Health Consultation

BADIN LAKE FISH TISSUE

STANLY and MONTGOMERY COUNTIES, NORTH CAROLINA

Prepared by the
North Carolina Health and Human Services

SEPTEMBER 18, 2009

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Prepared By:

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Acronyms

AT	Averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
CF	Conversion factor
cm	Centimeter
CREG	ATSDR Cancer Risk Evaluation Guide
CR	Contact rate
CV	Comparison Value
DAF	Dermal absorption efficiency
DPH	Division of Public Health
DWQ	Division of Water Quality
ED	Exposure duration
EF	Exposure frequency
EMEG	ATSDR Environmental Media Evaluation Guide
Kg	Kilogram
L	Liter
LOAEL	Lowest Observed Adverse Effect Level
MCLG	EPA Maximum Contaminant Level Goal
MCL	EPA Maximum Contaminant Level
M	Meter
mg	milligram
mg/kg	milligram per kilogram
ng/kg	nano-gram per kilogram
µg/kg	micro-gram per kilogram
µg/L	micro-gram per liter
µg	microgram
ng	nano-gram
NA	Not applicable
N.C. DENR	North Carolina Dept of Environment & Natural Resources
N.C. DHHS	North Carolina Dept of Health Human Services
NCDWQ	North Carolina Division of Water Quality, DENR
NOAEL	No Observed Adverse Effect Level
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PMCLG	EPA Proposed Maximum Contaminant Level Goal
ppm	Parts per million
ppb	Parts per billion
RfC	Reference Concentration
RfD	Reference Dose
SVOC	Semi-volatile organic compound
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WRC	North Carolina Wildlife Resources Commission

*** These acronyms may or may not be used in this report**

SUMMARY

Introduction

N.C. DPH's top priority is to ensure that the community has the best information possible to safeguard persons eating fish taken from Badin Lake.

Badin Lake in Stanly and Montgomery Counties, NC (Appendix A, Figures 1 and 2) is a popular recreational area for fishing, boating, and swimming. The Stanly County Health Director, in June 2008, requested that the N.C. Department of Health and Human Services Division of Public Health (DHHS/DPH) determine if persons may be subject to adverse health effects associated with eating fish taken from Badin Lake. Their concern was related to previously identified contamination in Badin Lake waters and sediments.

N.C. DPH recommended the collection of additional Badin Lake fish tissue data to determine if eating fish from Badin Lake presented a potential health hazard. Fish collections were representative of species eaten by Badin Lake fishers. Sampling and analytical services followed EPA guidelines for fish consumption advisory studies.

The N.C. Department of Environment and Natural Resources Division of Water Quality (N.C. DENR/DWQ) collected fish from Badin Lake in August and September 2008. Fish fillet samples were submitted for analysis to best represent the portion of fish commonly consumed by the local fishers. Fish tissue was analyzed for polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs), two classes of contaminants previously identified in Badin Lake.

Overview

N.C. DPH has reached three important conclusions about the fish in Badin Lake, NC.

Conclusion 1

N.C. DPH concludes that pregnant women, women who may become pregnant, and children under 15 that throughout their lifetime eat catfish and largemouth bass that contain PCBs from Badin Lake could harm their health. Other people's health could be harmed by eating more than one meal per week of catfish and largemouth bass that contain PCBs from Badin Lake. If community members follow these recommendations, their exposure to PCBs in fish from Badin Lake would not be at levels that would harm their health. With these diet modifications fish can remain an important part of a healthy diet and a good source of protein and other nutrients.

Basis for the Decision

PCBs were found in all the fish fillet samples. Total PCB concentrations in four samples (3 catfish and 1 largemouth bass) exceeded N.C. DHHS level of concern for total PCBs.

Next Steps

N.C. DPH is taking the following actions:

The State Health Director and DPH has issued a fish consumption advisory for catfish and largemouth bass in Badin Lake to inform people that eating quantities of contaminated fish that may result in adverse health effects. A pre-existing mercury fish consumption advisory was in place for areas of NC that include Badin Lake for catfish (east and south of Highway I-85) and largemouth bass (state-wide).

The resulting fish consumption recommendations for Badin Lake, covering both the PCBs and mercury, issued on February 10, 2009 for Badin Lake states:

"Do not eat more than one (1) meal a week of catfish or largemouth bass from Badin Lake. If you are pregnant, may become pregnant, are nursing, or are a child under 15 years of age, do not eat any of these fish. *Elevated levels of polychlorinated biphenyls (PCBs) have been found in some catfish and largemouth bass. Swimming, boating, and handling fish do not present a known health risk.*

Health Effects of PCBs

Eating more than one meal a week of these fish may increase a person's risk of developing health problems such as cancer, infection, or skin problems. The babies of pregnant or nursing women who eat these fish may experience developmental or other health problems."

- The recommended fish consumption advisory for Badin Lake was issued as a press release to local newspapers in Stanly and Montgomery Counties, NC, on February 10, 2009.
- The consumption advisory for Badin Lake was posted on N.C. DPH's fish advisory web site on February 10, 2009 (http://www.epi.state.nc.us/epi/fish/current.html).
- The recommended fish consumption advisory for Badin Lake was presented to the community in a public meeting on February 11, 2009. A question and answer period was held for the public after the meeting. Copies of the presentation slides, a study factsheet and a Frequently Asked Questions (FAQs) fact sheet, and PCB and mercury fact sheets were made available.
- The Badin Lake Fish Tissue Health Consultation, the study fact sheet, and the FAQs fact sheet are available on the HACE web page (http://www.epi.state.nc.us/epi/oee/hace/reports.html). The Health Consultation will also be available on ATSDR's web page (http://www.atsdr.cdc.gov/).
- N.C. DPH is working with the counties and property owners on the placement of fish advisory signs at recreational access points on Badin Lake.

	▪ N.C. DHHS' CARE-LINE staff is available to take telephone calls about the Badin Lake fish study. The CARE-LINE is a 24-hour/7-day a week toll-free information and referral telephone service. Staff includes Spanish-speaking specialists. Staff have been trained on how to respond to specific questions and when to refer questions to N.C. DPH toxicologists or physicians.
Conclusion 2	**N.C. DPH concludes that eating fish from Badin Lake is not expected to harm people's health due to PAHs because PAHs were not detected in the fish.**
Basis for the Decision	No PAH concentrations exceeding the analytical minimum reporting level were observed in any of the fish fillet samples.
Next Steps	No public health actions are needed regarding PAHs in fish in Badin Lake.
Conclusion 3	**DPH concludes that eating the other types of fish tested in this study (sunfish and crappie species) are not expected to harm people's health.**
Basis for the Decision	PCB levels measured in these types of fish were less than levels expected to cause adverse health effects.
Next Steps	No public health actions are needed regarding PCBs in sunfish and crappie species of fish in Badin Lake.
For More Information	If you have concerns about your health, you should contact your health care provider. You may call the N.C. DHHS CARE-LINE staff for additional information regarding the Badin Lake Fish Tissue Health Consultation and the fish consumption advisories. You may reach the CARE-LINE 24 hours a day, 7 days a week including state holidays by calling 1-800-662-7030 (English/Spanish) or 1-877-452-2514 (TTY). For local calls, you may dial 855-4400 (English/Spanish) or 919-733-4851 (TTY).

PURPOSE AND HEALTH ISSUES

The North Carolina Department of Health and Human Services Division of Public Health (N.C. DHHS/DPH) Occupational and Environmental Epidemiology Branch (OEEB), which is a cooperative agreement partner with the Agency for Toxic Substances and Disease Registry (ATSDR), was asked by Stanly County officials to conduct a public health consultation (PHC) on eating fish from Badin Lake. Stanly County officials were concerned with the potential health implications of eating fish caught in Badin Lake because of results of various environmental studies done on waters, sediments and fish collected from the lake. The available environmental data indicated that PCBs and PAHs are in Badin Lake sediments and PCBs have been detected in fish. Both PCBs and PAHs can move from water and sediments into fish. Fish can accumulate much higher concentrations of PCBs than are observed in the water or sediment to which they are exposed. People can be exposed to PCBs and PAHs by eating contaminated fish. Both PCBs and PAHs can cause adverse health effects if people eat food contaminated with high enough concentrations. The available environmental data were not adequate to allow N.C. DPH to make reliable estimates of potential health effects from eating Badin Lake fish. To provide the needed information, a comprehensive fish sampling and PCB and PAH analysis plan was recommended for Badin Lake. Fish were collected throughout the lake by biologists from the N.C. Department of the Environment and Natural Resources (N.C. DENR). N.C. DPH evaluated the additional sampling data in this health consultation and compared it to existing N.C. DPH fish consumption advisory action levels for PCBs. For PAHs, N.C. DPH developed draft advisory levels in fish to evaluate Badin Lake fish data.

BACKGROUND

Site Description and History

Badin Lake in Stanly and Montgomery Counties, NC (see Appendix A, Figure 1 and 2) is a popular recreational area for fishing, boating, and swimming. Badin Lake is an approximately 5,300-acre impoundment in the Yadkin-Pee Dee River Basin. Badin Lake is formed below the Tuckertown Dam on the Yadkin River and above the Falls Dam on the Pee Dee River in central NC.

Badin Lake sediment samples were collected for various EPA Resource Conservation and Recovery Act (RCRA) facility investigations overseen by N.C. Department of Environment and Natural Resources Division of Waste Management (DENR/DWM). Chemical analysis of sediments collected from Badin Lake in 1996 and 1997 indicated elevated levels of polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs) (NCDENR 2001). PCBs and PAHs are groups of complex persistent organic chemicals known to cause potential adverse ecological and human health effects from ingestion, inhalation, or direct contact (see the Glossary for additional information on PCBs and PAHs). In the aquatic environment, both PCBs and PAHs in the sediments and water can be taken up by living organisms (a process termed “bioaccumulation”), and be passed from one living organism to another in the food chain. Humans may be exposed to PCBs and PAHs in aquatic environments by contact with contaminated water or sediment, or eating contaminated fish or other organisms living in the lake.

Additional sediment samples collected in December 2007 indicated PCBs and PAHs were still in lake sediments (ESI 2008). Both sampling events were focused in the southwest region of the lake. Limited fish collections in 2004 performed by N.C. DENR biologists from a single location in Badin Lake (southwest region) indicated PCBs had accumulated in tissues of lower trophic level fish (bottom feeding flathead catfish) (DWQ 2004). No quantifiable levels of PCB congeners were identified in a 4-fish composite of upper trophic level fish (largemouth bass) collected during the same sampling event. The PCB analysis used in this study included a subset of the 209 PCB congeners (individual related chemicals collectively referred to as PCBs).

In June 2008, Stanly County officials requested the N.C. DPH to evaluate the potential for human health effects associated with eating fish from Badin Lake because of the environmental contaminants that had been found in previous environmental sampling. The DPH reviewed the existing water, sediment and fish tissue analytical data and determined they were not adequate to make a reliable estimate of potential health effects from eating Badin Lake fish.

Two classes of persistent organic chemicals, polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), were identified in sediments. Both are known to cause adverse ecological and human health effects through exposures including direct contact, inhalation and through contaminated foods. Both are known to move into the food chain, including fish, in aquatic environments. PCBs can accumulate in organisms high in the food chain to concentrations higher than the concentrations observed in water or sediment. A limited fish tissue study performed in 2004 found PCBs in Badin Lake fish.

PCB and PAH bioaccumulation in fish is difficult to model due to the complexity and number of factors related to movement of these types of compounds in aquatic environments. It is influenced by site-specific physical, chemical, biological and ecological characteristics. Variations in sediment particle size, organic carbon content, contaminant chemistry, and the water body-specific structure of the aquatic food-web all influence PCB and PAH uptake patterns in different trophic levels of fish within a particular water body. Fish at each trophic level are a potential source of exposure through ingestion and likely exhibit differing bioaccumulated concentrations and patterns of contaminants. These characteristics may also vary in different areas of a large lake, resulting in variable fish contaminant concentrations within a large water body. As a result, to better answer Stanly County's concerns, the DPH recommended collecting additional fish from Badin Lake and analyzing the fish for PAHs and PCBs.

Demographics

Recreational and subsistence fishing is common at multiple locations around Badin Lake. Collected fish species focused on those commonly consumed from Badin Lake. Persons potentially eating these fish include women of childbearing age, children, and all other members of the general public that participate in recreational and subsistence freshwater fishing. An estimated 9,550 persons in Stanly and Montgomery Counties participate in recreational fishing (USFWS 2006). This number is based on U.S. Fish and Wildlife Service information that suggests 11% of North Carolina's population participates in recreational fishing and the total combined populations of Stanly and Montgomery Counties (U.S. Census Bureau data for 2007;

Stanly County population = 59,195; Montgomery County population = 27,451). See Appendix C for additional demographics information.

COMMUNITY HEALTH CONCERNS

Concerns were expressed by community members to Stanly County officials regarding potential environmental health risks related to local industry historical activities in the Badin Lake area. Stanly County officials also expressed concerns about the water quality of Badin Lake and the potential exposure of recreational and subsistence fishers to contaminants that may have accumulated in the fish of Badin Lake. This concern resulted from data gathered in multiple environmental studies of waters and sediments collected in Badin Lake that indicated the presence of environmental contaminants. Stanly County petitioned the N.C. DPH for assistance in determining whether contaminants that may be accumulating in the fish in Badin Lake could present a health hazard to people catching and eating the fish.

DISCUSSION

Fish Advisories in North Carolina

Some environmental contaminants that are present in surface waters and sediments may ultimately be taken up by organisms from the water, sediments, or from contaminated food sources (this uptake process is termed “bioaccumulation”). Some chemicals can be passed from one organism to another as smaller organisms are eaten by larger organisms. Some of these environmental contaminants may increase in concentration as they are passed from one organism to another (a process termed “biomagnification”). The manner in which a chemical moves between the water, sediments, and aquatic organisms is unique to that chemical, and is related to its structure and chemical properties. Chemicals that accumulate in fish may ultimately be ingested by animals or people that eat the fish. Some of these chemicals may be harmful. If a person eats enough contaminated fish, and the contaminant concentrations in the fish are high enough, adverse health effects may result. (See the Glossary for further explanation of bioaccumulation and biomagnification.)

In the past, the N.C. DHHS has issued fish consumption advisories for environmental contaminants in fish including mercury, dioxins, and PCBs. Chemical contaminant concentrations in fish in NC water bodies are determined by collecting and analyzing fish for specific chemicals that may harm people eating the fish. Other State agencies, including the N.C. DENR/DWQ and the N.C. Wildlife Resource Commission (WRC), typically provide services or input to the N.C. DPH fish consumption advisory studies. These services include identification of fish collection locations, types of fish people typically catch and eat in a particular area, and fish collection and analytical sample preparation efforts. The N.C. DENR Water Quality Laboratory or contract laboratories may be used for tissue analyses. EPA guidance procedures are referenced for all aspects of the activities for fish consumption advisories, including fish collection, sample preparation, and analysis (EPA 2000a and 2000b).

The chemical concentrations in fish tissue are compared to contaminant-specific levels of concern (“action levels”) in fish tissue developed by the DPH. The level of concern is a contaminant concentration in fish that may result in adverse health effects if eaten at a frequency greater than the frequency of advised number of meals over a person's lifetime (70 years). Tissue concentrations may be evaluated as the mean value for a sample or a species, or as a concentration to fish size relationship for a species. The action levels are developed using calculation methods and exposure variables outlined in the EPA fish consumption advisory guidance documents (EPA 2000a and 2000b). Exposure variables used in calculations may also be taken from EPA's exposure factors handbook (EPA 1997a). Exposure variables include information such as meal size, average weight of persons eating fish, and contaminant loss factors with trimming and cooking the fish. Contaminant concentrations that cause adverse health effects are generally taken from EPA or ATSDR documents. The N.C. DPH monitors health effect data for specific contaminants and re-evaluates consumption advisory action levels as new health effect data becomes available. The exposure variables used for development of the DPH's PCB actions levels are listed in Appendix B, Table 1. The exposure variables selected by DPH are highly health protective to provide assurance that potential adverse health effects are not underestimated. The PCB action levels were developed in May 2007 using EPA health effects data for PCBs issued in 2003. Action levels are developed as a recommended number of fish meals per week or per month. A fish meal represents 6 oz. of uncooked fish. The number of meals is related to the concentration of the chemical of concern in the fish tissue. The higher the concentration of chemical, the fewer number of meals that are recommended over the prescribed time period. Action levels for a particular contaminant are developed for a range of concentrations in the fish tissue that correspond to different numbers of recommended meals per time period. Advisories may be issued for large areas of the state or for all of North Carolina for contaminants that have been found in elevated concentrations over large geographic regions. Some segments of the population (such as children or women that are pregnant or nursing) may be particularly sensitive to some environmental contaminants, and more stringent meal limitations may be issued for these populations relative to the general population.

Fish tissue analytical data is reviewed by the DPH staff for quality control, data validity and statistical analysis. Fish analytical data is presented to DHHS risk managers for final recommendations of "fish consumption advisories". Contaminant concentrations greater than the action levels result in the issuance of fish consumption advisories for specific species of fish for a water body. Some segments of the human population may be particularly sensitive to some contaminants. More restrictive meal limitations may be recommended for these populations, such as women who may become pregnant, women that are nursing, or children. The DPH has also issued fish consumption advisories for all of the state, or for large geographic areas of NC (such as "south and east of I-85"), when fish tissue data indicates pervasive elevated concentrations for specific contaminants, such as mercury. The PCB action levels are listed in Appendix B, Table 2.

Data collected in this study are not intended to identify the source of the contaminants identified in the Badin Lake fish. Possible sources of the PCBs detected in the Badin Lake fish include: (1) PCBs carried in the air from nearby or distant sources; (2) PCBs attached to water and soil washed into Badin Lake from upstream sources; and (3) PCBs put into the lake from industrial or residential sources located near or on the lake. PCBs are widely distributed in the environment, resulting from their prevalence of use for many years before their use was banned, their ability to be transported globally in the air and water, and their ability to remain in the environment for many years.

Badin Lake Fish Tissue Sampling and Analytical Study Design

The DPH coordinated the study design through the ATSDR Cooperative Agreement program staff in the Health Assessment, Consultation and Education (HACE) Program. The DPH staff worked with the local Health Departments, the N.C. DENR, the N.C. Wildlife Resources Commission (WRC), local industry and university toxicologists to develop the study plan. Fish were collected from throughout the lake and fillet samples analyzed for PCBs and PAHs. Fish were collected in the three main regions of the 5,300-acre lake. Specific species and types of fish were collected to represent the species people catch and eat from Badin Lake. Collected fish also represented the different feeding and habitat utilization characteristics that affect PAH and PCB concentrations.

The EPA and N.C. DWQ guidelines for fish collection, preparation, analysis, and quality control procedures were followed for the Badin Lake fish tissue study (EPA 2000a, EPA 2000b, DWQ 2006). The DPH and EPA protocols were followed for data assessment and determination of potential adverse human health effects (DPH 2007, EPA 2000b).

Seventy fish, representing three "trophic guilds", were collected by the DENR in August and September 2008. Fish were collected using boat-based electro-shocking. In aquatic systems, trophic guilds are groups of fish that feed on certain types of food within the food chain. There are three general groupings or guilds. These are: omnivores (referred to as "bottom feeders" or lower trophic level fish that eat plants and animals), insectivores (referred to as "middle feeders" or middle trophic level fish that feed on insects), and piscivores (referred to as "predators" or high trophic level fish that feed on other fish). Fish in different guilds will accumulate contaminants differently because of the differences in feeding activity and habitat.

The DENR prepared 30 fish tissue samples for analysis, 10 from each of the three regions of the lake. A quality control (duplicate) sample was included for each region. For each region, samples were prepared as combinations of one to three fish of the same species and of similar size. Fish tissue samples were prepared from fish fillets to best represent the portion of the fish people eat and thus provide the most realistic indicator of exposure concentrations. The 30 samples were submitted to a contract laboratory in October 2008 for PAH, PCB and percent lipid analysis. EPA analytical methods providing low detection capabilities for the 209 PCB congeners and 15 PAH compounds were specified. Analytical results were reported to the DPH in January 2009.

Catfish species were prepared as skin-less fillets, while all other species were prepared as skin-on fillets, representing the typical way individual species are prepared for eating. Of the 30 samples, 26 were composites prepared from 2 or 3 individual fish, and four were prepared from a single fish. A total of 10 samples, representing the three trophic guilds, were submitted for each of the three sampling regions of the lake (Appendix A, Figure 2). Analytical sample make-up and individual fish lengths and weights are listed in Appendix B, Table 3. Appendix B, Table 4 identifies the species collected for the three trophic guilds and number of fish collected for each guild.

Fish species collected at each trophic guild were those species and size commonly consumed from Badin Lake by recreational and subsistence fishers. Alternative species of the same trophic level were collected and used as surrogates for the designated species when the designated species, or an adequate number of a designated species, was not available within a sampling region. Three broad areas of the lake were sampled, covering the northeast, northwest, and southwest regions. Samples were collected in the three designated areas of the lake because of the overall size of the lake and to be certain that fish caught and eaten from any area of the lake were represented in the study. Collecting fish from the three regions of the lake provides information on how differences in contaminant concentrations and the mix of aquatic organisms in any particular region may influence the ultimate contaminant concentrations in the fish. Collecting fish from the three regions also eliminates the uncertainty of knowing if fish travel between the regions. No more than three fish were combined for a composite to reduce the potential of diluting elevated PCB or PAH concentrations in any one fish. Fish combined in composites were at least 75% of the length of the largest fish in the composite, as recommended in EPA guidance (EPA 2000a). Composite sampling is a standard practice for determining fish contaminant bioaccumulation, and it is a cost effective and efficient method for large area projects (Patil 2002). The three duplicate composites were prepared by DWQ and submitted to the analytical laboratory with unique identifiers for quality control purposes as “blind duplicates”. Collected fish were put on ice for transport to DWQ facilities where they were stored at -20°C until processed. DWQ processed the fish for analysis (skinning, filleting, homogenization, composite preparation) while partially frozen. After preparation, the homogenized samples were again stored at -20°C until over-night shipped while frozen to the analytical laboratory. The fish tissue samples were delivered to the laboratory for analysis in October 2008.

Badin Lake Fish Tissue Data Analysis

Fish tissue analysis was performed by SGS Environmental Services, Wilmington NC, a contract laboratory. Tissue samples were analyzed by EPA analytical Method 1668a high-resolution gas chromatography/high resolution mass spectrometry (“HRGC/HRMS”, EPA 1999). The 209 individual PCB congeners were reported on a wet-weight tissue basis (without lipid normalization). The reporting limit for individual PCB congeners was approximately 1 nano-gram per kilogram (ng/kg, or “parts per trillion”) wet weight. Analytical method 1668a provides analysis of all 209 PCB congeners that make up the common commercial Aroclor mixtures previously manufactured and used in the United States. Method 1668a also provides the greatest sensitivity to detect individual PCB components. It also provides the most accurate assessment of total PCB levels by eliminating quantitation biases related to Aroclor contaminant identification, overlap and mixing of Aroclor components, and alterations in Aroclor patterns due to selective weathering and bioaccumulation patterns.

PAH analysis was by EPA Method 8270 Selective Ion Monitoring (“SIM-GC/MS”, EPA SW-846). The reporting limit for individual PAH compounds was approximately 16 micro-grams per kilogram (µg/kg, or “parts per billion”). PAH compounds included in the fish tissue analyses are listed in Appendix B, Table 5. The PAH analyte list includes those PAH compounds in the EPA analytical method and in EPA’s fish tissue advisory guidance (EPA 2000a). Percent lipid was also determined on each fish tissue sample. Lipid analysis can be used as a general indicator of fish health, with normal ranges unique for each species.

Badin Lake Fish Tissue Results
Analytical results were reported in January 2009 as the wet-weight concentration of each PCB congener or individual PAH chemical for each of the 30 fish tissue samples submitted for analysis. Percent lipid was also reported for each sample. No PAHs above the minimum reportable concentration were found for any of the fish tissue samples. There was not adequate tissue provided to the laboratory to perform PAH analyses on three samples. PCBs were found in all 30 samples. Lipid analyses were within expected limits.

The N.C. DPH calculated total PCB concentrations for each sample by summing the concentration of each congener reported at a concentration equal to or greater than the minimum reporting concentration. Table 6 in Appendix B lists the total PCB data for the individual samples, arranged by region of the lake from where the sample was collected. Data is shown in "parts per million" units (milligrams per kilograms, or mg/kg) for direct comparison to units used in the N.C. DHHS' fish consumption advisory action level tables. Table 6 also identifies the trophic guild, fish species, and the number of individual fish that made up each tissue sample submitted for analysis. Weight, length and percent lipid information is also listed for each sample. These values represent the average values for fish making up a composite sample, or the value for an individual fish making up a sample. The duplicate samples are also included in Table 6.

Concentrations of total PCBs in each tissue sample were compared to the DHHS consumption advisory action levels for total PCBs in fish tissue (Appendix B, Table 2). Total PCB concentrations in four samples exceeded the DHHS consumption advisory action levels. Two catfish samples in the northwest region and one in the southwest region (including one that was analyzed in duplicate) were greater than the fish advisory action level of greater than 0.05 mg/kg for PCBs (>0.05 mg/kg). One of the three catfish samples (in the northwest region) exceeding the 0.05 mg/kg action level was greater than the next higher fish advisory action level of 0.11 mg/kg. One largemouth bass sample from the northwest region was greater than the lowest fish advisory action level for PCBs in fish tissue. A trend was observed between the length of catfish or largemouth bass and the concentration of PCBs in the tissue. As the length of the fish increased, PCB concentrations in the tissues increased. This indicates that as the fish get older and larger the concentration of PCBs in their tissue, and thus the exposure concentration increases. PCB concentrations in all sunfish or crappie were below the action level.

Data evaluation using the ATSDR ingestion exposure methodology: ATSDR outlines a complementary process to evaluate the potential for harmful ingestion exposures to environmental contaminants. To provide an alternative assessment of the fish tissue data from Badin Lake, the DPH also evaluated the fish data using the ATSDR methods. An explanation of the ATSDR methods for determination of potential adverse health effects is described in Appendix E.

ATSDR lists a health effects screening value of 0.00002 mg/kg/d as the daily oral exposure to PCBs (listed as the Minimal Risk Level, or "MRL", ATSDR 2000b) that would be expected to not result in adverse health effects to adults ingesting this concentration of PCBs daily for periods exceeding one year (a "chronic" exposure). This value is equal to the EPA chronic oral reference dose value (RfD) and is derived from an animal study in which the lowest adverse health effect was observed at a dose of 0.005 mg/kg/d, and resulted in adverse immunological effects to adult monkeys. ATSDR lists no chronic (long-term) human health effect study data for PCBs. ATSDR's health guidelines document (ATSDR 2008) lists a PCB oral exposure cancer slope factor (CSF) of 2 $(mg/kg/d)^{-1}$. This CSF is equivalent to the upper-bound value referenced by EPA (IRIS 2009). The EPA references using this CSF for human food chain exposures as it provides assurance that risk is not underestimated, and represents a value for high risk and high persistence PCBs, or any early-life exposure pathway. These values are applicable to "total PCBs".

For the ATSDR data evaluation approach, a site-specific exposure dose was calculated for each sample using the total PCB fish tissue concentration. This dose estimate was then used to calculate an estimate of the increased cancer risk for each sample. Estimated site-specific exposure doses and increased cancer risk estimates were calculated for each fish sample using the ATSDR calculation methods and the DPH's default exposure calculations for fish consumption advisories. A 50% loss of PCBs attributed to trimming and cooking losses, as identified in the EPA and DPH references, was included in the calculations. The calculated values are listed in Appendix B, Table 7. Estimated exposure doses for 11 of the 27 samples exceeded the ATSDR screening value. All were largemouth bass or catfish species. The estimated exposure dose of 7 of 10 catfish samples, and 4 of 9 largemouth bass samples, exceeded the ATSDR health effects screening value.

Five samples indicated "moderate" estimates of increased cancers and exceeded the DPH's increased cancer risk level criteria applied to fish consumption evaluations of one additional cancer in a population of 10,000 (1/10,000). The 5 samples included 4 catfish and 1 largemouth bass sample. If the increased cancer risk level of 1 additional cancer in a population of 100,000 exposed persons ("1/100,000", a more conservative or health protective level) is used as the screening value, then 9 of 10 catfish samples, all 9 largemouth bass samples, and 4 of 8 mid-trophic level samples (sunfish and crappie) exceed this level. The more conservative cancer risk screening level identifies additional samples at a "low" level of estimated increased cancer risks.

An alternative method to evaluate potential health hazards associated with eating PCB contaminated fish uses the "TEQ" approach. Concentrations of dioxin-like PCB congeners are multiplied by a toxicity equivalency factor (TEF) that relates their concentration to an equivalent concentration of the dioxin congener (2,3,7,8-TCDD). The concentrations of the 12 dioxin-like PCB congeners are totaled and increased cancer risks are estimated by multiplying by the dioxin cancer slope factor [150,000 $(mg/kg/d)^{-1}$, EPA 1997b]. Using the dioxin-like TEQ approach, 7 of 10 catfish and 4 of 9 largemouth bass indicate "moderate" levels of increased cancer risks using the 1/10,000 least conservative cancer risk screening level. If the more conservative 1/100,000 cancer risk screening value is applied to the TEQ-adjusted data, all 10 catfish and all 9 largemouth bass samples, as well as 4 of 8 middle trophic level samples (sunfish and crappie species) indicate "low" levels of increased cancer risk. TEQ adjusted cancer risk levels are provided in Appendix B, Table 8.

Evaluation of the Badin Lake fish tissue data using the ATSDR approach supports the conclusions drawn by the DPH process to determine the need for fish consumption advisories. Multiple samples of the catfish and largemouth bass species collected in Badin Lake had concentrations of total PCBs that exceeded screening values identified by multiple agencies, indicating the potential for adverse health effects if catfish and largemouth bass are consumed in adequate quantities over extended periods.

PCBs in the Environment

Polychlorinated biphenyls (PCBs) are a group of 209 synthetic organic compounds that were manufactured in the U.S. between 1930 and 1977. Commercial mixtures of PCBs manufactured in the U.S. went by the trade name "Aroclors". The manufacture of PCBs in the U.S. was banned in 1977 because of their persistence in the environment and evidence of potential adverse effects. There are no known natural sources of PCBs in the environment. Chemically, PCBs are biphenyls with 1-10 substituted chlorine atoms. PCBs have no known smell or taste. The different types of PCB chemicals are known as congeners, compounds distinguished by the number and location of chlorine atoms on the biphenyl structure. Some PCBs are resistant to biodegradation and are chemically stable; thus, potential environmental risks may be present for a long time.

PCBs stick strongly to soil particles and are not usually carried deep into the soil with rainwater. PCBs do not readily break down and may remain in the soil for months or years. Evaporation appears to be an important way by which the lighter PCBs leave the soil. PCBs enter the air by evaporation from both soil and water. In the atmosphere, PCBs are present as vapors or adsorbed on particles. They eventually return to land and water by settling as dust or precipitation (rain and snow). In general, the lighter the type of PCBs (low chlorinated PCBs), the further they may be transported from the source of contamination. In water, PCBs may be transported by currents, attach to bottom sediment or particles in the water, or evaporate into the air. Highly chlorinated PCBs are more likely to settle into sediments, while low-chlorinated PCBs tend to evaporate into the air. Through bioaccumulation, PCBs are taken up in small organisms and fish to levels that may be many times higher than in the water or sediment, with progressively higher concentrations accumulating in organisms moving up the food chain (ATSDR 2006).

The distribution of PCB congeners in Aroclors is altered considerably by physical, chemical, and biological processes after release into the environment, particularly when the process of biomagnification is involved. Aquatic environmental studies indicate that the chlorine content of PCBs increases at higher trophic levels (as they move higher up the food chain).

PCBs were never intended to be released directly into the environment; most uses were in closed industrial systems. Important properties of PCBs for industrial applications include thermal stability, fire and oxidation resistance, and solubility in organic compounds. PCBs were used as insulating fluids in electrical transformers and capacitors, as plasticizers, as lubricants, as fluids in vacuum pumps and compressors, and as heat transfer and hydraulic fluids. Although PCBs were once used extensively by industry, their production and use in the United States was banned by the EPA in 1977. Prior to the ban, the disposal of PCBs and PCB-containing equipment was not subject to federal regulation. Prior to regulation, of the approximately 1.25 billion pounds purchased by U.S. industry, 750 million pounds (60 percent) were still in use in capacitors and transformers, 55 million pounds (4 percent) had been destroyed by incineration or degraded in the environment, and over 450 million pounds (36 percent) were either in landfills or dumps, or were available to biota via air, water, soil, and sediments (EPA 2000a).

More information on PCBs is available in the ATSDR *Public Health Statement for Polychlorinated Biphenyls* included in Appendix D, or in the ATSDR *Toxicological Profile for Polychlorinated Biphenyls* (see References).

Limitations of the data

The fish tissue sampling was designed to assess potential adverse human health effects related to eating fish taken from Badin Lake. It was not designed to identify the source of the contamination found in the fish. Limitations of the data provided for this health consultation include:

- The fish tissue contaminant concentrations and fish consumption recommendations included in this report are relevant only for fish caught in Badin Lake.
- Fish consumption advisories are issued only for species of fish that are collected and analyzed. PCB or PAH levels for other species of fish are not available.
- Contaminant concentrations in collected fish may not be representative of contaminant concentrations in all areas of the lake that are accessible to fishers.
- The assessment of fish tissue data for this health consultation assumes ingestion of fish fillets. If persons consume other portions of the fish then the levels of contaminants to which they are exposed may differ from those in this report.
- Fish consumption advisories are based on average monthly exposures experienced over a lifetime. Exposure situations (that deviate substantially from the variables used for DPH's levels of concern may result in substantially different exposures.
- Exposure calculation parameters (i.e., body weight, consumption rate) used to develop the N.C. DHHS action levels may not be representative of all local exposed populations.
- Correction values for losses due to trimming and cooking may not be representative of species-specific exposure effects.
- Risk calculations do not take into consideration exposures and potential adverse health impacts due to related chemicals, which may induce health effects from similar modes of action.
- Other PCB and PAH exposure sources are not included in the proposed exposure investigation. Commercially caught fish and shellfish may be potentially significant sources of exposure.

POTENTIAL HEALTH EFFECTS OF EXPOSURE TO PCBs

This section discusses the health effects that could plausibly result from ingestion of contaminants identified in the fish living in Badin Lake. For a public health hazard to exist, people must be exposed to (come into contact with) the contamination at levels high enough and for long enough time to adversely affect their health. Evaluation of potential public health hazards is based on ATSDR assessment procedures. The N.C. DPH was asked to investigate potential health effects related to eating fish caught in Badin Lake. The DPH had previously determined that direct contact with contaminated lake water and sediment did not present a health hazard. As a result, a single exposure pathway was investigated in this study – eating fish caught in Badin Lake. Fish were collected from the three trophic levels (levels of organization of the aquatic food chain) represented in freshwater lakes in NC. Specific species were sought at each level, to represent those species commonly caught and eaten by recreational and subsistence fishers in the area.

ATSDR prefers to use site-specific conditions whenever possible to evaluate whether people are being exposed to contaminants at levels of health concern. Site-specific data for Badin Lake fishers for parameters such as typical body weight, the number of meals eaten per month, meal size, or proportion of species eaten, were not available for this study. The N.C. DPH must rely on reasonable assumptions rather than site-specific information in this instance. For this study, DPH used default exposure calculation parameters developed by the EPA and published in their Exposure Factors Handbook.

Health Effects Information

PCBs are extremely persistent in the environment and are bioaccumulated throughout the food chain. There is evidence that PCB health risks increase with increased chlorination because more highly chlorinated PCBs are retained more efficiently in fatty tissues. However, individual PCB congeners have widely varying potencies for producing a variety of adverse biological effects including hepatotoxicity, cardiovascular toxicity, developmental toxicity, immunotoxicity, neurotoxicity, and carcinogenicity. Some PCB congeners have been shown to exhibit "dioxin-like" effects. There is increasing evidence that many of the toxic effects of PCBs result from alterations in hormonal function. Because of the variety of hormonal effects, PCB mixtures may have complex interactive effects in biological systems. Because of the lack of sufficient toxicological data, EPA has not developed quantitative estimates of health risk for specific congeners. PCB mixtures have been classified as probable human carcinogens (EPA 2000a).

PCB exposure is associated with a wide array of adverse health effects in experimental animals, but the effects of PCB exposure in humans are less clear. Many effects have only recently been investigated (e.g., endocrine effects), and the implications of newer studies are not fully known.

PCBs are absorbed through the gastro-intestinal (GI) tract and distributed throughout the body. Absorption of PCBs from oral exposures is high (75 to 90%). Because of their lipophilic (“fat-loving”) nature, PCBs, especially those with higher levels of chlorinated congeners (those with 4 to 6 chlorines, tetra- through hexa-chlorobiphenyl), tend to accumulate in lipid-rich tissues (the liver, adipose tissue, skin, and breast milk). Absorption of tetra- and higher chlorinated congeners from breast milk by nursing infants has been observed in ranges from 90 to 100% of the exposure dose. Offspring can also be exposed to PCBs in the womb. Ultimately, the toxicity of a PCB mixture depends on the toxicity of the individual congeners, their interactions, and interactions with other chemical contaminants such as pesticides and dioxins.

Short-term high-level exposures of laboratory animals to PCBs have resulted in liver and kidney damage, neurological effects, developmental effects, endocrine effects, hematological effects and death.

In animal studies, numerous effects have been documented, including hepatic, gastrointestinal, hematological, dermal, body weight changes, endocrine, immunological, neurological, and reproductive effects. Most of the studies have involved oral exposure. Despite the variety of adverse effects observed in animals exposed to PCBs, obvious adverse effects in humans have been difficult to document. This has been attributed to the fact that, in most cases, the dosages tested in animals were considerably higher than those found in occupational exposures, and to the difficulties with interpreting epidemiological studies. Skin rashes and a persistent and severe form of acne (chloracne) have been reported following exposures to PCBs. Occupational and accidental human exposures have indicated that PCBs may affect many organs including the gastrointestinal, respiratory, immune, central nervous, and cardiovascular systems.

The EPA classifies PCBs as "probable" human carcinogens. This is based on studies that have found liver tumors in rats exposed to Aroclors 1260, 1254, 1242, and 1016 (each is a different commercial mixture of PCBs). Animal data indicates that PCBs with 54% chlorine content induce higher numbers of liver tumors in rats than other PCB mixtures. Human epidemiological studies of PCBs have not produced conclusive results. There is some evidence that suggests xeno-estrogens (man-made compounds with estrogenic hormone activity), including PCBs, may play a role in breast cancer development. Some studies have indicated an excess risk of several cancers, including: liver, biliary tract, gallbladder, gastrointestinal tract, pancreas, melanoma, and non-Hodgkin's lymphoma. Cancer effects are difficult to assess because of the long latency period required for cancer development and the multiple confounders arising from simultaneous exposures to other potential cancer-causing chemicals, lifestyle differences, and other factors. The currently available human evidence is considered inadequate but suggests that PCBs may cause cancer in humans

Individuals with liver and blood diseases or those with syndromes associated with impairment of the metabolic systems that help eliminate PCBs from the body may potentially be at greater risk from PCB exposure (EPA 2000b).

CHILD HEALTH CONSIDERATIONS

The ATSDR recognizes there are unique exposure risks concerning children that do not apply to adults. Children engage in increased outdoor activities and hand to mouth actions, and have lower body weights and higher intake rate than adults, which result in a greater dose of hazardous substance per unit of body weight. Other reasons that can affect a child's exposure response include genetic makeup, age, health, nutritional status, and exposure to other environmental substances. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage (ATSDR, 1999). Because adults are in charge of the housing, medical care and risk identification of children they should have as much information about environmental contaminants in order to make informed decisions which can affect the child's health.

Furthermore, it should be noted that the fetus may be particularly susceptible to the toxic effects of these chemicals. Laboratory studies of animals suggest that exposure of the human fetus and children to volatile organic compounds (VOCs) may result in adverse health effects.

PCB mixtures have been shown to cause adverse developmental effects in experimental animals. Data are inconclusive concerning developmental effects in humans. Several studies in humans have suggested that PCB exposure may cause adverse developmental effects in children and in developing fetuses. These include lower IQ scores, low birth weight, and lower behavior assessment scores. However, study limitations obscured interpretation of these results (ATSDR 2000, EPA 2000a).

Studies of women who consumed high amounts of fish contaminated with PCBs and other chemicals also had babies that weighed less than babies from women who did not eat the contaminated fish. Similar observations have been made in some studies of women with no known high exposure to PCBs, but not all studies have confirmed these findings. Babies born to women who ate fish contaminated with PCBs before and during pregnancy showed abnormal responses to tests of infant behavior. Some of these behaviors, such as problems with motor skills and a decrease in short-term memory, persisted for several years. However, in these studies, the women may have been exposed to other chemicals. Other studies suggest that the immune system may be affected in children born to and nursed by mothers exposed to increased levels of PCBs. There are no reports of structural birth defects in humans caused by exposure to PCBs or of health effects of PCBs in older children. It is not known whether PCB exposure can cause skin acne and rashes in children as occurs in some adults, although it is likely that the same effects would occur at very high PCB exposure levels.

Animal studies have shown harmful effects in the behavior of very young animals when their mothers were exposed to PCBs and the fetuses were exposed in the womb or by nursing. In addition, some animal studies suggest that exposure to PCBs causes an increased incidence of prenatal death and changes in the immune system, thyroid, and reproductive organs. Studies in monkeys showed that young animals developed skin effects from nursing after their mothers were exposed to PCBs. Some studies indicate that very high doses of PCBs may cause structural birth defects in animals.

Children can be exposed to PCBs both prenatally and from breast milk. PCBs are stored in the mother's body and can be released during pregnancy, when they can cross the placenta, and enter fetal tissues. Because PCBs dissolve readily in fat, they can accumulate in breast milk fat and be transferred to babies and young children. PCBs have been measured in umbilical cord blood and in breast milk. Some studies have estimated that an infant who is breast-fed for 6 months may accumulate in this period 6–12% of the total PCBs that will accumulate during its lifetime. However, in most cases, the benefits of breast-feeding outweigh any risks from exposure to PCBs in mother's milk. Because the brain, nervous system, immune system, thyroid, and reproductive organs are still developing in the fetus and child, the effects of PCBs on these target systems may be more profound after exposure during the prenatal and neonatal periods, making fetuses and children more susceptible to PCBs than adults (ATSDR 2000).

CONCLUSIONS

N.C. DPH reached three important conclusions in this health consultation:

DPH concludes that pregnant women, women who may become pregnant, and children under 15 that eat catfish and largemouth bass that contain PCBs from Badin Lake throughout their lifetime could harm their health. Other people's health could be harmed by eating more than one meal per week of catfish and largemouth bass that contain PCBs from Badin Lake.

N.C. DPH recommended a fish consumption advisory for Badin Lake due to concentrations of PCBs found in a study of fish collected from the lake in 2008. The advisory issued also included language related to a pre-existing mercury in fish advisory covering large areas of the state. The final advisory issued on February 10, 2009 for Badin Lake states:

> *"**Do not eat more than one (1) meal a week of catfish or largemouth bass from Badin Lake. If you are pregnant, may become pregnant, are nursing, or are a child under 15 years of age, do not eat <u>any</u> of these fish.** Elevated levels of polychlorinated biphenyls (PCBs) have been found in some catfish and largemouth bass. Swimming, boating, and handling fish do not present a known health risk.*
>
> ***Health Effects of PCBs***
>
> *Eating more than one meal a week of these fish may increase a person's risk of developing health problems such as cancer, infection, or skin problems. The babies of pregnant or nursing women who eat these fish may experience developmental or other health problems."*

If community members follow these recommendations, their exposure to PCBs in fish from Badin Lake would not be at levels that would harm their health. With these diet modifications fish can remain an important part of a healthy diet and a good source of protein and other nutrients.

DPH concludes that eating fish from Badin Lake is not expected to harm people's health due to PAHs because PAHs were not detected in the fish. No PAHs were detected at concentrations equal to or above the minimum reporting level in the fish taken from Badin Lake.

DPH concludes that eating the other types of fish tested in this study (sunfish and crappie species) are not *expected to harm people's health.* PCBs levels measured in these types of fish were less than levels expected to cause adverse health effects.

RECOMMENDATIONS

The N.C. DHHS/DPH issued a fish consumption advisory for catfish and largemouth bass due to concentrations of PCBs found in some fish in Badin Lake. The PCB advisory recommends:

- To not eat more than one meal per week of catfish or largemouth bass due to PCBs found in these types of fish.

A more restrictive advisory for mercury in fish covers areas of NC that include Badin Lake. There is a state-wide advisory for largemouth bass and a catfish advisory for the area of NC south and east of Highway I-85. The mercury advisory recommends:

- That women who are pregnant, nursing, or of child bearing age (15-44 years), and children under 15, not eat any catfish or largemouth bass, and
- That all other persons do not eat more than one meal per week of catfish or largemouth bass, due to mercury levels found in these types of fish.

DPH also recommends:

- That fish consumption advisory signs be posted at recreational access areas on Badin Lake.
- Future sampling of fish from Badin Lake is recommended to document changes in contaminant levels and determine if modification to the fish consumption advisory is appropriate.

PUBLIC HEALTH ACTION PLAN

The purpose of the Public Health Action Plan (PHAP) is to ensure that this health consultation provides a plan of action designed to mitigate or prevent potential adverse health effects.

A. Public Health Actions Completed

a. The State Health Director issued a fish consumption advisory for PCBs in catfish and largemouth bass in Badin Lake.
b. A press release was issued by Stanly County Health Department on February 10, 2009 announcing a public meeting on February 11, 2009. The release appeared in the local newspapers (in Albemarle and Charlotte NC).
c. A public meeting was held February 11, 2009 in Albemarle NC at the County offices. N.C. DPH presented the results of the fish tissue study and explained the fish consumption advisories. Handouts included:
    i. Copies of the public meeting presentation slides
    ii. Badin Lake fish study factsheet
    iii. Badin Lake fish study FAQs (Frequently Asked Questions)
    iv. PCB factsheet
    v. Mercury factsheet
d. The Badin Lake fish study factsheet & FAQs are available through the HACE web page (http://www.epi.state.nc.us/epi/oee/hace/reports.html)
e. A question and answer period was held after the public meeting presentation to answer questions. N.C. DPH staff also met one-on-one with citizens after the public meeting to answer additional questions. Contact information was provided for N.C. DPH staff for additional questions.
f. N.C. DPH trained the N.C. DHHS CARE-LINE staff to handle telephone calls

regarding the results of the fish tissue study and the fish consumption advisories (February 24, 2009). The CARE-LINE is a 24-hour/7-day a week toll-free information and referral telephone service. Staff includes Spanish-speaking specialists. Staff were trained on how to respond to specific questions and when to refer questions to N.C. DPH toxicologists or physicians.

g. A study and fish advisory summary was prepared for the NC Governor's Office on March 3, 2009.

B. **Public Health Actions Planned**

a. N.C. DPH is coordinating with Stanly and Montgomery Counties and property owners to develop fish advisory signs to be posted at approximately 20 recreational access points around Badin Lake. Signs are anticipated to be in place in 2009.

b. N.C. DPH is preparing a Health Consultation/ATSDR final report. The final report is expected to be completed in 2009.

c. The Badin Lake Fish Tissue Study final report will be posted on the N.C. DPH web site on the Health Assessment and Consultation (HACE) program web page (http://www.epi.state.nc.us/epi/oee/hace/reports.html) after ATSDR review. The report will also be available through the ATSDR web site (http://www.atsdr.cdc.gov/).

d. N.C. DPH contact information will be provided to answer questions from the public about the Badin Lake study and fish consumption advisory.

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CERTIFICATION

This Health Consultation for the Badin Lake site was prepared by the North Carolina Division of Public Health (NC DHHS) under a cooperative agreement with the Federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consult and update was initiated. Editorial review was completed by the cooperative agreement partner.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation, and concurs with its findings.

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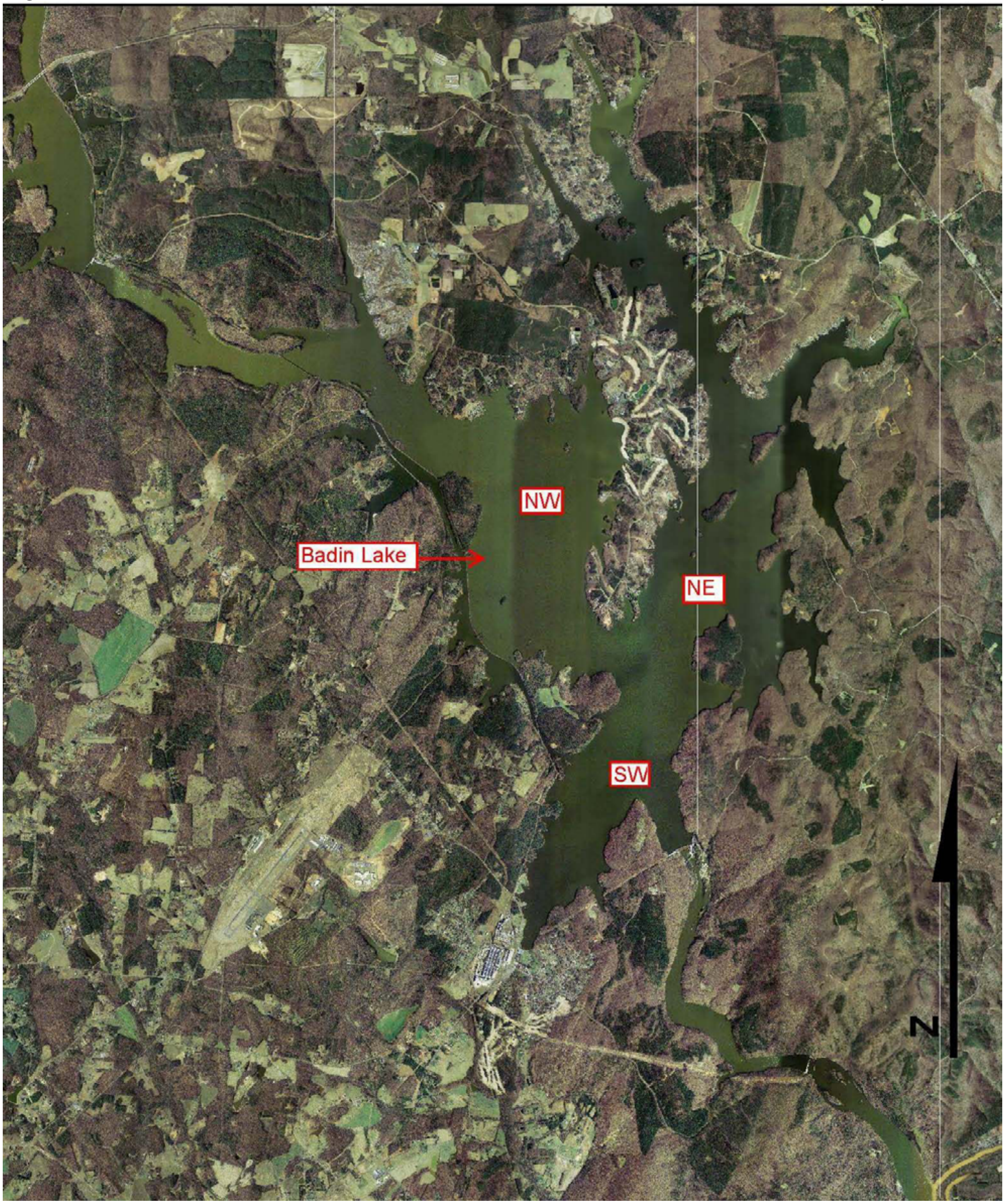
Appendix A

Figures

Figure 1. Location of Badin Lake, Stanly and Montgomery Counties, NC

Figure 2. Identification of three fish collection areas for the Badin Lake fish tissue study.



Appendix B

Tables

Table 1. Calculation parameters used for development of N.C. DHHS fish consumption advisory ingestion exposure calculations for total PCBs.

Parameter	Value	Source
Consumer body weight, BW	70 kg, all adults	USEPA 2000b
Meal size, MS	0.170 kg fish per meal[1] (6 oz.)	NC DHHS 2007, fish consumption calculations for PCB advisories; USEPA 2000a
Loss factor due to trimming & cooking	50%	NC DHHS 2007
Acceptable life-time cancer risk level, ACL	1×10^{-4} (1 in 10,000)	NC DHHS 2007, fish consumption calculations for PCB advisories;
Carcinogen exposure time	70 yr-lifetime	USEPA 2000b
EPA Reference Dose (RfD)	0.00002 mg/kg/day	NC DHHS 2007

[1] Represents 95th percentile for Native American subsistence fishers (USEPA 2000a)

Table 2. N.C. DHHS fish tissue consumption advisory levels for PCBs[1].

Total PCB concentration mg/kg (ppm)	Consumption advisory
<0.05	unlimited consumption
0.05 to 0.10	limit to one meal per week
0.11 to 0.50	limit to one meal per month
>0.50	do not eat

[1] NC DHHS 2007. As total PCB concentration in wet weight fish tissue.

Table 3. Individual fish measurements and fish tissue analytical sample make-up. Samples collected and fillet tissue samples prepared by N.C. DWQ.

Waterbody	*Location*	*Latitude*	*Longitude*	*Species*	*DWQ Fish ID #*	*Length (mm)*	*Weight (g)*	*Fillet Sample Type*
Badin Lake	SW arm	35.409	80.11427	RBS	08-225	182	114	skin on
Sampled 8/25/2008		35.4145	80.10844			181	119	
						196	155	
				RBS	08-226	176	107	skin on
						185	110	
						175	90	
				RBS	08-227	173	91	skin on
						171	99	
						163	88	
Species Codes:				WHC	08-228	291	349	skin off
BGS = Bluegill Sunfish						282	292	
BKS= Black Crappie				BRB	08-229	272	288	skin off
BRB= Brown Bullhead						279	276	
CHC = Channel Catfish						266	243	
FBH= Flat Bullhead				BRB	08-230	233	155	skin off
FHC = Flathead Catfish						217	145	
LMB = Largemouth Bass				LMB	08-231	460	1360	skin on
RBS = Redbreast Sunfish				LMB	08-232	372	811	skin on
RES= Redear Sunfish						371	950	
WHC= White Catfish						375	651	
				LMB	08-233	372	811	skin on
					(duplicate of 08-232)	371	950	
						375	351	
				LMB	08-234	302	372	skin on
						286	350	
Badin Lake	NW arm	35.47477	80.15227	RES	08-235	244	259	skin on
Sampled 8/25/2008		35.47792	80.15034			227	212	
						242	246	
				BKS	08-236	240	229	skin on
						240	233	
				CHC	08-237	509	1252	skin off
				CHC	08-238	425	647	skin off
						422	567	
				WHC	08-239	419	865	skin off
						405	916	
				WHC	08-240	304	316	skin off
						310	316	
						295	308	
				LMB	08-241	445	1740	skin on
						418	1163	
				LMB	08-242	350	642	skin on
						335	515	
				LMB	08-243	300	379	skin on
						302	369	
						312	403	
				CHC	08-244	425	647	skin off
					(duplicate of 08-238)	422	567	
Badin Lake	NE arm	35.49085	80.10131	BGS	08-245	193	175	skin on
Sampled 9/4/2008		35.4843	80.10641			183	132	
						183	123	
				RES	08-246	237	267	skin on
						232	225	
				BKS	08-247	196	132	skin on
						193	112	
						192	117	
				BRB	08-248	325	445	skin off
						327	464	
				FBH	08-249	242	204	skin off
				WHC	08-250	313	403	skin off
				LMB	08-251	448	1725	skin on
						427	1446	
						425	1341	
				LMB	08-252	448	1725	skin on
					(duplicate of 08-251)	427	1446	
						425	1341	
				LMB	08-253	387	873	skin on
						366	752	
						335	582	
				LMB	08-254	284	320	skin on
						242	209	

Notes: Latitutude and Longitude readings indicate upper and lower edges of sampling reach for each lake arm.
Fish ID #s consist of up to 3 composited individuals (all individual lengths and weights are shown).

Table 4. Trophic guild, species of fish collected, and number of samples submitted from Badin Lake fish collected in August and September 2008.

Trophic Guild	Fish Species (Common name, *Scientific name)*	Total number of guild samples submitted for analysis
Insectivores	Bluegill Sunfish (*Lepomis macrochirus*) Redbreast Sunfish (*Lepomis auritus*) Redear Sunfish (*Lepomismicrolophus*) Flat Bullhead Catfish (*Ameiurus platycephalus*)	18
Omnivores	Brown Bullhead Catfish(*Ameiurus nebulosus*) Channel Catfish (*Ictalurus punctatus*) White Catfish (*Ameiurus catus*)	20
Piscivores	Black Crappie (*Pomoxis nigromaculatus*) Largemouth Bass (*Micropterus salmoides*)	32

Table 5. Badin Lake fish tissue study PAH analyte list.

PAH fish tissue analyte list for method 8270-SIM
Acenaphthene
Acenaphthylene
Anthracene
Benzo[a]anthracene
Benzo[a]pyrene
Benzo[b]fluoranthene
Benzo[g,h,i]perylene
Benzo[k]fluoranthene
Chrysene
Dibenzo[a,h]anthracene
Fluoranthene
Fluorene
Indeno[1,2,3-c,d]pyrene
Phenanthrene
Pyrene

Table 6. Sample information and total PCB data for Badin Lake fish tissue samples collected in August and September 2008.

lake region	Northeast region									
fish species	Bluegill Sunfish	Redear Sunfish	Flat Bullhead Catfish	Brown Bullhead Catfish	Black Crappie	White Catfish	Large mouth Bass[1]	Large mouth Bass[1]	Large mouth Bass	Large mouth Bass
feeding type	insectivore	insectivore	insectivore	omnivore	piscivore	omnivore	piscivore	piscivore	piscivore	piscivore
no. fish in sample	3	2	1	2	3	1	3	3	3	2
total PCBs, mg/kg	0.00694	0.000888	0.00375	0.00763	0.00117	0.0119	0.0170	0.0179	0.00584	0.00449
weight, g	143	246	204	455	120	403	1,504	1,504	736	265
length, mm	186	235	242	326	194	313	433	433	363	263
lipid, %	1.27	0.31	0.71	1.67	0.23	2.39	0.91	0.46	0.42	0.83

lake region	Northwest region									
fish species	Redear Sunfish	Channel Catfish	Channel Catfish[1]	Channel Catfish[1]	Black Crappie	White Catfish	White Catfish	Large mouth Bass	Large mouth Bass	Large mouth Bass
feeding type	insectivore	omnivore	omnivore	omnivore	piscivore	omnivore	omnivore	piscivore	piscivore	piscivore
no. fish in sample	3	1	2	2	2	2	3	2	2	3
total PCBs, mg/kg	0.00159	0.117	0.0479	0.0505	0.00255	0.0417	0.0176	0.0526	0.0113	0.00655
weight, g	239	1,252	607	607	231	891	313	1,452	579	384
length, mm	238	509	424	424	240	412	303	432	343	305
lipid, %	0.29	4.81	1.69	1.74	0.53	0.94	1.29	1.19	0.60	0.26

lake region	Southwest Region									
fish species	Red Breast Sunfish	Red Breast Sunfish	Red Breast Sunfish	Brown Bullhead Catfish	Brown Bullhead Catfish	White Catfish	Large mouth Bass	Large mouth Bass	Large mouth Bass[1]	Large mouth Bass[1]
feeding type	insectivore	insectivore	insectivore	omnivore	omnivore	omnivore	piscivore	piscivore	piscivore	piscivore
no. fish in sample	3	3	3	3	2	2	2	1	3	3
total PCBs, mg/kg	0.0111	0.00765	0.0101	0.0322	0.0187	0.0532	0.00628	0.0399	0.0310	0.0325
weight, g	129	102	93	269	150	321	361	1,360	804	804
length, mm	186	179	169	272	225	287	294	460	373	373
lipid, %	0.49	0.24	0.42	0.68	0.86	0.61	0.52	0.91	0.73	1.08

Notes:
1. Blind duplicate samples submitted to contract laboratory for quality control purposes.
mg/kg = milligrams per kilogram, "parts per million"
total PCBs = total detected concentrations of all 209 PCB congeners

Table 7. Sample information, total PCB estimated exposures and increased cancer risk data for Badin Lake fish tissue samples collected in August and September 2008. Exposure and increased cancer risk values derived using ATSDR methods.

lake region	Northeast region									
fish species	Bluegill Sunfish	Redear Sunfish	Flat Bullhead Catfish	Brown Bullhead Catfish	Black Crappie	White Catfish	Large mouth Bass[1]	Large mouth Bass[1]	Large mouth Bass	Large mouth Bass
feeding type (trophic guild)	insectivore	insectivore	insectivore	omnivore	piscivore	omnivore	piscivore	piscivore	piscivore	piscivore
no. fish in sample	3	2	1	2	3	1	3	3	3	2
total PCBs, mg/kg	0.00694	0.000888	0.00375	0.00763	0.00117	0.0119	0.0170	0.0179	0.00584	0.00449
weight, g	143	246	204	455	120	403	1,504	1,504	736	265
length, mm	186	235	242	326	194	313	433	433	363	263
lipid, %	1.27	0.31	0.71	1.67	0.23	2.39	0.91	0.46	0.42	0.83
Exposure Dose, mg/kg/d - Total PCBs	**8.43E-06**	**1.08E-06**	**4.55E-06**	**9.27E-06**	**1.42E-06**	**1.45E-05**	**2.06E-05**	**2.17E-05**	**7.09E-06**	**5.45E-06**
Increased Cancer Risk - Total PCBs	**1.69E-05**	**2.16E-06**	**9.10E-06**	**1.85E-05**	**2.85E-06**	**2.89E-05**	**4.12E-05**	**4.34E-05**	**1.42E-05**	**1.09E-05**

lake region	Northwest region									
fish species	Redear Sunfish	Channel Catfish	Channel Catfish[1]	Channel Catfish[1]	Black Crappie	White Catfish	White Catfish	Large mouth Bass	Large mouth Bass	Large mouth Bass
feeding type (trophic guild)	insectivore	omnivore	omnivore	omnivore	piscivore	omnivore	omnivore	piscivore	piscivore	piscivore
no. fish in sample	3	1	2	2	2	2	3	2	2	3
total PCBs, mg/kg	0.00159	0.117068	0.04788	0.05048	0.00255	0.0417	0.0176	0.0526	0.01130	0.00655
weight, g	239	1,252	607	607	231	891	313	1,452	579	384
length, mm	238	509	424	424	240	412	303	432	343	305
lipid, %	0.29	4.81	1.69	1.74	0.53	0.94	1.29	1.19	0.60	0.26
Exposure Dose, mg/kg/d - Total PCBs	**1.93E-06**	**1.42E-04**	**5.81E-05**	**6.13E-05**	**3.10E-06**	**5.06E-05**	**2.14E-05**	**6.38E-05**	**1.37E-05**	**7.96E-06**
Increased Cancer Risk - Total PCBs	**3.86E-06**	**2.84E-04**	**1.16E-04**	**1.23E-04**	**6.19E-06**	**1.01E-04**	**4.28E-05**	**1.28E-04**	**2.75E-05**	**1.59E-05**

lake region	Southwest Region									
fish species	Red Breast Sunfish	Red Breast Sunfish	Red Breast Sunfish	Brown Bullhead Catfish	Brown Bullhead Catfish	White Catfish	Large mouth Bass	Large mouth Bass	Large mouth Bass[1]	Large mouth Bass[1]
feeding type (trophic guild)	insectivore	insectivore	insectivore	omnivore	omnivore	omnivore	piscivore	piscivore	piscivore	piscivore
no. fish in sample	3	3	3	3	2	2	2	1	3	3
total PCBs, mg/kg	0.01112	0.007651	0.01013	0.03225	0.01872	0.0532	0.0063	0.0399	0.03098	0.03251
weight, g	129	102	93	269	150	321	361	1,360	804	804
length, mm	186	179	169	272	225	287	294	460	373	373
lipid, %	0.49	0.24	0.42	0.68	0.86	0.61	0.52	0.91	0.73	1.08
Exposure Dose, mg/kg/d - Total PCBs	**1.35E-05**	**9.29E-06**	**1.23E-05**	**3.92E-05**	**2.27E-05**	**6.47E-05**	**7.63E-06**	**4.85E-05**	**3.76E-05**	**3.95E-05**
Increased Cancer Risk - Total PCBs	**2.70E-05**	**1.86E-05**	**2.46E-05**	**7.83E-05**	**4.55E-05**	**1.29E-04**	**1.53E-05**	**9.70E-05**	**7.52E-05**	**7.90E-05**

Notes: 1. Blind duplicate samples submitted to contract laboratory for quality control purposes.
mg/kg = milligrams per kilogram, "parts per million"
total PCBs = total detected concentrations of all 209 PCB congeners

Table 8. Increased cancer risk estimates for Badin Lake fish tissue samples collected in August and September 2008. Cancer risk evaluated using dioxin-like PCB congener TEQ method.

lake region	Northeast region									
fish species	Bluegill Sunfish	Redear Sunfish	Flat Bullhead Catfish	Brown Bullhead Catfish	Black Crappie	White Catfish	Large mouth Bass[1]	Large mouth Bass[1]	Large mouth Bass	Large mouth Bass
feeding type (trophic guild)	insectivore	insectivore	insectivore	omnivore	piscivore	omnivore	piscivore	piscivore	piscivore	piscivore
no. fish in sample	3	2	1	2	3	1	3	3	3	2
Concentration dl-PCB TEQs, mg/kg	2.37E-07	6.00E-09	1.82E-07	2.58E-07	8.00E-09	3.08E-07	5.81E-07	6.20E-07	2.14E-07	1.91E-07
Concentration ndl-PCBs, mg/kg	6.42E-03	8.36E-04	3.37E-03	7.02E-03	1.11E-03	1.10E-02	1.58E-02	1.66E-02	5.44E-03	4.20E-03
Increased CA Risk, dl-PCBs	4.32E-05	1.09E-06	3.32E-05	4.70E-05	1.46E-06	5.61E-05	1.06E-04	1.13E-04	3.90E-05	3.48E-05
Increased CA Risk, non-dl-PCBs	1.56E-05	2.03E-06	8.19E-06	1.71E-05	2.68E-06	2.67E-05	3.85E-05	4.04E-05	1.32E-05	1.02E-05
Total increased CA risk, PCBs	5.88E-05	3.12E-06	4.13E-05	6.40E-05	4.14E-06	8.28E-05	1.44E-04	1.53E-04	5.22E-05	4.50E-05

lake region	Northwest region									
fish species	Redear Sunfish	Channel Catfish	Channel Catfish[1]	Channel Catfish[1]	Black Crappie	White Catfish	White Catfish	Large mouth Bass	Large mouth Bass	Large mouth Bass
feeding type (trophic guild)	insectivore	omnivore	omnivore	omnivore	piscivore	omnivore	omnivore	piscivore	piscivore	piscivore
no. fish in sample	3	1	2	2	2	2	3	2	2	3
Concentration dl-PCB TEQs, mg/kg	1.20E-08	3.30E-06	1.20E-06	1.70E-06	1.80E-08	1.13E-06	4.58E-07	1.28E-06	3.44E-07	1.96E-07
Concentration ndl-PCBs, mg/kg	1.50E-03	1.08E-01	4.34E-02	4.58E-02	2.41E-03	3.85E-02	1.63E-02	4.96E-02	1.07E-02	6.14E-03
Increased CA Risk, dl-PCBs	2.19E-06	6.01E-04	2.18E-04	3.09E-04	3.28E-06	2.06E-04	8.34E-05	2.33E-04	6.27E-05	3.57E-05
Increased CA Risk, non-dl-PCBs	3.63E-06	2.63E-04	1.05E-04	1.11E-04	5.85E-06	9.34E-05	3.96E-05	1.20E-04	2.59E-05	1.49E-05
Total increased CA risk, PCBs	5.82E-06	8.64E-04	3.24E-04	4.20E-04	9.13E-06	3.00E-04	1.23E-04	3.53E-04	8.86E-05	5.06E-05

lake region	Southwest Region									
fish species	Red Breast Sunfish	Red Breast Sunfish	Red Breast Sunfish	Brown Bullhead Catfish	Brown Bullhead Catfish	White Catfish	Large mouth Bass	Large mouth Bass	Large mouth Bass[1]	Large mouth Bass[1]
feeding type (trophic guild)	insectivore	insectivore	insectivore	omnivore	omnivore	omnivore	piscivore	piscivore	piscivore	piscivore
no. fish in sample	3	3	3	3	2	2	2	1	3	3
Concentration dl-PCB TEQs, mg/kg	2.83E-07	7.00E-08	2.92E-07	7.47E-07	4.09E-07	1.73E-06	1.86E-07	8.68E-07	1.00E-06	1.28E-06
Concentration ndl-PCBs, mg/kg	1.02E-02	7.06E-03	9.27E-03	2.96E-02	1.74E-02	4.82E-02	5.84E-03	3.77E-02	2.85E-02	2.99E-02
Increased CA Risk, dl-PCBs	5.15E-05	1.28E-05	5.32E-05	1.36E-04	7.45E-05	3.15E-04	3.39E-05	1.58E-04	1.83E-04	2.33E-04
Increased CA Risk, non-dl-PCBs	2.48E-05	1.71E-05	2.25E-05	7.19E-05	4.23E-05	1.17E-04	1.42E-05	9.15E-05	6.91E-05	7.26E-05
Total increased CA risk, PCBs	7.64E-05	2.99E-05	7.57E-05	2.08E-04	1.17E-04	4.32E-04	4.81E-05	2.50E-04	2.52E-04	3.06E-04

Notes: **1. Blind duplicate samples submitted to contract laboratory for quality control purposes.**
mg/kg = milligrams per kilogram, "parts per million"
total PCBs = total detected concentrations of all 209 PCB congeners

CA = cancer
dl-PCB = dioxin-like PCB congeners
ndl-PCB = non-dioxin-like PCB congeners

Appendix C

Demographics

Stanly County Demographics (Census 2000)	Total Number	Percent	US Percent
Total population	58,100		
Ethnicity			
White	49,196	84.7	75.1
African American	6,657	11.5	12.3
Asian	1,049	1.8	3.6
Latino	1,237	2.1	12.5
Speak a language other than English	2,550	4.7	17.9
Individuals below poverty level	6,030	10.7	12.4

Montgomery County Demographics (Census 2000)	Total Number	Percent	US Percent
Total population	26,822		
Ethnicity			
White	18,527	69.1	75.1
African American	5,857	21.8	12.3
Asian	431	1.6	3.6
Latino	2,797	10.4	12.5
Speak a language other than English	3,038	12.2	17.9
Individuals below poverty level	3,957	15.4	12.4

Reference:

EnviroMapper. U.S.EPA. http://www.epa.gov/emefdata/em4ef.home

Appendix D

ATSDR PCB Public Health Statement

products (fat basis), 2 ppm in fish and shellfish (edible portions), and 3 ppm in poultry and red meat (fat basis).

OSHA regulates 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 42% chlorine PCBs, or to 0.5 mg/m^3 for 54% chlorine PCBs.

NIOSH recommends that workers not breathe air containing 42 or 54% chlorine PCB levels higher than 1 microgram per cubic meter of air ($\mu g/m^3$) for a 10-hour workday, 40-hour workweek.

EPA requires that companies that transport, store, or dispose of PCBs follow the rules and regulations of the federal hazardous waste management program. EPA also limits the amount of PCBs put into publicly owned waste water treatment plants. To minimize exposure of people to PCBs, EPA requires that industry tell the National Response Center each time 1 pound or more of PCBs have been released to the environment.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop F-32
Atlanta, GA 30333

Information line and technical assistance:
Phone: 888-422-8737
FAX: (770)-488-4178

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

To order toxicological profiles, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 800-553-6847 or 703-605-6000

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

PUBLIC HEALTH STATEMENT
POLYCHLORINATED BIPHENYLS (PCBS)

Division of Toxicology **November 2000**

This Public Health Statement is the summary chapter from the Toxicological Profile for Polychlorinated Biphenyls (PCBs). It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This public health statement tells you about polychlorinated biphenyls (PCBs) and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. PCBs have been found in at least 500 of the 1,598 current or former NPL sites. However, the total number of NPL sites evaluated for PCBs is not known. As more sites are evaluated, the sites at which PCBs are found may increase. This information is important because exposure to PCBs may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact. If you are exposed to PCBs, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with them. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT ARE POLYCHLORINATED BIPHENYLS (PCBs)?

PCBs are a group of synthetic organic chemicals that can cause a number of different harmful effects. There are no known natural sources of PCBs in the environment. PCBs are either oily liquids or solids and are colorless to light yellow. Some PCBs are volatile and may exist as a vapor in air. They have no known smell or taste. PCBs enter the environment as mixtures containing a variety of individual chlorinated biphenyl components, known as congeners, as well as impurities. Because the health effects of environmental mixtures of PCBs are difficult to evaluate, most of the information in this toxicological profile is about seven types of PCB mixtures that were commercially produced. These seven kinds of PCB mixtures include 35% of all the PCBs commercially produced and 98% of PCBs sold in the United States since 1970. Some commercial PCB mixtures are known in the United States by their industrial trade name, Aroclor. For example, the name Aroclor 1254 means that the mixture contains approximately 54% chlorine by weight, as indicated by the second two digits in the name. Because they don't burn easily and are good insulating materials, PCBs were used widely as coolants and lubricants in transformers, capacitors, and other electrical equipment. The manufacture of

PCBs stopped in the United States in August 1977 because there was evidence that PCBs build up in the environment and may cause harmful effects. Consumer products that may contain PCBs include old fluorescent lighting fixtures, electrical devices or appliances containing PCB capacitors made before PCB use was stopped, old microscope oil, and old hydraulic oil.

1.2 WHAT HAPPENS TO POLYCHLORINATED BIPHENYLS (PCBs) WHEN THEY ENTER THE ENVIRONMENT?

Before 1977, PCBs entered the air, water, and soil during their manufacture and use in the United States. Wastes that contained PCBs were generated at that time, and these wastes were often placed in landfills. PCBs also entered the environment from accidental spills and leaks during the transport of the chemicals, or from leaks or fires in transformers, capacitors, or other products containing PCBs. Today, PCBs can still be released into the environment from poorly maintained hazardous waste sites that contain PCBs; illegal or improper dumping of PCB wastes, such as old transformer fluids; leaks or releases from electrical transformers containing PCBs; and disposal of PCB-containing consumer products into municipal or other landfills not designed to handle hazardous waste. PCBs may be released into the environment by the burning of some wastes in municipal and industrial incinerators.

Once in the environment, PCBs do not readily break down and therefore may remain for very long periods of time. They can easily cycle between air, water, and soil. For example, PCBs can enter the air by evaporation from both soil and water. In air, PCBs can be carried long distances and have been found in snow and sea water in areas far away from where they were released into the environment, such as in the arctic. As a consequence, PCBs are found all over the world. In general, the lighter the type of PCBs, the further they may be transported from the source of contamination. PCBs are present as solid particles or as a vapor in the atmosphere. They will eventually return to land and water by settling as dust or in rain and snow. In water, PCBs may be transported by currents, attach to bottom sediment or particles in the water, and evaporate into air. Heavy kinds of PCBs are more likely to settle into sediments while lighter PCBs are more likely to evaporate to air. Sediments that contain PCBs can also release the PCBs into the surrounding water. PCBs stick strongly to soil and will not usually be carried deep into the soil with rainwater. They do not readily break down in soil and may stay in the soil for months or years; generally, the more chlorine atoms that the PCBs contain, the more slowly they break down. Evaporation appears to be an important way by which the lighter PCBs leave soil. As a gas, PCBs can accumulate in the leaves and above-ground parts of plants and food crops.

PCBs are taken up into the bodies of small organisms and fish in water. They are also taken up by other animals that eat these aquatic animals as food. PCBs especially accumulate in fish and marine mammals (such as seals and whales) reaching levels that may be many thousands of times higher than in water. PCB levels are highest in animals high up in the food chain.

1.3 HOW MIGHT I BE EXPOSED TO POLYCHLORINATED BIPHENYLS (PCBs)?

Although PCBs are no longer made in the United States, people can still be exposed to them. Many older transformers and capacitors may still contain PCBs, and this equipment can be used for 30 years or more. Old fluorescent lighting fixtures and old electrical devices and appliances, such as television sets and refrigerators, therefore may contain PCBs if they were made before PCB use was stopped. When these electric devices get hot during operation, small amounts of PCBs may get into the air and raise the level of PCBs in indoor air. Because devices that contain PCBs can leak with age, they could also be a source of skin exposure to PCBs.

Small amounts of PCBs can be found in almost all outdoor and indoor air, soil, sediments, surface water, and animals. However, PCB levels have generally decreased since PCB production stopped in 1977. People are exposed to PCBs primarily from contaminated food and breathing contaminated air. The major dietary sources of PCBs are fish (especially sportfish that were caught in contaminated lakes or rivers), meat, and dairy products. Between 1978 and 1991, the estimated daily intake of PCBs in adults from dietary sources declined from about 1.9 nanograms (a nanogram is a billionth part of a gram) to less than 0.7 nanograms. PCB levels in sportfish are still high enough so that eating PCB-contaminated fish may be an important source of exposure for some people. Recent studies on fish indicate maximum concentrations of PCBs are a few parts of PCBs in a million parts (ppm) of fish, with higher levels found in bottom-feeders such as carp. Meat and dairy products are other important sources of PCBs in food, with PCB levels in meat and dairy products usually ranging from less than 1 part in a billion parts (ppb) of food to a few ppb. Concentrations of PCBs in subsurface soil at a Superfund site have been as high as 750 ppm. People who live near hazardous waste sites may be exposed to PCBs by consuming PCB-contaminated sportfish and game animals, by breathing PCBs in air, or by drinking PCB-contaminated well water. Adults and children may come into contact with PCBs when swimming in contaminated water and by accidentally swallowing water during swimming. However, both of these exposures are far less serious than exposures from ingesting PCB-contaminated food (particularly sportfish and wildlife) or from breathing PCB-contaminated air.

Workplace exposure to PCBs can occur during repair and maintenance of PCB transformers; accidents, fires, or spills involving PCB transformers and older computers and instruments; and disposal of PCB materials. In addition to older electrical instruments and fluorescent lights that contain PCB-filled capacitors, caulking materials, elastic sealants, and heat insulation have also been known to contain PCBs. Contact with PCBs at hazardous waste sites can happen when workers breathe air and touch soil containing PCBs. Exposure in the contaminated workplace occurs mostly by breathing air containing PCBs and by touching substances that contain PCBs.

1.4 HOW CAN POLYCHLORINATED BIPHENYLS (PCBs) ENTER AND LEAVE MY BODY?

If you breathe air that contains PCBs, they can enter your body through your lungs and pass into the bloodstream. We do not know how fast or how much of the PCBs that are breathed will pass into the blood. A common way for PCBs to enter your body is by eating meat or fish products or other foods that contain PCBs. Exposure from drinking water is less than from food. It is also possible that PCBs can enter your body by breathing indoor air or by skin contact in buildings that have the kinds of old electrical devices that contain and can leak PCBs. For people living near waste sites or processing or storage facilities, and for people who work with or around PCBs, the most likely ways that PCBs will enter their bodies are from skin contact with contaminated soil and from breathing PCB vapors. Once PCBs are in your body, some may be changed by your body into other related chemicals called metabolites. Some metabolites of PCBs may have the potential to be as harmful as some unchanged PCBs. Some of the metabolites may leave your body in the feces in a few days, but others may remain in your body fat for months. Unchanged PCBs may also remain in your body and be stored for years mainly in the fat and liver, but smaller amounts can be found in other organs as well. PCBs collect in milk fat and can enter the bodies of infants through breast-feeding.

1.5 HOW CAN POLYCHLORINATED BIPHENYLS (PCBs) AFFECT MY HEALTH?

Many studies have looked at how PCBs can affect human health. Some of these studies investigated people exposed in the workplace, and others have examined members of the general population. Skin conditions, such as acne and rashes, may occur in people exposed to high levels of PCBs. These effects on the skin are well documented, but are not likely to result from exposures in the general population. Most of the human studies have many shortcomings, which make it difficult for scientists to establish a clear association between PCB exposure levels and health effects. Some studies in workers suggest that exposure to PCBs may also cause irritation of the nose and lungs, gastrointestinal discomfort, changes in the blood and liver, and depression and fatigue. Workplace concentrations of PCBs, such as those in areas where PCB transformers are repaired and maintained, are higher than levels in other places, such as air in buildings that have electrical devices containing PCBs or in outdoor air, including air at hazardous waste sites. Most of the studies of health effects of PCBs in the general population examined children of mothers who were exposed to PCBs. The possible health effects of PCBs in children are discussed in Section 1.6.

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Rats that ate food containing large amounts of PCBs for short periods of time had mild liver damage, and some died. Rats, mice, or monkeys that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia, acne-like skin conditions, and liver, stomach, and thyroid gland injuries. Other effects caused by PCBs in animals include reductions in the immune system function, behavioral alterations, and impaired reproduction. Some PCBs can mimic or block the action of hormones from the thyroid and other endocrine glands. Because hormones influence the normal functioning of many organs, some of the effects of PCBs may result from endocrine changes. PCBs are not known to cause birth defects. Only a small amount of information exists on health effects in animals exposed to PCBs by skin contact or breathing. This information indicates that liver, kidney, and skin damage occurred in rabbits following repeated skin exposures, and that a single exposure to a large amount of PCBs on the skin caused death in rabbits and mice. Breathing PCBs over several months also caused liver and kidney damage in rats and other animals, but the levels necessary to produce these effects were very high.

Studies of workers provide evidence that PCBs were associated with certain types of cancer in humans, such as cancer of the liver and biliary tract. Rats that ate commercial PCB mixtures throughout their lives developed liver cancer. Based on the evidence for cancer in animals, the Department of Health and Human Services (DHHS) has stated that PCBs may reasonably be anticipated to be carcinogens. Both EPA and the International Agency for Research on Cancer (IARC) have determined that PCBs are probably carcinogenic to humans.

1.6 HOW CAN POLYCHLORINATED BIPHENYLS (PCBs) AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

Children are exposed to PCBs in the same way as are adults: by eating contaminated food, breathing indoor air in buildings that have electrical devices containing PCBs, and drinking contaminated water. Because of their smaller weight, children's intake of PCBs per kilogram of body weight may be greater than that of adults. In addition, a child's diet often differs from that of adults. A Food and Drug Administration (FDA) study in 1991 estimated dietary intakes of PCBs for infants (6 months) and toddlers (2 years) of less than 0.001 and 0.002 μg/kg/day. Children who live near hazardous waste sites may accidentally eat some PCBs through hand-to-mouth behavior, such as by putting dirty hands or other soil/dirt covered objects in their mouths, or eating without washing their hands. Some children also eat dirt on purpose; this behavior is called pica. Children could also be exposed by playing with old appliances or electrical devices that contain PCBs.

It is possible that children could be exposed to PCBs following transport of the chemical on clothing from the parent's workplace to the home.

House dust in homes of workers exposed to PCBs contained higher than average levels of PCBs. PCBs have also been found on the clothing of firefighters following transformer fires. The most likely way infants will be exposed is from breast milk that contains PCBs. Fetuses in the womb are also exposed from the exposed mother.

In one study of women exposed to relatively high concentrations of PCBs in the workplace during pregnancy, their babies weighed slightly less at birth than babies born to women exposed to lower concentrations of PCBs. Studies of women who consumed high amounts of fish contaminated with PCBs and other chemicals also had babies that weighed less than babies from women who did not eat fish. Similar observations have been made in some studies of women with no known high exposure to PCBs, but not all studies have confirmed these findings. Babies born to women who ate fish contaminated with PCBs before and during pregnancy showed abnormal responses to tests of infant behavior. Some of these behaviors, such as problems with motor skills and a decrease in short-term memory, persisted for several years. However, in these studies, the women may have been exposed to other chemicals. Other studies suggest that the immune system may be affected in children born to and nursed by mothers exposed to increased levels of PCBs. There are no reports of structural birth defects in humans caused by exposure to PCBs or of health effects of PCBs in older children. It is not known whether PCB exposure can cause in skin acne and rashes in children as occurs in some adults, although it is likely that the same effects would occur at very high PCB exposure levels.

Animal studies have shown harmful effects in the behavior of very young animals when their mothers were exposed to PCBs and they were exposed in the womb or by nursing. In addition, some animal studies suggest that exposure to PCBs causes an increased incidence of prenatal death and changes in the immune system, thyroid, and reproductive organs. Studies in monkeys showed that young animals developed skin effects from nursing after their mothers were exposed to PCBs. Some studies indicate that very high doses of PCBs may cause structural birth defects in animals.

Children can be exposed to PCBs both prenatally and from breast milk. PCBs are stored in the mother's body and can be released during pregnancy, cross the placenta, and enter fetal tissues. Because PCBs dissolve readily in fat, they can accumulate in breast milk fat and be transferred to babies and young children. PCBs have been measured in umbilical cord blood and in breast milk. Some studies have estimated that an infant who is breast fed for 6 months may accumulate in this period 6–12% of the total PCBs that will accumulate during its lifetime. However, in most cases, the benefits of breast-feeding outweigh any risks from exposure to PCBs in mother's milk. You should consult your health care provider if you have any concerns about PCBs and breast feeding. Because the brain, nervous system, immune system, thyroid, and reproductive organs are still developing in the fetus and child, the effects of PCBs on these target systems may be more profound after exposure during the prenatal and neonatal periods, making fetuses and children more susceptible to PCBs than adults.

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1.7 HOW CAN FAMILIES REDUCE THEIR RISK OF EXPSOURE TO POLYCHLORINATED BIPHENYLS (PCBs)?

If your doctor finds that you have been exposed to significant amounts of polychlorinated biphenyls, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

You and your children may be exposed to PCBs by eating fish or wildlife caught from contaminated locations. Certain states, Native American tribes, and U.S. territories have issued fish and wildlife advisories to warn people about PCB-contaminated fish and fish-eating wildlife. These advisories will tell you what types and sizes of fish and game animals are of concern. An advisory may completely ban eating fish or game or tell you to limit your meals of a certain fish or game type. For example, an advisory may tell you not to eat a certain type of fish or game more than once a month. The advisory may tell you only to eat certain parts of the fish or game and how to prepare or cook the fish or game to decrease your exposure to PCBs. The fish or wildlife advisory may have special restrictions to protect pregnant women, nursing mothers, and young children. To reduce your children's exposure to PCBs, obey these advisories. Additional information on fish and wildlife advisories for PCBs, including states that have advisories, is provided in Chapter 6 (Section 6.7) and Chapter 8 of the toxicological profile. You can consult your local and state health departments or state natural resources department on how to obtain PCB advisories, as well as other important information, such as types of fish and wildlife and the locations that the advisories apply to.

Children should be told that they should not play with old appliances, electrical equipment, or transformers, since they may contain PCBs. Children who live near hazardous waste sites should be discouraged from playing in the dirt near these sites and should not play in areas where there was a transformer fire. In addition, children should be discouraged from eating dirt, and careful handwashing practices should be followed.

As mentioned in Section 1.3 of the profile, workplace exposure to PCBs can still occur during repair and maintenance of old PCB transformers; accidents, fires, or spills involving these transformers or other PCB-containing items; and disposal of PCB materials. If you are exposed to PCBs in the workplace, it may be possible to carry them home from work. Your occupational health and safety officer at work can tell you whether the chemicals you work with may contain PCBs and are likely to be carried home on your clothes, body, or tools. If this is the case, you should shower and change clothing before leaving work, and your work clothes should be kept separate from other clothes and laundered separately.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO POLYCHLORINATED BIPHENYLS (PCBs)?

Levels of PCBs in the environment were zero before PCBs were manufactured. Now, all people in industrial countries have some PCBs in their bodies. There are tests to determine whether PCBs are in the blood, body fat, and breast milk. These are not regular or routine clinical tests, such as the one for cholesterol, but could be ordered by a doctor to detect PCBs in people exposed to them in the environment and at work. If your PCB levels are higher than the background levels, this will show that you have been exposed to high levels of PCBs. However, these measurements cannot determine the exact amount or type of PCBs that you have been exposed to, or how long you have been exposed. Although these tests can indicate whether you have been exposed to PCBs to a greater extent than the general population, they do not predict whether you will develop harmful health effects. Blood tests are the easiest, safest, and probably the best method for detecting recent exposures to large amounts of PCBs. Results of such tests should be reviewed and carefully interpreted by physicians with a background in environmental and occupational medicine. Nearly everyone has been exposed to PCBs because they are found throughout the environment, and people are likely to have detectable amounts of PCBs in their blood, fat, and breast milk. Recent studies have shown that PCB levels in tissues from United States population are now declining.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health . Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors. Recommendations and regulations are periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for PCBs include the following:

The EPA standard for PCBs in drinking water is 0.5 parts of PCBs per billion parts (ppb) of water. For the protection of human health from the possible effects of drinking the water or eating the fish or shellfish from lakes and streams that are contaminated with PCBs, the EPA regulates that the level of PCBs in these waters be no greater than 0.17 parts of PCBs per trillion parts (ppt) of water. States with fish and wildlife consumption advisories for PCBs are identified in Chapter 6 (Section 6.7) and Chapter 8 of the toxicological profile.

The FDA has set residue limits for PCBs in various foods to protect from harmful health effects. FDA required limits include 0.2 parts of PCBs per million parts (ppm) in infant and junior foods, 0.3 ppm in eggs, 1.5 ppm in milk and other dairy

Appendix E

The ATSDR Health Effects Evaluation Process

The ATSDR Health Effects Evaluation Process

The ATSDR health effects evaluation process consists of two steps: a screening analysis, and at some sites, based on the results of the screening analysis and community health concerns, a more in-depth analysis to determine possible public health implications of site-specific exposure estimates.

In evaluating data, ATSDR uses comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific medium (soil, water, or air) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water and soil that someone may inhale or ingest each day.

The two step screening analysis process provides a consistent means to identify site contaminants that need to be evaluated more closely through the use of "comparison values" (CVs). The first step of the screening analysis is the "environmental guideline comparison" which involves comparing site contaminant concentrations to medium-specific comparison values derived by ATSDR from standard exposure default values. The second step is the "health guideline comparison" and involves looking more closely at site-specific exposure conditions, estimating exposure doses, and comparing them to dose-based health-effect comparison values.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. CVs are not thresholds of toxicity and do not predict adverse health effects. CVs serve only as guidelines to provide an initial screen of human exposure to substances. Contaminant concentrations at or below the relevant CV may reasonably be considered safe, but it does not automatically follow that any environmental concentration that exceeds a CV would be expected to produce adverse health effects. Different CVs are developed for cancer and non-cancer health effects. Non-cancer levels are based on validated toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds) and adults are exposed every day. Cancer levels are the media concentrations at which there could be a one additional cancer in a one million person population (one in a 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 non-cancer CVs exist, the lower level is used to be protective. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

After completing a screening analysis, site contaminants are divided into two categories. Those not exceeding CVs usually require no further analysis, and those exceeding CVs are selected for a more in-depth analysis to evaluate the likelihood of possible harmful effects.

The North Carolina Department of Public Health (N.C. DPH) uses the following screening values for public health assessments:

1. **Environmental Media Evaluation Guide (EMEG):** EMEGs are estimated contaminant concentrations in water, soil or air to which humans may be exposed over specified time periods and are not expected to result in adverse non-cancer health effects. EMEGs are

based on ATSDR "minimum risk levels" (MRLs) and conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.

2. **Reference Dose Media Evaluation Guides (RMEGs):** RMEGs represent concentrations of substances in water and soil to which humans may be exposed over specified time periods without experiencing non-cancer adverse health effects. The RMEG is derived from the U.S. Environmental Protection Agency's (EPA's) oral reference dose (RfD).

3. **Cancer Risk Evaluation Guide (CREG**): CREGs are estimated media-specific contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a 70-year lifetime. CREGs are calculated from EPA's cancer slope factors (CSFs) or inhalation unit risk (IUR) values.

4. **Maximum Contaminant Levels (MCL):** A Federal Maximum Contaminant Level (MCL) is the regulatory limit set by EPA that establishes the maximum permissible level of a contaminant in water that is deliverable to the user of a public water system. MCLs are based on health data, also taking into account economic and technical feasibility to achieve that level. (ATSDR 2005a)

5. **EPA Regional Screening Levels (RSL):** "Regional Screening Levels for Chemical Contaminants at Superfund Sites" are tables of risk-based screening levels, calculated using the latest toxicity values, default exposure assumptions and physical and chemical properties. The Regional Screening table was developed with input from EPA Regions III, VI, and IX in an effort to improve consistency and incorporate updated guidance. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)

Contaminant concentrations exceeding the appropriate CVs are further evaluated against ATSDR health guidelines. N.C. DPH also retains for further assessment contaminants that are known or suspected to be cancer-causing agents. To determine exposure dose, N.C. DHHS uses standard assumptions about body weight, ingestion or inhalation rates, and duration of exposure. Important factors in determining the potential for adverse health effects also include the concentration of the chemical, the duration of exposure, the route of exposure, and the health status of those exposed. Site contaminant concentrations and site-specific exposure conditions are used to make conservative estimates of site-specific exposure doses for children and adults that are compared to ATSDR health guidelines (HGs), generally expressed as Minimal Risk Levels (MRLs). An exposure dose (generally expressed as milligrams of chemical per kilogram of body weight per day or "mg/kg/day") is an estimate of how much of a substance a person may come into contact based on their actions and habits. Exposure dose calculations are based on the following assumptions as outlined by the ATSDR (ATSDR 2005a):

- Children between the ages of 1 and 6 ingest an average of 1 liter of water per day
- Children weigh an average of 15 kilograms
- Infants weigh an average of 10 kilograms
- Adults ingest an average of 2 liters of water per day
- Adults weigh an average of 70 kilograms

Ingestion of contaminants

Exposure doses for ingestion of contaminants are calculated using the concentrations of contaminants in milligrams per kilogram (mg/kg [mg/kg = ppm]). The following equation is used to estimate the exposure doses resulting from ingestion:

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

Where:

ED_s	=	exposure dose (mg/kg/day)
C	=	contaminant concentration (mg/kg)
IR	=	intake rate of contaminated medium (kilograms/day)
EF	=	exposure factor (unitless)
BW	=	body weight (kilograms)

The exposure factor is an expression of how often and how long a person may contact a substance in the environment. The exposure factor is calculated with the following general equation:

$$EF = \frac{F \times ED}{AT}$$

Where:

F	=	frequency of exposure (days/year)
ED	=	exposure duration (years)
AT	=	averaging time (ED x 365 days/year)

Health guidelines represent daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during the specified exposure duration. The potential for adverse health effects exists under the representative exposure conditions if the estimated site-specific exposure doses exceed the health guidelines and they are retained for further evaluation. A MRL is an estimate of daily human exposure to a substance (in milligrams per kilogram per day [mg/kg/day] for oral exposures) that is likely to be without non-cancer health effects during a specified duration of exposure. Exposures are based on the assumption a person is exposed to the maximum concentration of the contaminant with a daily occurrence.

Generally, site-specific exposure doses that do not exceed screening values are dropped from further assessment. Exposure doses that exceed MRLs, or are known or suspected cancer-causing agents, are carried through to the health-effects evaluation. The health-effects evaluation includes an in-depth analysis examining and interpreting reliable substance-specific health effects data (toxicological, epidemiologic, medical, and health outcome data) related to dose-response relationships for the substance and pathways of interest. The magnitude of the public health issue may be estimated by comparing the estimated exposures to “no observed” (NOAELs) and “lowest observed” (LOAELs) adverse effect levels in animals and in humans, when available.

ATSDR's toxicological profiles serve as the primary source of the health-effects data. Other sources of toxicological data include EPA's Integrated Risk Information System (IRIS) database, International Agency for Research on Cancer (IARC) Monographs, and the National Toxicology Program (NTP). Standard toxicology textbooks and peer-reviewed scientific journals of environmental toxicology or environmental health can also be consulted.

Theoretical increased numbers of cancers are calculated for known or suspected cancer-causing contaminants using the estimated site-specific exposure dose and cancer slope factor (CSF) provided in ATSDR health guideline documents.

Cancer risk is calculated using the equation:

$$\text{Lifetime risk} = \text{exposure} \times \text{cancer potency}$$

Where,

exposure = total exposure to a contaminant (mg/kg/d)
cancer potency = upper bound lifetime cancer risk per mg/kg/d

This theoretical calculation is based on the assumption there is no safe level of exposure to a chemical that causes cancer. However, the theoretical calculated risk is not exact and tends to overestimate the actual risk associated with exposures that may have occurred. This theoretical increased cancer risk estimate does not equal the increased number of cancer cases that will actually occur in the exposed population, but estimates a theoretical excess cancer risk expressed as the proportion of a population that may be affected by a carcinogen during a lifetime or other selected period of exposure. For example, an estimated cancer risk of 1×10^{-4} predicts the probability of one additional cancer over the background number of cancers in a population of 10,000. (The expected numbers of cancers in a population of 10,000 is approximately 3,300.) Qualitative assessment of the predicted increased numbers of cancers is also used, and represents terminology suggested by ATSDR and N.C. DPH.

Theoretical Increased Number of Cancers Qualitative Assessment Categories Utilized by N.C. DPH

Per population of	No Increased Risk	No Apparent Increased Risk	"Low"	"Moderate"	"High"	"Very High"
10,000	---	---	<1	1 to 9	10 to 100	>100
100,000	---	<1	1 to 9	10 to 99	100 to 1,000	>1,000
1,000,000	<1	<1 to 10	10 to 99	100 to 999	1,000 to 10,000	>10,000

Notes: "Low" theoretical increased number of cancers = 0.01%, and "Very High" = 1% increase over expected number of cancer cases in a typical population (approximately 33%)

Uncertainties are inherent in the public health assessment process. These uncertainties fall into the following categories: 1) the imprecision of the risk assessment process, 2) the incompleteness of the information collected and used in the assessment, and 3) the differences in opinion as to the implications of the information. These uncertainties are addressed in public health assessments by using worst-case assumptions when estimating or interpreting health risks. The health assessment calculations and screening values also incorporate safety margins. The assumptions, interpretations, and recommendations made throughout this public health assessment err in the direction of protecting public health.

Assessment of Chemical Interactions

To evaluate the risk for noncancerous effects in a mixture, ATSDR's guidance manual (*Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures*, 2004) prescribes the calculation of a hazard quotient (HQ) for each chemical. The HQ is calculated using the following formula:

$$HQ = \text{estimated dose} \div \text{applicable health guideline}$$

Generally, whenever the HQ for a chemical exceeds 1, concern for the potential hazard of the chemical increases. Individual chemicals that have HQs less than 0.1 are considered unlikely to pose a health hazard from interactions and are eliminated from further evaluation. If all of the chemicals have HQs less than 0.1, harmful health effects are unlikely, and no further assessment of the mixture is necessary. If two or more chemicals have HQs greater than 0.1, then these chemicals are to be evaluated further as outlined below.

Since the HQ is greater than 1 for both adults and children the hazard index (HI) will be calculated. The HQ for each chemical then is used to determine the (HI) for the mixture of chemicals. An HI is the sum of the HQs and is calculated as follows:

$$HI = HQ_1 + HQ_2 + HQ_3 + \ldots HQ_n$$

The HI is used as a screening tool to indicate whether further evaluation is needed. If the HI is less than 1.0, significant additive or toxic interactions are highly unlikely, so no further evaluation is necessary. If the HI is greater than 1.0, then further evaluation is necessary, as described below.

For chemical mixtures with an HI greater than 1.0, the estimated doses of the individual chemicals are compared with their NOAELs or comparable values. IF the dose of one or more of the individual chemicals is within one order of magnitude of its respective NOAEL (0.1 x NOAEL), then potential exists for additive or interactive effects. Under such circumstances, an in-depth mixtures evaluation should proceed as described in ATSDR's *Guidance Manual for the Assessment of Joint Action of Chemical Mixtures*.

If the estimated doses of the individual chemicals are less than 1/10 of their respective NOAELs, then significant additive or interactive effects are unlikely, and no further evaluation is necessary.

Reference:
(Andelman 1990). *Total Exposure of Volatile Organic Compounds in Potable Water*. In: Significance and Treatment of Volatile Organic Compounds in Water Supplies, Chapter 20. Lewis Publishers, Chelsea, MI.

Appendix F

ATSDR Glossary

Glossary

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

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

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

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

The Agency for Toxic Substances and Disease Registry (ATSDR)
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.

Aroclor
Trade name used in USA for PCB mixtures (see PCBs) made up of different structurally related chemicals called PCB congeners. PCB analyses may be reported as Aroclor mixtures represented by a numbering system that differentiates the various mixtures based on their component chemicals, such as "Aroclor 1242" or "Aroclor 1260".

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

Bioaccumulation
The net uptake of chemicals from the environment from all sources. The process whereby certain toxic substances collect in living tissues potentially posing a hazard to human health or the environment. A general term for the accumulation of substances, such as some metals or organic chemicals, in an organism. The accumulation process involves the biological sequestering of substances that enter the organism through respiration, food intake, or skin contact. The sequestering results in the organism having a higher concentration of the substance than the concentration in the organism's surrounding environment. The level at which a given substance is bioaccumulated depends on the rate of uptake, the mode of uptake (through the gills of a fish, ingested along with food, contact with skin) how quickly the substance is eliminated from the organism, transformation of the substance by metabolic processes, the lipid (fat) content of the organism, the chemical nature of the substance, environmental factors, and other biological and physical factors. As a rule the more hydrophobic (oil-like) a substance is the more likely it is to bioaccumulate in organisms, such as fish. Generally, the more lipid-like (fat-like) a chemical, the greater the potential for it to bioaccumulate. (USEPA, http://toxics.usgs.gov/definitions/bioaccumulation.html).

Biomagnification
The bioaccumulation of a substance up the food chain by transfer of residues of the substance in smaller organisms that are food for larger organisms. It generally refers to the sequence of processes that result in higher concentrations in organisms at higher levels in the food chain (at higher trophic levels). These processes result in an organism having higher concentrations of a substance than is present in the organism's food. Biomagnification can result in higher concentrations of the substance than would be expected if water were the only exposure mechanism. Accumulation of a substance only through contact with water is known as bioconcentration.

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

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

Cancer slope factor (CSF)
An estimate of possible increases in cancer cases in a population. A CSF is expressed in does units [$(mg/kg/d)^{-1}$] to allow comparison with calculated oral doses.

Carcinogen
A substance that causes cancer.

Chronic
Occurring over a long time.

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year).

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Congener
Congener is a term in chemistry that refers to one of many variants or configurations of a common chemical structure. See PCBs.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated

water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Environmental media

Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism

Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA

United States Environmental Protection Agency.

Exposure

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

Exposure pathway

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

Food chain

The feeding of one organism upon another in a sequence of food transfers. The system of feeding (trophic) levels found in a biological community, such as a lake. Members of one level feed upon the members of the level below and in turn are eaten by the members of the level above. See trophic level.

Hazard

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

Hazardous waste

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

Health consultation

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

Health education

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

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

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

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

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

Maximum Contaminant Level (MCL)
The highest level of a contaminant that EPA allows in drinking water. MCLs ensure that drinking water does not pose either a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible. Some states set MCLs which are more strict than EPA's.

Method reporting limit
The MRL is the lowest reported concentration, provided on the sample-analysis data report, after corrections have been made for sample dilution, sample weight, and (for soils and sediments) amount of moisture in the sample.

mg/kg
Milligram per kilogram.

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

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or **NPL)**
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

PAHs (polycyclic aromatic hydrocarbons or polynuclear aromatic hydrocarbons)
Exposure to polycyclic aromatic hydrocarbons usually occurs by breathing air contaminated by wild fires or coal tar, or by eating foods that have been grilled. PAHs have been found in at least 600 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA). Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot. Some PAHs are manufactured. These pure PAHs usually exist as colorless, white, or pale yellow-green solids. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in

medicines or to make dyes, plastics, and pesticides. Mice that were fed high levels of one PAH during pregnancy had difficulty reproducing and so did their offspring. These offspring also had higher rates of birth defects and lower body weights. It is not known whether these effects occur in people. Animal studies have also shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure. However, these effects have not been seen in people. The US Department of Health and Human Services (US DHHS) has determined that some PAHs may reasonably be expected to be carcinogens. Some people who have breathed or touched mixtures of PAHs and other chemicals for long periods of time have developed cancer. Some PAHs have caused cancer in laboratory animals when they breathed air containing them (lung cancer), ingested them in food (stomach cancer), or had them applied to their skin (skin cancer). (ATSDR ToxFAQs™ Polycylclic Aromatic Hydrocarbons (PAHs), http://www.atsdr.cdc.gov/)

PCBs (polychlorinated biphenyls)

Polychlorinated biphenyls (PCBs) are a mixture of individual chemicals, which are no longer produced in the United States, but are still found in the environment. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs are known to cause cancer in animals. Polychlorinated biphenyls are mixtures of up to 209 individual chlorinated compounds (known as **congeners**). There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the U.S. by the trade name **Aroclor**. PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they do not burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils. Few studies of workers indicate that PCBs were associated with certain kinds of cancer in humans, such as cancer of the liver and biliary tract. Rats that ate food containing high levels of PCBs for two years developed liver cancer. The US Department of Health and Human Services (US DHHS) has concluded that PCBs may reasonably be anticipated to be carcinogens. The EPA and the International Agency for Research on Cancer (IARC) have determined that PCBs are probably carcinogenic to humans. (ATSDR ToxFAQs™ Polychlorinated Biphenyls (PCBs), http://www.atsdr.cdc.gov/)

Point of exposure

The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population

A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)

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

ppb

Parts per billion.

ppm
Parts per million.

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

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

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

Risk
The probability that something will cause injury or harm.

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

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

Screening values
Screening values intended to be protective of human health and/or the environment are often defined as chemical concentrations in environmental media below which no additional attention is warranted. If chemical concentrations at a site exceed the screening values, then additional investigation or evaluation of that chemical is warranted. Risk-based screening values are derived from equations combining exposure assumptions with toxicity data. Also called comparison values by some programs. Screening values are specific to a matrix and are available for soil, sediment, air, water and for some plants and animals.

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

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

Substance
A chemical.

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

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

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

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

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

Trophic level
Trophic levels are the broad classes of organisms within an ecosystem (such as a freshwater lake) characterized by their feeding mode and position within the food chain. Members of one level feed upon the members of the level below and in turn are eaten by the members of the level above. See food chain.

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

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

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