancer and cancer effects.

Before effective engineering controls were applied, the incidence of hepatic angiosarcoma, a rare form of liver cancer, was increased in workers who experienced prolonged, high-level inhalation exposure (usually hundreds or thousands of parts per million). This type of cancer is very rare in the general population. Even in workers with a history of occupational exposure to vinyl chloride, the incidence of angiosarcoma of the liver is relatively low, being confined almost exclusively to PVC production workers, especially those who used to manually clean the inner walls of large vinyl chloride reactor vessels, a job category which, thanks to closed-system technology, no longer exists. Elevated levels of angiosarcoma of the liver have not been seen in

other individuals involved in the production or use of vinyl chloride. This low and limited occurrence of increased risk would seem to suggest that the carcinogenic potency of vinyl chloride is also relatively low (Williams and Weisburger 1991, page 182). For Myrtle Grove residents, the inhalation exposure route would be associated with a lifetime excess cancer risk of about 1.56×10^{-6} (see Appendix F). In qualitative terms, this represents a very low risk of cancer.

Based on the available data, ATSDR concludes that neither the magnitude nor the duration of dermal and inhalation exposures to vinyl chloride at MGTP was sufficient to produce any clinically adverse health effects (see Appendices E and F).

3.1.3 Total Vinyl Chloride Exposures

The limited data available suggest that the vinyl chloride contamination entered the well system sometime after April 1994. Sampling of the well system in April 1994 did not detect vinyl chloride, but in November 1997, the levels were 4.9 ppb and 6.3 ppb. The levels generally increased in the following years to a maximum concentration of 13.8 ppb in March 2001. Based on current toxicologic knowledge, it is unlikely that undocumented exposures in the past could have caused clinically significant health effects unless those exposures exceeded the maximum levels of vinyl chloride detected in water (13.8 ppb) or estimated in air (40 ppb) at MGTP by more than a hundredfold over an extended period of time. By comparison, maximum estimated total exposures to vinyl chloride from all routes combined (drinking, showering, bathing, cooking, dishwashing, and swimming) at MGTP were most likely less than 2–3 times maximum drinking water exposures alone. The total, worst-case exposures by all routes would be associated with a lifetime excess cancer risk of about 5.7×10^{-5} (see Appendices D, E, and F). In qualitative terms, this represents a very low risk of cancer. More importantly, data on the toxicology, epidemiology, and physical chemistry of vinyl chloride indicate that exposures at MGTP were of insufficient magnitude and duration to cause adverse health effects. ATSDR therefore concludes that the total vinyl chloride exposures at MGTP were not high enough to produce any of the known adverse health effects attributable to vinyl chloride.

3.2 Other Volatile Organic Compounds

The common chlorination by-products (also known as trihalomethanes) bromodichloromethane (3.1 ppb–20.6 ppb), bromoform (16.0 ppb–16.9 ppb), chlorodibromomethane (28.6 ppb–30.2 ppb), and chloroform (10.3 ppb–13.0 ppb) were all detected in the MGTP well system distribution line. These levels are normal for chlorinated drinking water and would not be expected to cause adverse health effects (ATSDR 1989, ATSDR 1990, ATSDR 1997a). In addition, cis-1,2-dichloroethylene (1.0 ppb–2.16 ppb) was detected at levels below health-based comparison values. ATSDR determined that none of these VOCs pose a hazard to human health, even at the highest levels detected in the water at MGTP.

3.3 Chemical Mixtures

The individual contaminants detected at this site are present at levels that are below those that might be expected to result in adverse health effects. On the basis on information from studies on the effects of chemical mixtures, ATSDR has concluded that the combined effect of the contaminants detected at the site is also not likely to result in adverse health effects. This conclusion is based on studies that suggest that a mixture produces no adverse noncancer health effects in dosed animals when the components of that mixture are present at levels below their respective no-observed-adverse-effect levels (NOAELs), which are concentrations estimated to produce no adverse effects in animals treated separately with the individual chemicals (Wade et al. 2002, Feron et al. 1993, Jonker et al. 1990, Jonker et al. 1993a, Jonker et al. 1993b, Groten et al. 1991). Carcinogens exhibit thresholds in the laboratory, no less than do noncarcinogens (SOT 1981, Williams and Weisburger 1991, Cunningham et al. 1994). It is likely that the previously stated principle regarding mixtures of noncarcinogens applies to mixtures of carcinogens as well. All measured levels of contaminants in the MGTP well system are below all known adverse effect levels published in ATSDR's toxicological profiles. Therefore, ATSDR considers that the combined effect of all of these contaminants is not likely to be of public health concern. (See Appendix H for additional information on chemical mixtures.) Nevertheless, ATSDR considers it prudent public health policy to reduce or eliminate wherever possible, excess exposure to substances which at higher concentrations can be toxic.

4 Community Concerns Evaluation

Because the petition focused on vinyl chloride exposures, ATSDR's responses in this section also focus on vinyl chloride. Most of the information concerning the known adverse health effects of vinyl chloride is from studies of vinyl chloride workers who breathed high levels in the past. These workplace levels are not typically found in either the workplace or the general environment today. The following text provides ATSDR's evaluation of each health concern that was reported by park residents with respect to the best toxicologic knowledge currently available.

- **Mild headaches.** Mild headaches are common, nonspecific symptoms that can be caused by many different chemical, physical, and/or biological stimuli, none of which affect everyone the same way at the same level of exposure. For example, some people get a headache when they breathe fresh air immediately after breathing very high levels of vinyl chloride (for example, higher than 1,000 ppm). In volunteers exposed for 5 minutes, twice a day, for 3 consecutive days, vinyl chloride caused headaches only at 20,000,000 ppb (ATSDR 1997b). This level is 500,000 times higher than the 40 ppb worst-case exposure level that MGTP residents might be exposed to while showering. Therefore, no such effects would be expected to occur from the maximum estimated exposures that may have occurred at MGTP. All concentrations of all substances detected in water at MGTP were below the lowest levels known to cause adverse health effects in animals or humans, including headaches.

- ***Skin rashes and irritation and changes in skin pigment.*** A worker who accidentally had escaping vinyl chloride vapor sprayed on his hands initially experienced numbness, then erythema (redness) and edema (swelling), before developing second degree burns (Harris 1953, ATSDR 1997b). Vinyl chloride is a liquid only under cold and pressure. Thus, the dermal effects of vinyl chloride are specific not to the chemical itself, but to the rapid evaporation from the skin and resulting freezing of tissue. Similar dermal effects could not be caused by low parts per billion levels in water at room temperature. None of the other chemicals detected in the water at MGTP would be expected to cause such effects either, at the concentrations detected. All were present at concentrations below levels known to cause adverse health effects, including dermal effects.
- ***Numbness.*** In the previously mentioned case of a worker exposed by having liquid vinyl chloride vapor sprayed on his hands, the worker reported that his hands felt numb for a short time before marked swelling and redness developed. Some PVC production workers exposed to very high levels of vinyl chloride have also reported problems with the blood flow in their hands (Raynaud's phenomenon). Their fingers turn white and hurt when they go into the cold, and it may take a long time to recover when they go into a warm place. This condition occurred most frequently among workers who cleaned vinyl chloride reactor tanks, a job that involved some of the highest of historical exposures (ATSDR 1997b). No such effects would be expected to occur in response to the maximum estimated exposures that may have occurred at MGTP. All substances detected in the water at MGTP were present at concentrations below levels known to cause adverse effects, including numbness.
- ***High blood pressure.*** Relative to unexposed workers, there was an increased incidence and severity of high blood pressure and edema (preeclampsia) during pregnancy in female workers exposed to vinyl chloride (ATSDR 1997b). Note that hypertensive disorders occur in 1%–3% of all pregnancies and result in 20% of all maternal deaths (Koren 1994). If these effects were, in fact, caused by vinyl chloride, the levels involved were probably between 10 ppm and 100 ppm (10,000 ppb and 100,000 ppb). No such effects would be expected to occur in response to the maximum estimated exposures that may have occurred at MGTP, because all substances detected in the water at MGTP were present at concentrations below levels known to cause adverse health effects, including high blood pressure.
- ***Stomach problems and nausea.*** Some workers breathing high levels of vinyl chloride reported stomach or gastrointestinal effects (ATSDR 1997b). Approximately 32% of the vinyl chloride workers examined by Lilis et al. (1975) reported a history of "gastritis, ulcers (gastric and duodenal) and upper gastrointestinal bleeding." Other symptoms reported by vinyl chloride workers included nausea, abdominal distension, and heartburn. Loss of appetite and nausea have been reported in Singapore workers exposed to 1 ppm–21 ppm vinyl chloride (Ho et al. 1991). However, these workers were selected on the

basis of liver dysfunction. No such effects would be expected to occur in response to the maximum estimated exposures that may have occurred at MGTP, because all substances detected in the water at MGTP were present at concentrations below levels known to cause adverse health effects, including stomach problems and nausea.

Asthma. Allergic diseases such as atopic dermatitis, rhinitis, and asthma are thought to result from a dysregulated immune response to commonly encountered antigens in genetically predisposed individuals (Lambrecht 2001). The most common substances causing allergic reactions in humans are certain drugs and plant and animal proteins, such as pollen, mold spores, dust mites, roach feces, animal dander, venom, and foods. Cold dry air, stress, respiratory infections, and exercise can trigger attacks in some individuals (Meggs 2001). Perhaps 2% of the cases of asthma in the United States are occupational lung diseases in which an acquired hypersensitivity results in a minority of workers who become sensitized by exposures to high concentrations of mineral/vegetable dusts or reactive substances (for example, toluene) in air (Dean and Murray 1991, 127-200). Vinyl chloride, however, is not among these known, occupational, asthma-inducing agents. Reports regarding other respiratory effects in workers who are exposed to vinyl chloride in the workplace are contradictory. Several human studies found no increased incidence of respiratory disease among vinyl chloride workers, but several other studies found evidence of lung damage, for example, an increased incidence of emphysema. Even the worst-case estimates of maximum total exposure to vinyl chloride at MGTP by all routes (inhalation, ingestion, and dermal contact) were below levels known to cause adverse health effects, including respiratory effects.

Miscarriages. There is no credible evidence of a link between vinyl chloride and miscarriages in humans. In mice, exposures as high as 30,000 ppm (or 30,000,000 ppb), 6 hrs/day for 5 days had no effect on pre- or post-implantation loss (ATSDR 1997b). No adverse health effects should be produced in response to the maximum estimated exposures at MGTP, because all substances detected in the water at MGTP were present at concentrations below all known effect levels.

Behavior problems and learning disabilities in school-age children. There is no evidence of a link between vinyl chloride exposure and behavior problems and learning disabilities in school-age children. None of the contaminants detected in the water at MGTP were present at concentrations that would be expected to cause adverse health effects.

Cancer, particularly cancer of the liver and breast. In previous decades, before the advent of better industrial hygiene practices, the incidence of an otherwise very rare form of liver cancer (hepatic angiosarcoma) was increased (but was still relatively low) in PVC production workers, especially those who manually cleaned vinyl chloride reaction vessels, a job category that no longer exists. The inhalation exposures associated with this job most likely ran into the hundreds or thousands of parts per million (Falk and

Steenland 1998). No other form of cancer has been consistently associated with high-level occupational exposures to vinyl chloride (ATSDR 1997b, Falk and Steenland 1998). Statistically significant increases in this same form of liver cancer have been produced experimentally in rats treated with chronic oral doses of 300 µg/kg/day by gavage in oil and 5 mg/kg/day in feed, and chronic inhalation doses greater than 100,000 ppb (ATSDR 1997b). The maximum estimated oral and inhalation doses to adult residents at MGTP were about 0.39 µg/kg/day and 40 ppb, respectively. In one inhalation study, a statistically significant increase of mammary tumors was produced in female rats at concentrations as low as 5,000 ppb for 52 weeks or about half the animals' lifetime. The maximum estimated inhalation exposures at Myrtle Grove would occur only during showering and were estimated to be less than 40 ppb (see Appendix E). As stated previously, the worst-case exposures by all routes were several orders of magnitude lower than all known effect levels and would be associated with a lifetime excess cancer risk of about 5.7×10^{-5} (see Appendices D, E, and F). In qualitative terms, this represents a very low risk of cancer. ATSDR therefore concludes that no adverse health effects of either a cancer or noncancer nature would be expected to result from the maximum vinyl chloride exposures experienced by Myrtle Grove residents.

- ***Development of lumps covering the body.*** ATSDR is unaware of any vinyl chloride-associated symptoms in humans or animals that would fit this description.
- ***Severe coughing which leads to nose bleeds.*** Nose bleeds and coughing are nonspecific health effects that are not attributable to vinyl chloride exposure.
- ***Vomiting blood and blood in stool.*** Vinyl chloride exposure has not been associated with vomiting blood. In a study of workers exposed by inhalation to vinyl chloride at occupational levels, almost a third reported a history of "gastritis, ulcers (gastric and duodenal) and upper gastrointestinal bleeding" (ATSDR 1997b). None of these effects have been attributed to low-dose oral exposures to vinyl chloride. The maximum estimated exposures at MGTP were below levels known to cause adverse health effects.

In addition to addressing these specific health concerns of the Myrtle Grove residents, community residents asked ATSDR to address other issues related to vinyl chloride and the vinyl chloride groundwater plume. The following text outlines these issues.

- ***Vinyl chloride's movement through the body.*** Among other things, the time required for the body to eliminate foreign substances (such as vinyl chloride) from the body depends on the amount that first entered the body. At the maximum estimated doses, most, if not all, of the vinyl chloride to which a resident was exposed on any given day at MGTP (the total exposure from ingestion, inhalation, and dermal contact) was distributed throughout the body in the bloodstream, metabolized to other more water-soluble substances in the liver, and probably excreted in the urine within 24 hours.

- ***Vinyl chloride's link to genetic damage and lupus.*** In the past, high occupational exposures (that is, tens, hundreds, or even thousands of parts per million in air) were associated with increased levels of generally reversible genetic damage and some specific mutations. However, the levels of exposure at MGTP are not expected to be associated with any detectable increase in genetic damage. The cause of lupus is unknown, but it appears to be an autoimmune disease. High titers of anti-DNA antibodies are almost specific for systemic lupus erythematosus, and 90% of cases occur in women (Merck Manual 1992). Vinyl chloride exposure is not a known risk factor for lupus.
- ***Arsenic in drinking water.*** Analysis of the water samples collected from the MGTP well system included metal analyses. Arsenic was not detected at or above the detection limit of 20 ppb. However, it is not known whether arsenic was in the water at levels below 20 ppb. Several epidemiologic studies in the United States have not detected an increased frequency of arsenical skin cancer in populations drinking water containing 100 ppb–200 ppb arsenic (ATSDR 2000). Adverse health effects would not be expected from drinking water containing arsenic at levels of 20 ppb or less.
- ***Rust-colored water that smells like sewage.*** Iron was detected in the MGTP water system at levels ranging from 1.76 milligrams per liter (mg/L) to 2.63 mg/L. Water having an iron concentration of 0.05 mg/L may stain plumbing fixtures. Iron in excess of 1.0 mg/L can cause an unpleasant taste, and be noticeable in the taste of coffee or tea. If chlorine is added to the water system as a disinfectant, a sediment may form and cause the water to have a rusty brown cloudy effect (Salvato 1982). It is important to know that iron is an essential element needed for human health. The other compounds detected in the MGTP well system would not cause the water to be brown. None of the contaminants detected in the MGTP well system would cause the water to have a sewage-like odor.
- ***Effects of vinyl chloride exposure in combination with common household cleaning products.*** At the levels detected in the MGTP well system, no combined effects would be expected. (See Appendix H, Chemical Mixtures.)
- ***Vinyl chloride drinking water studies.*** There are no studies—in either humans or animals—of the effects of drinking water containing vinyl chloride. However, there also have never been reports of adverse health effects being produced by vinyl chloride in drinking water. Much higher concentrations are attainable in oil, so vinyl chloride is typically administered to experimental animals in oil. It has also been administered in feed. The lowest level at which less-serious noncancer effects have been seen in animals treated orally with vinyl chloride is 18 µg/kg/day for microscopic sites of cellular alteration in the livers of rats dosed throughout their lives with vinyl chloride in feed. The lowest published cancer effect is 300 µg/kg/day for angiosarcoma of the liver in rats treated throughout their lives with vinyl chloride in oil. In humans, numerically equivalent chronic (2 L/day) drinking water exposures for a 70-kg adult would be 630 ppb (for 18 µg/kg/day) and 10,500 ppb (for 300 µg/kg/day), respectively.

- ***ATSDR's National Exposure Registry.*** ATSDR established and maintains a National Exposure Registry of persons exposed to specific hazardous substances in the environment. An important purpose of the registry is to help scientists understand how long-term exposure to hazardous substances may affect human health. The registry contains subregistries for specific compounds, and currently there are four active subregistries: trichloroethylene, trichloroethane, benzene, and dioxin. Vinyl chloride is not one of the compounds for which a subregistry has been established. Additional substances will be considered in the future when chemical selection is made for the subregistries.
- ***Prevalence of vinyl chloride in groundwater.*** As reported in ATSDR's Toxicological Profile on Vinyl Chloride, most drinking water systems do not contain vinyl chloride. In a 1982 survey, vinyl chloride was found in less than 1% of the 945 groundwater supplies tested in the United States. In this survey, the concentrations found in groundwater were up to 8.4 ppb, with a detection limit of 1 ppb. A separate report released in 1982 found concentrations of vinyl chloride in drinking water wells in New York State to be 50 ppb. Another report released in 1982 found that monitoring studies in nine states reported groundwater vinyl chloride concentrations at or below 380 ppb (ATSDR 1997b).
- ***Health care options for exposed residents.*** ATSDR does not have the legal authority to provide medical care or treatment to people who have been exposed to hazardous substances.

To address the residents' health care concerns, ATSDR staff members researched available health care options and found that several health care programs are potentially available for Myrtle Grove residents. First, LDHH offers medical assistance to current and former residents of Myrtle Grove. This assistance includes an initial physical examination of people who believe they have health problems associated with vinyl chloride exposure. LDHH can also assist in accessing health care coverage such as Medicaid.

Second, the Health Resources and Services Administration (HRSA) has a health care facility in Opelousas, Louisiana, that provides primary health care services to Louisiana residents with incomes 200% below the poverty level. HRSA also has a Louisiana Child Health Insurance Plan that allows for children to receive primary medical care if their parents' income is 200% below the poverty level. Third, the Southwest Center for Pediatric Environmental Health (known as the PED unit) can provide backup support to the medical community through telephone consultations to health care professionals. More information on these programs is available in Appendix G.

- ***Physician health education for area doctors and nurses.*** ATSDR's Division of Health Education and Promotion assisted in coordinating health care provider training for the

Myrtle Grove area. Continuing medical education credits were offered to physicians in the Plaquemine area. Training was provided in general environmental and occupational medicine. In addition, the training covered the potential effects of exposure to vinyl chloride. Experts from Tulane University and Meharry Medical College presented the information to the local health care providers who attended. ATSDR information cards “Environmental Exposure History” and “Evaluating Environmental Exposures” were given to those attending.

Community health education for exposed residents. A public meeting, requested by the petitioner, was held in Plaquemine on Saturday, April 6, 2002, the day after the health care provider training. At this public meeting, community members received information about ATSDR and were provided with a shortened version of the training given to the health care providers. Community members had the opportunity to ask questions and to provide input on future activities to be conducted in the Myrtle Grove area by the Division of Health Education and Promotion.

Potential groundwater exposures throughout Iberville Parish. In addition to addressing the health concerns of Myrtle Grove residents, ATSDR was asked to address the health concerns of residents in other areas of Iberville Parish with potential exposures to the vinyl chloride groundwater plume. These health concerns include hair loss, learning problems in school-age children, and skin rashes. To date, ATSDR obtained available water data from wells identified to be within the area known to have vinyl chloride contamination. ATSDR identified potential exposures from the use of ponds that are supplied by wells within the plume area. Some ponds are used for visual landscaping, like the golf course pond, but others may occasionally be used for swimming and fishing. In addition, water from several wells within the vinyl chloride groundwater plume area is being used or has recently been used by local businesses for sanitary purposes (to supply water for toilets and sinks). One well supplied a heat pump unit at a building supply business. The water from the heat pump was discharged into a surface drainage ditch. Potential exposures also exist for a few residents who use the vinyl chloride contaminated groundwater for irrigating their gardens. At this time, with the exception of the MGTP well system, no additional wells have been identified as primary drinking water sources. ATSDR is evaluating the information on these wells for public health significance and will report the results in a separate health consultation document.

5 Child Health Considerations

Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at the Myrtle Grove Trailer Park site.

Children who are the most likely to have been exposed to groundwater contaminants include the children who lived in the mobile homes and the children who visited the trailer park. However, based on all of the available data, past exposures to vinyl chloride in indoor air and drinking water at MGTP were too low to produce any adverse health effects in children (see Section 3 and Appendix D). Assuming a 10-kg body weight and daily consumption of 1 liter of water containing 13.8 ppb vinyl chloride (the highest level detected at MGTP from 1997 to 2001), a child's exposure dose would be 1.38 $\mu\text{g}/\text{kg}/\text{day}$, or less than 8% of the lowest dose producing effects of marginal clinical significance in laboratory rodents treated throughout their entire lifetimes. However, actual exposures in children living at MGTP would potentially be lower because (1) the children may have drunk water from other sources (for example, while at school), (2) the well water that the children did drink would not have contained the maximum detected amount of vinyl chloride during the duration of the exposure period, and (3) the exposures to children at MGTP would have lasted for a relatively short period of time compared to the lifetime exposures mentioned in the animal studies. All other substances detected in the well water at MGTP were also below levels that would cause adverse health effects in children exposed to the substances.

6 Conclusions

Residents of the Myrtle Grove Trailer Park were exposed to water that contained vinyl chloride and other volatile organic chemicals. Although exposure occurred, the levels of the chemicals detected were below levels likely to result in adverse health effects. ATSDR has therefore categorized the Myrtle Grove Trailer Park site as presenting No Apparent Public Health Hazard.

The source of the vinyl chloride plume has not been determined. People living in areas surrounding the MGTP site who use well water may currently be exposed to vinyl chloride-contaminated groundwater.

7 Recommendations

Continue monitoring the vinyl chloride groundwater plume to better characterize the plume and determine its source(s).

Evaluate potential exposures to vinyl chloride-contaminated groundwater in areas surrounding the Myrtle Grove Trailer Park site.

8 Public Health Action Plan

The actions described in this section are designed to ensure that this health consultation identifies public health hazards and provides a plan of action to mitigate and prevent adverse health effects resulting from exposure to hazardous substances in the environment. The US Environmental Protection Agency (EPA), the Louisiana Department of Environmental Quality (LDEQ), the Louisiana Department Health and Hospitals (LDHH), and ATSDR are working together to address issues regarding the vinyl chloride groundwater plume in Iberville Parish, Louisiana.

8.1 Completed Actions

- In August 2001 and March 2002, ATSDR staff members visited the Myrtle Grove Trailer Park to meet with the residents, gather health concerns, and provide background information about the agency.
- Since March 2001, LDEQ has sampled numerous well locations, collected and analyzed many groundwater samples, participated in several public meetings, established a repository of information at the Plaquemine library, performed a detailed reconnaissance

- of historical activities in the area, and called in national groundwater experts for assistance.
- Since March 2001, LDEQ has taken actions to assure that no one is drinking water from the aquifer in the area of contamination. The department has identified numerous water wells in the North Plaquemine area through discussions with long-time residents, door-to-door visits, public meetings, and calls to a LDEQ toll-free line.
 - Since March 2001, EPA has scaled up its oversight of the LDHH's implementation of the Safe Drinking Water Act program including a verification audit of LDHH's drinking water data and a review of LDHH's management system for data reporting.
 - In December 2001, EPA sampled wells at numerous locations.
 - In January 2002, EPA District Attorney activities included impaneling a special state grand jury to investigate possible criminal activity in connection with vinyl chloride contamination of groundwater in Plaquemine.
 - On April 5, 2002, LDHH sponsored a health care training event. Professors from Tulane University School of Public Health and Meharry Medical College School of Medicine conducted a health care provider workshop to provide Plaquemine area doctors and nurses with training in environmental and occupational medicine and with information on the potential health effects associated with exposure to vinyl chloride.
 - On April 6, 2002, ATSDR staff members held a public meeting to provide community members with health care information and information on ATSDR. The meeting provided an opportunity for community members to ask questions and provide input to the agency.
 - On July 23, 2002, ATSDR staff members held a public meeting to discuss the results of the draft health consultation with MGTP residents and other concerned individuals. During the meeting, ATSDR was requested to extend the comment period for the document by one month (that is, until September 20, 2002).
 - On August, 15, 2002, ATSDR held a public meeting to provide an overview of the community stress program activities and to determine the community's interest in having programs offered to health and human service agencies.
 - On August 26, 2002, ATSDR held a one-day training course on community stress to increase the level of understanding about stress and hazardous substance site activities. This course was offered to health and social services staff members, physicians, and interested community representatives.
 - On September 23 and 24, 2002, the complete two-day Community Stress Train-the-Responder course was held for local government representatives, mental health and social services staff members, local physicians, and community representatives.

8.2 Ongoing Actions

- LDEQ and EPA will continue to monitor and characterize the vinyl chloride groundwater plume.

- ATSDR will continue to gather available groundwater data and verify exposure pathway information for areas surrounding the MGTP site that may currently be affected by the vinyl chloride groundwater plume.
- Local, state, and federal government agencies will continue to work together to address issues related to the vinyl chloride contamination of the Plaquemine aquifer.

8.3 Planned Actions

- ATSDR will evaluate the additional data for public health significance in a separate health consultation.

9 Public Comment

ATSDR released the Myrtle Grove Trailer Park health consultation for public review and comment from June 18, 2002, through September 20, 2002. Appendix I contains both the comments received during the public comment period and ATSDR's response to those comments.

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| | |
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Appendix A – Figures

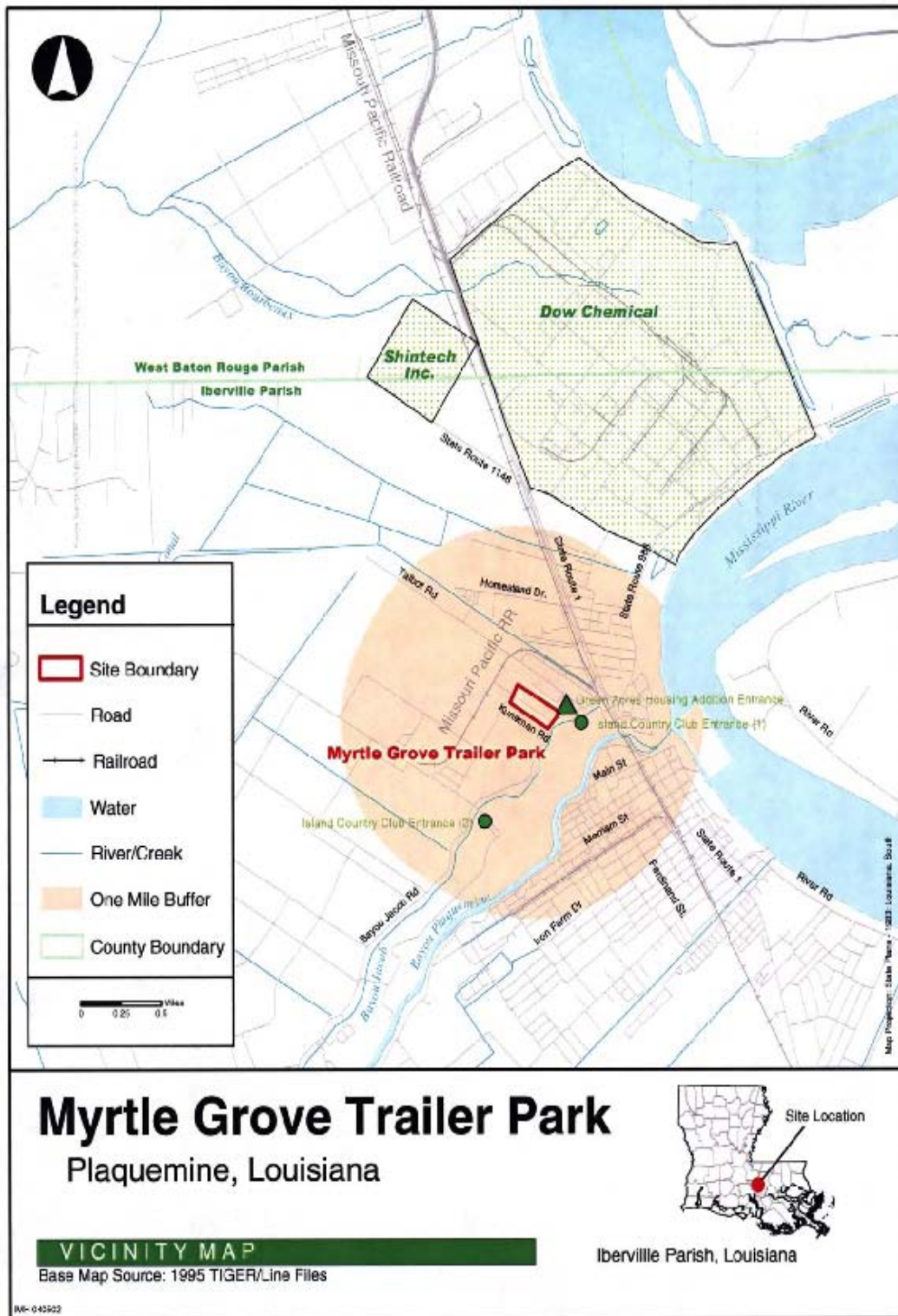


Figure 1: Myrtle Grove Trailer Park Site Location Map
Figure 1. Myrtle Grove Trailer Park Site Location Map

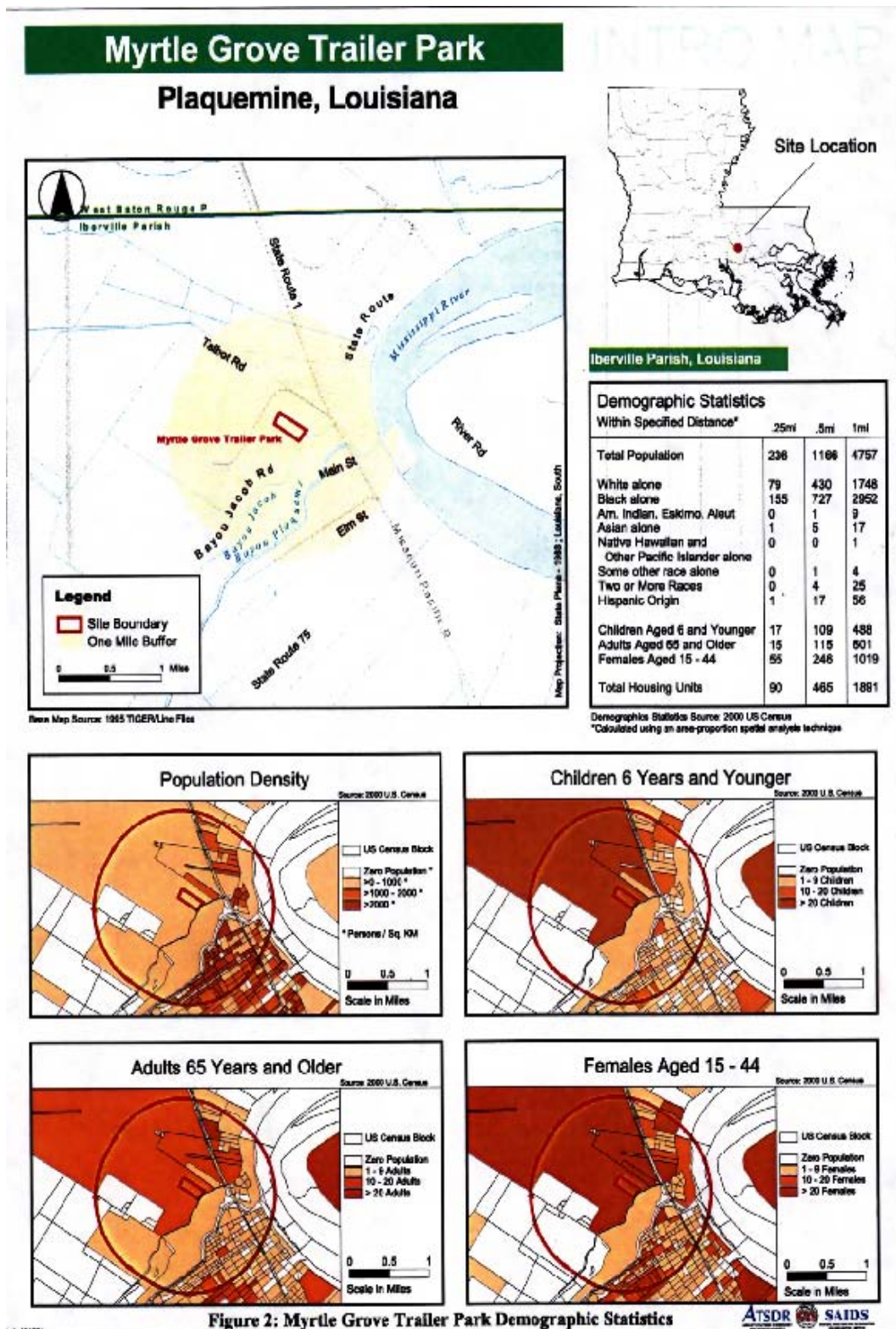


Figure 2. Demographic Statistics Within One Mile of the Myrtle Grove Trailer Park Site

Appendix B – Tables

**Table 1. Exposure Pathway Elements
Myrtle Grove Trailer Park
Plaquemine, Louisiana**

| Pathway Name | Exposure Pathway Elements | | | | | Time Frame |
|-------------------------------------|---------------------------|------------------|-------------------|-------------------------------|-----------------------|---|
| | Source | Media | Point of Exposure | Route of Exposure | Exposed Population | |
| Completed Exposure Pathways | | | | | | |
| Groundwater | Unknown | MGTP Well System | On site | Ingestion, Dermal, Inhalation | Residents of the MGTP | Past (before March 2001) |
| Eliminated Exposure Pathways | | | | | | |
| Groundwater | Unknown | MGTP Well System | On site | None | None | Current (after March 2001 to the present) |

MGTP = Myrtle Grove Trailer Park

**Table 2. Vinyl Chloride Concentrations in the
Myrtle Grove Trailer Park Well System
Plaquemine, Louisiana**

| Sample Collection Date | Well Head 1 Vinyl Chloride Concentrations (ppb) | Well Head 2 Vinyl Chloride Concentrations (ppb) | Distribution System Vinyl Chloride Concentrations (ppb) |
|-------------------------------|--|--|--|
| April 11, 1994 | ND (0.10) | ND (0.10) | NA |
| November 5, 1997 | 4.9 | 6.3 | NA |
| September 30, 1998 | 13.9* | 11.0* | NA |
| February 26, 2001 | 11.2 | 8.45 | NA |
| March 13, 2001 | 10.4 | 10.3 | NA |
| March 20, 2001 | NA | NA | 13.8 |

Source: Louisiana Department of Health and Hospitals (LDHH). 2002. January 29 letter sent by Mike Dessauer, LDHH, to Danielle Langmann, ATSDR, containing chemical sampling reports from the Myrtle Grove Trailer Park and Plaquemine Parish.

* QC was less than acceptable according to the statistical procedures required of the laboratory (that is, the instrument did not detect a prepared sample near the known level)

NA: Not available because no sample was collected

ND: Not detected (value in parenthesis is the minimum detection limit)

ppb: Parts per billion

**Table 3. Myrtle Grove Trailer Park Well System Sampling Data
Plaquemine, Louisiana**

| Compound | Well Head 1 – Concentration Range (ppb) | Well Head 2 – Concentration Range (ppb) | Distribution System – Concentration Range (ppb) |
|--------------------------|--|--|--|
| Bromodichloromethane | ND (0.10) | ND (0.10) | 3.1 – 20.6 |
| Bromoform | ND (0.23) | ND (0.23) | 16.0* – 16.9 |
| Chlorodibromomethane | ND (0.24) | ND (0.24) | 28.6 – 30.2 |
| Chloroform | ND (0.09) | 0.8 | 10.3 – 13.0 |
| cis-1,2-Dichloroethylene | 1.4 – 2.02 | 1.0 – 2.07 | 2.16 |

Source: Louisiana Department of Health and Hospitals (LDHH). 2002. January 29 letter sent by Mike Dessauer, LDHH, to Danielle Langmann, ATSDR, containing chemical sampling reports from the Myrtle Grove Trailer Park and Plaquemine Parish.

- * QC was less than acceptable according to the statistical procedures required of the laboratory (that is, the instrument did not detect a prepared sample near the known level)
- ND: Not detected (value in parenthesis is the component minimum detection limit from the 2001 sampling events)
- ppb: Parts per billion

Appendix C – ATSDR Methodology

ATSDR Methodology

ATSDR addresses the question of whether exposure to contaminants at the maximum concentrations detected would result in adverse health effects. While the relative toxicity of a chemical is important, the human body's response to a chemical exposure is determined by several additional factors. Among these factors are the following:

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

Lifestyle factors (for example, 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 a human body absorbs, distributes, metabolizes, and eliminates a contaminant. A unique combination of all these factors will determine the individual's physiologic response to a chemical contaminant and any adverse health effects the individual may suffer as a result of the chemical exposure.

ATSDR evaluates contaminants detected in environmental media at a site and determines whether an exposure to them has public health significance. ATSDR begins this evaluation by gathering reports that contain relevant environmental data for the site. These data are reviewed to determine whether contaminant levels are above health-based comparison values. Health-based comparison values are estimates of the daily human exposure to a substance that are not likely to result in adverse, noncancer health effects over a specified duration of exposure. These values are developed for specific media (such as air and water) and for specific durations of exposure (such as acute and chronic).

Health-based comparison values represent conservative levels of safety and not thresholds of toxicity. Thus, although concentrations at or below a comparison value may reasonably be considered safe, concentrations above a comparison value will not necessarily be harmful. Comparison values are intentionally designed to be much lower, usually by orders of magnitude, than the corresponding no-effect levels (or lowest-effect levels) determined in laboratory studies to ensure that even the most sensitive populations (such as children or the elderly) are protected.

To determine whether people are being exposed to contaminants or whether they were exposed in the past or will be exposed in the future, 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 at a site to determine whether all five factors exist and people are being exposed, were exposed, or may be exposed in the future. 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 calls a pathway “complete” if it is certain that people are exposed (or were exposed or will be exposed) to contaminated media. Completed pathways require that the five elements exist and indicate that exposure to the contaminant has occurred, is occurring, or will occur.
- ***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 have occurred, could be occurring, or could occur in the future.
- ***Eliminated Exposure Pathway.*** In an eliminated exposure pathway, at least one of the five elements is missing and will never be present. From a human health perspective, pathways can be eliminated from further consideration if ATSDR is able to show that (1) an environmental medium is not contaminated or that (2) no one is exposed to contaminated media.

Please refer back to Section 3 of this health consultation for ATSDR’s evaluation of environmental and human exposure pathway data for the Myrtle Grove Trailer Park site.

Appendix D – Vinyl Chloride Oral Exposure

Vinyl Chloride Oral Exposure

The text in this appendix provides additional information concerning ATSDR's toxicologic evaluation of vinyl chloride exposures via the oral route.

The maximum concentration of vinyl chloride recorded in drinking water at MGTP (13.8 ppb) would correspond to maximum doses of 1.38 micrograms per kilogram per day ($\mu\text{g}/\text{kg}/\text{day}$) for a 10-kilogram (kg) child drinking 1 liter per day (L/day) and 0.39 $\mu\text{g}/\text{kg}/\text{day}$ for a 70-kg adult assuming consumption of 2 L/day.

Based on animal studies by Til et al. (1983, 1991), EPA derived a chronic oral reference dose (RfD) of 3 $\mu\text{g}/\text{kg}/\text{day}$. This RfD was based on a human equivalent NOAEL (no-observed-adverse-effect level) of 90 $\mu\text{g}/\text{kg}/\text{day}$ for noncancerous liver cell polymorphism and a safety factor of 30. EPA derived this human NOAEL from a rat NOAEL of 130 $\mu\text{g}/\text{kg}/\text{day}$ for the same effect, using a PBPK (physiologically based pharmacokinetic) model that allowed improved calculation of the human dose that would be expected to result in the same level of toxicity as that observed in animals (IRIS 2002).

The dose received by an adult drinking this water would be 0.39 $\mu\text{g}/\text{kg}/\text{day}$, which is only 0.4% of the human equivalent NOAEL calculated by the EPA. The corresponding dose for a child (1.38 $\mu\text{g}/\text{kg}/\text{day}$) would be 1.5% of that human NOAEL.

Vinyl chloride is a known human carcinogen under certain circumstances. Vinyl chloride has been consistently associated with elevated incidences of rare angiosarcomas of the liver in humans, but only by inhalation and only at the extremely high occupational exposures that were once associated with certain job categories, mainly autoclave cleaners hired before 1970 (Zocchetti 2001). However, due to improvements in industrial hygiene made decades ago, these extremely high exposures no longer occur, even in occupational settings. Nevertheless, angiosarcoma of the liver still occurs at an extremely low rate in the general population (0.5–2.5 cases per 10,000,000) (Zocchetti 2001). But its cause remains largely unknown.

There are no drinking water studies of vinyl chloride exposure in humans (ATSDR 1997). However, the scientific literature contains no evidence of a strong relationship between nonoccupational, environmental exposure to vinyl chloride and angiosarcoma of the liver or any other cancer (Zocchetti 2001, Ward et al. 2001). In particular, there is no evidence that vinyl chloride in drinking water, at doses that are achievable outside the laboratory, can cause cancer in humans via the oral route.

However, at sufficiently high oral doses, vinyl chloride does cause hepatic angiosarcoma in animals. The lowest recorded cancer effect level (CEL) in laboratory animals exposed orally to vinyl chloride in oil is 300 $\mu\text{g}/\text{kg}/\text{day}$ for liver angiosarcoma in Sprague-Dawley rats treated by

gavage² 5 times a week for a year, that is, one-third to one-half the animals' lifetime (ATSDR 1997). In humans, this dose would be numerically (if not biologically) equivalent to 10,500 ppb in drinking water for an average 70-kg adult drinking 2 L/day, or 3,000 ppb for a 10-kg child drinking 1 L/day, for several decades. These levels are over 650 times higher than the maximum recorded level of vinyl chloride in the MGTP well system, and the residents were not exposed for decades. If one assumes that sufficiently high oral doses of vinyl chloride could induce cancer in humans, such high doses are evidently unattainable outside the laboratory. Based on all of the information in the preceding text, it is unlikely that the highest level of vinyl chloride detected in drinking water at MGTP would have resulted in adverse health effects in exposed residents. Nevertheless, because EPA's federal safe drinking water standards are legally enforceable, the residents of MGTP were provided with an alternative source of drinking water, as a prudent (that is, conservative) public health measure.

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²The term "gavage" refers to the administration of a test substance directly into the animal's stomach via a tube inserted down its throat. Because rats cannot vomit, this practice enables investigators to know exactly how much of the substance the animals received.

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Appendix E - Vinyl Chloride Inhalation Exposure Dose Calculation

Vinyl Chloride Inhalation Exposure Dose Calculation

Vinyl Chloride Exposure from Showering

When showering in contaminated water, a resident may be exposed from (1) breathing the portion of the contaminant that is released into the air and (2) absorbing the contaminant through the skin. In addition, a resident could inhale the contaminant in the vapor while showering and while standing in the bathroom immediately after showering. Inhalation and dermal exposures to volatile organic compounds (VOCs) in the shower may each be equal to or exceed exposures from ingestion of the contaminated drinking water (Jo et al. 1988, Andelman et al. 1990b, Mattie et al. 1994, Kezic et al. 1997, Kerger and Paustenbach 2000).

ATSDR made the following conservative assumptions to estimate “worst case” vinyl chloride exposure for residents who shower with water contaminated with vinyl chloride.

- A resident would take a 10-minute shower once every day
- A resident would spend an additional 15 minutes in the bathroom after showering
- The concentration of vinyl chloride in the bathroom both during and after showering (that is, throughout the entire 25 minutes of exposure) would be constant and equal to the maximum concentration achieved during showering, and
- The rate of skin absorption of vinyl chloride is similar to the rate for chloroform absorption.

The maximum concentration of vinyl chloride in the bathroom air can be estimated by use of simple one-compartment modeling. This concentration can be estimated using the following mathematical equation (Andelman 1990a):