Public Health Assessment for

WARD TRANSFORMER
RALEIGH, WAKE COUNTY, NORTH CAROLINA
EPA FACILITY ID: NCD003202603
OCTOBER 28, 2004

For Public Comment

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

Comment Period Ends:

DECEMBER 27, 2004

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release 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. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude 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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PUBLIC HEALTH ASSESSMENT

WARD TRANSFORMER

RALEIGH, WAKE COUNTY, NORTH CAROLINA

EPA FACILITY ID: NCD003202603

Prepared by:

Superfund Site Assessment Branch
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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.
(The legal definition of a health assessment is included on the inside front cover.) 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, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state and federal agencies, the companies responsible for cleaning up the site, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When informed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

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 (E60), Atlanta, GA 30333.

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Acronyms and Abbreviations

AL	U.S. EPA Action Level
ATSDR	Agency for Toxic Substances and Disease Registry
COC	Contaminant of Concern
CREG	Cancer Risk Evaluation Guide
CSF	Cancer Slope Factor
CV	Comparison Value
EMEG	Environmental Media Evaluation Guide
EPA	U.S. Environmental Protection Agency
ESI	Expanded Site Inspection
FDA	Food and Drug Administration
HOD	Health Outcome Data
IARC	International Agency for Research on Cancer
IUPAC	International Union of Pure and Applied Chemistry
LOAEL	Lowest Observed Adverse Effect Level
MCL	Maximum Contaminant Level
mg/kg/day	milligram per kilogram per day
mg/m^3	milligram per cubic meter
MRL	Minimal Risk Level
NCDENR	North Carolina Department of Environment and Natural Resources
NIOSH	National Institute for Occupational Safety and Health
NOAEL	No Observed Adverse Effect Level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated biphenyl
PHA	Public Health Assessment
ppb	part per billion
ppm	part per million
ppt	part per trillion
R3 RBC	U.S. EPA Region 3 Risk-based Concentration
R9 PRG	U.S. EPA Region 9 Preliminary Remediation Goal
RfD	Reference Dose
RI	Remedial Investigation
RMEG	Reference Media Evaluation Guide
SSL	U.S. EPA Soil Screening Level
TCDD	Tetrachlorodibenzodioxin
TEF	Toxicity Equivalency Factor
TEQ	Toxicity Equivalency Quotient
μg/L	microgram per liter
WHO	World Health Organization

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Summary

The Ward Transformer site is an operating transformer recycling facility located on Mount Herman Road in Raleigh, North Carolina. The facility is in a mostly industrial area close to U.S. 70, I-540, and the Raleigh-Durham International Airport. The facility has been in operation since about 1964. Before 1977, when the use of PCBs in transformer oil was discontinued, PCBs contaminated soils on the site and surface water and stream sediments downstream of the site.

On the basis of the information available about the Ward Transformer site, ATSDR concluded the following:

1. Edible portions of fish from areas downstream of the site have PCBs at levels high enough to increase the theoretical risk of cancer and adverse noncancer health effects for people who eat these fish regularly. The State of North Carolina has placed an advisory against eating carp or catfish from Lake Crabtree or any species of fish from Brier Creek, Brier Creek Reservoir, Little Brier Creek downstream of Brier Creek Parkway, and the tributary leading from the Ward Transformer site. The State of North Carolina also advises that consumption of fish species other than carp or catfish from Lake Crabtree be limited to no more than 1 meal per month.
2. Exposure of site workers to PCBs in soil could contribute to an increased theoretical risk of developing cancer.
3. Exposure to PCBs in sediment and surface water is not a significant contributor to overall theoretical cancer risk. However, sediments may contribute to PCB contamination in the aquatic food chain. As stated above, consumption of contaminated fish could increase the risk of cancer and adverse noncancer health effects.
4. The groundwater beneath the site is not being used for drinking water and therefore is not of public health concern at this time. However, limited data suggest that the groundwater might be impacted by site contaminants. Not enough information exists to determine whether health effects could be possible if the groundwater was used for drinking.

Because exposure to PCBs in fish and/or soil could increase the risk for cancer or adverse noncancer health effects if exposure is not reduced and/or prevented, ATSDR classifies the Ward Transformer site as a *public health hazard*.

ATSDR has made the following recommendations about the site:

1. ATSDR recommends that the public follow fish advisories placed by the State of North Carolina.
2. ATSDR recommends action be taken to minimize exposure of employees at Ward Transformer to PCBs in soil.
3. ATSDR recommends that action be taken to reduce the contribution of contaminants in sediment to the food chain.
4. If groundwater beneath the site is used for drinking water in the future, it should be fully characterized to determine its impact on public health.

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Purpose and Health Issues

The Ward Transformer site was proposed for the National Priorities List (NPL) on September 5, 2002 and listed on the NPL on April 30, 2003. Congress requires ATSDR to conduct public health activities on all sites proposed for or listed on the NPL. In this public health assessment (PHA), ATSDR evaluates the public health significance of the Ward Transformer site. ATSDR reviewed environmental data, potential exposure pathways, and community health concerns to determine whether adverse health effects are possible. In addition, this PHA recommends actions to prevent, reduce, or further identify the possibility for site-related adverse health effects.

Background

Site Description

The Ward Transformer site is an operating transformer recycling facility located on Mount Herman Road in Raleigh, Wake County, North Carolina. The facility is in a mostly industrial area close to U.S. 70, I-540, and the Raleigh-Durham International Airport. The facility has been in operation since about 1964. Before 1977, when the use of polychlorinated biphenyls (PCBs) in transformer oil was discontinued, PCBs contaminated soils on the site and surface water and stream sediments downstream of the site. The Ward Transformer company constructed a stormwater retention pond in 1972 and a water treatment plant in 1979. These treatment processes have operated consistently within permit requirements.

Demographics

Figure 1 shows demographic information for the area surrounding the site. Approximately 104 people, including about 12 children under age 6, live within a 1-mile radius of the site. The population around the site is about 85% Caucasian, 10% African American, and 4% Asian.

Land and Natural Resource Use

The Ward Transformer site covers about 11 acres in a sparsely populated area outside of Raleigh, North Carolina. The site is surrounded on three sides by other industrial properties and highways, and abuts land belonging to the Raleigh-Durham International Airport. The airport land is restricted, and the site and most of the surrounding industrial properties are fenced. Mount Herman Road dead-ends into a major highway (U.S. 70) a few hundred feet north of the site before continuing on the north site of U.S. 70.

The facility was constructed on previously undeveloped land in 1964 and has reconditioned transformers since that time. The main yard of the operating facility contains the reconditioning facility, offices, and hundreds of used transformers stored for possible resale. Some of the transformers have been on site for more than 10 years. The northern portion of the yard is now vacant but previously was leased to a forest products company and may have been used to store or recondition transformers before that. The yard is almost completely paved (some areas are aged and cracked) and is surrounded by an 8-foot high chain-link fence topped with barbed wire.

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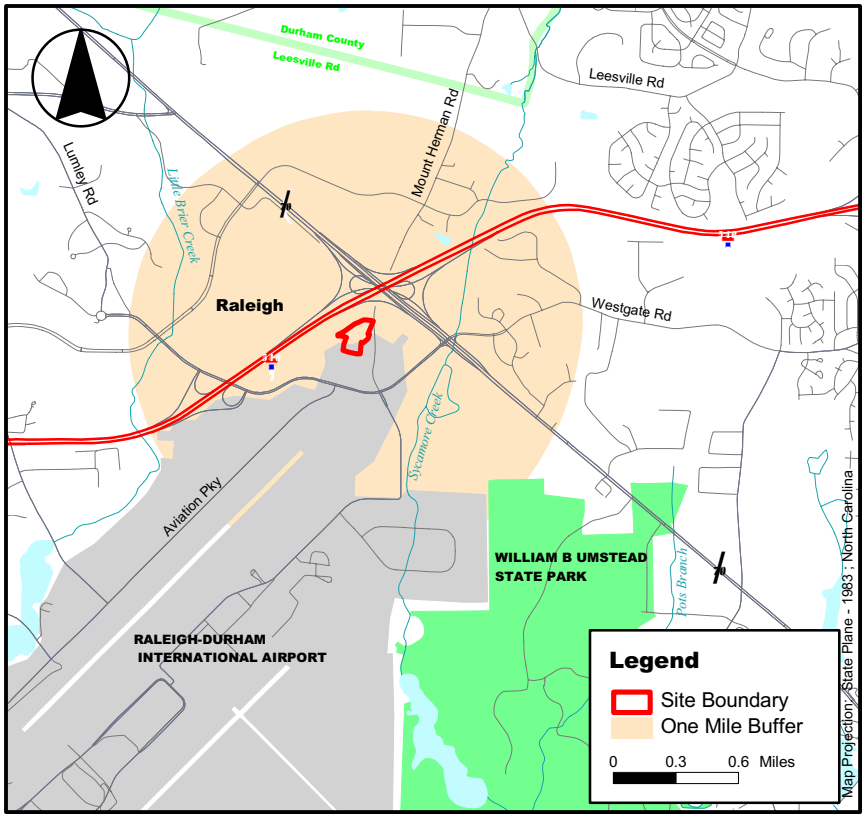
Figure 1. Site Location and Demographic Information, Ward Transformer, Raleigh, NC

Ward Transformer

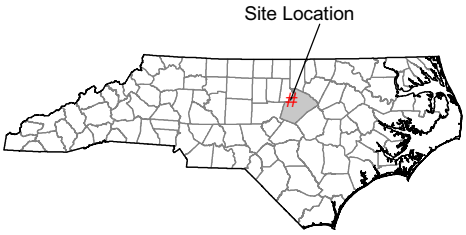
INTRO MAP

Raleigh, North Carolina

EPA Facility ID NCD003202603



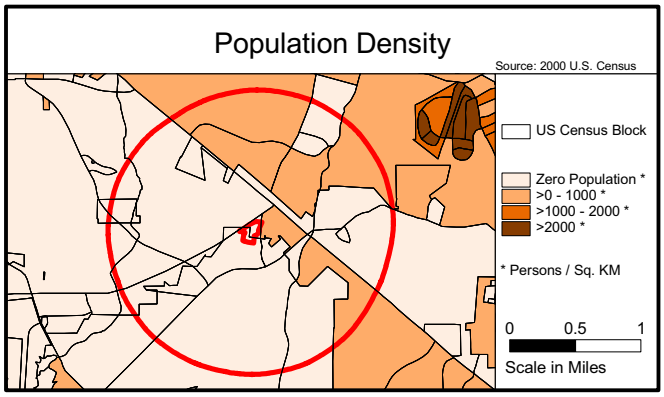
Base Map Source: 1995 TIGER/Line Files

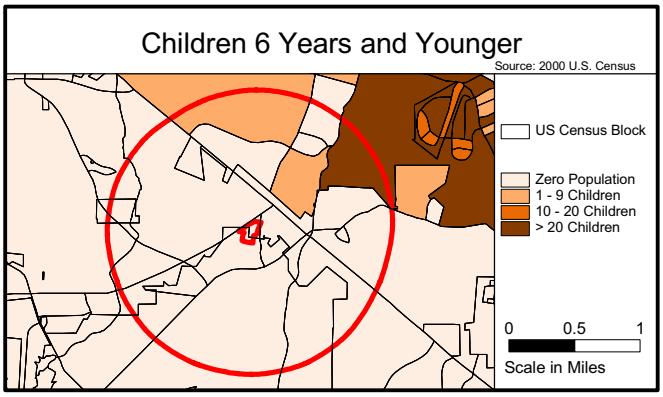


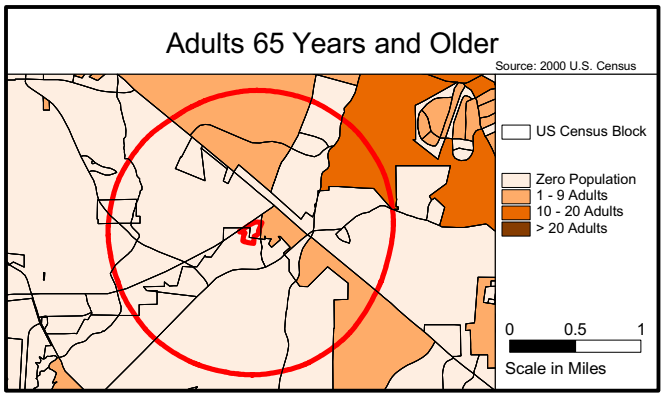
Wake County, North Carolina

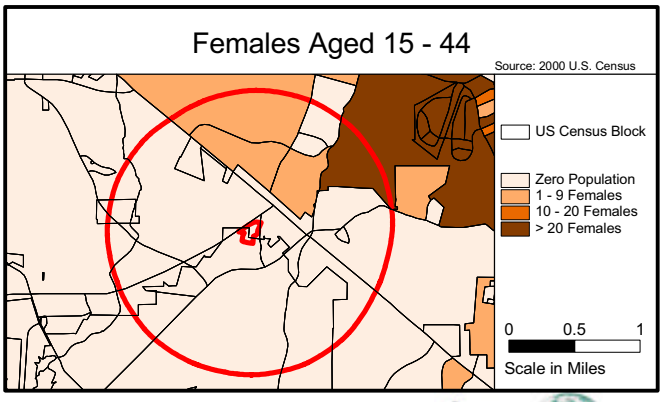
Demographic Statistics Within One Mile of Site*	
Total Population	104
White alone	88
Black alone	10
Am. Indian and Alaska Native alone	0
Asian alone	4
Native Hawaiian and Other Pacific Islander alone	0
Some other race alone	0
Two or More races	1
Hispanic or Latino	2
Children Aged 6 and Younger	12
Adults Aged 65 and Older	5
Females Aged 15 - 44	25
Total Housing Units	39

Demographics Statistics Source: 2000 US Census
*Calculated using an area-proportion spatial analysis technique









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Also in the main yard is a burnoff oven (similar to an incinerator), which was installed in 1973 and burned transformer oil in the past.

Before 1972, surface water runoff flowed overland to intermittent streams west and south of the facility. In 1972, two unlined lagoons were built in a fenced area immediately west of the main yard of the site for stormwater retention. A National Pollutant Discharge Elimination System (NPDES) permitted stormwater treatment plant and curbs to direct all stormwater runoff from the facility to the lagoons were installed in 1979. This treatment plant removes PCBs from water in the stormwater lagoon before releasing it to an unnamed stream that joins Little Brier Creek to the west and eventually flows into Lake Crabtree about 2 miles west and south of the site. The site is in compliance with its NPDES permit requirements.

PCBs have been measured in sediments and surface water in and around the creek more than a mile downstream of the site. The nearest downstream residences are approximately 1 mile downstream of the site; the residences appear to be at a higher elevation than the creek.

Groundwater is thought to flow toward the creeks. The only drinking water use of groundwater identified near the site was at a business located immediately north of the site. Employees of this business used an onsite drinking water well until 1995. The facility has been connected to the municipal water supply since April 1995.

Discussion

Data Used

The data used in this evaluation came from the following sources:

- Sampling of soil, sediment, and incinerator ash as part of the 1998 Expanded Site Inspection (ESI) performed by the North Carolina Department of Environment and Natural Resources (NCDENR) [1]. The ESI Report also presented results of soil and sediment sampling from past investigations, including the 1995 Site Inspection by the North Carolina Superfund Section, a 1993 Removal Investigation by the U.S. Environmental Protection Agency (EPA), and sampling in the late 1970s by the EPA.
- Sampling of soil, sediment, surface water, groundwater, and fish as part of the 2003 remedial investigation by EPA. EPA's contractor provided the data through the Remedial Investigation and Risk Assessment report revised in May 2004 [4].

The conclusions reached in this document are based on the data available at the time and might be modified on the basis of results of additional samples collected in the future.

ATSDR staff (Jill Dyken, Shan-Ching Tsai, Ruby Palmer, and Benjamin Moore) visited the site in March 2003. A walk-through to observe the main features of the site was conducted with EPA representatives (Luis Flores and Diane Barrett) and EPA contractors. The team observed the following:

- The fence around the facility was approximately 8 feet high, topped with barbed wire, and in good repair. Three sides around the lagoons was fenced with a tall fence in good repair, but the west side had only a very short fence (about 2 feet high) that could easily be stepped over. All fences had locks that could be accessed only by Ward employees.
- Most of the main yard was paved, but the pavement was aged and cracking in some areas. Hundreds of used transformers were densely packed in the yard.
- The former Horizon Forest Products building was vacant.
- About a dozen employees were reconditioning transformers inside the warehouse building on the Ward site.
- A number of 55-gallon drums were stored on pallets in the main yard near the burnoff oven.
- The burnoff oven was located in the main yard, between the warehouse building and the water treatment facility.

Also, ATSDR staff drove through the area surrounding the site to better understand the relationship between the site and the people living and working nearby. ATSDR staff observed the following:

- Surrounding industrial facilities had many cars in the parking lots, indicating daily worker populations in the area.
- One house was located about 300 feet northeast of the facility. This house had formerly been reported as occupied, but ATSDR could not determine whether it was currently occupied.
- Other than the one house, the areas immediately surrounding the facility were industrial properties, land belonging to the Raleigh-Durham airport and marked prominently with “No Trespassing” signs, or vacant land buffering the two major highways crossing near the Ward facility.
- Commercial and residential development is occurring on the other side of I-540, approximately 1 mile west (downstream) of the site.

Evaluation Process

The process by which ATSDR evaluates the possible health impact of contaminants is summarized here and described in more detail in Appendix A. The first step involves screening data for contaminants of concern (COCs). ATSDR uses comparison values (CVs) to determine which chemicals to examine more closely. CVs are concentrations of chemicals in the environment (air, water, or soil) below which adverse human health effects are not likely. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed. ATSDR also considers sampling location, data quality and community health concerns in determining which chemicals to evaluate further.

If a chemical contaminant is selected for further evaluation, the next step is to identify which chemicals and exposure situations could be a health hazard. Exposure doses for children and adults are calculated for COCs in site media (e.g., soil, groundwater, surface water, sediment, fish or shellfish). Exposure doses are the estimated amounts of a contaminant to which people come in contact under specified exposure situations. These exposure doses are compared with appropriate health guidelines for that chemical. Health guideline values are considered safe doses; that is, adverse health effects are unlikely below this level. If the exposure dose for a

chemical is greater than the health guideline, then the exposure dose is compared with known health effect levels identified in ATSDR's toxicological profiles and other current reference sources. If the COC is a carcinogen, the theoretical cancer risk is also estimated. These comparisons provide the basis for determining whether the exposure is a health hazard.

Because the Ward Transformer business involved recycling used transformers since the 1960s, the main contaminants of concern at the site are PCBs, which were used in transformers before 1977. Data were screened for all contaminants of concern, but an overview of PCBs is given here because they are likely to be the most important contaminants of concern at this site and because completed pathways for exposure were identified.

Polychlorinated Biphenyls

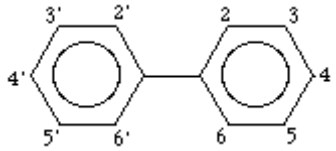
Overview

PCBs are a group of synthetic organic chemicals that exhibit insulating and flame retardant properties. They were first manufactured and used in the late 1920s. PCBs were used widely as coolants and lubricants in transformers and other electrical equipment and as process chemicals in the manufacture of common products including plastics, fluorescent lighting fixtures, and pesticides. PCBs are also relatively inert and take a long time to break down. In 1977, evidence that PCBs build up in the environment and may cause harmful effects led to a halt in the manufacture of PCBs in the United States. However, PCBs are still found throughout the world because they break down so slowly and may be transported long distances in the environment. People can be exposed to PCBs in air, water, soil, or sediments. Most exposure to PCBs, however, probably results from eating contaminated fish or meat. Because PCBs break down so slowly, tissue levels of PCBs tend to increase up the food chain as predators eat smaller species. In this way, the fish and meat people eat can be contaminated with higher levels of PCBs than those existing in the air, water, soil, or sediments.

Chemical Structure

The chemical structure of PCBs determines their toxicity. The base of every PCB is the biphenyl molecule, which consists of two benzene rings joined together (Figure 2). Hydrogen atoms are attached to each of the numbered corners representing carbon atoms in the diagram. To form a PCB, 2–10 chlorine atoms substitute for these hydrogen molecules [5].

Figure 2. Biphenyl Chemical Structure (from [6])



Chlorine atoms can substitute for hydrogen at any of the 10 numbered carbon atoms shown. The 209 possible combinations that can be formed are known as PCB congeners. One numbering system for naming PCBs is derived from the carbon atom numbers shown in Figure 2. Positions 2, 2', 6, and 6' are called *ortho* positions, positions 3, 3', 5, and 5' are called *meta* positions, and

positions 4 and 4' are called *para* positions. The benzene rings can rotate around the bond connecting them; when the rings are in the same plane, they are referred to as *planar* or *coplanar* PCBs. Planar PCBs have a structure similar to the chlorinated dioxins and furans and generally are more toxic than nonplanar PCBs. When the relatively large chlorine atoms are attached in opposing *ortho* positions, the molecule cannot lie flat; therefore, only non-*ortho* or mono-*ortho* PCBs can assume the planar configuration.

An alternative way to name PCB congeners is using a numbering system based on International Union of Pure and Applied Chemistry (IUPAC) rules for substituent characterization in biphenyls [5]. Using this system, congeners PCB-1 through PCB-209 are ordered, with increasing numbers increasing in degree and complexity of substitution, according to standard IUPAC rules.

The major U.S. producer of PCBs until 1977 marketed mixtures of PCBs under the trade name Aroclor. The Aroclors are identified by a 4-digit numbering code in which the final two digits indicate the approximate weight percentage of chlorine in the mixture (e.g., Aroclor 1260 contains about 60% chlorine). Each Aroclor is a mixture of various PCB congeners.

Health Effects Caused by PCB Exposure

Exposures of workers to high levels of airborne PCBs—many times higher than are likely to be present at Ward Transformer today—caused skin conditions, such as acne and rashes, and changes in blood and urine that might indicate liver damage. In animal studies, long-term oral exposure to PCBs caused various health effects, including liver damage, skin conditions, impaired reproduction, and immunologic and behavioral changes. PCBs are not known to cause serious birth defects. However, evidence exists that children exposed to PCBs in the womb (through their mother's consumption of contaminated fish) had neurobehavioral and developmental deficits [5,7]. In human and animal studies, PCBs are associated with certain kinds of cancer, such as cancer of the liver and biliary tract [5]. EPA considers PCBs probable human carcinogens. The evidence of PCBs' carcinogenicity in animal studies is sufficient and current evidence in humans is inadequate but suggestive [8].

Certain PCB congeners may exhibit toxicity similar to the chlorinated dibenzodioxins and dibenzofurans, structurally similar molecules. One of the most toxic and most studied of these molecules, 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD), can cause acne-like skin lesions, rashes, liver damage, hormonal changes, and increase the theoretical risk of cancer [9]. Toxicity of dioxin-like PCB congeners can be expressed as a fraction of the toxicity attributed to 2,3,7,8-TCDD, or a toxicity equivalency factor (TEF) [9,10,11]. Table 1 shows the TEF weighting factors used for the PCB congeners measured at the Ward Transformer site. Individual PCB congeners are multiplied by their respective TEF and summed, along with comparably weighted dioxins and furans, to obtain the toxicity equivalency quotient (TEQ). The TEQ can be compared directly with 2,3,7,8-TCDD toxicity information. This public health assessment evaluated PCBs individually and (when congener data were available) using TEQs to determine the specific dioxin-like toxicity.

Table 1. TEF Weighting Factors for PCB Congeners at the Ward Transformer Site

Congener Number	TEF Weighting Factor
PCB Congener #105	0.0001
PCB Congener #114	0.0005
PCB Congener #118	0.0001
PCB Congener #123	0.0001
PCB Congener #126	0.1
PCB Congener #156	0.0005
PCB Congener #157	0.0005
PCB Congener #167	0.00001
PCB Congener #169	0.01
PCB Congener #189	0.0001
PCB Congener #77	0.0001
PCB Congener #81	0.0001

Current Standards, Regulations, and Recommendations

EPA has set a regulatory maximum contaminant level (MCL) for PCBs in drinking water as 0.5 parts of PCBs per billion parts of water (ppb). For protection of human health from eating fish or shellfish from surface waters, EPA recommends that the level of PCBs in surface waters be no greater than 0.17 parts per trillion (ppt).

The State of North Carolina placed fish advisories for surface waters leading from the Ward Transformer site on the basis of the level of PCBs in fish from Lake Crabtree, Brier Creek, Little Brier Creek, Brier Creek Reservoir, and the tributary leading from the Ward Transformer site [12,13]. No other fish advisories based on PCBs were located in North Carolina [14]. The fish consumption advisories recommend that no fish be eaten from Brier Creek (downstream of Brier Creek Reservoir), Brier Creek Reservoir, Little Brier Creek (downstream of Brier Creek Parkway), or the unnamed tributary to Little Brier Creek. In addition, the advisories recommend that no carp or catfish from Lake Crabtree be eaten, and all other fish from Lake Crabtree be eaten at no more than one meal a month.

The Food and Drug Administration (FDA) has set residue limits (i.e., tolerances) for PCBs in various foods to protect consumers from harmful health effects. FDA limits include 0.2 parts per million (ppm) in infant and junior foods, 0.3 ppm in eggs, 1.5 ppm in milk and other dairy products, 2 ppm in edible portions of fish and shellfish, and 3 ppm in poultry and red meat [15].

The Occupational Safety and Health Administration (OSHA) requires that workers not be exposed by inhalation over a period of 8 hours for 5 days per week to more than 1 milligram per cubic meter of air (mg/m^3) for PCBs containing 42% chlorine or to 0.5 mg/m^3 for PCBs containing 54% chlorine. The National Institute for Occupational Safety and Health (NIOSH) recommends that workers not breathe air containing PCBs at levels higher than 0.001 mg/m^3 for a 10-hour workday, 40-hour workweek [16].

The National Toxicology Program and the International Agency for Research on Cancer (IARC) have classified PCBs as reasonably anticipated to be carcinogens and as probably carcinogenic to humans, respectively. EPA has classified PCBs as a probable human carcinogen. EPA has calculated an upper bound oral slope factor of 2 per milligram per kilogram per day

(2 [mg/kg/day]$^{-1}$) to be used for such exposures as food chain exposure, sediment or soil ingestion, presence of dioxin-like congeners, and early-life exposures. EPA also calculated less conservative oral slope factors for use in other situations (for example, when toxic PCB congeners make up less than ½% of the mixture or for more water-soluble congeners) [8].

Complete Exposure Pathways and Contaminants of Concern

Fish Pathway

People might eat fish caught from waters downstream from the site. Because site contaminants (particularly PCBs) build up over time in fish tissue, people who eat the fish might be exposed to contaminants by eating the fish.

Composite samples of fish were collected in May 2003 during the remedial investigation. Fish were sampled from the unnamed tributary to Little Brier Creek and the Brier Creek Reservoir. Whole body samples of fish from the unnamed tributary were collected, and both whole body and filet (with skin) samples were collected from the Brier Creek Reservoir. ATSDR used all the May 2003 data to screen for contaminants of concern, and further evaluation was performed using only the fish filet data, since it is assumed recreational fishers in the area do not eat the whole fish.

To evaluate the potential for health effects from eating the fish, ATSDR assumed the 95th percentile fish ingestion rate for freshwater recreational anglers of 25 grams per day for adults [17]. Small children weighing 22 pounds were estimated to consume 12.5 grams of fish per day, on average. These consumption rates correspond to about one fish meal per week, where adults eat 6 ounces of fish per meal and small children eat 3 ounces of fish. These assumptions are considered conservative for recreational consumption of fish from Brier Creek Reservoir. The reservoir is posted with “Do Not Eat Fish” signs, but ATSDR received anecdotal reports of people fishing there in the past. Also, fishers are unlikely to fish exclusively on the Brier Creek Reservoir, as assumed in this evaluation.

Table 2. Contaminants of Potential Concern in Composite Fish Filet Samples

Contaminant	Maximum Composite Filet Concentration, mg/kg	Estimated Dose for Child, mg/kg/day	Health Guideline, mg/kg/day	Health Guideline Source (defined in Appendix A)	Excess Cancer Risk, if applicable*
Total mercury	1.1	0.001	0.0003	Chronic MRL for organic mercury	Not Applicable
Aroclor 1260	2.6	0.003	0.00002	Chronic MRL for PCBs	7 in 10,000

* Based on 25-year exposure duration at adult dose of 0.00093 mg/kg/day.
Source: [4]

As shown in Table 2, two contaminants resulted in estimated exposure doses higher than health guidelines. These contaminants will be evaluated in the following paragraphs.

Mercury

The form of mercury that builds up in fish is methylmercury, an organic (carbon-containing) form of mercury. High levels of methylmercury can result in brain and kidney damage and can be especially harmful to developing children exposed either prenatally or after birth. The highest level of mercury measured in fish filets downstream of the Ward Transformer site is 1.1 mg/kg, only slightly higher than FDA's action level of 1 mg/kg for commercial seafood. The estimated child dose of 0.001 mg/kg/day is about the same as the dose of 0.0013 mg/kg/day that had no adverse health effects in human epidemiologic studies; however, other studies have suggested developmental effects may occur at similar doses [19]. Mercury is a widespread contaminant and was not known to be used at the Ward Transformer company. Although a slightly increased risk for health effects is possible from exposure to mercury through this pathway, Ward Transformer is unlikely to have contributed significantly to this risk.

Aroclor 1260

Aroclor 1260 consists of a mixture of PCBs. The estimated intake for children eating fish caught recreationally is 0.003 mg/kg/day and for adults is 0.0009 mg/kg/day. The chronic-duration minimal risk level derives from an animal study in which Rhesus monkeys fed as little as 0.005 mg/kg/day Aroclor 1254 for 23 months exhibited decreased antibody response and some mild clinical manifestations of toxicity (eyelid and toe/fingernail changes) [5]. An intermediate-duration minimal risk level (0.00003 mg/kg/day) is derived from an animal study in which monkeys fed as little as 0.0075 mg/kg/day for 20 weeks exhibited decrements in learning and neurobehavioral performance. For both children and adults, estimated doses for recreational consumption of fish are within an order of magnitude of the lowest observed adverse effect levels observed in these studies. If children and adults ate enough fish, adverse health effects could result. The most likely health effects would be mild immunologic or neurologic changes.

The excess cancer risk associated with eating filets from recreationally caught fish with the average Aroclor 1260 concentration listed in Table 2 was estimated, assuming daily and continual exposure over a 25-year period. The estimated theoretical excess cancer risk is about 7 in 10,000; ATSDR considers this a low-to-moderate increased risk for cancer. The actual risk of developing cancer depends on many factors, including actual consumption, actual contaminant levels in the fish consumed, genetics, lifestyle, and other environmental factors.

Update of Aroclor 1260 Analysis Based on November 2003 Fish Sampling

In November 2003, additional fish samples were collected further downstream from the May 2003 sampling locations. Fish were collected from the lower portion of Brier Creek Reservoir, from Brier Creek downstream from Brier Creek Reservoir and from three different areas in Lake Crabtree. Whole body samples were collected from Brier Creek, and both whole body and filet samples were collected from Brier Creek Reservoir and from Lake Crabtree. Filets had skin left on except for catfish filet samples which had the skin removed. The November fish samples were analyzed only for PCBs, PCB congeners, and dioxins/furans. ATSDR evaluated only the fish filet results, since it is assumed recreational fishers in the area do not eat the whole fish. A

summary of all of the Aroclor 1260 results, showing location, species, and average filet concentration of Aroclor 1260 for each species and location collected, is shown in Table 3.

Table 3. Fish Filet Sampling Result Summary, Ward Transformer Site, Raleigh, NC

Location	Fish Species	Average Composite Filet Aroclor 1260 Concentration in mg/kg
Brier Creek Reservoir	Bluegill sunfish	0.5
	Largemouth bass	1.6
	Brown bullhead	1.7
	Yellow bullhead	1.2
Lake Crabtree	Bluegill sunfish	0.2
	Largemouth bass	0.2
	Common carp	0.3
	Channel catfish	1.2

Assuming the same recreational consumption rates as above, all the filet concentrations in Table 3 would result in increased risk of cancer and noncancer health effects. Because of the lower PCB levels in Lake Crabtree sunfish and bass, limiting consumption of these fish to no more than 1 meal a month would be expected to minimize the risk of adverse health effects.

Soil Ingestion Pathway

Employees working on the site or people trespassing on or near the site could come into contact with contaminated soil. They could get particles of the soil on their skin, or they might unintentionally eat or breathe in the particles. Soil from the site has been sampled and analyzed for contaminants. Although people generally are exposed only to surface soil no more than 3 inches below ground surface, ATSDR used results from samples taken from 0–12 inches below ground surface to estimate surface concentration, since that was the only depth range available. This may overestimate or underestimate the actual concentration of contaminants to which people are exposed at the site. Table 4 lists the contaminants that were detected at least once in surface soil above the corresponding soil CV.

Table 4. Surface Soil Contaminants of Concern at Ward Transformer Site, Raleigh, NC

Contaminant	Maximum concentration in soil, ppm	Comparison Value (CV), ppm	CV Source (defined in Appendix A)
Arsenic	2	20 / 0.5	EMEG / CREG
Copper	6,300	2,900	R9 PRG
Iron	30,000	23,000	R9 PRG
DDT	33	30 / 2	RMEG / CREG
Aldrin	0.061	2 / 0.04	EMEG / CREG
Dieldrin	5.2	3 / 0.04	EMEG / CREG
Heptachlor Epoxide	0.21	0.7 / 0.08	RMEG / CREG
Aroclor 1260	1,700	0.4	CREG
Dioxin/Furan/PCB TEQ	0.06	0.00005	EMEG

Source: [4]
* Maximum of any single PCB congener.

For further screening, worst-case exposure doses for the contaminants listed in Table 4 were then estimated for adult workers, assuming they were exposed to the maximum concentrations listed.

In addition, although trespassing appears unlikely in the vicinity of the site, we estimated exposure doses for 10-year-olds who might regularly trespass on the site and be exposed to the maximum concentrations above. Details of the assumptions used in performing these calculations can be found in Appendix A. The estimated exposure doses for children and adults of arsenic, copper, iron, DDT, aldrin, dieldrin, and heptachlor epoxide were below noncancer health guideline values and resulted in a less than 1 in 10,000 excess cancer risk, and these doses are therefore not expected to result in any adverse health effects.

For further evaluation of Aroclor 1260 and dioxins/furans/PCBs, the average concentrations in surface soil were calculated because the long-term exposure would be to an average concentration rather than the maximum. These contaminants were evaluated in two ways: 1) Aroclor 1260 exposure was used to estimate risk using PCB toxicologic information, and 2) the TEQ for dioxins, furans, and dioxin-like PCB congeners (weighted for toxicity and summed) was used to assess risk using toxicologic information for 2,3,7,8-TCDD. Aroclor 1260 surface soil concentrations ranged from less than 0.036 ppm to 1,700 ppm in 67 samples collected at and in the immediate vicinity of the site. The average Aroclor 1260 was 89 ppm. Eleven of the surface soil samples also were analyzed for dioxins, furans, and specific PCB congeners. TEF-corrected \ concentrations in soils were summed to obtain the TEQ of total dioxin-like compounds. The TEQs in surface soil samples ranged from 0.00005 ppm to 0.06 ppm, and the average was 0.01 ppm as 2,3,7,8-TCDD.

Exposure to Aroclor 1260 in Surface Soil

Because Aroclors are mixtures of both dioxin-like and non-dioxin-like PCB congeners, summing the risk associated with both the Aroclor and with individual congeners included in the TEQ could overestimate risk by accounting for the dioxin-like PCB congener risk both individually and within the risk estimates for Aroclor. However, because the mass of dioxin-like PCB congeners is only about 2% of that of Aroclor, correcting the Aroclor concentration by subtracting out congener concentrations had a negligible effect on both the average concentration of Aroclor and on the calculated risk. Therefore, ATSDR proceeded with the evaluation using the uncorrected Aroclor value.

The average Aroclor 1260 concentration in surface soil is 89 ppm, which results in an average estimated doses of 0.00014 mg/kg/day and 0.00009 mg/kg/day for child trespassers and adult workers, respectively. The chronic-duration minimal risk level (0.00002 mg/kg/day) is derived from an animal study that found a lowest observed adverse effect level of 0.005 mg/kg/day [5]. The child dose is more than 30 times smaller than this level, and the worker dose is more than 50 times smaller. In addition, the actual exposure to Aroclor in surface soil would probably be smaller than estimated because access is restricted so that trespassing is highly unlikely, most of the site is paved, and workers most frequently access areas of the site that are paved. ATSDR considers adverse noncancer health effects from exposure to soil unlikely.

Aroclor 1260 is a probable human carcinogen. The contribution from soil exposure to theoretical excess cancer risk for a 25-year exposure period to an adult is about 6.5 in 100,000. Although this is a low cancer risk, it contributes to risk from multiple pathways, which will be addressed later.

Exposure to Dioxin-Like PCBs in Surface Soil

The average TEQ for dioxin-like PCBs in surface soils, 0.01 ppm, corresponded to estimated child and adult exposure doses of 1.6×10^{-8} and 1.0×10^{-8} mg/kg/day, respectively. The minimal risk level for 2,3,7,8-TCDD is based on a monkey study that showed altered social behavior at a lowest observed effect level of 1.2×10^{-7} mg/kg/day. The estimated doses are an order of magnitude lower than this level. Adverse noncancer health effects are not expected from occasional trespassing or worker exposure to PCB congeners in soil.

The theoretical excess cancer risk associated with exposure to dioxin-like PCBs in soil for a 25-year duration is about 5.5 in 10,000. ATSDR considers this a low-to-moderate increased risk for cancer. The overall cancer risk from multiple exposure pathways will be addressed later.

Sediment Pathway

People who trespass on impacted creek beds downstream from the site might unintentionally ingest some of the sediments from the creek or get the sediments on their skin. Sediment CVs were not available, so sediment CVs were set at 10 times the corresponding soil CV because sediment was assumed to be contacted one tenth as much as soil particles, so the concentration of contaminant could be 10 times as high for the same dose. As shown in Table 5, Aroclor 1260 was detected above the corresponding sediment CV.

Table 5. Sediment Contaminants of Concern at Ward Transformer Site, Raleigh, NC

Contaminant	Maximum concentration in sediment, ppm	Comparison Value (CV) for sediment, ppm*	CV Source (defined in Appendix A)
Aroclor 1260	62	4	Soil CREG × 10

* Sediment CV calculated as 10 times the soil CV because sediment ingestion was assumed to be one tenth of the average soil ingestion.
Source: [4]

ATSDR calculated an exposure dose for trespassers who contact Aroclor 1260 in sediment 4 times a week throughout the year for 25 years. The excess risk for cancer associated with such contact is not significantly elevated. However, the risk from exposure to Aroclor 1260 contributes to the cancer risk from multiple exposure pathways, which will be discussed later.

Surface Water Pathway

No use of surface water downstream of the site for drinking water was identified, but people who wade or swim in this water will get surface water on their skin and could ingest some of it. Incidental ingestion of the surface water was assumed to be no more than one tenth the normal drinking water ingestion. Therefore, surface water CVs were calculated as 10 times the drinking water CV. Table 6 lists the contaminants that were detected at least once above the corresponding surface water CV.

Table 6. Surface Water Contaminants of Concern at Ward Transformer Site, Raleigh, NC

Contaminant	Maximum concentration in surface water, µg/L	Surface Water Comparison Value (CV), µg/L*	CV Source (defined in Appendix A)
Manganese	7300	5000	Drinking Water RMEG × 10
Aldrin	0.044	3 / 0.02	Drinking Water EMEG / CREG × 10
Heptachlor Epoxide	0.055	1 / 0.04	Drinking Water RMEG / CREG × 10
Aroclor 1260	1.5	0.2	Drinking Water CREG × 10

* Surface water CV calculated as ten times the drinking water CV.
Source: [4]

For further screening, worst-case exposure doses for the contaminants listed in Table 6 were then estimated for trespassers who contact the maximum concentrations in surface water 4 times a week throughout the year over many years. Details of the assumptions used to perform these calculations can be found in Appendix A. The estimated child and adult exposure doses for manganese, aldrin, and heptachlor epoxide were below cancer and noncancer health guideline values and therefore not expected to result in any adverse health effects. In addition, the excess cancer risk associated with exposure to Aroclor 1260 in surface water is not significantly elevated. However, exposure to this contaminant contributes to the cumulative risk for cancer from multiple exposure pathways, which will be discussed later.

Cumulative Exposures

People could be exposed to site contaminants through more than one of the pathways discussed in this document. In this section, we consider whether multiple exposure pathways might result in an increased health risk over the pathway-specific analysis. Table 7 shows the relative contribution to overall theoretical cancer risk of all the pathways for Aroclor and PCB congeners. As indicated, most of the risk is contributed by the fish consumption and soil pathways. The sediment and surface water pathways have a negligible contribution to the overall risk. If a person were exposed to PCBs through all four pathways, the theoretical increased risk for cancer is about 2 in 1,000. ATSDR considers this a moderate-to-high increased risk for cancer. It should be noted that worst-case assumptions were used to obtain the theoretical cancer risk. The actual risk of developing cancer, which is likely to be much smaller than the upper bound estimate reported here, depends on many factors, including actual exposures, genetics, lifestyle, and other environmental factors.

Table 7. Contribution of Pathways and Contaminants to Overall Theoretical Cancer Risk, Ward Transformer Site, Raleigh, NC

Pathway	Aroclor 1260	Dioxin/Furan/PCB TEQ	Cumulative Risk of Pathway
Fish	6.6×10^{-4}	4.5×10^{-4}	1.0×10^{-3}
Soil	6.5×10^{-5}	5.5×10^{-4}	6.2×10^{-4}
Sediment	2.8×10^{-7}	4.7×10^{-10}	2.8×10^{-7}
Surface Water	7.0×10^{-7}	-	7.0×10^{-7}
Cumulative Risk	7.3×10^{-4}	1.0×10^{-3}	1.7×10^{-3}

of Contaminant			

Potential Exposure Pathways

Groundwater Pathway

No use of local groundwater for drinking water was identified in the vicinity of the site. Three wells near the site were previously used for drinking water. The well at Ward Transformer reportedly had been tested yearly before the company was connected to the municipal water supply in 1994; no contaminants were found above drinking water standards. Two other nearby wells were sampled in August 1994: a residential well had no detections of contaminants, and a well at a former auto shop had detectable petroleum constituents, at levels below drinking water standards. Therefore, because no evidence exists of actual exposure to harmful levels of contaminants in these wells, the groundwater pathway is considered incomplete.

ATSDR evaluated monitoring well data collected from the shallow groundwater during the RI. Data were available from 2 of the 5 monitoring wells installed on and around the Ward Transformer site. Some contaminants (including PCBs, chlorinated benzenes, pesticides, and some metals) were detected at levels above drinking water CVs (data not shown). ATSDR recommends that the groundwater beneath the site not be used for drinking unless the water is fully characterized to determine its public health impact.

Air Pathway

No measurements of air emissions from the facility are available. Although the burnoff oven on site has never been permitted to burn used transformer oil containing PCBs as fuel, it is known that some burning of PCB oil did occur during at least one year, and possibly more, in the past. This could have released dioxins from the incomplete burning of PCBs.

In the 1997 ESI, sampling of ash from the burnoff oven and in the soil directly underneath the oven showed high levels of metals, dioxins/furans, and Aroclor 1260. Ash from the burnoff oven is currently drummed and shipped offsite for disposal, so this pathway is incomplete. Because the pathway is currently incomplete and because no information exists to allow an evaluation of potential past exposures, this pathway will not be considered further.

Children's Health Considerations

ATSDR recognizes that infants and children might be more vulnerable than adults to exposures in communities with contaminated air, water, soil, or food. This potential vulnerability results from the following factors: 1) children are more likely to play outdoors and bring food into contaminated areas; 2) children are shorter and therefore more likely to contact dust and soil; 3) children's small size results in higher doses of chemical exposure per kg of body weight; and 4) developing body systems can sustain permanent damage if toxic exposures occur during critical growth stages. Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at the site.

Because of the limited access to the site and the surrounding areas, ATSDR considers small children unlikely to be directly exposed to site contaminants. Small children might be affected by previous exposure in the womb from their mothers' consumption of fish. Small children also might eat contaminated fish. Older children who trespass on nearby property might be exposed to contaminants in the surface water and sediments of streams downstream of the site. Refer to the appropriate section for discussion of the possible health effects for these exposure pathways.

Health Outcome Data

Health outcome data (HOD) can give a more thorough evaluation of the public health implications of a given exposure. HOD can include mortality information (e.g., the number of people dying from a certain disease) or morbidity information (e.g., the number of people in an area getting a certain disease or illness). The review is most effective when (1) a completed human exposure pathway exists, (2) contaminant levels are high enough to result in measurable health effects, (3) enough people are affected for the health effect to be measured, and (4) a database is available to identify disease rates for populations of concern.

A review of health outcome data was not performed for this site. Although completed exposure pathways exist at this site, the potentially exposed population is too small to allow statistical differences in the rates of occurrence of relatively uncommon diseases to be measured.

Community Health Concerns

ATSDR staff attended a public meeting at the Morrisville Commerce Building in Morrisville, North Carolina, on March 13, 2003. EPA organized the meeting to discuss the Ward Transformer site. Approximately 10 community members and 15 local, state, and federal officials attended the meeting. ATSDR discussed the PHA process and asked community members to share their health concerns related to contaminants at the site. Following are concerns expressed by members of the audience at the meeting; ATSDR responses were developed after the meeting as part of producing this public health assessment:

Concern: Are workers of the businesses around Ward Transformer exposed to hazardous levels of contaminants from the site?

Response: *Currently available data suggests that soil at surrounding businesses has not been impacted by the site. Assuming that workers at other businesses do not frequently contact the soil at the Ward Transformer site, no adverse health effects would be expected. EPA is still in the process of completing the remedial investigation for the site and determining the extent of contamination. They will present the findings at a public meeting.*

Concern: Is fish from Lake Crabtree safe to eat?

Response: *In May 2004, the State of North Carolina issued an advisory against eating carp and catfish from Lake Crabtree. They also advised people to limit consumption of all other fish from Lake Crabtree to no more than one meal per month. In addition to the advisory about Lake Crabtree, North Carolina has also issued advisories against eating any fish from Brier Creek*

downstream of Brier Creek Reservoir, Brier Creek Reservoir, Little Brier Creek downstream of Brier Creek Parkway, and one unnamed tributary to Little Brier Creek.

Concern: Flooding could have spread contamination beyond the areas already measured.

Response: *Although flooding might have dispersed contaminants from the site, such dispersal would have diluted the contaminants, so that very high levels would be unlikely to be contacted. Also, the contaminants would be difficult to measure accurately. ATSDR considers EPA's remedial investigation adequate to fully characterize the nature and extent of potentially hazardous contamination from the Ward Transformer site.*

Health Hazard Category

The levels of PCBs in edible portions of fish from areas downstream of the site are high enough to increase the risk for cancer and adverse noncancer health effects for recreational levels of consumption. In addition, exposure of workers to PCBs in soil could contribute to the potential risk of developing cancer. Therefore, ATSDR classifies the Ward Transformer site as a *public health hazard* because potential exposures to PCBs could result in adverse health effects if exposure is not reduced or prevented.

Although the theoretical risk calculations suggest increased risk for adverse health effects for workers and people eating fish from Brier Creek reservoir, it is important to note that these calculations were based on worst-case exposure scenarios. The actual exposures are likely to be much lower, so that the risk of adverse health effects occurring is low.

Conclusions

1. Edible portions of fish from areas downstream of the site have PCBs at levels high enough to increase the theoretical risk of cancer and adverse noncancer health effects for people who eat these fish regularly. The State of North Carolina has placed an advisory against eating carp or catfish from Lake Crabtree or any species of fish from Brier Creek, Brier Creek Reservoir, Little Brier Creek downstream of Brier Creek Parkway, and the tributary leading from the Ward Transformer site. The State of North Carolina also advises that consumption of fish species other than carp or catfish from Lake Crabtree be limited to no more than 1 meal per month.
2. Exposure of site workers to PCBs in soil could contribute to an increased theoretical risk of developing cancer.
3. Exposure to PCBs in sediment and surface water is not a significant contributor to overall theoretical cancer risk. However, sediments may contribute to PCB contamination in the aquatic food chain. As stated above, consumption of contaminated fish could increase the risk of cancer and adverse noncancer health effects.
4. The groundwater beneath the site is not being used for drinking water and therefore is not of public health concern at this time. However, limited data suggest that the groundwater might be impacted by site contaminants. Not enough information exists to determine whether health effects could be possible if the groundwater was used for drinking.

Recommendations

1. ATSDR recommends that the public follow fish advisories placed by the State of North Carolina.
2. ATSDR recommends action be taken to minimize exposure of employees at Ward Transformer to PCBs in soil.
3. ATSDR recommends that action be taken to reduce the contribution of contaminants in sediment to the food chain.
4. If groundwater beneath the site is used for drinking water in the future, it should be fully characterized to determine its impact on public health.

Public Health Action Plan

The public health action plan for the Ward Transformer site describes actions that have been or will be taken at the site by ATSDR and/or other government agencies. The purpose of the plan is to ensure that this PHA not only identifies public health hazards at the site, but also outlines a plan of action to prevent or minimize the potential for adverse human health effects from exposure to site-related hazardous substances. ATSDR will follow up on this plan to ensure that it is implemented.

Completed Actions

- ATSDR conducted a site visit to verify site conditions and to gather pertinent information and data for the site.
- ATSDR attended a public meeting to inform the community about the public health assessment process and to gather health concerns from the site community.
- The State of North Carolina issued an advisory against eating fish from Brier Creek Reservoir, Little Brier Creek downstream from Brier Creek Parkway, and the unnamed tributary of Little Brier Creek leading from Ward Transformer.
- The State of North Carolina issued an advisory against eating fish from Brier Creek downstream of Brier Creek Reservoir, catfish or carp from Lake Crabtree, and more than one meal per month of other fish species from Lake Crabtree.

Planned Actions

- ATSDR will review additional environmental sampling results for the site to evaluate any changes in possible public health implications.

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Appendix A. Explanation of Evaluation Process

Screening Process

In evaluating these data, ATSDR used comparison values (CVs) to determine which chemicals to examine more closely. CVs are the health-based thresholds for contaminant concentrations found in a specific media (air, soil, or water). They are used in the selection of contaminants for further evaluation. A CV incorporates assumptions about daily exposure to a chemical and the standard amount of air, water, and soil that someone might inhale or ingest each day.

A CV represents a concentration below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and noncancer health effects. Noncancer levels are based on valid toxicologic studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds or less) and adults are exposed every day. Cancer levels are based on a one-in-one-million excess cancer risk for an adult eating contaminated soil or drinking contaminated water every day for 70 years. For chemicals for which both cancer and noncancer levels exist, ATSDR uses the lower of the levels to be protective of human health. However, exceeding a CV does not mean that health effects will occur; it merely means that more evaluation is needed.

The CVs used in the evaluation in this document are listed below:

Environmental Media Evaluation Guides (EMEGs) are estimated contaminant concentrations in a media at which noncarcinogenic health effects are unlikely. EMEGs are derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL).

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

Reference Media Evaluation Guides (RMEGs) are estimated contaminant concentrations in a media at levels at which noncarcinogenic health effects are unlikely. RMEGs are derived from EPA's reference dose (RfD).

Region 9 Preliminary Remediation Goals (R9 PRGs) are the estimated contaminant concentrations in a media at which carcinogenic or noncarcinogenic health effects are unlikely. The PRGs used in this PHA were derived by use of provisional reference doses or CSFs calculated by EPA's Region 9 toxicologists and were last updated in October 2002.

Region 3 Risk-based Concentrations (R3 RBCs) are the estimated contaminant concentrations in a media at which carcinogenic or noncarcinogenic health effects are unlikely. The RBCs used in this PHA were derived by use of provisional reference doses or CSFs calculated by EPA's Region 3 toxicologists and were last updated in October 2003.

EPA Action Levels (ALs) are the estimated contaminant concentrations in water at which additional evaluation is needed to determine whether action is required to eliminate or reduce exposure. Action levels can be based on mathematical models.

EPA Soil Screening Levels (SSLs) are estimated contaminant concentrations in soil at which additional evaluation is needed to determine if action is required to eliminate or reduce exposure.

World Health Organization guidelines (WHO) are guidelines published by the World Health Organization for drinking water quality.

Some CVs may be based on different durations of exposure. Acute duration is defined as exposure lasting 14 days or less. Intermediate duration exposure lasts between 15 and 364 days, and chronic exposures last one year or more. Comparison values based on chronic exposure studies are used whenever available. If an intermediate or acute comparison value is used, it is denoted with a small *i* or *a* before the CV (e.g., iEMEG refers to the intermediate duration EMEG).

Determination of Exposure Pathways

ATSDR identifies human exposure pathways by examining environmental and human components that might lead to contact with COCs. A pathway analysis considers five principal elements: a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and an exposed 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 now occurring, or will occur in the future. 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 now, or could occur in the future. It should be noted that the identification of an exposure pathway does not imply that health effects will occur. Exposures might be, or might not be, substantive. Therefore, even if exposure has occurred, is now occurring, or is likely to occur in the future, human health effects might not result.

ATSDR reviewed site history, information on site activities, and the available sampling data. On the basis of this review, ATSDR identified numerous exposure pathways that warranted consideration.

Evaluation of Public Health Implications

The next step is to take those contaminants present at levels above the CVs and further identify which chemicals and exposure situations are likely to be a health hazard. Child and adult exposure doses are calculated for the site-specific exposure scenario, using our assumptions of who goes on the site and how often they contact the site contaminants. The exposure dose is the amount of a contaminant that gets into a person's body. Following is a brief explanation of how we calculated the estimated exposure doses for the site.

Fish Ingestion

Exposure doses for ingestion of fish downstream of the site were calculated using the average concentration measured in fish tissue samples, in mg/kg or ppm, multiplied by the 95th percentile ingestion rate for recreational fishers of 25 grams per day (g/day). An ingestion rate of 12.5 g/day was assumed for children. The calculated value was also multiplied by a conversion factor of 0.001 kilograms per gram. The multiplication product was divided by the average weight for an adult (70 kg or 154 pounds) or a one-year-old child (10 kg or 22 pounds) to obtain the exposure dose in mg/kg/day.

Soil Ingestion

Exposure doses for ingestion of contaminants present in soil were calculated by use of the maximum concentration measured in soil, in milligrams per kilogram (mg/kg), or parts per million (ppm). This maximum concentration is then multiplied by the soil ingestion rate for adults (100 mg/day) or children (200 mg/day). For worker exposures, the multiplication product was divided by the average weight for an adult, 70 kg (154 pounds). The resulting dose was then multiplied by a factor of 5/7, because the exposure was assumed to occur five days a week throughout the year. For exposure of child trespassers, the body weight used was 36 kg (80 pounds) and the exposure factor was 2/7 (2 days a week throughout the year).

Surface Water Ingestion

Exposure doses for surface water ingestion were calculated by use of the maximum concentration for a surface water contaminant, in milligrams per liter (mg/L). This maximum concentration was then multiplied by an incidental surface water ingestion rate of 0.2 L/day for adults or 0.1 L/day for children. These ingestion rates are 1/10th of the EPA default drinking water rates. The multiplication product was divided by the average weight for an adult (70 kg) or for a 10-year-old child (36 kg). The resulting dose was then multiplied by a factor of 4/7, because the exposure was assumed to occur four times a week throughout the year.

Sediment Ingestion

Exposure doses for ingestion of contaminants from the sediment were calculated by use of the maximum concentration measured in the sediment, in mg/kg or ppm, multiplied by 1/10th of the default soil ingestion rate—10 mg/day for adults or 20 mg/day for children. The multiplication product was divided by the average weight for an adult (70 kg) or a 10-year-old child (36 kg). The resulting dose was then multiplied by a factor of 4/7, because the exposure was assumed to occur four times a week throughout the year. The calculated value was also multiplied by a conversion factor of 0.001 kilograms per gram.

Noncancer Health Effects

The calculated exposure doses are then compared to an appropriate health guideline for that chemical. Health guideline values are considered safe doses; that is, health effects are unlikely below this level. The health guideline value is based on valid toxicological studies for a chemical, with appropriate safety factors built-in to account for human variation, animal-to-

human differences, and/or the use of the lowest adverse effect level. For noncancer health effects, the following health guideline values are used.

Minimal Risk Level (MRLs) - Developed by ATSDR

An MRL is 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. A list of MRLs can be found at http://www.atsdr.cdc.gov/mrls.html.

Reference Dose (RfD) - Developed by EPA

An RfD is an estimate, with safety factors built in, of the daily, life-time exposure of human populations to a possible hazard that is not likely to cause noncancerous health effects. RfDs can be found at http://www.epa.gov/iris.

If the estimated exposure dose for a chemical is less than the health guideline value, then the exposure is unlikely to cause a noncarcinogenic health effect in that specific situation. If the exposure dose for a chemical is greater than the health guideline, then the exposure dose is compared to known toxicologic values for that chemical and is discussed in more detail. These toxicologic values are doses derived from human and animal studies that are summarized in the ATSDR *Toxicological Profiles*. A direct comparison of site-specific exposure and doses to study-derived exposures and doses that cause adverse health effects is the basis for deciding whether health effects are likely or not.

Calculation of Risk of Carcinogenic Effects

The theoretical risk of developing cancer resulting from exposure to the contaminants was calculated by multiplying the site-specific adult exposure dose by EPA's corresponding oral slope factor (found at http://www.epa.gov/iris). The results estimate the maximum increase in risk of developing cancer after 70 years of exposure to the contaminant. The risk was then multiplied by the fraction (25/70) because the exposure was assumed to last 25 years.

The actual risk of cancer is probably lower than the calculated number, which gives a worst-case excess cancer risk. The method used to calculate EPA's oral slope factor assumes that high-dose animal data can be used to estimate the risk for low dose exposures in humans. The method also assumes that no safe level exists for exposure. Little experimental evidence exists to confirm or refute those two assumptions. Lastly, the method computes the 95% upper bound for the risk, rather than the average risk, suggesting that the cancer risk is actually lower, perhaps by several orders of magnitude.[2]

[2] U.S. Environmental Protection Agency (EPA), Office of Emergency and Remedial Response. Risk assessment guidance for Superfund, volume 1, human health evaluation manual. Washington (DC): U.S. Environmental Protection Agency; 1989.
[3] Agency for Toxic Substances and Disease Registry (ATSDR). Cancer policy framework. Atlanta (GA): U.S. Department of Health and Human Services; 1993.

Because of uncertainties involved in estimating carcinogenic risk, ATSDR employs a weight-of-evidence approach in evaluating all relevant data.[3] Therefore, the carcinogenic risk is described in words (qualitatively) rather than giving a numerical risk estimate only. The numerical risk estimate must be considered in the context of the variables and assumptions involved in their derivation and in the broader context of biomedical opinion, host factors, and actual exposure conditions. The actual parameters of environmental exposures must be given careful consideration in evaluating the assumptions and variables relating to both toxicity and exposure.

Appendix B. Exposure Pathways for Ward Transformer Site

Source for all pathways: Operations at Ward Transformer Site

Pathway Name	Environmental Media & Transport Mechanisms	Point of Exposure	Route of Exposure	Exposure Population	Time	Notes	Complete?
Soil	Spills from past operations	Site soils and soil at surrounding properties	Incidental ingestion, inhalation, dermal exposure	Nearby workers, trespassers (unlikely)	Past, present, future	Population might include children 10 years and older.	Y
Surface water	Runoff into lagoon; past release of contaminated water to streams; dissolution from contaminated sediments	Water in unnamed tributary, Little Brier Creek, possibly Crabtree Lake	Incidental ingestion, inhalation, dermal exposure	Trespassers at streams downstream from site	Past, present, future	Population might include children 10 years and older.	Y
Sediments	Deposition from surface water runoff into lagoon; past release of contaminated water to streams	Lagoon, along streams downstream of site	Incidental ingestion, dermal exposure	Trespassers at streams downstream from site	Past, present, future	Population might include children 10 years and older.	Y
Fish	Bioaccumulation of contaminants from surface water and sediments into fish	Meal prepared using fish from site area	Ingestion	Recreational fishers and their families	Past, present, future	Population might include young children	Y
Groundwater	Infiltration to groundwater	Groundwater wells supplying drinking water taps	Ingestion, inhalation, dermal exposure	Residents and workers near the site	Past, present, future	Population might include young children	N
Air	Past release of contaminants from burnoff oven	Area around site	Inhalation, dermal exposure	Residents and workers near the site	Past	Population might include young children	N

Appendix C. ATSDR Glossary of Environmental Health Terms

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

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

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.
Bioavailability	See **Relative Bioavailability**.
Biota	Used in public health, things that humans would eat – including

	animals, fish and plants.
Cancer	A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control
Cancer Slope Factor (CSF)	The slope of the dose-response curve for cancer. Multiplying the CSF by the dose gives a prediction of excess cancer risk for a contaminant.
Carcinogen	Any substance shown to cause tumors or cancer in experimental studies.
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 (CV)	Concentrations 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. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.
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 results.
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 the **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 **O**bserved **A**dverse **E**ffect **L**evel. 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 **R**isk **L**evel. 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 **N**ational **P**riorities **L**ist. (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 **O**bserved **A**dverse **E**ffect **L**evel. 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 **H**ealth **A**ssessment. 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). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, 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 not likely to cause harm to the person.

Relative Bioavailability The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.

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
– 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 (see **CERCLA**) and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting 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.