PUBLIC HEALTH ASSESSMENT

BRICK TOWNSHIP INVESTIGATION
(a/k/a BRICK TOWNSHIP AUTISM INVESTIGATION)

BRICK TOWNSHIP, OCEAN COUNTY, NEW JERSEY

Prepared by:

Superfund Site Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment 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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FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, fullscale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E56), Atlanta, GA 30333.

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SUMMARY

This public health assessment (PHA) was developed to address specific concerns brought to the attention of the Agency for Toxic Substances and Disease Registry (ATSDR) by a local parents group, Senator Torricelli and Representative Smith regarding concerns about a possible excess of children with autism spectrum disorders (ASD) in Brick Township, New Jersey. ATSDR was asked to assess hazardous chemical exposure in the environment from three areas: (1) the municipal drinking water supply, (2) swimming in the Metedeconk River, and (3) the Brick Township Landfill. This public health assessment evaluates possible exposures from these areas.

ATSDR collected data from the Environmental Protection Agency (EPA), New Jersey Department of Environmental Protection (NJDEP), Ocean County Health Department (OCHD) and the Brick Township Municipal Utilities Authority (BTMUA) to assess past and current possible exposures related to the three exposure pathways.

ATSDR evaluated the information collected on the Brick Township municipal drinking water supply and found that either well water or municipal drinking water contained tetrachloroethylene (PCE), trichloroethylene (TCE) or trihalomethanes (THMs) at various times during the study period. ATSDR discusses these contaminants at length in this report, but concluded the following: (1) TCE was never found in the distribution system for the municipal drinking water supply and therefore would not cause adverse health effects to children or pregnant mothers. (2) PCE was detected at low levels in the municipal drinking water supply several times between 1987 and 1994, but the observed levels were not sufficient to cause adverse health effects to children or pregnant mothers. (3) Total THM levels in the municipal drinking water supply exceeded 80 parts per billion (ppb), the EPA maximum contaminant level goal, several times during the study period. However, the locations in the water system where total THM levels were high do not match the locations and timing of the pregnancies of the majority of the autism cases plotted. Since there is no clear pattern linking the residences of the cases, during mothers' pregnancies, with location and timing of the high THM levels, it appears unlikely that THMs in the municipal drinking water supply were associated with ASD in Brick Township.

ATSDR evaluated information on the Metedeconk River and does not believe that levels of chemicals in the river would have been sufficient to cause adverse health effects to children or pregnant mothers who swam in the river in the past, because the continual current and tidal fluctuation of the Metedeconk River would dilute any past chemical releases to the river to trace amounts. Exposure to trace amounts through occasional swimming in the river (even more frequent swimming in summer months) would be unlikely to cause adverse health effects.

ATSDR evaluated information on the Brick Township Landfill and found that the groundwater beneath the landfill is contaminated with a variety of VOC's and metals. The contaminated groundwater beneath the landfill is not used for drinking water, thus preventing exposures which

could result in adverse health effects. Residents in the area are supplied water by the municipal drinking water system provided by the Brick Township Municipal Utilities Authority. ATSDR believes that any exposure to contaminated groundwater through the use of irrigation wells near the site would not have been at high enough levels or frequent enough to adversely affect the health of pregnant mothers or children.

PURPOSE AND ISSUES

In February 1998, ATSDR and the Centers for Disease Control and Prevention were contacted by a local parents group, U.S. Senator Robert Torricelli, and U.S. Representative Christopher Smith with a request to investigate concerns about a possible excess of children with autism and other pervasive developmental disorders in Brick Township, New Jersey. They also asked that ATSDR assess whether community members may have been exposed to hazardous chemicals in the environment. ATSDR requested assistance from the Centers for Disease Control and Prevention (CDC), because of CDC's experience related to autism research. With assistance from CDC, ATSDR developed a draft Public Health Action Plan (PHAP) for the Brick Township autism investigation. On April 1, 1998 Senator Torricelli, Representative Smith, and the parents were briefed on the draft PHAP and their comments were solicited. In addition, comments were received from a representative of the National Alliance for Autism Research (NAAR), who was advising the Brick parents. Based on the comments received, ATSDR and CDC developed a final draft of the PHAP.

The final PHAP outlined four main tasks: (1) Prepare a literature review of associations between autism and environmental contaminants, (2) Determine the prevalence of children with autism spectrum disorders among the residents of Brick Township during 1998, (3) Investigate environmental pathways for human exposure, with emphasis on the Metedeconk River, and (4) Inform the community through involvement and health education.

BACKGROUND

A. History

ATSDR and CDC began working on the four main tasks outlined in the final draft PHAP. The PHAP was subsequently revised after comments were received during a public meeting in Brick Township in September 1998, but the four main tasks remained the same. An outline of the four main tasks and their status is provided in this section.

1. Literature Review

In January, 1999 ATSDR completed and released to the public a consultation, entitled *Chemical Specific Consultation: Hazardous Substance Exposures and Autism.* The consultation is a review of the available scientific literature pertaining to hazardous substance exposures and autism. The literature review found that very few studies have investigated associations between exposure to hazardous substances and autism. For this reason the scope of the consultation was broadened to consider other exposure scenarios or chemical agents that might play a role in the etiology of autism. The available data suggest possible involvement of chemical exposure, along with strong evidence of genetic and suggestive evidence of immunological factors, in the

development of autism spectrum disorders. Evidence that exposure to hazardous substances in the environment prior to conception or during pregnancy or infancy is related to the development of autism may be suggestive, but not conclusive.

2. Prevalence Investigation

CDC's Developmental Disabilities Branch (DDB) was tasked with taking the lead on the prevalence investigation to determine the rate of ASD in Brick Township. This section summarizes the prevalence report.

a. Methods

The objective of this investigation was to determine the prevalence of autism in children age 3-10 years old who were residents of Brick Township in 1998. To do this, a two-phased approach was used. Phase I involved identifying all children who might meet the case definition for autism. This was done by reviewing records at schools, service providers (physicians or programs for children with autism), and from names provided by the citizen's group. Phase II was to verify case status from an examination by developmental clinicians. In addition to standard evaluation procedures, the Autism Diagnostic Observation Schedule was administered. Autism Spectrum Disorder was defined to include: autistic disorder, Asperger's disorder, and pervasive developmental disorder- not otherwise specified (PDD-NOS) as defined by the American Psychiatric Associations's Diagnostic and Statistical Manual - Fourth Revision (DSM-IV). The denominator was the estimated number of children ages 3-10 years in Brick Township in 1998.

b. Results

Phase I of the investigation identified 75 children with possible autism. In Phase II, 60 children were found to meet the DSM-IV criteria for an autism spectrum disorder (ASD). The prevalence of ASD was found to be 6.7 cases per 1,000 children (95% CI- 5.1-8.7). For the subset of 36 children who met the diagnosis for autistic disorder, the prevalence rate was 4.0 cases per 1,000 children (95% CI = 2.8-5.6). The male to female ratios ranged from 2.2-3.7 for autistic disorder and PDD-NOS, respectively. About half of the children were found to have an IQ score of less than or equal to 70. Of those children with a known town of birth residence, 66% were born in Brick Township. Seven children were reported to have a brother or sister who also had an ASD. Specific medical conditions were found in 5 of the 60 children.

c. Conclusions

The rates of ASD and autistic disorder in Brick Township are high compared with prevalence rates from previously published studies. The intense case finding of this study may have contributed, to some extent, to the high rate of autism found in Brick Township. For example,

recent studies that have employed intense case finding methods to study populations of comparable size or larger than the Brick Township population have found prevalences for autistic disorder as high as 3.1 cases per 1,000 children. However, these prevalences are still lower than the prevalence for autistic disorder found in Brick Township (i.e. 4 cases per 1,000 children). The epidemiologic characteristics of children with ASD in Brick Township, the predominance in males and the high proportion of children with IQ of 70 or less, are comparable to those found in previous studies. In addition, most of the children with autism in Brick Township were born in town, so migration cannot explain the high prevalence found.

3. Environmental Pathways

During discussions initiated while developing the PHAP parents expressed concern that hazardous substances might be present in the environment of Brick Township and that an increase in the number of children with autism may be attributable to exposure to these substances. There were three areas of concern regarding possible environmental contamination and exposure: (1) the municipal drinking water supply, (2) swimming in the Metedeconk River, and (3) the Brick Township Landfill. ATSDR has investigated each of these concerns and has summarized them in this report.

In addition, information on residence during pregnancy and birth, for the children who participated in Phase II of the prevalence study and were diagnosed with ASD, was obtained from families by ATSDR. The information collected indicated that 68%[1] of the children diagnosed with autism or PDD by CDC were born or conceived in Brick Township, 29% were born or conceived elsewhere, and for 3% the place of birth or conception could not be identified (see Appendix E, Figure 1). ATSDR also reviewed date of birth information for children in the study and calculated the beginning of the first trimester for each child.

4. Community Involvement

Community involvement plays a vital role in all public health activities carried out by ATSDR. ATSDR met with community members, local parents groups, as well as with town and federal officials on several occasions throughout the investigation. In addition, information regarding the investigation has been provided to local and national media upon request.

[1] This percentage varies slightly from the one in the prevalence investigation, because CDC used maternal address information and ATSDR used actual available street addresses and different denominators.

B. Demographics and Land Use

Brick Township is located in the northeast corner of Ocean County, New Jersey, approximately 50 miles south of Newark and approximately 60 miles north of Atlantic City. The Township has an estimated total population of 77,202 based on projections from 1990 census data. The population is mostly white (75,333) with some Hispanic (3352), Asian (1102), Black (628), and American Indian (139) populations. According to the 1990 census, 7,117 children between the ages of 3 to 10 years resided in Brick Township. [Demographic Statistics Source: 1999 Claritas Inc.]

DISCUSSION

A. Pathways Analyses

ATSDR identifies human exposure pathways by examining environmental and human factors which may lead to contact with contaminants of concern. A pathways analysis considers five principal elements: (1) a source of contamination, (2) transport through an environmental medium, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. Completed exposure pathways are those for which the five elements are evident, and indicate that exposure to a contaminant has occurred in the past, is currently occurring, or will occur in the future. ATSDR regards people who come into contact with contamination as exposed; for example, people who reside in an area with contaminants in air, or who drink water known to be contaminated, or who work or play in contaminated soil are considered to be exposed. Potential exposure pathways are those for which exposure seems possible, but one or more of the elements is not clearly defined. Potential pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring currently, or could occur in the future. Identification of an exposure pathway does not imply that health effects will occur. Exposures may be, or may not be, substantive. Thus, exposures may or may not cause adverse health effects.

ATSDR staff developed a list of contaminants of concern (see Appendix A) and then reviewed data and information from the Environmental Protection Agency (EPA), New Jersey Department of Environmental Protection (NJDEP), Ocean County Health Department (OCHD) and the Brick Township Municipal Utilities Authority (BTMUA) to assess past and current possible exposures.

B. Public Health Implications

The contaminants of concern identified have the potential to cause adverse health effects. However, for adverse health effects to occur, the pathway for exposure must be completed. A release does not always result in exposure. A person can only be exposed to a contaminant if they come into contact with the contaminant. Health effects resulting from the interaction of an individual with a hazardous substance in the environment depend on several factors. One is route

of exposure; that is whether the chemical is inhaled; consumed with food, soil, or water (ingestion); or whether it contacts the skin (dermal). Another factor is the dose level to which a person is exposed, and the amount of the exposure dose that is actually absorbed. Mechanisms by which chemicals are changed in the environment or inside the body, as well as the combination (types) of the chemicals also is important. Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the contaminants are absorbed, distributed, metabolized, and excreted. Together those factors and characteristics determine the health effects that may occur as a result of exposure to a contaminant. Substantial variation in those mechanisms exists among individuals.

1. Completed Exposure Pathways

Virtually all residents of Brick Township obtain their drinking water from the BTMUA, with the exception of residents of Brick Beach who are served by the New Jersey American Water Company. The BTMUA's water supply comes from both groundwater wells and surface water (the Metedeconk River). Prior to 1994 the BTMUA used primarily groundwater for distribution, but by 1994 the amount of surface water had increased gradually to about two-thirds of the supply. Today about 70% of the water supply is from surface water. The groundwater and surface water supplies are mixed at the treatment plant prior to being distributed to residences. At the treatment plant, the water goes through a disinfection process that includes the addition of chlorine. In 1995 the BTMUA began adding chlorine to the drinking water distribution system at two locations in addition to the water treatment facility (during the summer months only) to ensure continued disinfection of the drinking water throughout the system.

During the study period (1987-1995) two types of contaminants in the municipal drinking water supply were evaluated: solvents (i.e. TCE and PCE) and disinfection byproducts (i.e. trihalomethanes (THMs) such as chloroform and bromoform). Bromoform, chloroform and tetrachloroethylene (PCE) were found in the drinking water supply above ATSDR comparison values (see Appendix C) at various times during the study period. These chemicals are discussed in more detail below.

a. Trihalomethanes

The primary method of disinfection of drinking water used in the U.S. involves the addition of chlorine to drinking water. THM's and other disinfection byproducts are formed by the interaction of chlorine with organic matter in the water. Naturally occurring organic matter in the water is the result of the decomposition of plant matter (e.g., leaves) and the metabolism of aquatic biota (e.g., algae). The longer the chlorine has a chance to react with the organic matter in the water, the higher the amount of THMs produced. This means that areas furthest from the treatment plant are more likely to have higher THMs in the drinking water than areas closer to the treatment plant. In addition, in areas where there is a low use of water or where there is a "dead-

end" in the system, or where the system consists of small diameter pipes, the water tends to move very slowly and the chlorine has more time to react with any organic matter in the water to produce more THMs. As a result, residences in different areas can have very different levels of THMs in their drinking water. In addition, a sample taken in one location may have THM levels that are very different from homes that are less than 1 mile away. For example, homes located at a dead-end or low volume area of the system may have THM levels that differ substantially from levels found at nearby homes that are not at a low volume point in the system.

THMs will also vary in levels by season. In the summer and fall, there tends to be more organic matter in surface water (e.g., leaves and other vegetation), so there also tends to be more residual organic matter in the drinking water that can react with chlorine. (Ground water has very little organic matter so the chlorination of ground water produces very low or undetectable amounts of THMs.)

THMs include chloroform, bromoform, dibromochloromethane and bromodichloromethane. Other disinfection byproducts include MX (3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone) and the haloacetic acids (e.g., trichloroacetic acid). Teratogenicity, mutagenicity, and carcinogenicity have been suspected as being associated with the ingestion of several of the disinfection byproducts including THMs (Mills 1998, Boorman 1999).

THMs in drinking water have been linked to adult cancers in a few studies (Cantor 1997, Mills 1998). The strongest association is with bladder cancer. Associations have also been found for rectal and colon cancers. Recently, a study found an association between duration of residence with a chlorinated surface water source and brain cancer, but the association was found only for males (Cantor 1999). It is not known whether the cancers in these studies were caused by one or more of the THMs, by some other disinfection byproduct in the drinking water, or some combination of THMs and other disinfection byproducts.

THMs in drinking water have also been linked to adverse birth outcomes such as spontaneous abortion, small for gestational age, neural tube defects (NTD), oral cleft defects, and heart defects (Bove 1995, Waller 1998, Klotz 1999).

Of particular interest is the association between THMs and NTD. In two NJ studies, levels of THMs within the range found in some samples taken in Brick Township were associated with at least a two-fold increased risk of NTD (Bove 1995, Klotz 1999). On the other hand, a study conducted in Nova Scotia found a smaller increased risk of NTD with levels of THMs within the range found at Brick (Dodds 1999). An NTD is a defect of the spinal cord that occurs when the neural tube fails to close properly during the period between day 21 and day 26 of pregnancy. Recently, the drug thalidomide, which caused severe limb defects during an epidemic in Europe in the late 1950s and early 1960s, has been linked to an increased risk of autism (Stromland 1994, Rodier 1997). Among those exposed in utero to thalidomide, a high percentage developed

autism. However, all the cases of autism were exposed to thalidomide between day 20 and day 24 of the pregnancy. Those exposed to thalidomide at other periods during pregnancy did not develop autism. This evidence suggests an hypothesis that the period when the neural tube closes may also be a period when exposures to certain chemicals might lead to the development of an ASD. It also suggests an hypothesis that chemicals that cause NTD, since they act during this period of gestation, might also cause ASD. However, research on these hypotheses is at a very early stage. Therefore, it is currently unknown whether in utero exposure to environmental chemicals such as the disinfection byproducts of chlorination are associated with ASD.

THM's were found in the municipal drinking water supply approximately 356 times in samples taken between 1987 and 1995. Total THM's were detected at levels between 1 to 251 parts per billion (ppb)[2]. The highest THM level (251 ppb) was found at the Crab Shack. The next highest levels were also at the Crab Shack in August 1994 and ranged from 123 ppb to 142 ppb. During the study period, other sites which had at least one sample above 100 ppb but below 140 ppb were Crossroads Realty, Baywood Hardware, Greenbriar Clubhouse, Lionshead Clubhouse, and Shore Acre Plaza. Total Trihalomethanes exceeded 80 ppb approximately sixteen times in sampling data during the study period, but did not exceed the EPA Maximum Contaminant Level (MCL). The MCL was 100 ppb based on an annual rolling average during the study period. It should be noted however that the EPA revised the MCL for THMs in the Federal Register on December 16, 1998. The MCL was lowered from 100 ppb to 80 ppb, but community water systems serving 10,000 or more persons have been given until December 2001 to comply with this change. ATSDR used the MCL goal of 80 ppb for some of its analysis in this report to be conservative from a public health perspective. The primary THM detected in Brick Township water supplies was chloroform with a range of <1 ppb to 240 ppb. No data were available on the levels of disinfection byproducts other than THMs during this period.

ATSDR attempted to contact the families of the 43 children who participated in the clinical exams and who were diagnosed with ASD to obtain residence during pregnancy and date of birth information. Two families declined to be contacted by ATSDR and one family could not be contacted after repeated attempts to obtain residence during pregnancy. ATSDR was able to obtain date of birth information for 41 children and residence during pregnancy for 40 children. Therefore ATSDR used 41 children as the denominator for its calculations. Twenty eight (28) of the children who participated in the clinical exams and were diagnosed with ASD were born in Brick Township, 12 were born outside of Brick Township, and the place of birth for one child was unknown. The residence during pregnancy for children born in Brick Township was plotted through Geographic Information Systems (GIS) and indicated no apparent grouping or pattern (see Figure 4). Residence during pregnancy also was plotted and compared to the top 15 and top

[2] This 251 ppb THM value was used as the maximum value by ATSDR even though the BTMUA has suggested that the value is "out of line". Even though the value appears to be high it could not be refuted. ATSDR did note that over the study period (1987-1995) the next closest value was 142 ppb for this same sampling location.

50 THM levels found in the municipal drinking water system. This pattern also was random and did not indicate a relationship between residence and THM levels.

ATSDR calculated the month and year of the first trimester for children who participated in the clinical exams and were diagnosed with ASD. For approximately 40% of the children who participated in the clinical exams, the first trimester was in 1991 or 1992. ATSDR reviewed THM data for the years prior to 1991 and 1992. The peak THM level (251 ppb) was in March 1988 and there were several THM samples that exceeded 100 ppb in September 1990 and September 1992. These levels do not correspond with the birth or conception periods of children with autism or PDD. In 1988 when the peak THM level occurred in March one child in the study was in the first trimester. In 1990 several THM levels exceeded 100 ppb in September and there were four children in the study in their first trimester. In 1992 several THM levels exceeded 100 ppb in September and there were five children in the study in their first trimester at or about this time. In 1991 the year with the highest number of children in the study with ASD total THM levels did not exceed 100 ppb.

ATSDR plotted residence during pregnancy and distance to the nearest sampling locations with THM samples greater than 80 ppb and greater than 60 ppb. There were 14 participants within approximately one mile of a sampling point location where THM levels exceeded 80 ppb at least once between 1987 and 1995. Five of these 14 study participants lived within approximately one mile of a sampling point location where THM levels exceeded 80 ppb during the pregnancy period. Thus, about 18% (5/28) of the participants who lived in Brick Township resided within one mile of a sampling point that exceeded 80 ppb during their pregnancies. All of the 28 participants lived within approximately one mile of a sampling point location where THM levels exceeded 60 ppb at least once between 1987 and 1995. Eight of these 28 study participants (about 29%) lived within approximately one mile of a sampling point location where THM levels exceeded 60 ppb during the pregnancy period.

Based on these analysis, ATSDR is not able to show a clear pattern between elevated THM levels and the pregnancy period for children in the prevalence study.

THM data from other NJ water systems was compared to THM data in Brick Township. Out of 198 water companies with THM data available for review, between 1988 and 1993, the Brick Township water system ranked 30th for average THMs. This means that there were 29 systems in the state during this time period with higher average THM levels. About 45 out of these 198 systems have similar surface water systems to the one in Brick Township. However, out of the data reviewed for the 198 NJ water systems Brick Township had the 2nd highest reported THM level (251 ppb) which was obtained at the Crab Shack. Based on this THM data review, Brick Township's THM levels could be considered typical or average for similar surface water systems in NJ with the exception of the 251 ppb sample.

i. Bromoform

Bromoform is one of the THMs. It was found in samples from the Brick Township drinking water supply fourteen times between 1987 and 1995. The concentration of bromoform was detected at levels from 0.6 to 5 ppb. Bromoform exceeded the ATSDR comparison value of 4 ppb (see Appendix C) only once during the study period. In general, the range of bromoform found in the Brick Township water supply are similar to levels found in other areas of NJ as well as areas in the U.S. where the bromine content in water is very low. In areas of the U.S. where bromine levels in water are high, bromoform levels are ten to thirty times higher than the highest level found in the Brick Township supply.

Studies in animals indicate that long-term intake of bromoform can cause cancer. However, the levels found in the Brick Township water supply are very low and are not expected to increase a person's risk of developing cancer. Evidence from animal studies is sparse but has not indicated that bromoform is a teratogen. Other than the studies of THMs in drinking water, there have been no studies of exposure to bromoform and cancers or adverse birth outcomes in humans. ATSDR did perform a cancer risk analysis for bromoform found in the Brick Township drinking water supply (see Appendix D) and there appears to be no significant increased risk of cancer.

ii. Chloroform

Chloroform is another of the THMs. It was found in drinking water supply samples approximately 356 times between 1987 and 1995. The concentration of chloroform was detected at levels from 0.6 to 240 ppb[3]. Chloroform exceeded the ATSDR comparison value of 6 ppb in 320 of the samples in the study period.

Based on animal studies, chloroform may be anticipated to be a carcinogen and a teratogen. In one study, the offspring of mice exposed to chloroform by inhalation had increased incidences of cleft palate and growth retardation. The observed defects and growth retardation occurred among fetuses exposed during organogenesis (days 8-15 of gestation). ATSDR performed a cancer risk analysis for chloroform found in the Brick Township drinking water supply (see Appendix D) and there appears to be no significant increased risk of cancer.

[3] This 240 ppb chloroform value was used as the maximum value by ATSDR even though the BTMUA has suggested that the value is "out of line". ATSDR did note that over the study period (1987-1995) the next closest value was 116 ppb for this same sampling location. Even though the value appears to be high it could not be refuted. The possibility exists that persons may have been exposed at this level.

b. Tetrachloroethylene (PCE)

During 1987, two small municipal wells were found to be contaminated with the solvents PCE and TCE. These wells were shut down in early 1988. Water from these wells was sent (along with water from other ground water and surface water sources) to the treatment plant were it was mixed prior to disinfection. Because the water was mixed at the treatment plant, the PCE and TCE from the two contaminated wells were diluted by the rest of the water that was not contaminated with TCE and PCE prior to reaching Brick residences. In addition, because of the mixing of water prior to delivery, all residences served by the BTMUA received approximately the same amount of TCE and PCE. The amount of TCE and PCE in the drinking water reaching every home in Brick depended on the percentage of the total water that was supplied by the two contaminated wells. On average, these two wells supplied about 2% each to the total supply during 1987, but the percentage of total water supplied by these two wells varied depending on the demand on the system (e.g., more water is usually consumed in the summer months) and the pumping rates of each well in the system as well as the amount of water provided by surface water sources.

PCE was found in distribution system 12 times between 1987 and 1994 at levels between 0.13 to 6 ppb. PCE was not detected after 1994. PCE exceeded the ATSDR comparison values of 0.7 ppb in five of these samples. The EPA MCL for PCE is 5 ppb and was exceeded once during the study period.

Data reported by the NJDEP and reviewed by ATSDR indicated higher values for PCE in well #2 (170 ppb - 360 ppb) and well #8 (6 ppb - 29 ppb). These wells provided approximately 2% each to the total water supply and were mixed with water not contaminated with PCE at the treatment plant prior to distribution to homes, so high levels found at the well were substantially diluted by the time they reached homes. This is the reason why the well samples are high, but the distribution samples are no higher than 6 ppb.

PCE is a synthetic chemical that is widely used for dry cleaning fabrics and for metal-degreasing operations. It also is used as a starter material for making other chemicals and is used in some consumer products. Other names for tetrachloroethylene include perchloroethylene, PCE, perc, tetrachloroethene, perclene, and perchlor.

There have been a few studies linking PCE in drinking water to cancers in humans. In one study, exposure to high levels of PCE in drinking water (i.e., from about 500 ppb to over 1 ppm) was associated with increased risk of leukemia and bladder cancer. A second study of this same population found that similar levels of PCE in drinking water was associated with breast cancer. A study in NJ found an association between PCE levels greater than 5 ppb and increased risk of leukemia and non-Hodgkins lymphoma, but the increase was only among females. In Woburn,

MA, a 1979 drinking water sample from two contaminated wells detected trichloroethylene (TCE) at 267 ppb and PCE at 21 ppb. A cluster of childhood leukemia was linked to these drinking water contaminants (Lagakos, 1986). It is not clear whether the causative agent was TCE, PCE or the mixture, but since TCE was the predominant contaminant, the focus has been on TCE.

Based on human and animal studies, the International Agency for Cancer Research has determined PCE to be a probable human carcinogen. The U.S. EPA considers PCE to be on a continuum between probably and possibly carcinogenic to humans. ATSDR performed a cancer risk analysis for PCE found in the Brick Township drinking water supply (see Appendix D) and there appears to be no significant increased risk of cancer.

It is unknown whether PCE is a human teratogen. There is animal data indicating PCE at high doses can cause reduced fetal weight. A few studies have linked occupational exposure to PCE among dry cleaning workers and spontaneous abortions, but these findings have been contradicted by other studies that found no increased risk among dry cleaning workers. In a study conducted in NJ, PCE levels in drinking water above 10 ppb were associated with an increased risk of oral clefts. At U.S. Marine Corp Base, Camp LeJeune, NC, PCE levels in drinking water ranging from 76 ppb to 215 ppb were associated with a slight increase in small for gestational age among base residents. However, among the subgroup of Camp LeJeune mothers aged 35 years and older, the association between PCE exposure in drinking water and the risk of small for gestational age infants was nearly fourfold. In Woburn, MA, a 1979 drinking water sample from two contaminated wells detected trichloroethylene (TCE) at 267 ppb and PCE at 21 ppb. A study of birth outcomes parallel to the childhood cancer study found increased risks for several birth defects including NTD and an increased risk of small for gestational age. However, it is unclear whether the increased risks are due to the TCE, PCE or the mixture. Given that TCE was the predominant contaminant, the focus has been on TCE.

ATSDR also reviewed PCE data and compared it with the month and year of the first trimester for children who participated in the clinical exams and who were diagnosed with ASD in the prevalence study. Based on the data reviewed seven of the samples indicating PCE in the municipal drinking water were in either 1987 or 1988 and there was one positive sample for PCE in 1994. In 1987 the year with the most hits of PCE there was one child in the first trimester from the study. In 1988 there were three children in the first trimester from the study. In 1994 all children were through the first trimester before the positive PCE sample. Again the data are limited and the number of children in our study is small, but based on this information PCE levels and children diagnosed with autism or PDD in the prevalence study do not appear to be correlated.

2. Incomplete Exposure Pathways

In addition to the THMs, two other chemicals were found in BTMUA wells (#2 and #8) in 1987 and 1988. These were trichloroethylene (TCE) and tetrachloroethane. TCE and tetrachloroethane are not evaluated further in this report, since they were not detected in finished water or the distribution system. Therefore there would be no completed exposure pathway. To prevent possible exposure to these substances the BTMUA discontinued the use of wells 2 and 8 in January 1988.

3. Potential Exposure Pathways

a. Brick Township Landfill

The groundwater beneath the Brick Township Landfill has been shown to be contaminated with a variety of Volatile Organic Compounds (VOC's) and metals (see Appendix C, Table 2). ATSDR completed a Public Health Assessment (PHA) in 1989 and a Site Review and Update (SRU) in 1995 for the Brick Township Landfill. Copies of the PHA and SRU are available by request from ATSDR.

The landfill operated from 1949 through 1979. Disposal operations ceased at the landfill in May 1979. The landfill also has been known as McCormick's Dump, French's Landfill and as the Brick Township Landfill. The landfill was used for the disposal of municipal solid waste, bulk liquid waste, commercial and construction waste, and sewage and septic waste. Disposal records indicate that sewage and septic wastes, municipal solid wastes, and bulk liquid wastes were the most common materials disposed. An undetermined quantity of labeled and unlabeled 55 gallon drums were also disposed of at the landfill. The Brick Township Landfill was added to the EPA's National Priority List (NPL) in December 1982.

Sampling data has shown that the groundwater beneath the site is contaminated and the contaminant plume is migrating southeast from the site. In addition to groundwater contamination, the PHA noted on-site soil contamination and low level contamination of one private well in the landfill vicinity.

ATSDR previously concluded that the Brick Township Landfill presented **no apparent public health hazard**, because all residents in the area are supplied water by the municipal drinking water system, preventing exposure to contaminated groundwater. ATSDR recommended in its SRU that the landfill be secured on all boundaries to restrict entry and exposure to physical hazards, erect warning signs, and to fill in the borrow pit to prevent accidents. An ATSDR representative visited the site in January 2000 and noted that access to the site has been restricted

and warning signs have been posted. The borrow pit has not been filled, but Brick Township plans to fill the pit by summer 2000.

ATSDR also concluded in the SRU that the site constituted no apparent public health hazard in the *past* as a result of the ingestion of contaminated groundwater, because maximum exposure doses of chloroform and trichloroethylene detected in residential wells were below levels where adverse health effects were likely. This conclusion was based upon calculated exposure doses. It is unlikely that those residents exposed to chloroform or trichloroethylene in the *past* by drinking contaminated private well water will experience significant additional carcinogenic risk.

ATSDR received and reviewed additional data for this report on the contaminated groundwater plume that is migrating southeast from the site. The groundwater plume has spread further than noted in the past, but still does not present a public health hazard, because all residents in the area are on the municipal drinking water supply, which is supplied by the Brick Township Municipal Utilities Authority.

Based on the results from recent testing of the groundwater plume, Brick Township imposed a restriction on the use of private irrigation wells in the vicinity of the Brick Township Landfill in September 1999. This restriction remains in effect. As an added precaution, persons with private irrigation wells in the vicinity of the landfill will have their wells disconnected and sealed by Brick Township. These persons will then be hooked up by the Township to the municipal water system for irrigation purposes. ATSDR has reviewed recent sampling data and determined that levels of contamination from use of irrigation wells were not high enough or frequent enough to have caused adverse health effects. The disconnection and sealing of irrigation wells in the vicinity of the Brick Township Landfill will prevent future exposures to groundwater contaminants.

ATSDR plotted residence during pregnancy and distance to the Brick Township Landfill for children who participated in the clinical exams and were diagnosed with ASD (see Figure 7). There were three residences of study participants in the vicinity of the landfill. Two of the three residences are southwest of the landfill and one residence is south-southwest of the landfill. The closest of these three residences is approximately 0.3 miles to the southwest. Groundwater sampling indicates that the groundwater plume is moving away from the landfill site to the southeast, away from the residences of the study participants. Therefore, it is unlikely that the contaminated groundwater plume from the Brick Township Landfill is associated with the ASD for children in the prevalence study.

b. Fluid Packaging Spill

ATSDR reviewed the BTMUA report and sampling data regarding Fluid Packaging's discharge of VOC's and metals to the Cedar Branch Creek of the Metedeconk River. **ATSDR agrees with**

the BTMUA conclusion that the BTMUA's intake on the Metedeconk River was not impacted from the discharges from Fluid's storm sewer outfall. The storm sewer outfall from Fluid Packaging goes to the Cedar Bridge Branch which is more than a mile below Forge Pond, where the BTMUA collects water from the river. The BTMUA took surface water samples upstream from its intake as an added safety measure. The results of these samples showed no VOC's or semi-volatiles above ATSDR comparison values. The report also determined that groundwater flows established from the monitoring wells have not affected the BTMUA's well field, because groundwater contamination affiliated with Fluid is in shallow bearing zones and has an easterly flow. BTMUA wells are northeast of these monitoring wells.

ATSDR reviewed sediment data from the storm sewer outfall at Fluid Packaging. Most likely the VOC's found near the storm sewer outfall would be volatilized in the Cedar Branch Creek before they reached the Metedeconk River. Of the metals detected at the storm sewer outfall mercury was the most significant and it would tend to bind tightly with sediment near the outfall. Any remaining mercury would be significantly diluted as it moved downstream through Cedar Branch Creek and further diluted once entering the Metedeconk River.

c. Swimming in the Metedeconk River

ATSDR requested available environmental data for the Metedeconk River and the Windward Beach swimming area from the NJDEP, the OCHD and the BTMUA. Data for evaluating this possible exposure pathway was limited. **The data reviewed indicated no chemical contaminants above ATSDR Comparison Values for VOC's for the Metedeconk River upstream from the BTMUA's water intake.** No VOC data was available for the Windward Beach swimming area. The Metedeconk River is more than a half mile wide where Cedar Branch Creek enters and it is highly unlikely that contaminants from Fluid Packaging would reach the swimming area. In addition, ATSDR believes that due to the continual current and tidal fluctuation of the Metedeconk River that any past chemical releases to the river would be diluted to trace amounts. Exposure to these trace amounts through occasional swimming in the river (even more frequent swimming in summer months) would not be great enough to cause adverse health effects to pregnant mothers or young children.

5. ATSDR Child Health Initiative

To ensure that the health of the nation's children is protected, ATSDR has implemented an initiative for each investigation to protect children from exposure to hazardous waste. ATSDR recognizes the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their water, soil, air, or food. Infants and children are usually more susceptible to toxic substances than adults due to immature and developing organs. Children are more likely to be exposed to contaminants, because they play outdoors and they

often bring food into contaminated areas. These activities may increase their exposure to toxicants in dust, soil, and airborne particulate matter. Some children exhibit excessive hand to mouth behavior (pica), which may increase their intake of toxicants. Children are smaller, which results in higher doses. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care. ATSDR's evaluation contained within this document considered children as a susceptible sub-population. Estimates of exposure were calculated using conservative values for children (i.e. weight, ingestion rate, etc.).

COMMUNITY HEALTH CONCERNS

ATSDR staff met several times with the community, individually and during public forums. ATSDR held public meetings on September 24, 1998 and January 12, 1999. ATSDR also held availability and information sessions on January 13, 1999 and July 20, 1999. These meetings helped ATSDR understand and collect specific health concerns from the community. In addition to public meetings and availability sessions, ATSDR staff worked in conjunction with the OCHD to collect environmental information and concerns by mail. ATSDR and CDC also called and met with parents of children with autism during the investigation. The three main concerns from community members were incorporated into the PHAP: (1) Were there chemicals in the municipal drinking water supply at levels that may have adversely affected the health of pregnant mothers or children diagnosed with autism, (2) Could swimming in the Metedeconk River have adversely affected my child's health, and (3) Could environmental contamination at the Brick Township Landfill have adversely affected the health of pregnant mothers or children diagnosed with autism? These questions are addressed in the conclusions section below. ATSDR released the Public Comment version of this PHA on April 4, 2000 with a 30 day comment period beginning April 18th and ending May 22nd. On April 18th, ATSDR met with parents; local, state, and federal officials; and media representatives to discuss the PHA and answer questions regarding the document.

CONCLUSIONS

1. Were there chemicals in the municipal drinking water supply at levels that may have adversely affected pregnant mothers or children diagnosed with autism?

After reviewing and analyzing the data provided from the NJDEP, BTMUA and the OCHD on TCE, PCE, and THMs ATSDR concludes the following: (1) Based on the information provided TCE was never found in the distribution of the municipal drinking water supply and therefore, would not cause adverse health effects to children or pregnant mothers. (2) PCE was detected at low levels in the municipal drinking water supply several times between 1987 and 1994, but was mixed after the point of detection with millions of gallons of uncontaminated water prior to being

distributed to any residents of the township. Therefore, any PCE that may have reached a residence would have been diluted to a very low quantity and would not be expected to cause adverse health effects to children or pregnant mothers. (3) Total THM levels in the municipal drinking water supply exceeded 80 parts per billion (ppb) several times during the study period.

Since there is no clear pattern linking the residences of the cases, during mothers' pregnancies, with location and timing of the high THM levels, it appears unlikely that THMs in the municipal drinking water supply were associated with ASD in Brick Township.

2. Could swimming in the Metedeconk River have adversely affected my child's health?

ATSDR does not believe that levels of chemicals in the Metedeconk River, from the Fluid Packaging spill, would have been at sufficient levels to cause adverse health effects to children or pregnant mothers who swam in the river in the past, because the continual current and tidal fluctuation of the Metedeconk River would dilute any past chemical releases to the river to trace amounts. Exposure to trace amounts through occasional swimming in the river (even more frequent swimming in summer months) would not be likely to cause adverse health effects.

3. Could environmental contamination at the Brick Township Landfill have adversely affected pregnant mothers or children diagnosed with autism?

The groundwater beneath the Brick Township Landfill is contaminated with a variety of VOC's and metals. ATSDR believes that the contaminated groundwater would not have adversely affected pregnant mothers or children near the site, because residents in the area are supplied water by the municipal drinking water system, preventing exposure to the contaminated groundwater.
The municipal drinking water supply is maintained by the Brick Township Municipal Utilities Authority. ATSDR believes that any exposure to contaminated groundwater through the use of irrigation wells near the site would not have been at high enough levels or frequent enough to adversely affect the health of pregnant mothers or children.

Based on the review and analysis of data from the municipal drinking water supply, the Metedeconk River and the Brick Township Landfill ATSDR believes there to be no apparent public health hazard from these areas.

RECOMMENDATIONS

1. ATSDR encourages the BTMUA to continue to monitor and control THM levels in accordance with current regulations.

PUBLIC HEALTH ACTION PLAN

The Public Health Action Plan (PHAP) for the Brick Township Autism Investigation contains a description of actions taken and actions planned by the Agency for Toxic Substances and Disease Registry (ATSDR) and/or other government agencies after completion of this public health assessment.

A. Public Health Actions Taken

1. ATSDR and CDC developed a draft PHAP in March 1998. On April 1, 1998 Senator Torricelli, Representative Smith, and the parents were briefed on the PHAP and their comments were solicited.

2. ATSDR and CDC met with parents and Dr. Eric London of the National Alliance for Autism Research to learn more about concerns and obtain additional feedback on the PHAP.

3. ATSDR and CDC conducted public meetings in Brick Township on September 24, 1998 and January 12, 1999 to discuss the PHAP plan and provide additional opportunities for parents and community members to discuss the PHAP or specific community health concerns.

4. ATSDR prepared a draft consultation of current literature on possible associations between chemical exposure and autism. The draft consultation was completed and distributed in January 1999.

5. ATSDR also held availability and information sessions on January 13, 1999 and July 20, 1999.

6. In addition to meetings, ATSDR has provided two fact sheets and several update letters to the community. The last update letter was mailed in December 1999.

7. ATSDR released the Public Comment version of the Brick Township Investigation PHA on April 4, 2000 and allowed a 30 day comment period, which began April 18, 2000 and ended May 22, 2000.

8. ATSDR held meetings on April 18, 2000 with parents; local, state, and federal officials; and media representatives to discuss the Public Comment version of the PHA and to address questions and concerns regarding the document.

B. Public Health Actions Planned

1. ATSDR will continue to review any new environmental data associated with this investigation and if necessary, revise the conclusions and recommendations contained in this public health assessment.

DOCUMENTS REVIEWED

1. Agency for Toxic Substances and Disease Registry. 1990. Toxicological Profile for Bromoform. ATSDR.

2. Agency for Toxic Substances and Disease Registry. 1995. Toxicological Profile for Chloroform. ATSDR.

3. Agency for Toxic Substances and Disease Registry. 1993. Toxicological Profile for Tetrachloroethylene. ATSDR.

4. Agency for Toxic Substances and Disease Registry. 1989. Health Assessment for Brick Township Landfill. ATSDR.

5. Agency for Toxic Substances and Disease Registry. 1995. Site Review and Update for Brick Township Landfill. ATSDR.

6. Agency for Toxic Substances and Disease Registry. 1998. DRAFT Chemical Specific Consultation: Hazardous Substance Exposure and Autism. ATSDR.

7. Agency for Toxic Substances and Disease Registry. 1997. Volatile Organic Compounds In Drinking Water and Adverse Pregnancy Outcomes: United States Marine Corps Base Camp Lejeune, North Carolina. ATSDR.

8. Agency for Toxic Substances and Disease Registry. 2000. Groundwater Consultation for the Brick Township Landfill. ATSDR.

9. Birdsall Engineering, Inc. 1999. Remedial Investigation Report: Brick Township Landfill. Birdsall Engineering.

10. Boorman GA, Dellarco V, Dunnick JK, et al. 1999. Drinking Water Disinfection By-Products: Review and Approach to Toxicity Evaluation. Environmental Health Perspectives 107: 207-217.

11. Bove FJ, Fulcomer MC, Klotz JB, et al. 1995. Public Drinking Water Contamination and Birth Outcomes. American Journal of Epidemiology 141:850-862.

12. Brick Township Municipal Utilities Authority. 1998. Results of Fluid Packaging Data Review. BTMUA.

13. Cantor KP, Lynch CF, Hildesheim ME, et al. 1999. Drinking Water Source and Chlorination Byproducts in Iowa. III. Risk of Brain Cancer. American Journal of Epidemiology 150: 552-560.

14. Cantor, KP. 1997. Drinking Water and Cancer. Cancer Causes and Control 8: 292-308.

15. Dodds L, King W, Woolcott C, Pole J. 1999. Trihalomethanes in Public Water Supplies and Adverse Birth Outcomes. Epidemiology 10: 233-237.

16. Federal Register: December 16, 1998 (Volume 63, Number 241)] National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts.

17. Lagakos SW, Wessen, BJ, Zelen, M E. 1986. An Analysis of Contaminated Well Water and Health Effects in Woburn, MA wells. JAM Statistical Association 81:583-596.

18. Klotz JB, Pyrch LA. 1999. NTD's and Drinking Water Disinfection By-Products. Epidemiology 10:383-390.

19. Mills CJ, Bull RJ, Cantor KP, et al. 1998. Health Risks of Drinking Water Chlorination By-Products: Report of an Expert Working Group. Chronic Diseases in Canada 19: 91-102.

20. National Research Council (NRC), Subcommittee on Disinfectants and Disinfection By-Products. National Academy Press. Washington D.C. 1987.

21 New Jersey Department of Health. 1992. Report on Phase Iv-A: Public Drinking Water Contamination and Birth Weight, Fetal Deaths, and Birth Defects. NJDOH.

22. New Jersey Department of Environmental Protection and Energy. 1992. Decision Document: Brick Township Landfill Site. NJDEP.

23. Rodier PM, Ingram JL, Tisdale B, et al. 1997. Linking Etiologies in Humans and Animal Models: Studies of Autism. Reproductive Toxicology 11:417-422.

24. Stromland K, Nordin V, Miller M, et al. 1994. Autism in Thalidomide Embryopathy: A Population Study. Developmental Medicine and Child Neurology 36:351-356.

25. Waller K, Swan SH, DeLorenze G, Hopkins B. 1998. Trihalomethanes in Drinking Water and Spontaneous Abortion. Epidemiology 9:134-140.

Copies of ATSDR documents reviewed and cited in this PHA can be obtained by request from the Program Evaluation, Records, and Information Services Branch.

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Appendices

Appendix A
Contaminants of Concern

This list of Contaminants of Concern was compiled in part through ATSDR's literature review: Chemical Specific Consultation: Hazardous Substance Exposures and Autism. These chemicals were selected from studies and articles in the literature review, because they were ***suspected*** of causing or contributing to adverse health effects (i.e. autism or PDD) in children or during prenatal development. No one chemical or class of chemicals could be identified directly as a contributor to autism spectrum disorders, because very little is known about how biological and environmental factors contribute to autism and related disorders. This list was developed as a screening tool for looking at possible environmental exposures.

Contaminant	Concentration	Unit	Source
Acetone	1,000	ppb	CV
Anthracene	3,000	ppb	CV
Arsenic	3	ppb	CV
Benzene	1	ppb	CV
Benzo(b)flouranthene (PAH)	0.2	ppb	MCL
Benzo(a)pyrene (PAH)	0.005	ppb	CV
Benz(a)anthracene (PAH)	2,800	ppb	MCL
Bis(2-ethyl-hexyl)phthalate	6,000,000	ppb	MCL
Bromoform	**4**	**ppb**	**CV**
*Butyl benzyl phthalate	2,000	ppb	CV
Cadmium	5	ppb	CV
Carbon tetrachloride	0.3	ppb	CV
Chlordane	0.6	ppb	CV
Chlorobenzenes	100	ppb	CV
Chloroform	**6**	**ppb**	**CV**
Chromium	100	ppb	CV
Copper	100	ppb	CV
DDT	5	ppb	CV

Di-n-butyl phthalate	1,000	ppb	CV
Dibenzo(a,h)anthracene (PAH)	0.3	ppb	MCL
*1,2-Dichlorobenzene	600	ppb	CV
1,4-Dichlorobenzene	75	ppb	CV
Dichloroethanes	0	ppb	MCLG
1,1-Dichloroethene	0.06	ppb	CV
*Diethylstilbestrol			
Dioxin (2,3,7,8 TCDD)	.00001	ppb	CV
Endosulfan	20	ppb	CV
Ethyl benzene	700	ppb	CV
Flouranthene (PAH)	400	ppb	CV
Heptachlor	0.008	ppb	CV
Heptachlor epoxide	0.004	ppb	CV
Hexachlorocyclohexane	0.02	ppb	CV
" alpha	0.006	ppb	CV
" beta	0.02	ppb	CV
" gamma	0.4	ppb	CV
Lead	0	ppb	MCLG
Mercury	2	ppb	MCL
Methylene chloride	5	ppb	CV
Naphthalene	20	ppb	CV
Nickel	100	ppb	CV
PCB's	0.02	ppb	CV
Pyrene (PAH)	300	ppb	CV
Silver	50	ppb	CV
Tetrachloroethylene (PCE)	**0.7**	**ppb**	**CV**
Toluene	200	ppb	CV
1,1,1-Trichloroethane	200	ppb	CV
1,1,2-Trichloroethane	0.6	ppb	CV

Trichloroethylene	20	ppb	CV
Vinyl Chloride	0.2	ppb	CV
Xylene	2,000	ppb	CV
Zinc	3,000	ppb	CV

* No Toxicological Profile
CV-Comparison Value
MCL-Maximum Contaminant Level
MCLG-Maximum Contaminant Level Goal
ppb-parts per billion

Appendix B
Comparison Values

To determine which chemicals might have some relationship to fetal birth effects, autism, and PDD ATSDR performed a literature search and developed a list of Contaminants of Concern (Appendix A). ATSDR evaluated all available environmental data from 1987 through 1995 to look for the Contaminants of Concern. To select chemicals for further evaluation, comparison values were used. Comparison values are chemical concentrations that are found in specific media (air, soil, and water). They are designed to be conservative and non-site specific. Therefore, they are protective for all probable exposures. Comparison values are intended to be used only to screen out chemicals that do not need further evaluation. **They are not intended to be used as clean-up levels or to be indicators of public health effects.** Comparison Values are derived from toxicological information, using assumptions regarding body weights, ingestion rates, and exposure frequency and duration. Generally, the assumptions used are very conservative (i.e., worst case).

There are two different types of comparison values, those based on carcinogenic (cancer-causing) effects, and those based on noncarcinogenic effects. Cancer-based comparison values are calculated from the EPA's oral cancer slope factor or inhalation unit risk. They are calculated for a lifetime exposure a (70 years) with an unacceptable excess lifetime cancer risk of one case per million exposed people. Noncancer comparison values are calculated from ATSDR's minimal risk levels, or EPA's reference doses or reference concentrations. These values are calculated for adults, children, and small children who may eat large amounts of soil or drink large amounts of water (2 liters per day).

Appendix A contains the list of chemicals evaluated and the comparison values used to select the appropriate chemicals for more in-depth analysis (bolded items). A chemical is selected for further evaluation (bolded items in Appendix A) if the chemical was found in a valid environmental sample and exceeds comparison values. The presence of a chemical in the Appendix A table does not mean that either exposure to the chemical or adverse health effects has occurred or will occur. A chemical that has been bolded in the tables indicates that the chemical has potential for human exposures and potential for adverse human health effects. The selected chemical will be discussed in more detail in the health consultation, because of its potential for human exposure and adverse health effects.

The comparison values used in this health consultation are listed and described below:

Cancer Risk Evaluation Guides (CREGs) are estimated concentrations that would be expected to cause no more than one excess cancer in a million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors.

Environmental Media Evaluation Guides (EMEGs) are based on ATSDR's minimal Risk Levels (MRLs) and factor in body weight and ingestion or inhalation rates.

Minimal Risk Levels (MRLs) are an estimate of daily human exposure to a chemical (in milligrams of the chemical per kilogram of body weight per day [mg/kg/day]) that is likely to be without an appreciable risk of deleterious effects (noncarcinogenic) over a specified duration of exposure. MRLs are based on human and animal studies. They are reported in the ATSDR Toxicological Profiles for acute ($\leq$14 days), intermediate (15-365 days), and chronic ($\geq$365 days) exposures. Proposed MRLs are peer reviewed and available for public comment when the ATSDR Toxicological Profile for that chemical is out for public comment.

Reference Dose Media Evaluation Guides (RMEGs) are similar to EMEGs, except that they are based on EPA's reference doses (RfDs).

Reference Doses (RfDs) are developed by EPA. They are an estimate of the daily exposure to a chemical that is unlikely to cause adverse health effects even if the exposure occurs over a lifetime (70 years). RfDs do not consider carcinogenic effects. EPA has any proposed RfD peer reviewed before publishing them.

Appendix C
Table 1
Contaminants Detected in Brick Township Municipal Drinking Water, Above Environmental Screening Values
Source: BTMUA and NJDEP Data

Chemical	Observed Concentration Range (ppb)	Frequency of Detection	Comparison Value (ppb)	EPA Cancer Slope Factor in $(mg/kg/day)^{-1}$
Bromoform	0.6 - 5.0	14	4 (CREG) 2000 (EMEG)	0.0079
Chloroform	0.6 - 240	356	6 (CREG) 100 (EMEG)	0.0061
Tetrachloroethylene (PCE)	0.13 - 6.0	12	0.7 (CREG) 100 (RMEG)	0.052
Total Trihalomethanes	1.0 - 251	356	100 (MCL)	NA

- ppb - parts per billion
- ug/kg/day - micrograms of chemical per kilogram of body weight per day
- CREG - Cancer Risk Evaluation Guides
- EMEG - Environmental Media Evaluation Guides

Appendix C
Table 2
Contaminants Detected in Groundwater, Above Environmental Screening Values
Samples taken from Off-Site Monitoring Wells, Brick Township Landfill
Source: Remedial Investigation Data, January 1999

Chemical	Observed Concentration Range (ppb)	Comparison Value (ppb)	EPA Cancer Slope Factor in $(mg/kg/day)^{-1}$
Arsenic	8.5 - 269	.02 (CREG) 3 (EMEG)	1.5
Benzene	1.9 - 57	1 (CREG)	.029
Cadmium	5.4 - 228	2 (EMEG)	NA
Chlorobenzene	68 - 130	100 (MCL)	NA
Chromium	102 - 6,100	100 (MCL)	NA
Copper	1,250 - 2,020	100 (MCLG)	.04
Lead	10.9 - 2,230	0 (MCLG)	NA
Mercury	2.0 - 26.8	2 (MCL)	NA
Nickel	107 - 1,020	100 (MCL)	NA
Vinyl Chloride	12 - 71	.02 (CREG) .2 (EMEG)	1.9

Zinc	5,890 - 12,800	3000 (EMEG)	NA

- ppb - parts per billion
- ug/kg/day - micrograms of chemical per kilogram of body weight per day
- CREG - Cancer Risk Evaluation Guides
- EMEG - Environmental Media Evaluation Guides
- MCL - Maximum Contaminant Level

Appendix D
Theoretical Cancer Risk Associated with Exposure to Chemical Contaminants in the Brick Township Municipal Drinking Water Supply, Completed Exposure Pathway

Adults					
Chemical	**Maximum Concentration Detected (ppb)**	**Dose**	**EPA Cancer Slope Factor $(ug/kg/day)^{-1}$**	**Length of Exposure (70 years)**	**Theoretical Cancer Risk**
Bromoform	5	$3.0x10^{-5}$	0.0079	10/70	$2.4x10^{-7}$
Chloroform	240	$1.4x10^{-3}$	0.0061	10/70	$8.8x10^{-6}$
Tetrachloroehtylene (PCE)	6	$3.6x10^{-5}$	0.052	10/70	$1.9x10^{-6}$
Maximum Theoretical Cancer Risk for Adults from Exposure to Chemicals in Drinking Water					$1.1x10^{-5}$

- ppb - parts per billion
- ug/kg/day - micrograms of chemical per kilogram of body weight per day
- Dose - was calculated by assuming a 70 kilogram adult drank 2 liters of water containing the chemical at the maximum concentration found in the municipal drinking water.
- Dose considers exposure through ingestion, inhalation, and dermal contact.

Appendix D

Bromoform

Persons who ingested water between 1987 and 1995 may have been exposed to bromoform at a maximum concentration of 5ppb or 0.005 milligrams per liter (mg/l). The EPA has set a Maximum Contaminant Level of 80 ppb or 0.080 mg/l for the combination of bromoform and other trihalomethanes in drinking water. The estimated exposure dose was below EPA's reference dose (RfD) of 0.020 milligrams per kilogram per day (mg/kg/day) and below the no-observed-adverse-effect-level (NOAEL) of approximately 10 mg/kg/day. **ATSDR does not believe that adverse non-cancer health effects would occur due to these exposures.** The Department of Health and Human Services and EPA have determined that bromoform is reasonably anticipated to be a carcinogen. The EPA has calculated a cancer risk factor, which can be used to estimate the probability of excess cancer risk for a lifetime of exposure to bromoform. Cancer risk for exposure was estimated based on the maximum concentration of bromoform in the contaminated medium. **There appears to be no significant increased risk of cancer based upon these conservative estimations.**

Chloroform

Persons who ingested water between 1987 and 1995 could have been exposed to chloroform at a maximum concentration of 240 ppb or 0.240 milligrams per liter (mg/l). The EPA has set a Maximum Contaminant Level of 80 ppb or 0.080 mg/l for the combination of chloroform and other trihalomethanes in drinking water. The estimated exposure dose was below EPA's reference dose (RfD) of 0.010 milligrams per kilogram per day (mg/kg/day) and below the no-observed-adverse-effect-level (NOAEL) of approximately 6 mg/kg/day. **ATSDR does not believe that adverse non-cancer health effects would occur due to these exposures.** The Department of Health and Human Services and EPA have determined that chloroform is reasonably anticipated to be a carcinogen. The EPA has calculated a cancer risk factor, which can be used to estimate the probability of excess cancer risk for a lifetime of exposure to chloroform. Cancer risk for exposure was estimated based on the maximum concentration of chloroform in the contaminated medium. **There appears to be no significant increased risk of cancer based upon these conservative estimations.**

Tetrachloroethylene (PCE)

The MCL for PCE is currently at 5 ppb. This MCL is based on a cancer risk estimate. Persons who ingested water between 1987 and 1994 could have been exposed to PCE at a maximum concentration 6 ppb or 0.006 milligrams per liter (mg/l). The actual level of exposure is most likely much less than 6 ppb since the water from the wells contaminated with PCE was diluted with water from the rest of the Brick system before it reached Brick residents. The estimated

exposure dose was below EPA's reference dose (RfD) of 0.010 milligrams per kilogram per day (mg/kg/day) and below the no-observed-adverse-effect-level (NOAEL) of approximately 20 mg/kg/day. **ATSDR does not believe that adverse non-cancer health effects would occur due to these exposures.** The Department of Health and Human Services and EPA have determined that PCE is reasonably anticipated to be a carcinogen. The EPA has calculated a cancer risk factor, which can be used to estimate the probability of excess cancer risk for a lifetime of exposure to PCE. Cancer risk for exposure was estimated based on the maximum concentration of PCE in the contaminated medium. **There appears to be no significant increased risk of cancer based upon these conservative estimations.**

Exposure Scenario for Bromoform, Chloroform and Tetrachloroethylene

Exact information regarding possible exposures to bromoform, chloroform, and PCE were not available. To evaluate possible exposures certain assumptions were made by ATSDR. The following assumptions were made:

- persons exposed were adults;
- exposures occurred at the maximum concentration detected;
- the maximum period of time people would have been exposed was 9 months (270 days) per year for 10 years;
- the main routes of exposure were most likely ingestion, dermal contact, and inhalation from showering and other hot water uses.

Discussion of Theoretical Cancer Risk

ATSDR evaluated the theoretical cancer risk for exposure to bromoform, chloroform, and PCE in municipal drinking water in the tables above. The calculations presented in this Appendix over estimate the risk of cancer by several orders of magnitude (the real risk is 100s to 1,000s times lower). In addition cancer risk calculations generally assume a lifetime of exposure (70 years), where the maximum exposure period for Brick Township residents would be 10 years or less.

Even if the theoretical cancer risk calculations are correct, the predicted cancer occurrence for exposure to bromoform, chloroform, and PCE combined would be 1 per 100,000 in adults. In Brick Township the theoretical cancer risk calculations would predict less than 0.74 extra cancers in the adult population.

Calculation of rates:

These calculations were based on population figures from 1990 U.S. Census data indicating a total population for Brick Township of 66,414 and a child population (3-10 years old) of 7,117.

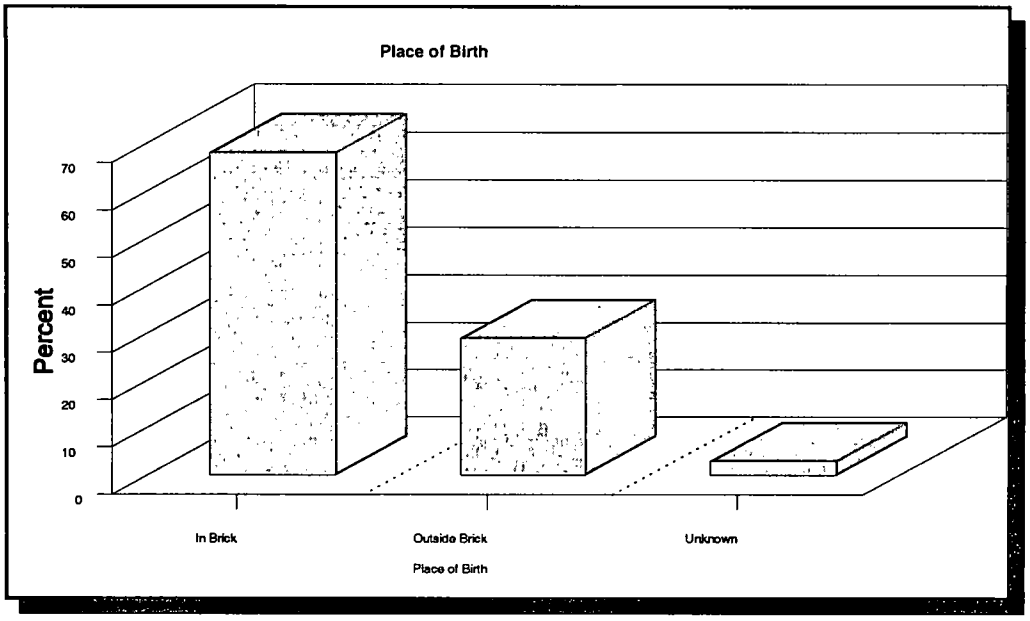
The number of children aged 3 to 10 years in Brick Township in 1998 was estimated by CDC using a 25% inflation factor. The 25% inflation factor was equivalent to the increase observed in the Brick Township student population for grades K through 5 in the school years, 1989-90 and 1998-99, which were provided by the Brick Township Public Schools. Using this inflation factor, the estimated number of children aged 3 to 10 years in Brick Township in 1998 was 8,896.

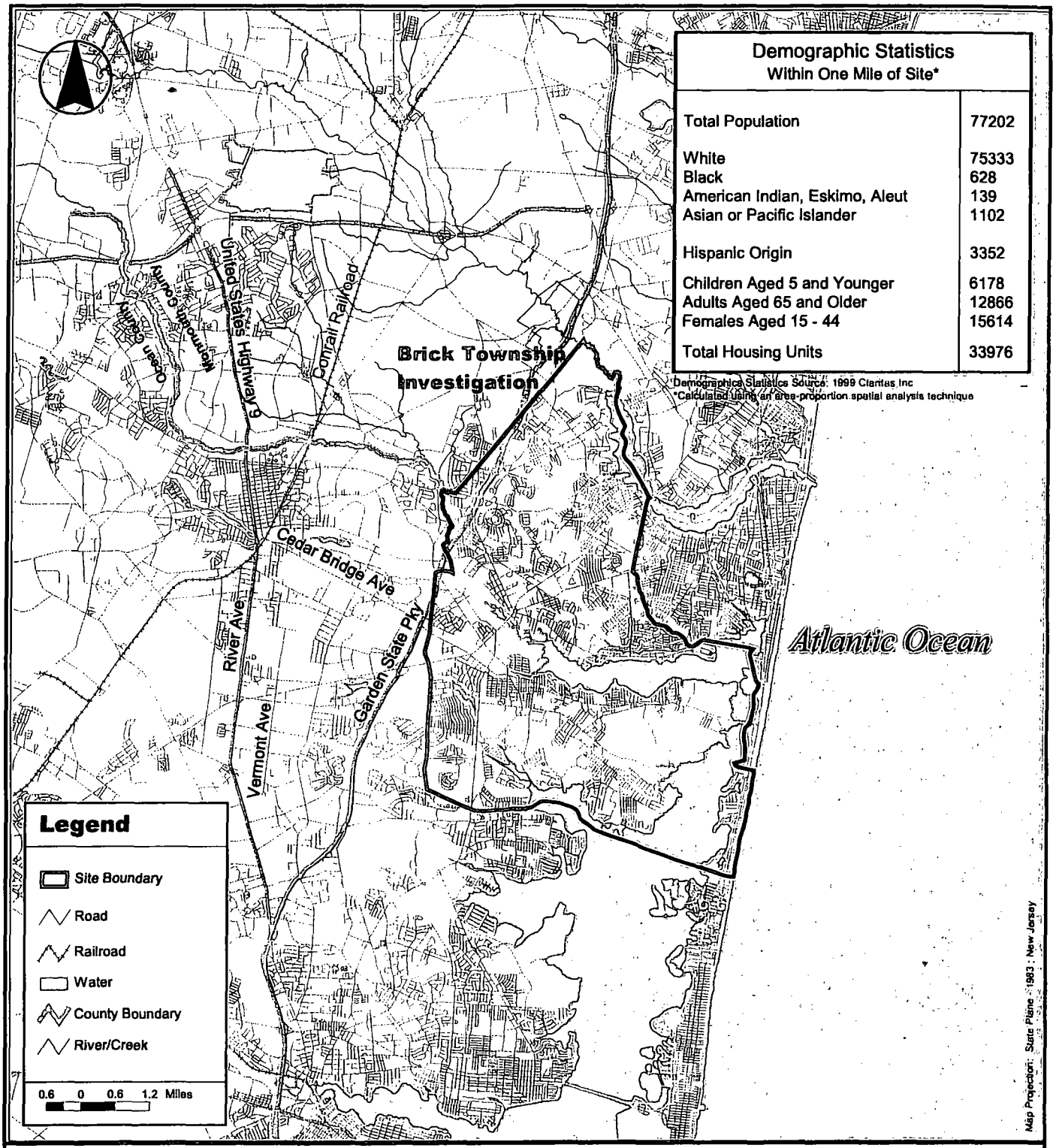
For consistency, the same inflation factor (25%) was then used by ATSDR to estimate the adult population in 1998. Using this inflation factor the estimated adult population in Brick Township in 1998 was 74,121.

Appendix E

Figures

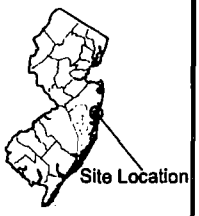
Figure 1
Place of Birth
for children who participated in the clinical exams and were diagnosed with ASD, (n=41)





Brick Township Investigation

Brick Township, New Jersey



VICINITY MAP

Ocean County, New Jersey

Base Map Source: 1995 TIGER/Line Files

SAIC GIS

JVA03092000

Figure 3: Brick Township Municipal Water System Map

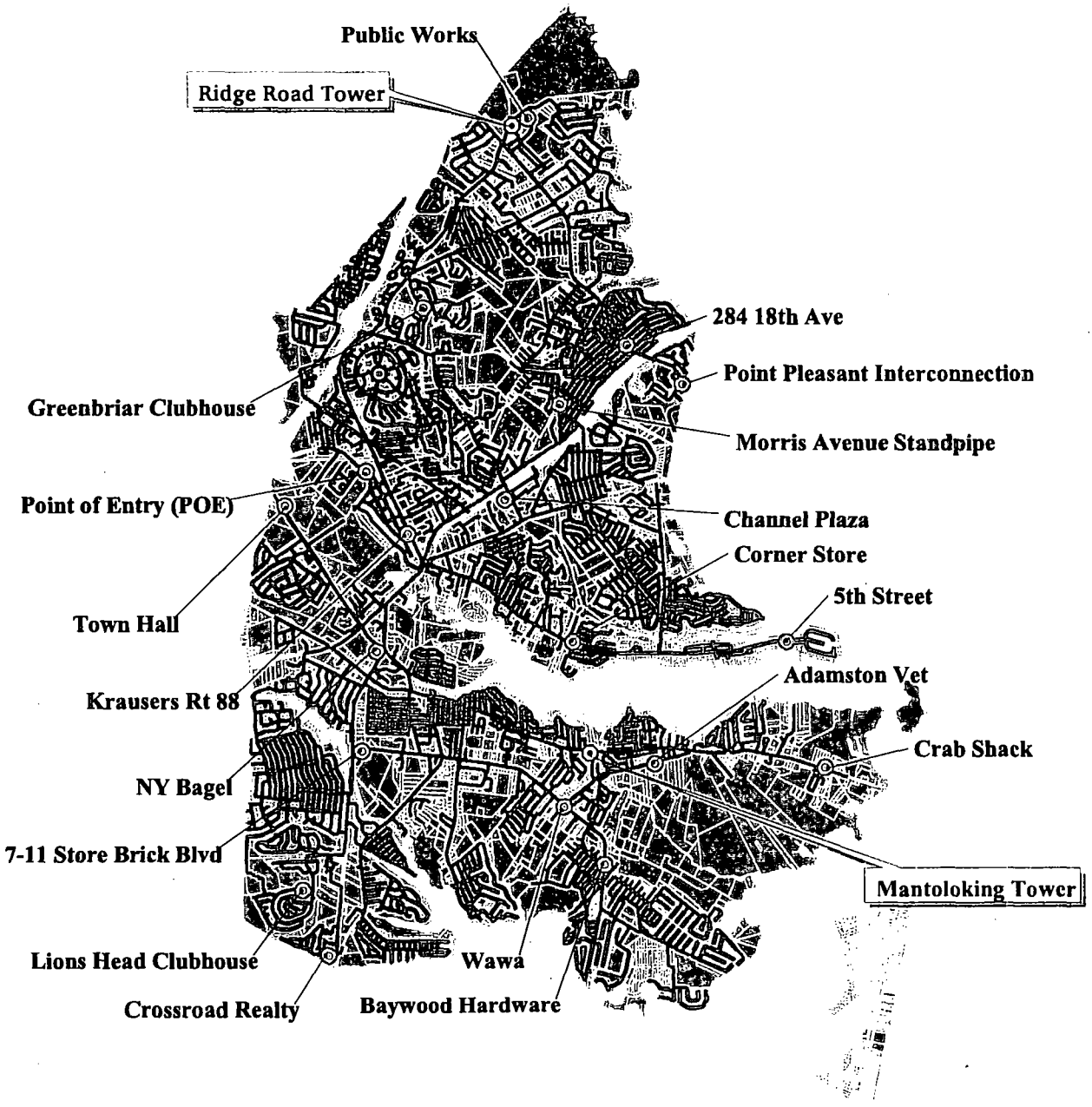
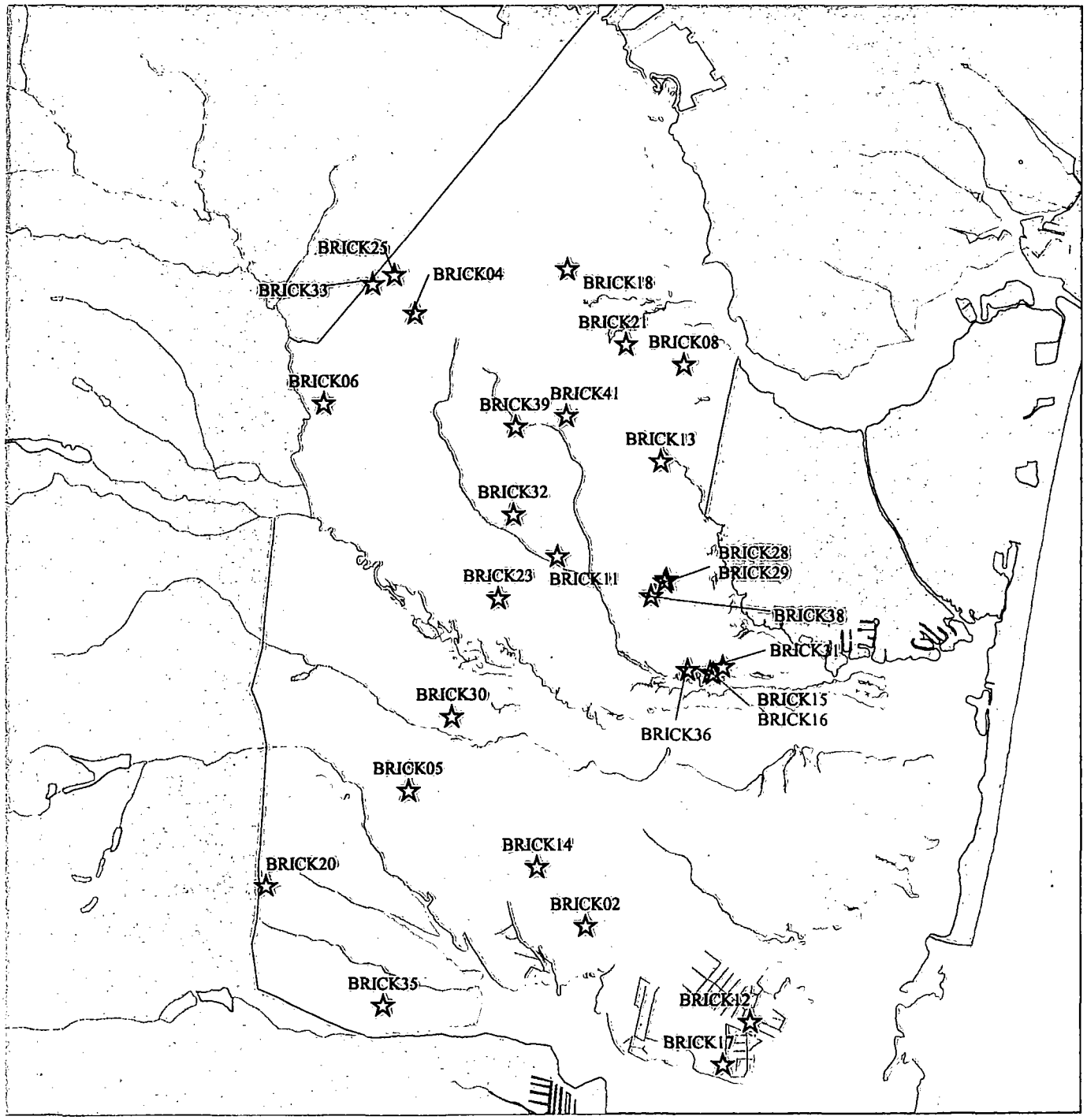


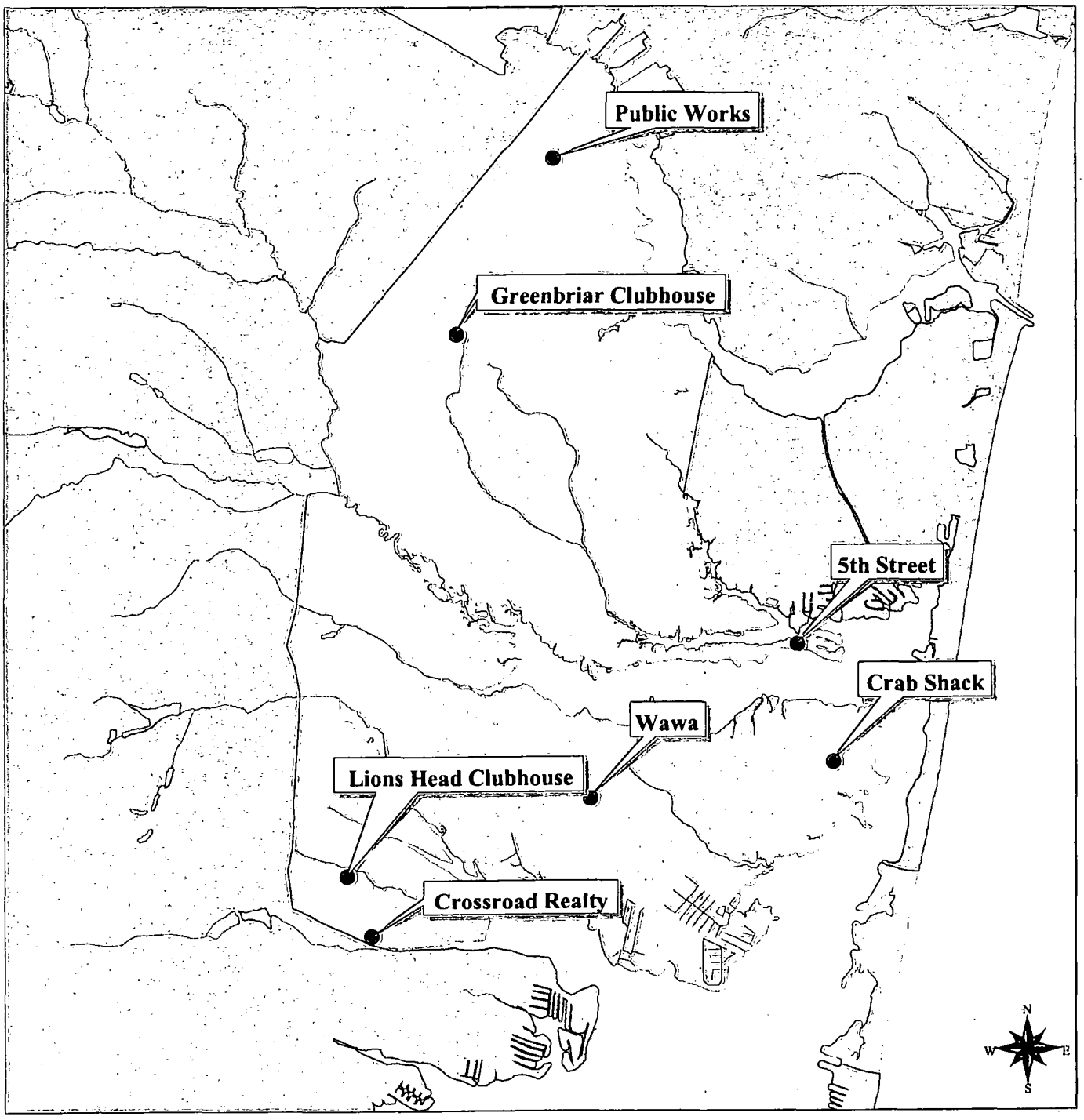
Figure 4: Brick Township Study Participants



03/02/2000 WDH

ATSDR SAAGIS

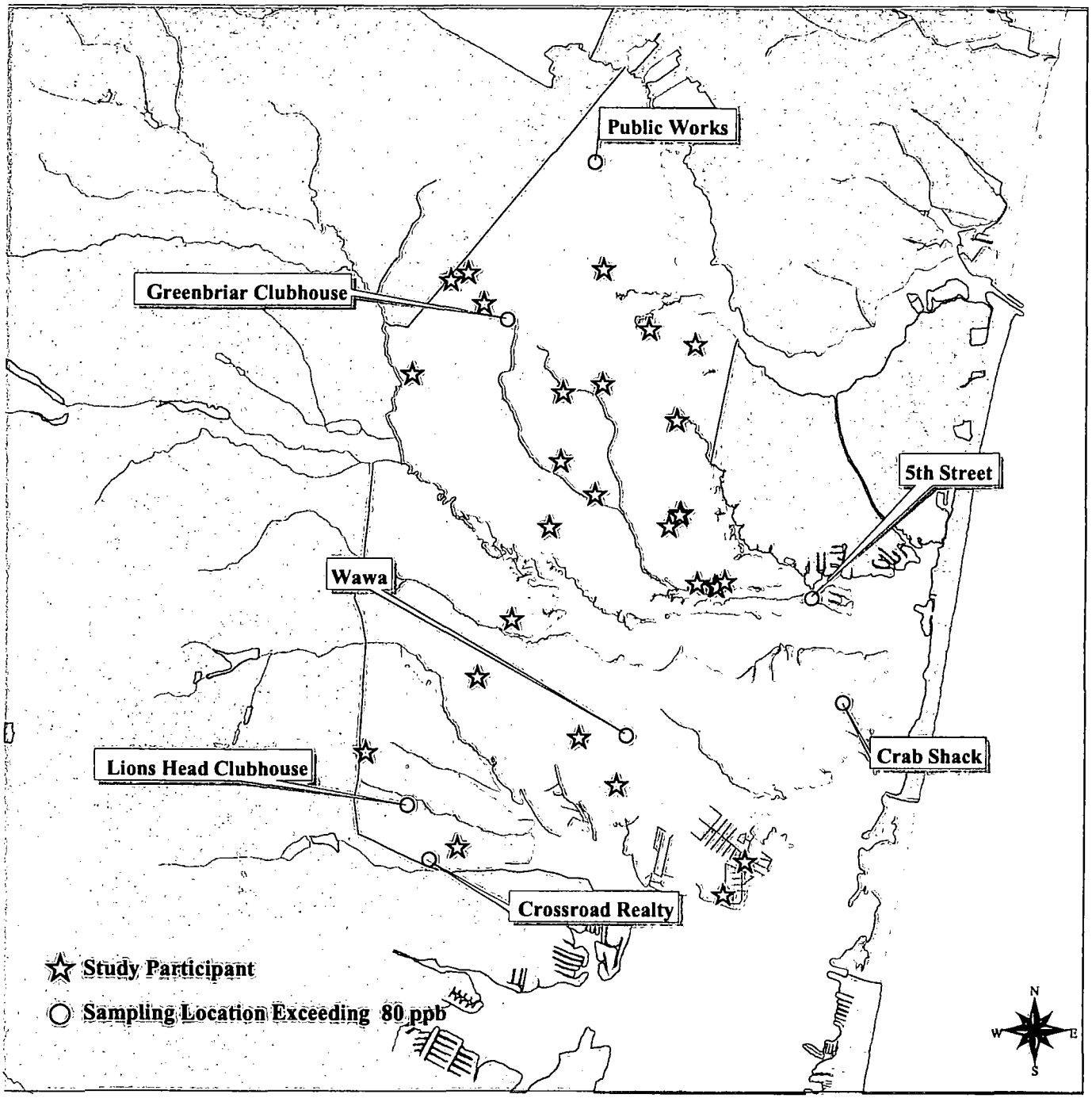
Figure 5: Locations of Total Trihalomethane Levels with at Least One Sample Above 80 Parts Per Billion



ATSDR SAA GIS

03/02/2000 WDH

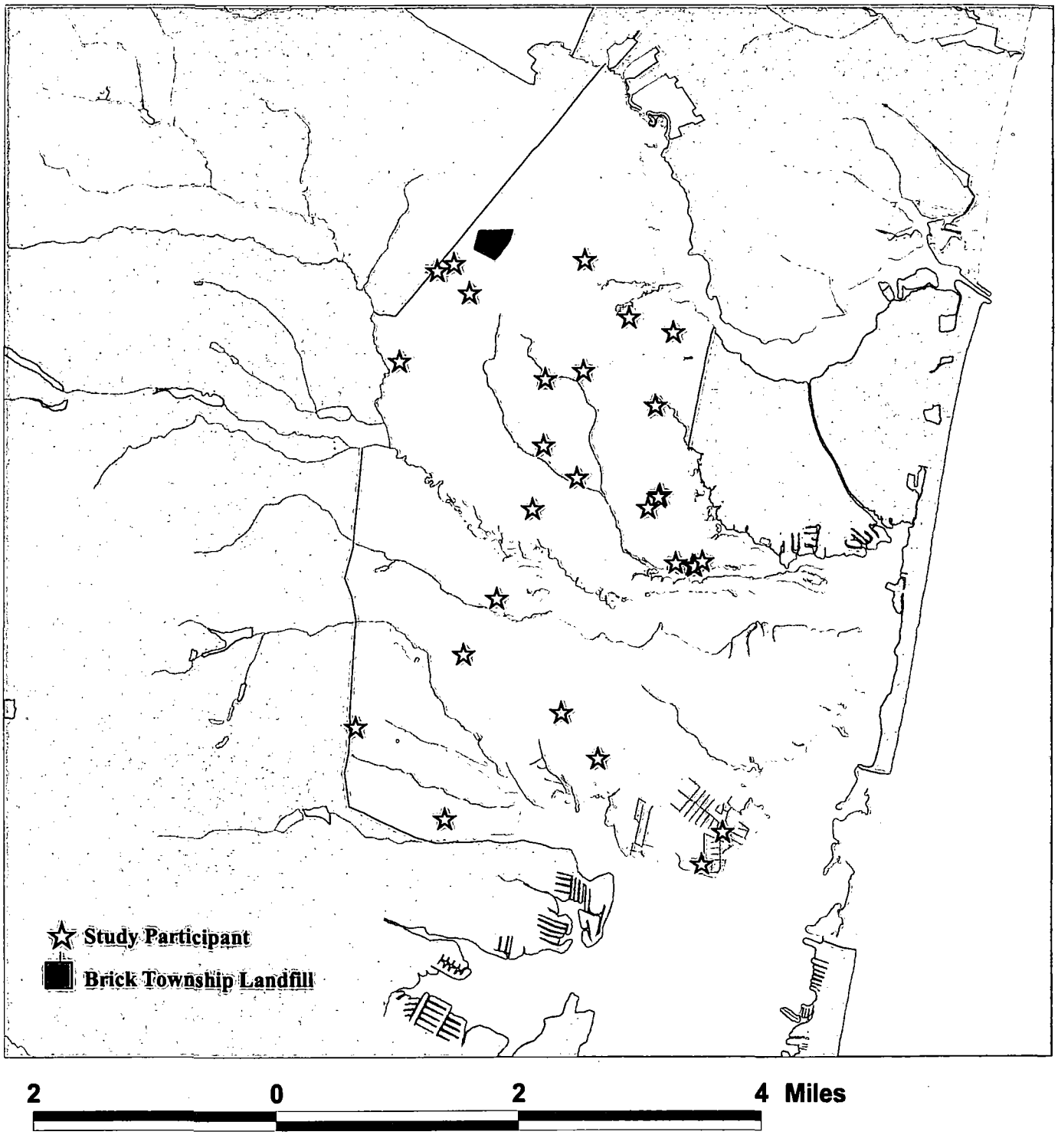
Figure 6: Locations of Total Trihalomethane Levels with at Least One Sample Above 80 Parts Per Billion with Residence at Birth/Conception for Study Participants



03/02/2000 WDH

ATSDR SAAGIS

Figure 7: Brick Township Landfill and Residence at Birth/Conception



03/02/2000 WDH

ATSDR SAAGIS

Appendix F
ATSDR Plain Language Glossary of Environmental Health Terms
Revised - 15 Dec 99

Absorption: How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure: Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect: A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect: A change in body function or the structures of cells that can lead to disease or health problems.

Antagonistic Effect: A response to a mixture of chemicals or combination of substances that is **less** than might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level: An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.

Biota: Used in public health, things that humans would eat – including animals, fish and plants.

CAP: See **C**ommunity **A**ssistance **P**anel.

Cancer: A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure: A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Completed Exposure Pathway: See **Exposure Pathway**.

Community Assistance Panel (CAP): A group of people from the community and health and environmental agencies who work together on issues and problems at hazardous waste sites.

Comparison Value: (CVs) Concentrations or the amount of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): **CERCLA** was put into place in 1980. It is also known as **Superfund.** This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

Concern: A belief or worry that chemicals in the environment might cause harm to people.

Concentration: How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant: See **Environmental Contaminant**.

Delayed Health Effect: A disease or injury that happens as a result of exposures that may have occurred far in the past.

Dermal Contact: A chemical getting onto your skin. (see **Route of Exposure**).

Dose: The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".

Dose / Response: The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration: The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

Environmental Media: Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Epidemiology: The study of the different factors that determine how often, in how many people, and in which people will disease occur.

Exposure: Coming into contact with a chemical substance.(For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:

1. Source of Contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

LOAEL: Lowest Observed Adverse Effect Level. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

Malignancy: See **Cancer**.

MRL: Minimal Risk Level. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The National Priorities List. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: No Observed Adverse Effect Level. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PHA: Public Health Assessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Plume: A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds and streams).

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). For examples: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area; or the number of people in a certain area.

PRP: **P**otentially **R**esponsible **P**arty. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

Public Health Assessment(s): See **PHA.**

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:

- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

Receptor Population: People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathway**).

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.

Route of Exposure: The way a chemical can get into a person's body. There are three exposure routes:
- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- or getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from chemical exposures at hazardous waste sites.

Sample Size: The number of people that are needed for a health study.

Sample: A small number of people chosen from a larger population (See **Population**).

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Special Populations: People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics: A branch of the math process of collecting, looking at, and summarizing data or information.

Superfund Site: See **NPL**.

Survey: A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do

surveys of more than nine people without approval from the U.S. Department of Health and Human Services.

Synergistic effect: A health effect from an exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together are greater than the effects of the chemicals acting by themselves.

Toxic: Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor.**

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

Appendix G
Public Comments and ATSDR's Responses

Comment: Throughout the report, the maximum contaminant level (MCL) for THMs is referred to as 80 ppb, reduced from 100 ppb in February 1999. This is wrong. The MCL for THMs was set at 100 ppb in 1979, was 100 ppb for the entire period of the autism investigation, and continues to be 100 ppb. THMs take a new MCL of 80 ppb in December 2001. We request that all text be adjusted to reflect this correction and that the milestone of 100 ppb be used in Figure 6 instead of 80 ppb.

Response: One page 9, first full paragraph ATSDR modified the text to read as follows: The EPA Maximum Contaminant Level (MCL) was 100 ppb based on an annual rolling average during the study period. It should be noted however that the EPA revised the MCL for THMs in the Federal Register on December 16, 1998. The MCL was lowered from 100 ppb to 80 ppb, but community water systems serving 10,000 or more persons have been given until December 2001 to comply with this change. ATSDR used the MCL goal of 80 ppb for some of its analysis in this report to be conservative from a public health perspective.

Comment: We think that including the single THM data point of 251 ppb (240 ppb chloroform) in the report is unfair and unnecessary, as well as misleading. We indicated in email dated January 27, 2000, sent with supporting documentation, that it was probably an error. This is obvious also from the fact that the next highest value was 142 ppb THM (116 ppb chloroform). Apparently 251 ppb compared to 100 ppb looks more favorable in an inconclusive investigation that 142 ppb compared to 100 ppb.

Response: ATSDR reviewed the information submitted on January 27, 2000 in regard to the 251 ppb THM data point. Based on our review of the data ATSDR believes that it was possible for this high THM level to exist at the Crab Shack sampling location. The information submitted to us indicating that the 251 ppb THM level was "probably" an error was not convincing enough to disregard the data point, so therefore it was included in our PHA with a qualifying footnote on page 9. ATSDR again chose to be conservative from a public health perspective. The data comes from documents that are public record and we do not believe inclusion of this data point is unfair or misleading. Removing the 251 ppb THM data point from the PHA would not change our recommendations or conclusions.

Comment: On page 8, in the first full paragraph, after "Groundwater has very little organic matter so the chlorination of groundwater produces very low or undetectable amounts of THMs.", why not state here that the groundwater was the primary

source of water that was treated for the period of the investigation instead of separating the two ideas on page 7 and 8?

Response: The first couple of paragraphs under Trihalomethanes were general introductory material in the PHA to help the public understand some of the issues around disinfection by-products. ATSDR included this statement to try and distinguish for the lay person that there is (1) a difference in the organic content of groundwater and surface water and (2) that because of the lower organic content in groundwater there would be less of a chemical reaction with the chlorine and therefore lower THM levels in the treated water.

Comment: Also on page 8, why is the obscure DBP, MX, mentioned with THMs and HAA's? There are more than 300 drinking water byproducts of chlorination and the report chooses to mention the one that sounds like nerve gas (VX). What purpose does it serve?

Response: ATSDR chose to mention DBP and MX, because of the known disinfection byproducts of chlorination they are two of the most potent in terms of mutagenicity. The full chemical name for MX is provided in parenthesis in the text on page 8 of the PHA, making it difficult to confuse one short chemical name with another (i.e. MX and VX).

Comment: Again on page 8, the last sentence of the third full paragraph states, "It is not known whether these cancers are caused by [1] one or more of the THMs, by [2] some other disinfection byproducts in drinking water, or [3] some combination of THMs and other disinfection byproducts." This statement implies that cancer is certainly caused by either 1, 2, or 3. Why is cancer even discussed in a report on autism prevalence anyway ?

Response: For clarification this sentence was changed to read as follows: It is not known whether the cancers *in these studies* were caused by one or more of the THMs, by some other disinfection byproduct in the drinking water, or some combination of THMs and other disinfection byproducts.

In addition, the cancer studies cited in the PHA help to provide the public with a complete picture of the toxicity of these compounds. ATSDR addressed cancer issues in the PHA, because cancer concerns were expressed to the agency, by members of the community, during one or more public availability sessions.

Comment: Regarding the landfill, the report indicates that "the groundwater beneath the landfill is contaminated with a variety of VOC's and metals." The next sentence

leaps to, "Contaminated groundwater would be unlikely to adversely effect pregnant mothers or children near the site, because residents in the area are supplied water by the municipal drinking water system, preventing exposure to the contaminated groundwater." We have seen results of analyses performed on wells around the landfill and wells from a significantly large residential area south and east of the landfill. This is some of the most thorough groundwater contamination we have seen, both from a variety of contaminant and level of concentration standpoint. Additionally, you make the sweeping conclusion that exposure was prevented because municipal water was supplied. This assumes 1) the contamination was known to exist and , 2) that residents used municipal water when their wells remained useable. Well use restrictions were not imposed until 1999. For a variety of reasons such as chlorine taste/odor, the fact that well water is 'free', and a false sense that well water is safe, people generally prefer their well to city water when given the choice. Yet the landfill is quickly brushed aside as a possible cause of alleged increased autism rate because "residents in the area are supplied water by the municipal drinking water system". Additionally, the "municipal drinking water system" that precluded "adverse affects to pregnant mothers and children" in this area is the Brick Township Municipal Utilities Authority and we request that be made clear on pages 2, 14, and 18. This is the same water that "contains bromoform, chloroform, and PCE above ATSDR comparison values" and is only "unlikely to be associated with ASD in Brick Township.

Response: The landfill summary paragraph beginning at the bottom of page one summarizes the Brick Township Landfill section beginning on page 14 of the PHA. ATSDR explains beginning on page 14 that a 1989 PHA and a 1995 Site Review and Update were completed and these documents concluded that there was *no apparent public health hazard*, because residents were supplied water by the municipal drinking water system (a.k.a. Brick Township Municipal Utilities Authority). Based on information obtained from the Ocean County Health Department and ATSDR's public availability sessions there was no indication that residents have been using private well water for drinking purposes in lieu of municipal drinking water. Based on current information ATSDR believes that there is no completed exposure pathway to the contaminated groundwater beneath the Brick Township Landfill. If ATSDR receives new information indicating residents are or have in the past used private well water for drinking water, for an extended period of time, we would consider that information in future PHA's or in other documents. Even though ATSDR does not believe that exposures to the groundwater occurred during the study period (except for sporadic use through irrigation, car washing, etc.) we did look at addresses during pregnancy for

children with autism spectrum disorder and did not find a relationship with the groundwater plume.

Comments were added on pages 2, 14, and 18 indicating that the municipal drinking water system is supplied by the Brick Township Municipal Utilities Authority.

Comment: On page 14, fifth paragraph, why does the ATSDR conclude that there is "no apparent public health hazard as a result of ingestion of contaminated groundwater [around the landfill] because maximum exposure doses of chloroform and TCE detected in residential wells were below levels where adverse health effects were likely". What about the dementing concentrations of mercury, arsenic, chromium, benzene, and chlorobenzene?

Response: The following sentences were added to paragraph 5, page 14 for clarification: This conclusion was based upon calculated exposure doses. It is unlikely that those residents exposed to chloroform or trichloroethylene in the *past* by drinking contaminated private well water will experience significant additional carcinogenic risk.

Even though ATSDR does not believe the levels of chloroform and TCE from contaminated private well water increased the risk for adult cancers, we do not know whether these levels could increase one's risk of childhood cancers, birth defects or developmental disorders such as autism. ATSDR did evaluate address during pregnancy for children with autism in the study and found no relationship with the groundwater plume.

Based on information reviewed by ATSDR chloroform and TCE were the only contaminants found in past residential well sampling. Mercury, arsenic, chromium, benzene, and chlorobenzene have been found in on and off-site monitoring wells, but were not detected in residential wells.

Comment: On pages 4 and 5, the report states that in Brick there were 6.7 ASD cases per 1000, and 4 of autism per 1000, quickly followed by stating 1 to 2 per 1000 could be expected. This immediately invites the conclusion that there are elevated levels in Brick. But then and only then is it indicated that the technique of "intense case finding" was employed and these prevalence rates are "similar" to other studies that employ "intense case finding" methods. But this is only mentioned after "we found 6.7 and 4, and 1 to 2 is the norm (paraphrased).

Response: The text beginning on page 4 was modified to read as follows: The intense case finding of this study may have contributed, to some extent, to the high rate of autism found in Brick Township. For example, recent studies that have employed intense case finding methods, to study populations of comparable size or larger than the Brick Township population, have found prevalences for autistic disorder as high as 3.1 cases per 1,000 children. However, these prevalences are still lower than the prevalence for autistic disorder found in Brick Township (i.e. 4 cases per 1,000 children). In addition, most of the children with autism in Brick Township were born in town, so migration cannot explain the high prevalence found.

The prevalence report prepared by CDC followed the standard outline for presenting scientific findings. As such, other factors that may impact results, such as methodological issues, are presented in the Discussion section along with other information that may assist with interpretation of investigation findings.

Comment: We request that the term U.S. and New Jersey" be replaced with "United States" on page 7, first sentence under a. Trihalomethanes. New Jersey is in the United States.

Response: This change was made on page 7.

Comment: In conclusion, the report used Brick's drinking water as a convenient subject to make statements like "probably does not cause cancer", in an effort to fill pages in a document that was probably not going to be well received. In the body of the report, there are 7.5 pages on the drinking water system, 1.5 on the landfill, 0.5 on Fluid Packaging, and 0.3 on swimming in the river. Also, the report suddenly and curiously changes focus away from autism and toward cancer, possibly because of the plethora of statements heard at the April 18 meeting, regarding the vagueness of the report. These statements included:

"We would not have that information at this time."
"Every study has its limitations."
"There is unknown in this."
"Muddier waters"
"We don't have all the data in hand to determine if Brick is high."
"There is no perfect study."

This change of focus also allowed for reference to a much larger pool of data pertaining to emotional, catastrophic illness, fitting of this report.

Response: ATSDR's PHA devotes more space to drinking water, because that was the only completed exposure pathway found in Brick Township and the contaminant levels in the municipal drinking water supply made it a plausible cause of the high autism prevalence, given the referenced studies on neural tube defects.

The main focus of the PHA was to address whether community members may have been exposed to hazardous chemicals in the environment. The community's main concern was the relationship between chemicals in the environment and autism, but cancer was a secondary concern expressed to our agency. The majority of the PHA is devoted to exposures relevant to autism, but cancer issues are discussed. ATSDR tried to keep cancer information separate from the main document by placing this information in Appendix D.

Comment: Both the contents and release of the Autism study in Brick Township, new Jersey was politics at its brilliant best and public service at its tragic worse. Twenty years of dumping mutagenic and carcinogenic chemicals being referred to as a "mineral oil spill" indicates the political nature of this entire report. It is more than a shame you think so little of our intelligence and so much of your own.

Response: ATSDR removed the term "mineral oil spill" on page 15, paragraph three and replaced it with "Volatile Organic Compounds (VOC's) and metals".

A list of the VOC's and metals and the levels at which they were found can be reviewed in the 1998 Brick Township Municipal Utilities Authority report titled Results of Fluid Packaging Data Review.

Comment: More information on autism spectrum disorder should be included. The current knowledge base of mechanism and prevalence should be discussed.

Response: For additional information regarding autism spectrum disorder and prevalence please see the Centers for Disease Control and Prevention report: Prevalence of Autism in Brick Township, New Jersey, 1998: Community Report, April 2000 and the ATSDR DRAFT Chemical Specific Consultation: Hazardous Substance Exposure and Autism, 1998.

Comment: Either a section on autism spectrum disorders and their etiology should be added to this report or the public should be directed to literature that will help them understand what is currently known about autism and the disease characteristics.

Response: General information on autism spectrum disorders, including information concerning etiologies, is contained in the ATSDR DRAFT Chemical Specific

Consultation: Hazardous Substance Exposure and Autism prepared by the ATSDR Division of Toxicology. A reference to this review and information on obtaining a copy, have been added to the report.

Other sources of information on autism spectrum disorders and their etiology can be obtained by contacting the following organizations:

- Centers for Disease Control and Prevention, Division of Birth Defects, Child Development, and Disability and Health
  http://www.cdc.gov/nceh/cddh

- National Alliance for Autism Research
  http://www.naar.org

- National Institute of Health
  http://www.niehs.nih.gov