Health Consultation

INTERNATIONAL PAPER (IP) SAVANNAH COMPLEX

SAVANNAH, GEORGIA

EPA FACILITY ID: GAD003275252

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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 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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Prepared By:

The U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
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List of Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
EPA	U.S. Environmental Protection Agency
GADNR	Georgia Department of Natural Resources
IP	International Paper Company
NEI	National Emissions Inventory
PM	particulate matter
PM_{10}	particulate matter with aerodynamic diameter smaller than 10 microns
$PM_{2.5}$	particulate matter with aerodynamic diameter smaller than 2.5 microns
TRI	Toxic Release Inventory
TSP	total suspended particulate

Summary

In response to a petition request and to respond to community health concerns, the Agency for Toxic Substances and Disease Registry (ATSDR) prepared this health consultation (consult) to evaluate possible environmental exposures to nearby residential communities to air pollutants released from industrial operations at the International Paper Company, Savannah Complex (IP Savannah Complex) located in Chatham County, Georgia. Primary industrial activities at this site are pulp and paper manufacturing, chemical processing and manufacturing, and various supporting operations. The community concerns covered many issues, ranging from exposures to unpleasant odors to the potential for air pollution to cause various health effects.

The Georgia Department of Natural Resources (GADNR) regulates the amount of air pollutants the IP Savannah Complex can release. The GADNR also requires the facility to operate air pollution control devices to help minimize potential air quality impacts. The IP Savannah Complex appears to consistently comply with its regulatory requirements. Nonetheless, the facility does release air pollutants that blow into areas where nearby residents live. Many other nearby industrial operations and motor vehicles also release some of the same pollutants. To be responsive to the community concerns, this health consultation focuses on air pollutants released from the IP Savannah Complex, but considers and acknowledges air quality impacts from other local industrial operations and emissions sources, to the extent appropriate.

The conclusions listed in this consult are based on a large amount of information ATSDR has collected over the past 2 years. Specifically, documents and relevant insights were considered from the IP Savannah Complex, GADNR, the U.S. Environmental Protection Agency (EPA), local community groups, and individual community members.

The following paragraphs review key findings:

- For years before 1988, little information is available on air pollution levels near the IP Savannah Complex. It is unlikely that past conditions could be replicated such that representative air measurements could be collected to measure past air pollution levels Due to these critical information gaps, ATSDR does not make any conclusions about air pollution levels prior to 1988.

- From 1988 to the present, the IP Savannah Complex has released dozens of pollutants into the air. The total amount of pollutants released across the entire facility has apparently decreased considerably since 1988, though data are not available for all pollutants released. Several other nearby industrial facilities and mobile sources release some of the same pollutants that are emitted by the IP Savannah Complex.

- From 1988 to the present, several studies measured air pollution levels throughout the Savannah area, including a large number of air pollution measurements at several locations near the IP Savannah Complex. None of these measurements appeared to have reached levels that would suggest a public health hazard at the locations where and the times when samples were collected. Although these air pollution measurements are quite extensive, not all pollutants released by the IP Savannah Complex have been measured. The most notable limitation is the lack of measurements for sulfur compounds and the

lack of measurements in the neighborhoods located closest to the IP Savannah Complex's industrial operations. Ongoing operation of industrial processes in compliance with health-protective permit requirements should help ensure that releases of these other pollutants do not present a public health hazard to nearby residents.

- Environmental odors near the IP Savannah Complex are at times unpleasant and a nuisance. Although several studies have measured airborne levels of several malodorous pollutants near the IP Savannah Complex, none of those measurements appear to have found odorous substances at levels that would indicate a public health hazard. The studies did not consider every odor-causing pollutant (e.g., hydrogen sulfide) released by the facility. Additionally, some current research indicates that some people may experience some adverse health symptoms such as headaches and nausea resulting from exposure to unpleasant environmental odors. However, several requirements in the facility's operating permit limit the amount of these malodorous pollutants that can be released. Ongoing facility compliance with these requirements should help to ensure the malodorous substances that have not been considered in the previous air pollution monitoring studies do not present a public health hazard in the future. Air monitoring for hydrogen sulfide in the adjacent residential neighborhoods would also provide further confidence in this conclusion, though it is unclear if any stakeholders have plans to conduct such a study.

The remainder of this health consultation describes how ATSDR reached these conclusions and summary statements. Persons interested in only a brief summary of the main conclusions and recommendations should refer to the end of this document. Those interested in how ATSDR evaluated the available data to develop the conclusions are encouraged to read the entire report. Appendices to this report include a glossary and background information on scientific terms used in this health consultation.

Purpose and Statement of Issues

ATSDR was petitioned to conduct a public health evaluation of exposures to nearby residents of pollutants from the IP Savannah Complex. Savannah residents and community groups expressed concern to ATSDR and other health agencies about potential health effects that might result from exposure to air pollutants emitted from the International Paper Savannah Complex.

After discussing these concerns with the petitioner, Savannah residents, and community groups, ATSDR identified the following ***objectives and scope*** for this health consultation.

What Is a Petition?

A petition is a written request from any community member or community representative asking ATSDR to conduct public health assessment activities to evaluate the community's potential exposure to environmental contaminants released at a hazardous waste site located in the community.

Objectives

- To respond to specific community concerns about air pollution levels believed to be associated with the IP Savannah Complex.
- To determine whether residents have been (post 1988) or are being exposed to outdoor air pollution at levels that present a public health hazard.

Scope

- ***Who:*** What populations are considered in the exposure evaluation? This health consultation addresses environmental exposures that local community members might experience, outside of any occupational exposures.
- ***When***: What exposure time frames are considered? This health consultation examines exposures that have occurred from 1988 to the present. Not enough information is available to make reliable exposure estimates for earlier time frames.
- ***Where:*** Over what area does this health consultation evaluate exposures? For most of the air pollution sources at the IP Savannah Complex, air quality impacts are expected to be greatest near the facility boundary and decrease with distance from the facility. However, there is no “magic line” that separates exposed and non-exposed populations. This health consultation evaluates exposures for locations within 2.5 miles of the IP Savannah Complex, with the understanding that the highest exposures occur in this area and that site-related exposures at locations further away are likely lower.
- ***What***: What pollutants are considered? The health consultation examines exposures to pollutants that the IP Savannah Complex releases (e.g., volatile organic compounds, particulate matter, sulfur compounds). Emissions from sources other than the IP Savannah Complex are considered in these evaluations, as appropriate, to provide perspective on exposures.

Other important decisions made about specific issues in this health consultation are as follows:

- **What time frame does this health consultation address?** ATSDR attempted to evaluate exposures for the entire time frame that industrial operations occurred at the IP Savannah Complex. However, only very limited information is available to evaluate local air pollution levels prior to 1988, largely because environmental regulations during those years typically focused on a small number of pollutants. Therefore, this health consultation evaluates exposures that may have occurred between 1988 and the present. Conclusions have not been made regarding possible exposures that may have occurred in years prior to 1988.

- **Which emissions sources does this health consultation consider?** The health concerns communicated to ATSDR specifically addressed air pollutants released from the IP Savannah Complex. However, ATSDR recognizes that several nearby industrial facilities and motor vehicular traffic throughout the Savannah area release many of the same pollutants. Some of these pollutants are also found in various household and consumer products. To respond directly to the community health concerns, this health consultation focuses primarily on pollutants released from the IP Savannah Complex, but air quality impacts from other sources are described and characterized, as appropriate.

- **Which exposure scenarios does this health consultation consider?** Consistent with community concerns, this health consultation focuses entirely on direct inhalation exposure to air pollution as agreed by community members, the petitioner, and ATSDR. This document does not address other possible exposure pathways or occupational exposures that may occur at this facility.

Background

The IP Savannah Complex site has supported an active paper mill since 1935. The original facility was operated by the Union Bag and Paper Corporation. A merger between Union Bag and Paper Corporation and Camp Corporation in 1957 created the Union Bag-Camp Paper Corporation, which was later renamed as the Union Camp Corporation. The International Paper Company acquired Union Camp Corporation in 1999 and currently maintains ownership of the mill. The location of the IP Savannah Complex is shown in Figure 1.

The IP Savannah Complex includes multiple different operational divisions. The International Paper Company's Containerboard Division operates at the site, and this division includes various pulp and paper manufacturing operations. Arizona Chemical Corporation (a wholly owned subsidiary of International Paper Company) operates at the IP Savannah Complex and processes many chemical by-products from the pulp and paper manufacturing processes. In 2003, Arizona Chemical Corporation entered into a joint venture with another company, Arboris LLC, to build new operations at the IP Savannah Complex to manufacture chemicals known as sterols. Overall, the IP Savannah Complex produces brown paper, paperboard, household chemicals, and selected other products.

The IP Savannah Complex manufacturers paper both from wood and waste paper. Wood typically arrives at the facility in logs, which are washed and debarked before being cut into tiny chips. The wood chips are then digested in "white liquor"—a chemical mixture that breaks wood

down into pulp. At the end of the digestion process, pulp of various grades is pumped to the paper mill to make different paper products. The leftover liquid mixture from the digesters is known as "black liquor." Through a series of chemical and physical processing steps, white liquor is recovered from the black liquor mixture and used again to digest wood. Another byproduct of the black liquor mixture is tall oil, which is further processed to make selected chemicals products. Boilers located at the facility generate the energy needed to sustain the operations at the IP Savannah Complex. These boilers are fueled by combustion of natural gas, coal, bark, fuel oil, and spent liquor-solids.

Taken together, the various pulp, paper, and chemical processing steps and power generation activities release many pollutants into the air. Examples include reduced sulfur compounds, volatile organic compounds, and fine particles (EPA 2002; GADNR 2002a, 2002b). The IP Savannah Complex operates numerous air pollution control devices to reduce releases of these and other pollutants. While these controls help minimize the facility's air quality impacts, the controls have occasionally experienced down time due to process upset conditions, power outages, scheduled preventive maintenance, or other causes. Information on the amount of air pollutants released into the air is presented later in this report (see "Review of Emissions Data").

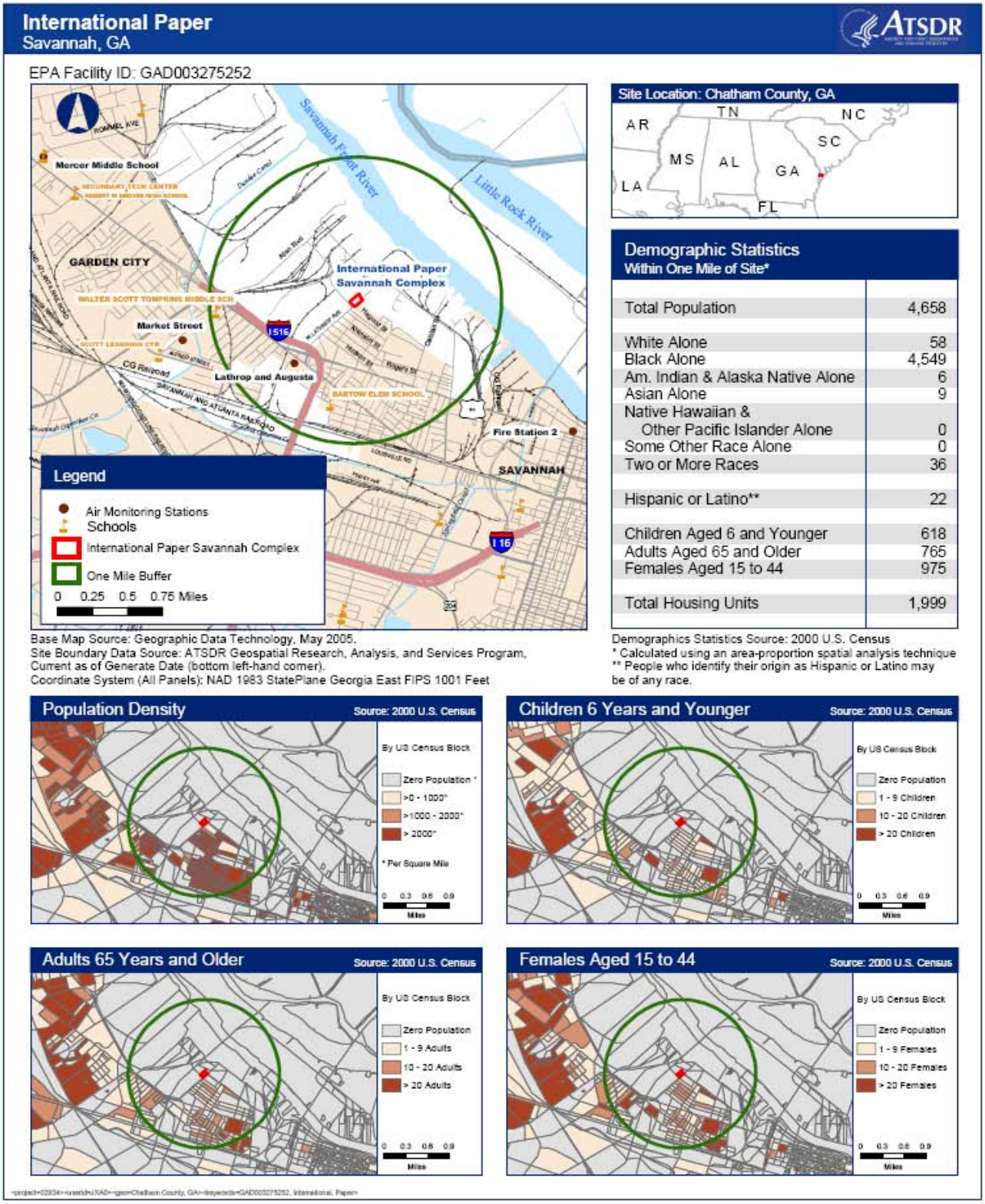
Operations at the IP Savannah Complex are subject to federal and state air pollution control regulations, as detailed in the facility air permits (GADNR 2002a, 2002b). State regulators periodically conduct unannounced inspections. These inspections have generally found that facility equipment operates in compliance with applicable permit conditions. Further information on regulatory compliance is presented later in this report (see "Review of Permitting and Compliance Information,").

Land Use and Demographics

ATSDR reviewed demographic data to determine the number of people who are potentially exposed to site-related air pollutants. Based on information compiled in the 2000 U.S. Census, an estimated 4,658 persons live within one mile of the IP Savannah Complex (see Figure 1).Of these residents, 618 are children (age 6 years and younger); 975 are women of childbearing age (between the ages of 15 and 44 years); and 765 are elderly (age 65 years and older). Most of these residents live in the Hudson Hill, West Savannah, and Woodville communities.

The closest residential neighborhoods are located in Savannah and are primarily southwest, south, and southeast of the facility (see Figure 1). These neighborhoods include many locations that residents frequent, such as schools, parks, community centers, places of worship, businesses, and a golf course. Some of these locations are in very close proximity (less than 300 yards) to the Arizona Chemical Corporation's industrial operations within the IP Savannah Complex. Later sections of this health consultation revisit the demographic data when evaluating potential exposures to air pollutants released from the IP Savannah Complex.

Figure 1. Demographic Information for the IP Savannah Complex

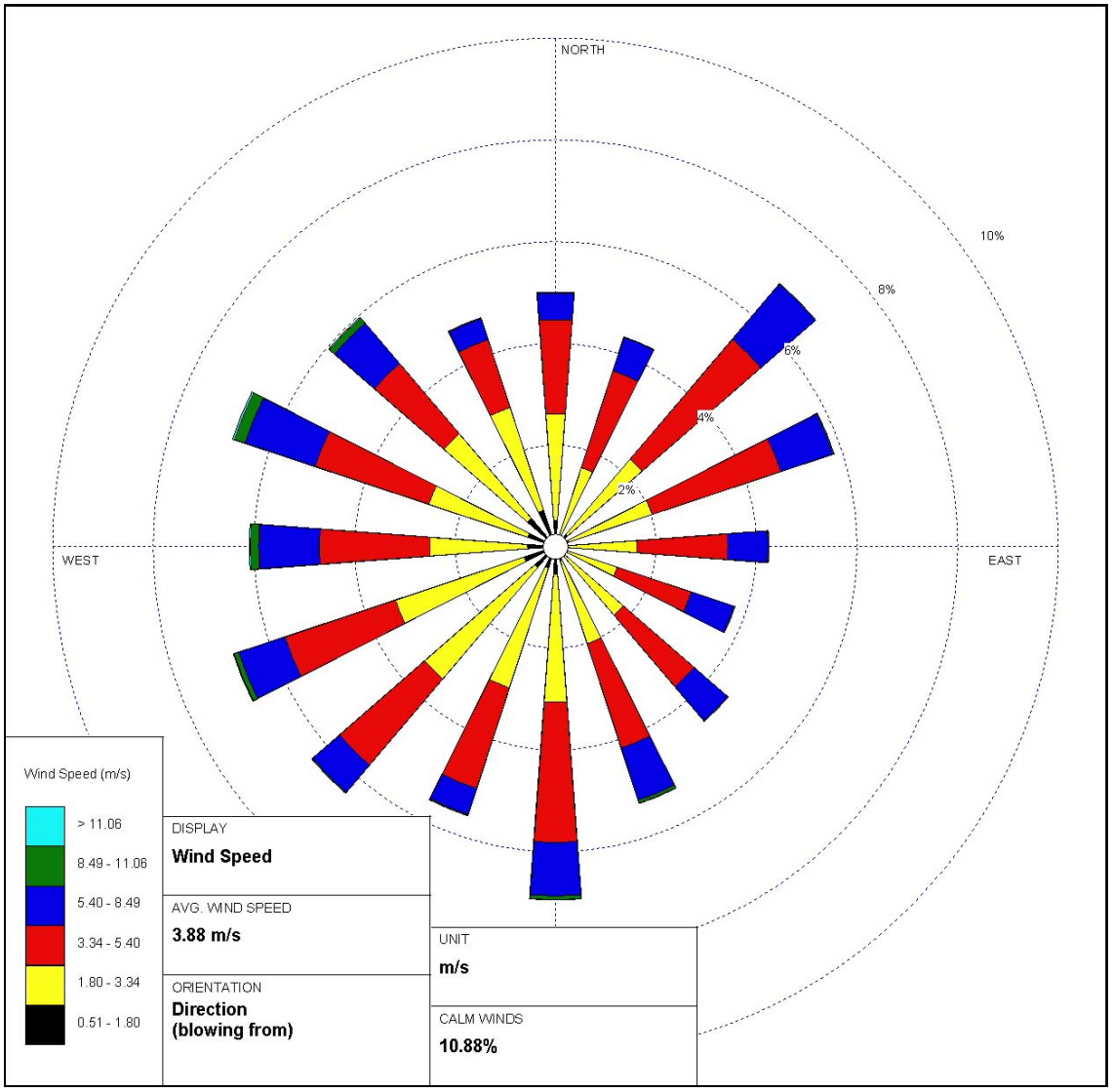


Climate and Meteorology

ATSDR reviewed climate and meteorology data in the Savannah area, because these variables affect how air pollutants move from their origins to downwind locations. Weather conditions in the Savannah area vary from one season to the next. For example, according to 30 recent years of weather observations made in southeast Georgia, the monthly average temperature in the area ranges from 50.5 degrees Fahrenheit (^{o}F) in January to 81.8 ^{o}F in July. The area receives roughly 49 inches of precipitation a year, mostly in the form of rain (NCDC 2002).

Prevailing wind patterns in the Savannah area are heavily influenced by the proximity to the ocean. Winds typically blow from the ocean toward land during the day (known as "sea breezes"), and in the opposite direction at night (known as "land breezes") (GADNR et al. 1995). Wind direction and speed are continuously measured at the Savannah/Hilton Head International Airport. These measurements are believed to represent conditions at the IP Savannah Complex, given the airport's close proximity and lack of significant terrain features in the area. To evaluate prevailing wind directions, ATSDR reviewed hourly wind measurements made at the airport for a recent 9-year period (1987–1992) (EPA 2007c). A windrose using this information was also developed (see Figure 2). The review of this data found that winds in the Savannah Area periodically blow in all compass directions, with no single predominant wind direction apparent for this region. Thus, nearby neighborhoods are likely downwind from the IP Savannah Complex at some times, and upwind from the industrial operations at others.

Figure 2. Windrose Displaying Winds Patterns in the Savannah Area



Community Health Concerns

Residents who live near the IP Savannah Complex have communicated a broad range of health concerns to ATSDR. These concerns fall into two general categories: health effects associated with exposure to air pollution and complaints regarding unpleasant odors. Examples of health effects that residents have mentioned to ATSDR include respiratory problems (e.g., asthma, bronchitis), gastrointestinal symptoms (e.g., nausea, vomiting), skin rashes, attention deficit disorders, lung cancer, and headaches. In addition, many residents who live near the IP Savannah Complex have noted various unpleasant odors, such as strong sulfur odors, rotten egg smells, peculiar odors, and odors similar to burning tires. In developing this health consultation, ATSDR carefully considered these and other concerns and the extent to which they might be associated with air pollutants released from the IP Savannah Complex and other local air pollution sources.

Discussion

This section summarizes how ATSDR evaluated air exposures to pollutants released from the IP Savannah Complex. The section first presents the exposure assessment methodology and then presents technical reviews of emissions data (or data on the amount of pollutants released into the air), air pollution measurements, and facility permitting and compliance information. The section concludes by presenting ATSDR's interpretations of the available data. The scientific assessment presented in this section forms the basis for ATSDR's conclusions and recommendations for this site, which are presented in the Conclusions and Recommendations sections near the end of this document.

Methodology

A critical element of this health consultation is *exposure*, or how humans come into contact with air pollutants. Analyzing exposure is important: if residents are not exposed to air pollutants, then the pollutants cannot pose a public health hazard and additional analyses are not necessary. If residents are exposed, then further analysis is needed to evaluate the exposure. Even if an exposure has occurred, that does not mean the exposed residents will have health effects or get sick. In cases where exposures have occurred, ATSDR considers several questions when determining if adverse health effects could occur:

- To what pollutants are people exposed?
- How often are people exposed, and for how long?
- What are the pollution levels to which people are exposed?

When evaluating sites with outdoor air quality issues, ATSDR needs information on air pollution levels and how these levels change with location and time. ATSDR uses various approaches to evaluate air pollution. The preferred approach is to review air sampling data, or direct measurements of pollutants in the air that people breathe. However, for most sites that ATSDR evaluates, air sampling data are not available for the entire range of pollutants, locations, and time frames of interest. In these cases, ATSDR uses other approaches to evaluate potential

exposures. These approaches include reviewing emissions data and facility air permits (see below).

Review of Emissions Data

ATSDR considered emissions data—or information on the amounts of pollutants released into the air—to determine which pollutants are of greatest interest for evaluating public health impacts for this site. The available site records provide extensive information into the IP Savannah Complex's air emissions from 1988 to the present. Some emissions data are based on direct measurements, but much of the emissions data are estimates derived from engineering calculations, engineering judgment, and process knowledge. These estimates present the best available information of emissions from the IP Savannah Complex. As with many emission estimates, theses estimates may overstate or understate actual facility emissions. As with many facilities, direct measurement of emissions is only required for a small number of emissions sources at the IP Savannah Complex and the required testing has routinely been conducted according to schedules outlined in the facility's operating permits.

Summary of Emissions Data

The IP Savannah Complex releases dozens of pollutants into the air. For many pollutants, estimates of the annual amounts released are available from 1988 to the present, during which time the total air pollutant releases decreased considerably. However, emissions data are not available for all pollutants released by the facility and the available data have inherent limitations and uncertainties. In addition, other nearby industrial facilities and mobile sources release some of the same pollutants emitted by the IP Savannah Complex.

The emissions data that ATSDR obtained is reviewed in the following paragraphs, commenting on the strengths and limitations of the individual data sources. At the end of this section is a summary of the main inferences that can be drawn from these data.

Toxics Release Inventory (TRI) Data

ATSDR accessed the entire history of air emissions data for industrial facilities in Chatham County from EPA's Toxics Release Inventory (TRI) website (EPA 2007a). As of the writing of this health consultation, emissions data are available from 1988 to 2004. ATSDR used these data to identify air pollutants of potential concern for the IP Savannah Complex and to gather perspective on how large this industrial emissions source is in comparison to other nearby industrial sources. TRI data was also used to determine other industrial facilities within 5 miles of the IP Savannah Complex (see Figure 3).

What Is the Toxics Release Inventory?

Starting in 1987, the U.S. Environmental Protection Agency (EPA) required facilities in certain industries to disclose the amounts of specific toxic chemicals that they release to the environment or manage as waste. The Toxics Release Inventory (TRI) is the publicly accessible database that contains the information submitted by facilities that meet the reporting requirements.

EPA's Web site on the TRI program (www.epa.gov/tri) presents extensive additional information on the strengths and limitations of using TRI data.

ATSDR often uses TRI data to identify the locations of selected facilities that release

toxic chemicals into the environment, but these data have limitations. For instance, TRI data are self-reported by industry, and the accuracy of these data is not known. Further, while TRI data offer extensive insights into large air emission sources, the data are not comprehensive because of various reporting exemptions. For example, facilities in certain industrial sectors, facilities with fewer than 10 employees, and facilities with relatively small toxic chemical uses are exempt from reporting. In addition, TRI data do not include emissions data from non-industrial sources, like motor vehicles. Finally, TRI reporting requirements have changed over the years, which can complicate efforts to interpret trends.

In general, TRI data provide useful insights into the relative magnitude of certain industrial emissions sources and help identify site-related pollutants of potential concern, but these data alone often are insufficient for drawing inferences about exposures and potential health effects.

Presented in Table 1 is the history of air emissions data that the IP Savannah Complex reported to TRI. ATSDR used the TRI data primarily to assess the completeness of air sampling studies (see Public Health Implications section). However, some additional inferences can be drawn from the TRI data:

- Between 1988 and 2004, air toxic emissions from the IP Savannah Complex have been dominated by several chemicals. Specifically, ammonia, hydrochloric acid aerosols, methanol, sulfuric acid aerosols, and toluene have accounted for more than 85% of the facility-wide TRI-reportable air toxic emissions during this time frame.

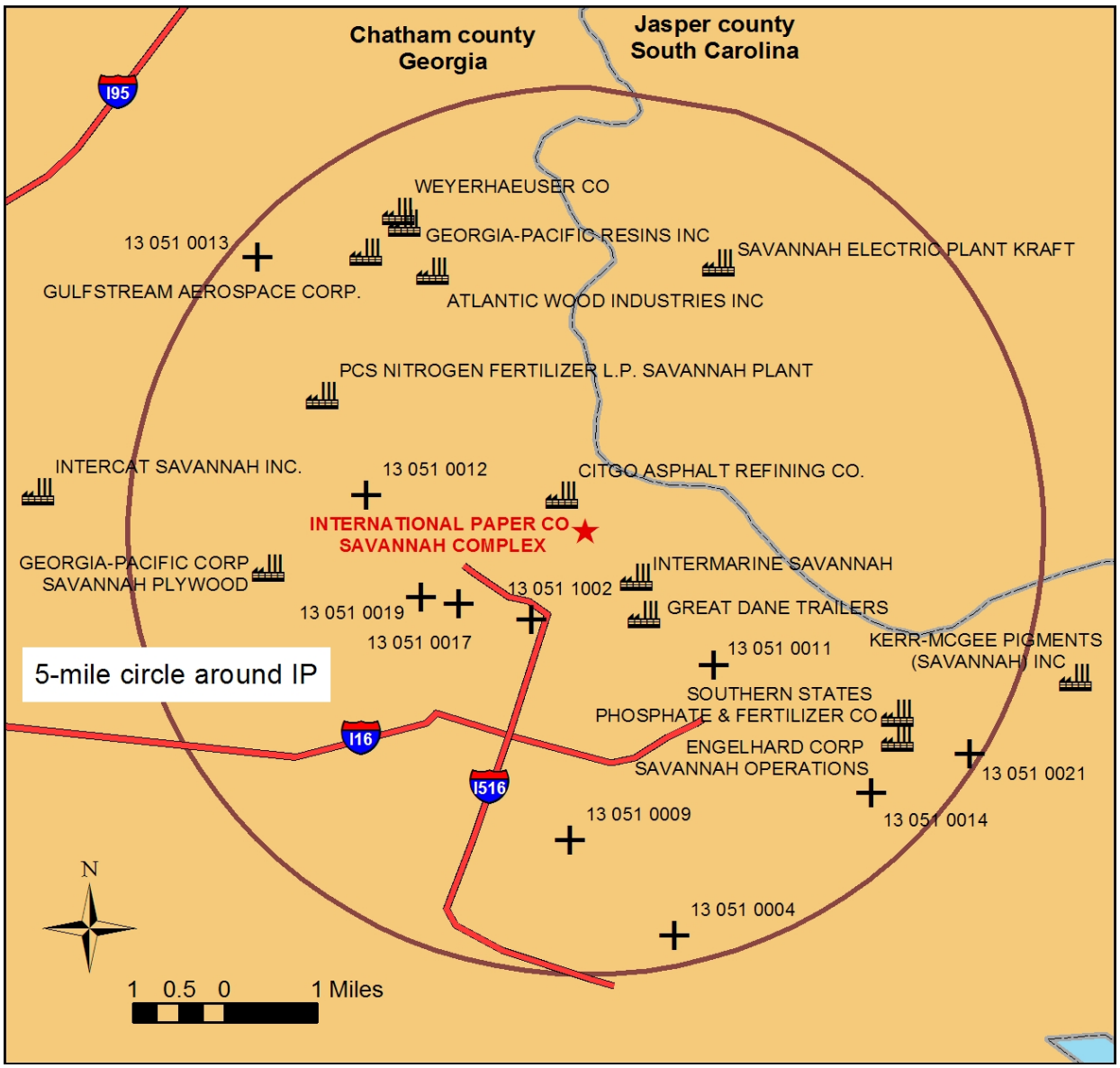
- The total facility-wide TRI-reportable air toxic emissions have decreased substantially over the years. In 2004, the facility-wide total air toxics emissions (based on TRI figures) were 15% of the 1988 levels. This reduction apparently resulted from a combination of various air pollution control measures phased in over the past 15 years and recent decommissioning of several unit operations (Katula 2006).

- In addition to reviewing the TRI emissions data for the IP Savannah Complex, ATSDR also considered emissions data for other industrial facilities throughout Chatham County. This was done because local air pollution levels typically result from a combination of emissions sources throughout an area, and generally do not come from a single source. Over the period of record, total TRI-reportable air emissions data from the IP Savannah Complex were higher than those for any other facility in Chatham County. This observation is provided only to give some perspective on the relative magnitude of air emissions from the IP Savannah Complex (i.e., they are clearly significant in comparison to other facilities), though ATSDR acknowledges that the total facility-wide air emissions summed across multiple pollutants offers limited insight on off-site air pollution levels.[1]

This health consultation revisits some of the observations regarding the TRI emissions data when commenting on the coverage of the air pollution measurements made in Chatham County.

[1] To elaborate on this point, low emission rates of highly toxic chemicals in some cases can be of far greater public health concern than high emission rates of less toxic chemicals. Further, emissions can disperse considerably between the time they are released and the time they reach exposed populations. For these and other reasons, health interpretations cannot be made from simply comparing different facilities' total emissions summed across pollutants.

Figure 3. Map Industrial Facilities Within 5 Miles of IP Savannah Complex



Sources: EPA 2005. GADNR 1994. TRI 2005.
Notes:

- The facilities displayed in Figure 3 represent the top TRI emitters from Chatham County located near IP Savannah. Except for "Intermarine Savannah", which either closed or changed names after 1994, all facilities displayed in the figure have been active between 1994 and 2002.
- Air monitoring stations in Figure 3 are represented with a "+" and each have a designated code number.
- The air monitoring stations displayed in Figure 3 include all stations in Georgia within five miles of IP Savannah where air pollutant concentrations were measured after 1994.
- ATSDR has identified air monitoring stations in Georgia from before 1994 in the vicinity of IP that measures air concentrations for criteria pollutants. However, ATSDR has not obtained data from air sampling prior to 1994. GADNR has expressed some concerns over the quality of this older data.
- ATSDR has not identified any air monitoring stations located in South Carolina near IP Savannah.

National Emissions Inventory Data

Data from the National Emissions Inventory (NEI) was accessed to get a very general sense for how a broader range of air emissions sources in Chatham County (not just the IP Savannah Complex) contribute to local air quality. While TRI data are useful in characterizing air emissions from large industrial sources, NEI data provide additional context on emissions, as this database tracks releases from smaller industrial sources, commercial operations (e.g., dry cleaning, gasoline stations), mobile sources, and natural sources.

Summarized in Table 2 is the 1999 NEI emissions data for Chatham County by percentages of estimated total county-wide emissions by source type of several pollutants. These data are presented to emphasize a few points about air pollution sources near the IP Savannah Complex. For example, the data show that air emissions in Chatham County do not occur exclusively from large industrial sources (see Public Health Implications: Near-Road Exposures). Emissions from mobile sources, some commercial facilities, and smaller industrial sources contribute to the county-wide emissions, with the estimated contributions varying from one pollutant to the next. This context is important to consider when interpreting measured air pollution levels (as discussed later in the document). Air pollution levels at a given location tend to be most highly influenced by the nearest emissions sources. Therefore, air quality impacts from the IP Savannah Complex are expected to be greatest near the facility and diminish with downwind distance, though other emissions sources (e.g., local vehicle traffic) also contribute to air pollution in the same area.

What Is the National Emissions Inventory?

EPA's National Emission Inventory (NEI) database contains information about sources that emit criteria air pollutants and their precursors, and hazardous air pollutants. The database includes estimates of annual air pollutant emissions from point, nonpoint, and mobile sources in the 50 States, the District of Columbia, Puerto Rico, and the Virgin Islands. EPA collects information about sources and releases an updated version of the NEI database every three years.

EPA's Web site on the NEI program (http://www.epa.gov/ttn/chief/net/) presents additional information on the NEI program.

Emissions Measurements

The IP Savannah Complex is required to measure emissions from stacks that vent several unit operations. For some sources, the facility must continuously monitor emissions to ensure compliance with regulations; for other sources, only periodic stack testing is required with testing frequencies ranging from quarterly to annual. The pollutants measured from selected stacks include total reduced sulfur, sulfur dioxide, and particulate matter. The IP Savannah Complex submits the measured emissions data to GADNR. GADNR reviews the measurements for compliance with emissions limits specified in the corresponding air permits. ATSDR reviewed relevant emissions measurements reports that were available in GADNR's files. Some of the emission reports date back to the early 1990s. The emissions measurements documented in these reports were typically well below the permitted limits. As is typical for many facilities, not all pollutants are required to be measured; therefore, emissions measurements do not provide information on the entire range of pollutants emitted from the IP Savannah Complex.

Other Emissions Data

While TRI and NEI and emissions testing data provide useful insights on emissions from industrial facilities, these data sets are not comprehensive and do not address all pollutants that may be released from industrial facilities. The IP Savannah Complex emits several pollutants in addition to those identified in the previous sections. These additional pollutants include (but are not limited to) various sulfur compounds (e.g., hydrogen sulfide) and numerous volatile organic compounds. Several sulfur compounds have very low odor thresholds. Though the exact amount of facility-wide emissions for these other pollutants is not known, evidence that these releases occur is gathered from permit applications submitted for the IP Savannah Complex and other site-related documents identified during a review of site-related files at GADNR.

One other source of emissions data identified is excess emission reports. Excess emission reports are submitted to GADNR by the IP Savannah Complex in cases when certain non-routine releases such as preventive maintenance, process upsets, or various unplanned events occur. Information from the excess emission reports confirm that increased emission rates occasionally occur over short time frames, but these reports do not document the air pollution levels that might have resulted.

Summary of Emissions Data

In summary, the emissions data confirm that the IP Savannah Complex emits dozens of pollutants into the air. Emission rates for many of these pollutants have been estimated, and total complex-wide emissions of toxic chemicals appears to have decreased considerably over the past 20 years. Although the accuracy of the emissions estimates is not known, the data documented in this report are believed to be the best available information on facility-wide emissions. Emissions data are fairly extensive for years between 1988 and the present. However, detailed data for years prior to 1988 do not appear to be available, presumably because environmental regulations during that time did not require systematic tracking of facility-wide emissions for most pollutants. While the IP Savannah Complex releases numerous pollutants into the air, several other local industrial sources and mobile sources also release some of these same pollutants. Later sections of this report (see Public Health Implications sections) revisit these main findings when commenting on the completeness of local air pollution measurements.

Review of Air Pollution Measurements

For this document, ATSDR reviewed several air sampling program reports conducted in Chatham County and within Savannah. These programs were designed to characterize community-wide exposures to air pollutants released from multiple sources, but most of these programs were not designed specifically to characterize long-term air quality impacts from the IP Savannah Complex. The following paragraphs summarize the

Summary of Air Pollution Measurements

Several thousand individual air pollution measurements have been made near the IP Savannah Complex since 1988. Short-term exposure to the measured levels of air pollution likely would not have resulted in adverse health effects, but this finding is limited to the days when and locations where measurements were taken. While extensive, the available air pollution measurements have important limitations that should be considered: The studies did not consider all pollutants of interest for the IP Savannah Complex, and the studies may not have captured the highest air quality impacts that may have occurred.

relevant air sampling studies, focusing only on those measurements made at locations within 2.5 miles of the IP Savannah Complex:[2]

1994 Chatham County Air Toxics Study

In response to community health concerns, GADNR conducted a study to characterize air pollution levels throughout Chatham County and evaluate their associated human health impacts. This study—the 1994 Chatham County Air Toxics Study—involved air quality measurements in two phases. During 2 weeks in February 1994, a preliminary study was conducted to orient field workers to the sampling equipment and to survey ambient air concentrations of selected pollutants. The second phase of the study was more intensive and occurred over approximately a 1-month time frame later in the spring. The final report for this study documents the air pollution measurements from only the second phase (GADNR et al. 1995).

The 1994 Chatham County Air Toxics Study focused on characterizing ambient air concentrations of 30 pollutants of interest that originate from a wide range of industrial and mobile sources throughout Chatham County.[3] These pollutants were measured using multiple sampling and analytical methods developed by EPA and the National Institute for Occupational Safety and Health (NIOSH). A few of these methods were modified by GADNR when applied to this program. The sample durations varied from 1 to 24 hours, depending on the pollutant being measured. Overall, samples were collected at 14 different locations in Chatham County, with the sampling schedule varying considerably from one location to the next.

This review focuses on measurements made at the three monitoring stations located within 2.5 miles of the IP Savannah Complex. These locations (see Figure 4) were named "Lathrop and Augusta," "Mercer School," and "Fire Station #2." The number of measurements at each station varied from one pollutant to the next. For the overwhelming majority of pollutants, however, no more than three valid sampling results were reported for each station. The quality of the measurements cannot be determined because the summary report does not include a detailed data quality narrative. But, the summary report does allude to some "…problems with the experimental procedures for analysis," without specifying the nature of these problems (GADNR et al. 1995).

The study's air quality measurements at the three monitoring stations of interest are summarized in Tables 3 through 5. Main points of interest for each table are as follows:

- Summarized in Table 3 are data for the 64 pollutants that (1) were detected in at least one sample at the three stations of interest and (2) have a health-based comparison value for acute exposures. As shown in the table, the highest measured concentrations for all 64 pollutants were lower than the corresponding health-based comparison value, suggesting that these pollutants' measured concentrations did not present a public health hazard over the time frame the study was conducted. Comparisons to health-based comparison values for chronic

[2] Data was reviewed from other more distant monitoring locations when preparing this health consultation. However, those data are not summarized here because air quality at more distant locations likely reflects greater contributions from emissions sources other than the IP Savannah Complex such as motor vehicle traffic and other industrial sources.

[3] While the summary report specifically identifies 30 pollutants of interest, measurements actually quantified ambient air concentrations of at least 80 additional pollutants. ATSDR considered the entire set of measurements when preparing this health consultation.

exposures were not conducted since this monitoring program was not designed to characterize air pollution levels over the longer term.

- Listed in Table 4 are 11 pollutants that were detected in the air at locations nearest the IP Savannah Complex, but for which health-based comparison values for acute exposure are not available. These pollutants include 10 hydrocarbons and one metal that are commonly found in ambient air at urban and suburban locations nationwide. The measured concentrations were not unusually elevated and showed no distinctive spatial variations that would suggest that they originated primarily from the IP Savannah Complex; therefore, these pollutants are not considered further in this health consultation.

- Identified in Table 5 are 26 additional pollutants that were considered in the 1994 study, but were not detected in any of the samples collected at locations nearest the IP Savannah Complex. It should be noted that some of these pollutants were detected at other monitoring stations in Chatham County—a trend suggesting that emissions sources other than the IP Savannah Complex were contributing to their presence.

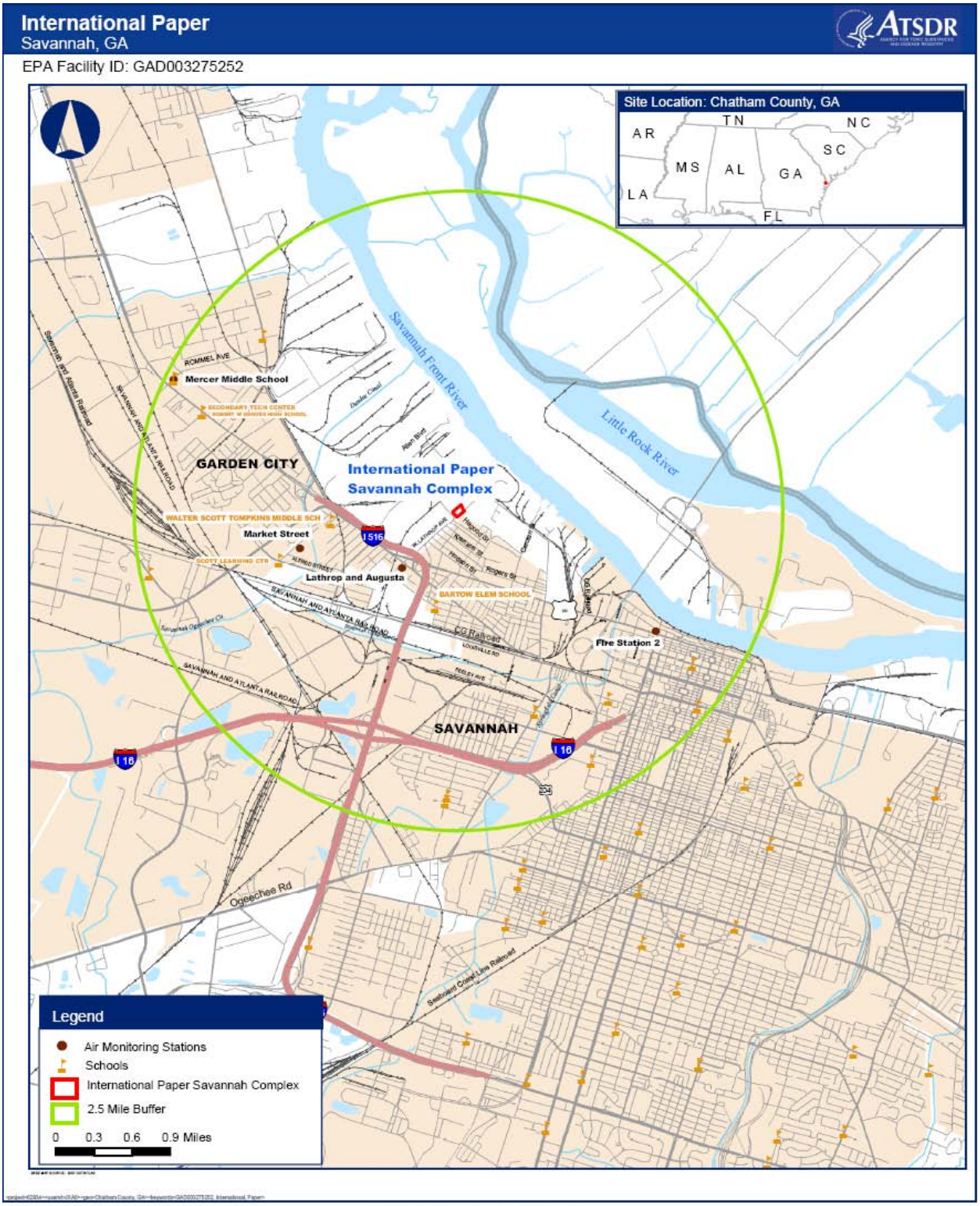
Health-Based Comparison Values

To interpret air pollution measurements, this health consultation uses a screening process to identify the pollutants of potential health concern that warrant more detailed evaluation. In this screening process, measured air pollution levels are compared with "health-based comparison values." These comparison values (defined in Appendix B) are developed from the scientific literature concerning exposure and health effects. To be protective of human health, most comparison values have safety factors built into them. In other words, these comparison values are intentionally selected to be lower than the lowest air pollution levels known to be associated with adverse health effects, considering an ample margin of safety.

As a result, air pollution levels *lower* than their corresponding health-based comparison values are generally considered to be safe and not expected to cause harmful health effects. But the opposite is not true: air pollution levels *greater* than comparison values are not necessarily harmful. Rather, pollutants found at levels above comparison values require a more detailed evaluation, considering the duration of exposure, demographics, and other factors. In short, ATSDR uses health-based comparison values to focus its evaluations on the pollutants of greatest health concern for a given site.

Appendix B defines the specific health-based comparison values used in this health consultation.

Figure 4. Ambient Air Monitoring Stations Located Within 2.5 Miles of the IP Savannah Complex



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In summary, the 1994 Chatham County Air Toxics Study did not detect any pollutants at concentrations at levels of concern for acute (or short-term) exposures. The study authors concluded that, with few exceptions, air pollution levels measured in the Savannah area were typically "well below" those observed in other large cities in Georgia (GADNR et al. 1995). As the most notable exception, the measured concentrations of formaldehyde were reportedly higher than anticipated, which triggered a follow-up investigation (see "1995-1996 Savannah Area Air Toxics Study," below).

The 1994 Chatham County Air Toxics Study has several strengths and limitations. The main strength of this study is that it represents the most extensive effort to date to characterize county-wide air quality for a wide range of pollutants, including numerous pollutants that the IP Savannah Complex emits in large quantities (i.e., those listed in Table 1). On the other hand, the main limitation is the study's temporal coverage: with sampling for most pollutants limited to just 3 days per station, the study was not designed to quantify or characterize air pollution over the longer term. Another concern, for purposes of this evaluation, is the study's spatial coverage. While perhaps appropriate for characterizing air quality for an entire county, the placement of monitoring stations may not have captured the highest air quality impacts from the IP Savannah Complex.

1995-1996 Savannah Area Air Toxics Study

Based on findings from the 1994 Chatham County Air Toxics Study, GADNR funded a follow-up study to further characterize air pollution levels of acetaldehyde, formaldehyde, and proprionaldehyde in Chatham County. Details of this study are documented in two publications (MacIntosh et al. 2000; UGA and GADNR 1997). The follow-up study lasted 1 year—December 1995 to November 1996—with air samples collected once a month at each of five monitoring stations. Two of these monitoring stations ("Lathrop and Augusta" and "Fire Station #2") were also considered in the previous 1994 study, and the other three stations were more than 2.5 miles from the IP Savannah Complex. On each scheduled sampling date, two consecutive 12-hour average air samples were collected at each location, providing insights on how air pollution levels varied between day and night. All samples were analyzed for the three pollutants of interest using an EPA-approved laboratory analytical method, and various indicators suggest that the measurements were of a known and high quality (UGA and GADNR 1997).

Summarized in Table 6 is the air pollution levels measured during the 1-year program. For all three pollutants (acetaldehyde, formaldehyde, and proprionaldehyde), every 12-hour average concentration at all five monitoring stations was lower than the corresponding health-based comparison values for acute exposures. Similarly, the highest annual average concentrations for acetaldehyde and propionaldehyde were lower than their corresponding health-based comparison values for long-term (or chronic) exposures. However, the annual average concentration of formaldehyde measured at all five monitoring stations—including the rural background station—exceeded ATSDR's Cancer Risk Evaluation Guide. Accordingly, this health consultation considered in greater detail the public health implications of long-term exposures to formaldehyde (see "Public Health Implications: Exposure to Air Pollutants"). The findings on potential exposures to formaldehyde as listed in the Public Health Implications section are as follows:

Residents near the IP Savannah Complex may be exposed to formaldehyde at levels similar to other parts of the US. The risk of cancer from formaldehyde is very low and may be zero. This risk also is similar to other parts of the US.

Union Camp's Toxic Air Pollutant Monitoring Program

In 1994, contractors to Union Camp Corporation conducted a short-term ambient air monitoring program to characterize air quality impacts at three fenceline locations around what this document refers to as the IP Savannah Complex (TRC 1995). The program spanned two 24-hour periods, during which eight consecutive 3-hour average samples were collected at each monitoring station. The first 24-hour period (July 18-19, 1994) occurred during a so-called "cold shut-down" period, or a time when the primary industrial processes were not operating. The second 24-hour period (July 23-24, 1994) occurred during a time when the facility was fully operational. The monitoring program considered 10 pollutants that the paper mill was known or suspected to emit. All measurements were made using sampling and analytical methods developed by either EPA or NIOSH, and information collected during the program suggests that the measurements were of a known and high quality (TRC 1995).

Listed in Table 7 are the highest 24-hour average concentrations measured during the 2-day study. Some of these values occurred on the day when the facility was operating, while others occurred on the day when the facility was shut down. Regardless, every 24-hour average concentration measured in this program was lower than its corresponding health-based comparison value for acute exposures, suggesting that the measured concentrations did not present a public health hazard during the two 24-hour periods that air samples were collected.

While this study offers insights into air pollution levels nearest the IP Savannah Complex, the limited time frame of the study is a major limitation. In short, the study provides a "snapshot" of air pollution levels near the IP Savannah Complex for a single 24-hour period when the facility was fully operational. Air pollution levels over the longer term cannot be inferred with confidence from these limited measurements. The study authors acknowledge this limitation in their summary report: "The data sets described in this report are limited in that they only cover a few measurement days, and…it is inappropriate to over-analyze the results" (TRC 1995).

GADNR's Statewide Monitoring Program

GADNR routinely monitors air pollution levels in cities throughout Georgia, including Savannah. In recent years, the agency has summarized its routine air pollution measurements in annual surveillance reports (GADNR 1988-2005). ATSDR obtained these reports, downloaded summary data from EPA's Air Quality System, and from GADNR's Ambient Monitoring Program database (GADNR 2007). EPA's Air Quality System is an online clearinghouse of air quality measurements reported by state and local pollution control agencies nationwide (EPA 2007d). Data in these reports and databases from monitoring stations located within approximately 2.5 miles of the IP Savannah Complex were evaluated for this consultation.

Listed in Table 8 are the relevant GADNR monitoring stations that operated at some point between 1988 and 2006 and identifies the pollutants that were measured. For this time frame, extensive monitoring occurred for lead, sulfur dioxide, particulate matter (of different size fractions), and the composition of particulate matter. For the criteria pollutants (i.e., lead, sulfur

dioxide, and particulate matter), the measured concentrations were consistently lower than EPA's corresponding health-based National Ambient Air Quality Standards (NAAQS). Of note is the annual average ambient air concentrations of fine particulate matter ($PM_{2.5}$) were below the NAAQS by a small margin.

Moreover, the measured concentrations of components of fine particulate matter (e.g., metals and other pollutants found in the particles that can be most easily inhaled) were generally safely below corresponding health-based comparison values. The information presented in Tables 9 and 10 can generally be summarized as follows:

- **Short-term exposures.** Summarized in Table 9 are the highest 24-hour average concentrations of 25 pollutants that GADNR measured at a location approximately 1 mile from industrial operations at the IP Savannah Complex. As shown in the table, the maximum 24-hour average concentrations measured during this 3-year monitoring effort were all lower than the pollutants' corresponding health-based comparison values, suggesting that the measured concentrations likely would not present a public health hazard for short-term (or acute) exposures.

- **Long-term exposures.** Summarized in Table 10 are the highest annual average concentrations measured between 2002 and 2004 for pollutants that GADNR measured at this same monitoring location. With two exceptions, every pollutant's annual average concentration was considerably lower than the corresponding health-based comparison value, suggesting that long-term (or chronic) exposures to these air pollution levels do not present a public health hazard. As the exceptions, annual average concentrations of arsenic and cadmium both exceeded a screening value for potential carcinogenic effects. Since measurements of these two pollutants exceeded a screening value, a more detailed health evaluation was conducted for this document (see "Public Health Implications: Exposure to Air Pollutants"). The findings on potential exposure to arsenic and cadmium as listed in the Public Health Implications section are as follows:

  Residents near the IP Savannah Complex may be exposed to arsenic at levels similar to concentrations typically found in remote areas of the US. The risk of cancer from arsenic in air is very low and may be zero. The risk also is similar to other parts of the US.

  Residents near the IP Savannah Complex may be exposed to cadmium at levels typically found in other parts of the US. The risk of cancer from cadmium in air is very low and may be zero. The risk also is similar to other parts of the US.

- **Other pollutants.** Presented in Table 9 and Table 10 are data for only those pollutants that have health-based comparison values. GADNR's particulate monitoring program measured air pollution levels for nearly 30 other constituents of fine particulate matter. These other pollutants are either relatively benign or do not have sufficient toxicological information to derive comparison values. Regardless, ATSDR reviewed the measured concentrations for these additional pollutants and found the levels to be generally consistent with those that are routinely measured at other locations across the state and country.

Therefore, the rather large set of data available from GADNR's routine monitoring in the Savannah area suggests that the air pollutants measured have not reached levels that are a public health hazard, with the possible exception of longer-term exposures to arsenic and cadmium, which are reviewed in more detail below (see "Public Health Implications: Exposure to Air Pollutants"). However, this data set suffers from some of the same limitations identified for other studies reviewed above. Because this program was not designed specifically to characterize air quality impacts from any single facility, GADNR's ongoing monitoring does not consider the entire range of site-related pollutants of potential concern, nor does this program include monitoring stations in the areas closest to the IP Savannah Complex.

Summary of Air Pollution Measurements

Overall, air pollution levels in Savannah have been measured in several studies conducted between 1988 and the present. Taken together, these studies offer several thousand individual observations of air pollution levels at locations within 2.5 miles of the IP Savannah Complex. All of the individual measurements were lower than health-based comparison values for acute exposures (for those pollutants for which health-based comparisons values have been derived), suggesting that short-term exposure to air pollution would not result in adverse health effects on the days when and locations where measurements were taken. Long-term monitoring efforts at locations within 2.5 miles of the IP Savannah Complex have occurred for several pollutants: acetaldehyde, formaldehyde, propionaldehyde, sulfur dioxide, particulate matter, and selected metals. These measurements were also consistently below health-based comparison values for chronic exposure, with the exceptions of arsenic, cadmium, and formaldehyde, which are reviewed in greater detail later in this health consultation (see "Public Health Implications: Exposure to Air Pollutants").

The studies reviewed for this consultation seem to indicate air pollution levels are not occurring at levels of health concern. However, the available studies have important limitations, namely the somewhat limited spatial and temporal coverage of air pollution measurements and that certain pollutants of interest (e.g., some sulfur compounds such as hydrogen sulfide) have not been measured in the immediate vicinity of the IP Savannah Complex.

Review of Permitting and Compliance Information

Facility compliance information characterizes the extent to which operations meet specifications outlined in permits and regulations, which can be useful context for public health evaluations. Specifically, given that permits and regulations are typically developed to be protective of human health and the environment, facilities with perfect compliance records are generally less likely to pose public health hazards than those with routine violations. However, there are many exceptions to this generalization: some facilities with no air permit violations may present significant public health hazards, while other facilities with routine violations (perhaps procedural ones) may present no public health hazards. For these and other reasons, public health conclusions are typically not based on compliance information alone.

ATSDR considered several observations when evaluating the IP Savannah Complex's compliance with air regulations. First, ATSDR considered information downloaded from EPA's Enforcement and Compliance History Online (ECHO) database, which indicates that the IP

Savannah Complex was not subject to any recent enforcement activities and had no financial penalties associated with violations of federal air regulations. This database also indicates that the facility has no "high-priority violations" with Clean Air Act requirements. In short, there does not appear to be evidence of the IP Savannah Complex being in significant noncompliance or having repeated violations of air pollution control regulations. This observation is generally consistent with information ATSDR obtained when conducting a file review at the Air Protection Branch of GADNR's Environmental Protection Division.

Additionally, recent regulatory developments have likely reduced the amount of pollutants that the IP Savannah Complex releases into the air. For instance, in 1998, EPA passed its "Cluster Rule," which set strict pollution control standards for pulp and paper mills nationwide. This rule required IP Savannah Complex to employ "maximum achievable control technology" on many air emissions sources. Compliance with this regulation has led to enhanced air pollution controls, particularly for emissions of total reduced sulfur compounds (Katula, 2006).

Overall, compliance information for the IP Savannah Complex indicates that the facility routinely operates within limits established in its environmental permits. This observation provides some assurance—but no guarantee—that the facility's air pollutant releases fall within health-protective bounds.

Public Health Implications

Public Health Implications: Exposure to Air Pollutants

To evaluate whether the public health implications of exposure to pollutants released from the IP Savannah Complex, ATSDR considered the combined set of air pollution measurements described earlier in this health consultation. As emphasized previously, the levels of air pollution measured in the area reflect contributions from many different emissions sources and should not be attributed solely to the IP Savannah Complex.

Presented in Table 11 are pollutants released by the IP Savannah Complex that have been considered in at least one of the air pollution studies conducted in the area. The table also identifies pollutants known to be released by the IP Savannah Complex, but have not been measured in the air around the facility. Following is ATSDR's interpretations of these two lists:

- The top half of Table 11 identifies the pollutants that the IP Savannah Complex releases for which some air pollution measurements are available for areas within 2.5 miles of the facility. The air pollution levels measured for every pollutant listed in the top part of this table are below ATSDR's comparison values for acute exposures. This means that the measured air pollution levels were not a public health hazard and no further toxicological evaluation is needed to evaluate brief exposures to those chemicals.

- ATSDR also considered long-term average measurements, which are available for 15 of the pollutants identified in the top half of Table 11 The long-term average airborne levels for nearly every one of these pollutants were well below ATSDR's comparison values for chronic exposures, therefore these chemicals do not present a health hazard over the longer term. However, three pollutants (two of which have been documented in the emissions from

the IP Savannah Complex) had annual average concentrations greater than ATSDR's comparison values for chronic exposures. A more detailed review of their public health implications follows:

Arsenic.

The highest annual average concentration of arsenic near the IP Savannah Complex is 0.0014 :g/m^3. As a result, ATSDR evaluated the public health implications of long-term exposures to these airborne levels. When considering the arsenic levels, it is important to note that arsenic is routinely found in airborne particles collected throughout the country, even in rural areas. Thus, the presence of airborne arsenic near the IP Savannah Complex does not necessarily mean that the pollutant originated from the pulp and paper mill operations. Additionally, annual average concentrations of arsenic in remote areas of the United States typically range from <0.001 to 0.003 :g/m^3 (ATSDR 2005). The measured arsenic levels near the IP Savannah Complex are at the lower end of this range.

Evidence of increased lung cancer incidences associated with arsenic exposure stems primarily from studies of humans exposed to arsenic while working at smelters. Studies examining workers at smelters in Washington and Sweden provide the strongest evidence of carcinogenic effects. Arsenic levels were above a time-weighted average of 69 :g/m^3 at the Washington smelter and above a time-weighted average of 50 :g/m^3 at the Ronnskar smelter in Sweden. These levels are more than 35,000 times higher than the levels measured at the IP Savannah Complex. Both studies found that the risk for respiratory cancers resulting from arsenic exposure increased with increasing concentration and increasing exposure durations (ATSDR 2005).

U.S. EPA has a method for estimating the cancer risk of arsenic in air. The cancer risk from arsenic in air is estimated by multiplying the air concentration of arsenic by what is called a cancer slope factor. The resulting number is an estimate of the number of cancers in a population. The equation for estimating cancer follows:

Inhalation cancer risk = air concentration of arsenic x cancer slope factor for arsenic

The resulting risk of cancer is called an excess cancer risk because it is the risk of cancer above the already existing background risk of cancer. U.S. EPA also states that the risk could be zero. Therefore, one interprets the excess cancer risk as being between 0 and some number for every 1 million people exposed to arsenic in air. The estimated cancer risk is above the already established background risk of cancer, which is about 1 in every 2 men and 1 in every 3 women over a lifetime.

The estimated cancer risk from arsenic in air at 0.0014 ug/m3 is somewhere between 0 and 6 cases of cancer for every 1 million people exposed for a lifetime. It is important to remember that other parts of the United States have similar concentrations of arsenic in air and therefore have similar estimates of cancer risk.

Residents near the IP Savannah Complex may be exposed to arsenic at levels similar to concentrations typically found in remote areas of the US. The risk of cancer from arsenic in air is very low and may be zero. The risk also is similar to other parts of the US.

Cadmium

The highest annual average concentration of cadmium measured near the IP Savannah Complex is 0.0023 :g/m^3. When examining the cadmium levels further, ATSDR noted that cadmium is a component of airborne particles found throughout the country, even in remote locations. Moreover, annual average concentrations of cadmium in urban areas across the United States typically range from 0.003 to 0.040 :g/m^3 (ATSDR 1999a). The measured cadmium levels near the IP Savannah Complex fall below this range of concentrations.

ATSDR does not have a health guideline for inhalation exposure to cadmium; therefore, it is necessary to compare the measured air concentration in a community directly to human or animal studies to decide if harmful effects might be possible. The cadmium concentrations measured near the IP Savannah Complex are 6,000 times lower than levels that damage the lungs of rats and 10,000 times lower than levels that damage the kidneys in humans. Therefore, non-cancerous harmful effects from cadmium in air are unlikely in people who live near the IP Savannah Complex.

ATSDR also further examined information regarding potential cancer-causing effects from cadmium exposure. Through numerous human and laboratory animal studies, scientists have explored the relationship between breathing cadmium and an increased risk of developing cancer. Human studies consider workers exposed to cadmium at various manufacturing plants and smelters. Data from these human studies have provided conflicting evidence about whether or not cadmium exposure leads to an increased risk of cancer. However, one study of humans clearly showed an increase in lung cancer deaths in workers who were exposed to cadmium for decades.

Data from laboratory animals (rats) have clearly shown that cadmium increases lung tumors at concentrations of 13-30 :g/m^3 and above. (ATSDR 1999a). T

Like arsenic, EPA has developed a cancer slope factor for cadmium that allows scientists to estimate cancer risk. At an average concentration of 0.0023 ug/m3, somewhere between 0 and 4 extra cases of cancer might be expected for every 1 million people exposed for a lifetime. The risk of cancer from cadmium in air is very low and may be zero. It is important to remember that other parts of the US have a similar risk of cancer from cadmium in air.

Residents near the IP Savannah Complex may be exposed to cadmium at levels typically found in other parts of the US. The risk of cancer from cadmium in air is very low and may be zero. The risk also is similar to other parts of the US.

Formaldehyde

The highest annual average concentration of formaldehyde measured near the IP Savannah Complex is 1.95 ppb. ATSDR researched these measured concentrations further, and reached several important conclusions. Though emitted from the IP Savannah Complex, formaldehyde is also released by motor vehicles and other sources. In large cities, peak formaldehyde levels in air are associated with high vehicular traffic. As a result, formaldehyde in outdoor air is found throughout the US. Cities typically have average formaldehyde levels of 2 to 15 ppb (ATSDR 1999).

For this reason, the airborne levels of formaldehyde near the IP Savannah Complex are not unusually elevated and part of the air pollution exposures that people typically experience in urban and suburban locations across the United States .ATSDR further evaluated potential carcinogenic effects and found that concerns about associations with cancer were prompted by studies in the 1980s showing a link between nasal tumors in rodents and formaldehyde exposure. Based on these concerns, scientists have conducted over 40 epidemiological studies to assess possible carcinogenic effects in humans. These studies report conflicting results. Rodent studies consistently report a correlation between formaldehyde levels of 10,000-15,000 ppb and nasal cancers. Like arsenic and cadmium, the EPA has developed a cancer slope factor for formaldehyde that allows scientists to estimate cancer risk. At an average concentration of 1.95 ppb, somewhere between 0 and 3 extra cases of cancer might be expected for every 100,000 people exposed for a lifetime. The risk of cancer from formaldehyde in air is very low and may be zero. It is important to remember that other parts of the US have a similar or slightly higher risk of cancer from formaldehyde in air.

Residents near the IP Savannah Complex may be exposed to formaldehyde at levels similar to other parts of the US. The risk of cancer from formaldehyde is very low and may be zero. This risk also is similar to other parts of the US.

- Listed in the bottom half of Table 11 are several pollutants found in IP Savannah Complex's emissions, but for which no off-site air pollution measurements are available. This table should not be viewed as a complete list, as there are likely additional pollutants released by the facility (e.g., sterols) that may not have state or federal emissions reporting requirements.

  ATSDR rarely encounters situations in which ambient air monitoring studies have considered every pollutant from the site of interest. The key question is whether the available data cover an adequate subset of the pollutants in order to make definitive conclusions about local air quality. Based on the review of the site-related pollutants (see Table 11), ATSDR believes the available data provide a sufficient basis for evaluating the air exposure pathway from the IP Savannah Complex, because air quality measurements have been made for many of the pollutants that are most toxic and released in largest quantities. One possible exception to this finding is for hydrogen sulfide—a pollutant that (1) is released in relatively large quantities from the IP Savannah Complex, (2) might account for some of the odor issues in the surrounding neighborhoods, and (3) is toxic for both acute and chronic exposures. Accordingly, future efforts to measure air quality impacts from the IP Savannah Complex should consider measuring ambient air concentrations of hydrogen sulfide.

In summary, since 1988 thousands of air pollution measurements have been made at locations within 2.5 miles of the IP Savannah Complex. Many of these measurements considered pollutants that the facility releases in relatively large quantities. None of these measurements reached levels that would indicate a public health hazard at the locations where and the times when samples were collected, both for short-term (acute) and long-term (chronic) exposures. Some potentially harmful pollutants (at high levels) are found in the air near the facility, but the levels measured appear to be consistent with levels found in suburban and urban areas around the country. This may indicate these pollutants may originate from air pollution sources common to city environments (e.g., motor vehicles). This issue is discussed in more detail below (see "Public Health Implications: Near-Roadway Exposures").

Public Health Implications: Environmental Odors

Several residents have informed ATSDR of unpleasant environmental odors in neighborhoods surrounding the IP Savannah Complex, and residents have filed numerous complaints with GADNR about these odors. The presence of unpleasant odors around pulp and paper mills is well documented (e.g., EPA 1998; WDHFS 2000), and is not unique to the IP Savannah Complex. While emissions sources other than IP Savannah Complex might contribute to odors detected near the site, it is clear that the IP Savannah Complex releases several malodorous pollutants (e.g., sulfur compounds, ammonia, and certain oxygenated compounds) that may well cause some of the unpleasant odors detected in the community.

The public health implications of environmental odors are difficult to address. Some studies have suggested that odors from pulp mills are *associated with* certain health effects (e.g., watery eyes, headaches, breathing difficulties); however, these studies could not determine whether the odors actually *caused* these problems (EPA 1998). There are several reasons why the health implications of odors are difficult to evaluate. For instance, the presence of an odor could result from exposure to many different chemicals, some may be toxic and others are essentially benign. In addition, because some air pollutants can be smelled by humans at levels much lower than levels of health concern, the presence of an environmental odor does not necessarily mean unhealthy exposures occur. Another complicating factor is that odor perception varies greatly from one person to the next. For example, some people may react to environmental odors at concentrations below levels of health concern defying classic toxicological principles.

Historically, unpleasant environmental odors have been recognized as “warning” signs of potential risks to human health, although not direct triggers of health effects. Odors from environmental sources may cause health symptoms depending on many individual and environmental factors. However, some current research indicates that some people may experience some adverse health effects such as headaches and nausea resulting from exposure to unpleasant environmental odors (Schiffman, 2005).

Due to these and other reasons, ATSDR typically bases its public health conclusions on the airborne levels of odor-causing pollutants, rather than on the presence of odors. Air pollution measurements have identified some malodorous substances in the air near the IP Savannah Complex: formaldehyde, methanol, and carbon disulfide. As noted previously, these studies indicated that the measured pollutants were not at levels of health concern at the locations where and the dates when samples were collected. Malodorous pollutants measured in the air to date near the IP Savannah Complex have not been shown to be at levels that present a public health hazard. This finding is based on a relatively large amount of air sampling data. It should be noted that the air pollution studies conducted in the area did not measure air concentrations of hydrogen sulfide, which is emitted from several operations at the IP Savannah Complex. However, industrial operations that are believed to release larger quantities of hydrogen sulfide and related compounds are regulated through the facility’s air permits. Facility compliance with the IP Savannah Complex’s air permit should help to ensure that facility emissions do not present a public health hazard.

In summary, although several studies have measured airborne levels for several malodorous substances, none of those measurements found environmental odors at levels that would indicate

a public health hazard. Moreover, recently enacted federal air pollution control laws have targeted air releases of odorous substances from pulp and paper mills, and compliance with these regulations should help ensure that emissions of these pollutants do not increase in the future. Community-based air monitoring for hydrogen sulfide in the adjacent residential neighborhoods would provide further confidence in this conclusion, though it is unclear if any stakeholders have plans to conduct such a study.

Public Health Implications: Near-Roadway Exposures

Though the focus of this health consultation is on air quality impacts of pollutants released from the IP Savannah Complex, ATSDR found that ambient air concentrations of several pollutants near the facility are affected by a number of sources, including mobile sources. The presence of mobile source air toxics in outdoor air is well-documented for nearly every urban and suburban location where air pollution measurements have been collected. ATSDR includes this finding in the health consultation to provide residents some background information on the different factors that affect air quality. Information provided in this section is not meant to imply that Savannah's air quality is affected more by mobile sources than by the IP Savannah Complex, or vice versa.

The extent to which mobile sources contribute to air pollution levels varies considerably from one pollutant to the next (see Table 2). For carbon monoxide, nitrogen oxides, and volatile organic compounds, mobile sources generally account for a substantial portion of pollutant releases in urban settings, and specifically in Chatham County. Many hazardous air pollutants—including some known carcinogens—also originate from mobile sources. EPA has recently estimated that roughly one-third of Americans live in locations where mobile source air toxics account for air pollution levels that present an elevated theoretical lifetime cancer risk, and these risks are most pronounced in areas with the greatest motor vehicle traffic (EPA 2007e). With the advent of cleaner mobile source technologies (both for vehicles and fuels), however, air quality impacts from mobile sources and associated health risks are expected to decrease in coming years.

While mobile sources clearly are a factor in some of Savannah's air quality issues, mobile sources are not a dominant factor for all pollutants. For example, mobile sources likely account for only a small fraction of the malodorous pollutants found in the air near the IP Savannah Complex. Several other pollutants identified during the air pollution studies (e.g., chlorinated compounds) also generally do not originate from mobile sources in considerable quantities.

Overall, the previous discussion is meant to offer some insights into the various factors that affect air quality in urban and suburban settings. While scientists may debate the precise extent to which mobile sources or industrial sources affect air pollution levels, it is important to note that the findings in this health consultation are based on the actual air pollution levels measured in multiple studies, regardless of the origin of those air pollutants.

Child Health Considerations

In communities concerned about air pollution, the many physical differences between children and adults should be emphasized. Children could be at greater risk than are adults from certain kinds of exposures. Some children are outdoors longer than adults, which can increase their

exposure potential to poor air quality. Also, a child's lower body weight 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.

Where possible, this health consultation explicitly considered child health issues when evaluating the measured air pollution levels. Specifically, when evaluating the ambient air monitoring data, ATSDR applied health-based comparison values developed to be protective of children whenever health-based comparison values were available. As one example, the health-based comparison values used to assess particulate matter exposures were developed to protect the health of sensitive populations, including children and asthmatics. While the measured air pollution levels were lower than such health-based comparison values, ATSDR acknowledges there may not be enough information about other site-related pollutants to determine whether children are more sensitive to exposures than adults.

Based on information collected by the 2000 Census, 618 of residents in the communities in a 1 mile radius the IP Savannah Complex are children (age 6 years and younger). Many of these residents live in the Hudson Hill, West Savannah, and Woodville communities. The closest residential neighborhoods are located primarily southwest, south, and southeast of the facility. These neighborhoods include many locations that children frequent, such as schools, parks, community centers, places of worship, and businesses. Some of these locations are in very close proximity (less than 300 yards) to the Arizona Chemical Corporation's industrial operations within the IP Savannah Complex.

None of the information evaluated in this health consult indicates a public health hazard exists from chemical releases from the IP Savannah Complex to children in communities near the IP Savannah Complex.

Conclusions

ATSDR has reached the following conclusions regarding the air exposure pathway for the International Paper Savannah Complex:

- For years before 1988, little information is available on air pollution levels near the IP Savannah Complex. It is unlikely that past conditions could be replicated such that representative air measurements could be collected to measure past air pollution levels. Due to these critical information gaps, ATSDR cannot make any conclusions about air pollution levels prior to 1988.

- From 1988 to the present, the IP Savannah Complex has released dozens of pollutants into the air. The total amount of pollutants released across the entire facility has apparently decreased considerably since 1988, though data are not available for all pollutants released. Several other nearby industrial facilities and mobile sources release some of the same pollutants that are emitted by the IP Savannah Complex.

- Since 1988, thousands of air pollution measurements have been made at locations within 2.5 miles of the IP Savannah Complex. None of these measurements appeared to have reached levels that would suggest a public health hazard at the locations where and the times when samples were collected. The available air pollution measurements, though extensive, do not cover all pollutants released by the IP Savannah Complex. The most notable limitation is the lack of measurements for sulfur compounds and the lack of measurements in the neighborhoods located closest to the IP Savannah Complex's industrial operations. Ongoing operation of facility processes in compliance with health-protective permit requirements should help ensure that releases of these other pollutants do not present a public health hazard to nearby residents.

- Environmental odors near the IP Savannah Complex are at times unpleasant and a nuisance. While several studies have measured airborne levels for several malodorous substances near the IP Savannah Complex, none of those measurements appear to have found odorous substances at levels that would indicate a public health hazard. The studies did not consider every odor-causing pollutant (e.g., hydrogen sulfide) released by the facility. Additionally some current research indicates that some people may experience some adverse health symptoms such as headaches and nausea resulting from exposure to unpleasant environmental odors. However, several requirements in the facility's operating permit restrict the amount of these additional pollutants that can be released. Ongoing compliance with these requirements should help to ensure that the malodorous substances that have not been considered in the previous air pollution monitoring studies do not present a public health hazard in the future. Air monitoring for hydrogen sulfide in the adjacent residential neighborhoods would also provide further confidence in this conclusion, though it is unclear if any stakeholders have plans to conduct such a study.

Recommendations

The available air pollution measurements suggest there is no apparent public health hazard, but those measurements are limited in terms of the pollutants and locations that they cover. The most notable limitation is the lack of measurements for sulfur compounds and the lack of measurements in the neighborhoods located closest to the IP Savannah Complex's industrial operations. While the available information suggests that air pollution levels are not a public health hazard, monitoring for sulfur compounds in this neighborhood would help provide assurance that a health hazard does not exists. Therefore, during the public comment period of this health consultation, ATSDR discussed with external partners and stakeholders associated with the International Paper Savannah Complex the possibility of conducting community-based air monitoring for sulfur compounds in the communities closest to the IP Savannah Complex.

ATSDR recommends that the management of International Paper Savannah Complex continue efforts and procedures to reduce facility emissions. If facility conditions change, the management of International Paper Savannah Complex and the Georgia Department of Natural Resources should ensure that facility emissions do not adversely impact the communities in Savannah, GA.

Public Health Action Plan

Since accepting the petition to evaluate community health concerns regarding the IP Savannah Complex, ATSDR has conducted various activities to evaluate air pollution levels and to coordinate with the local community. A timeline of the main activities conducted to date follows.

- In November 2002, ATSDR visited Savannah, met community members who expressed health concerns about air pollutants released from the IP Savannah Complex, and toured the residential neighborhoods surrounding the facility.

- In January 2003, ATSDR agreed to conduct two public health consultations, an ATSDR document that examines hazardous substances, health outcomes, and community concerns to determine whether people could be harmed by coming into contact with those substances. It was determined that the first health consultation would focus on the determination of available air data and the second health consultation would provide an evaluation of available air data and possible health implications.

- In 2003 - 2005, ATSDR obtained and reviewed records from state and local agencies on the amounts of air pollutants released from local facilities, studies that measured local air pollution levels, and health studies.

- On September 27, 2005, ATSDR conducted a public meeting for the residents of the Hudson Hill community. ATSDR presented a draft public health outreach plan and discussed the status of the public health consultations.

- On January 6, 2006, ATSDR released its draft public health consultation that focused on the determination of available air data.

- In March 2006, ATSDR conducted a file review of records maintained by GADNR's Environmental Protection Division and obtained information from representatives of the IP Savannah Complex on facility emissions and past air sampling efforts.

- In April 2006, ATSDR issued a fact sheet to the Hudson Hill community to solicit community, local industries, and federal, state, and local governmental agencies participation in a community workgroup. The purpose of the workgroup was to:

  Increase the community's awareness and knowledge of how ATSDR works with communities to prevent environmental exposure,

  Inform and educate the community about findings of the public health consultation, and

  Inform and educate the community about the process of determining if there are health effects.

- On October 27, 2006, Harambee House Inc. was selected to receive technical assistance and funding for a 2-year U.S. EPA Community Action for a Renewed Environment (CARE) project.

- In February 2007, ATSDR updated its public health action plan to address the concerns of the community

- On May 22-23, 2007, ATSDR conducted a community workgroup meeting and public availability meeting for the community.

- On May 29-31, 2008, ATSDR will conduct a respiratory workshop/health fair and physician/health care provider health education training course.

- During the public comment period of this consult, ATSDR discussed with external partners and stakeholders associated with the International Paper Savannah Complex the possibility of conducting community-based air monitoring for sulfur compounds in the communities closest to the IP Savannah Complex. At the time of the release of this consult, ATSDR was not aware of any planned additional community-based air monitoring studies for sulfur compounds in the communities closest to the IP Savannah Complex.

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Table 1. IP Savannah Complex Air Emissions Reported to TRI (Page 1 of 3)

Chemical	Emissions (pounds), by Calendar Year					
	1988	1989	1990	1991	1992	1993
Acetaldehyde	NR	NR	NR	NR	NR	48,005
Acetone	1,227,000	1,102,200	862,200	274,000	217,000	204,000
Ammonia	NR	NR	NR	NR	NR	NR
Arsenic compounds	NR	NR	NR	NR	NR	NR
Barium compounds	NR	NR	NR	NR	NR	NR
Benzo(g,h,i)perylene	NR	NR	NR	NR	NR	NR
Biphenyl	NR	0	240	4,300	5,000	4,900
Catechol	60	0	640	630	980	80
Chlorine	250	250	11	NR	NR	NR
Copper compounds	NR	NR	NR	NR	NR	NR
Cresol (mixed	NR	NR	NR	NR	NR	NR
Dioxins	NR	NR	NR	NR	NR	NR
Ethylene glycol	60	0	30	18	15	NR
Formaldehyde	24,250	222	450	195	25,010	24,000
Hydrochloric acid	740,750	360,000	340,000	380,000	610,000	600,000
Hydrogen fluoride	NR	NR	NR	NR	NR	NR
Lead compounds	NR	NR	NR	NR	NR	NR
Maleic anhydride	250	28	1,070	1,100	1,440	170
Manganese	NR	NR	NR	NR	NR	NR
Mercury compounds	NR	NR	NR	NR	NR	NR
Methanol	12,018,000	11,022,000	8,622,000	2,237,000	1,739,000	1,636,000
Methyl ethyl ketone	NR	NR	NR	39,110	53,300	45,320
Naphthalene	NR	NR	NR	NR	43,000	33,000
Nickel compounds	NR	NR	NR	NR	NR	NR
Phenol	NR	NR	NR	NR	4,200	3,600
PACs	NR	NR	NR	NR	NR	NR
Sulfuric acid	430,000	300,000	240,000	241,400	302,300	312,300
Toluene	324,000	401,000	375,000	250,000	205,000	163,000
Vanadium	NR	NR	NR	NR	NR	NR
Xylene (mixed	NR	3,520	1,850	1,800	25,000	25,400
Zinc compounds	750	780	1,400	800	1,400	800

Source: EPA 2007a.

Notes: The chemicals listed are those having air emissions data (greater than 0 pounds) reported to TRI in any year between 1988 and 2004. In the chemical list, "dioxins" refers to dioxin and dioxin-like compounds (with emissions in grams, not pounds), and "PACs" refers to polycyclic aromatic compounds.

For hydrochloric acid and sulfuric acid, TRI reporting requirements changed. Between 1988 and 1993, these chemicals were reportable regardless of their physical state. From 1994 to the present, they are reportable only when found in the aerosol form.

Emissions of zero pounds per year means that facility usage for the chemical exceeded reporting thresholds, but the estimated facility-wide air emissions were less than 0.5 pounds per year.

"NR" means "Not Reported": For any given year, TRI reporting is only required if an industrial facility's chemical usage exceeds certain thresholds. "NR" entries designate years when chemical usage at the IP Savannah Complex presumably did not exceed reporting thresholds.

Table 1 (Continued). IP Savannah Complex Air Emissions Reported to TRI (Page 2 of 3)

Chemical	Emissions (pounds), by Calendar Year					
	1994	1995	1996	1997	1998	1999
Acetaldehyde	174,800	174,300	162,080	191,490	167,060	172,840
Acetone	NR	NR	NR	NR	NR	NR
Ammonia	132,700	120,500	130,500	133,500	152,500	164,500
Arsenic compounds	NR	NR	NR	NR	200	190
Barium compounds	NR	NR	210	1,120	1,520	1,660
Benzo(g,h,i)perylene	NR	NR	NR	NR	NR	NR
Biphenyl	3,700	5,000	4,950	NR	NR	NR
Catechol	60	70	0	0	0	0
Chlorine	NR	NR	NR	NR	NR	NR
Copper compounds	NR	NR	NR	2,360	2,660	2,750
Cresol (mixed	4,200	NR	NR	NR	NR	NR
Dioxins	NR	NR	NR	NR	NR	NR
Ethylene glycol	NR	NR	NR	NR	NR	NR
Formaldehyde	38,026	27,020	26,880	29,690	26,580	28,710
Hydrochloric acid	490,000	420,000	427,000	430,000	453,000	461,000
Hydrogen fluoride	NR	NR	NR	33,300	37,000	37,500
Lead compounds	NR	NR	NR	NR	NR	NR
Maleic anhydride	370	440	420	410	460	410
Manganese	NR	NR	15,600	15,300	16,500	2,800
Mercury compounds	NR	NR	NR	NR	NR	NR
Methanol	1,413,000	1,406,800	1,236,420	1,437,170	1,266,920	1,296,940
Methyl ethyl ketone	25,400	32,350	19,030	22,220	19,170	19,850
Naphthalene	NR	NR	NR	NR	NR	NR
Nickel compounds	NR	NR	NR	1,150	1,210	1,270
Phenol	8,400	20,000	4,300	4,690	3,540	3,290
PACs	NR	NR	NR	NR	NR	NR
Sulfuric acid	362,400	330,000	302,000	145,000	166,000	172,000
Toluene	159,000	265,000	264,000	311,900	300,600	257,800
Vanadium compounds	NR	NR	NR	NR	NR	NR
Xylene (mixed	6,500	18,500	16,080	17,580	14,080	13,850
Zinc compounds	990	1,100	1,600	1,640	1,500	1,630

Source: EPA 2007a.

Notes: The chemicals listed are those having air emissions data (greater than 0 pounds) reported to TRI in any year between 1988 and 2004. In the chemical list, "dioxins" refers to dioxin and dioxin-like compounds (with emissions in grams, not pounds), and "PACs" refers to polycyclic aromatic compounds.

For hydrochloric acid and sulfuric acid, TRI reporting requirements changed. Between 1988 and 1993, these chemicals were reportable regardless of their physical state. From 1994 to the present, they are reportable only when found in the aerosol form.

Emissions of zero pounds per year means that facility usage for the chemical exceeded reporting thresholds, but the estimated facility-wide air emissions were less than 0.5 pounds per year.

"NR" means "Not Reported": For any given year, TRI reporting is only required if an industrial facility's chemical usage exceeds certain thresholds. "NR" entries designate years when chemical usage at the IP Savannah Complex presumably did not exceed reporting thresholds.

Table 1 (Continued). IP Savannah Complex Air Emissions Reported to TRI (Page 3 of 3)

Chemical	Emissions (pounds), by Calendar Year				
	2000	2001	2002	2003	2004
Acetaldehyde	154,090	137,570	86,650	91,400	111,070
Acetone	NR	NR	NR	NR	NR
Ammonia	213,500	178,500	178,500	175,500	184,500
Arsenic compounds	170	160	130	0	120
Barium compounds	1,320	1,350	660	50	50
Benzo(g,h,i)perylene	9.8	1.63	1.04	0.9	1.1
Biphenyl	NR	NR	45,500	47,500	75,500
Catechol	0	0	0	0	0
Chlorine	NR	NR	NR	NR	NR
Copper compounds	2,560	2,380	230	150	160
Cresol (mixed	NR	NR	NR	NR	NR
Dioxins	0.00857 grams	0.00312 grams	0.00422 grams	0.00201 grams	0.00201 grams
Ethylene glycol	NR	NR	NR	NR	NR
Formaldehyde	24,700	32,610	28,605	28,510	33,459
Hydrochloric acid	437,000	402,000	384,000	340,000	361,000
Hydrogen fluoride	1,100	1,200	2,200	2,000	2,300
Lead compounds	NR	240	180	130	150
Maleic anhydride	410	505	628	668	582
Manganese	2,600	2,100	2,200	200	200
Mercury compounds	32.4	28.9	30.6	25.61	27.7
Methanol	1,600,910	1,351,790	791,700	957,830	1,033,324
Methyl ethyl ketone	21,590	24,310	13,330	NR	NR
Naphthalene	NR	NR	NR	NR	2,800
Nickel compounds	750	1,090	350	120	140
Phenol	2,860	1,590	9,350	10,130	9,350
PACs	73	181	143	131	146.7
Sulfuric acid	135,000	146,000	116,000	94,000	88,000
Toluene	256,500	264,300	253,000	270,000	262,700
Vanadium compounds	NR	NR	670	530	570
Xylene (mixed	12,970	7,400	7,230	10,810	11,240
Zinc compounds	1,800	1,720	590	290	350

Source: EPA 2007a.

Notes: The chemicals listed are those having air emissions data (greater than 0 pounds) reported to TRI in any year between 1988 and 2004. In the chemical list, "dioxins" refers to dioxin and dioxin-like compounds (with emissions in grams, not pounds), and "PACs" refers to polycyclic aromatic compounds.

For hydrochloric acid and sulfuric acid, TRI reporting requirements changed. Between 1988 and 1993, these chemicals were reportable regardless of their physical state. From 1994 to the present, they are reportable only when found in the aerosol form.

Emissions of zero pounds per year means that facility usage for the chemical exceeded reporting thresholds, but the estimated facility-wide air emissions were less than 0.5 pounds per year.

"NR" means "Not Reported": For any given year, TRI reporting is only required if an industrial facility's chemical usage exceeds certain thresholds. "NR" entries designate years when chemical usage at the IP Savannah Complex presumably did not exceed reporting thresholds.

Table 2. 1999 Air Emissions in Chatham County, by Selected Source Categories

Pollutant	Percentage of Estimated Total County-Wide Emissions (1999), by Source Category		
	Point Sources	Area Sources	Mobile Sources
Carbon monoxide	26.2%	3.6%	70.2%
Nitrogen oxides	50.5%	2.8%	46.7%
Particulate matter	75.2%	18.4%	6.4%
Sulfur dioxide	92.8%	0.6%	6.6%
Volatile organic compounds	19.1%	34.5%	46.4%

Source: EPA 2007b.

Notes: Data are listed for criteria pollutants and their precursors. The "particulate matter" data are for particles with aerodynamic diameter less than 2.5 microns (also known as $PM_{2.5}$).

"Point sources" are stationary sources of air pollution, typically large industrial facilities. These include power plants, chemical manufacturing operations, and the IP Savannah Complex.

"Area sources" are smaller air pollution sources that individually do not emit enough pollutants to be considered a point source, but collectively throughout an area can account for a considerable quantity of emissions. Examples of area sources include agricultural tilling, dry cleaners, and gasoline stations.

Mobile sources refer to any vehicle or equipment with a gasoline or diesel engine (e.g., motor vehicles, construction equipment) as well as aircraft and marine vessels.

Table 3. Summary of the 1994 Chatham County Air Toxics Study (Pollutants detected during the study that have health-based comparison values for acute exposures)

Pollutant	Highest Ambient Air Concentration Measured	Health-based Comparison Value	
		Concentration	Type (see footnote)
1,1,1-Trichloroethane	7.46 ppb	2,000 ppb	1
1,1-Dichloroethylene	0.09 ppb	10 ppb	4
1,2,4-Trimethylbenzene	0.593 ppb	250 ppb	4
1,2-Dichloroethane	19.47 ppb	40 ppb	4
1,3,5-Trimethylbenzene	0.118 ppb	250 ppb	4
1,3-Butadiene	0.07 ppb	50 ppb	4
1,3-Dichlorobenzene	0.06 ppb	100 ppb	4
1,4-Dichlorobenzene	0.06 ppb	2,000 ppb	1
1-Butene	2.333 ppb	70 ppb	4
1-Ethyl-2-methylbenzene	0.15 ppb	250 ppb	4
1-Ethyl-3-methylbenzene	0.28 ppb	250 ppb	4
1-Ethyl-4-methylbenzene	0.287 ppb	250 ppb	4
1-Pentene	2.214 ppb	30 ppb	4
2-Methylpentane	1.67 ppb	80 ppb	4
3-Methylpentane	1.353 ppb	1,000 ppb	4
Acetaldehyde	1.22 ppb	50 ppb	4
Acetone	0.46 ppb	26,000 ppb	1
a-Pinene	0.085 ppb	10 ppb	4
Benzene	1.464 ppb	9 ppb	1
Carbon tetrachloride	0.14 ppb	300 ppb	3
Chlorobenzene	0.03 ppb	100 ppb	4
Chloroethane	0.05 ppb	15,000 ppb	1
Chloroform	0.09 ppb	100 ppb	1
cis-1,3-Dichloropropylene	0.02 ppb	10 ppb	4
cis-2-Butene	0.261 ppb	600 ppb	4
cis-2-Pentene	0.134 ppb	30 ppb	4
Cyclohexane	0.521 ppb	420 ppb	4
Cyclopentane	0.508 ppb	1,200 ppb	4
Dichlorotetrafluoroethane	0.02 ppb	10,000 ppb	4
Ethane	3.732 ppb	10,000 ppb	4
Ethylbenzene	0.142 ppb	460 ppb	4
Ethylene	2.444 ppb	1,000 ppb	4
Formaldehyde	13.63 ppb	40 ppb	1
Freon 11	0.58 ppb	5,000 ppb	4
Isobutane	4.672 ppb	2,000 ppb	4
Isobutene	0.335 ppb	600 ppb	4

Table 3 (Continued). Summary of the 1994 Chatham County Air Toxics Study (Pollutants that were detected during the study and that have health-based comparison values for acute exposures)

Pollutant	Highest Ambient Air Concentration Measured	Health-based Comparison Value	
		Concentration	Type (see footnote)
Isopentane	4.66 ppb	1,200 ppb	4
Isoprene	0.968 ppb	5 ppb	4
Methylcyclohexane	0.984 ppb	4,000 ppb	4
Methylcyclopentane	1.195 ppb	750 ppb	4
Methylene chloride	0.87 ppb	600 ppb	1
m-Xylene	0.898 ppb	2,000 ppb	1
n-Butane	4.756 ppb	8,000 ppb	4
n-Butylbenzene	0.15 ppb	500 ppb	4
n-Hexane	2.432 ppb	500 ppb	4
n-Octane	0.192 ppb	750 ppb	4
n-Pentane	3.938 ppb	1,200 ppb	4
o-Xylene	0.34 ppb	2,000 ppb	1
Propane	2.02 ppb	10,000 ppb	4
Propene	0.723 ppb	68,100 ppb	4
Propionaldehyde	0.22 ppb	8 ppb	4
p-Xylene	0.356 ppb	2,000 ppb	1
Styrene	0.562 ppb	5,000 ppb	3
Tetrachloroethylene	0.04 ppb	200 ppb	1
Toluene	4.481 ppb	1,000 ppb	1
trans-1,3-Dichloropropylene	0.06 ppb	10 ppb	4
trans-2-Butene	0.328 ppb	600 ppb	4
trans-2-Pentene	0.328 ppb	30 ppb	4
Trichloroethylene	1.023 ppb	2,000 ppb	1
Trichlorotrifluoroethane	0.18 ppb	5,000 ppb	4
Arsenic	0.006 :g/m^3	0.19 :g/m^3	3
Chromium	0.001 :g/m^3	1 :g/m^3	4
Lead	0.02 :g/m^3	1.5 :g/m^3	2
Nickel	0.011 :g/m^3	6 :g/m^3	3

Source: GADNR et al. 2005.

Notes: The highest concentrations shown are among the three monitoring stations ("Lathrop and Augusta," "Mercer School," and "Fire Station #2") located within 2.5 miles of the IP Savannah Complex. The measured concentrations reflect contributions from all nearby emissions sources and should not be viewed as resulting solely from emissions from the IP Savannah Complex.

Codes used for health-based comparison values follow (Note: See Appendix B for definitions of these comparison values and the hierarchy by which they were used.):

1 = ATSDR Environmental Media Evaluation Guide for acute exposures
2 = EPA National Ambient Air Quality Standard
3 = California acute reference exposure levels
4 = Texas effects screening levels for short-term exposures

Table 4. Summary of the 1994 Chatham County Air Toxics Study (pollutants detected during the study but without health-based comparison values for acute exposures)

Pollutant	Highest Measured Concentration
2,3,4-Trimethylpentane	0.101 ppb
2,3-Dimethylpentane	0.256 ppb
2,4-Dimethylpentane	0.105 ppb
2-Methyl-1-butene	0.317 ppb
2-Methyl-2-butene	1.175 ppb
3-Methyl-1-butene	0.103 ppb
4-Methyl-1-butene	0.262 ppb
b-Pinene	0.359 ppb
Camphene	0.592 ppb
n-Propylbenzene	4.614 ppb
Zinc	0.004 :g/m^3

Source: GADNR et al. 2005.
Notes: The highest concentrations shown are among the three monitoring stations ("Lathrop and Augusta," "Mercer School," and "Fire Station #2") located within 2.5 miles of the IP Savannah Complex. The measured concentrations reflect contributions from all nearby emissions sources and should not be viewed as resulting solely from emissions from the IP Savannah Complex.

Table 5. Summary of the 1994 Chatham County Air Toxics Study (pollutants never detected during the study at stations nearest the IP Savannah Complex)

Pollutants Not Detected in Samples from Stations Nearest the IP Savannah Complex		
3-Methyl-1-pentene	Benzo(k)fluroanthene	Indeno(1,2,3-cd)pyrene
Acenaphthene	Cadmium	Isopropylbenzene
Acenaphthylene	Catechol	Methanol
Acetylene	Chrysene	Naphthalene
Anthracene	cis-3-Hexene	Polychlorinated biphenyls
Benzo(a)anthracene	Epichlorohydrin	Phenanthrene
Benzo(a)pyrene	Ethylene glycol	Phenol
Benzo(b)fluoranthene	Fluoranthene	Pyrene
Benzo(g,h,i)perylene	Fluorene	

Source: GADNR et al. 2005.

Notes: The table is based on samples collected at the three monitoring stations ("Lathrop and Augusta," "Mercer School," and "Fire Station #2") located within 2.5 miles of the IP Savannah Complex. Some of these pollutants were detected at other stations in Chatham County, but located further away from the industrial area.

The failure to detect methanol likely resulted from the use of a relatively insensitive analytical method (i.e., a detection limit of approximately 75 ppb). All other pollutants had considerably lower detection limits.

Table 6. Summary of the 1995-1996 Savannah Area Air Toxics Study

Pollutant	Averaging Period for Concentration	Concentration (ppb)	Health-based Comparison Value	
			Concentration (ppb)	Type
Acetaldehyde	12-hour average	4.22	50	3
	Annual average	1.28	3	4
Formaldehyde	12-hour average	5.54	40	1
	Annual average	1.95	0.07	2
Propionaldehyde	12-hour average	3.83	8	3
	Annual average	0.67	0.8	4

Source: McIntosh et al., 2000; and UGA and GADNR 2007.

Notes: The table shows the highest concentrations (both 12-hour average and annual average) observed among the five different monitoring stations. In all cases but one, the highest concentrations occurred at the "Lathrop and Augusta" station. As the exception, the highest 12-hour average propionaldehyde concentration was observed at the rural background sampling station.

The measured concentrations reflect contributions from all nearby emissions sources and should not be viewed as resulting solely from emissions from the IP Savannah Complex.

Codes used for health-based comparison values (Note: See Appendix B for definitions of these comparison values and the hierarchy by which they were used.):

1 = ATSDR Environmental Media Evaluation Guide for acute exposures
2 = ATSDR Cancer Risk Evaluation Guide
3 = Texas effects screening levels for short-term exposures
4 = Texas effects screening levels for long-term exposures

Table 7. Summary of Union Camp Corporation's 1994 Toxic Air Pollutant Monitoring Program

Pollutant	Facility Conditions During Measurement	Highest 24-Hour Average Concentration (ppb)	Health-based Comparison Value	
			Concentration (ppb)	Type
Acetaldehyde	Not operating	1.34	50	3
Acrolein	Not operating	2.20	3	1
Benzaldehyde	Operating	0.87	5	3
Benzene	Not operating	1.86	9	1
Carbon disulfide	Not operating	1.30	10	3
Chloromethane	Operating	1.02	500	1
Formaldehyde	Operating	7.73	40	1
Hydrochloric acid	Not operating	7.39	1,400	2
Methylene chloride	Not operating	16.36	600	1
Toluene	Operating	14.69	1,000	1

Source: TRC 1995. Values in the table calculated from the raw data.

Notes: The table shows the highest 24-hour average concentrations detected during the 2-day study. Some of the concentrations occurred when the facility was fully operational; others occurred when most of the facility's operations were down.

The measured concentrations reflect contributions from all nearby emissions sources and should not be viewed as resulting solely from emissions from the IP Savannah Complex.

Codes used for health-based comparison values follow (Note: See Appendix B for definitions of these comparison values and the hierarchy by which they were used.):

1 = ATSDR Environmental Media Evaluation Guide for acute exposures
2 = California acute reference exposure levels
3 = Texas effects screening levels for short-term exposures

Table 8. GADNR's Ambient Air Monitoring Stations Near the IP Savannah Complex (1988-2006)

Identification Code for Monitoring Station	Location	Pollutants Measured	Time Frames over which Monitoring Occurred
13-051-0011	Fire Station #2 at Indian and Broad Street	Lead	1988-1996
		TSP	1988-1997
13-051-0017	402 Market Street (near the intersection with Alfred Street) at "Scott School"	Metals	2002-2004
		$PM_{2.5}$	1999-2006
		Sulfur dioxide	1999-2001
		TSP	1988-1997
13-051-0091	Mercer Middle School	$PM_{2.5}$	1999-2006
		Sulfur dioxide	1999-2001
		TSP	1988-1997
13-051-1002	West Lathrop and August Avenues	PM_{10}	1988-2005
		$PM_{2.5}$	2003-2006
		Sulfur dioxide	1988, 2002-2006
		TSP	1988-1997

Source: EPA 2007d; GADNR 1998-2005.
Notes: This document only summarizes monitoring that has occurred between 1988 and the present. Limited data are available for earlier years.
The table lists GADNR monitoring stations located within approximately 2.5 miles of the IP Savannah Complex. GADNR has operated several additional monitoring stations at locations throughout Chatham County.
Abbreviations used in the table:
TSP = total suspended particulates
PM_{10} = particulate matter with aerodynamic diameters smaller than 10 microns
$PM_{2.5}$ = particulate matter with aerodynamic diameters smaller than 2.5 microns

Table 9. Summary of GADNR's Ambient Air Monitoring for Constituents of Particulate Matter (2002-2004): Short-Term Exposures

Pollutant	Highest 24-Hour Average Ambient Air Concentration (:g/m^3)	Health-based Comparison Value	
		Concentration (:g/m^3)	Type (see footnote)
Aluminum	0.496	50	4
Antimony	0.028	5	4
Arsenic	0.012	0.19	3
Barium	0.035	5	4
Bromine	0.009	7	4
Cadmium	0.008	0.1	4
Chlorine	0.522	210	3
Chromium	0.0092	1	4
Cobalt	0.00132	0.2	4
Copper	0.006	100	3
Lead	0.0171	1.5	2
Magnesium	0.0851	50	4
Manganese	0.011	2	4
Mercury	0.005	1.8	3
Molybdenum	0.0038	50	4
Nickel	0.027	6	3
Potassium	0.288	20	4
Selenium	0.004	2	4
Silicon	0.952	50	4
Silver	0.0097	0.1	4
Strontium	0.00221	20	4
Sulfur	4.07	50	4
Tin	0.016	20	4
Tungsten	0.0104	10	4
Vanadium	0.15	0.2	1

Source: EPA 2007d.

Notes: The table shows the highest 24-hour average concentrations measured between 2002 and 2004 at the 402 Market Street monitoring station, which is located approximately 1 mile away from the nearest industrial operations at the IP Savannah Complex. More than 150 valid ambient air samples were collected during this time frame.

Data are based on measurements of chemical constituents of fine particulate matter (or $PM_{2.5}$). Data are shown for only those constituents that have health-based comparison values for acute exposures.

The measured concentrations reflect contributions from all nearby emissions sources and should not be viewed as resulting solely from emissions from the IP Savannah Complex.

Codes used for health-based comparison values follow (Note: See Appendix B for definitions of these comparison values and the hierarchy by which they were used.):

1 = ATSDR Environmental Media Evaluation Guide for acute exposures
2 = EPA National Ambient Air Quality Standard
3 = California acute reference exposure levels
4 = Texas effects screening levels for short-term exposures

Table 10. Summary of GADNR's Ambient Air Monitoring for Constituents of Particulate Matter (2002-2004): Long-Term Exposures

Pollutant	Highest Annual Average Ambient Air Concentration (:g/m^3)	Health-based Comparison Value	
		Concentration (:g/m^3)	Type (see footnote)
Aluminum	0.0715	5	4
Antimony	0.0061	0.5	4
Arsenic	0.0014	0.0002	2
Barium	0.015	0.5	4
Bromine	0.0031	0.7	4
Cadmium	0.0023	0.0006	2
Chlorine	0.0388	1.5	4
Chromium	0.0007	0.1	4
Cobalt	0.0004	0.1	1
Copper	0.0014	1	4
Lead	0.0023	1.5	3
Magnesium	0.0107	5	4
Manganese	0.0017	0.04	1
Mercury	0.0013	0.2	1
Molybdenum	0.0017	5	4
Nickel	0.0045	0.09	1
Potassium	0.0783	2	4
Selenium	0.0009	0.2	4
Silicon	0.1833	5	4
Silver	0.0025	0.01	4
Strontium	0.0008	2	4
Sulfur	1.449	5	4
Tin	0.0054	2	4
Tungsten	0.0029	1	4

Source: EPA 2007d.

Notes: The table shows the highest annual average concentrations based on results collected between 2002 and 2004 at the 402 Market Street monitoring station, which is located approximately 1 mile away from the nearest industrial operations at the IP Savannah Complex. More than 150 valid ambient air samples were collected during this time frame.

Data are based on measurements of chemical constituents of fine particulate matter (or $PM_{2.5}$). Data are shown for only those constituents that have health-based comparison values for chronic exposures.

The measured concentrations reflect contributions from all nearby emissions sources and should not be viewed as resulting solely from emissions from the IP Savannah Complex.

Codes used for health-based comparison values follow (Note: See Appendix B for definitions of these comparison values and the hierarchy by which they were used.):

1 = ATSDR Environmental Media Evaluation Guide for chronic exposures
2 = ATSDR Cancer Risk Evaluation Guide
3 = EPA National Ambient Air Quality Standard
4 = Texas effects screening levels for long-term exposures

Table 11. Summary of Air Pollutants Measured near the IP Savannah Complex (1988-2006)

Pollutants Released by the IP Savannah Complex and Measured at Monitoring Locations within 2.5 Miles of the Facility		
Acetaldehyde*	Ethylene glycol	Particulate matter*
Acetone	Formaldehyde*	Phenol
Ammonia*	Hydrochloric acid	Polcyclic aromatic compounds
Arsenic compounds*	Lead compounds*	Sulfur dioxide*
Barium compounds*	Manganese compounds*	Sulfuric acid (sulfate)*
Benzo(g,h,i)perylene	Mercury compounds*	Toluene
Catechol	Methanol	Vanadium compounds*
Chlorine	Naphthalene	Xylene
Copper compounds*	Nickel compounds*	Zinc compounds*
Pollutants Released by the IP Savannah Complex for which No Nearby Air Pollution Measurements Are Available		
Biphenyl	Dioxins	Maleic anhydride
Carbon monoxide	Hydrogen fluoride	Methyl ethyl ketone
Cresols	Hydrogen sulfide	Total reduced sulfur

Notes: The pollutants listed in this table are those that the IP Savannah Complex has reported to TRI (see Table 1) plus additional compounds identified in the text of this report (see "Review of Emissions Data," page 10). Though extensive, this list does not cover every pollutant released by the facility.

Pollutants listed in the top half of the table were evaluated in at least one air sample collected within 2.5 miles of the IP Savannah Complex. Those with an asterisk (*) have at least one full year of valid monitoring data available.

Pollutants listed in the bottom half of the table have not been considered in any of the air pollution measurements taken at locations within 2.5 miles of the IP Savannah Complex.

Appendix A. ATSDR Glossary of Terms

ATSDR Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, **1-888-422-8737**.

A B C | D E F | G H I | J K L | M N O | P Q R S | T U V | W X Y Z

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, *ambient* air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is **less** than would be

expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level

An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation

Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study

A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring

Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake

The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing

Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota

Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden

The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP [see Community Assistance Panel.]

Cancer

Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk

A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen

A substance that causes cancer.

Case study

A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study

A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number

A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.
CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]
Chronic
Occurring over a long time [compare with acute].
Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]
Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.
Community Assistance Panel (CAP)
A group of people from a community and from health and environmental agencies who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.
Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Completed exposure pathway [see exposure pathway].
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).
Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.
Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
top
Delayed health effect
A disease or an injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.
Dermal contact
Contact with (touching) the skin [see route of exposure].
Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.
Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.
Disease prevention
Measures used to prevent a disease or reduce its severity.
Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.
DOD
United States Department of Defense.
DOE
United States Department of Energy.
Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.
Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).
Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.
Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.
EPA
United States Environmental Protection Agency.
Epidemiologic surveillance [see Public health surveillance].

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Exposure registry
A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

top

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life ($t_{½}$)
The time it takes for half the original amount of a substance to disappear. In the

environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard

A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)

The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste

Potentially harmful substances that have been released or discarded into the environment.

Health consultation

A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education

Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation

The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to evaluate the possible association between the occurrence and exposure to hazardous substances.

Health promotion

The process of enabling people to increase control over, and to improve, their health.

Health statistics review

The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard

The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence

The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

top

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.
Mutagen
A substance that causes mutations (genetic damage).
Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.
National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or **NPL)**
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.
National Toxicology Program (NTP)
Part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.
No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.
No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.
No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.
NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]
top
Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.
Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.
Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.
Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].
Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public health surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [see Resource Conservation and Recovery Act (1976, 1984)]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample

A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size

The number of units chosen from a population or an environment.

Solvent

A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination

The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations

People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder

A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics

A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance

A chemical.

Substance-specific applied research

A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Superfund Amendments and Reauthorization Act (SARA)

Superfund Amendments and Reauthorization Act (SARA)

In 1986, SARA amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water

Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see public health surveillance]

Survey

A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect

A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

top

Teratogen

A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent

Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile

An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology

The study of the harmful effects of substances on humans or animals.

Tumor

An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor

Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard

A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Volatile organic compounds (VOCs)

Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

Other glossaries and dictionaries:
Environmental Protection Agency EXIT
National Library of Medicine (NIH) EXIT

Appendix B. Health-Based Comparison Values

Health-Based Comparison Values

Following are definitions of the various health-based comparison values that ATSDR used in this health consultation to put the measured air pollution levels into perspective. When selecting health-based comparison values for this evaluation, ATSDR first referred to its own published values. In cases where ATSDR-developed health-based comparison values were not available, ATSDR considered consensus values developed by other health or environmental agencies, both state and federal. The following list defines the types of health-based comparison values and the hierarchy in which they were used in this document.

CREG: Cancer Risk Evaluation Guide, a highly conservative and theoretical value that is believed to be associated with no more than one excess cancer in a million persons exposed over a lifetime.

EMEG: Environmental Media Evaluation Guide, a media-specific comparison value that is used to select contaminants of concern. Levels below the EMEG are not expected to cause adverse non-carcinogenic health effects. These have been developed for acute exposure scenarios, intermediate exposure scenarios, and chronic exposure scenarios.

NAAQS: National Ambient Air Quality Standard, an ambient air concentration that EPA has established to evaluate air quality. The standards are health-based and were designed to be protective of many sensitive populations, such as people with asthma and children. The standards have been developed only for a small subset of pollutants, and their averaging times and statistical interpretations vary among the regulated pollutants.

California acute reference exposure levels:

Developed by the California Environmental Protection Agency, these values are concentrations "…at or below which no adverse health effects are anticipated for a specified exposure duration…" and these values are "…designed to protect the most sensitive individuals in the population by inclusion of margins of safety" (CalEPA 1999).

Texas effects screening levels:

Developed by the Texas Commission on Environmental Quality (TCEQ), these values are "…chemical-specific air concentrations set to protect human health and welfare" (TCEQ 2006). TCEQ explains that "…exposure to an air concentration at or below the effects screening level is not likely to cause an adverse health effect in the general public, including sensitive subgroups such as children, the elderly, pregnant women, and people with pre-existing health conditions" (TCEQ 2006).