PUBLIC HEALTH ASSESSMENT
Evaluation of Current (1990 to 2003) and Future Chemical Exposures in the Vicinity of the Oak Ridge Reservation

U. S. Department of Energy Oak Ridge Reservation
Oak Ridge, Anderson County, Tennessee
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Prepared by:

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

Foreword

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

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

Exposure

As the first step in the evaluation, ATSDR scientists review environmental data to see what chemicals are present, where the chemicals were found, and how people might come into contact with the chemicals. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When environmental data do not allow ATSDR to fully evaluate exposure, the report will indicate what further sampling data are needed.

Health Effects

If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these exposures may result in harmful effects. ATSDR recognizes that developing fetuses, infants, and children can be more sensitive to exposures than are adults. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable than adults. Thus, the health impact to the children is considered first when evaluating exposure and the potential adverse effects to a community. The health impacts to other groups within the community (such as the elderly, chronically ill, and people engaging in high-exposure practices) also receive special attention during the evaluation.

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

Conclusions

This report presents conclusions about the public health threat, if any, posed by a site. Any health threats that have been determined for high-risk groups (such as children, the elderly, chronically ill people, and people engaging in high-risk practices) are summarized in the Conclusions section of the report. Ways to stop or reduce exposure are recommended in the Public Health Action Plan section.

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

Community

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

Comments

If, after reading this report, you have questions or comments, we encourage you to send them to us. Letters should be addressed as follows:

Attention: Aaron Borrelli
Manager, ATSDR Records Center
Agency for Toxic Substances and Disease Registry
1600 Clifton Rd. (E-60)
Atlanta, GA 30333

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Acronyms

AI	adequate intake
AMRL	acute minimal risk level
ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control and Prevention
CDD	chlorinated dibenzo-p-dioxin
CEL	cancer effect level
CEMEG	chronic environmental media evaluation guide
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMRL	chronic minimal risk level
CREG	cancer risk evaluation guide
CSF	cancer slope factor
CV	comparison value
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DOE	U.S. Department of Energy
DRI	dietary reference intake
EFPC	East Fork Poplar Creek
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
FAMU	Florida Agriculture and Mechanical University
FDA	U.S. Food and Drug Administration
HCDD	hexachlorodibenzo-p-dioxin
HCH	hexachlorocyclohexane
IEMEG	intermediate environmental media evaluation guide
IMRL	intermediate minimal risk level
IRIS	Integrated Risk Information System
L/day	liters per day
LOAEL	lowest-observed-adverse-effect level
LTHA	lifetime health advisory
MCLG	maximum contaminant level goal
MCPA	2-methyl-4-chlorophenoxyacetic acid
MCPP	2-(2-methyl-4-chlorophenoxy) propionic acid
MRL	minimal risk level
mg/day	milligram per day
mg/kg	milligram per kilogram
mg/kg/day	milligram per kilogram per day
mg/L	milligram per liter
NAAQS	national ambient air quality standard
NAS	National Academy of Sciences
NOAEL	no-observed-adverse-effect level
NPL	National Priorities List
NTIS	National Technical Information Service
OREIS	Oak Ridge Environmental Information System
ORR	Oak Ridge Reservation

ORRHES	Oak Ridge Reservation Health Effects Subcommittee
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PHA	public health assessment
PHAWG	public health assessment work group
ppb	parts per billion
ppm	parts per million
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RDA	recommended dietary allowance
RfD	reference dose
RMEG	reference dose media evaluation guide
TCDD	tetrachlorodibenzo-p-dioxin
TDEC	Tennessee Department of Environment and Conservation
TDOH	Tennessee Department of Health
TEF	toxic equivalency factor
TEQ	toxic equivalent
TSCA	Toxic Substances Control Act
µg/day	microgram per day
µg/dL	microgram per deciliter
µg/L	microgram per liter
µg/m^3	micrograms per cubic meter
WBR	Watts Bar Reservoir
WHO	World Health Organization

I. Summary

In 1942, the federal government established the Oak Ridge Reservation (ORR) in Anderson and Roane Counties in Tennessee as part of the Manhattan Project to research, develop, and produce special nuclear materials for nuclear weapons. In 1989, the ORR was added to the U.S. Environmental Protection Agency's (EPA's) National Priorities List because over the years, ORR operations have generated a variety of radioactive and nonradioactive wastes that are present in old waste sites or that have been released to the environment. The U.S. Department of Energy (DOE) is cleaning up the ORR under a Federal Facility Agreement with EPA and the Tennessee Department of Environment and Conservation (TDEC). DOE, EPA, and TDEC are working together to investigate and remediate site-related chemical releases and waste sites from past and present activities at the site.

Since 1992, the Agency for Toxic Substances and Disease Registry (ATSDR) has responded to requests and addressed health concerns of community members, civic organizations, and other government agencies by working extensively to determine whether levels of environmental contamination at and near the ORR present a public health hazard to communities surrounding the ORR. ATSDR has identified and evaluated several public health issues and has worked closely with many parties. ATSDR is the principal federal public health agency charged with evaluating human health effects of exposure to hazardous substances in the environment. Whereas the Tennessee Department of Health (TDOH) conducted the Oak Ridge Health Studies to evaluate whether off-site populations have been exposed in the past, ATSDR's activities have focused on current public health issues related to Superfund cleanup activities at the site.

To expand on the efforts of TDOH, ATSDR scientists conducted a review and a screening analysis of TDOH's Phase I and Phase II screening-level evaluation of past exposure (1944 to 1990) to identify contaminants of concern for further evaluation. Based on this review, ATSDR scientists have completed or are conducting public health assessments (PHAs) on iodine 131 releases from the X-10 site, mercury releases from the Y-12 plant, polychlorinated biphenyls (PCBs), radionuclide releases from White Oak Creek, uranium releases from the Y-12 plant, uranium and fluoride releases from the K-25 site, and other topics such as contaminant releases from the Toxic Substances Control Act (TSCA) Incinerator and contaminated off-site groundwater. In conducting these PHAs, ATSDR scientists evaluate and analyze the information and findings from previous studies and investigations to assess the public health implications of past and current exposure. This PHA documents ATSDR's screening of recent (1990 to 2003)[1] environmental data, addresses whether additional chemicals require further evaluation, and discusses the public health implications related to potential exposures. PCBs and mercury, as well as the groundwater pathway, are not addressed in this PHA; these topics are being evaluated individually in separate PHAs.

According to the information reviewed for this PHA, ATSDR concludes that current and future exposures to ORR site-related chemicals (individually or in combination) in soil, sediment, surface water, biota (other than fish), and air do not pose a public health hazard. Very limited "dioxin" data exist for fish; therefore, ATSDR cannot determine whether exposure to dioxins in

[1] Data from before 1990 were evaluated during TDOH's past screening evaluation. Because ATSDR began the current screening evaluation in 2003, this was used as the cut-off year for "current" data.

fish poses a public health hazard. The available data on dioxins in fish are for fish of an unidentified species from a pond near the K-25 site. In the absence of additional data on dioxins in fish near the ORR, ATSDR recommends following the current State of Tennessee fish advisories. Following current fish advisories will reduce exposure to contaminants in fish.

II. Background

II.A. Site Description

In 1942, the federal government established the Oak Ridge Reservation (ORR) in Anderson and Roane Counties in Tennessee as part of the Manhattan Project to research, develop, and produce special radioactive materials for nuclear weapons (ChemRisk 1993a; TDOH 2000). Four facilities were built at that time. The Y-12 plant, the K-25 site, and the S-50 site were created to enrich uranium. The X-10 site was created to demonstrate processes for producing and separating plutonium (TDOH 2000). The Clinch River forms the southern and western boundaries of the reservation, and most of the property is within the Oak Ridge city limits (EUWG 1998). (See Figure 1 for the location of the ORR.)

When the federal government acquired the ORR in 1942, the reservation consisted of 58,575 acres (91.5 square miles). Since that time, the federal government has transferred 24,340 acres (38.0 square miles) to other parties, such as the city of Oak Ridge and the Tennessee Valley Authority. The U.S. Department of Energy (DOE) continues to control the remaining 34,235 acres (53.5 square miles) (ORNL 2002). Most of the contamination is located at the three main facilities. These areas are heavily guarded and fenced, and access to them requires a clearance badge.

II.B. Operational History

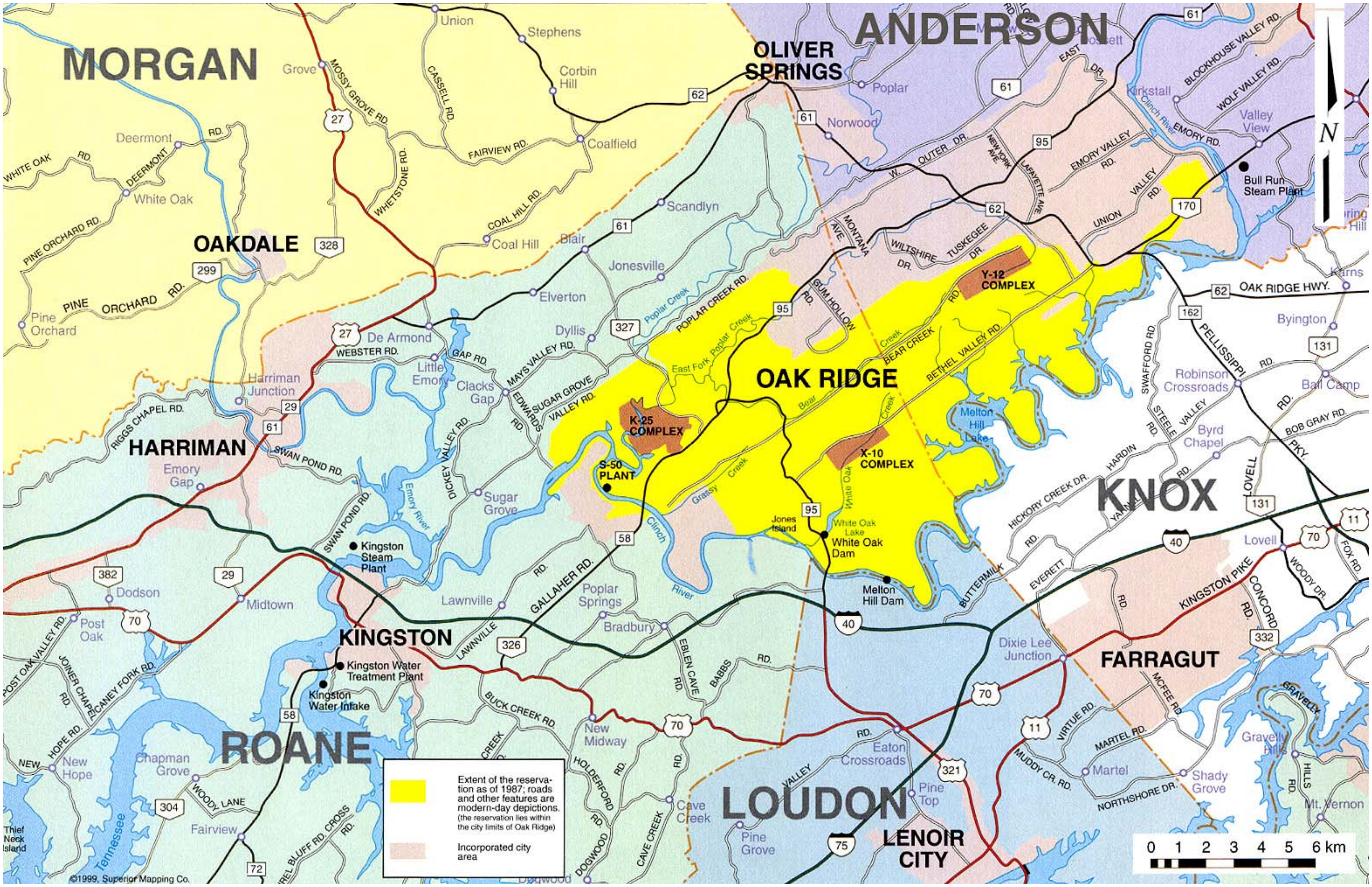
Y-12 Plant

The Y-12 plant was built in 1943 to house equipment for electromagnetically enriching uranium. The atomic bomb that was dropped in Hiroshima, Japan, contained uranium produced at the Y-12 plant (TDOH 2000). In 1952, the Y-12 facilities were converted to fabricate nuclear weapon components (ChemRisk 1999). During the Cold War, a column-exchange process (Colex) that used large quantities of mercury as an extraction solvent to enrich lithium in lithium 6 was built and operated (TDOH 2000). At the end of the Cold War, the Y-12 missions were curtailed. In 1992, the major focus of the Y-12 plant was the remanufacture of nuclear weapon components and the dismantlement and storage of strategic nuclear materials from retired nuclear weapons systems. The Y-12 plant is now known as the Y-12 National Security Complex and is primarily used for disassembling nuclear weapons and for storing highly enriched uranium (TDOH 2000).

X-10 Site

The X-10 site (formerly known as the Clinton Laboratories and now part of what is referred to as the Oak Ridge National Laboratory) was built in 1943, as a pilot plant to produce and separate plutonium. The government had intended to operate the facility for only 1 year; however, operations were continued and expanded (ChemRisk 1993a; TDOH 2000). Over time, operations at the X-10 site grew to include non-weapons-related activities, such as nuclear fission product separation, nuclear reactor safety and development, and radionuclide production for worldwide use in the medical, industrial, and research fields. Today, the Oak Ridge National Laboratory receives worldwide recognition as a facility for research and development in several areas of science and technology (ChemRisk 1993a). In addition, the Oak Ridge National Laboratory produces numerous radioactive isotopes that have significant uses in medicine and research (TDEC 2002).

Figure 1. Location of the Oak Ridge Reservation



Source: ChemRisk 1999

K-25 Site

From 1945 to 1964, the main objective of the K-25 site (formerly known as the Oak Ridge Gaseous Diffusion Plant) was to use gaseous diffusion to enrich weapons-grade uranium (ChemRisk 1999; EPA 2002a). From 1965 to 1985, the site used uranium hexafluoride in the gaseous diffusion process to manufacture commercial-grade uranium (EUWG 1998). All gaseous diffusion operations ceased at the site in 1985 (ChemRisk 1993a; ORHASP 1999). Since the K-25 site was officially closed in 1987, many activities have been conducted to clean up wastes and to restore the environment around the site. Since 1996, reindustrialization has been the focus of the K-25 site, which has been renamed the East Tennessee Technology Park (ORHASP 1999; TDOH 2000). The site also maintains the Toxic Substances and Control Act (TSCA) Incinerator, which is the only facility in the country authorized to incinerate wastes with radioactive and hazardous contaminants that contain polychlorinated biphenyls (PCBs) (TDEC 2002).

S-50 Site

Construction of the former S-50 liquid thermal diffusion plant began on June 6, 1944, and operations were underway by October 1944. The purpose of the plant was to assess the financial and scientific feasibility of separating uranium 235 from uranium 238 through liquid thermal diffusion. Because of several equipment malfunctions and contaminant releases to the Clinch River and to the air, the plant operated for less than a year and was closed in September 1945 (ChemRisk 1999). Because all of the facility's buildings were destroyed and buried in 1946, there are no physical remains of the S-50 site (ChemRisk 1999; TDEC 2002).

II.C. Remedial and Regulatory History

Because ORR operations have generated a variety of radioactive and chemical wastes, the ORR was added to U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL) in 1989 (EPA 2002b). DOE is conducting cleanup activities at the ORR under a Federal Facility Agreement, which is an interagency agreement with EPA and the Tennessee Department of Environment and Conservation (TDEC). This agreement allows for input from the public. These parties are working together to investigate and remediate hazardous waste from past and present activities at the site. DOE is integrating required measures from the Resource Conservation and Recovery Act (RCRA) with response actions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

> The Federal Facility Agreement, which was implemented on January 1, 1992, is a legally binding agreement that established timetables, procedures, and documentation for remedial actions at the ORR. The Federal Facility Agreement is available online at http://www.bechteljacobs.com/ettp_ffa.shtml.

Contaminants such as uranium and mercury are present in old waste sites, which occupy 5 to 10 percent of the ORR. The abundant rainfall (an annual average of 55 inches) and high water tables (for example, 0 to 20 feet below ground surface) on the reservation contribute to leaching of these contaminants, resulting in contaminated soil, surface water, sediments, and groundwater (EUWG 1998).

Since 1986 (when initial cleanup activities commenced), DOE has initiated approximately 50 response actions under the Federal Facility Agreement that address contamination and disposal issues on the reservation. To consolidate investigation and remediation of environmental contamination, the contaminated areas were divided into five large tracts of land, generally associated with the major hydrologic watersheds (EUWG 1998). The annual *Remediation Effectiveness Reports for the U.S. Department of Energy Oak Ridge Reservation* documents the progress of ongoing remedial actions and future planned actions at the site (e.g., SAIC 2004). The Remediation Effectiveness Reports are available at the DOE Information Center.

II.D. Land Use and Natural Resources

The ORR currently occupies a little over 34,000 acres. The three major DOE installations—the East Tennessee Technology Park (formerly the K-25 site and the Oak Ridge Gaseous Diffusion Plant), the Oak Ridge National Laboratory (formerly the X-10 site), and the Y-12 National Security Complex (formerly the Y-12 plant)—occupy about 30 percent of that acreage. The remaining 70 percent was established as a National Environmental Research Park in 1980, to provide protected land for environmental science research and education, and to demonstrate that energy technology development can coexist with a quality environment. Large portions of the reservation have grown into full forests over the past several decades. Some of this land includes areas known as "deep forest" that contain ecologically significant flora and fauna; portions of the ORR are considered to be biologically rich (SAIC 2002).

The ORR also includes an area set aside for residential, commercial, and support services. The city of Oak Ridge, created in 1942 to provide housing to the employees of the ORR, was originally controlled by the military (Friday and Turner 2001). The self-governing portion of the city of Oak Ridge comprises about 14,000 acres and contains housing, schools, parks, shops, offices, and industrial areas. The urban population of Oak Ridge continued to grow over several decades, and some residential properties are next to the ORR boundary line. Outside the urban areas, much of the region (about 40 percent) is still a pattern of farms and small communities, as it was historically (ChemRisk 1993b).

A number of maps of this area indicate a wide range of land types (including urban or built-up land, agricultural land, rangeland, forestland, water, and wetlands) and land uses (including residential, commercial, public and semi-public, industrial, transportation, communication, utility, and extractive [e.g., mining]) (ChemRisk 1993b).

Agriculture (beef and dairy cattle) and forestry had been the two predominant land uses in the area around the ORR; however, both of these uses are currently declining. For many years, milk was produced, bottled, and distributed locally. Corn, tobacco, wheat, and soybeans were the major crops grown in the area. Small game and waterfowl are hunted in the area (both on and off the ORR), and deer are hunted during certain periods (ChemRisk 1993b). Radiological monitoring is performed during the annual deer hunts to "provide assurance that harvested animals do not contain levels of radionuclides which would result in significant internal exposure to humans consuming meat from the animals" (Teasley 1995). Fishing is not permitted on site, but fish from the ORR can move into publicly accessed areas.

II.E. Demographics

Demographic data provide information on the size and characteristics of a given population. ATSDR examined demographic data to determine the number of people living in the vicinity of the ORR and to determine the presence of sensitive populations, such as children (age 6 years and younger), women of childbearing age (age 15 to 44 years), and the elderly (age 65 years and older). According to the 2000 U.S. Census, 153 children, 403 women of childbearing age, and 423 elderly persons live within a quarter mile of the ORR; 778 children, 1,935 women of childbearing age, and 1,681 elderly persons live within a mile of the ORR (see Figure 2).

Demographics also provide details on population mobility and residential history in a particular area. This information helps ATSDR evaluate how long residents might have been exposed to environmental contaminants. The numbers of people living in the counties surrounding the ORR from 1940 to 2000 are listed in Table 1. The numbers of people living in the main cities within these counties from 1940 to 2000 are listed in Table 2.

Table 1. Population of Counties Surrounding the ORR from 1940 to 2000

County	*1940*	*1950*	*1960*	*1970*	*1980*	*1990*	*2000*
Anderson County	26,504	59,407	60,032	60,300	67,346	68,250	71,330
Blount County	41,116	54,691	57,525	63,744	77,770	85,969	105,823
Knox County	178,468	223,007	250,523	276,293	319,694	335,749	382,032
Loudon County	19,838	23,182	23,757	24,266	28,553	31,255	39,086
Meigs County	6,393	6,080	5,160	5,219	7,431	8,033	11,086
Morgan County	15,242	15,727	14,304	13,619	16,604	17,300	19,757
Rhea County	16,353	16,041	15,863	17,202	24,235	24,344	28,400
Roane County	27,795	31,665	39,133	38,881	48,425	47,227	51,910

Sources: Bureau of the Census 1900–1990, 2000

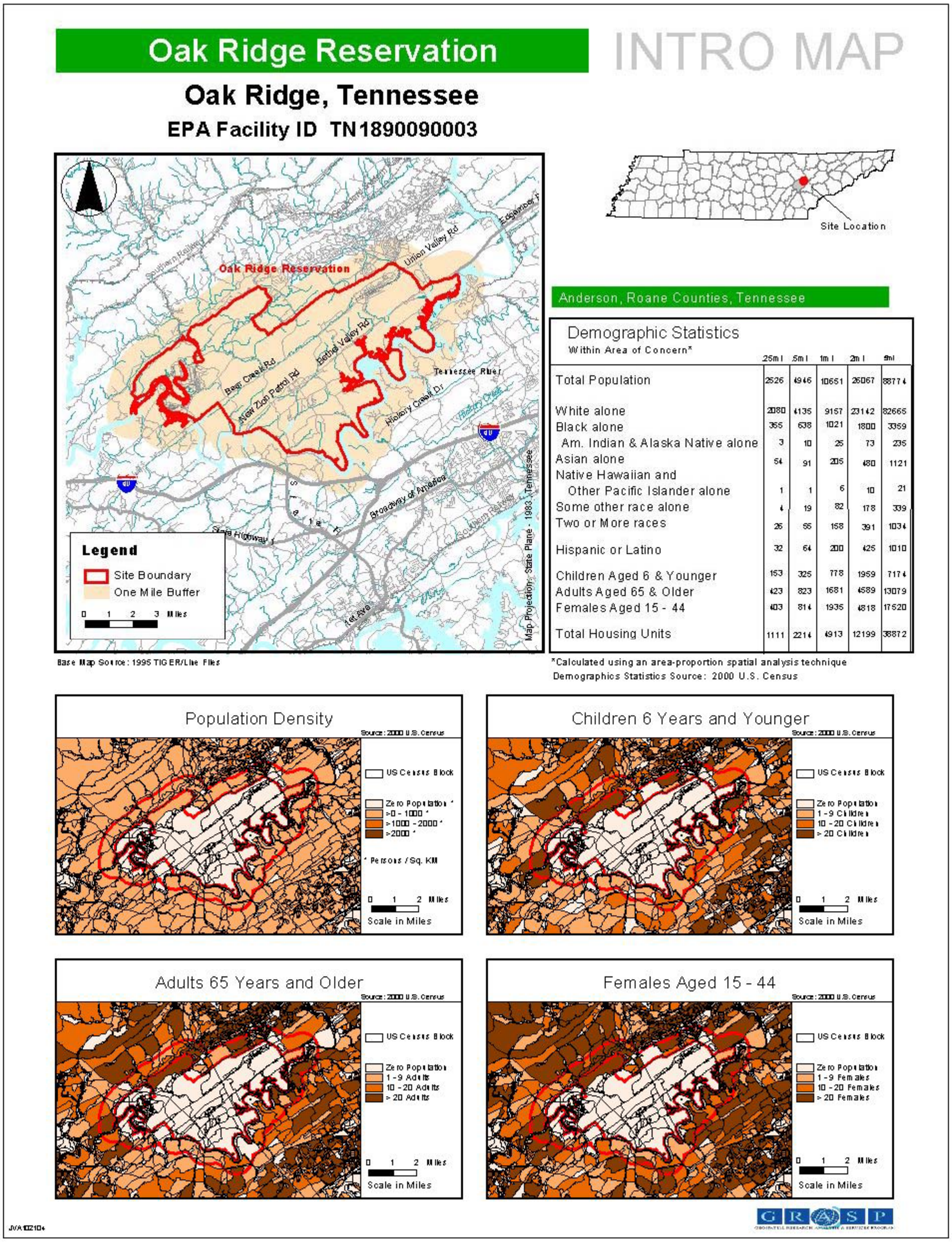
Table 2. Population of Cities Surrounding the ORR from 1940 to 2000

	1940	*1950*	*1960*	*1970*	*1980*	*1990*	*2000*
Clinton	2,761	3,712	4,943	4,794	7,790	8,972	9,409
Harriman	5,620	6,389	5,931	8,734	8,303	7,119	6,744
Kingston	880	1,627	2,010	4,142	4,561	4,552	5,264
Knoxville	111,580	124,769	111,827	174,587	175,045	165,121	173,890
Lenoir City	4,373	5,159	4,979	5,324	5,505	6,147	6,819
Loudon	3,017	3,567	3,812	3,728	4,199	4,026	4,476
Maryville	5,609	7,742	10,348	13,808	17,480	19,208	23,120
Oak Ridge	3,000*	30,229	27,169	28,319	27,662	27,310	27,387
Oliver Springs	—	189	1,163	3,405	3,659	3,433	3,303
Rockwood	3,981	4,272	5,345	5,259	5,695	5,348	5,774
Spring City	1,569	1,725	1,800	1,756	1,951	2,199	2,025

Sources: Bureau of the Census 1940, 1950, 1960, 1970, 1980, 1990, 2000; ChemRisk 1993b; City of Oak Ridge 1989; Convention and Visitors Bureau 2003

* Combined population on land that was established as Oak Ridge in 1942, with 13,000 initial residents.

Figure 2. Demographics Within a 5-Mile Radius of the ORR



Demographic Statistics Within Area of Concern*	.25mi	.5mi	1mi	2mi	5mi
Total Population	2526	4946	10651	26067	88774
White alone	2080	4135	9157	23142	82665
Black alone	355	638	1021	1800	3359
Am. Indian & Alaska Native alone	3	10	25	73	235
Asian alone	54	91	205	480	1121
Native Hawaiian and Other Pacific Islander alone	1	1	6	10	21
Some other race alone	4	19	82	178	339
Two or More races	26	55	158	391	1034
Hispanic or Latino	32	64	200	425	1010
Children Aged 6 & Younger	153	325	778	1959	7174
Adults Aged 65 & Older	423	823	1681	4589	13079
Females Aged 15 - 44	403	814	1935	4818	17520
Total Housing Units	1111	2214	4913	12199	38872

By presenting decade-by-decade size comparison for the available census intervals, Table 2 understates the city of Oak Ridge's dramatic population growth in contrast with the growth of its neighbors. Oak Ridge was established for the 13,000 people expected to work at the ORR (Friday and Turner 2001); by July 1944, its population had increased to 50,000. The population peaked at 75,000 in 1945, but decreased to 30,229 by 1950, and then to 27,169 by 1960; however, it was relatively stable thereafter (see Table 2) (City of Oak Ridge 1989). In 1959, about 14,000 acres within the city of Oak Ridge became self-governing (ChemRisk 1993b). Almost since its establishment, the city of Oak Ridge has been one of the largest population centers in eastern Tennessee (ChemRisk 1993b).

II.F. Public Health Activities

Since 1992, ATSDR has addressed the health concerns of community members, civic organizations, and other government agencies by working extensively to determine whether levels of environmental contamination at and near the ORR present a public health hazard. During this time, ATSDR has identified and evaluated several public health issues and has worked closely with many parties, including community members, civic organizations, physicians, and several federal, state, and local environmental and health agencies. Since the Tennessee Department of Health (TDOH) conducted the Oak Ridge Health Studies to evaluate whether off-site populations experienced exposures in the *past,* ATSDR's activities have focused on *current* and *future* public health issues. The ATSDR ORR Web site (http://www.atsdr.cdc.gov/HAC/oakridge/phact/index.html) highlights the major public health activities conducted by ATSDR at the ORR.

Oak Ridge Reservation Health Effects Subcommittee (ORRHES). The ORRHES was established in 1999, by ATSDR and the Centers for Disease Control and Prevention (CDC) under the authority of the Federal Advisory Committee Act, and as a subcommittee of the U.S. Department of Health and Human Services' Citizens Advisory Committee on Public Health Service Activities and Research at DOE sites. The subcommittee consisted of people who represented diverse interests, expertise, backgrounds, and communities, as well as liaison members from federal and state agencies. It was created to provide a forum for communication and collaboration between the citizens and the agencies that are evaluating public health issues and conducting public health activities at the ORR. To help ensure citizen participation, the meetings of the subcommittee's work groups were open to the public and everyone could attend and present their ideas and opinions. The subcommittee performed the following functions:

- Served as a citizen advisory group to CDC and to ATSDR and made recommendations on matters related to public health activities and research at the ORR.
- Gave citizens an opportunity to collaborate with agency staff members and to learn more about the public health assessment process and other public health activities.
- Helped to prioritize the public health issues and community concerns being evaluated by ATSDR.

The ORRHES created various work groups to conduct in-depth exploration of specific issues and present findings to the subcommittee for deliberation. Work group meetings were also open to all who wished to attend and participate.

ATSDR Field Office. From 2001 to 2005, ATSDR maintained a field office in the city of Oak Ridge. The office was opened to promote collaboration between ATSDR and the communities surrounding the ORR by providing community members with opportunities to become involved in ATSDR's public health activities at the ORR.

Other Public Health Activities. ATSDR, CDC's National Center for Environmental Health and National Institute for Occupational Safety and Health, TDOH, TDEC, and DOE have responded over the years to workers and communities concerned about potential exposures and reported unexplained illnesses afflicting workers and residents. The *Compendium of Public Health Activities* (ATSDR et al. 2000) outlines the past and present strategies used to address and evaluate public health issues related to chemical and radioactive substances released from the ORR. The compendium can be found on the ATSDR ORR Web site at http://www.atsdr.cdc.gov/HAC/oakridge/phact/c_toc.html.

Where Can One Obtain More Information on ATSDR's Activities at the ORR?

ATSDR has conducted several analyses that are not documented here, as have other agencies that have been involved with this site. Community members can find more information on ATSDR's past activities in the following three ways:

1. *Visit one of the records repositories*. Copies of ATSDR's publications on the ORR, along with publications from other agencies, can be viewed in records repositories at public libraries and the DOE Information Center (located at 475 Oak Ridge Turnpike, Oak Ridge, Tennessee; 865-241-4780). For directions to these repositories, please contact ATSDR at 1-800-CDC-INFO (1-800-232-4636).

2. *Visit the ATSDR or ORRHES Web sites.* These Web sites include past publications, schedules of future events, and other materials. ATSDR's ORR Web site is at http://www.atsdr.cdc.gov/HAC/oakridge. The most comprehensive summary of past activities can be found at http://www.atsdr.cdc.gov/HAC/oakridge/phact/c_toc.html.

3. *Contact ATSDR directly*. Residents can contact representatives from ATSDR directly by dialing the agency's toll-free number, 1-800-CDC-INFO (1-800-232-4636).

II.G. Past Screening Evaluation

In 2001, ATSDR scientists reviewed and analyzed TDOH's Oak Ridge Health Studies to identify contaminants that required further public health evaluation. One major aspect of the Health Studies was a pair of screening evaluations, called the Phase I and Phase II screening evaluations. During the Phase I and Phase II screening evaluations, TDOH conducted extensive reviews of available information and conducted qualitative and quantitative analyses of past (1944 to 1990) releases and off-site exposures to hazardous substances from the entire ORR (see Figure 3).

- *Phase I* of the Oak Ridge Health Studies was a dose reconstruction feasibility study. This study evaluated all past releases of hazardous substances and operations at the ORR. Its objective was to determine the quantity, quality, and potential usefulness of the available information on past releases and subsequent exposure pathways. Phase I began in May 1992 and was completed in September 1993. A brief summarizing Phase I is provided in Appendix C.

- *Phase II (also referred to as the Oak Ridge Dose Reconstruction)* of the Oak Ridge Health Studies began in mid-1994 and was completed in early 1999. Phase II primarily consisted of a dose reconstruction study focusing on past releases of radioactive iodine, radionuclides from White Oak Creek, mercury, and PCBs. In addition to the full dose reconstruction analyses, the Phase II effort included additional detailed screening analyses for releases of uranium and several other toxic substances that had not been fully characterized during Phase I. (A brief in Appendix C summarizes the Screening-Level Evaluation of Additional Potential Materials of Concern. The full report is available at http://www2.state.tn.us/health/CEDS/OakRidge/ORidge.html.)

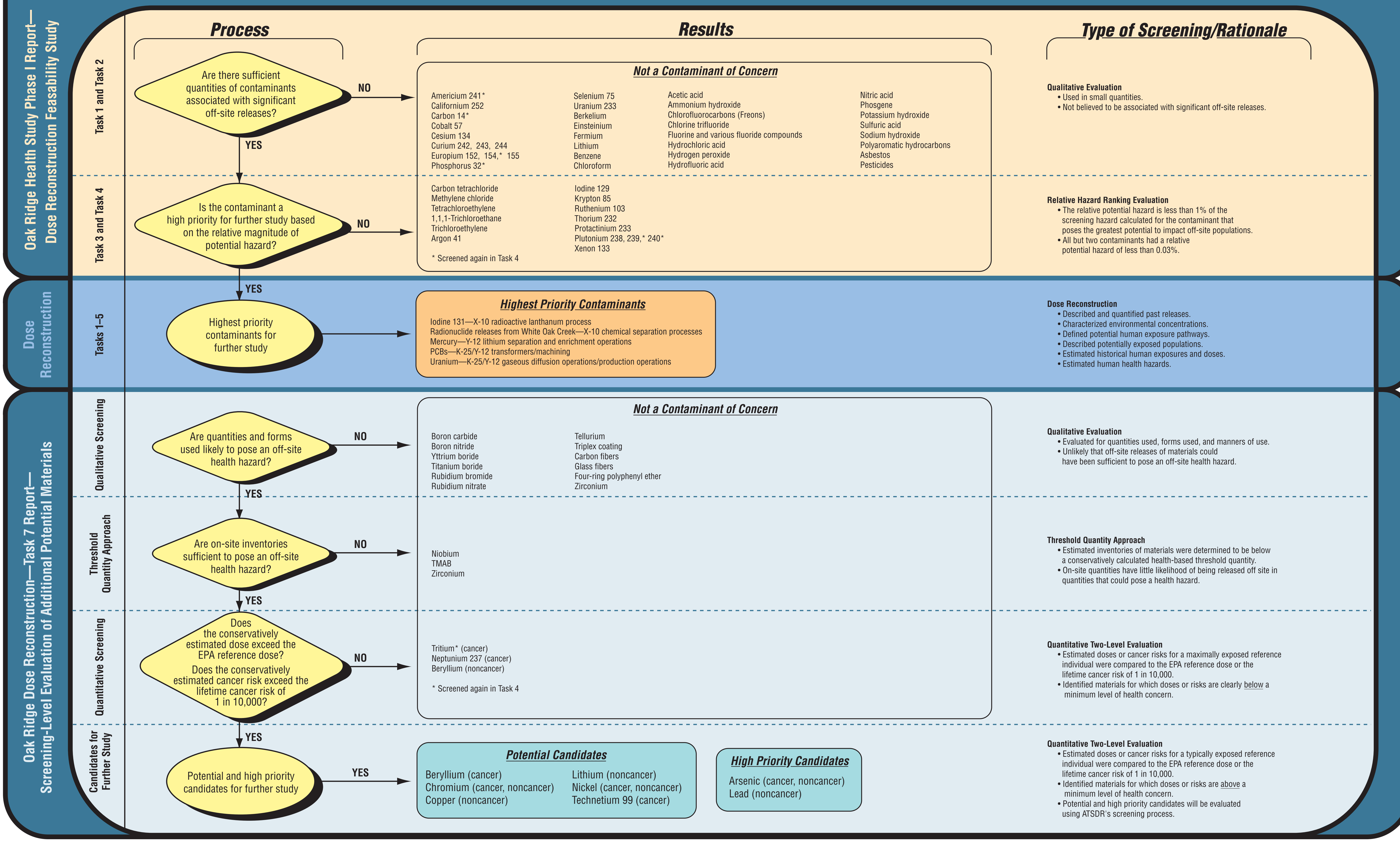
On the basis of ATSDR's review and analysis of TDOH's Phase I and Phase II screening evaluations, ATSDR scientists have completed or are conducting public health assessments on Y-12 plant uranium releases; K-25 site uranium and fluoride releases; White Oak Creek radionuclide releases; Y-12 plant mercury releases; X-10 site iodine 131 releases; X-10 site, Y-12 plant, and K-25 site PCB releases; and other issues of community concern, such as contaminant releases from the TSCA Incinerator and contaminated off-site groundwater. The public health assessment is the primary public health process ATSDR is using to further evaluate these contaminants.

> TDOH conducted the Oak Ridge Health Studies to evaluate whether off-site populations have been exposed in the past. Task 7 of the Oak Ridge Dose Reconstruction was a screening-level evaluation of potential chemicals of concern, using data through 1990. This public health assessment documents ATSDR's screening of environmental data from 1990 to 2003, and addresses whether additional chemicals (not identified by Task 7) require further evaluation.

This public health assessment documents ATSDR's screening of recent (1990 to 2003)[2] environmental data to address whether additional chemicals require further evaluation and discusses the public health implications related to estimated exposure doses.

[2] Data from before 1990 were evaluated during TDOH's past screening evaluation. Because ATSDR initiated the current screening evaluation in 2003, this was used as the cut-off year for "current" data.

Figure 3. State of Tennessee Screening Process for Past Exposure



III. Evaluation of Environmental Contamination and Potential Exposure Pathways

III.A. Introduction

What Does Exposure Mean?

Chemicals released into the environment have the potential to cause harmful health effects, but a release does not always result in exposure. If no one comes in contact with a chemical—if there is no completed exposure pathway—then exposure does not occur, and thus adverse health effects do not result. Often the general public does not have access to the source area of contamination or areas where contaminants are moving through the environment. Understanding how people have access to these areas becomes important in determining whether people could come in contact with the contaminants.

> A completed exposure pathway has five elements: (1) a source of contamination, (2) an environmental medium (such as soil, water, or air) through which a chemical is transported, (3) a point of exposure, (4) a route of exposure, and (5) an exposed population (receptor population). The source is the place where the chemical was released. The environmental media transport the chemicals. The point of exposure is the place where persons come in contact with the media. The route of exposure (for example, ingestion, inhalation, or dermal contact) is the way the contaminant enters the body. The people exposed are called the receptor population. A potential exposure pathway exists when one or more of the elements is missing, but available information suggests that exposure is possible.

The route a chemical takes from its source (where it began) to its exposure point (where it ends), and how people can contact it (how people get exposed) is called the exposure pathway. An exposure pathway could involve air, surface water, groundwater, soil, sediment, or even plants and animals. Exposure can occur by breathing, eating, drinking, or by skin contact with a substance containing the chemical contaminant.

How Does ATSDR Determine Which Exposure Situations to Evaluate?

ATSDR scientists evaluate site-specific conditions to determine whether people are being exposed to site-related chemicals. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, water, air, or biota) is occurring through ingestion, dermal (skin) contact, or inhalation.

If exposure is possible, ATSDR scientists then consider whether environmental contamination is present at levels that might affect public health. ATSDR evaluates environmental contamination using available environmental sampling data and, in some cases, modeling studies.

More information about the ATSDR evaluation process can be found in ATSDR's *Public Health Assessment Guidance Manual* at http://www.atsdr.cdc.gov/HAC/PHAManual/toc.html or by contacting ATSDR at 1-800-232-4636. An interactive program that provides an overview of the public health assessment process ATSDR uses to evaluate whether people will be harmed by hazardous materials is available at http://www.atsdr.cdc.gov/training/public-health-assessment-overview/html/index.html.

If People Are Exposed, Will They Get Sick?

Chemical exposure does not always result in harmful health effects. The type and degree of health effects that occur in an individual as the result of contact with a chemical depend on the exposure concentration (how much), the frequency of exposure (how often), the duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and potentially the combination of chemicals. Once exposure occurs, factors such as age, gender, genetics, lifestyle, nutritional status, and health status influence how a person absorbs, distributes, metabolizes, and excretes the contaminant. Taken together, these factors and characteristics determine the health effects that can occur as a result of exposure to a chemical.

III.B. Methodology

ATSDR screened all available current chemical data to determine whether concentrations were above ATSDR's comparison values (see the description below). Figure 4 illustrates ATSDR's chemical screening process. ATSDR also reviewed relevant toxicologic and epidemiologic data to obtain information about the toxicity of the chemicals to more completely understand the public health implications of exposure.

Comparing Environmental Concentrations to Comparison Values

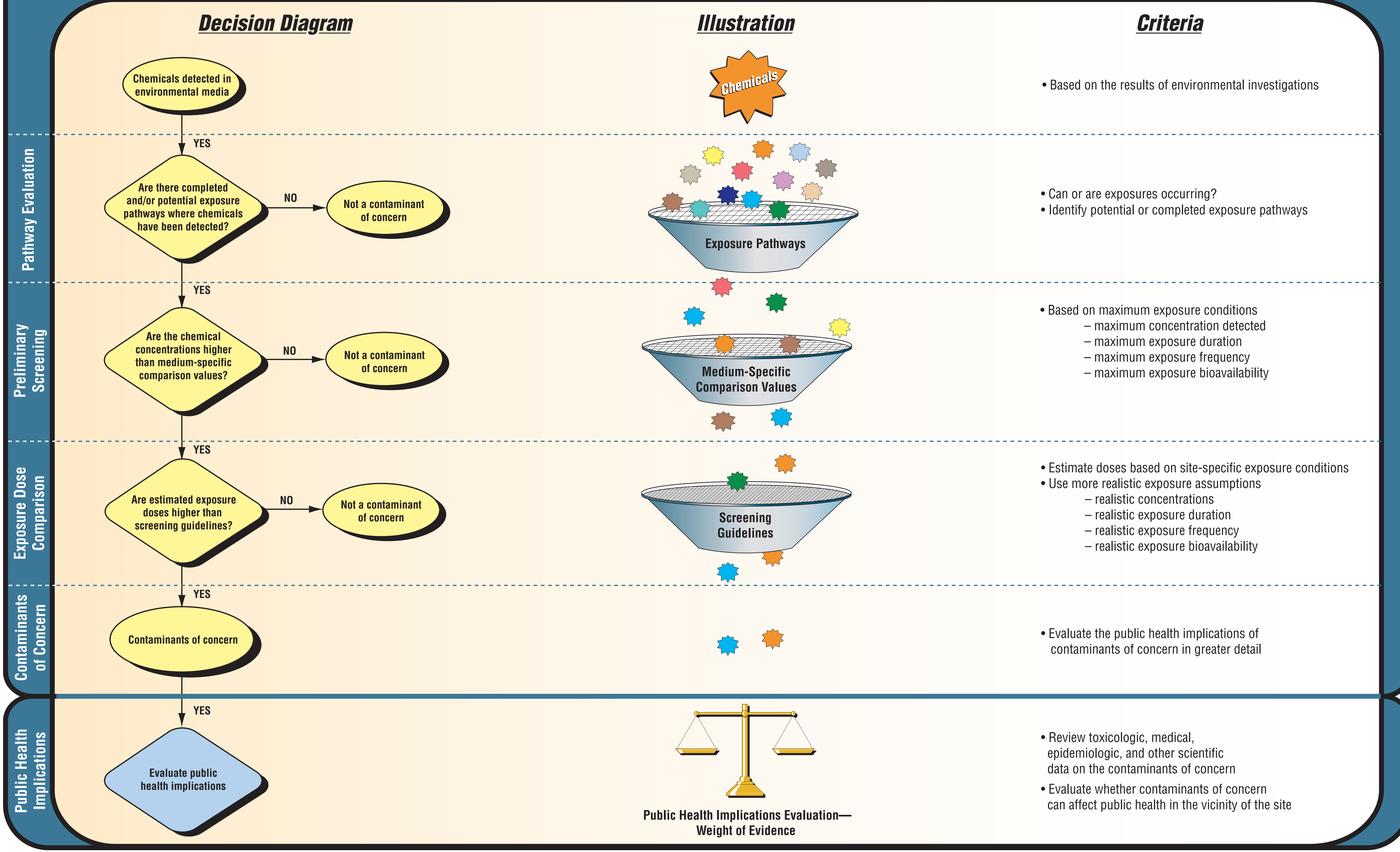
ATSDR uses comparison values to screen chemicals that require additional evaluation.

ATSDR uses the term "conservative" to refer to values that are protective of public health in essentially all situations.

ATSDR selects chemicals for further evaluation by comparing the maximum environmental concentrations against media-specific health-based comparison values. The maximum concentrations are used at this step of the screening process as a conservative measure even though we know that people are exposed to a range of concentrations and not just to the maximum reported levels. Comparison values are developed by ATSDR from available scientific literature concerning exposure and health effects. Comparison values are derived for soil/sediment, water, and air[3] and reflect a concentration that is not expected to cause harmful health effects for a given contaminant, assuming a standard daily contact rate (for example, the amount of water or soil consumed or the amount of air breathed) and representative body weight (child or adult). Because they reflect concentrations that are much lower than those that have been observed to cause adverse health effects, comparison values are protective of public health in essentially all exposure situations. As a result, **exposures to chemical concentrations detected at or below ATSDR's comparison values are not expected to cause health effects in people. Therefore, levels below media-specific comparison values do not pose a public health hazard and are not evaluated further for a given medium.**

[3] ATSDR has not derived comparison values for biota.

Figure 4. ATSDR Chemical Screening Process



ATSDR's cancer risk evaluation guides (CREGs), environmental media evaluation guides (EMEGs), and reference dose media evaluation guides (RMEGs) are conservative, health-based comparison values developed for screening environmental concentrations for further evaluation. EPA's risk-based concentration (RBC) is a health-based comparison value developed to screen sites not yet on the NPL, respond rapidly to citizens' inquiries, and spot-check formal baseline risk assessments. Please see Appendix A for a glossary of these and other terms used in this public health assessment.

While concentrations at or below the respective comparison value can be considered safe, it does not automatically follow that any environmental concentration exceeding a comparison value would be expected to produce adverse health effects. Comparison values are not health effect thresholds. ATSDR comparison values represent concentrations that are many times lower than levels at which no effects were observed in studies on experimental animals or in human epidemiologic studies. The likelihood that adverse health outcomes will actually occur depends on site-specific conditions, individual differences, and factors that affect the route, magnitude, and duration of actual exposure. **If contaminant concentrations are above comparison values, ATSDR further analyzes exposure variables (such as site-specific exposure duration and frequency) for health effects, including the toxicity of the chemical, epidemiology studies, and the weight-of-evidence.**

Weight-of-evidence is the extent to which the available scientific information supports the hypothesis that a substance causes an adverse effect in humans. For example, factors that determine the weight-of-evidence that a chemical poses a hazard to humans include the number of tissue sites affected by the agent; the number of animal species, strains, genders, and number of experiments and doses showing a response; the dose-response relationship; statistical significance in the occurrence of the adverse effect in treated subjects compared with untreated controls; and the timing of the occurrence of the adverse effect.

Essential nutrients (e.g., calcium, magnesium, phosphorus, potassium, and sodium) are minerals that maintain basic life functions; therefore, certain doses are recommended on a daily basis. Because these chemicals are necessary for life, comparison values do not exist for them. They are found in many foods, such as milk, bananas, and table salt. For example, the Food and Nutrition Board of the Institute of Medicine of the National Academy of Sciences has recommended the following adequate intakes (AI) and recommended dietary allowance (RDA) for phosphorus: For infants 0 to 6 months and 7 to 12 months old, the AIs are 100 and 275 milligrams per day (mg/day), respectively. For children 1 to 3 years and 4 to 8 years old, the RDAs are 460 and 500, respectively. For children 9 to 18 years old, the RDA is 1,250 mg/day. Adults 19 years and older have an RDA of 700 mg/day. A no-observed-adverse-effect level (NOAEL) for phosphorus for adults is 10.2 grams/day—or more than 10,000 mg/day. Therefore, calcium, magnesium, phosphorus, potassium, and sodium were not considered for further evaluation.

A **NOAEL** is the highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals in a study.

Comparing Estimated Exposure Doses to Screening Guideline Values

If chemical concentrations are above comparison values, ATSDR further evaluates the chemical and potential exposure. ATSDR does this by calculating exposure doses and comparing the doses to protective screening guideline values, including ATSDR's minimal risk levels (MRLs) and

EPA's reference doses (RfDs). **Estimated exposure doses that are less than screening guideline values pose no public health hazard and are not evaluated further.**

> An exposure dose, expressed in milligrams per kilogram per day (mg/kg/day), is the estimated amount of chemical a person is exposed to over time.

When estimating hypothetical exposure doses, health assessors evaluate chemical concentrations to which people could have been exposed, and assess the length of time (duration) and the frequency of exposure to these contaminant concentrations. Collectively, these factors influence an individual's physiological response to chemical exposure and potential outcomes. Where possible in this public health evaluation, ATSDR used site-specific information regarding the frequency and duration of exposures. When site-specific information was not available, ATSDR employed several protective assumptions to estimate exposures.

The following general equation was used to calculate exposure doses:

$$\text{Estimated exposure dose} = \frac{C \times IR \times EF \times ED}{BW \times AT}$$

where:

C = Concentration of chemical
IR = Intake rate
EF = Exposure frequency, or number of exposure events per year of exposure
ED = Exposure duration, or the duration over which exposure occurs
BW = Body weight
AT = Averaging time, or the period over which cumulative exposures are averaged

Environmental concentrations of most soil and sediment contaminants are log-normally distributed; meaning that a few samples have high concentrations while most of the samples have much lower concentrations (Shacklette and Boergen 1984). EPA's soil screening guidance (EPA 1996a, 2002c) recommends use of a spatially averaged concentration (i.e., the 50th percentile concentration over the exposure area). However, ATSDR chose to use a more conservative second-tier screening concentration[4] (defined as one standard deviation above the average concentration) to estimate exposure doses during this phase of the screening process (i.e., to identify chemicals for further evaluation) to account for the variability of the samples. Use of the second-tier screening concentration is a health-protective estimate of the concentration; it results in a more protective screening process because the exposure doses are calculated using a concentration that is higher than the average concentration.

Using the general equation given above, the exposure parameters listed in Table 3, and the second-tier screening concentration, ATSDR derived hypothetical exposure doses for residents living near the site. ATSDR compared these estimated site-specific exposure doses against noncancer and cancer screening guideline values. ATSDR's MRLs and EPA's RfDs are estimated doses of daily human exposure to substances that are likely to be without appreciable

[4] For chemicals detected in at least 10 percent of the samples, the second-tier screening concentrations were calculated using detected concentrations only and do not take into account nondetected values. For chemicals detected in less than 10 percent of the samples, ATSDR calculated second-tier screening concentrations using half the detection limit for nondetected samples.

risk of adverse *noncancer* health effects over a specified duration of exposure. MRLs and RfDs are derived for chemicals using the NOAEL/lowest-observed-adverse-effect level (LOAEL)/uncertainty factor approach. They are derived when reliable and sufficient human or animal data exist to identify the most sensitive health effect for a given route of exposure. MRLs and RfDs are generally based on the most sensitive end point considered to be of relevance to humans. Because of the lack of precise toxicologic information on people who might be most sensitive (for example, infants, the elderly, or persons who are nutritionally or immunologically compromised) to the effects of hazardous substances, MRLs and RfDs have built-in safety factors, making them considerably lower than doses at which health effects have been observed. Therefore, these screening guideline values are below doses that cause adverse health effects in people most sensitive to such effects. Consistent with the public health principle of prevention, ATSDR uses this conservative (protective) approach to maximize human health protection and to address the uncertainty in toxicologic information.

These chemical-specific guideline values, which serve as screening levels, are used to identify chemicals for further consideration. It is important to note that MRLs and RfDs are not thresholds for health effects and are not intended to define cleanup or action levels. They are intended only to serve as a screening tool to help public health professionals decide what chemicals and pathways to look at more closely. While estimated exposure doses that are less than MRLs or RfDs are not considered to be a public health hazard, exposure to doses above these screening values does not automatically imply that adverse health effects will occur. Rather, it is an indication that ATSDR should further examine the health effect levels reported in the scientific literature and more fully review potential exposures.

In addition, to screen for cancer effects, ATSDR multiplied estimated chronic-exposure doses (30-year exposure averaged over 70 years) by EPA's cancer slope factors (CSFs), which estimate the relative potency of carcinogens. This calculation estimated a theoretical excess cancer risk expressed as the proportion of a population that might be affected by a carcinogen during a lifetime of exposure. For example, an estimated cancer risk of 1×10^{-6} predicts the probability of one additional cancer over background in a population of 1 million. Because conservative models are used to derive CSFs, the doses associated with these hypothetical risks are typically orders of magnitude lower than doses reported in the toxicologic literature to cause carcinogenic effects. As such, a low cancer risk estimate indicates that the toxicologic literature would support a finding that no excess cancer risk is likely. A higher cancer risk estimate, however, indicates that ATSDR should carefully review the scientific literature before making conclusions about potential cancer risks.

Table 3. Parameters Used in the Exposure Dose Calculations for ORR

	Soil	***Sediment***	***Surface Water***	***Biota***			
				Fish		***Game***	***Vegetation***
Intake Rate P Adult P Child P Pica child	 0.00005 kg/day 0.0002 kg/day 0.005 kg/day	 0.0001 kg/day 0.0001 kg/day NA	 0.5 liter/day* 0.5 liter/day* NA	*Subsistence* 0.065 kg/day 0.02 kg/day NA	*Recreational* 0.008 kg/day 0.003 kg/day NA	 0.002 kg/day 0.001 kg/day NA	 0.0016 kg/kg/day§ 0.0016 kg/kg/day§ NA
Exposure Frequency P Adult P Child P Pica child	 291.2 days/year 291.2 days/year 52 days/year	 12 days/year 12 days/year NA		 365 days/year 365 days/year NA			
Exposure Duration P Adult P Child P Pica child	 30 years 6 years 3 years						
Body Weight P Adult P Child P Pica child	 70 kg 13 kg 10 kg						
Averaging Time P Adult P Child P Pica child	*Noncancer* 365 days/year × 30 years 365 days/year × 6 years 365 days/year × 3 years			*Cancer/Lifetime* 365 days/yr × 70 years NA NA			

*The surface water intake rate was changed to 0.15 liter/day for the public health evaluation (see Section IV.C) to represent a three-hour swimming event (EPA 1999).

§The body weight parameter is built into the intake rate for the vegetation dose equation (EPA 1999; Table 13-63).

Exposure doses are not calculated for the air pathway. Screening guidelines are reported in concentrations.

Cancer doses assume a 30-year exposure averaged over a 70-year lifetime.

kg = kilogram

NA = not applicable

Intake Rates	**Rough Equivalents**
0.005 kg of soil	1 teaspoon
0.00005 kg of soil	1/100th of a teaspoon
0.0001 kg of sediment	1/50th of a teaspoon
0.5 liter of water	2 cups
0.065 kg of fish	2 ounces
0.008 kg of fish	1/4th of an ounce
0.002 kg of game	1/16th of an ounce
0.0016 kg/kg/day of vegetation	90 lbs/year (adult)

Comparing Estimated Exposure Doses to Health Effect Levels

If the MRLs or RfDs are exceeded, ATSDR determines the public health implications of estimated exposures by examining the effect levels discussed in the scientific literature and more fully reviews exposure potential. ATSDR reviews available human studies as well as experimental animal studies. This information is used to understand the disease-causing potential of a chemical and to compare site-specific exposure dose estimates with doses shown to cause health effects. This process enables ATSDR to weigh the available evidence in light of uncertainties and offer perspective on the plausibility of harmful health outcomes under site-specific conditions.

Sources for Health-Based Guidelines

By Congressional mandate, ATSDR prepares toxicological profiles for hazardous substances found at contaminated sites. Toxicological profiles were used to evaluate potential health effects at the ORR. ATSDR's toxicological profiles are available on the Internet at http://www.atsdr.cdc.gov/toxpro2.html or by contacting the National Technical Information Service (NTIS) at 1-800-553-6847. EPA also develops health effects guidelines, and in some cases, ATSDR relied on EPA's guidelines to evaluate potential health effects. These guidelines are found in EPA's Integrated Risk Information System (IRIS)—a database of human health effects that could result from exposures to various substances found in the environment. IRIS is available on the Internet at http://www.epa.gov/iris. For more information about IRIS, please call EPA's IRIS hotline at (202) 566-1676 or send an e-mail to hotline.iris@epa.gov.

III.C. Environmental Data

> It is important to note that ATSDR is assuming exposure to the contaminated media. The location of each detection was not individually evaluated to determine whether anyone is actually being exposed.

As discussed earlier, exposure to a contaminant is an important factor in ATSDR's evaluation. If no one comes in contact with a contaminant, then no exposure occurs, and thus no health effects could occur. Therefore, this screening of current and future chemical exposures focuses primarily on contaminants detected in off-site locations, where exposures are more likely to occur (as opposed to on-site locations, where access is restricted).[5] However, because there are limited off-site air samples, and people have access to on-site fish and game, on-site exposures to these media are also included. See Figure 5 for the exposure pathways ATSDR evaluated in this health assessment. ATSDR evaluated exposures to chemicals detected in off-site groundwater in a separate, pathway-specific public health assessment. (Copies of the document can be obtained from ATSDR's Web site: http://www.atsdr.cdc.gov/HAC/oakridge/phact/groundwater/index.html.) Appendix D contains maps depicting the number of samples collected from and the number of chemicals sampled at each location in each media.

For this public health evaluation, ATSDR used environmental sampling data collected within the ORRHES Area of Interest (see Figure 6) from 1990 to 2003. The Oak Ridge Environmental

[5] Most of the site-related contamination is at the three main ORR facilities (X-10, Y-12, and K-25). These areas are heavily guarded, fenced, and access requires a clearance badge.

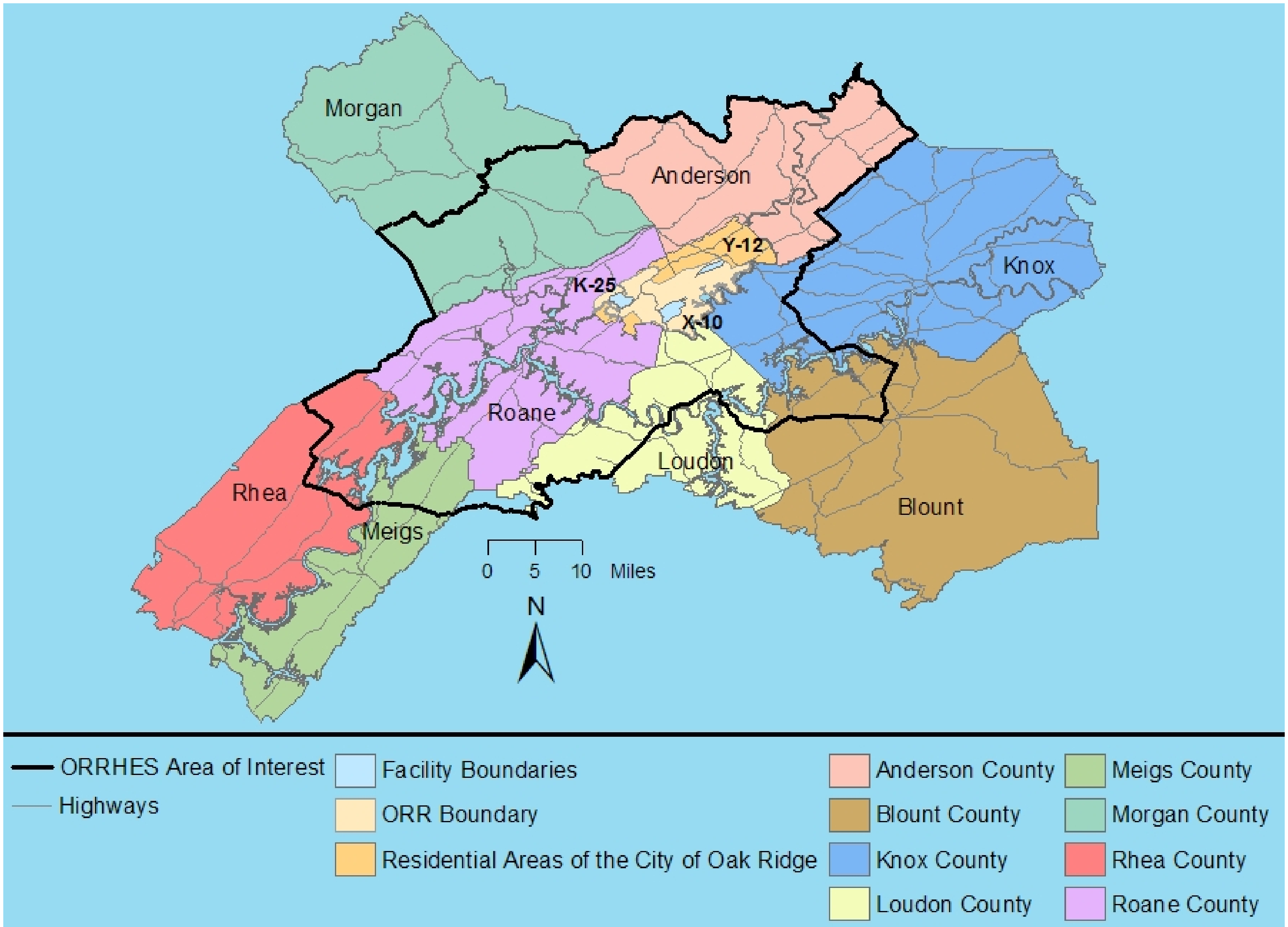
Information System (OREIS)—a centralized, standardized, quality-assured, and configuration-controlled environmental data management system—supplied the data. DOE created OREIS to integrate the abundant environmental data on the ORR into one database, facilitating public and government access to environmental operations data while maintaining data quality. DOE's objective was to ensure that the database had long-term retention of the environmental data and useful methods to access the information. OREIS contains data on compliance, environmental restoration, and surveillance activities. Information from all key surveillance activities and environmental monitoring efforts is entered into OREIS. As new studies are completed, the environmental data are entered as well.

ATSDR's database manager scrutinized the data evaluated in this public health assessment to ensure proper quality assurance/quality control. ATSDR did not use any data in this evaluation that were deemed unreliable. For example, surface water data are typically reported in micrograms per liter (µg/L) or milligrams per liter (mg/L). Some surface water data in OREIS were reported in milligrams per kilogram (mg/kg). ATSDR suspected that the media code had been interpreted incorrectly and these data were actually fish data. Since this could not be confirmed, the data were not used in this evaluation.

Scenarios for past, current, and future exposure to PCBs and mercury will be addressed in chemical-specific public health assessments. Two of ATSDR's public health assessments address exposure to uranium from the ORR: one on uranium releases from the Y-12 plant (already released; available at http://www.atsdr.cdc.gov/HAC/oakridge/phact/y12/index.html) and another, still being prepared, that addresses past and current exposure to uranium and fluoride releases from the K-25 site. ATSDR scientists have also released or are conducting public health assessments on the following issues associated with the ORR: iodine 131 releases from the X-10 site, radionuclide releases from White Oak Creek, mercury releases from the Y-12 plant, contaminated off-site groundwater, PCB releases from the X-10 site, the Y-12 plant, and the K-25 site, and contaminant releases from the TSCA Incinerator. The documents released to date are available at http://www.atsdr.cdc.gov/HAC/oakridge/phact/index.html and can also be ordered through a toll-free ATSDR telephone number, 1-800-232-4636.

Figure 5. Possible Exposure Situations Evaluated

Figure 6. ORRHES Area of Interest



III.D. Screening Results

Off-Site Soil

OREIS contains almost 10,000 records[6] of chemicals sampled in off-site soil from November 5, 1990, to September 1, 2001. These samples were analyzed for a total of 286 chemicals.[6] See Figures D-1 and D-2 in Appendix D for the number of off-site soil samples collected from and the number of chemicals sampled at each location.

ATSDR compared the maximum concentration for each chemical detected off site to that chemical's conservative health-based comparison value. The maximum concentrations for 22 chemicals were detected above comparison values. ATSDR calculated exposure doses for these 22 chemicals, using the equation described in Section III.B, "Methodology," and the exposure parameters listed in Table 3. ATSDR then compared these exposure doses to the acute and chronic noncancer and cancer screening guidelines (see Table 4, Table 16, and Table 17). Four chemicals exceeded noncancer and/or cancer screening guidelines, and are further evaluated in Section IV, "Public Health Implications." Figure 7 shows the results of ATSDR's chemical screening process. Chemicals without screening guidelines are discussed in Appendix B. Pica child exposures are evaluated in Section IV.B, "Children's Health Considerations."

Chemicals Detected Above Comparison Values in Off-Site Soil (22 Chemicals)

Inorganics

- Arsenic
- Cadmium
- Chromium
- Iron
- Lead

Organics

- Benzidine
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- bis(2-Chloroethyl) ether
- Chrysene
- trans-Chlordane
- Dibenzo(a,h)anthracene

Organics (continued)

- 3,3'-Dichlorobenzidine
- Heptachlor epoxide
- Hexachlorobenzene
- Hexachlorodibenzo-p-dioxin (HCDD)
- Indeno(1,2,3-cd)pyrene
- n-Nitroso-di-n-butylamine
- n-Nitrosodi-n-propylamine
- 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)

Chemicals with Exposure Doses Above Cancer/Noncancer Screening Guidelines in Off-Site Soil (4 Chemicals)

Inorganics

- Arsenic
- Iron
- Lead

Organics

- Benzidine

[6] Records for mercury, uranium, and PCBs are not included in the total because ATSDR has evaluated or is evaluating them in separate, chemical-specific public health assessments.

Off-Site Sediment

OREIS contains about 56,000 records[7] of chemicals sampled in off-site sediment from January 15, 1990, to September 1, 2001. These samples were analyzed for a total of 319 chemicals.[7] See Figures D-3 and D-4 in Appendix D for the number of off-site sediment samples collected from and the number of chemicals sampled at each location.

ATSDR compared the maximum concentration for each chemical detected off-site to that chemical's conservative health-based comparison value. The maximum concentrations for 33 chemicals were detected above comparison values. ATSDR calculated exposure doses for these 33 chemicals, using the equation described in Section III.B, "Methodology," and the exposure parameters listed in Table 3. ATSDR then compared these exposure doses to the noncancer and cancer screening guidelines (see Table 18 and Table 19). None of the chemicals detected in off-site sediment exceeded noncancer or cancer screening guidelines. Therefore, exposure to off-site sediment is not a health hazard. Figure 7 shows the results of ATSDR's chemical screening process. Chemicals without screening guidelines are discussed in Appendix B.

Chemicals Detected Above Comparison Values in Off-Site Sediment (33 Chemicals)

Inorganics

- Arsenic
- Cadmium
- Copper
- Iron
- Lead
- Manganese

Organics

- Aldrin
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- bis(2-Chloroethyl) ether
- cis-Chlordane
- trans-Chlordane
- DDD, p,p'-
- DDE, p,p'-
- DDT, p,p'-
- di(2-Ethylhexyl)phthalate
- Dibenzo(a,h)anthracene
- 3,3'-Dichlorobenzidine

Organics (continued)

- Dieldrin
- Heptachlor
- Heptachlor epoxide
- Hexachlorobenzene
- Hexachlorocyclohexane (HCH), alpha-
- HCH, beta-
- HCH, delta-
- HCH, gamma-
- HCDD
- Indeno(1,2,3-cd)pyrene
- n-Nitrosodi-n-propylamine
- Pentachlorophenol
- Toxaphene

Off-Site Surface Water

OREIS contains more than 93,000 records[7] of chemicals sampled in off-site surface water from January 8, 1990, to September 10, 2002. These samples were analyzed for a total of 310 chemicals.[7] See Figures D-5 and D-6 in Appendix D for the number of off-site surface water samples collected from and the number of chemicals sampled at each location.

ATSDR compared the maximum concentration for each chemical detected off site to that chemical's conservative health-based comparison value. The maximum concentrations for 75

[7] Records for mercury, uranium, and PCBs are not included in the total because ATSDR has evaluated or is evaluating them in separate, chemical-specific public health assessments.

chemicals were detected above comparison values. ATSDR calculated exposure doses for these 75 chemicals, using the equation described in Section III.B, "Methodology," and the exposure parameters listed in Table 3. ATSDR then compared these exposure doses to the noncancer and cancer screening guidelines (see Table 20 and Table 21). None of the chemicals detected in off-site surface water exceeded noncancer or cancer screening guidelines. Therefore, exposure to off-site surface water is not a health hazard. Figure 7 shows the results of ATSDR's chemical screening process. Chemicals without screening guidelines are discussed in Appendix B.

Chemicals Detected Above Comparison Values in Off-Site Surface Water (75 Chemicals)

Inorganics

- Aluminum
- Ammonia
- Antimony
- Arsenic
- Barium
- Beryllium
- Boron
- Cadmium
- Chlorine
- Chromium
- Copper
- Iron
- Lead
- Lithium
- Manganese
- Nickel
- Nitrate
- Nitrate and Nitrite
- Selenium
- Silver
- Thallium
- Vanadium
- Zinc

Organics

- Aldrin
- Benzene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Bis(2-chloroethyl) ether
- Bromodichloromethane
- Bromoform
- Carbazole
- Carbon tetrachloride
- cis-Chlordane
- trans-Chlordane
- Chlorodibromomethane
- Chloroethane
- Chloromethane
- Chrysene
- Dibenzo(a,h)anthracene
- 3,3'-Dichlorobenzidine
- 1,2-Dichloroethane
- 1,3-Dichloropropene, cis-
- 1,3-Dichloropropene, trans-
- Di(2-ethylhexyl)phthalate
- Dieldrin
- 2,4-Dinitrophenol
- 4,6-Dinitro-o-cresol

Organics (continued)

- HCDD
- Heptachlor
- Heptachlor epoxide
- Hexachlorobenzene
- Hexachlorobutadiene
- alpha-HCH
- beta-HCH
- delta-HCH
- Hexachloroethane
- Indeno(1,2,3-cd)pyrene
- Methoxychlor
- Methylene chloride
- 2-Nitroaniline
- 3-Nitroaniline
- 4-Nitroaniline
- Nitrobenzene
- n-Nitrosodi-n-propylamine
- n-Nitrosodiphenylamine
- Pentachlorophenol
- TCDD
- 1,1,2,2-Tetrachloroethane
- 1,1,2-Trichloroethane
- 2,4,6-Trichlorophenol
- Toxaphene
- Trichloroethylene
- Vinyl chloride

Biota

Fish

OREIS contains more than 16,000 records[8] of chemicals sampled in fish (e.g., bass, carp, catfish, crayfish, and sunfish) from May 29, 1990, to August 14, 2002. A total of 147 different chemicals[8] were analyzed—43 chemicals in fish collected from East Fork Poplar Creek (EFPC), 64 chemicals in fish collected from the Clinch River, 81 chemicals in fish collected from the Watts Bar Reservoir (WBR), and 124 chemicals in fish collected from on-site locations. See Figures D-7 through D-10 in Appendix D for the number of fish samples collected from and the number of chemicals sampled at each location.

Subsistence-level comparison values do not exist for chemicals detected in fish species. Therefore, as an initial screen, ATSDR calculated exposure doses for chemicals detected in fish samples (whole, filet, muscle, and unknown portions) using (1) the equation described in Section III.B, "Methodology"; (2) the subsistence exposure parameters listed in Table 3; and (3) the average of the maximum concentrations detected for each group/species.[9] Exposure doses are most likely overestimated because the inclusion of whole fish and crayfish data—fillet and muscle (edible portions) typically have less contamination. ATSDR compared these exposure doses to noncancer and cancer screening guidelines. Estimated exposure doses for the following 12 chemicals exceeded the screening guidelines for at least one location.

Chemicals with Initial Screen Exposure Doses Above Screening Guidelines (12 Chemicals)

Inorganics

- Arsenic
- Cadmium
- Chromium
- Thallium

Organics

- Aldrin
- Benzo(a)pyrene
- Dibenzo(a,h)anthracene
- Dieldrin
- HCH, alpha-
- Heptachlor epoxide
- TCDD
- Toxaphene

As a second screen, ATSDR calculated recreational and subsistence-level exposure doses using the second-tier screening concentrations for the chemicals listed above. Then ATSDR compared these doses to noncancer and cancer screening guidelines (see Table 22 through Table 29). For this level of the evaluation, the fish were grouped by species and by location.[10] Chemicals that exceeded noncancer or cancer screening guidelines in at least one fish species during this second

[8] Records for mercury, uranium, and PCBs are not included in the total because ATSDR has evaluated or is evaluating them in separate, chemical-specific public health assessments.

[9] ATSDR averaged the maximum concentrations for each group/species of fish (across multiple sampling locations and events) because individual species data were available for multiple chemicals and for multiple sampling locations. In addition, people may only eat certain fish species and/or different species may have different territorial and behavioral patterns (i.e., chemicals may accumulate differently in different species found at different locations).

level of screening are further evaluated in the Public Health Implications section (see Section IV). Figure 7 shows the results of ATSDR's chemical screening process. Chemicals without screening guidelines are discussed in Appendix B.

Chemicals with Second Screen Exposure Doses Above Screening Guidelines in EFPC Fish (6 Chemicals)

Inorganics	*Organics*
▪ Arsenic	▪ Dibenzo(a,h)anthracene
▪ Cadmium	▪ Dieldrin
▪ Chromium	▪ Heptachlor epoxide

Chemicals with Second Screen Exposure Doses Above Screening Guidelines in Clinch River Fish (6 Chemicals)

Inorganics	*Organics*
▪ Arsenic	▪ Aldrin
	▪ Dieldrin
	▪ HCH, alpha-
	▪ Heptachlor epoxide
	▪ Toxaphene

Chemicals with Second Screen Exposure Doses Above Screening Guidelines in WBR Fish (8 Chemicals)

Inorganics	*Organics*
▪ Arsenic	▪ Aldrin
▪ Chromium	▪ Dieldrin
	▪ HCH, alpha-
	▪ Heptachlor epoxide
	▪ TCDD
	▪ Toxaphene

Chemicals with Second Screen Exposure Doses Above Screening Guidelines in On-Site Fish (8 Chemicals)

Inorganics	*Organics*
▪ Arsenic	▪ Aldrin
▪ Cadmium	▪ Dieldrin
▪ Thallium	▪ HCH, alpha-
	▪ Heptachlor epoxide
	▪ Toxaphene

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[10] As a second screen, ATSDR believes, grouping the data by species and location provides a more comprehensive representation of potential exposure patterns and estimated exposure doses for people consuming fish from water bodies near the reservation.

Game

OREIS contains more than 2,200 records[11] of chemicals sampled in game species (e.g., turtles and wood ducks) from March 28, 1990, to May 23, 1996. A total of 118 different chemicals were analyzed—27 chemicals[11] in game collected from off-site locations and 118 chemicals[11] in game collected from on-site locations. See Figures D-11 through D-14 in Appendix D for the number of game samples collected from and the number of chemicals sampled at each location.

Comparison values do not exist for chemicals detected in game species. Therefore, as an initial screen, ATSDR calculated exposure doses using (1) the equation described in Section III.B, "Methodology"; (2) the exposure parameters listed in Table 3; and (3) the average of the maximum detected concentrations.[12] ATSDR compared these exposure doses to noncancer and cancer screening guidelines. No exposure doses for chemicals detected in game from *off-site* locations exceeded the screening guidelines. Calculated exposure doses exceeded the screening guidelines for the following eight chemicals detected in game from *on-site* locations.

Chemicals with Initial Screen Exposure Doses Above Screening Guidelines in On-Site Game (8 Chemicals)

Inorganics
- Aluminum
- Antimony
- Cadmium
- Iron
- Manganese
- Thallium

Organics
- 4,6-Dinitro-o-cresol
- 2,4-Dinitrophenol

As a second screen, ATSDR calculated exposure doses using the second-tier screening concentrations for the chemicals listed above and compared these doses to noncancer screening guidelines[13] (see Table 30). For this part of the evaluation, the game samples collected on site were grouped by species. Exposure doses for seven of the eight chemicals exceeded noncancer screening guidelines during this second level of screening, and are further evaluated in the Public Health Implications section (see Section IV). Figure 7 shows the results of ATSDR's chemical screening process. Chemicals without screening guidelines are discussed in Appendix B.

[11] Records for mercury and PCBs are not included in the total because ATSDR has evaluated or is evaluating them in separate, chemical-specific public health assessments.
[12] ATSDR averaged the maximum concentrations for each game species (across multiple sampling locations and events) because individual species data were available for multiple chemicals and for multiple sampling locations.
[13] During the second level of screening, chemicals detected in game species were evaluated for noncarcinogenic effects only—cancer screening guidelines are not available for these chemicals.

Chemicals with Second Screen Exposure Doses Above Screening Guidelines in On-Site Game (7 Chemicals)

Inorganics
- Antimony
- Cadmium
- Iron
- Manganese
- Thallium

Organics
- 4,6-Dinitro-o-cresol
- 2,4-Dinitrophenol

Off-Site Vegetation

OREIS contains 236 records[14] of chemicals sampled in vegetation (e.g., beets, kale, and tomatoes) from July 30, 1992, to September 8, 1992. These samples were analyzed for a total of six chemicals.[14] See Figures D-15 and D-16 in Appendix D for the number of off-site vegetation samples collected from and the number of chemicals sampled at each location.

Comparison values do not exist for chemicals detected in vegetation. Therefore, as an initial screen, ATSDR calculated exposure doses for the six chemicals using (1) the equation described in Section III.B, "Methodology"; (2) the exposure parameters listed in Table 3; and (3) the average of the maximum concentrations.[15] ATSDR compared these exposure doses to noncancer and cancer screening guidelines. Calculated exposure doses exceeded the screening guidelines for the following three chemicals detected in vegetation from off-site locations.

Chemicals with Initial Screen Exposure Doses Above Screening Guidelines in Off-Site Vegetation (3 Chemicals)

Inorganics
- Arsenic
- Cadmium
- Chromium

As a second screen, ATSDR calculated exposure doses using the second-tier screening concentrations for the chemicals listed above and compared these doses to noncancer and cancer screening guidelines (see Table 31 and Table 32). For this level of the evaluation, the vegetation samples were grouped by type (beets, kale, tomatoes, and unknown terrestrial plant). All three chemicals exceeded noncancer and/or cancer screening guidelines during this second level of screening, and are further evaluated in Section IV, "Public Health Implications." Figure 7 shows the results of ATSDR's chemical screening process.

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[14] Records for mercury and uranium are not included in the total because ATSDR has evaluated or is evaluating them in separate, chemical-specific public health assessments.

[15] ATSDR averaged the maximum concentrations for each vegetation species (across multiple sampling locations and events) because individual species data were available for multiple chemicals and for multiple sampling locations.

Chemicals with Second Screen Exposure Doses Above Screening Guidelines in Off-Site Vegetation (3 Chemicals)

Inorganics
- Arsenic
- Cadmium
- Chromium

Air

OREIS contains about 1,100 records[16] of chemicals sampled in the air from July 31, 1997, to June 30, 2002, from air monitoring stations near the East Tennessee Technology Park. Five different chemicals[16] were analyzed at these locations. See Figures D-17 and D-18 in Appendix D for the number of air samples collected from and the number of chemicals sampled at each location.

ATSDR compared the maximum detected concentration for each chemical to that chemical's conservative health-based comparison value. Based on this initial screen (see Table 33), ATSDR further evaluated the following three chemicals in Section IV, "Public Health Implications." (Beryllium and lead were not detected above comparison values.)

Chemicals Detected Above Comparison Values in Air (3 Chemicals)

Inorganics
- Arsenic
- Cadmium
- Chromium

The list of chemicals evaluated for public health implications, as shown in Figure 7, is compiled from the list of chemicals exceeding screening guidelines. To eliminate duplication, the chemicals are combined across the different media.

[16] Records for mercury and uranium are not included in the total because ATSDR has evaluated or is evaluating them in separate, chemical-specific public health assessments.

Figure 7. Results from ATSDR's Chemical Screening Process

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

	Decision Diagram	Results	Criteria
Pathway Evaluation	Are there completed and/or potential exposure pathways where chemicals have been detected? — NO → Not a contaminant of concern; YES ↓	Off-Site Soil; Off-Site Sediment; Off-Site Surface Water; Off-Site and On-Site Fish; Off-Site and On-Site Game; Off-Site Vegetation; Off-Site and On-site Air	• Based on the results of environmental investigations • Can or are exposures occurring • Identify potential or completed exposure pathways
Preliminary Screening	Are the chemical concentrations higher than medium-specific comparison values? — NO → Not a contaminant of concern; YES ↓	Chemicals Detected Above Comparison Values (see below)	• Based on maximum exposure conditions – maximum concentration detected – maximum exposure duration – maximum exposure frequency – maximum exposure bioavailability
Exposure Dose Comparison	Are estimated exposure doses higher than screening guidelines? — NO → Not a contaminant of concern; YES ↓	Chemicals with Exposure Doses Above Cancer/Noncancer Screening Guidelines (see below)	• Estimate doses based on site-specific exposure conditions • Use more realistic exposure assumptions – realistic concentrations – realistic exposure duration – realistic exposure frequency – realistic exposure bioavailability
Contaminants of Concern	Contaminants of concern; YES ↓	Chemicals Evaluated for Public Health Implications (see below)	• Evaluate the public health implications of contaminants of concern in greater detail
Public Health Implications	Evaluate public health implications	Conclusions (see below)	• Review toxicologic, medical, epidemiologic, and other scientific data on the contaminants of concern • Evaluate whether contaminants of concern can affect public health in the vicinity of the site

Chemicals Detected Above Comparison Values

Soil — *22 chemicals*
Arsenic
Benzidine
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Cadmium
Chlordane, trans
bis(2-Chloroethyl) ether
Chromium
Chrysene
Dibenzo(a,h)anthracene
3,3'-Dichlorobenzidine
HCDD
Heptachlor epoxide
Hexachlorobenzene
Indeno(1,2,3-cd)pyrene
Iron
Lead
n-Nitroso-di-n-butylamine
n-Nitrosodi-n-propylamine
TCDD

Sediment — *33 chemicals*
Aldrin
Arsenic
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Cadmium
Chlordane, cis
Chlordane, trans
bis(2-Chloroethyl) ether
Copper
DDD, p,p'-
DDE, p,p'-
DDT, p,p'-
Dibenzo(a,h)anthracene
3,3'-Dichlorobenzidine
Dieldrin
di(2-Ethylhexyl)phthalate
HCDD
HCH, alpha
HCH, beta
HCH, delta
HCH, gamma
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
Indeno(1,2,3-cd)pyrene
Iron
Lead
Manganese
n-Nitrosodi-n-propylamine
Pentachlorophenol
Toxaphene

Surface Water — *75 chemicals*
Aldrin
alpha-HCH
Aluminum
Ammonia
Antimony
Arsenic
Barium
Benzene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Beryllium
beta-HCH
Bis(2-chloroethyl) ether
Boron
Bromodichloromethane
Bromoform
Cadmium
Carbazole
Carbon tetrachloride
cis-Chlordane
trans-Chlordane
Chlorine
Chlorodibromomethane
Chloroethane
Chloromethane
Chromium
Chrysene
Copper
delta-HCH
Di(2-ethylhexyl)phthalate
Dibenzo(a,h)anthracene
1,2-Dichloroethane
1,3-Dichloropropene, cis-
1,3-Dichloropropene, trans-
2,4-Dinitrophenol
3,3'-Dichlorobenzidine
Dieldrin
4,6-Dinitro-o-cresol
HCDD
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
Indeno(1,2,3-cd)pyrene
Iron
Lead
Lithium
Manganese
Methoxychlor
Methylene chloride
Nickel
Nitrate
Nitrate and nitrite
2-Nitroaniline
3-Nitroaniline
4-Nitroaniline
Nitrobenzene
n-Nitrosodi-n-propylamine
n-Nitrosodiphenylamine
Pentachlorophenol
Selenium
Silver
TCDD
1,1,2,2-Tetrachloroethane
Thallium
Toxaphene
1,1,2-Trichloroethane
2,4,6-Trichlorophenol
Trichloroethylene
Vanadium
Vinyl chloride
Zinc

Fish* — *12 chemicals*
Aldrin
Arsenic
Benzo(a)pyrene
Cadmium
Chromium
Dibenzo(a,h)anthracene
Dieldrin
HCH, alpha
Heptachlor epoxide
TCDD
Thallium
Toxaphene

Game* — *8 chemicals*
Aluminum
Antimony
Cadmium
4,6-Dinitro-o-cresol
2,4-Dinitrophenol
Iron
Manganese
Thallium

Vegetation* — *3 chemicals*
Arsenic
Cadmium
Chromium

Air — *3 chemicals*
Arsenic
Cadmium
Chromium

* Comparison values do not exist for chemicals detected in fish, game, and vegetation. Therefore, as an initial screen, ATSDR calculated exposure doses using the average of the maximum concentrations and compared these exposure doses to noncancer and cancer screening guidelines.

Chemicals with Exposure Doses Above Cancer/Noncancer Screening Guidelines

Soil — *4 chemicals*
Arsenic (pica only)
Benzidine
Iron
Lead (pica only)

Sediment — *0 chemicals*

Surface Water — *0 chemicals*

Fish — *11 chemicals*
Aldrin
Arsenic
Cadmium
Chromium
Dibenzo(a,h)anthracene
Dieldrin
HCH, alpha
Heptachlor epoxide
TCDD
Thallium
Toxaphene

Game — *7 chemicals*
Antimony
Cadmium
4,6-Dinitro-o-cresol
2,4-Dinitrophenol
Iron
Manganese
Thallium

Vegetation — *3 chemicals*
Arsenic
Cadmium
Chromium

Air* — *3 chemicals*
Arsenic
Cadmium
Chromium

* Chemicals in air were retained for further evaluation based on the initial screen against comparison values.

Chemicals Evaluated for Public Health Implications

Aldrin & Dieldrin, Antimony, Arsenic, Benzidine, Cadmium, Chromium, Dibenzo(a,h)anthracene, 4,6-Dinitro-o-cresol, 2,4-Dinitrophenol, Dioxin (TCDD), Heptachlor epoxide, HCH, alpha, Iron, Lead, Manganese, Thallium, Toxaphene

Conclusions

ATSDR concludes that current and future exposures to site-related chemicals (individually or in combination) in soil, sediment, surface water, biota, and air do not pose a public health hazard. Because there are very limited data, exposure to dioxins in fish poses an indeterminate public health hazard. Therefore, ATSDR recommends following the current State of Tennessee fish advisories.

IV. Public Health Implications

IV.A. Introduction

This section of the public health assessment evaluates the public health implications of acute and chronic exposure to chemicals of concern for adults and children. See Figure 7 for a list of chemicals evaluated for public health implications. In these evaluations, ATSDR considered multiple factors, including bioavailability, chemical and physical properties, and the frequency and duration of the estimated exposures. For cases in which a population is affected by more than one exposure pathway, ATSDR also considered the combinations of chemicals and exposure routes. ATSDR considered characteristics of the exposed population—such as age, gender, genetics, lifestyle, nutritional status, and health status—which influence how individuals absorb, distribute, metabolize, and excrete contaminants. Where appropriate, these characteristics are included in the chemical-specific discussions.

ATSDR tries to estimate realistic, site-specific exposure scenarios to enable comparisons to actual health effect levels reported in the scientific literature. For example, 0.15 liters per day (L/day) (the amount of water ingested during a 3-hour swimming event; EPA 1999) was used as the surface water intake rate in this section of the public health assessment instead of the 0.5 L/day used in the screening evaluation. In this level of the evaluation, an average concentration is used to estimate a more probable exposure dose. Because all of the chemicals were not detected in all of the samples, it is more likely that people would be exposed to a range of concentrations over time.

For chemicals detected in at least 10 percent of the samples, averages were calculated using detected concentrations only and do not take into account nondetected values. Even though this method tends to overestimate the true average values, ATSDR chose to base its health evaluations on the more conservative averages to be more protective of public health. For chemicals detected in less than 10 percent of the samples, ATSDR calculated averages using 1/2 the detection limit for nondetected samples.

In the case of pica behavior (see the "Children's Health Considerations" section), the estimated exposure doses were calculated using the maximum concentration and then compared to acute health effect levels (acute MRLs) because this exposure pattern can be episodic and short term.

As previously discussed, health guidelines (MRLs and RfDs) are derived for chemicals using the NOAEL/LOAEL/uncertainty factor approach. Generally, the uncertainty factor (also known as the safety factor) consists of multiples of 10, each representing a specific area of uncertainty inherent in the available animal or human study data. For example, a factor of 10 could be used to account for differences between animals and humans; a second factor of 10 could then be used to account for differences among people; while an additional factor of 10 could be used to account for the use of a LOAEL, instead of a NOAEL. An additional uncertainty factor that is greater than zero and less than or equal to 10 can also be used. The magnitude of the factor depends on the professional assessment of scientific uncertainties of the study and the quality of the database. Health guidelines are generally based on the LOAELs reported in the literature, often from a single study (the "critical study"). In addition to the critical study, other studies can provide chemical-specific, dose-response data.

The following discussion focuses primarily on contaminants detected in off-site locations. Because there are limited off-site air samples, however, and people have access to on-site fish and game, on-site exposures to these media are also discussed when appropriate.

IV.B. Children's Health Considerations

ATSDR recognizes that developing fetuses, infants, and children have unique vulnerabilities. Children are not small adults; a child's exposure can differ from an adult's in many ways. A child drinks more liquid, eats more food, and breathes more air per unit of body weight than an adult, and has a larger skin surface area in proportion to body volume. A child's behavior and lifestyle also influence exposure levels. Children crawl on the floor, put things in their mouths, play closer to the ground, and spend more time outdoors. These behaviors can result in longer exposure durations and higher intake rates.

In addition, children's metabolic pathways, especially in the first few months after birth, are less developed than those of adults. In some cases, children are better able than adults to deal with chemicals, but in others, they are less able and more vulnerable. Some chemicals that are not highly toxic in adults are in children.

Children grow and develop rapidly in the first few months and years of life. Some organ systems, especially the nervous and respiratory systems, can be permanently damaged if exposed to high levels of certain chemicals during this period. Also, young children have less ability to avoid hazards, because they lack knowledge and depend on adults for decisions.

This section of the public health assessment evaluates hazards to children displaying pica behavior (a craving for non-nutritive substances like soil). Information on the incidence of soil pica behavior is limited. A study described in EPA's *Exposure Factors Handbook* (EPA 1999) showed that the incidence of soil pica behavior was approximately 16 percent among children from a rural black community in Mississippi. This behavior was described as a cultural practice among the community surveyed, however, so that community may not represent the general population. In five other studies, only one child out of more than 600 ingested an amount of soil significantly greater than the range of other children. Although these studies did not include data for all populations and represented short-term ingestion only, it can be assumed that the incidence rate of child pica behavior in the general population is low.

There is little information on the amount of soil ingested (measured in mg/day) by children with pica behavior (EPA 1999). Intake rates between 1,000 and 10,000 mg/day have been used to estimate exposure doses for pica children. In this health assessment, ATSDR assumed a soil intake rate of 5,000 mg/day for 52 days per year (once a week) to represent pica behavior in children aged 1 to 3 years old. ATSDR believes that this is a health-protective assumption and likely overestimates soil consumption. In the case of pica behavior, estimated exposure doses were calculated using the maximum surface soil concentration detected in an area of likely exposure. ATSDR then compared these doses to acute health effect levels (e.g., acute MRLs), since this exposure pattern can be episodic and short-term (see Table 4). Doses below the acute MRLs are not considered to be a health hazard because MRLs have built-in safety factors, making them considerably lower than levels at which health effects have been observed.

ATSDR evaluated pica exposures to the 22 chemicals detected above comparison values in off-site soil. As shown in Table 4, most of the chemicals were not detected at levels constituting a health hazard for children exhibiting pica behavior. Only potential pica exposure to soil containing arsenic, iron, and lead is evaluated further.

Arsenic

Arsenic occurs naturally in the environment and is usually combined with other elements such as oxygen, chlorine, and sulfur. When combined with these elements arsenic is called inorganic arsenic. When combined with carbon and hydrogen, it is called organic arsenic. The organic forms of arsenic are usually less harmful than the inorganic forms (ATSDR 2000a). To be protective of public health, ATSDR assumed that all of the arsenic was in the more harmful inorganic form.

Using the maximum detected concentration (77.3 ppm; collected from a residential property), the estimated pica child exposure dose for arsenic in soil (5.5×10^{-3} milligrams per kilogram per day [mg/kg/day]) is slightly above the acute MRL. The next highest residential concentration (12.7 ppm; collected on the same day from the same location as the maximum concentration) is not at a level constituting a health hazard (the estimated exposure dose of 9.0×10^{-4} mg/kg/day is below the acute MRL). The acute MRL is based on a study in which health effects were observed in people exposed to 5.0×10^{-2} mg/kg/day of arsenic through ingesting poisoned soy sauce (Mizuta et al. 1956). ATSDR does not expect pica child exposures to result in adverse health effects in the ORR area; however, if pica children are exposed to the maximum detected concentration, they may suffer adverse acute effects (e.g., gastrointestinal distress, vomiting, or diarrhea).

Iron

Iron is a naturally occurring element in the environment. Iron is also an important mineral, which assists in the maintenance of basic life functions. It combines with protein and copper to make hemoglobin, which transports oxygen in the blood from the lungs to other parts of the body, including the heart. It also aids in the formation of myoglobin, which supplies oxygen to muscle tissues (ANR 2003). Without sufficient iron, the body cannot produce enough hemoglobin or myoglobin to sustain life. Iron deficiency is a condition that occurs when the body does not receive enough iron. Despite iron being the fourth most abundant metal in the earth’s crust, iron deficiency is the world’s most common cause of anemia. The National Academy of Sciences’ (NAS’s) dietary reference intake (DRI) for children 1 to 3 years old is 7 mg/day (NAS 2001).

According to the FDA, doses greater than 200 mg per event could poison or kill a child (FDA 1997). Doses of this magnitude are generally the result of children accidentally ingesting iron pills, not iron in soil or water. Acute iron poisoning has been reported in children less than 6 years of age who have accidentally overdosed on iron-containing supplements for adults. Because iron is not considered to cause harmful health effects in general, toxicological and epidemiological literature is limited.

Table 4. Estimated Pica Child Exposure Doses for Chemicals Detected in Off-Site Soil Compared to Acute Screening Guidelines

Chemical	*Maximum Concentration (ppm)*	*Pica Child Exposure Dose (mg/kg/day)*	*Acute Screening Guideline (mg/kg/day)*	*Source*	*Does the Pica Dose Exceed the Screening Guideline?*
Inorganics					
Arsenic	77.3	5.5E-03	0.005	Acute MRL	Yes
Cadmium	41.3	2.9E-03	0.02	Tox profile*	No
Chromium	*Below comparison values*				
Iron	31,500	158 mg/day	7 mg/day	DRI	Yes
Lead	625	4.5E-02	0.02	Acute LOAEL	Yes
Organics					
Benzidine	4.13	2.9E-04	0.003	RfD	No
Benzo(a)anthracene	4.13	2.9E-04	0.003	RfD§	No
Benzo(a)pyrene	4.13	2.9E-04	0.003	RfD§	No
Benzo(b)fluoranthene	4.13	2.9E-04	0.003	RfD§	No
Benzo(k)fluoranthene	*Below comparison values*				
bis(2-Chloroethyl) ether	4.13	2.9E-04	0.0075	Tox profile†	No
Chrysene	*Below comparison values*				
trans-Chlordane	2.8	2.0E-04	0.001	Acute MRL (chlordane)	No
Dibenzo(a,h)anthracene	4.13	2.9E-04	0.003	RfD§	No
3,3'-Dichlorobenzidine	4.13	2.9E-04	0.003	RfD (benzidine)	No
Heptachlor epoxide	0.97	6.9E-05	0.008	Tox profile*	No
Hexachlorobenzene	4.13	2.9E-04	0.008	Acute MRL	No
HCDD	*Below comparison values*				
Indeno(1,2,3-cd)pyrene	4.13	2.9E-04	0.003	RfD§	No
n-Nitroso-di-n-butylamine	4.13	2.9E-04	0.095	Acute MRL (n-nitrosodi-n-propylamine)	No
n-Nitrosodi-n-propylamine	0.79	5.6E-05	0.095	Acute MRL	No
TCDD	*Below comparison values*				

Pica doses were calculated using the following formula:

pica dose = (maximum concentration×0.005 kg/day×52 days/year×3 years)/(10 kg×(365 days/year×3 years))

Soil samples collected from Atomic City Auto Parts were not included because this is a separate industrial site that children are unlikely to have access to and the contaminated soil was removed. These data were not removed, however, during the screening assessment or from the summary information provided in Table 16 and Table 17.

"Below comparison values" means that when the Atomic City Auto Parts data were removed, the remaining soil concentrations were below the conservative health-based comparison values.

* The acute screening guideline was derived from limited acute toxicological data available in ATSDR's toxicological profile. A safety factor of 100 or 1,000 was applied to account for differences between animals and humans and to account for the use of a LOAEL, instead of a NOAEL. These acute screening guidelines should be considered unofficial and are for use in this health assessment only.

§The acute screening guideline was derived from the chronic oral RfD for anthracene. A safety factor of 100 was applied for use of a chronic guideline value. These acute screening guidelines should be considered unofficial and are for use in this health assessment only.

†The acute screening guideline was derived from an acute LD50 value available in ATSDR's toxicological profile. A safety factor of 10,000 was applied for use of an LD50 value. This acute screening guideline should be considered unofficial and is for use in this health assessment only.

DRI = dietary reference intake
LOAEL = lowest-observed-adverse-effect level
mg/kg/day = milligram per kilogram per day
MRL = minimal risk level
ppm = parts per million
RfD = reference dose

For comparison, ATSDR used a modification of the dose equation (dose = concentration × intake rate) to calculate a daily consumption from exposure to iron in soil. Exposure to the maximum concentration of iron collected from a residential area (31,500 ppm) would increase a pica child's daily consumption of iron by 158 mg/day, assuming 100 percent absorption. The median daily intake of dietary iron is roughly 11 to 13 mg/day for children 1 to 8 years old and 13 to 20 mg/day for adolescents 9 to 18 years old (NAS 2001). While the estimated daily consumption of iron for a pica child exceeds the NAS DRI, the daily increase in consumption is not likely to cause a pica child's daily dose to exceed levels known to induce poisoning (greater than 200 mg/event). Further, to the ATSDR health assessors' knowledge, no case of acute iron toxicity has ever occurred as a direct result of soil consumption. The absence of such cases probably reflects the large amount of soil that would have to be ingested, combined with the much lower intestinal absorption of iron from soil than from food, and the fact that the human body regulates its own iron level. Therefore, ATSDR does not expect that children exhibiting pica behavior would experience adverse health effects from exposure to iron in soil.

Lead

Lead is a naturally occurring bluish-gray metal found in small amounts in the Earth's crust and in all environmental media. The harmful effects from lead exposure have been known for a long time. Young children and fetuses have been the main focus of health effects research because they are most sensitive to potential effects from lead exposure. Because of health concerns, lead in gasoline, paints, ceramic products, caulking materials, and pipe solder has been dramatically reduced in the past few decades.

Six surface soil lead concentrations exceeded the screening value (400 ppm). The five highest lead concentrations detected in surface soil were located on the Atomic City Auto Parts industrial property where soil removal activities have been conducted (the contaminated soil has been removed). The only remaining soil sample (625 ppm) that exceeded the soil screening value is located in a residential area.

Assuming 100 percent bioavailability of the lead, the estimated exposure dose (4.5×10^{-2} mg/kg/day) for a child exhibiting pica behavior was slightly above the noncancer screening guideline (0.02 mg/kg/day; acute LOAEL in a human study). Further, ATSDR reviewed 122 studies of human and animal exposures to various doses of lead. In general, exposure doses below 0.001 mg/kg/day do not harm humans or animals. Exposure doses from 0.001 to 0.01 mg/kg/day have been shown to produce minor changes in blood cells. Harmful effects have been observed in animals when doses reach and exceed 0.01 mg/kg/day (ATSDR 1999b). However, studies indicate that not all of the ingested lead is absorbed via the gastrointestinal tract.

> As a prudent public health practice, ATSDR supports routine blood lead testing, especially for children between the ages of 6 months and 6 years at high risk for having elevated blood lead levels. For more information about CDC's Childhood Lead Poisoning Prevention Program, visit http://www.cdc.gov/nceh/lead/lead.htm.

In humans, there is a correlation between the levels of lead in blood and the harmful effects that may result. Blood lead levels can be elevated via exposure to contaminated soil, paint, dust, air, food, and/or drinking water. Neurological effects are the most important health effect. CDC considers a child to have an elevated blood lead level if the amount of lead is 10 micrograms per deciliter (µg/dL) or higher. Epidemiologic studies have consistently found that non-pica children's blood lead levels increase by about 3.8 µg/dL for every 1,000 ppm increase in soil lead levels. The lead concentrations detected in off-site soil ranged from 5.3 to 625 ppm.

Hypothetically (worst-case scenario), if children exhibiting routine pica behavior were exposed to 625 ppm of lead in soil with 100 percent absorption, their blood lead levels could reach and exceed 10 µg/dL. However, ATSDR believes that this scenario is unlikely.

IV.C. Public Health Evaluation

Chronic exposure to specific chemicals of concern is discussed in this section. The discussion of potential health effects for each chemical of concern is based on calculated exposure doses for current and future scenarios and documented health effects from human and animal studies. It is important to remember that an exposed person would not necessarily experience adverse health effects. It is also important to note that ATSDR is *assuming* exposure to the contaminated media. The location of each detection was not individually evaluated to determine whether anyone is actually being exposed.

ATSDR evaluated pathway-specific exposure doses for populations that may be exposed to specific chemicals via multiple exposure pathways to reflect a total estimated dose. Of all the chemicals screened for current and future exposure scenarios (off-site soil, sediment, surface water, biota, and air; on-site fish, game, and air), none are expected to result in adverse effects when considered across pathways.

Table 5 summarizes the completed and potential exposure pathways evaluated in this public health assessment. This table presents the exposure pathways, exposure routes, potentially affected populations, and public health implications for each contaminant that exceeded screening guidelines (see Table 16 through Table 33). A more detailed discussion of these chemicals follows the table.

Table 5. Summary of Completed and Potential Exposure Pathways for Contaminants Above Screening Guidelines

Substance Name	Retained Pathway(s)	Exposure Route(s)	Potentially Affected Population(s)	Public Health Implications
Aldrin/dieldrin	Biota (fish)	Ingestion	Child & adult—subsistence	None expected
Antimony	Biota (on-site game)	Ingestion	Child	None expected
Arsenic	Biota (fish & vegetation) Air	Ingestion Inhalation	Child & adult Adult	None expected None expected
Benzidine	Soil	Ingestion	Adult	None expected
Cadmium	Biota (fish & game) Biota (vegetation) Air	Ingestion Ingestion Inhalation	Child & adult Child & adult Child & adult	None expected None expected (see text) None expected
Chromium	Biota (fish & vegetation) Air	Ingestion Inhalation	Child & adult Adult	None expected None expected
Dibenzo(a,h)anthracene	Biota (EFPC crayfish)	Ingestion	Adult—subsistence	None expected
2,4-Dinitrophenol	Biota (unknown game)	Ingestion	Child	None expected
4,6-Dinitro-o-cresol	Biota (unknown game)	Ingestion	Child	None expected
Dioxin	Biota (unknown fish)	Ingestion	Child & adult	Indeterminate—follow fish advisories
Heptachlor epoxide	Biota (fish)	Ingestion	Child & adult—subsistence & recreational	None expected
alpha-HCH	Biota (fish)	Ingestion	Adult—subsistence	None expected
Iron	Soil Biota (unknown game)	Ingestion Ingestion	Child Child & adult	None expected None expected
Manganese	Biota (unknown game)	Ingestion	Child	None expected
Thallium	Biota (fish & game)	Ingestion	Child & adult	None expected
Toxaphene	Biota (fish)	Ingestion	Child & adult—subsistence	None expected

This table only presents chemicals that exceeded screening guidelines during the second-tier screening process.
EFPC = East Fork Poplar Creek

Aldrin/Dieldrin

Aldrin and dieldrin are the common names of two structurally similar compounds once used as insecticides. These chemicals are made in a laboratory and do not occur naturally in the environment. The two chemicals are discussed together because aldrin readily changes into dieldrin once it enters the environment or the body.

Aldrin and dieldrin are no longer produced or used. From the 1950s until 1970, aldrin and dieldrin were used extensively as insecticides on crops such as corn and cotton. The U.S. Department of Agriculture canceled all uses of aldrin and dieldrin in 1970. In 1972, however, EPA approved the use of aldrin and dieldrin for killing termites. Use of aldrin and dieldrin to control termites continued until 1987. In 1987, the manufacturer voluntarily canceled the registration for use in controlling termites.

As shown in Table 22 through Table 29, the estimated exposure doses for children and adults under the subsistence fishing exposure scenario are above their respective noncancer and cancer screening guidelines for aldrin/dieldrin in fish (mainly sunfish). As such, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from fish ingestion. The aldrin and dieldrin levels detected in all other media are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer and cancer screening guidelines) and will not be discussed further.

Table 6 shows estimated exposure doses for fish consumption that exceeded the noncancer or cancer screening guideline for aldrin and dieldrin, respectively. For this level of the evaluation, however, ATSDR calculated the estimated exposure doses using average concentrations to more closely reflect expected exposure patterns (people are exposed to a range of concentrations over time).

Table 6. Estimated Exposure Doses for Aldrin and Dieldrin

Medium	*Average Concentration (ppm)*	*Subsistence-Level Exposure Dose (mg/kg/day)*		
		Child	*Adult*	*Lifetime*
Aldrin				
Clinch River sunfish	0.042	6.5E-05	3.9E-05	1.7E-05
WBR sunfish	0.035	5.4E-05	3.3E-05	1.4E-05
On-site Sunfish	0.039	6.0E-05	3.6E-05	1.6E-05
Dieldrin				
EFPC sunfish	0.040	6.2E-05	3.7E-05	1.6E-05
Clinch River sunfish	0.045	6.9E-05	4.2E-05	1.8E-05
WBR sunfish	0.041	6.3E-05	3.8E-05	1.6E-05
On-site sunfish	0.060	9.2E-05	5.6E-05	2.4E-05
Clinch River catfish	0.012	1.8E-05	1.1E-05	4.8E-06
WBR catfish	0.009	1.4E-05	8.4E-06	3.6E-06
On-site catfish	0.012	*Below screening guidelines*		4.8E-06
On-site bass	0.027	4.2E-05	2.5E-05	1.1E-05

The chronic MRL for aldrin is 3.0×10^{-5} mg/kg/day.
The chronic MRL for dieldrin is 5.0×10^{-5} mg/kg/day.
"Below screening guidelines" means that the calculated doses were below screening guidelines during the second-tier screening evaluation (see Section III.D).

Based on the reported results, sunfish contained the highest levels of aldrin and dieldrin. The estimated exposure doses for consumption of catfish, crayfish, and bass are lower than the exposure doses estimated for consumption of sunfish. As such, ATSDR will use sunfish as a surrogate for all species since the estimated exposure doses from eating sunfish are expected to be the greatest.

All estimated exposure doses for recreational fishing exposure patterns were below levels constituting a hazard for all species. Aldrin/dieldrin exposure doses from ingestion (subsistence) of sunfish are above their respective screening guidelines in multiple locations (e.g., the Clinch River, EFPC, WBR, and on-site sampling locations). In all these locations, if “sunfish” represents 25 percent of the ingested fish over a lifetime of subsistence level exposures (using the average concentrations), then the exposure doses are below screening guidelines for both cancer and noncancer effects. This means that a person could eat about 13 pounds of aldrin/dieldrin-contaminated fish per year for 30 years and not experience adverse health effects. Therefore, adverse health effects are not expected.

Further, the noncancer screening guidelines for aldrin and dieldrin are based on studies in which adverse effects were observed at doses of 2.5×10^{-2} mg of aldrin/kg/day, while no adverse effects were observed at doses of 5.0×10^{-3} mg of dieldrin/kg/day (ATSDR 2002). Cancer effects were reported at doses ranging from 0.33 to 1.5 mg/kg/day (ATSDR 2002). All of the estimated subsistence-level exposure doses (i.e., children and adults eating 16 pounds [lbs] of fish/year and 52 lbs fish/year, respectively) are at least two to three orders of magnitude below these health effect levels (see Table 6).

Antimony

Antimony is a silvery white metal that is naturally found in the environment. It can enter the body when a person eats food contaminated with it. After a few hours, a small amount enters the bloodstream and mostly distributes to the liver, lungs, intestines, and spleen. Antimony then leaves the body in urine and feces over several weeks (ATSDR 1992).

As shown in Table 30, the estimated exposure dose for a child eating on-site game is above the antimony noncancer screening guideline. As such, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential for eating game. The antimony levels detected in all other media are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer screening guidelines).

The estimated exposure dose for a child ingesting on-site game was above the noncancer screening guideline when assuming 100 percent absorption. However, antimony is only slowly absorbed from the gastrointestinal tract. Based on animal data, gastrointestinal absorption of antimony was estimated to be 2 to 7 percent (ATSDR 1992). To account for this poor absorption, ATSDR assumed that 10 percent of the antimony was absorbed. The estimated exposure dose using an absorption value of 10 percent (5.0×10^{-5} mg/kg/day) is below the noncancer screening guideline (4.0×10^{-4} mg/kg/day). Remember that the screening guideline is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects. Estimated doses that are less than this value are not considered to be a health hazard. As such, exposure to antimony is not expected to result in adverse health effects.

Arsenic

Arsenic is naturally occurring in the environment and is usually combined with other elements such as oxygen, chlorine, and sulfur. When combined with these elements arsenic is called inorganic arsenic. When combined with carbon and hydrogen, it is called organic arsenic. The organic forms of arsenic are usually less harmful than the inorganic forms (ATSDR 2000a). To be protective of public health, ATSDR assumed that all of the arsenic was in the more harmful inorganic form.

The estimated exposure doses for children and adults ingesting fish and vegetation (Table 22 through Table 29, Table 31, and Table 32), and for people inhaling air (Table 33) are above the arsenic noncancer and cancer screening guidelines. As such, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from these pathways. The arsenic levels detected in soil, sediment, surface water, and game are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer and cancer screening guidelines) and will not be discussed further.

Table 7 shows the exposure doses for media that exceeded the arsenic noncancer or cancer screening guidelines. For this level of the evaluation, however, ATSDR recalculated the estimated exposure doses using average concentrations to represent more realistic exposure scenarios and assumed that 10 percent of the total arsenic detected in fish and crayfish was in the inorganic form.

Table 7. Estimated Exposure Doses for Arsenic

Medium	*Average Concentration (ppm)*	*Exposure Dose (mg/kg/day)*		
		Child	*Adult*	*Lifetime*
EFPC crayfish	0.38	5.8E-05	3.5E-05	1.5E-05
On-site crayfish	0.25	3.8E-05	2.3E-05	9.9E-06
Clinch River catfish	0.64	9.8E-05	5.9E-05	2.5E-05
WBR catfish	0.23	3.5E-05	2.1E-05	9.2E-06
Clinch River sunfish	0.45	6.9E-05	4.2E-05	1.8E-05
WBR sunfish	0.12	1.8E-05	1.1E-05	4.8E-06
On-site sunfish	0.19	2.9E-05	1.8E-05	7.6E-06
Clinch River bass	0.28	4.3E-05	2.6E-05	1.1E-05
WBR bass	0.18	2.8E-05	1.7E-05	7.2E-06
On-site bass	0.22	3.4E-05	2.0E-05	8.8E-06
WBR unknown fish	0.17	2.6E-05	1.6E-05	6.8E-06
On-site unknown fish	0.31	4.8E-05	2.9E-05	1.2E-05
Off-site kale	1.4	2.2E-03	2.2E-03	9.6E-04
Off-site tomato	1.5	2.4E-03	2.4E-03	1.0E-03
Air	0.00056 µg/m³	NA		

The chronic MRL for arsenic is 3.0×10^{-4} mg/kg/day.
Exposure doses for fish represent subsistence-level fishing.
ATSDR assumed that 10 percent of the total arsenic detected in fish and crayfish was in the inorganic form.
The average kale and tomato concentrations are based on samples from both edible and inedible portions.
Air CREG = 0.0002 µg/m³
NA = not applicable

Ingestion is the primary way arsenic enters the body. Once arsenic is in the body, the liver changes some of it into a less harmful organic form. Both inorganic and organic forms of arsenic leave the body in urine. Studies have shown that 45 to 85 percent of the arsenic is eliminated within 1 to 3 days; however, some remains for several months or longer (Buchet et al. 1981; Crecelius 1977; Mappes 1977; Tam et al. 1979).

The scientific literature indicates that some dermal health effects could result from ingesting arsenic—hyperkeratosis and hyperpigmentation were reported in humans exposed to 1.4×10^{-2} mg/kg/day of arsenic in their drinking water for more than 45 years (Tseng et al. 1968). However, because estimates of water intake and dietary arsenic are highly uncertain in this and similar studies, some scientists argue that reported effects may actually be associated with doses higher than 1.4×10^{-2} mg/kg/day. Further, these effects have never been reported in a U.S. population.

Fish

Fish and shellfish can accumulate arsenic, but more than 80 percent of the arsenic found in fish is in an organic form (arsenobetaine or fish arsenic), which is not harmful (ATSDR 2000a; FDA 1993; Francesconi and Edmonds 1997; NAS 2001). The U.S. Food and Drug Administration (FDA) proposes that 10 percent of the total arsenic be estimated as inorganic arsenic (FDA 1993). When ATSDR applied this factor, the estimated subsistence-level exposure doses for arsenic in fish were below the screening guidelines. Further, all subsistence-level exposure doses are orders of magnitude below levels shown to cause harmful health effects (1.4×10^{-2} mg/kg/day) (see Table 7). Thus, the subsistence-level exposure doses are below levels constituting a health hazard; eating fish with the detected levels of arsenic is not expected to result in adverse health effects.

Vegetation

Limited vegetable data (18 kale samples and 15 tomato samples) were used to evaluate exposure to arsenic via locally grown vegetables. Arsenic was detected in less than 60 percent of the kale and tomato samples analyzed. Plants vary in the amount of arsenic they absorb from the soil and where they store arsenic. Some plants move arsenic from the roots to the leaves, while others absorb it and store it in the roots only.

- Fruit-type vegetables, such as tomatoes, concentrate arsenic in the roots, and less arsenic is taken up in the fruit.
- Leafy vegetables also store arsenic in their roots, but some is stored in the stems and leaves. Lettuce and some members of the *Brassica* plant family (such as collards, kale, mustard, and turnip greens) store more arsenic in the leaves than other crops, but not at concentrations high enough to cause health effects.
- Root crops such as beets, turnips, carrots, and potatoes absorb most of the arsenic in the surface skin of the vegetable. Peeling the skins of root crops can help eliminate the portion of the plant that contains arsenic.

The maximum arsenic concentration (0.06 ppm) detected in an *edible* portion of the vegetables was found in kale leaves. If an adult ate 90 lbs of vegetables/year (which is equivalent to the intake rate assumption of 0.0016 kg/kg/day for a 70 kg adult) containing the maximum concentration of arsenic, the exposure dose would be 1.0×10^{-4} mg/kg/day. A child eating about 17 lbs of vegetables/year (which is equivalent to the intake rate assumption of 0.0016 kg/kg/day for a 13 kg child) with the maximum concentration would have the same estimated dose. This exposure dose is below the screening guideline (3.0×10^{-4} mg/kg/day), as well as two orders of magnitude below levels shown to cause harmful health effects (1.4×10^{-2} mg/kg/day). Further, people are not expected to consume their yearly diet of vegetables from local gardens, and a portion of arsenic in plants is in the less toxic form (organic arsenic). Therefore, ATSDR does not expect adverse health effects to result from exposure to arsenic in locally grown produce.

Air

Limited air monitoring data collected on the ORR were used to evaluate exposure to arsenic via the inhalation pathway. The average air level was 0.00056 micrograms per cubic meter ($\mu g/m^3$)—which slightly exceeds the comparison value of 0.0002 $\mu g/m^3$. Air samples were collected on the ORR, thus the surrounding off-site population would have been exposed to lower levels due to dispersion, downwash effects, and increasing distance. Therefore, ATSDR does not believe that adverse effects would result in the general population from air related arsenic exposure.

Benzidine

Benzidine is a manufactured chemical that does not occur naturally. It is a crystalline solid that may be grayish-yellow, white, or reddish-gray. In the environment, benzidine is found in either its “free” state (as an organic base) or as a salt. Benzidine was used to produce dyes for cloth, paper, and leather. It is no longer produced or used commercially in the United States.

In soil, most benzidine is likely to be strongly attached to soil particles, so it does not easily pass into underground water. Benzidine can slowly be destroyed by certain other chemicals, light, and some microorganisms (for example, bacteria). Certain fish, snails, algae, and other forms of water life may take up and store very small amounts of benzidine, but accumulation in the food chain is unlikely.

As shown in Table 17, the estimated exposure dose for adults exposed to benzidine in off-site soil is above the cancer screening guideline. As such, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from exposure to benzidine in soil. The benzidine levels detected in all other media are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer and cancer screening guidelines or benzidine was not detected).

Very little information is available on the noncancer health effects that may be caused by exposure to benzidine. Benzidine contact with your skin could possibly cause a skin allergy. Benzidine can cause cancer in humans. This has been shown in studies of workers who were exposed for many years to levels much higher than the general population would experience. It is important to note that most of the workers did not develop cancer, even after such high exposures. When cancer does occur, however, most often it is cancer of the urinary bladder.

Benzidine was detected in two of 26 off-site surface soil samples. The two surface soil samples were from two separate residential properties, located approximately 0.5 mile apart. The reported concentrations were above ATSDR's cancer screening value for soil. The estimated exposure dose for a person exposed for 125 days per year for 30 years is below the cancer screening value. Based on the conservative exposure assumptions, the tightly bound nature of benzidine to soil and organic material, and the unlikelihood that the general population or people living near the two locations would come in routine contact with benzidine-impacted surface soil (detected in less than 8 percent of the samples), ATSDR does not expect adverse health effects from exposure to benzidine in surface soil.

Cadmium

Cadmium is an element that occurs naturally in the Earth's crust. All soils and rocks, including coal and mineral fertilizers, contain some cadmium. Pure cadmium is a soft, silver-white metal. It is often found as part of small particles in air. It does not have a distinctive flavor or smell, so it is unnoticeable in water, food, and air. Food and cigarette smoke are the largest potential sources of cadmium exposure for the general population. Average cadmium levels in U.S. foods range from 2 to 40 parts per billion (ppb) of cadmium per parts of food. Average cadmium levels in cigarettes range from 1,000 to 3,000 ppb. The current U.S. average dietary intake of cadmium in adults is about 4.0×10^{-4} mg/kg/day; smokers receive an additional amount—about 4.0×10^{-4} mg/kg/day—from cigarettes (ATSDR 1999a). Most ingested cadmium passes through the gastrointestinal tract without being absorbed (Kjellstrom et al. 1978).

The estimated exposure doses for children and adults eating EFPC fish (Table 22), on-site fish (Table 28), on-site game (Table 30), and off-site vegetation (Table 31); and people inhaling the air (Table 33) are above the ATSDR cadmium screening guidelines. As such, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from these pathways. The cadmium levels detected in soil, sediment, and surface water are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer screening guidelines) and will not be discussed further.

Table 8 shows the exposure doses for media that exceeded the cadmium screening guidelines using the second-tier screening concentrations. ATSDR does not have a specific screening value for cadmium in biota (crayfish, fish, game, or vegetables) but has derived an MRL of 0.0002 mg/kg/day for chronic oral exposure to cadmium. The chronic oral MRL is based on a lifetime accumulated threshold of 2,000 mg of cadmium from dietary sources. The threshold is associated with kidney effects (e.g., proteinuria, or protein in the urine) seen in residents of cadmium-polluted areas of Japan. The average cadmium concentration in locally grown rice was used as the measure of cadmium intake and proteinuria was used as the index of renal damage. A relevant consideration is whether the proteinuria caused by cadmium exposure should be considered an adverse effect. The increased excretion of low-molecular-weight proteins *per se* probably has no adverse effect on health. Several studies have indicated that increased calcium excretion also occurs at about the same level as proteinuria, though—and this is an adverse effect if it leads to increased calcium wasting and osteoporosis, particularly in post-menopausal women.

EPA has calculated oral chronic RfDs for cadmium of 0.001 and 0.0005 mg/kg/day for ingestion of food and water, respectively. The critical effect is significant proteinuria in humans chronically exposed to cadmium, using a NOAEL of 200 mg of cadmium per gram wet weight in the renal cortex and a kinetic model assuming 2.5 or 5 percent cadmium absorption from food or water, respectively, and 0.01 percent cadmium excretion per day (EPA 2004b). ATSDR's chronic oral MRL (0.0002 mg/kg/day) is comparable to the EPA RfD for water (0.0005 mg/kg/day). This is probably due to the fact that the moisture content of cooked rice is about 75 percent, roughly a 3:1 ratio of water-to-rice. As such, when evaluating exposures via the consumption of rehydrated foods (such as rice, pasta, and beans), ATSDR uses the MRL/RfD for water. When considering exposures from hydrated foods (such as fish, game, and vegetables), however, ATSDR uses the RfD for food because it more closely matches the media being evaluated.

Table 8. Estimated Exposure Doses for Cadmium

Medium		***Average Concentration (ppm)***	***Exposure Dose (mg/kg/day)***	
			Child	***Adult***
EFPC crayfish	Subsistence	3.0	4.6E-03	2.8E-03
	Recreational		6.9E-04	3.4E-04
On-site crayfish	Subsistence	2.1	3.2E-03	2.0E-03
	Recreational		4.8E-04	2.4E-04
EFPC sunfish	Subsistence	1.2	1.8E-03	1.1E-03
	Recreational		2.8E-04	1.4E-04
On-site sunfish	Subsistence	0.83	1.3E-03	7.7E-04
	Recreational		1.9E-04	9.5E-05
On-site creek chub	Subsistence	0.86	1.3E-03	8.0E-04
	Recreational		2.0E-04	9.8E-05
On-site bass	Subsistence	0.24	3.7E-04	2.2E-04
	Recreational		*Below screening guidelines*	
On-site unidentified fish	Subsistence	0.80	1.2E-03	7.4E-04
	Recreational		1.8E-04	9.1E-05
On-site unknown aquatic bird		4.3	3.3E-04	1.2E-04
On-site unknown terrestrial animal		4.5	3.5E-04	1.3E-04
Off-site beets		0.69	1.1E-03	1.1E-03
Off-site kale		0.60	9.6E-04	9.6E-04
Off-site tomatoes (edible portion only)		0.17	2.7E-04	2.7E-04
Air		0.00065 µg/m³	NA	

The chronic MRL for cadmium is 2.0×10^{-4} mg/kg/day.
The EPA oral RfDs for cadmium are 1.0×10^{-3} mg/kg/day and 5.0×10^{-4} mg/kg/day from ingestion of food and water, respectively.
Air CREG = 0.0006 $\mu g/m^3$
The tomato data were screened (see Section III.D) using both fruit and root samples. However, for the public health implications section we focused on the edible portion of the tomato plant (i.e., the fruit).
"Below screening guidelines" means that the calculated doses were below screening guidelines during the second-tier screening evaluation (see Section III.D).
NA = not applicable

Fish

As noted above, most ingested cadmium passes through the gastrointestinal tract without being absorbed (Kjellstrom et al. 1978). EPA has derived an oral RfD for food that reflects differences in absorption between cadmium in food and cadmium in water. The estimated exposure doses for children and adults under the recreational exposure scenario (see Table 8) are below the screening guideline for food (1.0×10^{-3} mg/kg/day) and below the NOAEL for humans (2.1×10^{-3} mg/kg/day; ATSDR 1999a).

The estimated exposure doses for subsistence behavior were above the screening guideline for sunfish and crayfish for adults and sunfish, creek chub, crayfish, and an unidentified fish species for children. The estimated exposure doses for adults and children eating locally caught crayfish at subsistence levels were also above the human NOAELs. (Subsistence levels, per the default assumption, are about 16 lbs/year for children and 52 lbs/year for adults—more than a pound per month for children and a pound per week for adults.) These doses could have health effects (e.g., proteinuria), but we believe that the recreational consumption rates (2.4 lbs/year and 6.4 lbs/year for children and adults, respectively) are more realistic regarding locally harvested crayfish. As previously mentioned, the exposure doses for adults and children via recreational activities are below levels constituting a health hazard.

The estimated exposure doses for subsistence behavior were slightly above the EPA RfD for children consuming sunfish, creek chub, and an unidentified fish species and only for adults consuming EFPC sunfish. However, these estimated doses were below the human NOAEL under the default assumptions of eating approximately 16 lbs/year and 52 lbs/year for children and adults, respectively. The estimated exposure doses were calculated using limited species/area-specific fish data. For on-site fish there were a total of 69 fish samples (38/69 had cadmium) and for EFPC fish there were 7 samples (7/7 sunfish had cadmium). None of the 122 fish samples from the Clinch River had detectable levels of cadmium; only 2 of 88 fish samples from WBR had cadmium. Given that subsistence fishing behavior would likely occur at multiple locations (e.g., the Clinch River, EFPC, and WBR) to provide roughly 16 lbs of fish/year and 52 lbs of fish/year for children and adults, respectively, and that cadmium was infrequently detected (in less than 8 percent of the fish samples), exposure to cadmium in fish is not expected to result in adverse health effects.

Game

Adult and child exposure doses for an unknown on-site aquatic bird and terrestrial animal exceeded the ATSDR screening guideline for cadmium but were below the EPA RfD for cadmium in food (see Table 8). All other game (Canada goose and wood duck) were below the ATSDR screening guideline for cadmium. Thus, exposure to cadmium via ingestion of game is not expected to result in adverse health effects.

Vegetables

The exposure doses from eating kale and tomatoes are below EPA's RfD for ingestion of food (1.0×10^{-3} mg/kg/day). With an exposure dose of 1.1×10^{-3} mg/kg/day, eating beets only slightly exceeds the RfD, but is below the human NOAEL assuming a consumption rate of 90 lbs of vegetables/year (which is equivalent to the intake rate assumption of 0.0016 kg/kg/day for a 70 kg adult).

Air

Limited air monitoring data were used to evaluate exposure to cadmium via the inhalation pathway. Air samples were collected on the ORR, and the average air level was 0.00065 $\mu g/m^3$—which slightly exceeds the screening guideline of 0.0006 $\mu g/m^3$. The surrounding population would have been exposed to lower levels due to dispersion, downwash effects, and increasing distance; as such, the ambient levels off site would have been below the screening level. Therefore, ATSDR does not believe that the general population would suffer adverse effects from air-related cadmium exposure.

Chromium

Chromium is a naturally occurring element found in rocks, animals, plants, soil, and volcanic gases. Chromium occurs in the environment in several chemical forms depending on the valance state of the chromium metal (e.g., trivalent [III] chromium or hexavalent [VI] chromium). Trivalent chromium—an essential nutrient—is more likely to be found in the environment and the body than hexavalent chromium. Trivalent chromium helps regulate how the body uses insulin. Hexavalent chromium is considerably more toxic to humans than trivalent chromium. The absorption of orally ingested chromium is relatively poor, with less than 10 percent absorption for the trivalent and hexavalent forms (ATSDR 2000b).

The estimated exposure doses for children and adults eating EFPC crayfish (Table 22), eating WBR fish (Table 26), eating off-site vegetation (Table 31), and inhaling the air (Table 33) are above the hexavalent chromium screening guidelines. As such, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from these pathways. The chromium levels detected in soil, surface water, sediment, and game are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer screening guideline) and will not be discussed further.

Table 9 shows the exposure doses for media that exceeded the hexavalent chromium screening guidelines. For this level of the evaluation, however, ATSDR recalculated the estimated exposure doses using average concentrations to represent more realistic exposure scenarios. Further, because the environmental data are not specific as to valence, ATSDR estimated exposure doses assuming that 50 percent of the measured concentrations are present as the more toxic hexavalent form. To account for chromium's poor absorption, ATSDR assumed that 10 percent of the chromium was absorbed.

Table 9. Estimated Exposure Doses for Chromium

Medium	Average Concentration (ppm)	Exposure Dose (mg/kg/day)	
		Child	Adult
EFPC crayfish	1.5	1.2E-04	*Below*
WBR unknown fish	5.6	4.3E-04	2.6E-04
Off-site kale	7.6	6.1E-04	6.1E-04
Off-site tomato	9.9	7.9E-04	7.9E-04
Air	0.0013 µg/m^3	NA	

The chronic RfD for hexavalent chromium is 3.0×10^{-3} mg/kg/day.
Air CREG = 0.00008 µg/m^3
Exposure doses for fish represent subsistence-level fishing.
ATSDR assumed 50 percent of the chromium detected was in the more harmful hexavalent form. Therefore, doses are calculated using one half the average concentration.
To account for the poor absorption of chromium, ATSDR assumed that 10 percent of the chromium was absorbed.
"Below" means that the calculated doses were below screening guidelines during the second-tier screening evaluation (see Section III.D).
NA = not applicable

ATSDR has not established a screening guideline for ingestion of chromium because the available data are insufficient or too contradictory to establish minimum effect levels. Because chromium is an essential nutrient, the National Research Council has established a range of "estimated safe and adequate daily dietary intakes" for it. This range is 50 to 200 micrograms per day (µg/day) (NAS 1989, 1994). The value at the upper end of the range, 200 µg/day, has been adopted by ATSDR as an interim guideline for oral exposure to hexavalent and trivalent chromium compounds (ATSDR 2000b). This interim guideline is equivalent to an exposure dose of 3.0×10^{-3} mg/kg/day for a 70-kilogram adult, and 2.0×10^{-2} mg/kg/day for a 13-kilogram child. EPA's RfD for chronic oral exposure, based on animal studies, is 3.0×10^{-3} mg/kg/day (EPA 2004c).

Biota

The estimated exposure doses related to chromium in biota were above screening guidelines for EFPC crayfish, WBR unknown species of fish, and off-site vegetation when assuming 100 percent absorption. When considering the poor absorption of chromium from the gastrointestinal tract (less than 10 percent), however, the resulting exposure doses were below the screening guideline (see Table 9). Estimated doses that are less than the screening guideline are not considered to be a health hazard. Therefore, ATSDR does not expect adverse health effects to result from exposure to chromium in biota.

Air

Limited air monitoring data collected on the ORR were used to evaluate exposure to chromium via the inhalation pathway. The average concentration of chromium in measured air was 0.0013 µg/m^3, which exceeds the ATSDR cancer comparison value but is within the acceptable cancer risk level of one in 10,000. Furthermore, the average air level does not exceed EPA's established noncancer inhalation guideline value of 0.008 µg/m^3 for hexavalent chromium. Therefore, ATSDR does not expect adverse effects to result from chromium exposure in air.

Dibenzo(a,h)anthracene

Dibenzo(a,h)anthracene is one of more than 100 different polycyclic aromatic hydrocarbons (PAHs). PAHs are formed during incomplete burning and generally occur as complex mixtures, rather than single compounds. All other PAHs were below screening values individually and/or in combination for all pathways considered. Because screening values do not exist for all PAHs, ATSDR used the "toxicity equivalency factors" (TEFs) available in the scientific literature. The TEF approach can be applied to individual congeners to generate a single concentration for the compound class. (Note that the highest reported concentrations of PAHs in surface soil were located on an industrial property—Atomic City Auto Parts—where the contaminated soil has been removed. This has eliminated exposure to impacted soil on that property, so these highest soil concentrations were deleted from consideration for current and future soil exposures. As such, ATSDR does not expect adverse effects to result from exposure to PAHs in surface soil.)

As shown in Table 23, the estimated exposure dose for adults eating EFPC crayfish at a subsistence level is above the dibenzo(a,h)anthracene cancer screening guideline. Accordingly, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from eating EFPC crayfish. (None of the dibenzo(a,h)anthracene levels detected in other media are high enough to constitute a health hazard: either the estimated doses are below the noncancer and cancer screening guidelines or dibenzo(a,h)anthracene was not detected.) When the lifetime exposure dose is recalculated using the average concentration (0.15 parts per million, or ppm), the resulting dose (6.0×10^{-6} mg/kg/day) is below levels constituting a health hazard (i.e., below the screening guideline, which uses safety factors that make it considerably lower than levels at which health effects have been observed). Additionally, it is unlikely that people would be able to maintain a subsistence diet on crayfish alone. As such, ATSDR does not expect adverse health effects to result from exposure to dibenzo(a,h)anthracene in crayfish.

2,4-Dinitrophenol

Dinitrophenols are a class of manufactured chemicals that do not occur naturally in the environment. There are six different dinitrophenols. The most commercially important dinitrophenol, 2,4-dinitrophenol, is a yellow, odorless solid. It is used in making dyes, wood preservatives, explosives, and insect control substances, and as a photographic developer.

As shown in Table 30, the estimated exposure doses for children and adults eating on-site game are above the 2,4-dinitrophenol noncancer screening guideline. Accordingly, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from eating on-site game. The 2,4-dinitrophenol levels detected in soil, sediment, surface water, and on-site fish are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer screening guideline or 2,4-dinitrophenol was not detected).[17]

To further evaluate exposures from eating game, ATSDR recalculated the exposure doses using the average concentration (55 ppm) to represent a more realistic exposure scenario. The estimated exposure doses for children and adults eating on-site game (unknown terrestrial

[17] 2,4-Dinitrophenol was not sampled in off-site fish, off-site game, or vegetation.

animals) are 4.2×10^{-3} mg/kg/day and 1.6×10^{-3} mg/kg/day, respectively. Only the child dose slightly exceeds EPA's chronic RfD for 2,4-dinitrophenol (2.0×10^{-3} mg/kg/day). The LOAEL (2.0 mg/kg/day) used to derive the chronic RfD is from a human study and incorporates an uncertainty factor of 1,000. The highest estimated exposure dose was about 475 times less than the LOAEL. Based on the low number of samples, the margin of safety relative to the LOAEL, and the conservative assumptions used for the estimation of exposure doses, adverse effects are not expected from eating on-site game.

4,6-Dinitro-o-Cresol

Dinitrocresols are a class of manufactured chemicals that do not occur naturally in the environment. There are 18 different dinitrocresols. The most commercially important dinitrocresol, 4,6-dinitro-o-cresol, is a yellow, odorless solid. It is used primarily for insect control and crop protection.

As shown in Table 30, the estimated exposure doses for children eating game caught on site are above the 4,6-dinitro-o-cresol noncancer screening guideline. As such, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from eating on-site game. The 4,6-dinitro-o-cresol levels detected in soil, sediment, surface water, and on-site fish are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer screening guideline or 4,6-dinitro-o-cresol was not detected).[18]

The frequency of detection was low for the data set (17 percent, or one in six samples). Therefore, only this one detected sample (3.5 ppm) was used to estimate the exposure dose. The estimated exposure dose for children eating on-site game (unknown terrestrial animals) is 2.7×10^{-4} mg/kg/day. This dose only slightly exceeds EPA's provisional RfD for 4,6-dinitro-o-cresol (1.0×10^{-4} mg/kg/day). Based on the low frequency of detection and conservative assumptions used for the estimation of exposure doses, adverse effects are not expected.

Dioxin (Chlorinated Dibenzo-p-Dioxins)

Chlorinated dibenzo-p-dioxins (CDDs) are a family of 75 chemically related compounds commonly known as chlorinated dioxins. One of these compounds is called 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). It is one of the most toxic of the CDDs and one of the most studied.

In their pure forms, CDDs are crystals or colorless solids. CDDs enter the environment as mixtures containing a number of individual components. CDDs are not intentionally manufactured by industry except for research purposes. They (mainly 2,3,7,8-TCDD) can be formed during the chlorine bleaching process at pulp and paper mills. CDDs are also formed during chlorination by waste and drinking water treatment plants. They can occur as contaminants in the manufacture of certain organic chemicals. CDDs are also released into the air as emissions from municipal solid waste and industrial incinerators.

The estimated exposure doses for people eating unknown species of fish from WBR (Table 26 and Table 27) were above the dioxin noncancer and cancer screening guidelines. Therefore,

[18] 4,6-Dinitro-o-cresol was not sampled in off-site fish, off-site game, or off-site vegetation.

ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from fish ingestion. The dioxin levels detected in soil, sediment, and surface water are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer and cancer screening guidelines).[19]

The estimated exposure doses for children and adults eating fish (unknown species) from WBR are above the screening guidelines (see Table 10). The data set used to estimate the exposure dose consisted of three fish samples (unknown fish species) collected from a pond near the K-25 site. Due to the lack of "dioxin" fish data, ATSDR classifies the potential for public health effects to result from exposure to dioxin in fish as an indeterminate public health hazard. In the absence of additional data, ATSDR recommends following the State of Tennessee fish advisories. If community members are concerned and wish to reduce their exposures, they can follow the cleaning and cooking methods presented in *A Guide to Healthy Eating of the Fish You Catch*, provided in Appendix C.

Table 10. Exposure Doses for Dioxin

Medium		***Average Total Relative Concentration (ppm)***	***Exposure Dose (mg/kg/day)***		
			Child	***Adult***	***Lifetime***
Unknown fish	Subsistence Recreational	0.000028	4.3E-08 6.5E-09	2.6E-08 3.2E-09	1.1E-08 1.4E-09

The chronic MRL for TCDD is 1.0×10^{-9} mg/kg/day.

Total relative concentrations were calculated using the toxic equivalency factor (TEF) approach for dioxins. This approach to evaluating health hazards has been developed and used to some extent to guide public health decisions (see EPA 1996b and ATSDR 2000c for more details). In short, the TEF approach compares the relative potency of individual congeners with that of TCDD, the best-studied member of this chemical class. The concentration or dose of each dioxin-like congener is multiplied by its TEF to arrive at a toxic equivalent (TEQ), and the TEQs are added to give the total toxic equivalency. The total toxic equivalency is then compared to reference exposure levels for TCDD expected to be without significant risk for producing health hazards.

[19] Dioxins and furans were not sampled in EFPC fish, Clinch River fish, on-site fish, off-site game, or vegetation.

Fish Advisories for Waterways Near the ORR

Tennessee River
Catfish, striped bass, and hybrid (striped bass-white bass) bass should not be eaten. Children, pregnant women, and nursing mothers should not consume white bass, sauger, carp, smallmouth buffalo, and largemouth bass, but other people can safely consume one meal per month of these species.

Clinch River
Striped bass should not be eaten. Children, pregnant women, and nursing mothers should not consume catfish and sauger, but other people can safely consume one meal per month of these species.

East Fork Poplar Creek
No fish should be eaten.

For the advisory, go to http://www.state.tn.us/environment/wpc/publications/advisories.pdf.

Heptachlor Epoxide

Heptachlor epoxide is a breakdown product of heptachlor, a synthetic chemical used before 1988 to kill insects in homes, in buildings, and on food crops. Heptachlor epoxide was not manufactured—bacteria in the environment form heptachlor epoxide from heptachlor. Ingestion of soil containing heptachlor epoxide is one way the chemical can enter the body. The toxicokinetics (i.e., absorption, distribution, metabolism, and excretion) of heptachlor epoxide is not well studied in humans. Animal studies suggest that heptachlor epoxide is primarily stored in adipose tissue (i.e., fat). One animal study reported that the levels of heptachlor epoxide decreased to below detection limits 6 to 8 weeks after exposure (ATSDR 1993a).

As shown in Table 22 through Table 29, the estimated exposure doses for children and adults under the subsistence fishing exposure scenarios are above the chronic oral screening guidelines for heptachlor epoxide. The only recreational exposure scenario above the heptachlor epoxide noncancer screening guideline is for a child eating sunfish from EFPC. Accordingly, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from fish ingestion. The heptachlor epoxide levels detected in soil, sediment, surface water, and on-site game are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer and cancer screening guidelines) and will not be discussed further.[20]

Table 11 shows the exposure doses for media that exceeded the heptachlor epoxide noncancer and cancer screening guidelines. For this level of the evaluation, however, ATSDR recalculated the estimated exposure doses using average concentrations to represent more realistic exposure scenarios.

[20] Heptachlor epoxide was not sampled in off-site game or off-site vegetation.

Table 11. Estimated Exposure Doses for Heptachlor Epoxide

Medium		Average Concentration (ppm)	Exposure Dose (mg/kg/day)		
			Child	Adult	Lifetime
EFPC sunfish	Subsistence	0.038	5.8E-05	3.5E-05	1.5E-05
	Recreational		8.8E-06	*Below screening guidelines*	
Clinch River sunfish	Subsistence	0.039	6.2E-05	3.7E-05	1.6E-05
	Recreational		*Below screening guidelines*		
WBR sunfish	Subsistence	0.031	4.8E-05	2.9E-05	1.2E-05
	Recreational		*Below screening guidelines*		
On-site sunfish	Subsistence	0.031	4.8E-05	2.9E-05	1.2E-05
	Recreational		*Below screening guidelines*		
Clinch River catfish	Subsistence	0.005	7.7E-06	4.6E-06	2.0E-06
	Recreational		*Below screening guidelines*		
WBR catfish	Subsistence	0.005	7.7E-06	4.6E-06	2.0E-06
	Recreational		*Below screening guidelines*		
On-site catfish	Subsistence	0.009	1.4E-05	8.4E-06	3.6E-06
	Recreational		*Below screening guidelines*		

The chronic RfD for heptachlor epoxide is 1.3×10^{-5} mg/kg/day.

"Below screening guidelines" means that the calculated doses were below screening guidelines during the second-tier screening evaluation (see Section III.D).

The estimated exposure doses for adults and children eating fish are above their respective guidelines for noncancer and cancer effects (see Table 22 through Table 29). The highest exposure doses were for subsistence children and adults eating sunfish from the Clinch River. The Clinch River data set used to estimate exposure doses for sunfish had 13 percent detects (13/100 sunfish samples). The oral screening guideline for heptachlor epoxide is based on a study in which liver-to-body weight ratios were significantly increased in dogs fed heptachlor epoxide at doses of 1.25×10^{-2} mg/kg/day for 60 weeks (Dow Chemical Company 1958). Supporting animal studies report no adverse health effects for doses ranging from 2.5×10^{-2} to 2.5×10^{-1} mg/kg/day (EPA 2004a). The estimated exposure doses are at least 400 times below these health effect levels. As such, adverse effects are not expected.

EPA classifies heptachlor epoxide as a probable human carcinogen based on rodent studies in which liver carcinomas were induced in two strains of mice and female rats (EPA 2004a). There are three epidemiologic studies of workers exposed to chlordane and/or heptachlor. One retrospective cohort study of pesticide applicators was considered inadequate in sample size and duration of follow up. This study showed marginal statistically significant increased mortality from bladder cancer. Two other retrospective cohort studies were based on pesticide manufacturing workers. Neither of these studies showed any statistically significant increased cancer mortality. Both of these populations also had confounding exposures to other chemicals (EPA 2004a).

The estimated exposure doses for cancer effects are slightly above the cancer screening guidelines. Based on the low probability that a person would be exposed to significant levels over 30 years, the conservative exposure assumptions, and the lack of statistically significant cancer mortality in three human studies, ATSDR does not expect cancer effects from exposure to heptachlor epoxide in fish.

Alpha-Hexachlorocyclohexane (Alpha-HCH)

Hexachlorocyclohexanes are synthetic chemicals that were once used as insecticides. They exist in eight chemical forms called isomers, each of which is named according to the position of the hydrogen atoms (ATSDR 2003). Alpha-HCH is one of these isomers.

The estimated exposure dose for subsistence behavior was slightly above the cancer screening guideline for people ingesting sunfish from the Clinch River (see Table 25), WBR (see Table 27), and on site (see Table 29). The alpha-HCH levels detected in all other media are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer and cancer screening guidelines). Table 12 shows the exposure doses for sunfish that exceeded the alpha-HCH cancer screening guideline. For this level of the evaluation, however, ATSDR recalculated the estimated exposure doses using average concentrations to represent more realistic exposure scenarios.

Table 12. Estimated Exposure Doses for alpha-HCH

Medium	***Average Concentration (ppm)***	***Subsistence-Level Exposure Dose (mg/kg/day)***		
		Child	***Adult***	***Lifetime***
Clinch River sunfish	0.042	*Below screening guidelines*		1.7E-05
WBR sunfish	0.035	*Below screening guidelines*		1.4E-05
On-site sunfish	0.034	*Below screening guidelines*		1.4E-05

"Below screening guidelines" means that the calculated doses were below screening guidelines during the second-tier screening evaluation (see Section III.D).

The estimated lifetime exposure doses (see Table 12) are well below the cancer effect levels (CELs) reported in the literature (CELs range from 2 to 90 mg/kg/day; ATSDR 2003). Based on the conservative assumptions used to estimate exposure and the unlikelihood that subsistence behavior would occur with sunfish only, ATSDR does not expect adverse health effects from exposure to alpha-HCH in fish.

Iron

Iron is a naturally occurring element in the environment. In fact, it is the fourth most abundant element in the Earth's crust by weight (LANL 2001). The most common iron ore is hematite, which frequently can be seen as black sand along beaches and stream banks. It is hard and brittle, and is usually combined with other metals to form alloys, including steel.

Iron is an important mineral that assists in the maintenance of basic life functions. It combines with protein and copper to make hemoglobin, which transports oxygen in the blood from the lungs to other parts of the body, including the heart. It also aids in the formation of myoglobin, which supplies oxygen to muscle tissues (ANR 2003). Without sufficient iron, the body cannot produce enough hemoglobin or myoglobin to sustain life. Despite the fact that iron is the fourth most abundant metal in the earth's crust, iron deficiency is the world's most common cause of anemia. The NAS DRI for children 4- to 8- years-old is 10 mg/day (NAS 2001).

Too much iron, however, can be dangerous to children. According to the FDA, doses greater than 200 mg per event could poison or kill a child (FDA 1997). Doses of this magnitude are generally the result of children accidentally ingesting iron pills, not ingesting iron in soil or in water. Acute iron poisoning has been reported in children less than 6 years of age who have accidentally overdosed on iron-containing supplements for adults. Because iron is not considered to cause harmful health effects in general, toxicological and epidemiological literature is limited.

The average adult stores about 1 to 3 grams of iron in his or her body. A balance between dietary uptake and loss maintains this equilibrium. There is no physiologic mechanism of iron excretion. Consequently, absorption alone regulates body iron stores.

The estimated exposure doses for children ingesting off-site soil (Table 16) and people eating on-site game (Table 30) are above the iron noncancer screening guideline. Accordingly, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from these pathways. The iron levels detected in sediment, surface water, and fish are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer screening guideline) and will not be discussed further.[21]

Table 13 shows the exposure doses for media that exceeded the iron noncancer screening guideline. For this level of the evaluation, however, ATSDR recalculated the estimated exposure doses using average concentrations to represent more realistic exposure scenarios. ATSDR also calculated daily intake rates.

Table 13. Estimated Exposure Doses and Daily Intake Rates for Iron

Medium	***Average Concentration (ppm)***	***Exposure Dose (mg/kg/day)***		***Daily Intake Rates (mg/day)***	
		Child	***Adult***	***Child***	***Adult***
Off-site soil	23,000	2.8E-01	*Below*	5	*Below*
On-site unknown terrestrial animal	7,600	5.8E-01	2.2E-01	8	15

The chronic RfD for iron is 3.0×10^{-1} mg/kg/day.
"Below" means that the calculated doses were below screening guidelines during the second-tier screening evaluation (see Section III.D).

Soil

Based on the child soil intake rate, the soil iron concentration at which the DRI of 10 mg/day would be reached was calculated to be 50,000 ppm (assuming 200 mg soil/day for 365 days/year at 100 percent absorption). Concentrations of iron in soil ranged from 5,790 to 61,600 ppm, with an average concentration of about 23,000 ppm. The body normally reduces absorption of iron from the gastrointestinal tract in response to higher concentrations. As a result, the levels of iron found in the soil are not likely to pose a health hazard to children.

For comparison, ATSDR calculated a daily consumption from exposure to the iron in soil using a modification of the dose equation (dose = concentration × intake rate). Exposure to the average level of iron in the soil would increase a non-pica child's daily consumption of iron by 5 mg/day, assuming 100 percent absorption. The median daily intake of dietary iron is roughly 11 to 13 mg/day for children 1 to 8 years old and 13 to 20 mg/day for adolescents 9 to 18 years old (NAS 2001). The daily consumption of iron for a child does not exceed the NAS DRI for children 4 to

[21] Iron was not sampled in off-site vegetation.

8 years old (10 mg/day; NAS 2001), and the daily increase in consumption is not likely to cause a child's daily dose to exceed levels known to induce poisoning (greater than 200 mg/event). Therefore, ATSDR does not expect that non-pica children would experience adverse health effects from exposure to iron in soil.

Game

ATSDR estimated a daily exposure dose for eating game (unknown terrestrial animal) by multiplying the average concentration of iron detected (7,600 ppm or mg/kg) by the daily intake rate (0.002 kg of game/day for an adult and 0.001 kg/day for a child). Based on this estimate, eating game could have increased an adult's daily consumption of iron by 15 mg/day and a child's daily consumption of iron by 8 mg/day. These estimated daily increases in game consumption are not expected to cause a person's daily dose to exceed levels known to induce poisoning (e.g., greater than 200 mg/event). Further, the body uses a homeostatic mechanism to keep iron burdens at a constant level despite variations in the diet (Eisenstein and Blemings 1998). Therefore, ingesting game containing this level of iron is not expected to result in adverse noncancer health effects.

Manganese

Manganese is naturally found in many types of rocks and comprises about 0.1 percent of the Earth's crust (ATSDR 2000d). It is an essential trace element and is required by the body to break down amino acids and produce energy. Manganese can enter the body via ingestion, but most manganese is excreted in feces—only 3 to 5 percent of manganese is absorbed by the body when ingested (Davidsson et al. 1988; Mena et al. 1969). Typically, people have small amounts of manganese in their bodies. Under normal circumstances, the amount is regulated so the body has neither too much nor too little (EPA 1984). For example, if large amounts of manganese are consumed, large amounts will be excreted.

As shown in Table 30, the estimated exposure dose for a child eating on-site game is above the manganese noncancer screening guideline. As such, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential for this pathway. The manganese levels detected in all other media are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer screening guideline).

The Food and Nutrition Board of the National Research Council determined that 2 to 5 mg of manganese/day is an "estimated safe and adequate daily dietary intake" (NRC 1989). The World Health Organization (WHO) concluded that 2 to 3 mg/day is "adequate" and 8 to 9 mg/day is "perfectly safe" (WHO 1973). Based on these studies, EPA has determined that an appropriate RfD for manganese in food is 10 mg/day, which EPA calculated to a NOAEL of 0.14 mg/kg/day. The estimated exposure dose for a child ingesting on-site game (9.8×10^{-2} mg/kg/day) is below this NOAEL. Further, only a small amount of manganese is absorbed, and a homeostatic mechanism regulates the amount in the body. Therefore, ATSDR does not expect adverse health effects from exposure to manganese in game.

Thallium

Pure thallium is a bluish-white metal that is found in trace amounts in the Earth's crust. In the past, thallium was obtained as a byproduct from smelting other metals. In its pure form, thallium is odorless and tasteless. It can also be found combined with other substances such as bromine, chlorine, fluorine, and iodine to form a colorless-to-white or yellow substance. Thallium is used mostly in manufacturing electronic devices, switches, and closures, primarily for the semiconductor industry. It also has limited use in the manufacture of special glass, and for certain medical procedures. Thallium has not been produced in the United States, however, since 1984.

As shown in Table 28 and Table 30, the estimated exposure doses for children and adults eating on-site fish (specifically, bass and sunfish) and game (unknown terrestrial animal) are above the thallium noncancer screening guideline. Accordingly, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from eating fish and game. The thallium levels detected in soil, sediment, surface water, and off-site fish are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer screening guideline) and will not be discussed further.[22]

Table 14 shows the estimated exposure doses for media that exceeded the thallium noncancer screening guideline. For this level of the evaluation, however, ATSDR recalculated the estimated exposure doses using average concentrations to represent more realistic exposure scenarios.

Table 14. Estimated Exposure Doses for Thallium

Medium		*Average Concentration (ppm)*	*Exposure Dose (mg/kg/day)*	
			Child	*Adult*
On-site bass	Subsistence	0.027	4.2E-05	*Below*
	Recreational		*Below screening guidelines*	
On-site sunfish	Subsistence	1.0	1.5E-03	9.3E-04
	Recreational		2.3E-04	1.1E-04
On-site unknown terrestrial animal		1.8	1.4E-04	5.1E-05

The chronic RfD for thallium is 7.0×10^{-5} mg/kg/day.

"Below" and "Below screening guidelines" mean that the calculated doses were below screening guidelines during the second-tier screening evaluation (see Section III.D).

EPA has RfDs for several thallium compounds. Each RfD covers a particular compound and is based on animal studies for that compound. For example, the RfD for thallium sulfate is based on a failure to observe harmful effects in rats that were administered as much as 0.25 mg/kg/day of thallium by gavage (stomach tube). EPA divided this dose by an uncertainty factor of 3,000 to account for humans being more sensitive than rats to thallium, for some humans being more sensitive than others, and for a lack of reproductive and chronic toxicity data to derive the RfD (EPA 2004d).

On average, a person takes in about 2 micrograms of thallium per gram of food daily. The thallium dose that did not cause toxic effects in rats (2.3×10^{-1} mg/kg/day) was about 150 times

[22] Thallium was not sampled in off-site vegetation.

higher than the estimated exposure dose for a child and 250 times higher than an adult with subsistence exposure patterns for on-site fish. The exposure doses for the recreational fishing scenario and eating on-site game are thousands of times lower than the level at which no health effects were seen in rats. Based on this margin of safety, adverse effects are not expected.

Toxaphene

Toxaphene is an insecticide containing more than 670 chemicals. It is usually found as a solid or a gas, and in its original form it is a yellow to amber waxy solid that smells like turpentine. It does not burn and it evaporates when in solid form or when mixed with liquids. Toxaphene is also known as camphechlor, chlorocamphene, polychlorocamphene, and chlorinated camphene. It was used primarily in the southern United States to control insects on cotton and other crops. It was also used to control insects on livestock and to kill unwanted fish in lakes. Toxaphene was one of the most heavily used insecticides in the United States until 1982, when it was canceled for most uses. All uses were banned in 1990.

As shown in Table 22 through Table 29, the estimated exposure doses for children and adults ingesting fish are above the toxaphene noncancer and cancer screening guidelines. Accordingly, ATSDR further examined the effect levels reported in the scientific literature and more fully reviewed exposure potential from fish ingestion. The toxaphene levels detected in all other media are not at levels constituting a health hazard (i.e., the estimated doses are below the noncancer and cancer screening guidelines) and will not be discussed further.[23]

Table 15 shows the exposure doses for media that exceeded the toxaphene noncancer or cancer screening guidelines. For this level of the evaluation, however, ATSDR recalculated the estimated exposure doses using average concentrations to represent more realistic exposure scenarios.

Table 15. Estimated Exposure Doses for Toxaphene

Medium		***Average Concentration (ppm)***	***Subsistence-Level Exposure Dose (mg/kg/day)***		
			Child	***Adult***	***Lifetime***
Clinch River sunfish	Subsistence	0.84	1.3E-03	7.8E-04	3.3E-04
	Recreational		*Below screening guidelines*		
WBR sunfish	Subsistence	0.70	1.1E-03	6.5E-04	2.8E-04
	Recreational		*Below screening guidelines*		
On-site sunfish	Subsistence	0.78	1.2E-03	7.2E-04	3.1E-04
	Recreational		*Below screening guidelines*		
WBR bass	Subsistence	0.24	3.7E-04	2.2E-04	9.6E-05
	Recreational		*Below screening guidelines*		
On-site bass	Subsistence	1.9	2.9E-03	1.8E-03	7.6E-04
	Recreational		*Below screening guidelines*		9.3E-05
WBR catfish	Subsistence	0.20	3.1E-04	1.9E-04	8.0E-05
	Recreational		*Below screening guidelines*		

The intermediate MRL for toxaphene is 1.0×10^{-3} mg/kg/day.
"Below screening guidelines" means that the calculated doses were below screening guidelines during the second-tier screening evaluation (see Section III.D).

[23] Toxaphene was not sampled in off-site vegetation.

The frequency of detection was low for all data sets (ranging from 2 to 17 percent). The NOAEL (0.35 mg/kg/day) used to derive the intermediate-duration MRL is from an animal study and incorporates an uncertainty factor of 300 (ATSDR 1996). The highest estimated exposure dose was about 120 times less than the NOAEL. The estimated exposure doses for subsistence behavior are also well below (almost 17,000 times less than) the cancer effects levels reported in the scientific literature (CELs range from 12.9 to 55.6 mg/kg/day; ATSDR 1996). Based on the low frequency of detection and conservative assumptions used for the estimation of exposure doses, adverse effects are not expected.

Multiple Chemical Exposures

ATSDR has reviewed the scientific literature on chemical interactions and noted that if the estimated exposure doses for individual contaminants are well below doses shown to cause adverse effects, then the combined effects of multiple chemicals are not expected to result in adverse health effects. Therefore, ATSDR does not expect interactive health effects because, for each chemical evaluated, the conservatively estimated exposure doses are below health effect levels reported in the scientific literature.

ATSDR does not expect interactive health effects from exposure to multiple chemicals because, for each chemical evaluated, the conservatively estimated exposure doses are below health effect levels reported in the scientific literature.

Several animal and human studies (Berman et al. 1992; Caprino et al. 1983; Drott et al. 1993; Harris et al. 1984) have reported thresholds for interactions. Studies have shown that exposure to a mixture of chemicals is unlikely to produce adverse health effects as long as components of that mixture are detected at levels below the NOAEL for individual compounds (Feron et al. 1995; Seed et al. 1995). Additionally, Jonker et al. (1990) and Groten et al. (1991) demonstrated the absence of interactions at doses tenfold or more below effect thresholds. In two separate subacute toxicity studies in rats (Groten et al. 1997; Jonker et al. 1993), adverse effects disappeared altogether as the dose was decreased to below the threshold level. Other studies have provided evidence that exposure to chemical mixtures, in which the chemicals were administered at doses near their individual thresholds, can produce additive toxic effects. For example, rats exposed to a mixture of sub-threshold doses of 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene experienced signs of liver toxicity (Stacey 1989). The dose given to the rats in this study was greater than 2,000 mg/kg, while the estimated exposure doses in the United States and Canada are below 0.003 mg/kg/day (ATSDR 2004).

The interactions of carcinogens are more difficult to quantify at environmental doses because a large study group (humans or animals) is needed for statistical significance at the lower doses observed from environmental exposure. In the mid-1970s, under contract to the National Cancer Institute, 12 chemicals were tested in 918 pair-wise tests in over 14,500 rats (Gough 2002). Dose levels were expected to produce tumors in 20 to 80 percent of the exposed animals. The results of that study produced no convincing evidence for synergistic carcinogen interactions while 20 possible cases of antagonism were observed (Gough 2002). In an animal study, Takayama et al. (1989) reported that 40 substances tested in combination at 1/50 of their CELs resulted in an increase in cancer. However, Hasegawa et al. (1994) reported no increase in cancer when dosing animals at 1/100 of the CELs for 10 compounds. It should be noted that typical environmental exposures to chemicals (noncarcinogens and carcinogens) are more than 1,000 times below laboratory-induced health effect thresholds.

IV.D. Pregnant and Breast-Feeding Women's Health Considerations

Woman and infants can sometimes be affected differently from the general population by chemicals in the environment. The effect of hormonal variations, pregnancy, and lactation can change the way a woman's body responds to some chemicals. Past exposures experienced by the mother, as well as exposure during pregnancy and breast-feeding, can expose a fetus or infant to chemicals through the placenta or breast milk. Depending on the stage of pregnancy, the nature of the chemical involved, and the dose of that chemical, fetal exposure can result in a variety of problems, including miscarriage, still birth, and birth defects.

Based on the evaluation in Section IV.C., ATSDR does not expect pregnant and breast-feeding women to experience adverse effects from exposures to site-related chemicals in soil, sediment, surface water, biota (other than fish), and air.

Due to limited sampling data, dioxins in fish pose an indeterminate health hazard. Therefore, it would be prudent public health practice for pregnant and breast-feeding women to limit their consumption of locally caught fish. Although fish are a healthy food that provide many nutritional benefits, it is unknown whether the potential risks of exposure to dioxin contamination outweigh the benefits of eating fish.

> Due to the levels of PCBs, the State of Tennessee advises pregnant women and nursing mothers to not eat catfish, striped bass, hybrid bass (striped bass–white bass), white bass, sauger, carp, smallmouth buffalo, and largemouth bass from the Tennessee River or striped bass, catfish, and sauger from the Clinch River.

V. Health Outcome Data Evaluation

Health outcome data are measures of disease occurrence in a population. Common sources of health outcome data are existing databases (cancer registries, birth defects registries, and death certificates) that measure morbidity (disease) or mortality (death). Health outcome data can provide information on the general health status of a community—where, when, and what types of diseases occur and to whom they occur. Public health officials use health outcome data to look for unusual patterns or trends in disease occurrence by comparing disease occurrences in different populations over periods of years. These health outcome data evaluations are descriptive epidemiologic analyses. They are exploratory in that they provide additional information about human health effects and they are useful in that they help identify the need for public health intervention activities (for example, community health education). That said, however, health outcome data cannot—and are not meant to—establish cause and effect between environmental exposures to hazardous materials and adverse health effects in a community.

ATSDR scientists generally consider health outcome data evaluation when a plausible, reasonable expectation emerges of adverse health effects associated with the observed levels of exposure to contaminants. In this PHA, ATSDR scientists determined that current and future exposures to ORR site-related chemicals (individually or in combination) in soil, sediment, surface water, biota (other than fish), and air do not pose a public health hazard. Very limited "dioxin" data exist for fish; therefore, exposure to dioxins in fish poses an indeterminate public health hazard.

Criteria for Conducting a Health Outcome Data Evaluation

To determine how to use or analyze health outcome data in the public health assessment process, or even whether to use the data at all, ATSDR scientists receive input from epidemiologists, toxicologists, environmental scientists, and community involvement specialists. These scientists consider the following criteria, based only on site-specific exposure considerations, to determine whether a health outcome data evaluation should be included in the PHA.

1. Is there at least one current (or past) potential or completed exposure pathway at the site?
2. Can the time period of exposure be determined?
3. Can the population that was or is being exposed be quantified?
4. Are the estimated exposure doses(s) and the duration(s) of exposure sufficient for a plausible, reasonable expectation of health effects?
5. Are health outcome data available at a geographic level or with enough specificity to be correlated to the exposed population?
6. Do the validated data sources or databases have information on the specific health outcome(s) or disease(s) of interest—for example, are the outcome(s) or disease(s) likely to occur from exposure to the site contaminants—and are those data accessible?

Using the findings of the exposure evaluation in this PHA, ATSDR sufficiently documented completed exposure pathways. However, current and future exposures to ORR site-related chemicals in soil, sediment, surface water, biota, and air do not pose a public health hazard. Because the estimated doses are not expected to cause health effects, no further analysis of health outcome data is appropriate. Analysis of site-related health outcome data is not scientifically reasonable unless the level of estimated exposure is likely to result in an observable number of health effects. And because such an estimate of exposure is not feasible, the requirement to consider analysis of site-related health outcome data on the basis of exposure is fulfilled.

VI. Community Health Concerns

Responding to community health concerns is an essential part of ATSDR's overall mission and commitment to public health. ATSDR has actively gathered comments and other information from the people who live and work near the ORR; ATSDR is particularly interested in hearing from residents of the area, civic leaders, health professionals, and community groups. ATSDR addresses these community health concerns in the ORR public health assessments that are related to those concerns.

To improve the documentation and organization of community health concerns at the ORR, ATSDR developed a **Community Health Concerns Database** specifically designed to compile and track community health concerns related to the site. The database allows ATSDR to record, track, and respond appropriately to all community concerns and to document its responses to these concerns.

From 2001 to 2005, ATSDR compiled more than 3,000 community health concerns obtained from the ATSDR/ORRHES community health concerns comment sheets, written correspondence, phone calls, newspapers, comments made at public meetings (ORRHES and work group meetings), and surveys conducted by other agencies and organizations. These concerns were organized in a consistent and uniform format and imported into the database.

The community health concerns addressed in this section of the public health assessment include those in the ATSDR Community Health Concerns Database that are related to current and future chemical releases from the ORR. These concerns and ATSDR's responses are sorted and organized by category. Additional community concerns are addressed in the appropriate public health assessments.

VI.A. Chemical Mixtures

There were 17 individual comments specifically related to chemical mixtures and potential interactive effects in the Community Health Concerns Database. In this public health assessment on screening off-site current and future chemical exposure, ATSDR has considered interactive effects (cumulative, additive, synergistic, and antagonistic) of chemicals following exposure to multiple chemicals to the extent of the scientific knowledge in this area (please see the "Multiple Chemical Exposure" section on page 60). ATSDR does not expect interactive health effects of multiple chemicals because for each chemical evaluated the conservatively estimated exposure doses are below health effect levels reported in the scientific literature. The scientific literature surrounding chemical interactions indicates that if the estimated exposure doses for individual contaminants are below doses shown to cause adverse effects, then the combined effects of multiple chemicals are not expected to result in adverse health effects.

VI.B. Future Land Use

There was one concern that exposure to environmental contamination is causing adverse health effects, which will negatively impact future land use. ATSDR has concluded that current (1990 to 2003) and future exposures to site-related chemicals in soil, sediment, surface water, biota (other than fish), and air pose no apparent public health hazard. "No apparent public health hazard" means that people may be exposed to contaminated media, but that exposure to contamination is not expected to result in adverse health effects. Dioxins pose an indeterminate public health hazard in an unknown fish species, but ATSDR does not expect adverse health effects to occur. Exposure to mercury, PCBs, uranium, fluoride, iodine 131, off-site groundwater, releases from the TSCA Incinerator, and radiological releases from White Oak Creek are evaluated in other public health assessments. The documents released to date are available at http://www.atsdr.cdc.gov/HAC/oakridge/phact/index.html and can also be ordered through a toll-free ATSDR telephone number, 1-800-232-4636.

VI.C. General Concerns

One comment was concerned whether it would be difficult to account for people tending to fish from more than one location. ATSDR accounted for this type of activity by using a conservative (protective) approach when calculating exposure doses—including using the species with the highest average concentration, using the sampling location with the highest average concentration, and assuming an adequate fish species population for recreational and subsistence behavior.

Another comment was related to exposure routes, including animal migration and deer hunting. ATSDR considered multiple exposure routes (current and future exposures to site-related chemicals in soil, sediment, surface water, groundwater, biota [game, fish, and vegetables], and air) based on environmental data from 1990 to 2003. In 1993, ATSDR released a health consultation that evaluated whether it was safe to eat fish from EFPC. ATSDR concluded that there was not an acute health hazard for people eating fish, but there was a hypothetical increased risk of adverse effects for people who frequently ingested fish over many years from EFPC at the levels reported in the health consultation. However, ATSDR currently believes this exposure scenario is unlikely because EFPC is not a productive fishing location. Copies of this health consultation, entitled *Y-12 Weapons Plant Chemical Releases into East Fork Poplar Creek* (ATSDR 1993b), are available from http://www.atsdr.cdc.gov/HAC/PHA/efork1/y12_toc.html.

VI.D. Odor/Stench/Public Nuisance

One commenter indicated that drinking water changes color and is sometimes cloudy. Oak Ridge receives and distributes public water from a treatment plant that collects surface water from Melton Hill Lake. The public water intake is approximately 1 mile upstream from the ORR.

Under the Safe Drinking Water Act, EPA sets standards for many substances in public drinking water and specifies treatments for providing safe drinking water. The public water supplies for Oak Ridge and throughout the State of Tennessee are continually monitored for these regulated substances. To ask specific questions related to your drinking water, contact TDEC's Environmental Assistance Center in Knoxville, Tennessee at 865-594-6035. To find additional information related to your water supply or other water supplies in the area, please call EPA's Safe Drinking Water Hotline at 1-800-426-4791 or visit EPA's Safe Drinking Water Web site at http://www.epa.gov/safewater.

VI.E. Ongoing Activities of Health Concern

Five comments asked whether ATSDR would be screening chemicals from other currently operating plants/facilities and/or continuing releases from the ORR. During the public health assessment process, ATSDR evaluates environmental data (i.e., levels of chemicals in specific media), regardless of source. As such, any releases to soil, sediment, surface water, groundwater, biota, and air were evaluated with respect to public health.

VI.F. Screening Issues

One commenter asked about thorium levels detected at or near the site. ATSDR has reviewed available environmental data and determined that thorium levels are below screening values, and thus not a public health hazard for current and/or future exposures.

One comment stated that "the screening is done only for a finite period of time." In this public health assessment, the chemical screening process evaluated environmental data from 1990 to 2003, to assess current and future exposures.

Several comments were related to availability/existence of biological testing for specific chemicals. Testing methods are available for certain compounds. The most common is for blood lead levels. Mercury can also be tested for in blood and urine. A 24-hour urine collection is used for chronic mercury exposures typically seen with environmental scenarios. Blood testing for mercury is used to assess more acute exposures associated with industrial uses and poisoning. For additional information regarding biological testing, please contact your local physician or poison control center.

VI.G. Soil, Sediment, and Surface Water Concerns

Several comments expressed concern over the "background soil sample" locations, with respect to which counties were included. Background soil samples were collected from Morgan, Loudon, and Knox Counties, but not from Roane, Anderson, and Blount Counties. ATSDR believes that the background soil samples are representative of the area and are appropriate to use in this public health assessment.

Several concerns were expressed regarding the robustness of the soil, sediment, and surface water data used to assess exposures. ATSDR believes the data set is adequate to evaluate current and future exposures to soil, sediment, and surface water. Appendix D contains maps that depict the number of samples collected from and the number of chemicals sampled at each location in each medium.

- The OREIS environmental database contains almost 10,000 records of chemicals sampled in off-site soil from November 5, 1990, to September 1, 2001. A total of 286 different chemicals were analyzed.

- OREIS contains about 56,000 records of chemicals sampled in off-site sediment from January 15, 1990, to September 1, 2001. A total of 319 different chemicals were analyzed.

- OREIS contains more than 93,000 records of chemicals sampled in off-site surface water from January 8, 1990, to September 10, 2002. A total of 310 different chemicals were analyzed.

VI.H. Scarboro Concerns

Scarboro residents have expressed concern that their community might be contaminated with chemicals currently being released from the ORR. To address this concern, ATSDR screened and evaluated the environmental data collected by the Florida Agriculture and Mechanical University (FAMU) and EPA. ATSDR's Scarboro-specific public health evaluation follows.[24]

Scarboro Environmental Sampling

In 1998, FAMU sampled soil, sediment, and surface water in the Scarboro community to address community concerns about environmental monitoring in the neighborhood. All samples were analyzed for mercury, gross alpha/beta, uranium, and gamma-emitting radionuclides. About 10 percent of the samples were also analyzed for target compound list organics, target analyte list inorganics, strontium 90, thorium, and plutonium (FAMU 1998).

In 2001, EPA collected soil, sediment, and surface water samples from the Scarboro community to respond to community concerns, identify data gaps, and validate the sampling performed by FAMU in 1998. All samples were subjected to a full analytical scan, including inorganic metals, volatile organic compounds, semi-volatile organic compounds, radiochemicals, organochlorine pesticides, and PCBs (EPA 2003).

Methodology

The same methodology that was used to screen and evaluate current (1990 to 2003) environmental data was applied to the Scarboro-specific health evaluation (see Section III.B). ATSDR selected contaminants for further evaluation by comparing the maximum detected concentrations in Scarboro against health-based comparison values. Comparison values are derived using conservative exposure assumptions and reflect concentrations much lower than those that have been observed to cause adverse health effects. This means they are protective of public health in essentially all exposure situations; concentrations detected at or below ATSDR's comparison values are not a public health hazard and are not evaluated further.

ATSDR derived exposure doses for those contaminants that were detected above comparison values. When estimating exposure doses, health assessors evaluate chemical concentrations to which people could be exposed, together with the length of time and the frequency of exposure. ATSDR applied several protective assumptions to estimate exposures for Scarboro residents. ATSDR then compared the exposure doses to protective screening guideline values, including ATSDR's MRLs and EPA's RfDs. Estimated exposure doses that are below screening guideline values are not a public health hazard and are not evaluated further.

[24] Radionuclides are evaluated separately.

Scarboro Results

Soil

- 207 chemicals were analyzed.
- 40 chemicals were detected.
- 4 chemicals were detected above comparison values (arsenic, iron, gamma-chlordane, and heptachlor epoxide; see Table 34).
- 2 chemicals were detected above noncancer screening guidelines (heptachlor epoxide and iron; see Table 37).
- 0 chemicals were detected above cancer screening guidelines (see Table 38).

Sediment

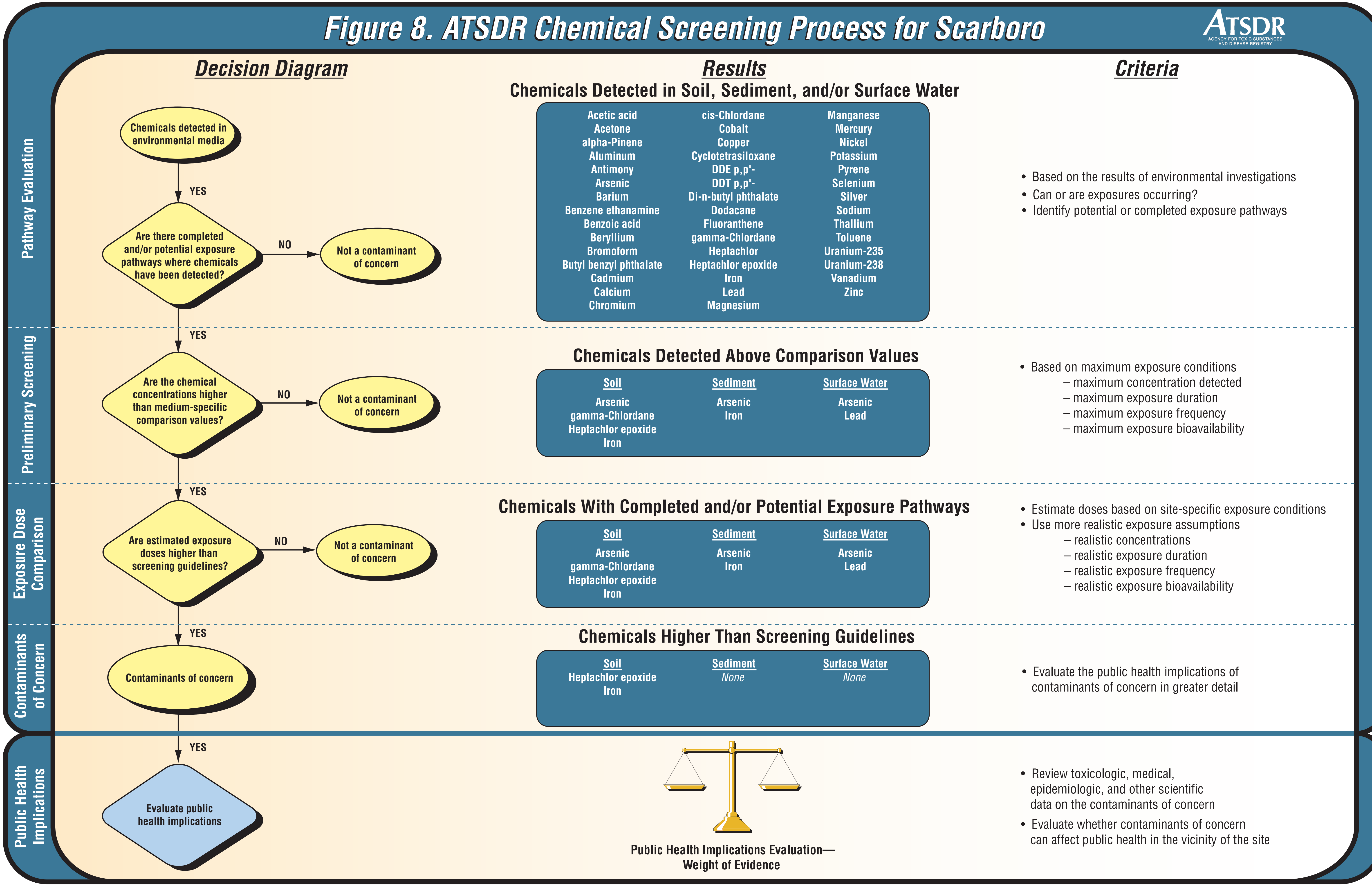
- 206 chemicals were analyzed.
- 32 chemicals were detected.
- 2 chemicals were detected above comparison values (arsenic and iron; see Table 35).
- 0 chemicals were detected above noncancer and cancer screening guidelines (see Table 37 and Table 38).

Surface Water

- 201 chemicals were analyzed.
- 23 chemicals were detected.
- 2 chemicals were detected above comparison values (arsenic and lead; see Table 36).
- 0 chemicals were detected above noncancer and cancer screening guidelines (see Table 37 and Table 38).

Figure 8 shows ATSDR's chemical screening process for the Scarboro public health evaluation. Chemicals without screening guidelines are discussed in Appendix B.

Figure 8. ATSDR Chemical Screening Process for Scarboro



Public Health Implications—Scarboro

A release of a chemical does not always result in human exposure, and human exposure does not always result in adverse health effects. Because screening guideline values were exceeded for two chemicals detected in soil (heptachlor epoxide and iron), ATSDR examined the health effect levels discussed in the scientific literature and more fully reviewed exposure potential for these chemicals. This information is used to describe the disease-causing potential of a particular chemical and to compare site-specific dose estimates with doses shown in applicable studies to result in illness. This process enables ATSDR to weigh the available evidence in light of uncertainties and offer perspective on the plausibility of harmful health outcomes under site-specific conditions.

Heptachlor Epoxide

The calculated dose for adults is below the noncancer and cancer screening guidelines for heptachlor epoxide; therefore, adults are not being exposed to heptachlor epoxide at levels constituting a health hazard. The calculated dose for pica children is below the acute screening guideline; therefore, pica children are not being exposed to heptachlor epoxide at levels constituting a health hazard. Because the calculated doses estimated for a non-pica child is above the noncancer screening guideline, ATSDR further examined the harmful effect levels reported in the scientific literature and more fully reviewed exposure potential for non-pica children.

Heptachlor epoxide is a breakdown product of heptachlor, a synthetic chemical used before 1988 for killing insects in homes, in buildings, and on food crops. Heptachlor epoxide was not manufactured—bacteria in the environment form heptachlor epoxide from heptachlor. Ingestion of soil containing heptachlor epoxide is one way the chemical can enter the body. The toxicokinetics (i.e., absorption, distribution, metabolism, and excretion) of heptachlor epoxide are not well studied in humans. Animal studies suggest that heptachlor epoxide is primarily stored in adipose tissue (i.e., fat). One animal study reported that the levels of heptachlor epoxide decreased to below detection limits 6 to 8 weeks after exposure (ATSDR 1993a).

ATSDR estimated that a non-pica child is expected to receive a dose of 0.000015 mg/kg/day from exposure to the soil in Scarboro. The oral screening guideline for heptachlor epoxide is based on a study in which liver-to-body weight ratios were significantly increased in animals fed heptachlor epoxide at doses of 0.0125 mg/kg/day for 60 weeks (Dow Chemical Company 1958). Supporting animal studies report no adverse health effects for doses ranging from 0.025 to 0.25 mg/kg/day (EPA 2004a). The estimated dose for non-pica children in Scarboro is well below these health effect levels.

Therefore, ATSDR does not expect that children who incidentally ingest soil from Scarboro would experience adverse health effects from exposure to heptachlor epoxide.

Iron

The calculated dose for adults is below the noncancer screening guideline for iron; therefore, adults are not being exposed to iron at levels constituting a health hazard. The estimated doses for both a pica child and non-pica child were above the acute and chronic noncancer screening guidelines, respectively. Therefore, ATSDR further examined the harmful effect levels reported in the scientific literature and more fully reviewed exposure potential.

Iron is a naturally occurring element in the environment. In fact, it is the fourth most abundant element in the Earth's crust by weight (LANL 2001). The most common iron ore is hematite, which frequently can be seen as black sand along beaches and stream banks. It is hard and brittle, and is usually combined with other metals to form alloys, including steel.

Iron is also an important mineral that assists in the maintenance of basic life functions. It combines with protein and copper to make hemoglobin, which transports oxygen in the blood from the lungs to other parts of the body, including the heart. It also aids in the formation of myoglobin, which supplies oxygen to muscle tissues (ANR 2003). Without sufficient iron, the body cannot produce enough hemoglobin or myoglobin to sustain life. Iron deficiency (anemia) is a condition that occurs when the body does not receive enough iron. NAS's DRI for children 1 to 3 years old is 7 mg/day and for children 4 to 8 years old is 10 mg/day (NAS 2001).

According to the FDA, doses greater than 200 mg per event could poison or kill a child (FDA 1997). Doses of this magnitude are generally the result of children accidentally ingesting iron pills and are not from ingesting iron in soil. Acute iron poisoning has been reported in children less than 6 years of age who have accidentally overdosed on iron-containing supplements for adults. Because iron is not considered to cause harmful health effects in general, toxicological and epidemiological literature is limited.

For comparison, ATSDR calculated a daily consumption from exposure to the iron in soil using a modification of the dose equation (dose = concentration × intake rate). Exposure to iron in the soil would increase a pica child's daily consumption of iron by 149 mg/day and a non-pica child's daily consumption of iron by 5.1 mg/day. The median daily intake of dietary iron is roughly 11 to 13 mg/day for children 1 to 8 years old and 13 to 20 mg/day for adolescents 9 to 18 years old (NAS 2001). The daily increase in consumption of iron (from ingesting soil) by a non-pica child is within the NAS- and FDA-recommended intake guidelines, and well below the dose known to induce poisoning (e.g., greater than 200 mg/event). While the daily consumption of iron for a pica child exceeds the NAS and FDA recommended intake guidelines, the daily increase in consumption is not likely to cause a pica child's daily dose to exceed levels known to induce poisoning. Further, to the ATSDR health assessors' knowledge, no case of acute iron toxicity has ever occurred as a direct result of soil consumption. The absence of such cases probably reflects the large amount of soil that would have to be ingested combined with the much lower intestinal absorption of iron from soil than from food, and the fact that the human body regulates its own iron level. Therefore, ATSDR does not expect that children who incidentally ingest the soil or who exhibit pica behavior would experience adverse health effects from exposure to iron in Scarboro soil.

Conclusions

None of the soil, sediment, or surface water samples collected from the Scarboro community contained chemicals at levels posing a public health hazard.

VI.I. Cancer Concerns

Area residents have voiced concerns about cancer. Citizens living in the communities surrounding the ORR expressed many concerns to the ORRHES about a perceived increase in cancer in areas surrounding the ORR. A 1993 TDOH survey of eight counties surrounding the ORR indicated that cancer was mentioned as a health problem more than twice as much as any other health problem. The survey also showed that 83 percent of the surveyed population in the surrounding counties believed it was very important to examine the actual occurrence of disease among residents in the Oak Ridge area.

> "Cancer incidence" refers to newly diagnosed cases of cancer that are reported to the Tennessee Cancer Registry.

To address these concerns, ORRHES requested that ATSDR conduct an assessment of health outcome data (cancer incidence) in the eight counties surrounding the ORR (see Figure 6). Therefore, ATSDR conducted an assessment of cancer incidence using data already collected by the Tennessee Cancer Registry. This assessment is a descriptive epidemiologic analysis that provides a general picture of the occurrence of cancer in each of the eight counties. The purpose of this evaluation was to provide citizens living in the ORR area with information regarding cancer rates in their county compared to the State of Tennessee. The evaluation only examines cancer rates at the population level, not at the individual level. It is not designed to evaluate specific associations between adverse health outcomes and documented human exposures, and it does not—and cannot—establish cause and effect.

The results of the assessment of cancer incidence, released in 2006, indicated both higher and lower rates of certain cancers in some of the counties examined when compared to cancer incidence rates for the State of Tennessee. Most of the cancers in the eight-county area occurred at expected levels, and no consistent pattern of cancer occurrence was identified. The reasons for the increases and decreases of certain cancers are unknown. ATSDR's ORR Assessment of Cancer Incidence is available online at http://www.atsdr.cdc.gov/HAC/oakridge/phact/cancer_oakridge/index.html.

In addition, over the last 20 years, local, state, and federal health agencies have conducted public health activities to address and evaluate public health issues and concerns related to chemical and radioactive substances released from the ORR. For more information, please see the Compendium of Public Health Activities at http://www.atsdr.cdc.gov/HAC/oakridge/phact/c_toc.html. The documents ATSDR has released to date are available from http://www.atsdr.cdc.gov/HAC/oakridge/phact/index.html.

VI.J. Private Vegetable Gardens

Because some people may only eat vegetables from their own garden, ATSDR specifically looked at exposures from eating the edible portion of vegetables sampled from each garden. Using the same assumptions and methodologies described in Section III.B, "Methodology," ATSDR determined that none of the chemicals were detected at levels constituting a health hazard. If people are concerned, they should consider building raised-bed gardens and filling them with "clean" topsoil and compost, or increasing the organic matter in the soil by adding compost or manure from outside sources such as commercial garden centers.

VII. Conclusions

Based on ATSDR's evaluation of current (1990–2003) and future chemical exposures in the vicinity of the Oak Ridge Reservation, ATSDR concludes the following:

- Current and future exposures to site-related chemicals in soil, sediment, surface water, biota (other than fish), and air pose no apparent public health hazard. "No apparent public health hazard" means that people may be exposed to contaminated media, but that exposure to contamination is not expected to result in adverse health effects.

- Dioxins pose an indeterminate public health hazard in an unknown fish species due to limited sampling data.

VIII. Recommendations

Because dioxin data for fish are very limited, ATSDR recommends following the current State of Tennessee fish advisories to reduce exposure to contaminants in fish.

IX. Public Health Action Plan

The public health action plan for the Oak Ridge Reservation (ORR) contains a description of actions taken at the site and those to be taken at the site following the completion of this public health assessment. The purpose of the public health action plan is to ensure that this document not only identifies potential and ongoing public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to harmful substances in the environment. The following public health actions at the ORR are completed or ongoing:

Completed Actions

- In 1991, the Tennessee Department of Health (TDOH) began a two-phase research project to determine whether environmental releases from the ORR harmed people who lived nearby. Phase I focused on assessing the feasibility of doing historical dose reconstruction and identifying contaminants that were most likely to have effects on public health. Phase II efforts included full dose reconstruction analyses of iodine 131, mercury, polychlorinated biphenyls (PCBs), and radionuclides, as well as a more detailed health effects screening analysis for releases of uranium and other toxic substances (a summary can be found in the *Oak Ridge Dose Reconstruction Project Summary Report, Volume 7*). Phase II was completed in January 2000.

- In 1992, the U.S. Department of Energy (DOE) conducted a *Background Soil Characterization Project* in the area around Oak Ridge.

- In 2004, the Agency for Toxic Substances and Disease Registry (ATSDR) released the final ORR Public Health Assessment for Y-12 Uranium Releases. The document is available from http://www.atsdr.cdc.gov/HAC/oakridge/phact/y12/index.html.

- In 2005, ATSDR released the final ORR Public Health Assessment for the TSCA Incinerator. The document is available from http://www.atsdr.cdc.gov/HAC/oakridge/phact/tsca/index.html.

- In 2006, ATSDR released the final ORR Public Health Assessment for Contaminated Off-site Groundwater Exposures. The document is available from http://www.atsdr.cdc.gov/HAC/oakridge/phact/groundwater/index.html.

- In 2006, ATSDR released the final ORR Public Health Assessment for White Oak Creek Radionuclide Releases. The document is available from http://www.atsdr.cdc.gov/HAC/oakridge/phact/white_oak/index.html.

Ongoing Actions

- ATSDR is conducting public health assessments on the releases of uranium and fluorides from the K-25 site; iodine 131 from the X-10 site; mercury from the Y-12 plant; and PCBs from the X-10 site, the Y-12 plant, and the K-25 site.

X. Preparers of Report

Karl V. Markiewicz, Ph.D.
Senior Toxicologist
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Jack Hanley, M.P.H.
Environmental Health Scientist
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

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TABLES

Table 16. Estimated Exposure Doses for Chemicals in Off-Site Soil Compared to Noncancer Screening Guidelines

Substance Name	*Minimum (ppm)*	*Maximum (ppm)*	*2nd Tier Screening Concentration (ppm)*	*Estimated Exposure Dose (mg/kg/day)*		*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
				Child	*Adult*			*Child*	*Adult*
Inorganics									
Arsenic	1	77.3	15	1.8E-04	8.4E-06	0.0003	CMRL	No	No
Cadmium	0.0702	41.3	11	1.3E-04	6.0E-06	0.0002	CMRL	No	No
Chromium	9.4	546[§]	100	1.2E-03	5.8E-05	0.003	RfD (CrVI)	No	No
Iron	5,790	61,600[§]	32,000	3.9E-01	1.8E-02	0.3	RfD	Yes	No
Lead	5.3	3,040[§]	570	7.0E-03	3.3E-04	0.02	Acute LOAEL	No	No
Organics									
Benzidine*	4.0	4.13	1.8	4.1E-05	1.9E-06	0.003	RfD	No	No
Benzo(a)anthracene	0.12	158[§]	39	*Evaluated for carcinogenic effects (see Table 17)*					
Benzo(a)pyrene	0.14	156[§]	36	*Evaluated for carcinogenic effects (see Table 17)*					
Benzo(b)fluoranthene	0.29	206[§]	47	*Evaluated for carcinogenic effects (see Table 17)*					
Benzo(k)fluoranthene	0.17	95.4[§]	23	*Evaluated for carcinogenic effects (see Table 17)*					
bis(2-Chloroethyl) ether	0.42	4.13	2.6	*Evaluated for carcinogenic effects (see Table 17)*					
Chrysene	0.16	134[§]	32	*Evaluated for carcinogenic effects (see Table 17)*					
trans-Chlordane	0.096	2.8	1.1	1.3E-05	6.0E-07	0.0006	CMRL (chlordane)	No	No
Dibenzo(a,h)anthracene	0.066	22.7[§]	7.6	*Evaluated for carcinogenic effects (see Table 17)*					
3,3'-Dichlorobenzidine	0.79	4.13	2.4	*Evaluated for carcinogenic effects (see Table 17)*					
Heptachlor epoxide	0.0096	0.97	0.48	5.8E-06	2.7E-07	0.000013	RfD	No	No
Hexachlorobenzene	0.42	4.13	2.7	3.3E-05	1.5E-06	0.00005	CMRL	No	No
HCDD	2.47E-05	0.000801[§]	0.00053	*Evaluated for carcinogenic effects (see Table 17)*					
Indeno(1,2,3-cd)pyrene	0.049	4.7[§]	2.5	*Evaluated for carcinogenic effects (see Table 17)*					
n-Nitroso-di-n-butylamine*	4.0	4.13	1.8	5.1E-05	2.4E-06	0.095	AMRL (n-nitrosodi-n-propylamine)	No	No
n-Nitrosodi-n-propylamine	0.42	0.79	0.63	7.7E-06	3.6E-07	0.095	AMRL	No	No
TCDD	1.98E-08	0.000117[§]	0.000039	4.8E-10	2.2E-11	1E-09	CMRL	No	No

Doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.0002 kg/day×291.2 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.00005 kg/day×291.2 days/year×30 years)/(70 kg×(365 days/year×30 years))

ppm = parts per million

RfD = reference dose (EPA)

*Chemical was detected in less than 10% of the samples. The second-tier screening concentration was estimated using 1/2 the detection limit for nondetected samples.

[§]The maximum concentration was detected in an industrial area (Atomic City Auto Parts) that has since been remediated (i.e., all the contaminated soil has been removed).

The second-tier screening concentrations are rounded.

CMRL = chronic minimal risk level (ATSDR)

LOAEL = lowest observed adverse effect level (ATSDR)

AMRL = acute minimal risk level (ATSDR)

CrVI = chromium VI

mg/kg/day = milligram per kilogram per day

Table 17. Estimated Exposure Doses for Chemicals in Off-Site Soil Compared to Cancer Screening Guidelines

Substance Name	*2nd Tier Screening Conc. (ppm)*	*Estimated Exposure Dose (mg/kg/day)*	*EPA's Oral Cancer Slope Factor $(mg/kg/day)^{-1}$*	*Risk*	*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*
Inorganics					
Arsenic	15	3.6E-06	1.5	5.4E-06	No
Cadmium	11	*Evaluated for noncarcinogenic effects (see Table 16)*			
Chromium	100	*Evaluated for noncarcinogenic effects (see Table 16)*			
Iron	32,000	*Evaluated for noncarcinogenic effects (see Table 16)*			
Lead	570	*Evaluated for noncarcinogenic effects (see Table 16)*			
Organics					
Benzidine*	1.8	8.3E-07	230	1.9E-04	Yes
Benzo(a)anthracene	39	9.6E-06	0.73	7.0E-06	No
Benzo(a)pyrene	36	8.8E-06	7.3	6.4E-05	No
Benzo(b)fluoranthene	47	1.2E-05	0.73	8.5E-06	No
Benzo(k)fluoranthene	23	5.5E-06	0.073	4.0E-07	No
bis(2-Chloroethyl) ether	2.6	6.3E-07	1.1	7.0E-07	No
Chrysene	32	7.7E-06	0.0073	5.6E-08	No
trans-Chlordane	1.1	2.6E-07	0.35	9.1E-08	No
Dibenzo(a,h)anthracene	7.6	1.8E-06	7.3	1.3E-05	No
3,3'-Dichlorobenzidine	2.4	5.8E-07	0.45	2.6E-07	No
Heptachlor epoxide	0.48	1.2E-07	9.1	1.1E-06	No
Hexachlorobenzene	2.7	6.6E-07	1.6	1.1E-06	No
HCDD	0.00053	1.3E-10	6,200	8.1E-07	No
Indeno(1,2,3-cd)pyrene	2.5	6.0E-07	0.73	4.4E-07	No
n-Nitroso-di-n-butylamine*	1.8	6.0E-07	5.4	3.3E-06	No
n-Nitrosodi-n-propylamine	0.63	1.5E-07	7	1.1E-06	No
TCDD	0.000039	9.6E-12	150,000	1.4E-06	No

Doses were calculated using the following formula:

dose = (second-tier screening concentration×0.00005 kg/day×291.2 days/year×30 years)/(70 kg×(365 days/year×70 years))

Risk was calculated by multiplying the cancer dose by EPA's oral cancer slope factor.

*Chemical was detected in less than 10% of the samples. The second-tier screening concentration was estimated using 1/2 the detection limit for nondetected samples.

The second-tier screening concentrations are rounded.

conc. = concentration

mg/kg/day = milligram per kilogram per day

ppm = parts per million

Table 18. Estimated Exposure Doses for Chemicals in Off-Site Sediment Compared to Noncancer Screening Guidelines

Substance Name	Minimum (ppm)	Maximum (ppm)	2nd Tier Screening Conc. (ppm)	Estimated Exposure Dose (mg/kg/day)		Noncancer Screening Guideline (mg/kg/day)	Source	Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?	
				Child	Adult			Child	Adult
Inorganics									
Arsenic	0.3	432	37	9.3E-06	1.7E-06	0.0003	CMRL	No	No
Cadmium	0.05	98.1	7.3	1.9E-06	3.4E-07	0.0002	CMRL	No	No
Copper	1.1	14,500	650	1.6E-04	3.1E-05	0.04	RfD	No	No
Iron	1,410	113,000	33,000	8.4E-03	1.6E-03	0.3	RfD	No	No
Lead	0.72	1,520	120	3.0E-05	5.6E-06	0.02	Acute LOAEL	No	No
Manganese	140	7,230	2,700	6.8E-04	1.3E-04	0.05	RfD	No	No
Organics									
Aldrin	0.00007	1.8	0.47	1.2E-07	2.2E-08	0.00003	CMRL	No	No
Benzo(a)anthracene	0.011	23.2	2.1	*Evaluated for carcinogenic effects (see Table 19)*					
Benzo(a)pyrene	0.013	30.1	2.5	*Evaluated for carcinogenic effects (see Table 19)*					
Benzo(b)fluoranthene	0.013	42.4	3.1	*Evaluated for carcinogenic effects (see Table 19)*					
Benzo(k)fluoranthene	0.0067	20.5	2.1	*Evaluated for carcinogenic effects (see Table 19)*					
bis(2-Chloroethyl) ether	0.17	3.4	1.4	*Evaluated for carcinogenic effects (see Table 19)*					
cis-Chlordane	0.00025	18	4.6	1.2E-06	2.2E-07	0.0006	CMRL (chlordane)	No	No
trans-Chlordane	0.00024	18	4.6	1.2E-06	2.2E-07	0.0006	CMRL (chlordane)	No	No
DDD, p,p'-	0.00018	4.3	1.1	*Evaluated for carcinogenic effects (see Table 19)*					
DDE, p,p'-	0.00016	4.3	1.1	*Evaluated for carcinogenic effects (see Table 19)*					
DDT, p,p'-	0.00024	4.3	1.1	2.8E-07	5.3E-08	0.0005	RfD	No	No
di(2-Ethylhexyl)phthalate	0.015	256	16	4.1E-06	7.6E-07	0.06	CMRL	No	No
Dibenzo(a,h)anthracene	0.014	4.2	1.4	*Evaluated for carcinogenic effects (see Table 19)*					
3,3'-Dichlorobenzidine	0.22	6.7	2.7	*Evaluated for carcinogenic effects (see Table 19)*					
Dieldrin	0.00015	4.3	1.1	2.9E-07	5.3E-08	0.00005	CMRL	No	No
Heptachlor	0.00007	1.8	0.46	1.2E-07	2.2E-08	0.0005	RfD	No	No
Heptachlor epoxide	0.00044	1.8	0.48	1.2E-07	2.3E-08	0.000013	RfD	No	No
Hexachlorobenzene	0.17	3.4	1.4	3.4E-07	6.4E-08	0.00005	CMRL	No	No
HCH, alpha-	0.0001	1.8	0.48	1.2E-07	2.3E-08	0.008	CMRL	No	No
HCH, beta-	0.00044	1.8	0.48	1.2E-07	2.3E-08	0.0006	IMRL	No	No
HCH, delta-	0.00044	1.8	0.48	1.2E-07	2.3E-08	0.0003	RfD (gamma-HCH)	No	No
HCH, gamma-	0.00022	1.8	0.48	1.2E-07	2.3E-08	0.0003	RfD	No	No
HCDD	6.28E-05	0.000575	0.00068	*Evaluated for carcinogenic effects (see Table 19)*					

Table 18. Estimated Exposure Doses for Chemicals in Off-site Sediment Compared to Noncancer Screening Guidelines (continued)

Substance Name	Minimum (ppm)	Maximum (ppm)	2nd Tier Screening Conc. (ppm)	Estimated Exposure Dose (mg/kg/day)		Noncancer Screening Guideline (mg/kg/day)	Source	Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?	
				Child	Adult			Child	Adult
Indeno(1,2,3-cd)pyrene	0.017	13.4	1.8	*Evaluated for carcinogenic effects (see Table 19)*					
n-Nitrosodi-n-propylamine	0.17	3.4	1.4	3.4E-07	6.4E-08	0.095	AMRL	No	No
Pentachlorophenol	0.026	16	6.4	1.6E-06	3.0E-07	0.001	CMRL	No	No
Toxaphene	0.044	43	12	2.9E-06	5.4E-07	0.001	IMRL	No	No

Doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.0001 kg/day×12 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.0001 kg/day×12 days/year×30 years)/(70 kg×(365 days/year×30 years))

The second-tier screening concentrations are rounded.

AMRL = acute minimal risk level (ATSDR)

CMRL = chronic minimal risk level (ATSDR)

conc. = concentration

IMRL = intermediate minimal risk level (ATSDR)

LOAEL = lowest observed adverse effect level (ATSDR)

mg/kg/day = milligram per kilogram per day

ppm = parts per million

RfD = reference dose (EPA)

Table 19. Estimated Exposure Doses for Chemicals in Off-Site Sediment Compared to Cancer Screening Guidelines

Substance Name	2nd Tier Screening Conc. (ppm)	Estimated Exposure Dose (mg/kg/day)	EPA's Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Risk	Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?
Inorganics					
Arsenic	37	7.4E-07	1.5	1.1E-06	No
Cadmium	7.3	*Evaluated for noncarcinogenic effects (see Table 18)*			
Copper	650	*Evaluated for noncarcinogenic effects (see Table 18)*			
Iron	33,000	*Evaluated for noncarcinogenic effects (see Table 18)*			
Lead	120	*Evaluated for noncarcinogenic effects (see Table 18)*			
Manganese	2,700	*Evaluated for noncarcinogenic effects (see Table 18)*			
Organics					
Aldrin	0.47	9.5E-09	17	1.6E-07	No
Benzo(a)anthracene	2.1	4.3E-08	0.73	3.1E-08	No
Benzo(a)pyrene	2.5	5.1E-08	7.3	3.7E-07	No
Benzo(b)fluoranthene	3.1	6.3E-08	0.73	4.6E-08	No
Benzo(k)fluoranthene	2.1	4.2E-08	0.073	3.1E-09	No
bis(2-Chloroethyl) ether	1.4	2.7E-08	1.1	3.0E-08	No
cis-Chlordane	4.6	9.3E-08	0.35	3.3E-08	No
trans-Chlordane	4.6	9.3E-08	0.35	3.3E-08	No
DDD, p,p'-	1.1	2.3E-08	0.24	5.5E-09	No
DDE, p,p'-	1.1	2.3E-08	0.34	7.8E-09	No
DDT, p,p'-	1.1	2.3E-08	0.34	7.7E-09	No
di(2-Ethylhexyl)phthalate	16	3.2E-07	0.014	4.5E-09	No
Dibenzo(a,h)anthracene	1.4	2.8E-08	7.3	2.0E-07	No
3,3'-Dichlorobenzidine	2.7	5.4E-08	0.45	2.4E-08	No
Dieldrin	1.1	2.3E-08	16	3.6E-07	No
Heptachlor	0.46	9.3E-09	4.5	4.2E-08	No
Heptachlor epoxide	0.48	9.7E-09	9.1	8.8E-08	No
Hexachlorobenzene	1.4	2.7E-08	1.6	4.4E-08	No
HCH, alpha-	0.48	9.7E-09	6.3	6.1E-08	No
HCH, beta-	0.48	9.7E-09	1.8	1.7E-08	No
HCH, delta-	0.48	9.7E-09	1.3	1.3E-08	No
HCH, gamma-	0.48	9.7E-09	1.3	1.3E-08	No
HCDD	0.00068	1.4E-11	6,200	8.5E-08	No
Indeno(1,2,3-cd)pyrene	1.8	3.5E-08	0.73	2.6E-08	No
n-Nitrosodi-n-propylamine	1.4	2.7E-08	7	1.9E-07	No
Pentachlorophenol	6.4	1.3E-07	0.12	1.5E-08	No
Toxaphene	12	2.3E-07	1.1	2.6E-07	No

Doses were calculated using the following formula:

dose = (second-tier screening concentration×0.0001 kg/day×12 days/year×30 years)/(70 kg×(365 days/year×70 years))

Risk was calculated by multiplying the cancer dose by EPA's oral cancer slope factor.
The second-tier screening concentrations are rounded.
conc. = concentration
mg/kg/day = milligram per kilogram per day   ppm = parts per million

Table 20. Estimated Exposure Doses for Chemicals in Off-Site Surface Water Compared to Noncancer Screening Guidelines

Substance Name	*Minimum (ppb)*	*Maximum (ppb)*	*2nd Tier Screening Conc. (ppb)*	*Estimated Exposure Dose (mg/kg/day)*		*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
				Child	*Adult*			*Child*	*Adult*
Inorganics									
Aluminum	6.2	21,000	1,400	1.8E-03	3.3E-04	1	RfD	No	No
Ammonia	20	13,000	5,700	7.2E-03	1.3E-03	0.3	IMRL	No	No
Antimony*	0.1	41	49	6.2E-05	1.2E-05	0.0004	RfD	No	No
Arsenic*	0.76	69	40	5.0E-05	9.4E-06	0.0003	CMRL/RfD	No	No
Barium	6.4	250	71.5	9.0E-05	1.7E-05	0.07	RfD	No	No
Beryllium*	0.03	26	1.6	2.0E-06	3.8E-07	0.002	CMRL/RfD	No	No
Boron	3.16	470	77	9.8E-05	1.8E-05	0.09	RfD	No	No
Cadmium*	0.2	13	2.9	3.7E-06	6.8E-07	0.0002	CMRL	No	No
Chlorine	2	1,400	430	5.4E-04	1.0E-04	0.1	RfD	No	No
Chromium	0.25	70	11.5	1.5E-05	2.7E-06	0.003	RfD (CrVI)	No	No
Copper	0.7	381	42	5.4E-05	9.9E-06	0.04	RfD	No	No
Iron	4.8	1,100,000	41,000	5.2E-02	9.7E-03	0.3	RfD	No	No
Lead	0.29	370	28	3.6E-05	6.7E-06	0.02	Acute LOAEL	No	No
Lithium	1.3	4,050	340	4.3E-04	8.1E-05	0.02	RfD	No	No
Manganese	1.07	2,430	220	2.8E-04	5.1E-05	0.05	RfD	No	No
Nickel	0.37	49	10	1.3E-05	2.4E-06	0.02	RfD	No	No
Nitrate	80	52,800	11,000	1.4E-02	2.5E-03	1.6	RfD	No	No
Nitrate and nitrite	100	47,500	6,300	7.9E-03	1.5E-03	0.1	RfD (nitrite)	No	No
Selenium*	0.97	54	55	6.9E-05	1.3E-05	0.005	CMRL/RfD	No	No
Silver	0.36	61	13	1.6E-05	3.0E-06	0.005	RfD	No	No
Thallium*§	0.5	39	46	5.8E-05	1.1E-05	0.00007	RfD	No	No
Vanadium	0.35	81	14	1.7E-05	3.2E-06	0.007	RfD	No	No
Zinc	0.88	1,270	150	1.9E-04	3.5E-05	0.3	CMRL	No	No
Organics									
Aldrin*	0.0063	0.052	0.07	9.4E-08	1.8E-08	0.00003	CMRL/RfD	No	No
Benzene*	0.3	10	4.6	5.8E-06	1.1E-06	0.003	RfD	No	No
Benzo(a)anthracene*	0.9	10	5.6	*Evaluated for carcinogenic effects (see Table 21)*					
Benzo(a)pyrene*	10	10	5.6	*Evaluated for carcinogenic effects (see Table 21)*					
Benzo(b)fluoranthene*	0.8	17	5.8	*Evaluated for carcinogenic effects (see Table 21)*					
Benzo(k)fluoranthene*	1.2	10	5.6	*Evaluated for carcinogenic effects (see Table 21)*					
Bis(2-chloroethyl) ether*	10	10	5.6	*Evaluated for carcinogenic effects (see Table 21)*					

Table 20. Estimated Exposure Doses for Chemicals in Off-Site Surface Water Compared to Noncancer Screening Guidelines (continued)

Substance Name	Minimum (ppb)	Maximum (ppb)	2nd Tier Screening Conc. (ppb)	Estimated Exposure Dose (mg/kg/day)		Noncancer Screening Guideline (mg/kg/day)	Source	Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?	
				Child	Adult			Child	Adult
Bromodichloromethane	1	10	3.1	3.9E-06	7.3E-07	0.02	CMRL	No	No
Bromoform*	1	10	4.2	5.3E-06	9.8E-07	0.2	CMRL/RfD	No	No
Carbazole*	10	10	5.3	*Evaluated for carcinogenic effects (see Table 21)*					
Carbon tetrachloride*§	1	10	13	1.7E-05	3.1E-06	0.0007	RfD	No	No
cis-Chlordane*	0.0063	0.5	0.13	*Evaluated for carcinogenic effects (see Table 21)*					
trans-Chlordane*	0.0063	0.5	0.13	*Evaluated for carcinogenic effects (see Table 21)*					
Chlorodibromomethane*	5	10	4.6	5.8E-06	1.1E-06	0.03	CMRL	No	No
Chloroethane*	1.6	34	6.5	8.2E-06	1.5E-06	0.4	RfD	No	No
Chloromethane*	1	10	5.9	*Evaluated for carcinogenic effects (see Table 21)*					
Chrysene*	1	10	5.6	*Evaluated for carcinogenic effects (see Table 21)*					
Dibenzo(a,h)anthracene*	10	10	5.8	*Evaluated for carcinogenic effects (see Table 21)*					
3,3'-Dichlorobenzidine*	10	20	11	*Evaluated for carcinogenic effects (see Table 21)*					
1,2-Dichloroethane*	1	100	9.1	1.1E-05	2.1E-06	0.03	RfD	No	No
1,3-Dichloropropene, cis-*	5	10	4.6	*Evaluated for carcinogenic effects (see Table 21)*					
1,3-Dichloropropene, trans-*	5	10	4.6	*Evaluated for carcinogenic effects (see Table 21)*					
Di(2-ethylhexyl)phthalate	0.6	230	39	4.9E-05	9.1E-06	0.06	CMRL	No	No
Dieldrin*	0.0049	0.1	0.2	1.9E-07	3.6E-08	0.00005	CMRL/RfD	No	No
2,4-Dinitrophenol*	25	50	27	3.4E-05	6.3E-06	0.002	RfD	No	No
4,6-Dinitro-o-cresol*	25	50	26	3.3E-05	6.1E-06	0.0001	RfD	No	No
HCDD	0.000013	0.000013	0.000013	*Evaluated for carcinogenic effects (see Table 21)*					
Heptachlor*	0.0063	0.052	0.07	9.4E-08	1.8E-08	0.0005	RfD	No	No
Heptachlor epoxide*	0.0034	0.052	0.07	9.4E-08	1.8E-08	0.000013	RfD	No	No
Hexachlorobenzene*	10	10	5.6	7.1E-06	1.3E-06	0.00005	CMRL	No	No
Hexachlorobutadiene*	10	10	5.6	7.1E-06	1.3E-06	0.0002	RfD	No	No
alpha-HCH*	0.0063	0.052	0.07	9.4E-08	1.7E-08	0.008	CMRL	No	No
beta-HCH*	0.0063	0.052	0.07	9.4E-08	1.7E-08	0.0006	IMRL	No	No
delta-HCH*	0.0063	0.052	0.07	*Evaluated for carcinogenic effects (see Table 21)*					
Hexachloroethane*	10	10	5.6	7.1E-06	1.3E-06	0.001	RfD	No	No
Indeno(1,2,3-cd)pyrene*	1	10	5.7	*Evaluated for carcinogenic effects (see Table 21)*					
Methoxychlor*	0.063	260	23	2.9E-05	5.5E-06	0.005	RfD	No	No
Methylene chloride	0.5	52	15	1.9E-05	3.5E-06	0.06	CMRL	No	No
2-Nitroaniline*	10	50	27	*Evaluated for carcinogenic effects (see Table 21)*					

Table 20. Estimated Exposure Doses for Chemicals in Off-Site Surface Water Compared to Noncancer Screening Guidelines (continued)

Substance Name	*Minimum (ppb)*	*Maximum (ppb)*	*2nd Tier Screening Conc. (ppb)*	*Estimated Exposure Dose (mg/kg/day)*		*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
				Child	*Adult*			*Child*	*Adult*
3-Nitroaniline*	10	50	27	*Evaluated for carcinogenic effects (see Table 21)*					
4-Nitroaniline*	10	50	26	*Evaluated for carcinogenic effects (see Table 21)*					
Nitrobenzene*	10	10	5.6	7.1E-06	1.3E-06	0.0005	RfD	No	No
n-Nitrosodi-n-propylamine*	10	10	5.6	7.1E-06	1.3E-06	0.095	AMRL	No	No
n-Nitrosodiphenylamine*	10	10	5.6	*Evaluated for carcinogenic effects (see Table 21)*					
Pentachlorophenol*	25	50	26			0.001	CMRL	No	No
TCDD	0.00002	0.00002	0.00002	2.5E-11	4.7E-12	1.0E-09	CMRL	No	No
1,1,2,2-Tetrachloroethane*	1	10	4.6	5.8E-06	1.1E-06	0.04	CMRL	No	No
1,1,2-Trichloroethane*	5	10	4.6	5.8E-06	1.1E-06	0.004	RfD	No	No
2,4,6-Trichlorophenol*	10	10	5.6	*Evaluated for carcinogenic effects (see Table 21)*					
Toxaphene*	0.63	5.2	2.7	3.4E-06	6.3E-07	0.001	IMRL	No	No
Trichloroethylene	0.34	23	8.1	1.0E-05	1.9E-06	0.0003	RfD	No	No
Vinyl chloride*	5	10	5.7	7.2E-06	1.3E-06	0.00002	CMRL	No	No

Doses were calculated using the following formulas:

child dose = ((second-tier screening concentration/1,000)×0.5 liters/day×12 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = ((second-tier screening concentration/1,000)×0.5 liters/day×12 days/year×30 years)/(70 kg×(365 days/year×30 years))

The second-tier screening concentrations are rounded.

*Chemical was detected in less than 10% of the samples. The second-tier screening concentration was estimated using 1/2 the detection limit for nondetected samples.

§The thallium and carbon tetrachloride data contained outliers that were three orders of magnitude higher than the second highest concentration. These data points were removed.

CMRL = chronic minimal risk level (ATSDR)

conc. = concentration

CrVI = chromium VI

IMRL = intermediate minimal risk level (ATSDR)

LOAEL = lowest observed adverse effect level (ATSDR)

mg/kg/day = milligram per kilogram per day

ppb = parts per billion

RfD = reference dose (EPA)

Table 21. Estimated Exposure Doses for Chemicals in Off-Site Surface Water Compared to Cancer Screening Guidelines

Substance Name	*2nd Tier Screening Conc. (ppb)*	*Estimated Exposure Dose (mg/kg/day)*	*EPA's Oral Cancer Slope Factor (mg/kg/day)$^{-1}$*	*Risk*	*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*
Inorganics					
Aluminum	1,400	*Evaluated for noncarcinogenic effects (see Table 20)*			
Ammonia	5,700	*Evaluated for noncarcinogenic effects (see Table 20)*			
Antimony*	49	*Evaluated for noncarcinogenic effects (see Table 20)*			
Arsenic*	40	4.0E-06	1.5	6.0E-06	No
Barium	71.5	*Evaluated for noncarcinogenic effects (see Table 20)*			
Beryllium*	1.6	*Evaluated for noncarcinogenic effects (see Table 20)*			
Boron	77	*Evaluated for noncarcinogenic effects (see Table 20)*			
Cadmium*	2.9	*Evaluated for noncarcinogenic effects (see Table 20)*			
Chlorine	430	*Evaluated for noncarcinogenic effects (see Table 20)*			
Chromium	11.5	*Evaluated for noncarcinogenic effects (see Table 20)*			
Copper	42	*Evaluated for noncarcinogenic effects (see Table 20)*			
Iron	41,000	*Evaluated for noncarcinogenic effects (see Table 20)*			
Lead	28	*Evaluated for noncarcinogenic effects (see Table 20)*			
Lithium	340	*Evaluated for noncarcinogenic effects (see Table 20)*			
Manganese	220	*Evaluated for noncarcinogenic effects (see Table 20)*			
Nickel	10	*Evaluated for noncarcinogenic effects (see Table 20)*			
Nitrate	11,000	*Evaluated for noncarcinogenic effects (see Table 20)*			
Nitrate and nitrite	6,300	*Evaluated for noncarcinogenic effects (see Table 20)*			
Selenium*	55	*Evaluated for noncarcinogenic effects (see Table 20)*			
Silver	13	*Evaluated for noncarcinogenic effects (see Table 20)*			
Thallium*§	46	*Evaluated for noncarcinogenic effects (see Table 20)*			
Vanadium	14	*Evaluated for noncarcinogenic effects (see Table 20)*			
Zinc	150	*Evaluated for noncarcinogenic effects (see Table 20)*			
Organics					
Aldrin*	0.07	7.5E-09	17	1.3E-07	No
Benzene*	4.6	4.6E-07	0.055	2.5E-08	No
Benzo(a)anthracene*	5.6	5.6E-07	0.73	4.1E-07	No
Benzo(a)pyrene*	5.6	5.7E-07	7.3	4.1E-06	No
Benzo(b)fluoranthene*	5.8	5.8E-07	0.73	4.3E-07	No
Benzo(k)fluoranthene*	5.6	5.6E-07	0.073	4.1E-08	No
Bis(2-chloroethyl) ether*	5.6	5.6E-07	1.1	6.2E-07	No
Bromodichloromethane	3.1	3.1E-07	0.062	1.9E-08	No
Bromoform*	4.2	4.2E-07	0.0079	3.3E-09	No
Carbazole*	5.3	5.3E-07	0.02	1.1E-08	No
Carbon tetrachloride*§	13	1.3E-06	0.13	1.7E-07	No
cis-Chlordane*	0.13	*Evaluated for noncarcinogenic effects (see Table 20)*			
trans-Chlordane*	0.13	*Evaluated for noncarcinogenic effects (see Table 20)*			
Chlorodibromomethane*	4.6	6.5E-07	0.0029	1.9E-09	No
Chloroethane*	6.5	5.9E-07	0.013	7.7E-09	No
Chloromethane*	5.9	5.6E-07	0.0073	4.1E-09	No
Chrysene*	5.6	5.8E-07	7.3	4.2E-06	No
Dibenzo(a,h)anthracene*	5.8	1.1E-06	0.45	5.0E-07	No
3,3'-Dichlorobenzidine*	11	9.1E-07	0.091	8.3E-08	No
1,2-Dichloroethane*	9.1	6.5E-07	0.0029	1.9E-09	No

Table 21. Estimated Exposure Doses for Chemicals in Off-Site Surface Water Compared to Cancer Screening Guidelines (continued)

Substance Name	*2nd Tier Screening Conc. (ppb)*	*Estimated Exposure Dose (mg/kg/day)*	*EPA's Oral Cancer Slope Factor $(mg/kg/day)^{-1}$*	*Risk*	*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*
1,3-Dichloropropene, cis-*	4.6	*Evaluated for noncarcinogenic effects (see Table 20)*			
1,3-Dichloropropene, trans-*	4.6	*Evaluated for noncarcinogenic effects (see Table 20)*			
Di(2-ethylhexyl)phthalate	39	3.9E-06	0.014	5.5E-08	No
Dieldrin*	0.2	1.5E-08	16	2.5E-07	No
2,4-Dinitrophenol*	27	*Evaluated for noncarcinogenic effects (see Table 20)*			
4,6-Dinitro-o-cresol*	26	*Evaluated for noncarcinogenic effects (see Table 20)*			
HCDD	0.000013	1.3E-12	6,200	8.2E-09	No
Heptachlor*	0.07	7.5E-09	4.5	3.4E-08	No
Heptachlor epoxide*	0.07	7.5E-09	9.1	6.8E-08	No
Hexachlorobenzene*	5.6	5.6E-07	1.6	9.0E-07	No
Hexachlorobutadiene*	5.6	5.6E-07	0.078	4.4E-08	No
alpha-HCH*	0.07	7.5E-09	6.3	4.7E-08	No
beta-HCH*	0.07	7.5E-09	1.8	1.3E-08	No
delta-HCH*	0.07	*Evaluated for noncarcinogenic effects (see Table 20)*			
Hexachloroethane*	5.6	5.6E-07	0.014	7.9E-09	No
Indeno(1,2,3-cd)pyrene*	5.7	5.8E-07	0.73	4.2E-07	No
Methoxychlor*	23	*Evaluated for noncarcinogenic effects (see Table 20)*			
Methylene chloride	15	1.5E-06	0.0075	1.1E-08	No
2-Nitroaniline*	27	*Evaluated for noncarcinogenic effects (see Table 20)*			
3-Nitroaniline*	27	*Evaluated for noncarcinogenic effects (see Table 20)*			
4-Nitroaniline*	26	*Evaluated for noncarcinogenic effects (see Table 20)*			
Nitrobenzene*	5.6	*Evaluated for noncarcinogenic effects (see Table 20)*			
N-nitrosodi-n-propylamine*	5.6	5.6E-07	7	4.0E-06	No
N-nitrosodiphenylamine*	5.6	5.6E-07	0.0049	2.8E-09	No
Pentachlorophenol*	26	2.6E-06	0.12	3.1E-07	No
TCDD	0.00002	2.0E-12	150,000	3.0E-07	No
1,1,2,2-Tetrachloroethane*	4.6	4.6E-07	0.2	9.2E-08	No
1,1,2-Trichloroethane*	4.6	4.6E-07	0.057	2.6E-08	No
2,4,6-Trichlorophenol*	5.6	5.6E-07	0.011	6.2E-09	No
Toxaphene*	2.7	2.7E-07	1.1	3.0E-07	No
Trichloroethylene	8.1	8.2E-07	0.4	3.3E-07	No
Vinyl chloride*	5.7	5.8E-07	1.4	8.1E-07	No

Doses were calculated using the following formula:

dose = ((second-tier screening concentration/1,000)×0.5 liters/day×12 days/year×30 years)/(70 kg×(365 days/year×70 years))

Risk was calculated by multiplying the exposure dose by EPA's oral cancer slope factor.

The second-tier screening concentrations are rounded.

*Chemical was detected in less than 10% of the samples. The second-tier screening concentration was estimated using 1/2 the detection limit for nondetected samples.

[§]The thallium and carbon tetrachloride data contained outliers that were three orders of magnitude higher than the second highest concentration. These data points were removed.

conc. = concentration

mg/kg/day = milligram per kilogram per day

ppb = parts per billion

Table 22. Estimated Exposure Doses for Chemicals in Fish Caught in EFPC Compared to Noncancer Screening Guidelines

Substance Name	*Species*	*Minimum (ppm)*	*Maximum (ppm)*	*2nd Tier Screening Conc. (ppm)*	*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Subsistence Estimated Exposure Dose (mg/kg/day)*		*Does the Subsistence Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*		*Recreational Estimated Exposure Dose (mg/kg/day)*		*Does the Recreational Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
							Child	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*	*Adult*
Inorganics														
Arsenic	Crayfish	0.2557	0.5122	0.51	0.0003	CMRL	7.9E-04	4.7E-04	Yes	Yes	1.2E-04	5.8E-05	No	No
Arsenic	Sunfish spp.	0.0484	0.1721	0.12	0.0003	CMRL	2.6E-04	1.5E-04	No	No	3.8E-05	1.9E-05	No	No
Cadmium	Crayfish	2.1588	3.7445	3.7	0.0002	CMRL	5.7E-03	3.4E-03	Yes	Yes	8.5E-04	4.2E-04	Yes	Yes
Cadmium	Sunfish spp.	0.3654	1.8589	1.7	0.0002	CMRL	2.7E-03	1.6E-03	Yes	Yes	4.0E-04	2.0E-04	Yes	No
Chromium	Crayfish	0.3473	3.2609	2.9	0.003	RfD	4.4E-03	2.7E-03	Yes	No	6.6E-04	3.3E-04	No	No
Chromium	Sunfish spp.	0.1997	0.7746	0.64	0.003	RfD	9.8E-04	5.9E-04	No	No	1.5E-04	7.3E-05	No	No
Organics														
Aldrin	Sunfish spp.	ND	ND	ND	0.00003	CMRL	ND	ND	No	No	ND	ND	No	No
Aldrin	Crayfish	0.00099	0.0012	0.0012	0.00003	CMRL	1.9E-06	1.2E-06	No	No	2.9E-07	1.4E-07	No	No
Benzo(a)pyrene	Sunfish spp.	ND	ND	ND	NA	NA	ND	ND	No	No	ND	ND	No	No
Benzo(a)pyrene	Crayfish	0.0023	0.041	0.033	*Evaluated for carcinogenic effects (see Table 23)*									
Dibenzo(a,h) anthracene	Sunfish spp.	ND	ND	ND	NA	NA	ND	ND	No	No	ND	ND	No	No
Dibenzo(a,h) anthracene	Crayfish	0.0011	0.047	0.037	*Evaluated for carcinogenic effects (see Table 23)*									
Dieldrin	Crayfish	0.002	0.0049	0.0052	0.00005	CMRL	7.9E-06	4.8E-06	No	No	1.2E-06	5.9E-07	No	No
Dieldrin	Sunfish spp.	0.0065	0.079	0.066	0.00005	CMRL	1.0E-04	6.1E-05	Yes	Yes	1.5E-05	7.5E-06	No	No
alpha-HCH	Sunfish spp.	ND	ND	ND	0.008	CMRL	ND	ND	No	No	ND	ND	No	No
alpha-HCH	Crayfish	0.0016	0.0057	0.0053	0.008	CMRL	8.2E-06	5.0E-06	No	No	1.2E-06	6.1E-07	No	No
Heptachlor epoxide	Crayfish	0.00027	0.0027	0.0027	0.000013	RfD	4.1E-06	2.5E-06	No	No	6.2E-07	3.1E-07	No	No
Heptachlor epoxide	Sunfish spp.	0.0021	0.08	0.068	0.000013	RfD	1.0E-04	6.3E-05	Yes	Yes	1.6E-05	7.7E-06	Yes	No
Toxaphene	Crayfish	ND	ND	ND	0.001	IMRL	ND	ND	No	No	ND	ND	No	No
Toxaphene	Sunfish spp.	ND	ND	ND	0.001	IMRL	ND	ND	No	No	ND	ND	No	No

Table 22. Estimated Exposure Doses for Chemicals in Fish Caught in EFPC Compared to Noncancer Screening Guidelines (continued)

Noncancer subsistence-level doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.02 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.065 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

Noncancer recreational-level doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.003 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.008 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

The second-tier screening concentrations are rounded.

CMRL = chronic minimal risk level (ATSDR)
conc. = concentration
EFPC = East Fork Poplar Creek
IMRL = intermediate minimal risk level (ATSDR)
mg/kg/day = milligram per kilogram per day
NA = not available
ND = not detected
ppm = parts per million
RfD = reference dose (EPA)
spp = species
Unknown = "unknown aquatic animal"

Table 23. Estimated Exposure Doses for Chemicals in Fish Caught in EFPC Compared to Cancer Screening Guidelines

Substance Name	*Species*	*2nd Tier Screening Conc. (ppm)*	*EPA's Oral Cancer Slope Factor $(mg/kg/day)^{-1}$*	*Estimated Exposure Dose (mg/kg/day)*		*Risk*		*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*	
				Subsistence	*Recreational*	*Subsistence*	*Recreational*	*Subsistence*	*Recreational*
Inorganics									
Arsenic	Crayfish	0.51	1.5	2.0E-04	2.5E-05	3.0E-04	3.7E-05	Yes	No
Arsenic	Sunfish spp.	0.12	1.5	6.6E-05	8.1E-06	9.9E-05	1.2E-05	No	No
Cadmium	Crayfish	3.7	*Evaluated for noncarcinogenic effects (see Table 22)*						
Cadmium	Sunfish spp.	1.7	*Evaluated for noncarcinogenic effects (see Table 22)*						
Chromium	Crayfish	2.9	*Evaluated for noncarcinogenic effects (see Table 22)*						
Chromium	Sunfish spp.	0.64	*Evaluated for noncarcinogenic effects (see Table 22)*						
Organics									
Aldrin	Sunfish spp.	ND	17	ND	ND	ND	ND	No	No
Aldrin	Crayfish	0.0012	17	4.9E-07	6.1E-08	8.4E-06	1.0E-06	No	No
Benzo(a)pyrene	Sunfish spp.	ND	7.3	ND	ND	ND	ND	No	No
Benzo(a)pyrene	Crayfish	0.033	7.3	1.3E-05	1.6E-06	9.6E-05	1.2E-05	No	No
Dibenzo(a,h)anthracene	Sunfish spp.	ND	7.3	ND	ND	ND	ND	No	No
Dibenzo(a,h)anthracene	Crayfish	0.037	7.3	1.5E-05	1.8E-06	1.1E-04	1.3E-05	Yes	No
Dieldrin	Crayfish	0.0052	16	2.1E-06	2.5E-07	3.3E-05	4.0E-06	No	No
Dieldrin	Sunfish spp.	0.066	16	2.6E-05	3.2E-06	4.2E-04	5.2E-05	Yes	No
alpha-HCH	Sunfish spp.	ND	6.3	ND	ND	ND	ND	No	No
alpha-HCH	Crayfish	0.0053	6.3	2.1E-06	2.6E-07	1.3E-05	1.6E-06	No	No
Heptachlor epoxide	Crayfish	0.0027	9.1	1.1E-06	1.3E-07	9.7E-06	1.2E-06	No	No
Heptachlor epoxide	Sunfish spp.	0.068	9.1	2.7E-05	3.3E-06	2.5E-04	3.0E-05	Yes	No
Toxaphene	Crayfish	ND	1.1	ND	ND	ND	ND	No	No
Toxaphene	Sunfish spp.	ND	1.1	ND	ND	ND	ND	No	No

Cancer subsistence-level doses were calculated using the following formula:

dose = (second-tier screening concentration×0.065 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×70 years))

Cancer recreational-level doses were calculated using the following formula:

dose = (second-tier screening concentration×0.008 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×70 years))

The second-tier screening concentrations are rounded.

conc. = concentration
EFPC = East Fork Poplar Creek
mg/kg/day = milligram per kilogram per day
ND = not detected
ppm = parts per million
Unknown aquatic = "unknown aquatic animal"

Table 24. Estimated Exposure Doses for Chemicals in Fish Caught in the Clinch River Compared to Noncancer Screening Guidelines

Substance Name	*Species*	*Minimum (ppm)*	*Maximum (ppm)*	*2nd Tier Screening Conc. (ppm)*	*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Subsistence Estimated Exposure Dose (mg/kg/day)*		*Does the Subsistence Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*		*Recreational Estimated Exposure Dose (mg/kg/day)*		*Does the Recreational Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
							Child	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*	*Adult*
Inorganics														
Arsenic	Catfish	0.64	0.64	0.64	0.0003	CMRL	9.8E-04	5.9E-04	Yes	Yes	1.5E-04	7.3E-05	No	No
Arsenic	Sunfish spp.	0.018	1.1	0.79	0.0003	CMRL	1.2E-03	7.4E-04	Yes	Yes	1.8E-04	9.0E-05	No	No
Arsenic	Bass spp.	0.14	0.45	0.37	0.0003	CMRL	5.7E-04	3.4E-04	Yes	Yes	8.5E-05	4.2E-05	No	No
Cadmium	Sunfish spp.	ND	ND	ND	0.0002	CMRL	ND	ND	No	No	ND	ND	No	No
Cadmium	Catfish	ND	ND	ND	0.0002	CMRL	ND	ND	No	No	ND	ND	No	No
Cadmium	Bass spp.	ND	ND	ND	0.0002	CMRL	ND	ND	No	No	ND	ND	No	No
Chromium	Bass spp.	ND	ND	ND	0.003	RfD	ND	ND	No	No	ND	ND	No	No
Chromium	Catfish	0.12	0.406	0.47	0.003	RfD	7.2E-04	4.3E-04	No	No	1.1E-04	5.3E-05	No	No
Chromium	Sunfish spp.	0.044	0.822	0.38	0.003	RfD	5.8E-04	3.5E-04	No	No	8.7E-05	4.3E-05	No	No
Thallium	Bass spp.	ND	ND	ND	0.00007	RfD	ND	ND	No	No	ND	ND	No	No
Thallium	Catfish	0.0025	0.029	0.035	0.00007	RfD	5.3E-05	3.2E-05	No	No	8.0E-06	3.9E-06	No	No
Thallium	Sunfish spp.	0.0035	0.0075	0.0068	0.00007	RfD	1.0E-05	6.3E-06	No	No	1.6E-06	7.7E-07	No	No
Organics														
Aldrin	Bass spp.	0.0027	0.0027	0.0027	0.00003	CMRL	4.2E-06	2.5E-06	No	No	6.2E-07	3.1E-07	No	No
Aldrin	Catfish	0.013	0.013	0.013	0.00003	CMRL	2.0E-05	1.2E-05	No	No	3.0E-06	1.5E-06	No	No
Aldrin	Sunfish spp.	0.033	0.051	0.047	0.00003	CMRL	7.3E-05	4.4E-05	Yes	Yes	1.1E-05	5.4E-06	No	No
Dieldrin	Bass spp.	0.00097	0.015	0.0093	0.00005	CMRL	1.4E-05	8.6E-06	No	No	2.1E-06	1.1E-06	No	No
Dieldrin	Catfish	0.00047	0.027	0.021	0.00005	CMRL	3.2E-05	1.9E-05	No	No	4.8E-06	2.4E-06	No	No
Dieldrin	Sunfish spp.	0.0005	0.102	0.085	0.00005	CMRL	1.3E-04	7.9E-05	Yes	Yes	2.0E-05	9.8E-06	No	No
alpha-HCH	Bass spp.	0.0002	0.0014	0.0016	0.008	CMRL	2.5E-06	1.5E-06	No	No	3.8E-07	1.9E-07	No	No
alpha-HCH	Catfish	0.00045	0.013	0.016	0.008	CMRL	2.4E-05	1.4E-05	No	No	3.6E-06	1.8E-06	No	No
alpha-HCH	Sunfish spp.	0.033	0.051	0.047	0.008	CMRL	7.3E-05	4.4E-05	No	No	1.1E-05	5.4E-06	No	No
Heptachlor epoxide	Bass spp.	0.0016	0.008	0.0062	0.000013	RfD	9.5E-06	5.7E-06	No	No	1.4E-06	7.1E-07	No	No
Heptachlor epoxide	Catfish	0.00052	0.013	0.0098	0.000013	RfD	1.5E-05	9.1E-06	Yes	No	2.3E-06	1.1E-06	No	No
Heptachlor epoxide	Sunfish spp.	0.0006	0.051	0.051	0.000013	RfD	7.9E-05	4.8E-05	Yes	Yes	1.2E-05	5.9E-06	No	No

Table 24. Estimated Exposure Doses for Chemicals in Fish Caught in the Clinch River Compared to Noncancer Screening Guidelines (continued)

Substance Name	*Species*	*Minimum (ppm)*	*Maximum (ppm)*	*2nd Tier Screening Conc. (ppm)*	*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Subsistence Estimated Exposure Dose (mg/kg/day)*		*Does the Subsistence Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*		*Recreational Estimated Exposure Dose (mg/kg/day)*		*Does the Recreational Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
							Child	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*	*Adult*
Toxaphene	Bass spp.	ND	ND	ND	0.001	IMRL	ND	ND	No	No	ND	ND	No	No
Toxaphene	Catfish	0.2	0.2	0.2	0.001	IMRL	3.1E-04	1.9E-04	No	No	4.6E-05	2.3E-05	No	No
Toxaphene	Sunfish spp.	0.656	1.024	0.94	0.001	IMRL	1.5E-03	8.8E-04	Yes	No	2.2E-04	1.1E-04	No	No

Noncancer subsistence-level doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.02 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.065 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

Noncancer recreational-level doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.003 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.008 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

The second-tier screening concentrations are rounded.
CMRL = chronic minimal risk level (ATSDR)
conc. = concentration
IMRL = intermediate minimal risk level (ATSDR)
mg/kg/day = milligram per kilogram per day
ND = not detected
ppm = parts per million
RfD = reference dose (EPA)
spp = species

Table 25. Estimated Exposure Doses for Chemicals in Fish Caught in the Clinch River Compared to Cancer Screening Guidelines

Substance Name	*Species*	*2nd Tier Screening Conc. (ppm)*	*EPA's Oral Cancer Slope Factor $(mg/kg/day)^{-1}$*	*Estimated Exposure Dose (mg/kg/day)*		*Risk*		*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*	
				Subsistence	*Recreational*	*Subsistence*	*Recreational*	*Subsistence*	*Recreational*
Inorganics									
Arsenic	Catfish	0.64	1.5	2.5E-04	3.1E-05	3.8E-04	4.7E-05	Yes	No
Arsenic	Sunfish spp.	0.79	1.5	3.2E-04	3.9E-05	4.7E-04	5.8E-05	Yes	No
Arsenic	Bass spp.	0.37	1.5	1.5E-04	1.8E-05	2.2E-04	2.7E-05	Yes	No
Cadmium	Sunfish spp.	ND	NA	ND	ND	ND	ND	No	No
Cadmium	Catfish	ND	NA	ND	ND	ND	ND	No	No
Cadmium	Bass spp.	ND	NA	ND	ND	ND	ND	No	No
Chromium	Bass spp.	ND	NA	ND	ND	ND	ND	No	No
Chromium	Catfish	0.47	*Evaluated for noncarcinogenic effects (see Table 24)*						
Chromium	Sunfish spp.	0.38	*Evaluated for noncarcinogenic effects (see Table 24)*						
Thallium	Bass spp.	ND	NA	ND	ND	ND	ND	No	No
Thallium	Catfish	0.035	*Evaluated for noncarcinogenic effects (see Table 24)*						
Thallium	Sunfish spp.	0.0068	*Evaluated for noncarcinogenic effects (see Table 24)*						
Organics									
Aldrin	Bass spp.	0.0027	17	1.1E-06	1.3E-07	1.8E-05	2.2E-06	No	No
Aldrin	Catfish	0.013	17	5.2E-06	6.4E-07	8.8E-05	1.1E-05	No	No
Aldrin	Sunfish spp.	0.051	17	1.9E-05	2.3E-06	3.2E-04	3.9E-05	Yes	No
Dieldrin	Bass spp.	0.015	16	3.7E-06	4.5E-07	5.9E-05	7.3E-06	No	No
Dieldrin	Catfish	0.027	16	8.3E-06	1.0E-06	1.3E-04	1.6E-05	Yes	No
Dieldrin	Sunfish spp.	0.102	16	3.4E-05	4.2E-06	5.4E-04	6.7E-05	Yes	No
alpha-HCH	Bass spp.	0.0014	6.3	6.6E-07	8.1E-08	4.1E-06	5.1E-07	No	No
alpha-HCH	Catfish	0.013	6.3	6.2E-06	7.6E-07	3.9E-05	4.8E-06	No	No
alpha-HCH	Sunfish spp.	0.051	6.3	1.9E-05	2.3E-06	1.2E-04	1.5E-05	Yes	No
Heptachlor epoxide	Bass spp.	0.008	9.1	2.5E-06	3.0E-07	2.2E-05	2.8E-06	No	No
Heptachlor epoxide	Catfish	0.013	9.1	3.9E-06	4.8E-07	3.5E-05	4.4E-06	No	No
Heptachlor epoxide	Sunfish spp.	0.051	9.1	2.0E-05	2.5E-06	1.9E-04	2.3E-05	Yes	No
Toxaphene	Bass spp.	ND	1.1	ND	ND	ND	ND	No	No
Toxaphene	Catfish	0.2	1.1	8.0E-05	9.8E-06	8.8E-05	1.1E-05	No	No
Toxaphene	Sunfish spp.	1.024	1.1	3.8E-04	4.6E-05	4.1E-04	5.1E-05	Yes	No

Table 25. Estimated Exposure Doses for Chemicals in Fish Caught in the Clinch River Compared to Cancer Screening Guidelines (continued)

Cancer subsistence-level doses were calculated using the following formula:

dose = (second-tier screening concentration×0.065 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×70 years))

Cancer recreational-level doses were calculated using the following formula:

dose = (second-tier screening concentration×0.008 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×70 years))

The second-tier screening concentrations are rounded.

conc. = concentration

mg/kg/day = milligram per kilogram per day

NA = not available

ND = not detected

ppm = parts per million

spp = species

Table 26. Estimated Exposure Doses for Chemicals in Fish Caught in WBR Compared to Noncancer Screening Guidelines

Substance Name	*Species*	*Minimum (ppm)*	*Maximum (ppm)*	*2nd Tier Screening Conc. (ppm)*	*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Subsistence Estimated Exposure Dose (mg/kg/day)*		*Does the Subsistence Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*		*Recreational Estimated Exposure Dose (mg/kg/day)*		*Does the Recreational Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
							Child	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*	*Adult*
Inorganics														
Arsenic	Catfish	0.012	1.1	0.66	0.0003	CMRL	1.0E-03	6.1E-04	Yes	Yes	1.5E-04	7.5E-05	No	No
Arsenic	Unknown	0.1	0.46	0.30	0.0003	CMRL	4.6E-04	2.8E-04	Yes	No	6.9E-05	3.4E-05	No	No
Arsenic	Bass spp.	0.008	0.32	0.26	0.0003	CMRL	3.9E-04	2.4E-04	Yes	No	5.9E-05	2.9E-05	No	No
Arsenic	Sunfish spp.	0.006	0.83	0.32	0.0003	CMRL	4.9E-04	3.0E-04	Yes	No	7.4E-05	3.7E-05	No	No
Cadmium	Catfish	ND	ND	ND	0.0002	CMRL	ND	ND	No	No	ND	ND	No	No
Cadmium	Sunfish spp.	ND	ND	ND	0.0002	CMRL	ND	ND	No	No	ND	ND	No	No
Cadmium	Unknown	0.05	0.06	0.062	0.0002	CMRL	9.5E-05	5.8E-05	No	No	1.4E-05	7.1E-06	No	No
Chromium	Catfish	0.043	0.28	0.33	0.003	RfD	5.1E-04	3.1E-04	No	No	7.6E-05	3.8E-05	No	No
Chromium	Sunfish spp.	0.12	0.8	0.46	0.003	RfD	7.0E-04	4.2E-04	No	No	1.1E-04	5.2E-05	No	No
Chromium	Unknown	0.1	44.6	16	0.003	RfD	2.5E-02	1.5E-02	Yes	Yes	3.7E-03	1.8E-03	Yes	No
Thallium	Catfish	0.0025	0.006	0.0067	0.00007	RfD	1.0E-05	6.2E-06	No	No	1.6E-06	7.7E-07	No	No
Thallium	Sunfish spp.	0.0045	0.022	0.014	0.00007	RfD	2.2E-05	1.3E-05	No	No	3.2E-06	1.6E-06	No	No
Organics														
Aldrin	Unknown	ND	ND	ND	0.00003	CMRL	ND	ND	No	No	ND	ND	No	No
Aldrin	Sunfish spp.	0.0056	0.048	0.049	0.00003	CMRL	7.5E-05	4.5E-05	Yes	Yes	1.1E-05	5.6E-06	No	No
Aldrin	Catfish	0.00083	0.018	0.013	0.00003	CMRL	2.0E-05	1.2E-05	No	No	3.0E-06	1.5E-06	No	No
Aldrin	Bass spp.	0.00054	0.014	0.009	0.00003	CMRL	1.4E-05	8.4E-06	No	No	2.1E-06	1.0E-06	No	No
Dieldrin	Unknown	ND	ND	ND	0.00005	CMRL	ND	ND	No	No	ND	ND	No	No
Dieldrin	Sunfish spp.	0.00148	0.096	0.079	0.00005	CMRL	1.2E-04	7.3E-05	Yes	Yes	1.8E-05	9.0E-06	No	No
Dieldrin	Catfish	0.00044	0.036	0.018	0.00005	CMRL	2.7E-05	1.6E-05	No	No	4.1E-06	2.0E-06	No	No
Dieldrin	Bass spp.	0.0005	0.03	0.013	0.00005	CMRL	2.0E-05	1.2E-05	No	No	3.0E-06	1.5E-06	No	No
alpha-HCH	Unknown	ND	ND	ND	0.008	CMRL	ND	ND	No	No	ND	ND	No	No
alpha-HCH	Catfish	0.01	0.01	0.01	0.008	CMRL	1.5E-05	9.3E-06	No	No	2.3E-06	1.1E-06	No	No
alpha-HCH	Bass spp.	0.01	0.02	0.022	0.008	CMRL	3.4E-05	2.0E-05	No	No	5.1E-06	2.5E-06	No	No
alpha-HCH	Sunfish spp.	0.0056	0.048	0.049	0.008	CMRL	7.5E-05	4.5E-05	No	No	1.1E-05	5.6E-06	No	No

Table 26. Estimated Exposure Doses for Chemicals in Fish Caught in WBR Compared to Noncancer Screening Guidelines (continued)

Substance Name	*Species*	*Minimum (ppm)*	*Maximum (ppm)*	*2nd Tier Screening Conc. (ppm)*	*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Subsistence Estimated Exposure Dose (mg/kg/day)*		*Does the Subsistence Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*		*Recreational Estimated Exposure Dose (mg/kg/day)*		*Does the Recreational Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
							Child	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*	*Adult*
Heptachlor epoxide	Unknown	ND	ND	ND	0.000013	RfD	ND	ND	No	No	ND	ND	No	No
Heptachlor epoxide	Sunfish spp.	0.0013	0.048	0.048	0.000013	RfD	7.4E-05	4.5E-05	Yes	Yes	1.1E-05	5.5E-06	No	No
Heptachlor epoxide	Catfish	0.0012	0.018	0.0096	0.000013	RfD	1.5E-05	8.9E-06	Yes	No	2.2E-06	1.1E-06	No	No
Heptachlor epoxide	Bass spp.	0.00044	0.016	0.007	0.000013	RfD	1.1E-05	6.5E-06	No	No	1.6E-06	8.0E-07	No	No
TCDD	Unknown	8.7E-06	8.7E-06	9E-06	1E-09	CMRL	1.3E-08	8.1E-09	Yes	Yes	2.0E-09	9.9E-10	Yes	No
Toxaphene	Bass spp.	0.24	0.24	0.24	0.001	IMRL	3.7E-04	2.2E-04	No	No	5.5E-05	2.7E-05	No	No
Toxaphene	Catfish	0.12	0.28	0.31	0.001	IMRL	4.8E-04	2.9E-04	No	No	7.2E-05	3.6E-05	No	No
Toxaphene	Sunfish spp.	0.088	0.96	0.98	0.001	IMRL	1.5E-03	9.1E-04	Yes	No	2.3E-04	1.1E-04	No	No

Noncancer subsistence-level doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.02 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.065 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

Noncancer recreational-level doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.003 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.008 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

The second-tier screening concentrations are rounded.
CMRL = chronic minimal risk level (ATSDR)
conc. = concentration
IMRL = intermediate minimal risk level (ATSDR)
mg/kg/day = milligram per kilogram per day
ND = not detected
ppm = parts per million
RfD = reference dose (EPA)
spp = species
WBR = Watts Bar Reservoir
Unknown = “unknown aquatic animal”

Table 27. Estimated Exposure Doses for Chemicals in Fish Caught in WBR Compared to Cancer Screening Guidelines

Substance Name	*Species*	*2nd Tier Screening Conc. (ppm)*	*EPA's Oral Cancer Slope Factor (mg/kg/day)$^{-1}$*	*Estimated Exposure Dose (mg/kg/day)*		*Risk*		*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*	
				Subsistence	*Recreational*	*Subsistence*	*Recreational*	*Subsistence*	*Recreational*
Inorganics									
Arsenic	Catfish	0.66	1.5	2.6E-04	3.2E-05	3.9E-04	4.8E-05	Yes	No
Arsenic	Unknown aquatic	0.30	1.5	1.2E-04	1.5E-05	1.8E-04	2.2E-05	Yes	No
Arsenic	Bass spp.	0.26	1.5	1.0E-04	1.3E-05	1.5E-04	1.9E-05	Yes	No
Arsenic	Sunfish spp.	0.32	1.5	1.3E-04	1.6E-05	1.9E-04	2.4E-05	Yes	No
Cadmium	Catfish	ND	NA	ND	ND	ND	ND	No	No
Cadmium	Sunfish spp.	ND	NA	ND	ND	ND	ND	No	No
Cadmium	Unknown aquatic	0.062	*Evaluated for noncarcinogenic effects (see Table 26)*						
Chromium	Catfish	0.33	*Evaluated for noncarcinogenic effects (see Table 26)*						
Chromium	Sunfish spp.	0.46	*Evaluated for noncarcinogenic effects (see Table 26)*						
Chromium	Unknown aquatic	16	*Evaluated for noncarcinogenic effects (see Table 26)*						
Thallium	Catfish	0.0067	*Evaluated for noncarcinogenic effects (see Table 26)*						
Thallium	Sunfish spp.	0.014	*Evaluated for noncarcinogenic effects (see Table 26)*						
Organics									
Aldrin	Unknown aquatic	ND	17	ND	ND	ND	ND	No	No
Aldrin	Sunfish spp.	0.049	17	1.9E-05	2.4E-06	3.3E-04	4.0E-05	Yes	No
Aldrin	Catfish	0.013	17	5.2E-06	6.3E-07	8.8E-05	1.1E-05	No	No
Aldrin	Bass spp.	0.009	17	3.6E-06	4.4E-07	6.1E-05	7.5E-06	No	No
Dieldrin	Unknown aquatic	ND	16	ND	ND	ND	ND	No	No
Dieldrin	Sunfish spp.	0.079	16	3.1E-05	3.9E-06	5.0E-04	6.2E-05	Yes	No
Dieldrin	Catfish	0.018	16	7.1E-06	8.7E-07	1.1E-04	1.4E-05	Yes	No
Dieldrin	Bass spp.	0.013	16	5.2E-06	6.3E-07	8.2E-05	1.0E-05	No	No
alpha-HCH	Unknown aquatic	ND	6.3	ND	ND	ND	ND	No	No
alpha-HCH	Catfish	0.01	6.3	4.0E-06	4.9E-07	2.5E-05	3.1E-06	No	No
alpha-HCH	Bass spp.	0.022	6.3	8.8E-06	1.1E-06	5.5E-05	6.8E-06	No	No
alpha-HCH	Sunfish spp.	0.049	6.3	1.9E-05	2.4E-06	1.2E-04	1.5E-05	Yes	No
Heptachlor epoxide	Unknown aquatic	ND	9.1	ND	ND	ND	ND	No	No
Heptachlor epoxide	Sunfish spp.	0.048	9.1	1.9E-05	2.4E-06	1.7E-04	2.1E-05	Yes	No
Heptachlor epoxide	Catfish	0.0096	9.1	3.8E-06	4.7E-07	3.5E-05	4.3E-06	No	No
Heptachlor epoxide	Bass spp.	0.007	9.1	2.8E-06	3.4E-07	2.5E-05	3.1E-06	No	No

Table 27. Estimated Exposure Doses for Chemicals in Fish Caught in WBR Compared to Cancer Screening Guidelines (continued)

Substance Name	Species	2nd Tier Screening Conc. (ppm)	EPA's Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Estimated Exposure Dose (mg/kg/day)		Risk		Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?	
				Subsistence	Recreational	Subsistence	Recreational	Subsistence	Recreational
TCDD	Unknown aquatic	9E-06	150,000	3.5E-09	4.3E-10	5.2E-04	6.4E-05	Yes	No
Toxaphene	Bass spp.	0.24	1.1	9.6E-05	1.2E-05	1.1E-04	1.3E-05	Yes	No
Toxaphene	Catfish	0.31	1.1	1.2E-04	1.5E-05	1.4E-04	1.7E-05	Yes	No
Toxaphene	Sunfish spp.	0.98	1.1	3.9E-04	4.8E-05	4.3E-04	5.3E-05	Yes	No

Cancer subsistence-level doses were calculated using the following formula:
adult dose = (second-tier screening concentration×0.065 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×70 years))
Cancer recreational-level doses were calculated using the following formula:
adult dose = (second-tier screening concentration×0.008 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×70 years))
The second-tier screening concentrations are rounded.
conc. = concentration
mg/kg/day = milligram per kilogram per day
NA = not available
ND = not detected
ppm = parts per million
spp = species
Unknown aquatic = “unknown aquatic animal”
WBR = Watts Bar Reservoir

Table 28. Estimated Exposure Doses for Chemicals in Fish Caught On Site Compared to Noncancer Screening Guidelines

Substance Name	*Species*	*Minimum (ppm)*	*Maximum (ppm)*	*2nd Tier Screening Conc. (ppm)*	*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Subsistence Estimated Exposure Dose (mg/kg/day)*		*Does the Subsistence Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*		*Recreational Estimated Exposure Dose (mg/kg/day)*		*Does the Recreational Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
							Child	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*	*Adult*
Inorganics														
Arsenic	Creek chub	0.0855	0.112	0.11	0.0003	CMRL	1.7E-04	1.0E-04	No	No	2.5E-05	1.3E-05	No	No
Arsenic	Crayfish	0.2196	0.2749	0.28	0.0003	CMRL	4.2E-04	2.6E-04	Yes	No	6.4E-05	3.1E-05	No	No
Arsenic	Unknown	0.137	0.39	0.38	0.0003	CMRL	5.8E-04	3.5E-04	Yes	Yes	8.8E-05	4.3E-05	No	No
Arsenic	Sunfish spp.	0.026	1.3	0.44	0.0003	CMRL	6.7E-04	4.1E-04	Yes	Yes	1.0E-04	5.0E-05	No	No
Arsenic	Bass spp.	0.045	0.96	0.34	0.0003	CMRL	5.3E-04	3.2E-04	Yes	Yes	7.9E-05	3.9E-05	No	No
Cadmium	Creek chub	0.529	1.11	1.2	0.0002	CMRL	1.8E-03	1.1E-03	Yes	Yes	2.7E-04	1.3E-04	Yes	No
Cadmium	Crayfish	1.9136	2.3827	2.4	0.0002	CMRL	3.6E-03	2.2E-03	Yes	Yes	5.4E-04	2.7E-04	Yes	Yes
Cadmium	Bass spp.	0.028	0.8282	0.63	0.0002	CMRL	9.7E-04	5.9E-04	Yes	Yes	1.5E-04	7.2E-05	No	No
Cadmium	Sunfish spp.	0.0416	1.9608	1.6	0.0002	CMRL	2.4E-03	1.5E-03	Yes	Yes	3.7E-04	1.8E-04	Yes	No
Cadmium	Unknown	0.12	1.8	1.4	0.0002	CMRL	2.2E-03	1.3E-03	Yes	Yes	3.3E-04	1.6E-04	Yes	No
Chromium	Creek chub	0.242	0.356	0.35	0.003	RfD	5.4E-04	3.3E-04	No	No	8.1E-05	4.0E-05	No	No
Chromium	Crayfish	0.5469	1.3066	1.3	0.003	RfD	1.9E-03	1.2E-03	No	No	2.9E-04	1.4E-04	No	No
Chromium	Bass spp.	0.12	2.1	1.5	0.003	RfD	2.2E-03	1.3E-03	No	No	3.3E-04	1.7E-04	No	No
Chromium	Unknown	0.27	0.69	0.61	0.003	RfD	9.4E-04	5.7E-04	No	No	1.4E-04	7.0E-05	No	No
Chromium	Sunfish spp.	0.062	0.7173	0.43	0.003	RfD	6.6E-04	4.0E-04	No	No	9.9E-05	4.9E-05	No	No
Thallium	Creek chub	ND	ND	ND	0.00007	RfD	ND	ND	No	No	ND	ND	No	No
Thallium	Unknown	0.01	0.024	0.027	0.00007	RfD	4.1E-05	2.5E-05	No	No	6.2E-06	3.1E-06	No	No
Thallium	Bass spp.	0.005	0.049	0.058	0.00007	RfD	8.9E-05	5.4E-05	Yes	No	1.3E-05	6.6E-06	No	No
Thallium	Sunfish spp.	0.009	9.2	4.1	0.00007	RfD	6.3E-03	3.8E-03	Yes	Yes	9.5E-04	4.7E-04	Yes	Yes
Organics														
Aldrin	Crayfish	ND	ND	ND	0.00003	CMRL	ND	ND	No	No	ND	ND	No	No
Aldrin	Catfish	0.0023	0.0055	0.0062	0.00003	CMRL	9.5E-06	5.7E-06	No	No	1.4E-06	7.0E-07	No	No
Aldrin	Bass spp.	0.00039	0.0042	0.0039	0.00003	CMRL	6.0E-06	3.6E-06	No	No	8.9E-07	4.4E-07	No	No
Aldrin	Sunfish spp.	0.033	0.042	0.043	0.00003	CMRL	6.5E-05	3.9E-05	Yes	Yes	9.8E-06	4.9E-06	No	No
Benzo(a)pyrene	Sunfish spp.	0.00041	0.00041	0.0004	*Evaluated for carcinogenic effects (see Table 29)*									

Table 28. Estimated Exposure Doses for Chemicals in Fish Caught On Site Compared to Noncancer Screening Guidelines (continued)

Substance Name	*Species*	*Minimum (ppm)*	*Maximum (ppm)*	*2nd Tier Screening Conc. (ppm)*	*Noncancer Screening Guideline (mg/kg/day)*	*Source*	*Subsistence Estimated Exposure Dose (mg/kg/day)*		*Does the Subsistence Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*		*Recreational Estimated Exposure Dose (mg/kg/day)*		*Does the Recreational Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*	
							Child	*Adult*	*Child*	*Adult*	*Child*	*Adult*	*Child*	*Adult*
Benzo(a)pyrene	Catfish	0.033	0.033	0.033	*Evaluated for carcinogenic effects (see Table 29)*									
Benzo(a)pyrene	Crayfish	0.0042	0.0071	0.0077	*Evaluated for carcinogenic effects (see Table 29)*									
Dibenzo(a,h)anthracene	Catfish	0.033	0.033	0.033	*Evaluated for carcinogenic effects (see Table 29)*									
Dibenzo(a,h)anthracene	Sunfish spp.	0.0056	0.0056	0.0056	*Evaluated for carcinogenic effects (see Table 29)*									
Dibenzo(a,h)anthracene	Crayfish	0.00093	0.0013	0.0014	*Evaluated for carcinogenic effects (see Table 29)*									
Dieldrin	Crayfish	0.0082	0.011	0.012	0.00005	CMRL	1.8E-05	1.1E-05	No	No	2.7E-06	1.3E-06	No	No
Dieldrin	Catfish	0.0012	0.028	0.023	0.00005	CMRL	3.5E-05	2.1E-05	No	No	5.3E-06	2.6E-06	No	No
Dieldrin	Bass spp.	0.00081	0.11	0.069	0.00005	CMRL	1.1E-04	6.4E-05	Yes	Yes	1.6E-05	7.8E-06	No	No
Dieldrin	Sunfish spp.	0.011	0.083	0.085	0.00005	CMRL	1.3E-04	7.9E-05	Yes	Yes	2.0E-05	9.7E-06	No	No
alpha-HCH	Crayfish	ND	ND	ND	0.008	CMRL	ND	ND	No	No	ND	ND	No	No
alpha-HCH	Catfish	ND	ND	ND	0.008	CMRL	ND	ND	No	No	ND	ND	No	No
alpha-HCH	Bass spp.	ND	ND	ND	0.008	CMRL	ND	ND	No	No	ND	ND	No	No
alpha-HCH	Sunfish spp.	0.0026	0.042	0.048	0.008	CMRL	7.4E-05	4.5E-05	No	No	1.1E-05	5.5E-06	No	No
Heptachlor epoxide	Crayfish	0.0016	0.0042	0.0047	0.000013	RfD	7.3E-06	4.4E-06	No	No	1.1E-06	5.4E-07	No	No
Heptachlor epoxide	Bass spp.	0.00057	0.011	0.0084	0.000013	RfD	1.3E-05	7.8E-06	No	No	1.9E-06	9.6E-07	No	No
Heptachlor epoxide	Catfish	0.0019	0.02	0.016	0.000013	RfD	2.4E-05	1.4E-05	Yes	Yes	3.6E-06	1.8E-06	No	No
Heptachlor epoxide	Sunfish spp.	0.0006	0.073	0.053	0.000013	RfD	8.2E-05	4.9E-05	Yes	Yes	1.2E-05	6.1E-06	No	No
Toxaphene	Catfish	ND	ND	ND	0.001	IMRL	ND	ND	No	No	ND	ND	No	No
Toxaphene	Crayfish	ND	ND	ND	0.001	IMRL	ND	ND	No	No	ND	ND	No	No
Toxaphene	Bass spp.	1.9	1.9	1.9	0.001	IMRL	2.9E-03	1.8E-03	Yes	Yes	4.4E-04	2.2E-04	No	No
Toxaphene	Sunfish spp.	0.656	0.832	0.85	0.001	IMRL	1.3E-03	7.9E-04	Yes	No	2.0E-04	9.7E-05	No	No

Noncancer subsistence-level doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.02 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.065 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

Noncancer recreational-level doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.003 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.008 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

Table 28. Estimated Exposure Doses for Chemicals in Fish Caught On Site Compared to Noncancer Screening Guidelines (continued)

The second-tier screening concentrations are rounded.
CMRL = chronic minimal risk level (ATSDR)
conc. = concentration
IMRL = intermediate minimal risk level (ATSDR)
mg/kg/day = milligram per kilogram per day
ND = not detected
ppm = parts per million
RfD = reference dose (EPA)
spp = species
Unknown = "unknown aquatic animal"

Table 29. Estimated Exposure Doses for Chemicals in Fish Caught On Site Compared to Cancer Screening Guidelines

Substance Name	*Species*	*2nd Tier Screening Conc. (ppm)*	*EPA's Oral Cancer Slope Factor (mg/kg/day)-1*	*Estimated Exposure Dose (mg/kg/day)*		*Risk*		*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*	
				Subsistence	*Recreational*	*Subsistence*	*Recreational*	*Subsistence*	*Recreational*
Inorganics									
Arsenic	Creek chub	0.11	1.5	4.4E-05	5.4E-06	6.6E-05	8.1E-06	No	No
Arsenic	Crayfish	0.28	1.5	1.1E-04	1.3E-05	1.6E-04	2.0E-05	Yes	No
Arsenic	Unknown aquatic	0.38	1.5	1.5E-04	1.9E-05	2.3E-04	2.8E-05	Yes	No
Arsenic	Sunfish spp.	0.44	1.5	1.7E-04	2.1E-05	2.6E-04	3.2E-05	Yes	No
Arsenic	Bass spp.	0.34	1.5	1.4E-04	1.7E-05	2.0E-04	2.5E-05	Yes	No
Cadmium	Creek chub	1.2	*Evaluated for noncarcinogenic effects (see Table 28)*						
Cadmium	Crayfish	2.4	*Evaluated for noncarcinogenic effects (see Table 28)*						
Cadmium	Bass spp.	0.63	*Evaluated for noncarcinogenic effects (see Table 28)*						
Cadmium	Sunfish spp.	1.6	*Evaluated for noncarcinogenic effects (see Table 28)*						
Cadmium	Unknown aquatic	1.4	*Evaluated for noncarcinogenic effects (see Table 28)*						
Chromium	Creek chub	0.35	*Evaluated for noncarcinogenic effects (see Table 28)*						
Chromium	Crayfish	1.3	*Evaluated for noncarcinogenic effects (see Table 28)*						
Chromium	Bass spp.	1.5	*Evaluated for noncarcinogenic effects (see Table 28)*						
Chromium	Unknown aquatic	0.61	*Evaluated for noncarcinogenic effects (see Table 28)*						
Chromium	Sunfish spp.	0.43	*Evaluated for noncarcinogenic effects (see Table 28)*						
Thallium	Creek chub	ND	NA	ND	ND	ND	ND	No	No
Thallium	Unknown aquatic	0.027	*Evaluated for noncarcinogenic effects (see Table 28)*						
Thallium	Bass spp.	0.058	*Evaluated for noncarcinogenic effects (see Table 28)*						
Thallium	Sunfish spp.	4.1	*Evaluated for noncarcinogenic effects (see Table 28)*						
Organics									
Aldrin	Crayfish	ND	17	ND	ND	ND	ND	No	No
Aldrin	Catfish	0.0062	17	2.5E-06	3.0E-07	4.2E-05	5.1E-06	No	No
Aldrin	Bass spp.	0.0039	17	1.5E-06	1.9E-07	2.6E-05	3.2E-06	No	No
Aldrin	Sunfish spp.	0.043	17	1.7E-05	2.1E-06	2.9E-04	3.5E-05	Yes	No
Benzo(a)pyrene	Sunfish spp.	0.0004	7.3	1.6E-07	2.0E-08	1.2E-06	1.5E-07	No	No
Benzo(a)pyrene	Catfish	0.033	7.3	1.3E-05	1.6E-06	9.6E-05	1.2E-05	No	No
Benzo(a)pyrene	Crayfish	0.0077	7.3	3.1E-06	3.8E-07	2.2E-05	2.8E-06	No	No
Dibenzo(a,h)anthracene	Catfish	0.033	7.3	1.3E-05	1.6E-06	9.6E-05	1.2E-05	No	No
Dibenzo(a,h)anthracene	Sunfish spp.	0.0056	7.3	2.2E-06	2.7E-07	1.6E-05	2.0E-06	No	No

Table 29. Estimated Exposure Doses for Chemicals in Fish Caught On Site Compared to Cancer Screening Guidelines (continued)

Substance Name	Species	2nd Tier Screening Conc. (ppm)	EPA's Oral Cancer Slope Factor (mg/kg/day)$^{-1}$	Estimated Exposure Dose (mg/kg/day)		Risk		Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?	
				Subsistence	Recreational	Subsistence	Recreational	Subsistence	Recreational
Dibenzo(a,h)anthracene	Crayfish	0.0014	7.3	5.5E-07	6.7E-08	4.0E-06	4.9E-07	No	No
Dieldrin	Crayfish	0.012	16	4.6E-06	5.7E-07	7.4E-05	9.1E-06	No	No
Dieldrin	Catfish	0.023	16	9.2E-06	1.1E-06	1.5E-04	1.8E-05	Yes	No
Dieldrin	Bass spp.	0.069	16	2.7E-05	3.4E-06	4.4E-04	5.4E-05	Yes	No
Dieldrin	Sunfish spp.	0.085	16	3.4E-05	4.2E-06	5.4E-04	6.7E-05	Yes	No
alpha-HCH	Crayfish	ND	6.3	ND	ND	ND	ND	No	No
alpha-HCH	Catfish	ND	6.3	ND	ND	ND	ND	No	No
alpha-HCH	Bass spp.	ND	6.3	ND	ND	ND	ND	No	No
alpha-HCH	Sunfish spp.	0.048	6.3	1.9E-05	2.4E-06	1.2E-04	1.5E-05	Yes	No
Heptachlor epoxide	Crayfish	0.0047	9.1	1.9E-06	2.3E-07	1.7E-05	2.1E-06	No	No
Heptachlor epoxide	Bass spp.	0.0084	9.1	3.3E-06	4.1E-07	3.0E-05	3.7E-06	No	No
Heptachlor epoxide	Catfish	0.016	9.1	6.2E-06	7.6E-07	5.7E-05	7.0E-06	No	No
Heptachlor epoxide	Sunfish spp.	0.053	9.1	2.1E-05	2.6E-06	1.9E-04	2.4E-05	Yes	No
Toxaphene	Catfish	ND	1.1	ND	ND	ND	ND	No	No
Toxaphene	Crayfish	ND	1.1	ND	ND	ND	ND	No	No
Toxaphene	Bass spp.	1.9	1.1	7.6E-04	9.3E-05	8.3E-04	1.0E-04	Yes	Yes
Toxaphene	Sunfish spp.	0.85	1.1	3.4E-04	4.1E-05	3.7E-04	4.6E-05	Yes	No

Cancer subsistence-level doses were calculated using the following formula:

dose = (second-tier screening concentration×0.065 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×70 years))

Cancer recreational-level doses were calculated using the following formula:

dose = (second-tier screening concentration×0.008 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×70 years))

The second-tier screening concentrations are rounded.

conc. = concentration

mg/kg/day = milligram per kilogram per day

NA = not available

ND = not detected

ppm = parts per million

spp = species

Unknown aquatic = "unknown aquatic animal"

Table 30. Estimated Exposure Doses for Chemicals in Game Caught On Site Compared to Noncancer Screening Guidelines

Substance Name	Species	Minimum (ppm)	Maximum (ppm)	2nd Tier Screening Conc. (ppm)	Estimated Exposure Dose (mg/kg/day)		Noncancer Screening Guideline (mg/kg/day)	Source	Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?	
					Child	Adult			Child	Adult
Inorganics										
Aluminum	Unknown terrestrial animal	0.0987	15,300	10,400	8.0E-01	3.0E-01	1	RfD	No	No
Antimony	Unknown terrestrial animal	0.0224	14.3	12	8.9E-04	3.3E-04	0.0004	RfD	Yes	No
Cadmium	Canadian goose	0.41	3.2	2.5	1.9E-04	7.2E-05	0.0002	CMRL	No	No
Cadmium	Unknown aquatic bird	1.53	7.21	7.1	5.5E-04	2.0E-04	0.0002	CMRL	Yes	Yes
Cadmium	Unknown terrestrial animal	0.0033	32.4	13	9.7E-04	3.6E-04	0.0002	CMRL	Yes	Yes
Cadmium	Unknown terrestrial bird	ND	ND	ND	ND	ND	0.0002	CMRL	ND	ND
Cadmium	Wood duck	ND	ND	ND	ND	ND	0.0002	CMRL	ND	ND
Iron	Unknown terrestrial animal	0.6878	36,200	18,000	1.4E+00	5.1E-01	0.3	RfD	Yes	Yes
Manganese	Unknown terrestrial animal	0.291	10,200	4,000	3.1E-01	1.1E-01	0.14	RfD	Yes	No
Manganese	Unknown terrestrial bird	0.36	0.5	0.53	4.1E-05	1.5E-05	0.14	RfD	No	No
Thallium	Unknown terrestrial animal	0.93	2.9	2.6	2.0E-04	7.5E-05	0.00007	RfD	Yes	Yes
Organics										
4,6-Dinitro-o-cresol	Unknown terrestrial animal	3.5	3.5	3.5	2.7E-04	1.0E-04	0.0001	RfD	Yes	No
2,4-Dinitrophenol	Unknown terrestrial animal	3.5	75	82	6.3E-03	2.3E-03	0.002	RfD	Yes	Yes

Noncancer doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.001 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.002 kg/day×365 days/year×30 years)/(70 kg×(365 days/year×30 years))

The second-tier screening concentrations are rounded.
CMRL = chronic minimal risk level (ATSDR)
conc. = concentration
mg/kg/day = milligram per kilogram per day
ND = not detected
ppm = parts per million
RfD = reference dose (EPA)

All chemicals detected in game species caught on site were evaluated for noncarcinogenic effects only—cancer screening guidelines are not available for these chemicals.

Table 31. Estimated Exposure Doses for Chemicals in Vegetation Species Collected Off Site Compared to Noncancer Screening Guidelines

Substance Name	Species	Minimum (ppm)	Maximum (ppm)	2nd Tier Screening Conc. (ppm)	Estimated Exposure Dose (mg/kg/day)		Noncancer Screening Guideline (mg/kg/day)	Source	Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?	
					Child	Adult			Child	Adult
Inorganics										
Arsenic	Beets	0.0702	0.0702	0.07	1.1E-04	1.1E-04	0.0003	CMRL	No	No
Arsenic	Kale	0.0341	5.3428	3.0	4.8E-03	4.8E-03	0.0003	CMRL	Yes	Yes
Arsenic	Tomatoes	0.4371	3.6404	2.6	4.2E-03	4.2E-03	0.0003	CMRL	Yes	Yes
Arsenic	Unknown terrestrial plant	ND	ND	ND	ND	ND	0.0003	CMRL	ND	ND
Cadmium	Beets	0.6857	0.6857	0.69	1.1E-03	1.1E-03	0.0002	CMRL	Yes	Yes
Cadmium	Kale	0.2332	1.5643	1.0	1.7E-03	1.7E-03	0.0002	CMRL	Yes	Yes
Cadmium	Tomatoes	0.1084	2.7098	2.0	3.3E-03	3.3E-03	0.0002	CMRL	Yes	Yes
Cadmium	Unknown terrestrial plant	ND	ND	ND	ND	ND	0.0002	CMRL	ND	ND
Chromium	Beets	0.1446	0.5144	0.52	8.3E-04	8.3E-04	0.003	RfD	No	No
Chromium	Kale	0.061	24.446	16	2.6E-02	2.6E-02	0.003	RfD	Yes	Yes
Chromium	Tomatoes	0.0472	30.296	21	3.4E-02	3.4E-02	0.003	RfD	Yes	Yes
Chromium	Unknown terrestrial plant	0.3437	0.3437	0.34	5.5E-04	5.5E-04	0.003	RfD	No	No

Noncancer doses were calculated using the following formulas:

child dose = (second-tier screening concentration×0.0016 kg/kg/day×365 days/year×6 years)/(365 days/year×6 years))

adult dose = (second-tier screening concentration×0.0016 kg/kg/day×365 days/year×30 years)/(365 days/year×30 years))

The second-tier screening concentrations are rounded.

CMRL = chronic minimal risk level (ATSDR)

conc. = concentration

mg/kg/day = milligram per kilogram per day

ND = not detected

ppm = parts per million

RfD = reference dose (EPA)

Table 32. Estimated Exposure Doses for Chemicals in Vegetation Collected Off Site Compared to Cancer Screening Guidelines

Substance Name	*Species*	*2nd Tier Screening Conc. (ppm)*	*Estimated Exposure Dose (mg/kg/day)*	*EPA's Oral Cancer Slope Factor $(mg/kg/day)^{-1}$*	*Risk*	*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*
Inorganics						
Arsenic	Beets	0.07	4.8E-05	1.5	7.2E-05	No
Arsenic	Kale	3	2.1E-03	1.5	3.1E-03	Yes
Arsenic	Tomatoes	2.6	1.8E-03	1.5	2.7E-03	Yes
Arsenic	Unknown terrestrial plant	ND	ND	1.5	ND	No
Cadmium	Beets	0.69	*Evaluated for noncarcinogenic effects (see Table 31)*			
Cadmium	Kale	1	*Evaluated for noncarcinogenic effects (see Table 31)*			
Cadmium	Tomatoes	2	*Evaluated for noncarcinogenic effects (see Table 31)*			
Cadmium	Unknown terrestrial plant	ND	ND	NA	ND	No
Chromium	Beets	0.52	*Evaluated for noncarcinogenic effects (see Table 31)*			
Chromium	Kale	16	*Evaluated for noncarcinogenic effects (see Table 31)*			
Chromium	Tomatoes	21	*Evaluated for noncarcinogenic effects (see Table 31)*			
Chromium	Unknown terrestrial plant	0.34	*Evaluated for noncarcinogenic effects (see Table 31)*			

Cancer doses were calculated using the following formula:
dose = (second-tier screening concentration×0.0016 kg/kg/day×365 days/year×30 years)/(365 days/year×70 years))
Risk was calculated by multiplying the cancer dose by EPA's oral cancer slope factor.
The second-tier screening concentrations are rounded.
mg/kg/day = milligram per kilogram per day
NA = not available
ND = not detected
ppm = parts per million

Table 33. Chemicals Detected at Air Monitoring Stations

Substance Name	*Minimum ($\mu g/m^3$)*	*Maximum ($\mu g/m^3$)*	*Average ($\mu g/m^3$)*	*2nd Tier Screening Conc. ($\mu g/m^3$)*	*Number of Times Detected*	*Sample Total*	*Percent Detected*	*Comparison Value ($\mu g/m^3$)*	*Source*	*Maximum Above CV?*	*2nd Tier Screening Conc. Above CV?*	*Number of Times Above CV*
Inorganics												
Arsenic	0.000001	0.00685	0.00056	0.00134	132	224	59%	0.0002	CREG	Yes	Yes	98
Beryllium	0.00001	0.00002	0.00001	0.00001	5	219	2%	0.0004	CREG	No	No	0
Cadmium	0.00004	0.00376	0.00065	0.00129	241	241	100%	0.0006	CREG	Yes	Yes	88
Chromium	0.00000	0.04560	0.00128	0.00565	179	219	82%	0.00008	CREG (CrVI)	Yes	Yes	161
Lead	0.00001	0.00888	0.00347	0.00535	242	243	100%	1.5	NAAQS	No	No	0

There are discrepancies between OREIS and DOE's annual reports for some of the air monitoring data. The highest values were used in this evaluation.
conc. = concentration
CREG = cancer risk evaluation guide
CrVI = chromium VI
CV = comparison value
$\mu g/m^3$ = micrograms per cubic meter
NAAQS = National Ambient Air Quality Standard

Table 34. Chemicals Detected in the Soil in the Scarboro Community

Substance Name	Minimum (ppm)	Maximum (ppm)	Average (ppm)	Number of Times Detected	Sample Total	Comparison Value (ppm)	Source	Maximum Above CV?
Inorganics								
Aluminum	8,530	32,900	17,000	13	16	100,000	IEMEG	No
Antimony	0.0383	0.113	0.076	6	16	20	RMEG	No
Arsenic	1	6.39	4.0	13	16	0.5	CREG	Yes
Barium	36.6	206	95	13	16	4,000	RMEG	No
Beryllium	0.509	1.35	0.80	13	16	100	CEMEG	No
Cadmium	0.0702	0.57	0.38	13	16	10	CEMEG	No
Chromium	13.8	26.6	20	13	16	200	RMEG (CrVI)	No
Cobalt	4.7	60	14	13	16	500	IEMEG	No
Copper	13.3	44.3	22	13	16	2,000	IEMEG	No
Iron	14,900	29,700	21,000	13	16	23,000	Residential RBC	Yes
Lead	5.3	130	45	13	16	400	Soil Screening Level	No
Manganese	122	1,930	760	13	16	3,000	RMEG	No
Nickel	9.42	60.9	16	13	16	1,000	IEMEG	No
Selenium	1.46	1.87	1.7	3	16	300	CEMEG	No
Silver	0.39	0.39	0.39	2	16	300	RMEG	No
Thallium	0.287	0.377	0.34	6	16	5.5	Residential RBC	No
Vanadium	17.7	35.6	26	13	16	200	IEMEG	No
Zinc	24.8	153	74	13	16	20,000	CEMEG	No
Organics								
Acetone	0.0098	0.0098	0.0098	1	16	5,000	RMEG	No
Benzoic acid	0.0824	0.123	0.017	4	24	200,000	RMEG	No
Bromoform	0.0019	0.0025	0.0022	4	16	90	CREG	No
cis-Chlordane	0.011	1.7	0.86	4	16	2	CREG (chlordane)	No
DDE, p,p'-	0.0017	0.0017	0.0017	2	16	2	CREG	No
DDT, p,p'-	0.002	0.002	0.002	2	16	2	CREG	No
Fluoranthene	0.074	0.0824	0.10	4	16	2,000	RMEG	No
gamma-Chlordane	0.012	2.8	1.4	4	16	2	CREG (chlordane)	Yes

Table 34. Chemicals Detected in the Soil in the Scarboro Community (continued)

Substance Name	Minimum (ppm)	Maximum (ppm)	Average (ppm)	Number of Times Detected	Sample Total	Comparison Value (ppm)	Source	Maximum Above CV?
Heptachlor	0.013	0.19	0.13	3	16	0.2	CREG	No
Heptachlor epoxide	0.011	0.97	0.65	3	16	0.08	CREG	Yes
Pyrene	0.068	0.068	0.068	1	16	2,000	RMEG	No

Essential nutrients (calcium, magnesium, potassium, and sodium) are not included in the table.
CEMEG = chronic environmental media evaluation guide
CrVI = chromium VI
CREG = cancer risk evaluation guide
CV = comparison value
IEMEG = intermediate environmental media evaluation guide
ppm = parts per million
RBC = risk-based concentration
RMEG = reference dose media evaluation guide

Table 35. Chemicals Detected in the Sediment in the Scarboro Community

Substance Name	Minimum (ppm)	Maximum (ppm)	Average (ppm)	Number of Times Detected	Sample Total	Comparison Value (ppm)	Source	Maximum Above CV?
Inorganics								
Aluminum	5,830	21,000	10,000	4	5	100,000	IEMEG	No
Antimony	0.0507	0.0949	0.073	2	5	20	RMEG	No
Arsenic	1.62	5.17	3.7	4	5	0.5	CREG	Yes
Barium	76.4	91.4	81	4	5	4,000	RMEG	No
Beryllium	0.576	0.977	0.75	4	5	100	CEMEG	No
Cadmium	0.124	0.29	0.22	4	5	10	CEMEG	No
Chromium	14.3	26.6	20.6	4	5	200	RMEG (CrVI)	No
Cobalt	7.91	15	9.8	4	5	500	IEMEG	No
Copper	7.29	17.4	10	4	5	2,000	IEMEG	No
Iron	12,500	23,900	20,700	4	5	23,000	Residential RBC	Yes
Lead	9	101	32.5	4	5	400	Soil Screening Level	No
Manganese	542	680	590	4	5	3,000	RMEG	No
Nickel	9.3	16.1	11	4	5	1,000	IEMEG	No
Selenium	0.936	1.13	1.03	2	5	300	CEMEG	No
Thallium	0.23	0.31	0.27	2	5	5.5	Residential RBC	No
Vanadium	15.7	33	23	4	5	200	IEMEG	No
Zinc	51.7	94	74	4	5	20,000	CEMEG	No
Organics								
Benzoic acid	0.206	0.206	0.206	1	8	200,000	RMEG	No
Bromoform	0.0022	0.0022	0.0022	1	5	90	CREG	No
cis-Chlordane	0.0005	0.002	0.0015	3	5	2	CREG (chlordane)	No
Di-n-butyl phthalate	0.54	0.54	0.54	1	5	5,000	RMEG	No
gamma-Chlordane	0.00075	0.0017	0.0014	3	5	2	CREG (chlordane)	No

Essential nutrients (calcium, magnesium, potassium, and sodium) are not included in the table.
CEMEG = chronic environmental media evaluation guide
CREG = cancer risk evaluation guide
CrVI = chromium VI
CV = comparison value
IEMEG = intermediate environmental media evaluation guide
ppm = parts per million
RBC = risk-based concentration
RMEG = reference dose media evaluation guide

Table 36. Chemicals Detected in the Surface Water in the Scarboro Community

Substance Name	Minimum (ppb)	Maximum (ppb)	Average (ppb)	Number of Times Detected	Sample Total	Comparison Value (ppb)	Source	Maximum Above CV?
Inorganics								
Aluminum	261	1,640	798	4	5	20,000	IEMEG	No
Antimony	0.21	0.21	0.21	1	5	4	RMEG	No
Arsenic	0.83	0.88	0.86	2	5	0.023	CREG	Yes
Barium	17.6	106	68	4	5	700	RMEG	No
Beryllium	0.06	0.06	0.06	2	5	20	CEMEG	No
Chromium	2.36	2.56	2.46	2	5	100	LTHA	No
Cobalt	0.36	0.96	0.8	4	5	100	IEMEG	No
Copper	1.83	3.16	2.5	2	5	300	IEMEG	No
Iron	565	1,160	765	4	5	10,950	RBC	No
Lead	0.48	1.06	0.77	2	5	0	MCLG	Yes
Manganese	39.4	292	170	4	5	500	RMEG	No
Nickel	1.87	2.73	2.3	2	5	100	LTHA	No
Selenium	2.04	2.04	2.04	1	5	50	CEMEG	No
Silver	0.105	0.14	0.12	2	5	50	RMEG	No
Vanadium	1.87	2.48	2.2	2	5	30	IEMEG	No
Zinc	3.93	12.4	8.2	2	5	3,000	CEMEG	No
Organics								
Butyl benzyl phthalate	15.8	15.8	15.8	1	5	2,000	RMEG	No
Di-n-butyl phthalate	11.7	31.4	21.5	2	9	1,000	RMEG	No
Toluene	5	5	5	1	5	200	IEMEG	No

Essential nutrients (calcium, magnesium, potassium, and sodium) are not included in the table.
CEMEG = chronic environmental media evaluation guide for drinking water
CREG = cancer risk evaluation guide for drinking water
CV = comparison value
IEMEG = intermediate environmental media evaluation guide for drinking water
LTHA = lifetime health advisory for drinking water
MCLG = maximum contaminant level goal for drinking water
ppb = parts per billion
RBC = risk-based concentration for tap water
RMEG = reference dose media evaluation guide

Table 37. Estimated Exposure Doses for Chemicals in Scarboro Compared to Noncancer Screening Guidelines

Substance Name	*Maximum Concentration (ppm)*	*2nd Tier Screening Conc. (ppm)*	*Estimated Exposure Dose (mg/kg/day)*			*Acute Screening Guideline (mg/kg/day)*	*Source*	*Chronic Screening Guideline (mg/k/day)*	*Source*	*Does the Estimated Exposure Dose Exceed the Noncancer Screening Guideline?*		
			Pica	*Child*	*Adult*					*Pica*	*Child*	*Adult*
Surface Soil												
Arsenic	6.39	6.03	4.6E-04	7.4E-05	3.4E-06	0.005	AMRL	0.0003	CMRL	No	No	No
gamma-Chlordane	2.8	3.01	2.0E-04	3.7E-05	1.7E-06	0.001	Acute MRL (chlordane)	0.0006	CMRL	No	No	No
Heptachlor epoxide	0.97	1.20	6.9E-05	1.5E-05	6.9E-07	0.008	Tox profile*	0.000013	RfD	No	Yes	No
Iron	29,700	25,600	149 mg/day	3.1E-01	1.5E-02	10 mg/day	DRI	0.3	RfD	Yes	Yes	No
Sediment												
Arsenic	5.17	5.25	NA	1.3E-06	2.5E-07	NA	NA	0.0003	CMRL	NA	No	No
Iron	23,900	26,200	NA	6.6E-03	1.2E-03	NA	NA	0.3	RfD	NA	No	No
Surface Water												
Arsenic	0.88	0.0009	NA	1.1E-06	2.1E-07	NA	NA	0.0003	CMRL	NA	No	No
Lead	1,160	0.0012	NA	1.5E-06	2.8E-07	NA	NA	0.02	Acute LOAEL	NA	No	No

Soil doses were calculated using the following formulas:
pica dose = (maximum concentration×0.005 kg/day×52 days/year×3 years)/(10 kg×(365 days/year×3 years))
child dose = (second-tier screening concentration×0.0002 kg/day×291.2 days/year×6 years)/(13 kg×(365 days/year×6 years))
adult dose = (second-tier screening concentration×0.00005 kg/day×291.2 days/year×30 years)/(70 kg×(365 days/year×30 years))
Sediment doses were calculated using the following formulas:
child dose = (second-tier screening concentration×0.0001 kg/day×12 days/year×6 years)/(13 kg×(365 days/year×6 years))
adult dose = (second-tier screening concentration×0.0001 kg/day×12 days/year×30 years)/(70 kg×(365 days/year×30 years))
Surface water doses were calculated using the following formulas:
child dose = (second-tier screening concentration×0.5 L/day×12 days/year×6 years)/(13 kg×(365 days/year×6 years))
adult dose = (second-tier screening concentration×0.5 L/day×12 days/year×30 years)/(70 kg×(365 days/year×30 years))
* The acute screening guideline was derived from limited acute toxicological data available in ATSDR's toxicological profile. A safety factor of 1,000 was applied. These acute screening guidelines should be considered unofficial and are for use in this health assessment only.

AMRL = acute minimal risk level
CMRL = chronic minimal risk level
conc. = concentration
DRI = dietary reference intake
LOAEL = lowest-observed-adverse-effect level
mg/kg/day = milligram per kilogram per day
NA = not applicable
ppm = parts per million
RfD = reference dose

Table 38. Estimated Exposure Doses for Chemicals in Scarboro Compared to Cancer Screening Guidelines

Substance Name	*2nd Tier Screening Concentration (ppm)*	*Estimated Lifetime Exposure Dose (mg/kg/day)*	*EPA's Oral Cancer Slope Factor $(mg/kg/day)^{-1}$*	*Risk*	*Does the Estimated Exposure Dose Exceed the Cancer Screening Guideline (10^{-4})?*
Surface Soil					
Arsenic	6.03	1.5E-06	1.5	2.2E-06	No
gamma-Chlordane	3.01	7.4E-07	0.35	2.6E-07	No
Heptachlor epoxide	1.20	2.9E-07	9.1	2.7E-06	No
Iron	25,600	*Evaluated for noncarcinogenic effects (see* Table 37*)*			
Sediment					
Arsenic	5.25	1.1E-07	1.5	1.6E-07	No
Iron	26,200	*Evaluated for noncarcinogenic effects (see* Table 37*)*			
Surface Water					
Arsenic	0.0009	9.0E-08	1.5	1.3E-07	No
Lead	0.0012	*Evaluated for noncarcinogenic effects (see* Table 37*)*			

Soil doses were calculated using the following formula:

lifetime dose = (second-tier screening concentration×0.00005 kg/day×291.2 days/year×70 years)/(70 kg×(365 days/year×70 years))

Sediment doses were calculated using the following formula:

lifetime dose = (second-tier screening concentration×0.0001 kg/day×12 days/year×70 years)/(70 kg×(365 days/year×70 years))

Surface water doses were calculated using the following formula:

lifetime dose = (second-tier screening concentration×0.5 L/day×12 days/year×70 years)/(70 kg×(365 days/year×70 years))

Risk was calculated by multiplying the exposure dose by EPA's oral cancer slope factor.

mg/kg/day = milligram per kilogram per day

ppm = parts per million

APPENDICES

Appendix A. ATSDR Glossary of Environmental Health Terms

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

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-800-CDC-INFO (1-800-232-4636).

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].

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

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, ambient air).

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

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

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.

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

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 risk evaluation guide (CREG)
Estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (10^{-6}) persons exposed over a 70-year life span. ATSDR's CREGs are calculated from EPA's cancer potency factors.

Cancer slope factor (CSF)
An estimate of possible increases in cancer cases in a population. The relative potency of carcinogens is calculated by multiplying estimated chronic-exposure doses (defined in this document as a 30-year exposure averaged over 70 years) by EPA's CSFs.

Carcinogen
A substance that causes cancer.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure].

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 [compare with screening guideline].

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)
CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances. This law was later amended by the Superfund Amendments and Reauthorization Act (SARA).

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

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

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

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

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

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

Environmental media evaluation guide (EMEG)
A media-specific comparison value that is used to select contaminants of concern. Levels below the EMEG are not expected to cause adverse noncarcinogenic health effects.

EPA
United States Environmental Protection Agency.

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

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

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

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

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

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

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

Half-life (t½)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25 percent of the original number of radioactive atoms remain.

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.

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

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

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

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

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.

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

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

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

Migration
Moving from one location to another.

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

Mortality
Death. Usually the cause (a specific disease, a condition, or an injury) is stated.

MRL [see minimal risk level]

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.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

Noncancer
Used in this document to mean health end points other than cancer, such as developmental, reproductive, immunological, and other systemic effects.

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

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

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

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

ppb
Parts per billion.

ppm
Parts per million.

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

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

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

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

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

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

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

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

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

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

Radionuclide
Any radioactive isotope (form) of any element.

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

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.

Reference dose media evaluation guide (RMEG)
Lifetime exposure level at which adverse, noncarcinogenic health effects would not be expected to occur.

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

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

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

RfD [see reference dose]

Risk
The probability that something will cause injury or harm.

Risk-based concentration (RBC)
A contaminant concentration that is not expected to cause adverse health effects over long-term exposure.

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

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

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

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

Screening Guideline
Used in this document as noncancer and cancer health guideline values (e.g., minimal risk levels, reference doses, and cancer slope factors) that are compared to calculated exposure doses [see minimal risk level, reference dose, and cancer slope factor]. Estimated exposure doses that are less than screening guideline values are not a public health hazard [compare with comparison value].

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

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

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

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

Substance
A chemical.

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

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

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

Surveillance [see public health surveillance]

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

TEF/TEQ
The toxic equivalency factor (TEF) approach compares the relative potency of individual congeners with that of tetrachlorodibenzo-p-dioxin (TCDD), the best-studied member of this chemical class. The concentration or dose of each dioxin-like congener is multiplied by its TEF to arrive at a toxic equivalent (TEQ), and the TEQs are added to give the total toxic equivalency. The total toxic equivalency is then compared to reference exposure levels for TCDD expected to be without significant risk for producing health hazards.

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

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

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

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

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

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

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/ocepaterms/)
National Library of Medicine (NIH) (http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)

Appendix B

Off-Site Chemicals Without Comparison Values

Table B-1. Chemicals Detected in Off-Site Soil

Substance Name	Average Concentration (ppm)	Highest Dose (mg/kg/day)	Surrogate Screening Guideline	Surrogate Screening Guideline Source	Does the Dose/ Concentration Exceed the Screening Guideline?
Inorganics					
Thorium	28	3.4E-04	0.6–18 ppm	ATSDR/NCRP	Yes
Organics					
4-Aminobiphenyl	3.4	3.4E-04	5 ppm	FDA 21CFR74	No
1-Bromo-4-phenoxy benzene	1.2	4.2E-05	10 ppm	ATSDR-benzene	No
bis(2-Chloroethoxy)methane	1.2	1.5E-05	100 ppm	PADEP	No
P-Chloro-m-cresol	0.51	1.5E-05	1,000 ppm	Anbesol Teething Gel	No
alpha-Chloronaphthalene	4.1	6.3E-06	8.0E-02 mg/kg/day	EPA RfD for beta-chloronaphthalene	No
4-Chlorophenyl phenyl ether	1.1	5.0E-05	0.8 ppm	TCEQ-TRRP for soil	Yes
Dibenz(a,j)acridine	4.1	1.4E-05	1.4E-04 mg/kg/day	Calculated from CalEPA TEF and EPA oral slope factor (benzo(a)pyrene)	No
p(Dimethylamino)azobenzene	4.1	5.0E-05	2.2E-05 mg/kg/day	Calculated from CalEPA oral unit risk factor	Yes
7,12-Dimethylbenz(a)anthracene	4.1	5.0E-05	4.0E-07 mg/kg/day	Calculated from CalEPA oral unit risk factor	Yes
Endosulfan sulfate	0.022	5.0E-05	100 ppm	CEMEG (endosulfan)	No
Endrin ketone	0.022	2.7E-07	20 ppm	CEMEG (endrin)	No
Ethyl methanesulfonate	4.1	2.7E-07	100 ppm	PADEP	No
2-Fluorophenol	1.4	5.0E-05	1.6 ppm	TCEQ-TRRP for soil as 2-chlorophenol	No
Methyl methanesulfonate	4.1	1.7E-05	100 ppm	PADEP as ethyl methanesulfonate	No
3-Methylcholanthrene	4.1	5.0E-05	4.5E-06 mg/kg/day	Calculated from CalEPA oral unit risk factor	Yes
beta-Naphthylamine	6.9	5.0E-05	2.7 ppm	TCEQ—media-specific concentration residential soil	Yes

The average concentrations are rounded. Averages were calculated using detected concentrations only and do not take into account nondetected values.

Highest doses were calculated using the following formula:

child dose = (average concentration×0.0002 kg/day×291.2 days/year×6 years)/(13 kg×(365 days/year×6 years))

CalEPA = California Environmental Protection Agency
CEMEG = chronic environmental media evaluation guide
EPA = U.S. Environmental Protection Agency
FDA = U.S. Food and Drug Administration
mg/kg/day = milligram per kilogram per day
NCRP = National Council on Radiation Protection and Measurements
PADEP = Pennsylvania Department of Environmental Protection
TCEQ = Texas Commission on Environmental Quality
TRRP = Texas Risk Reduction Program
PHA = public health assessment
ppm = parts per million
RfD = reference dose
TEF = toxic equivalency factor
URF = unit risk factors

Table B-2. Chemicals Detected in Off-Site Sediment

Substance Name	Average Concentration (ppm)	Highest Dose (mg/kg/day)	Surrogate Screening Guideline	Surrogate Screening Guideline Source	Does the Dose/ Concentration Exceed the Screening Guideline?
Inorganics					
Phosphate	406	1.0E-04	FDA—generally recognized as safe		No
Silicon	410	1.0E-04	Biologically inert		No
Thorium	54	1.4E-05	0.6–18 ppm	ATSDR/NCRP	Yes
Organics					
Acetic acid	0.011	2.8E-09	40,000–80,000 ppm	Vinegar	No
1-Bromo-4-phenoxy benzene	0.77	1.9E-07	0.28 ppm	TCEQ—TRRP as bromophenyl phenylether, -4	Yes
Bis(2-chloroethoxy) methane	0.77	1.9E-07	100 ppm	PADEP	No
Carbon-14	19,000	4.8E-03	ATSDR—radiation dose screening PHA		
Chlorine atom	18,000	4.6E-03	32 ppm	TCEQ—TRRP for soil	Yes
p-Chloro-m-cresol	0.77	1.9E-07	20 ppm	ATSDR—EMEG 4-chlorophenol	No
4-Chlorophenyl phenyl ether	0.77	1.9E-07	0.8 ppm	TCEQ—TRRP for soil	No
Cyclotetrasiloxane	0.027	6.8E-09	NJ value	Data QA/QC	No—presumptive evidence/ estimated value
Dodacane	0.0074	1.9E-09	NJ value	Data QA/QC	No—presumptive evidence/ estimated value
Endosulfan sulfate	0.45	1.1E-07	100 ppm	CEMEG (endosulfan)	No
Endrin ketone	0.46	1.2E-07	20 ppm	CEMEG (endrin)	No
Hydrocarbon	13	3.3E-06	880 ppm	NM TPH screening guidelines	No
Nitrogen, kjeldahl	1,600	4.0E-04	20,000 ppm	EMEG (ammonia)	No
Total combustible organics	198,000	5.0E-02	10 ppm	EMEG (benzene)	Yes
Total petroleum hydrocarbons	150	3.8E-05	880 ppm	NM TPH screening guidelines	No

The average concentrations are rounded. Averages were calculated using detected concentrations only and do not take into account nondetected values.

Highest doses were calculated using the following formula:

child dose = (average concentration×0.0001 kg/day×12 days/year×6 years)/(13 kg×(365 days/year×6 years))

CEMEG = chronic environmental media evaluation guide
EMEG = environmental media evaluation guide
FDA = U.S. Food and Drug Administration
mg/kg/day = milligram per kilogram per day
NCRP = National Council on Radiation Protection and Measurements
PADEP = Pennsylvania Department of Environmental Protection
TCEQ = Texas Commission on Environmental Quality
NM = New Mexico
PHA = public health assessment
ppm = parts per million
QA/QC = quality assurance/quality control
TPH = total petroleum hydrocarbons
TRRP = Texas Risk Reduction Program

Table B-3. Chemicals Detected in Off-Site Surface Water

Substance Name	*Average Concentration (ppb)*	*Highest Dose (mg/kg/day)*	*Surrogate Screening Guideline*	*Surrogate Screening Guideline Source*	*Does the Dose/ Concentration Exceed the Screening Guideline?*
Inorganics					
Bicarbonate, dissolved	180,000	2.3E-01	500,000 ppb	Alkalinity EPA—SMCL	No
Cesium	0.61	7.7E-07	1 ppb	ATSDR background	No
Chloride	119,000	5.1E-01	250,000 ppb	EPA—SMCL	No
Silicon	2,100	2.7E-03	Biologically inert		No
Sulfate	625,000	3.1E+00	250,000 ppb	EPA—SMCL	No
Sulfide	4,000	5.1E-03	500 ppb	Rotten egg odor in water	Yes, as hydrogen sulfide
Sulfur	8,200	1.0E-02	250,000 ppb	EPA—SMCL as sulfate	No
Organics					
bis(2-Chloroethoxy)methane*	10	1.3E-05	5 ppb	NYSDEC groundwater quality standard	Yes
Bromide*	59	1.8E-04	300,000 ppb	Secondary MCL for chloride	No
1-Bromo-4-phenoxy benzene*	10	1.3E-05	5 ppb	Benzene MCL	Yes
4-Chlorophenyl phenyl ether*	10	1.3E-05	0.061 ppb	TCEQ TRRP residential ground water (2 liters/day)	Yes
Orthophosphate*	287	4.0E-04	Food grade chemical—added to drinking water to reduce lead leaching FDA—generally recognized as safe		No
p-Chloro-m-cresol*	10	1.3E-05	1 ppb	NYSDEC groundwater quality standard	Yes
Thorium*	0.87	1.1E-06	ATSDR—Radiation Dose Screening PHA		
Tetraoxo-sulfate(1-)	21,000	2.7E-02	250,000 ppb	EPA—SMCL as sulfate	No
Total petroleum hydrocarbons	1,050	1.3E-03	1,400 ppb	New Mexico TPH screening guidelines	No

*Chemical was detected in less than 10% of the samples. The average concentration was estimated using 1/2 the detection limit for nondetected samples.

The average concentrations are rounded. Unless otherwise noted, averages were calculated using detected concentrations only and do not take into account nondetected values.

Highest doses were calculated using the following formula:

child dose = ((average concentration/1,000)×0.5 liters/day×12 days/year×6 years)/(13 kg×(365 days/year×6 years))

EPA = U.S. Environmental Protection Agency
FDA = U.S. Food and Drug Administration
MCL = maximum contaminant level
mg/kg/day = milligram per kilogram per day
NYSDEC = New York State Department of Environmental Conservation
ppb = parts per billion
SMCL = secondary maximum contaminant level
TCEQ = Texas Commission on Environmental Quality
TPH = total petroleum hydrocarbons
TRRP = Texas Risk Reduction Program

Table B-4. Chemicals Detected in Fish Collected Off-Site

Substance Name	*Location*	*Average Concentration (ppm)*	*Highest Dose (mg/kg/day)*	*Surrogate Screening Guideline*	*Surrogate Screening Guideline Source*	*Does the Dose/ Concentration Exceed the Screening Guideline?*
Inorganics						
Lead	Clinch River	0.44	6.8E-04	2.0 ppm	FDA 21CFR173	No
	WBR	0.32	4.9E-04	2.0 ppm	FDA 21CFR173	No
Organics						
Endosulfan sulfate	Clinch River	0.075	1.2E-04	8.1 ppm	RBC (endosulfan)	No
Endrin ketone	Clinch River	0.079	1.2E-04	0.41 ppm	RBC (endrin)	No
	WBR	0.066	1.0E-04			No
Endrin aldehyde	Clinch River	0.011	1.7E-05	0.41 ppm	RBC (endrin)	No
	WBR	0.021	3.2E-05			No
2,2',3,4',5',6-Hexachloro-1,1'-biphenyl	Clinch River	0.031	4.8E-05	2.0E-05 mg/kg/day	CMRL (Aroclor 1254)	Yes for noncancer (No for cancer)
	WBR	0.019	2.9E-05			Yes for noncancer (No for cancer)
3,3',4,4',5,5'-Hexachloro-1,1'-biphenyl	WBR	0.01	1.5E-05	2.0E-05 mg/kg/day	CMRL (Aroclor 1254)	No for cancer and noncancer
Nonachlor, cis-	Clinch River	0.027	4.2E-05	0.0006 mg/kg/day	CMRL (chlordane)	No
	WBR	0.017	2.6E-05			No
Nonachlor, trans-	Clinch River	0.047	7.2E-05	0.0006 mg/kg/day	CMRL (chlordane)	No
	WBR	0.033	5.1E-05			No
Nonachlor, trans-	Clinch River	0.006	9.2E-06	0.0006 mg/kg/day	CMRL (chlordane)	No
	WBR	0.0092	1.4E-05			No

The average concentrations are rounded. Averages were calculated using detected concentrations only and do not take into account nondetected values.

Highest doses were calculated using the following formula:

subsistence child dose = (average concentration×0.02 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

CMRL = chronic minimal risk level
FDA = U.S. Food and Drug Administration
mg/kg/day = milligram per kilogram per day
PCB = polychlorinated biphenyl
ppm = parts per million
RBC = risk-based concentration
WBR = Watts Bar Reservoir

Table B-5. Chemicals Detected in Off-Site Game

Substance Name	*Average Concentration (ppm)*	*Highest Dose (mg/kg/day)*	*Surrogate Screening Guideline*	*Surrogate Screening Guideline Source*	*Does the Dose/Concentration Exceed the Screening Guideline?*
Organics					
Nonachlor, cis	0.0055	4.2E-07	0.0006 mg/kg/day	CMRL (chlordane)	No
Nonachlor, trans	0.0051	3.9E-07	0.0006 mg/kg/day	CMRL (chlordane)	No

The average concentrations are rounded. Averages were calculated using detected concentrations only and do not take into account nondetected values.

Highest doses were calculated using the following formula:

child dose = (average concentration×0.001 kg/day×365 days/year×6 years)/(13 kg×(365 days/year×6 years))

CMRL = chronic minimal risk level

mg/kg/day = milligram per kilogram per day

ppm = parts per million

Screening guidelines are available for all chemicals detected in vegetation and air.

Table B-6. Chemicals Detected in Scarboro

Substance Name	Average Concentration (ppm)	Highest Dose (mg/kg/day)	Surrogate Screening Guideline	Surrogate Screening Guideline Source	Does the Dose/Concentration Exceed the screening Guideline?
Soil					
Acetic acid	0.012	1.4E-07	40,000–80,000 ppm	Vinegar	No
alpha-Pinene	0.045	5.5E-07	37.5 mg/kg/day lowest NOAEL	EPA: Federal Register [FR Doc. 98-31063] (11/19/1998)	No
Benzene ethanamine	0.0088	1.1E-07	0.1 mg/kg/day	FDA—amphetamine pediatric dose of 10 mg/tablet	No
Cyclotetrasiloxane	0.043	5.3E-07	NJ value	Data QA/QC	No—presumptive evidence/estimated value
Sediment					
Acetic acid	0.011	2.7E-09	40,000–80,000 ppm	Vinegar	No
Cyclotetrasiloxane	0.027	6.9E-09	NJ value	Data QA/QC	No—presumptive evidence/estimated value
Dodacane	0.0074	1.9E-09	NJ value	Data QA/QC	No—presumptive evidence/estimated value

The average concentrations are rounded. Averages were calculated using detected concentrations only and do not take into account nondetected values.

Highest soil doses were calculated using the following formula:

non-pica child dose = (average concentration×0.0002 kg/day×291.2 days/year×6 years)/(13 kg×(365 days/year×6 years))

Highest sediment doses were calculated using the following formula:

child dose = (average concentration×0.0001 kg/day×12 days/year×6 years)/(13 kg×(365 days/year×6 years))

mg/kg/day = milligram per kilogram per day

ppm = parts per million

APPENDIX C

Summary Briefs

ORRHES Brief
Oak Ridge Reservation Health Effects Subcommittee

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Dose Reconstruction Feasibility Study
Oak Ridge Health Study Phase I Report

Site: Oak Ridge Reservation
Study area: Oak Ridge Area
Time period: 1942–1992
Conducted by: Tennessee Department of Health and the Oak Ridge Health Agreement Steering Panel

Purpose

The Dose Reconstruction Feasibility Study had two purposes: first, to identify past chemical and radionuclide releases from the Oak Ridge Reservation (ORR) that have the highest potential to impact the health of the people living near the ORR; and second, to determine whether sufficient information existed about these releases to estimate the exposure doses received by people living near the ORR.

Background

In July 1991, the Tennessee Department of Health initiated a Health Studies Agreement with the U.S. Department of Energy (DOE). This agreement provides funding for an independent state evaluation of adverse health effects that may have occurred in populations around the ORR. The Oak Ridge Health Agreement Steering Panel (ORHASP) was established to direct and oversee this state evaluation (hereafter called the Oak Ridge Health Studies) and to facilitate interaction and cooperation with the community. ORHASP was an independent panel of local citizens and nationally recognized scientists who provided direction, recommendations, and oversight for the Oak Ridge Health Studies. These health studies focused on the potential effects from off-site exposures to chemicals and radionuclides released at the reservation since 1942. The state conducted the Oak Ridge Health Studies in two phases. Phase 1 is the Dose Reconstruction Feasibility Study described in this summary.

Methods

The Dose Reconstruction Feasibility Study consisted of seven tasks. During Task 1, state investigators identified historical operations at the ORR that used and released chemicals and radionuclides. This involved interviewing both active and retired DOE staff members about past operations, as well as reviewing historical documents (such as purchase orders, laboratory records, and published operational reports). Task 1 documented past activities at each major facility, including routine operations, waste management practices, special projects, and accidents and incidents. Investigators then prioritized these activities for further study based on the likelihood that releases from these activities could have resulted in off-site exposures.

During Task 2, state investigators inventoried the available environmental sampling and research data that could be used to estimate the doses that local populations may have received from chemical and radionuclide releases from the ORR. These data, obtained from DOE and other federal and state agencies (such as the U.S. Environmental Protection Agency, Tennessee Valley

Authority, and the Tennessee Division of Radiological Health), were summarized by environmental media (such as surface water, sediment, air, drinking water, groundwater, and food items). As part of this task, investigators developed abstracts which summarize approximately 100 environmental monitoring and research projects that characterize the historical presence of contaminants in areas outside the ORR.

Based on the results of Tasks 1 and 2, investigators identified a number of historical facility processes and activities at ORR as having a high potential for releasing substantial quantities of contaminants to the off-site environment. These activities were recommended for further evaluation in Tasks 3 and 4.

Tasks 3 and 4 were designed to provide an initial, very rough evaluation of the large quantity of information and data identified in Tasks 1 and 2, and to determine the potential for the contaminant releases to impact the public's health. During Task 3, investigators sought to answer the question: How could contaminants released from the Oak Ridge Reservation have reached local populations? This involved identifying the exposure pathways that could have transported contaminants from the ORR site to residents.

Task 3 began with compiling a list of contaminants investigated during Task 1 and Task 2. These contaminants are listed in Table 1. The contaminants in the list were separated into four general groups: radionuclides, nonradioactive metals, acids/bases, and organic compounds. One of the first steps in Task 3 was to eliminate any chemicals on these lists that were judged unlikely to reach local populations in quantities that would pose a health concern. For example, acids and bases were not selected for further evaluation because these compounds rapidly dissociate in the environment and primarily cause acute health effects, such as irritation. Likewise, although chlorofluorocarbons (Freon) were used in significant quantities at each of the ORR facilities, they were judged unlikely to result in significant exposure because they also rapidly disassociate. Also, some other contaminants (see Table 2) were not selected for further evaluation because they were used in relatively small quantities or in processes that are not believed to be associated with significant releases. Investigators determined that only a portion of contaminants identified in Tasks 1 and 2 could have reached people in the Oak Ridge area and potentially impacted their health. These contaminants, listed in Table 3, were evaluated further in Tasks 3 and 4.

The next step in Task 3 was to determine, for each contaminant listed in Table 3, whether a complete exposure pathway existed. A complete exposure pathway means a plausible route by which the contaminant could have traveled from ORR to off-site populations. Only those contaminants with complete exposure pathways would have the potential to cause adverse health effects. In this feasibility study, an exposure pathway is considered complete if it has the following three elements:

- A source that released the contaminant into the environment;
- A transport medium (such as air, surface water, soil, or biota) or some combination of these media (e.g., air ➔ pasture ➔ livestock milk) that carried the contaminant off the site to a location where exposure could occur; and
- An exposure route (such as inhalation, ingestion, or—in the case of certain radionuclides that emit gamma or beta radiation—immersion) through which a person could come into contact with the contaminant.

In examining whether complete exposure pathways existed, investigators considered the characteristics of each contaminant and the environmental setting at the ORR. Contaminants that lacked a source, transport medium, or exposure route were eliminated from further consideration because they lacked a complete exposure pathway. Through this analysis, investigators identified a number of contaminants with complete exposure pathways.

During Task 4, investigators sought to determine qualitatively which of the contaminants with complete exposure pathways appeared to pose the greatest potential to impact off-site populations. They began by comparing the pathways for each contaminant individually. For each contaminant, they determined which pathway appeared to have the greatest potential for exposing off-site populations, and they compared the exposure potential of the contaminant's other pathways to its most significant pathway. They then divided contaminants into three categories—radionuclides, carcinogens, and noncarcinogens—and compared the contaminants within each category based on their exposure potential and on their potential to cause health effects. This analysis identified facilities, processes, contaminants, media, and exposure routes believed to have the greatest potential to impact off-site populations. The results are provided in Table 4.

The Task 4 analysis was intended to provide a preliminary framework to help focus and prioritize future quantitative studies of the potential health impacts of off-site contamination. These analyses are intended to provide an initial approach to studying an extremely complex site. However, care must be taken in attempting to make broad generalizations or draw conclusions about the potential health hazard posed by the releases from the ORR.

In Task 5, investigators described the historical locations and activities of populations most likely to have been affected by the releases identified in Task 4. During Task 6, investigators compiled a summary of the current toxicologic knowledge and hazardous properties of the key contaminants. Task 7 involved collecting, categorizing, summarizing, and indexing selected documents relevant to the feasibility study.

Study Group

A study group was not selected.

Exposures

Seven completed exposure pathways associated with air, six completed exposure pathways associated with surface water, and ten completed exposure pathways associated with soil/sediment were evaluated for radionuclides and chemical substances (metals, organic compounds, and polycyclic aromatic hydrocarbons) released at the ORR from 1942 to 1992.

Outcome Measures

No outcome measures were studied.

Conclusions

The feasibility study indicated that past releases of the following contaminants have the greatest potential to impact off-site populations.

- **Radioactive iodine**
  The largest identified releases of radioactive iodine were associated with radioactive lanthanum processing from 1944 through 1956 at the X-10 facility.

- **Radioactive cesium**
  The largest identified releases of radioactive cesium were associated with various chemical separation activities that took place from 1943 through the 1960s.

- **Mercury**
  The largest identified releases of mercury were associated with lithium separation and enrichment operations that were conducted at the Y-12 facility from 1955 through 1963.

- **Polychlorinated biphenyls**
  Concentrations of polychlorinated biphenyls (PCBs) found in fish taken from the East Fork Poplar Creek and the Clinch River have been high enough to warrant further study. These releases likely came from electrical transformers and machining operations at the K-25 and Y-12 plants.

State investigators determined that sufficient information was available to reconstruct past releases and potential off-site doses for these contaminants. The steering panel (ORHASP) recommended that dose reconstruction activities proceed for the releases of radioactive iodine, radioactive cesium, mercury, and PCBs. Specifically they recommended that the state should continue the tasks begun during the feasibility study, and should characterize the actual release history of these contaminants from the reservation; identify appropriate fate and transport models to predict historical off-site concentrations; and identify an exposure model to use in calculating doses to the exposed population.

The panel also recommended that a broader-based investigation of operations and contaminants be conducted to study the large number of ORR contaminants released that have lower potentials for off-site health effects, including the five contaminants (chromium VI; plutonium-239, -240, and -241; tritium; arsenic; and neptunium-237) that could not be qualitatively evaluated during Phase 1 due to a lack of available data. Such an investigation would help in modifying or reinforcing the recommendations for future health studies.

Additionally, the panel recommended that researchers explore opportunities to conduct epidemiologic studies investigating potential associations between exposure doses and adverse health effects in exposed populations.

TABLE 1
LIST OF CONTAMINANTS INVESTIGATED DURING TASK 1 AND TASK 2

X-10	K-25	Y-12
Radionuclides		
Americium-241 Argon-41 Barium-140 Berkelium Californium-252 Carbon-14 Cerium-144 Cesium-134,-137 Cobalt-57,-60 Curium-242,-243,-244 Einsteinium Europium-152,-154,-155 Fermium Iodine-129, -131, -133 Krypton-85 Lanthanum-140 Niobium-95 Phosphorus-32 Plutonium-238, -239, -240, -241 Protactinium-233 Ruthenium-103, -106 Selenium-75 Strontium-89, -90 Tritium Uranium-233,-234, -235, -238 Xenon-133 Zirconium-95	Neptunium-237 Plutonium-239 Technetium-99 Uranium-234, -235, -238	Neptunium-237 Plutonium-239, -239, -240, -241 Technetium-99 Thorium-232 Tritium Uranium-234, -235, -238
Nonradioactive Metals		
None initially identified	Beryllium Chromium (trivalent and hexavalent) Nickel	Arsenic Beryllium Chromium (trivalent and hexavalent) Lead Lithium Mercury
Acids/Bases		
Hydrochloric acid Hydrogen peroxide Nitric acid Sodium hydroxide Sulfuric acid	Acetic acid Chlorine trifluoride Fluorine and fluoride compounds Hydrofluoric acid Nitric acid Potassium hydroxide Sulfuric acid	Ammonium hydroxide Fluorine and various fluorides Hydrofluoric acid Nitric acid Phosgene
Organic Compounds		
None initially identified	Benzene Carbon tetrachloride Chloroform Chlorofluorocarbons (Freons) Methylene chloride Polychlorinated biphenyls 1,1,1-Trichloroethane Trichloroethylene	Carbon tetrachloride Chlorofluorocarbons (Freons) Methylene chloride Polychlorinated biphenyls Tetrachloroethylene 1,1,1-Trichloroethane Trichloroethylene

TABLE 2

CONTAMINANTS NOT WARRANTING FURTHER EVALUATION IN TASK 3 AND TASK 4

Radionuclides
Americium-241 Californium-252 Carbon-14 Cobalt-57 Cesium-134 Curium-242, -243, -244 Europium-152, -154, -155 Phosphorus-32 Selenium-75 Uranium-233 Berkelium Einsteinium Fermium
Nonradioactive Metals
Lithium
Organic Compounds
Benzene Chlorofluorocarbons (Freons) Chloroform
Acids/Bases
Acetic acid Ammonium hydroxide Chlorine trifluoride Fluorine and various fluoride compounds Hydrochloric acid Hydrogen peroxide Hydrofluoric acid Nitric acid Phosgene Potassium hydroxide Sulfuric acid Sodium hydroxide

TABLE 3

CONTAMINANTS FURTHER EVALUATED IN TASK 3 AND TASK 4

Radionuclides	Nonradioactive Metals	Organic Compounds
Argon-41 Barium-140 Cerium-144 Cesium-137 Cobalt-60 Iodine-129, -131, -133 Krypton-85 Lanthanum-140 Neptunium-237 Niobium-95 Plutonium-238, -239, -240, -241 Protactinium-233 Ruthenium-103, -106 Strontium-89, 90 Technetium-99 Thorium-232 Tritium Uranium-234 -235, -238 Xenon-133 Zirconium-95	Arsenic Beryllium Chromium (trivalent and hexavalent) Lead Mercury Nickel	Carbon tetrachloride Methylene chloride Polychlorinated biphenyls Tetrachloroethylene 1,1,1-Trichloroethane Trichloroethylene

TABLE 4

HIGHEST PRIORITY CONTAMINANTS, SOURCES, TRANSPORT MEDIA, AND EXPOSURE ROUTES

Contaminant	Source	Transport Medium	Exposure Route
Iodine-131, -133	X-10 Radioactive lanthanon (RaLa) processing (1944-1956)	Air to vegetable to dairy cattle milk	Ingestion
Cesium-137	X-10 Various chemical separation processes (1944-1960s)	Surface water to fish Soil/sediment Soil/sediment to vegetables; livestock/game (beef); dairy cattle milk	Ingestion Ingestion Ingestion
Mercury	Y-12 Lithium separation and enrichment operations (1955-1963)	Air Air to vegetables; Livestock/game (beef); dairy cattle milk Surface water to fish Soil/sediment to livestock/game (beef); vegetables	Inhalation Ingestion Ingestion Ingestion
Polychlorinated biphenyls	K-25 and Y-12 Transformers and machining	Surface water to fish	Ingestion

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

ORRHES Brief

Oak Ridge Reservation Health Effects Subcommittee

Screening-Level Evaluation of Additional Potential Materials of Concern, July 1999—Task 7

Site: Oak Ridge Reservation
Study area: Oak Ridge Area
Time period: 1942–1990
Conducted by: Tennessee Department of Health and the Oak Ridge Health Agreement Steering Panel

Purpose

The purpose of this screening-level evaluation was to determine whether additional contaminants that existed at Oak Ridge Reservation (ORR), other than the five already identified in the Oak Ridge Dose Reconstruction Feasibility Study (iodine, mercury, polychlorinated biphenyls [PCBs], radionuclides, and uranium), warrant further evaluation of their potential for causing health effects in off-site populations.

Background

In July 1991, the Tennessee Department of Health in cooperation with the U.S. Department of Energy initiated a Health Studies Agreement to evaluate the potential for exposures to chemical and radiological releases from past operations at ORR. The Oak Ridge Dose Reconstruction Feasibility Study was conducted from 1992 to 1993 to identify those operations and materials that warranted detailed evaluation based on the risks posed to off-site populations. The feasibility study recommended that dose reconstructions be conducted for radioactive iodine releases from X-10 radioactive lanthanum processing (Task 1), mercury releases from Y-12 lithium enrichment (Task 2), PCBs in the environment near Oak Ridge (Task 3), and radionuclides released from White Oak Creek to the Clinch River (Task 4). In addition, the study called for a systematic search of historical records (Task 5), an evaluation of the quality of historical uranium effluent monitoring data (Task 6), and additional screening of materials that could not be evaluated during the feasibility study (Task 7).

The Oak Ridge Health Agreement Steering Panel (ORRHES) was established to direct and oversee the Oak Ridge Health Studies and to facilitate interaction and cooperation with the community. This group is composed of local citizens and nationally recognized scientists.

Methods

During the Task 7 Screening-Level Evaluation, three different methods (qualitative screening, the threshold quantity approach, and quantitative screening) were used to evaluate the importance of materials with respect to their potential for causing off-site health effects. Twenty-five materials or groups of materials were evaluated. Please see Table 1 for a summary of the methods used to evaluate each material/group of materials.

- *Qualitative screening*—All materials used on ORR were qualitatively screened for quantities used, forms used, and/or manners of use. If it was unlikely that off-site releases were sufficient to pose an off-site health hazard, then these materials were not evaluated quantitatively. If off-site exposures were likely to have occurred at harmful levels, then the materials were evaluated quantitatively.

- *Threshold quantity approach*—When information was insufficient to conduct quantitative screening, inventories of materials used at ORR were estimated based on historical records and interviews of workers. These estimated inventories of materials were determined to be either above or below a conservatively calculated health-based threshold quantity. If the estimates for a material were below the calculated threshold quantity, then it was determined to be highly unlikely to have posed a risk to human health through off-site releases.

- *Quantitative screening*—The quantitative screening used a two-level screening approach to identify those materials that could produce health risks (i.e., doses) to exposed people that are clearly below minimum levels of health concern (Level I Screen) and above minimum levels of health concern (Refined Level I Screen). Health-based decision guides were established by the Oak Ridge Health Agreement Steering Panel and represent minimum levels of health concern.

  — The Level I Screening calculates a screening index for a maximally exposed reference individual who would have received the highest exposure. This conservative (protective) screening index is not expected to underestimate exposure to any real person in the population of interest. If the estimated Level I screening index was below the ORRHES decision guide, then the hazard to essentially all members of the population, including the maximally exposed individual, would be below the minimum level of health concern. In addition, the Level I screening index would be so low that further detailed study of exposures is not warranted because the screening index is below the threshold for consideration of more extensive health effects studies. However, if during the Level I Screening, the screening index was above the ORRHES decision guide, then the contaminant was further evaluated using Refined Level I Screening.

  — The Refined Level I Screen calculates a less conservative, more realistic screening index by using more reasonable exposure parameters than the Level I Screen. In addition, depending upon the contaminant, a less conservative environmental concentration was sometimes used. However, the transfer factors and toxicity values remained the same for both screening levels. The Refined Level I Screening maintains considerable conservatism because of these conservative transfer factors and toxicity values.

  If the Refined Level I screening index was below the ORRHES decision guide, then the hazard to most members of the population would be below minimum levels of health concern. In addition, the Refined Level I screening index would be so low that further detail study of exposure is not warranted because the screening index is below the threshold for consideration of more extensive health effects studies and was given a low priority for further study. However, if during the Refined Level I Screening, the screening index was above the ORRHES decision guide, then the contaminant was determined to be of high priority for a detail evaluation.

Study Group

The screening evaluation focuses on the potential for health effects to occur in off-site residents. The Level I Screen estimates a dose for the hypothetical maximally exposed individual who would have received the highest exposure and would have been the most at-risk. The Refined Level I Screen estimates a dose for a more typically exposed individual in the targeted population. The study group for exposure from lead were children because they are particularly sensitive to the neurological effects of lead.

Exposures

Quantitative screening used mathematical equations to calculate a screening index (theoretical estimates of risk or hazard) from multiple exposure pathways, including inhalation; ground exposure (for radionuclides); ingestion of soil or sediment; and ingestion of vegetables, meat, milk, and/or fish.

Outcome Measures

No outcome measures were studied.

Results

Screening-level analyses were performed for seven carcinogens. They were evaluated according to source, resulting in 10 separate analyses. Three of the Level I Screen analyses (Np-237 from K-25, Np-237 from Y-12, and tritium from Y-12) yielded results that were below the decision guides. Refined Level I Screens were performed on the other seven carcinogenic assessments. The results of five separate analyses (beryllium from Y-12, chromium VI from ORR, nickel from K-25, technetium-99 from K-25, and technetium-99 from Y-12) were below the decision guides, and two analyses (arsenic from K-25 and arsenic from Y-12) were above the decision guides.

Arsenic was released into the air from the burning of coal at several coal-fired steam plants located on the Oak Ridge Reservation and into the soil, sediment, and surface water from coal piles and disposal of fly ash from the steam plants. Lead was likely released into soil, sediment, and surface water from the disposal of liquid waste into the Y-12 storm sewers and may have been released into the air from process stacks and the plant ventilation system.

Screening-level analyses were performed for seven noncarcinogens. These, too, were evaluated according to source, resulting in eight separate analyses. One Level I Screen analysis (beryllium from Y-12) yielded results that were below the decision guide. Refined Level I Screens were performed on the other seven noncarcinogenic assessments. Four analyses (chromium VI from ORR, copper from K-25, lithium from Y-12, and nickel from K-25) were below the decision guides and three analyses (arsenic from K-25, arsenic from Y-12, and lead from Y-12) were above the decision guides.

Three materials (niobium, zirconium, and tetramethylammoniumborohydride [TMAB]) were evaluated using the threshold quantity approach because information was insufficient to perform quantitative screening. None of the three was determined to be present in high enough quantities at the Y-12 Plant to have posed off-site health hazards.

Conclusions

Based on the qualitative and quantitative screening, the materials were separated into three classes in terms of potential off-site health hazards: not candidates for further study, potential candidates for further study, and high priority candidates for further study. (as shown in Table 2).

- *Not candidates*—Five materials at the K-25 and 14 materials used at the Y-12 Plant were determined to not warrant further study. All of these chemicals were eliminated because either (1) quantitatively, they fell below Level I Screening decision guides; (2) not enough material was present to have posed an off-site health hazard according to the threshold quantity approach; or (3) qualitatively, the quantities used, forms used, and/or manners of usage were such that off-site releases would not have been sufficient to cause off-site health hazards.

- *Potential candidates*—Three materials at the K-25 (copper powder, nickel, and technetium-99), three materials used at the Y-12 Plant (beryllium compounds, lithium compounds, and technetium-99), and one material used at ORR (chromium VI) were determined to be potential candidates for further study. These materials were identified as potential candidates because (1) their Level I Screening indices exceeded the decision guides and (2) their Refined Level I Screening indices did not exceed the decision guides.

- *High priority candidates*—One material used at the K-25 (arsenic) and two at the Y-12 Plant (arsenic and lead) were determined to be high priority candidates for further study. They were chosen as high priority materials because their Refined Level I Screening indices exceeded the decision guides.

Two issues remaining from the Dose Reconstruction Feasibility Study were evaluated during Task 7: the possible off-site health risks associated with asbestos and the composition of plutonium formed and released to the environment.

- *Asbestos*—Asbestos could not be fully evaluated during the feasibility study; therefore, it was qualitatively evaluated during this task for the potential for off-site releases and community exposure. Available information on the use and disposal of asbestos, as well as off-site asbestos monitoring, was summarized. None of the investigations performed to date have identified any asbestos-related exposure events or activities associated with community exposure, making it very unlikely that asbestos from ORR has caused any significant off-site health risks.

- *Plutonium*—The records that documented the rate of plutonium release did not specify the isotopic composition of the product formed. As a result, during the feasibility study, the project team made the assumption that the plutonium that was formed and released was plutonium-239. If incorrect, this assumption could have significant ramifications on the screening of past airborne plutonium releases. Therefore, the composition of the plutonium formed and released was evaluated further during this task. Plutonium inventory from X-10 was calculated, and plutonium-239 was found to comprise at least 99.9% of the plutonium present in Clinton Pile fuel slugs. This result confirmed that the assumptions made in the feasibility study did not introduce significant inaccuracy into the screening evaluation that was conducted.

TABLE 1

Summary of Screening Methods Used for Each Material

Qualitative Screening			
Material	**Source**	**Notes**	
Boron carbide, boron nitride, yttrium boride, titanium boride, rubidium nitrate, triplex coating, carbon fibers, glass fibers, and four-ring polyphenyl ether	ORR	Evaluated based on quantities used, forms used, and manners of usage.	
Tellurium	Y-12	Evaluated based on quantities used, forms used, and manners of usage.	
Threshold Quantity Approach			
Material	**Source**	**Media**	**Threshold Values**
Niobium	Y-12 Used in production of two alloys, mulberry and binary	Air Surface water	Evaluated using a reference dose derived from an LD50, an empirically derived dispersion factor for airborne releases from Y-12 to Scarboro, and estimated average East Fork Poplar Creek (EFPC) flow rates.
Tetramethylammoniumboro-hydride (TMAB)	Y-12 Use classified	Air Surface water	Inventory quantities and specific applications remain classified.
Zirconium	Y-12 Used in production of an alloy, mulberry	Air Surface water	Evaluated using a reference dose derived from an ACGIH Threshold Limit Value for occupational exposure, an empirically derived dispersion factor for air released from Y-12 to Scarboro, and estimated average EFPC flow rates.

TABLE 1
Summary of Screening Methods Used for Each Material (continued)

Quantitative Screening			
Material	**Source**	**Media**	**Exposure Values**
Arsenic Level I Screen and Refined Level I Screen	K-25 Y-12 Released as a naturally occurring product in coal, which was used in coal-fired steam plants	Air	Based on coal use and dispersion modeling to Union/Lawnville (K-25) and Scarboro (Y-12).
		Surface water	Used maximum in Poplar Creek (K-25) and the 95% upper confidence limit (UCL) on the mean concentration in McCoy Branch (Y-12).
		Soil/sediment	Used sediment core concentration detected in Poplar Creek to represent the early 1960s (K-25) and the 95% UCL on the mean concentration in McCoy Branch (Y-12).
		Food items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Beryllium compounds Level I Screen and Refined Level I Screen	Y-12 Used in production	Air	Used Y-12 stack monitoring data and an empirical dispersion factor for releases to Scarboro.
		Surface water	Used maximum concentration measured in EFPC.
		Soil	Used maximum concentration measured in EFPC.
		Food items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Copper Level I Screen and Refined Level I Screen	K-25 Use of copper powder is classified	Air	Based on airborne concentrations measured at the most-affected on-site air sampler that were adjusted according to the ratio of dispersion model results at that sampler to those at Union/Lawnville.
		Surface water	Used maximum concentration measured during the Clinch River Remedial Investigation.
		Soil/sediment	Used highest mean concentration in Clinch River.
		Food items	Based on concentrations in air, soil, and water and NCRP biotransfer factor and an ATSDR bioconcentration factor.

TABLE 1
Summary of Screening Methods Used for Each Material (continued)

Quantitative Screening (continued)			
Material	**Source**	**Media**	**Exposure Values**
Hexavalent chromium (Chromium VI) Level I Screen and Refined Level I Screen	ORR Used in cooling towers to control corrosion	Air	Based on modeling of emission and drift from K-25 cooling towers to Union/Lawnville.
		Surface water	Used maximum concentration measured in Poplar Creek before 1970.
		Soil	Used average concentration of total chromium measured during the EFPC Remedial Investigation; assumed to be 1/6 (16.7%) chromium VI.
		Food items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Lead EPA's Integrated Exposure Uptake Biokinetic model	Y-12 Used in production of components, in paints, and as radiation shielding	Air	Estimated from background concentrations of lead prior to mid-1970s.
		Surface water	Used maximum concentration measured in EFPC (a higher concentration was detected near Y-12; however it was considered to be anomalous).
		Soil/sediment	Used maximum concentration measured in the EFPC Remedial Investigation, the 95% UCL, and the 95% UCL multiplied by 3.5 for a higher past concentration.
		Food items	Based on concentrations in air, soil, and water and biotransfer and bio-concentration factors from literature.
Lithium Level I Screen and Refined Level I Screen	Y-12 Used in lithium isotope separation, chemical, and component fabrication	Air	Used stack sampling data from two lithium processing buildings and an empirical dispersion factor for releases to Scarboro.
		Surface water	Used highest quarterly average measured in EFPC.
		Soil/sediment	Used maximum concentration measured in the EFPC floodplain.
		Food items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.

TABLE 1
Summary of Screening Methods Used for Each Material (continued)

Quantitative Screening (continued)			
Material	**Source**	**Media**	**Exposure Values**
Neptunium-237 Level I Screen	K-25 Y-12 Found in recycled uranium	Air	Based on levels in recycled uranium, an estimated release fraction, and dispersion modeling to Union/Lawnville (K-25) and Scarboro (Y-12).
		Surface water	Based on reported releases to Clinch River (K-25) and EFPC (Y-12), corrected for dilution.
		Soil/sediment	Used maximum concentrations detected in Clinch River (K-25) and EFPC (Y-12).
		Food items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Nickel Level I Screen and Refined Level I Screen	K-25 Used in the production of barrier material for the gaseous diffusion process	Air	Based on the 95% UCL for the year of the highest measured concentrations in on-site air samplers and dispersion modeling to Union/Lawnville.
		Surface water	Used 95% UCL for the year of the highest concentrations in Clinch River.
		Soil/sediment	Used highest mean concentration in Clinch River.
		Food items	Based on concentrations in air, soil, and water and NCRP biotransfer and bioconcentration factors.
Technetium-99 Level I Screen and Refined Level I Screen	K-25 Y-12 Product of fission of uranium atoms and from neutron activation of stable molybdenum-98	Air	Used an average of concentrations modeled to Union/Lawnville (K-25) and Scarboro (Y-12).
		Surface water	Used maximum concentration detected in Clinch River (K-25) and EFPC (Y-12).
		Soil/sediment	Used maximum concentration from the K-25 perimeter and EFPC (Y-12).
		Food items	Based on concentrations in air, soil, and water and biotransfer and bioconcentration factors from literature.

TABLE 1
Summary of Screening Methods Used for Each Material (continued)

Quantitative Screening (continued)			
Material	**Source**	**Media**	**Exposure Values**
Tritium Level I Screen	Y-12 Used in deuterium gas production and lithium deuteride recovery operations	Surface water	Evaluated based on deuterium inventory differences and the peak tritium concentration in the deuterium that was processed at Y-12; the release estimate was used with the International Atomic Energy Agency method for tritium dose assessment, assuming all the tritium that escaped was released to EFPC.

TABLE 2
Categorization of Materials Based on Screening Results

Contaminant Source	Not Candidates for Further Study (Level I result was below the decision guide)	Potential Candidates for Further Study (Refined Level I result was below the decision guide)	High Priority Candidates for Further Study (Refined Level I result was above the decision guide)
K-25	Neptunium-237 (cancer) Evaluated qualitatively (quantities, forms, and manner of use were not sufficient): • Carbon fibers • Four-ring polyphenyl ether • Glass fibers • Triplex coating	• Copper powder (noncancer) • Nickel (cancer) • Nickel (noncancer) • Technetium-99 (cancer)	• Arsenic (cancer) • Arsenic (noncancer)
Y-12 Plant	• Beryllium compounds (noncancer) • Neptunium-237 (cancer) • Tritium (cancer) Evaluated using Threshold Quantity Approach (not enough material was present): • Niobium (noncancer) • TMAB • Zirconium (noncancer) Evaluated qualitatively (quantities, forms, and manner of use were not sufficient): • Boron carbide • Boron nitride • Rubidium nitrate • Rubidium bromide • Tellurium • Titanium boride • Yttrium boride • Zirconium	• Beryllium compounds (cancer) • Lithium compounds (noncancer) • Technetium-99 (cancer)	• Arsenic (cancer) • Arsenic (noncancer) • Lead (noncancer) Arsenic was released into the air from the burning of coal at several coal-fired steam plants located on the Oak Ridge Reservation and into the soil, sediment, and surface water from coal piles and disposal of fly ash from the steam plants. Lead was likely released into soil, sediment, and surface water from the disposal of liquid waste into the Y-12 storm sewers and may have been released into the air from process stacks and the plant ventilation system.
ORR (all complexes)		• Chromium VI (cancer) • Chromium VI (noncancer)	

Introduction

Fish are an important part of a healthy diet. They are a lean, low-calorie source of protein. Some sport fish caught in the nation's lakes, rivers, oceans, and estuaries, however, may contain chemicals that could pose health risks if these fish are eaten in large amounts.

The purpose of this brochure is not to discourage you from eating fish. It is intended as a guide to help you select and prepare fish that are low in chemical pollutants. By following these recommendations, you and your family can continue to enjoy the benefits of eating fish.

Fish taken from polluted waters might be hazardous to your health. Eating fish containing chemical pollutants may cause birth defects, liver damage, cancer, and other serious health problems.

Chemical pollutants in water come from many sources. They come from factories and sewage treatment plants that you can easily see. They also come from sources that you can't easily see, like chemical spills or runoff from city streets and farm fields. Pollutants are also carried long distances in the air.

Fish may be exposed to chemical pollutants in the water, and the food they eat. They may take up some of the pollutants into their bodies. The pollutants are found in the skin, fat, internal organs, and sometimes muscle tissue of the fish.

What can I do to reduce my health risks from eating fish containing chemical pollutants ?

Following these steps can reduce your health risks from eating fish containing chemical pollutants. The rest of the brochure explains these recommendations in more detail.

1. ***Call your local or state environmental health department.*** Contact them before you fish to see if any advisories are posted in areas where you want to fish.
2. ***Select certain kinds and sizes of fish for eating.*** Younger fish contain fewer pollutants than older, larger fish. Panfish feed on insects and are less likely to build up pollutants.
3. ***Clean and cook your fish properly.*** Proper cleaning and cooking techniques may reduce the levels of some chemical pollutants in the fish.

Health Note

Advisories are different from fishing restrictions or bans or limits. Advisories are issued to provide ***recommendations*** for limiting the amount of fish to be eaten due to levels of pollutants in the fish.

A Message from the Administrator

Christine Todd Whitman

I believe water is the biggest environmental issue we face in the 21st Century in terms of both quality and quantity. In the 30 years since its passage, the Clean Water Act has dramatically increased the number of waterways that are once again safe for fishing and swimming. Despite this great progress in reducing water pollution, many of the nation's waters still do not meet water quality goals. I challenge you to join with me to finish the business of restoring and protecting our nation's waters for present and future generations.

For More Information

For more information about reducing your health risks from eating fish that contain chemical pollutants, contact your local or state health or environmental protection department. You can find the telephone number in the blue section of your local telephone directory.

You may also contact:

U.S. Environmental Protection Agency
Office of Water
Fish and Wildlife Contamination Program (4305T)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
web address: www.epa.gov/ost/fish

United States Environmental Protection Agency
Office of Water (4101M)
EPA 823-F-02-005 • April 2002

In celebration of the 30th anniversary of the Clean Water Act, EPA presents

A Guide to Healthy Eating of the Fish You Catch

ATSDR

Catching Fish

How can I find out if the waters that I fish in are polluted?

It's almost impossible to tell if a water body is polluted simply by looking at it. However, there are ways to find out.

First, look to see if warning signs are posted along the water's edge. If there are signs, follow the advice printed on them.

Second, even if you don't see warning signs, call your local or state health or environmental protection department and ask for their advice. Ask them if there are any advisories on the kinds or sizes of fish that may be eaten from the waters where you plan to fish. You can also ask about fishing advisories at local sporting goods or bait shops where fishing licenses are sold.

If the water body has not been tested, follow these guidelines to reduce your health risks from eating fish that might contain small amounts of chemical pollutants.

Health Note

Some chemical pollutants, such as mercury and PCBs, can pose greater risks to women of childbearing age, pregnant women, nursing mothers, and young children. This group should be especially careful to greatly reduce or avoid eating fish caught from polluted waters.

Do some fish contain more pollutants than others?

Yes. You can't look at fish and tell if they contain chemical pollutants. The only way to tell if fish contain harmful levels of chemical pollutants is to have them tested in a laboratory. Follow these simple guidelines to lower the risk to your family:

- If you eat gamefish, such as lake trout, salmon, walleye, and bass, eat the smaller, younger fish (within legal limits). They are less likely to contain harmful levels of pollutants than larger, older fish.
- Eat panfish, such as bluegill, perch, stream trout, and smelt. They feed on insects and other aquatic life and are less likely to contain high levels of harmful pollutants.
- Eat fewer fatty fish, such as lake trout, or fish that feed on the bottoms of lakes and streams such as catfish and carp. These fish are more likely to contain higher levels of chemical pollutants.

Cleaning Fish

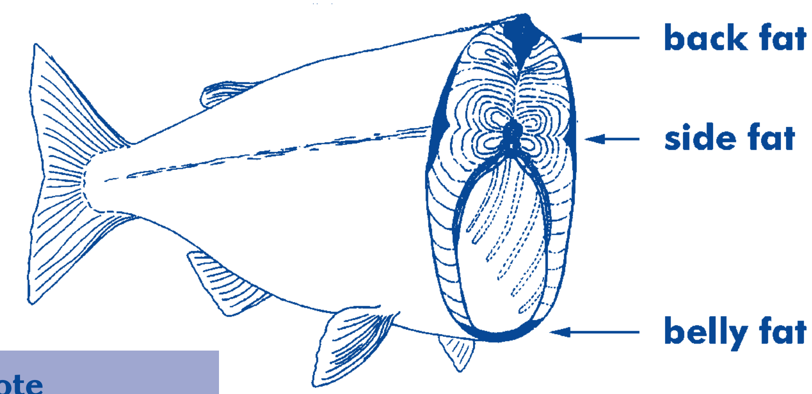
Can I clean my fish to reduce the amount of chemical pollutants that might be present?

Yes. It's always a good idea to remove the skin, fat, and internal organs (where harmful pollutants are most likely to accumulate) before you cook the fish.

As an added precaution:

- Remove and throw away the head, guts, kidneys, and the liver.

Trim away the skin and fatty tissue before cooking to reduce the level of some pollutants in the fish you eat.



Health Note

Mercury is found throughout the tissue in fish, so these cleaning and cooking techniques will not reduce the amount of mercury in a meal of fish.

- Fillet fish and cut away the fat and skin before you cook it.
- Clean and dress fish as soon as possible.

Remember that with any fresh meat, always follow proper food handling and storage techniques. To prevent the growth of bacteria or viruses, keep freshly caught fish on ice and out of direct sunlight.

Cooking Fish

Can I cook my fish to reduce my health risk from eating fish containing chemical pollutants?

Yes. The way you cook fish can make a difference in the kinds and amounts of chemical pollutants remaining in the fish. Fish should be properly prepared and grilled, baked, or broiled. By letting the fat drain away, you can remove pollutants stored in the fatty parts of the fish. Added precautions include:

- Avoid or reduce the amount of fish drippings or broth that you use to flavor the meal. These drippings may contain higher levels of pollutants.
- Eat less fried or deep fat-fried fish because frying seals any chemical pollutants that might be in the fish's fat into the portion that you will eat.
- If you like smoked fish, it is best to fillet the fish and remove the skin before the fish is smoked.

APPENDIX D

Media Maps

Figure D-1. Number of Off-Site Soil Samples Collected from Each Location

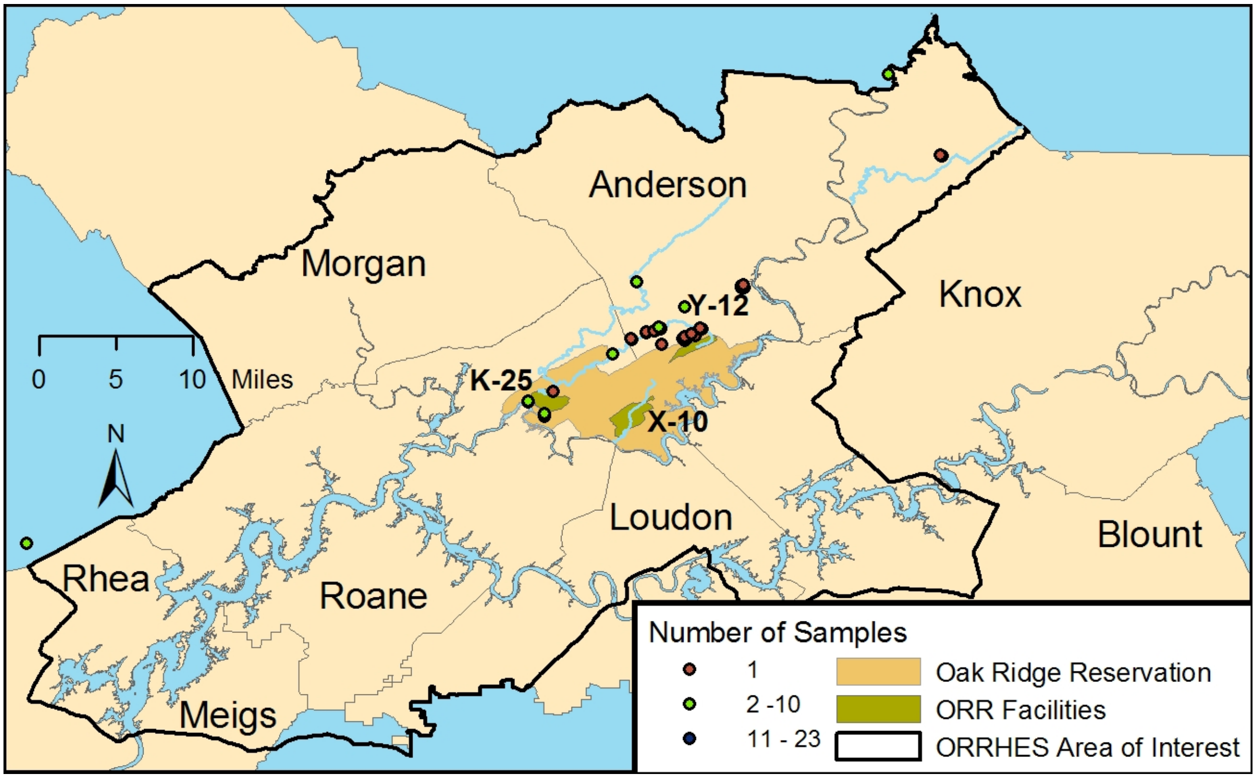


Figure D-2. Number of Chemicals Sampled at Each Off-Site Soil Location

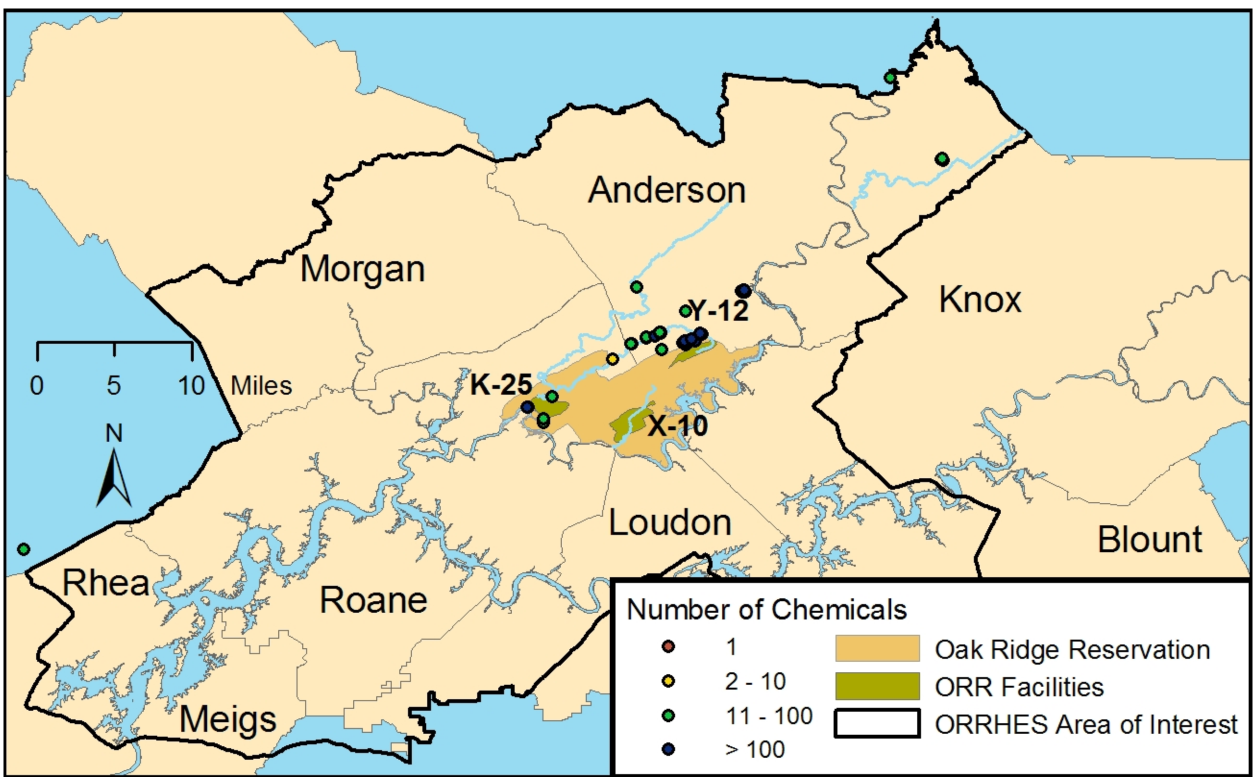


Figure D-3. Number of Off-Site Sediment Samples Collected from Each Location

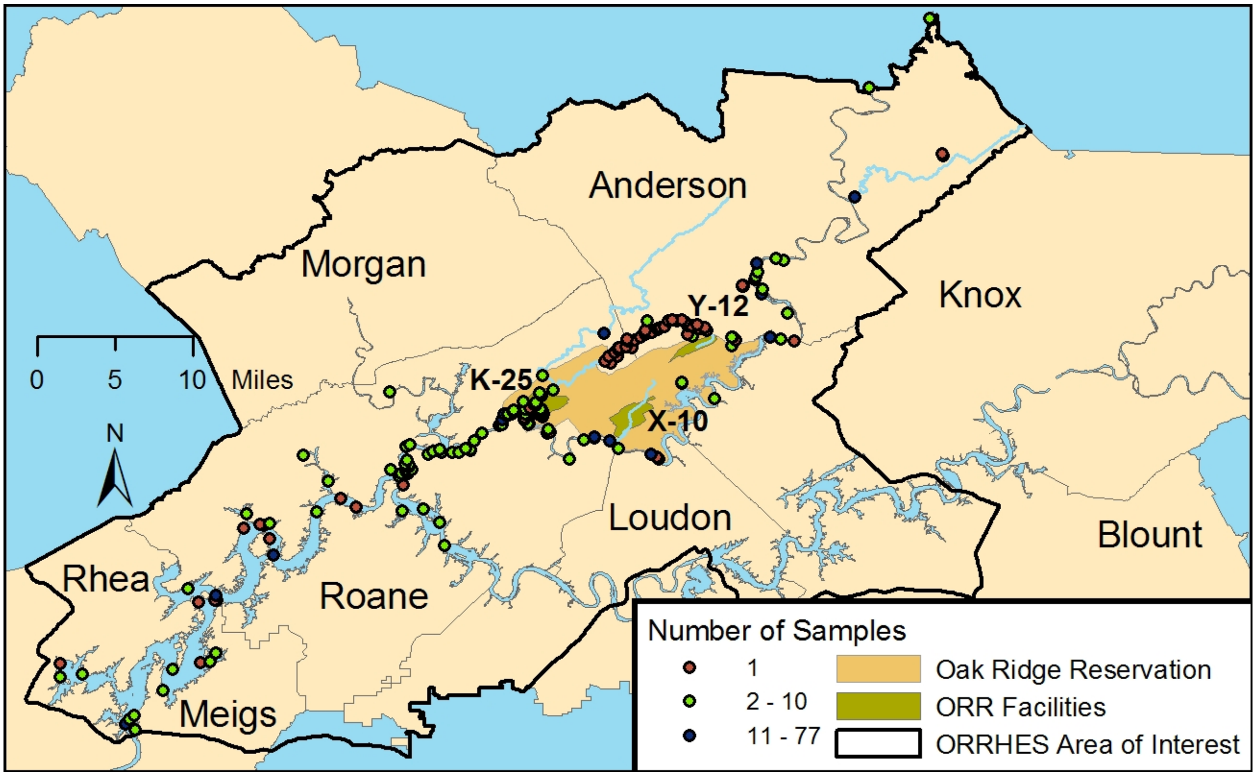


Figure D-4. Number of Chemicals Sampled at Each Off-Site Sediment Location

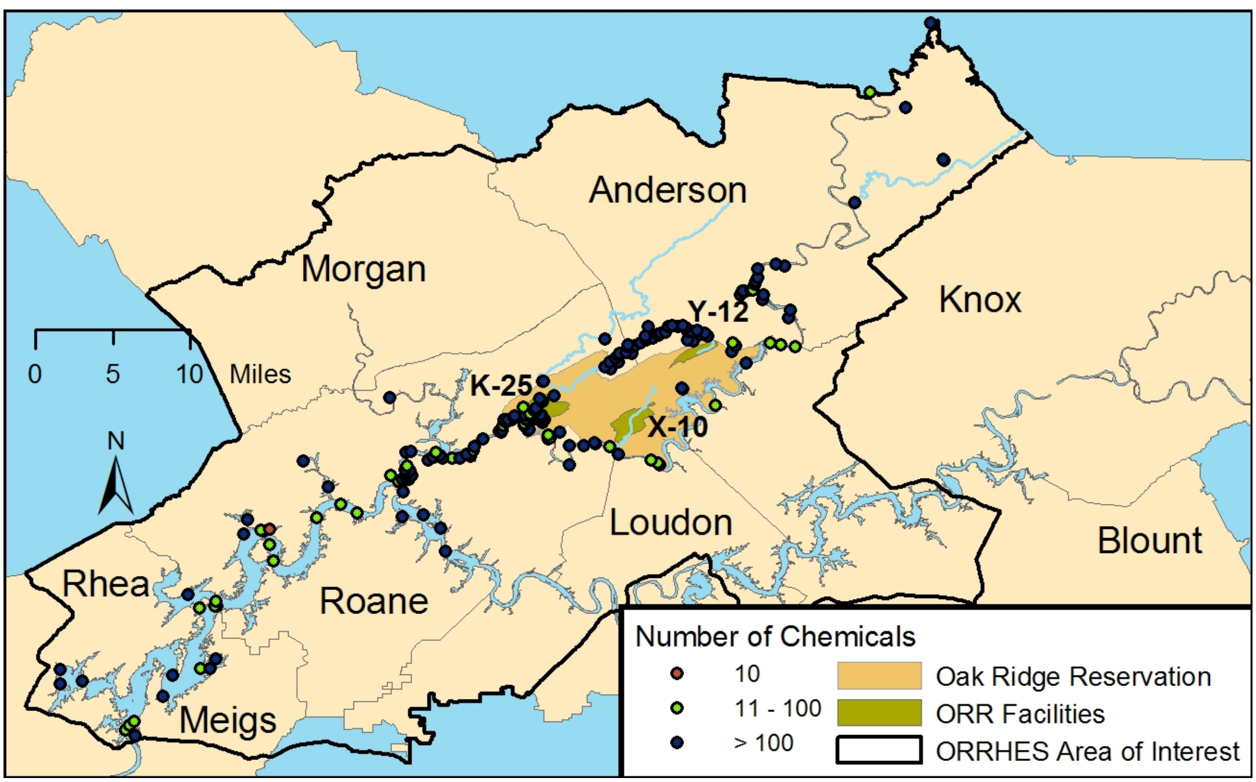


Figure D-5. Number of Off-Site Surface Water Samples Collected from Each Location

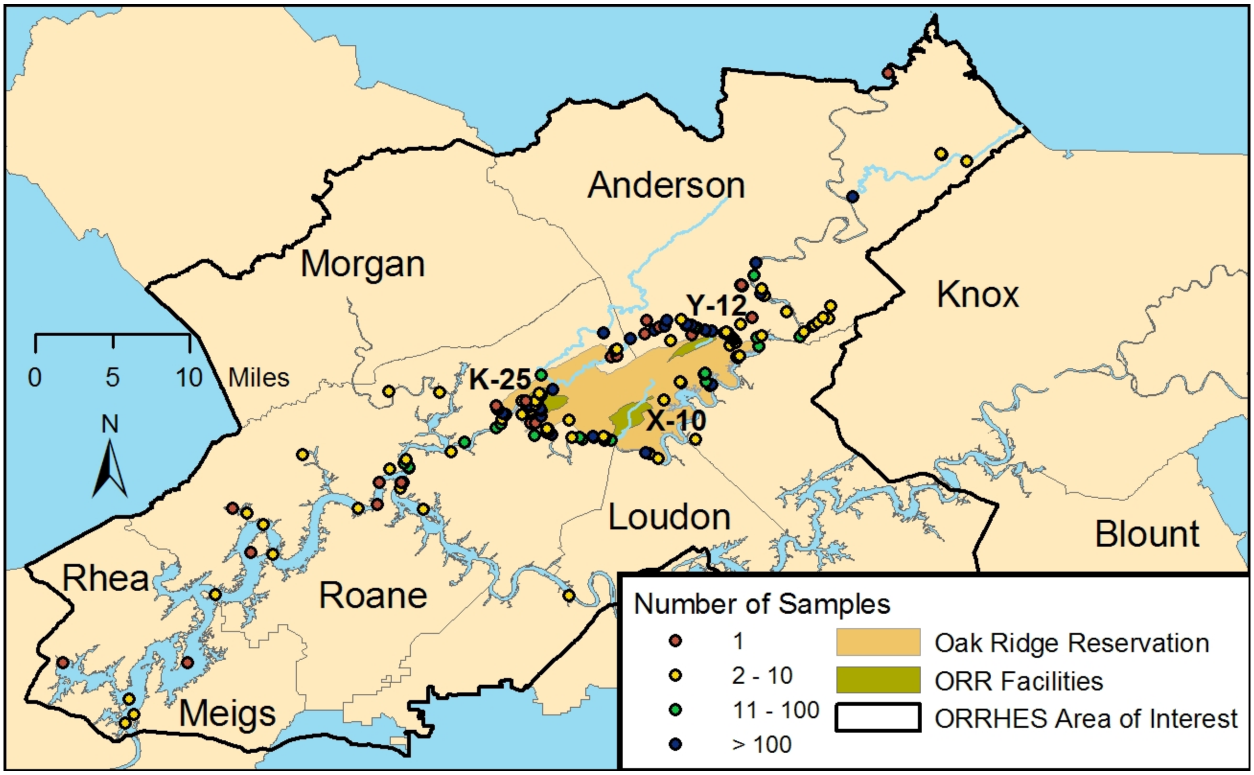


Figure D-6. Number of Chemicals Sampled at Each Off-Site Surface Water Location

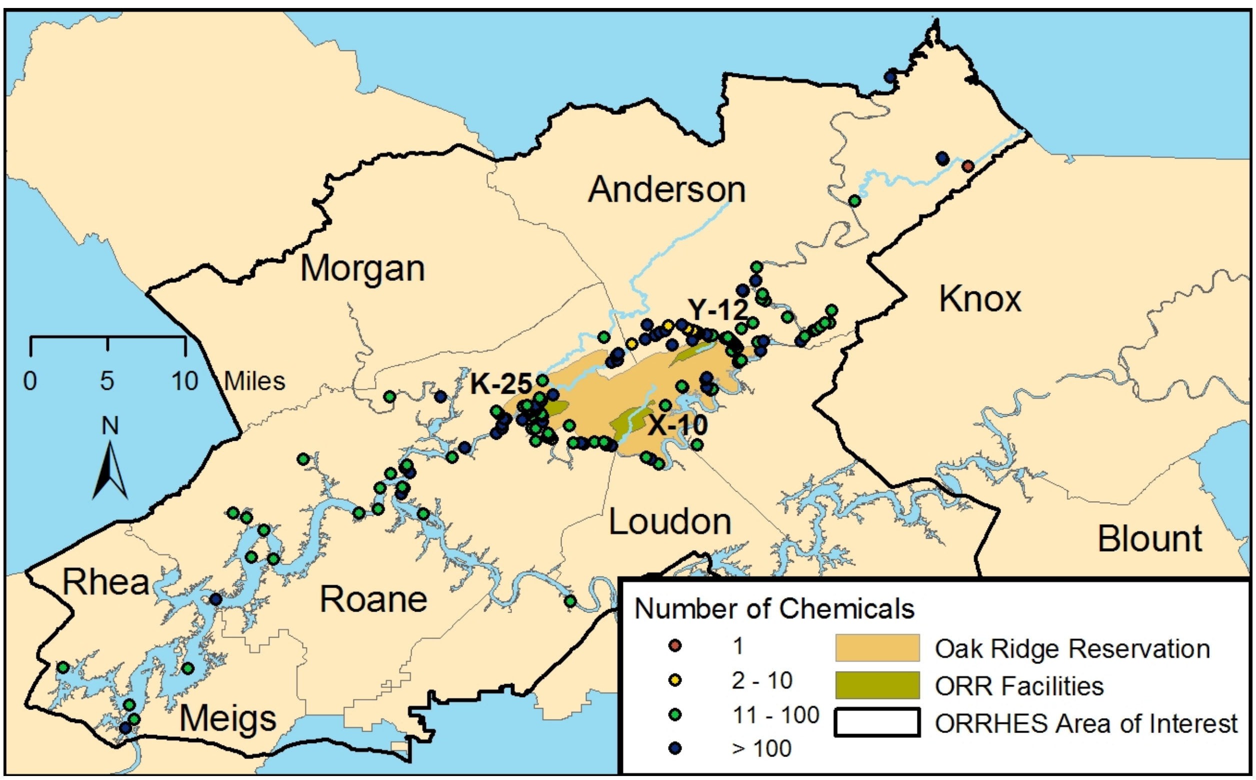


Figure D-7. Number of Off-Site Fish Samples Collected from Each Location

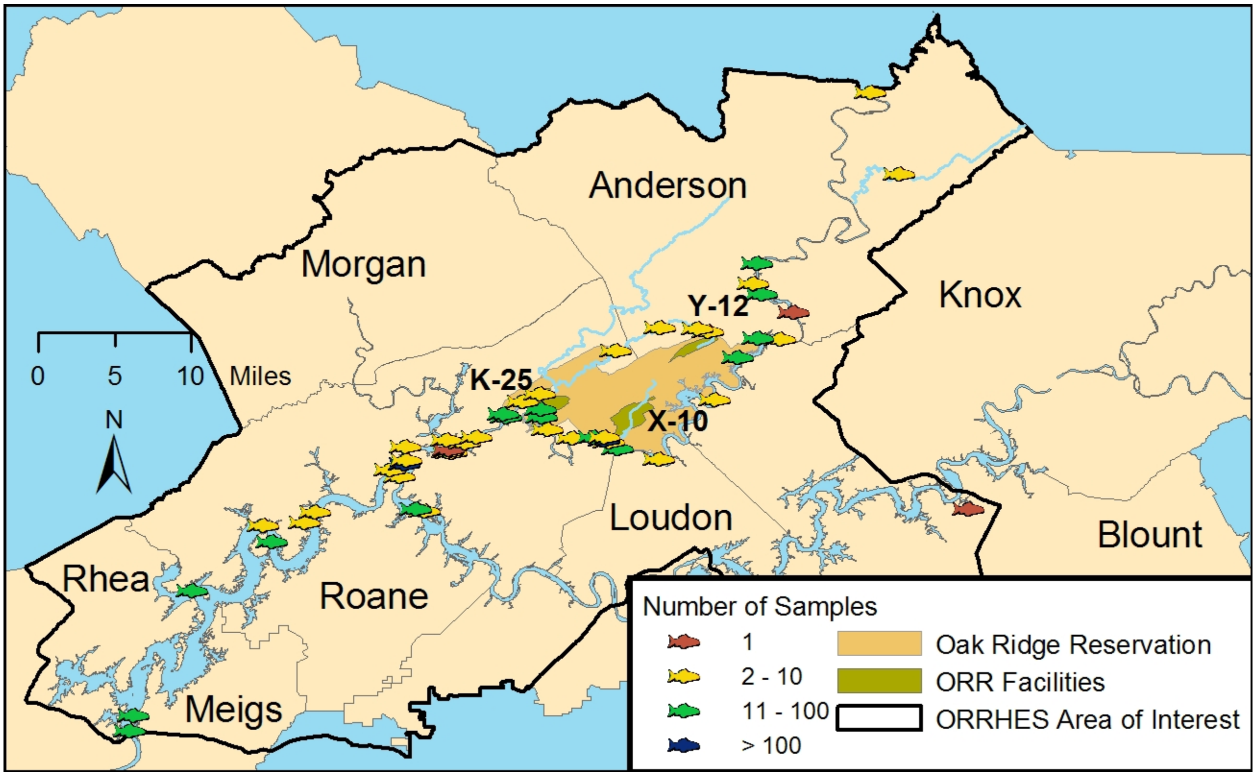


Figure D-8. Number of Chemicals Sampled at Each Off-Site Fish Location

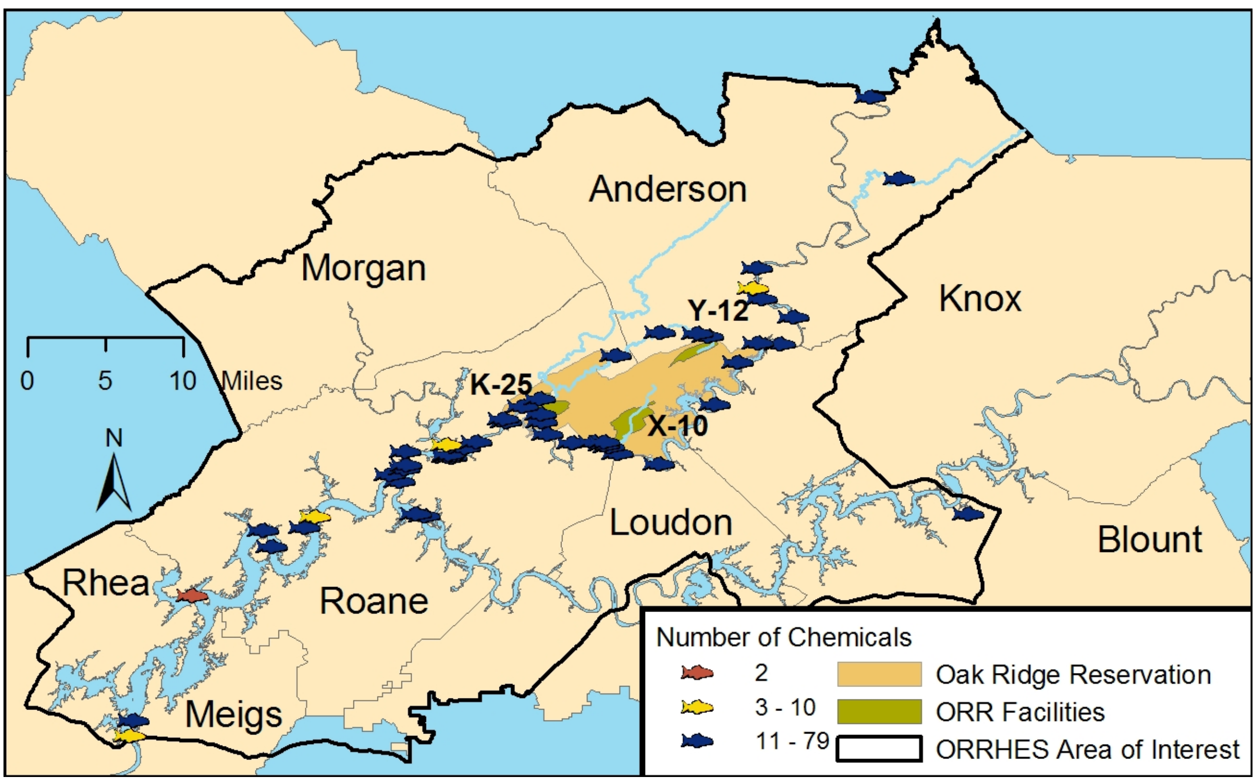


Figure D-9. Number of On-Site Fish Samples Collected from Each Location

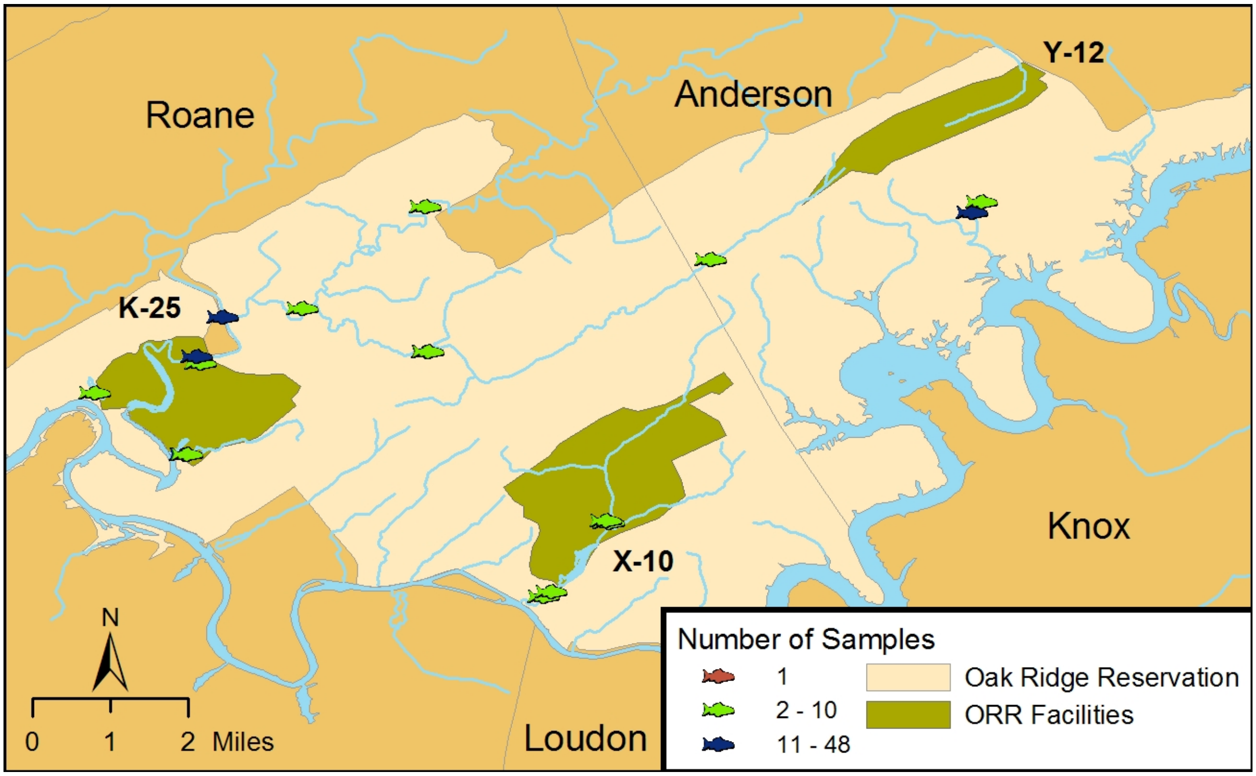


Figure D-10. Number of Chemicals Sampled at Each On-Site Fish Location

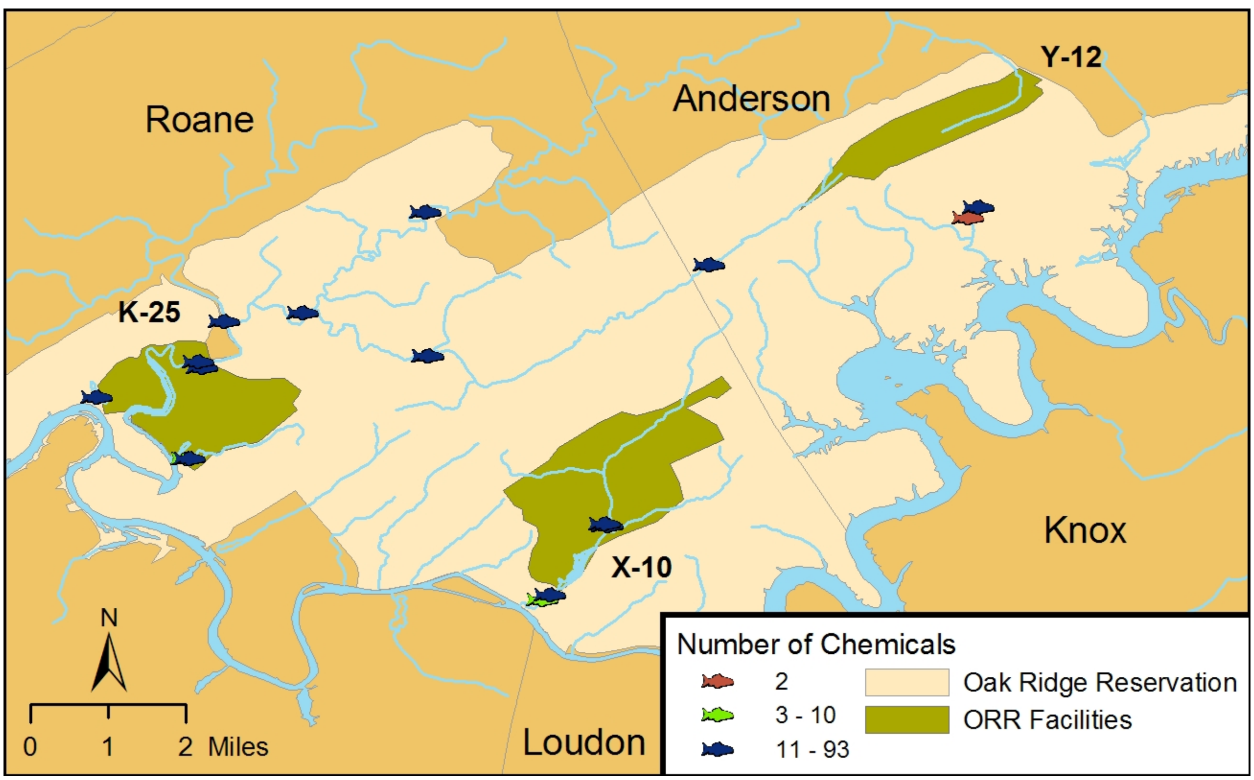


Figure D-11. Number of Off-Site Game Samples Collected from Each Location

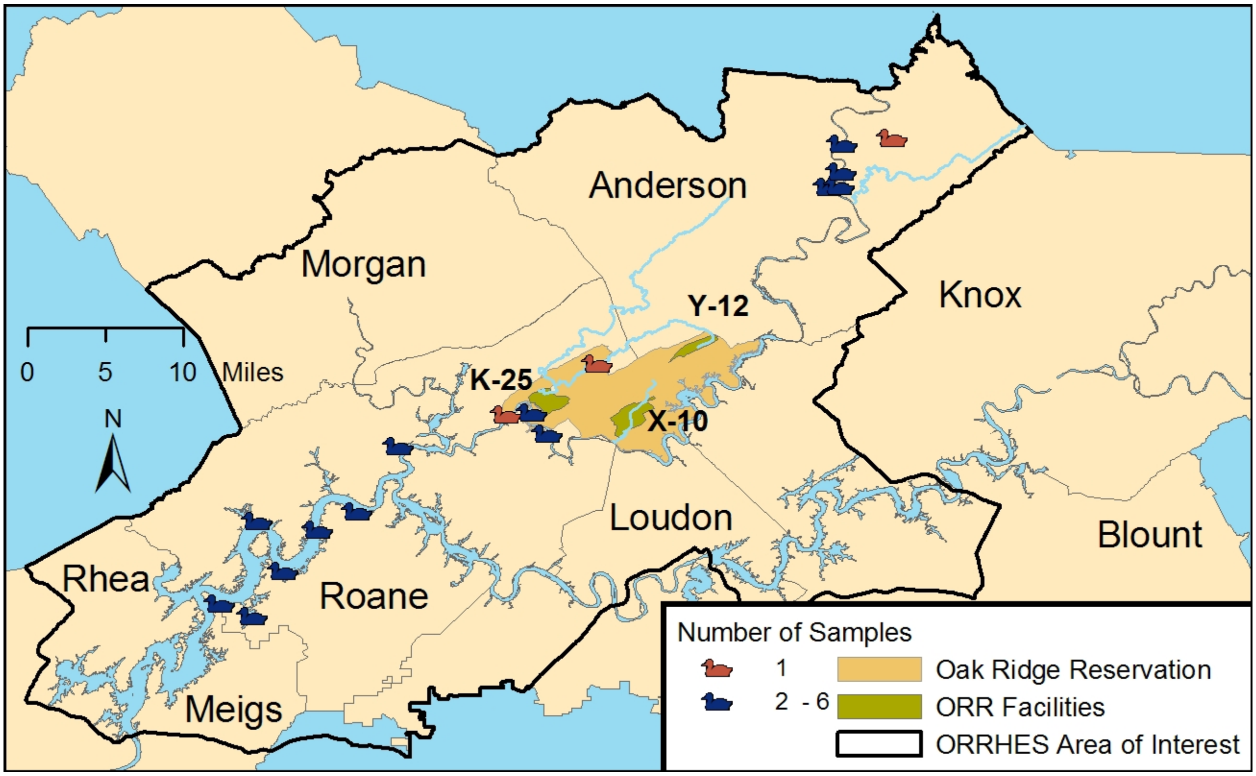


Figure D-12. Number of Chemicals Sampled at Each Off-Site Game Location

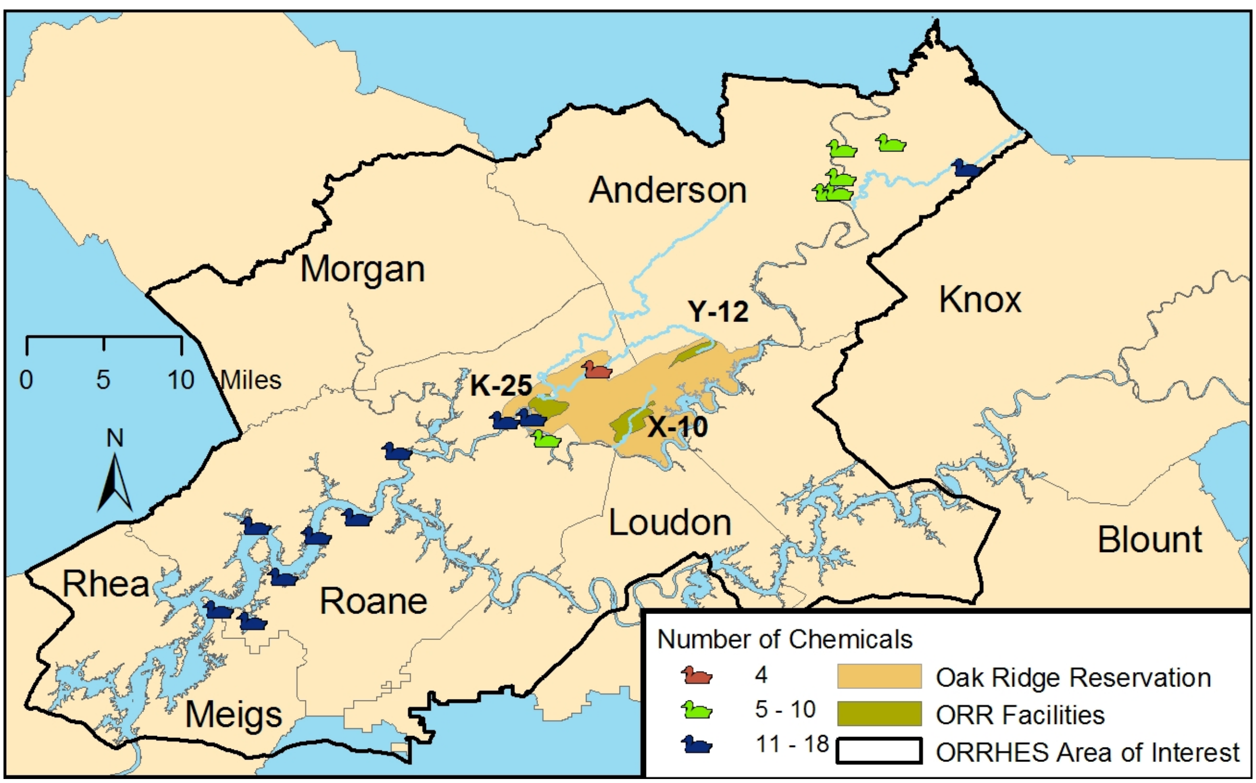


Figure D-13. Number of On-Site Game Samples Collected from Each Location

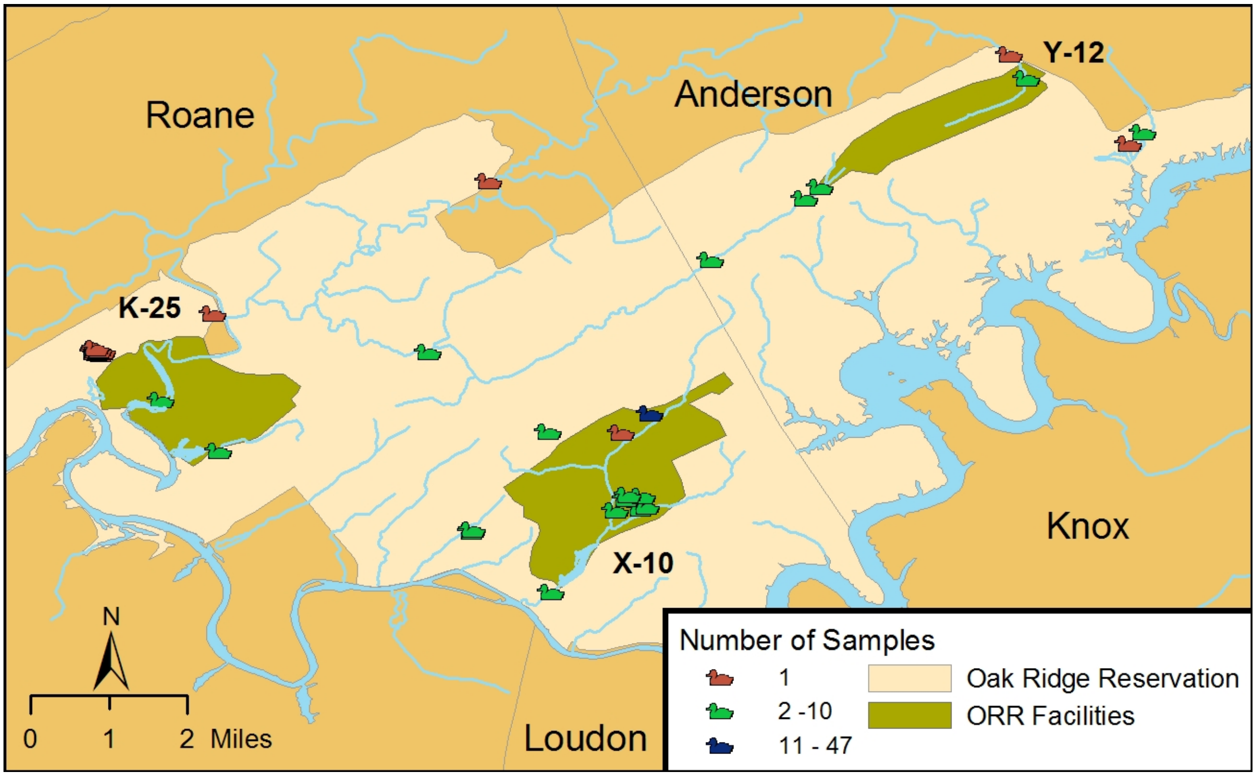


Figure D-14. Number of Chemicals Sampled at Each On-Site Game Location

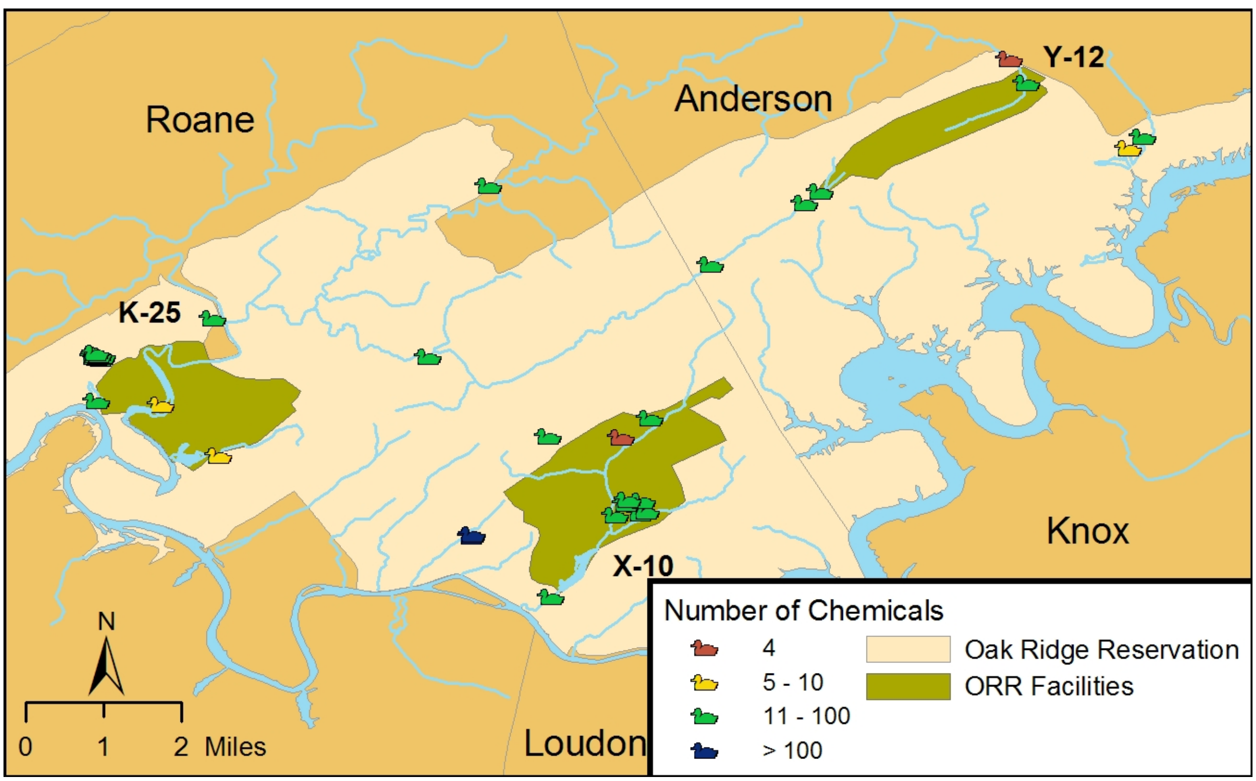


Figure D-15. Number of Off-Site Vegetation Samples Collected from Each Location

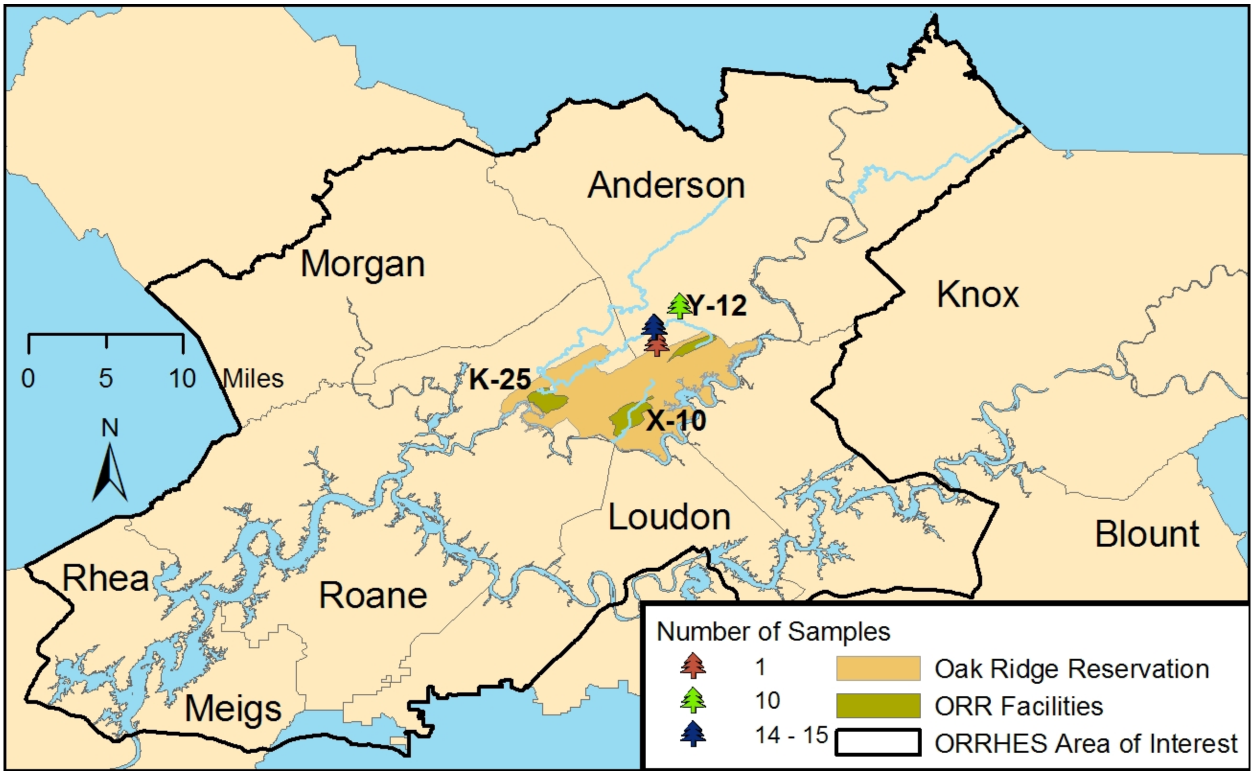


Figure D-16. Number of Chemicals Sampled at Each Off-Site Vegetation Location

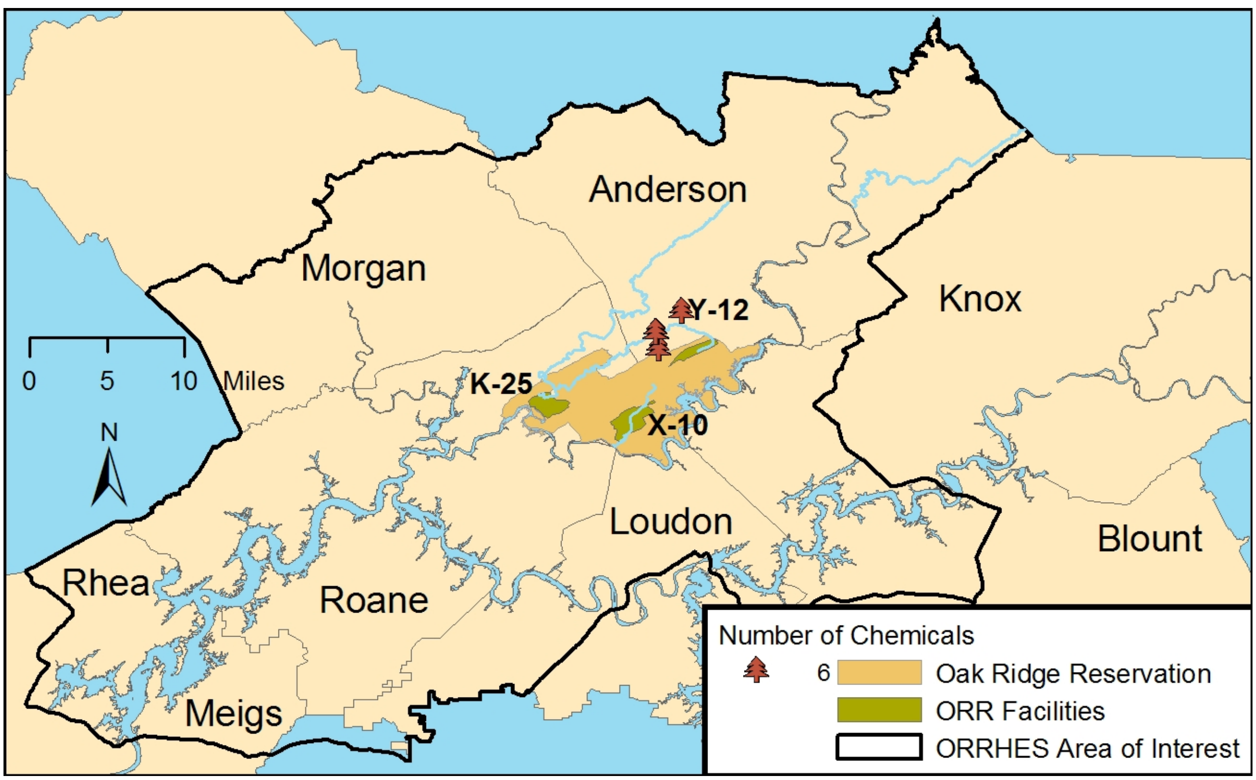


Figure D-17. Number of Air Samples Collected from Each Location

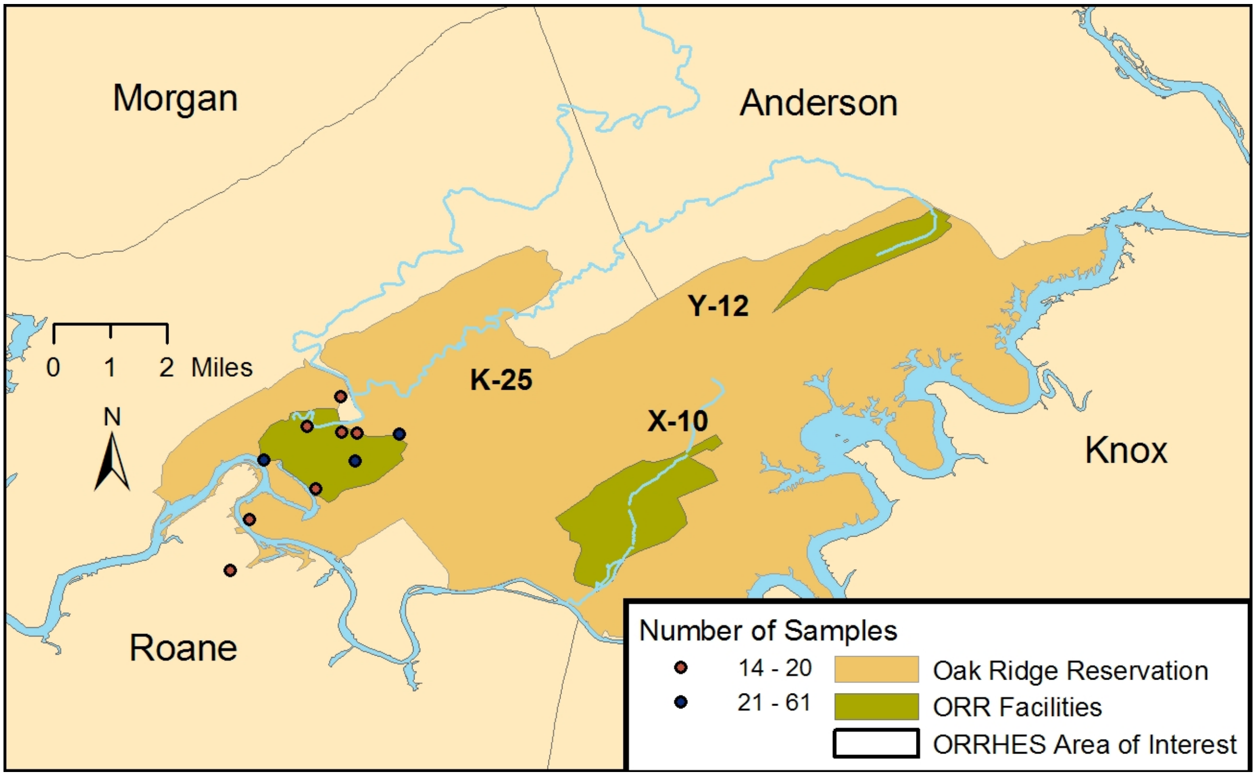
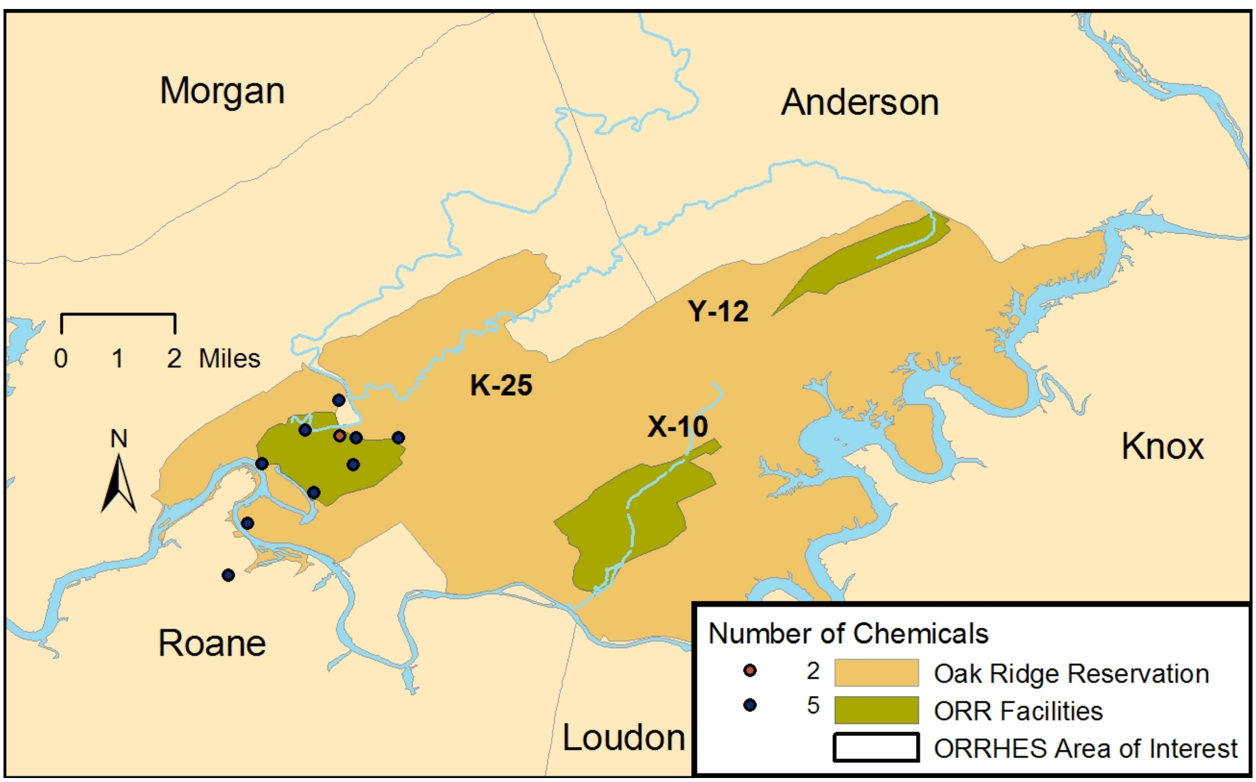


Figure D-18. Number of Chemicals Sampled at Each Air Location



APPENDIX E

Responses to Public Comments

ATSDR received the following comments from the public and local organizations during the public comment period (September 12 to November 18, 2005) for the *Evaluation of Current (1990 to 2003) and Future Chemical Exposures in the Vicinity of the Oak Ridge Reservation* public health assessment (October 2005). For comments that questioned the validity of statements made in the document, ATSDR verified or corrected the statements.

	Public Comment	ATSDR's Response
1	The entire report needs to be very carefully scrutinized by someone with expertise in human nutrition. I believe that CDC has people available to call upon for nutrition consultation. Select someone who is well acquainted with the new recommendations of the National Academy of Sciences/Food and Nutrition Board (NAS/FNB). If there is no one suitable in-house, DHHS has some people with this background. And/or, ATSDR may wish to consider someone from the NAS/FNB.	ATSDR's health assessor, who has expertise in human nutrition, provided input on the public health evaluation.
	This is important because what is presented in this document about nutrients as contaminants is only about half right. Take, as an example, iron, which is discussed on page 41 as well as throughout the report. Although the relevant citation NAS (2001) was included in the reference list (page 88), it was not used to establish the acute screening guideline nor was the NAS/FNB tolerable upper intake level (UL) taken into consideration. The source listed for iron in Table 4 is given as the RDA (Recommended Dietary Allowance) which may need to be replaced by the more current DRI (Dietary Reference Intake). Both are NAS/FNB notations. Also, the reference Kurtzweil, P (1993) is way too old to use in this report. Discrepancies between NAS/FNB and other organizations identified in the context of the discussion reflect a time lag among organizations in adjusting their values and are not particularly useful in understanding the author's reasoning.	ATSDR replaced the recommended dietary allowance (RDA) with the dietary reference intake (DRI) for iron. The tolerable upper intake level (UL) for children 1 to 3 years of age is 40 mg/day, which represents the maximum level of daily iron intake likely to pose no risk of adverse effects (NAS 2001). Although the UL was not discussed in the public health assessment, exposure doses are expected to be well below this level due to poor absorption of iron from soil, and the fact that the human body regulates its own iron level. Therefore, ATSDR does not expect that exposure levels would be higher than the UL. ATSDR removed the Kurtzweil (1993) reference.

	Public Comment	ATSDR's Response
2	Pp. i and ii. We appreciate the author's effort to be more explicit about children who are sensitive to exposures by adding the fetus and infant to the list of high risk groups (pages *i and ii)*. However, we are very concerned that pregnant and breastfeeding women are not included. The pregnant woman and fetus need to be viewed as one--an interactive pair. Understanding the condition of the fetus takes into account consideration of placental transfer of chemicals and the overall condition of the mother in pregnancy. These two (mother and baby) should not be separated until birth...ever...even on paper. A similar argument can be made for the breastfeeding woman and her infant. Breastfeeding is an interactive process that influences the health and well-being of both mother and infant. It is just plain wrong to separate them to consider the effects of exposure on the infant alone. Please reconsider this issue in this and future ATSDR reports. It does no honor to science to ignore common sense.	A new section, Section IV.D, "Pregnant and Breast-Feeding Women," has been added to address this sensitive population. Please see that section of the final public health assessment for more details.
3	Pp. 2 and 50-53. Cadmium apparently poses a potential problem for regular consumption of homegrown vegetables, particularly tomatoes. No comment is made concerning the locations from which samples of vegetables containing cadmium were obtained, and no sampling data for vegetables grown in Scarboro are reported. However, DOE has sampled tomatoes grown in Scarboro annually for several years, and those data are in the OREIS database. Those data should be included and analyzed in this PHA.	Figures D-15 and D-16 show the number of off-site vegetation samples collected from and the number of chemicals sampled at each location. All applicable data from the Oak Ridge Environmental Information System (OREIS) database were included and analyzed during ATSDR's evaluation. Additional samples were analyzed for radionuclides, but these data were evaluated separately.
4	Pp. 3–6. The operational history section doesn't provide any information on the process or maintenance chemicals used at the facilities that would be the basis for conducting this PHA.	ATSDR screened and evaluated all applicable data available in the OREIS database, regardless of whether the chemical was considered to be site-related.
5	Pp. 6–7. The remedial and regulatory history does not discuss any chemical contamination issues, nor does it discuss any chemical remediation objectives addressed by the ORR site cleanup Records of Decision. Line 36 on page 6 does not mention any potential chemical contamination that is the subject of this PHA.	So as not to overwhelm the reader with details already discussed in other publicly available reports, ATSDR referred the reader to the annual *Remediation Effectiveness Reports for the U.S. Department of Energy Oak Ridge Reservation*, which document the progress of ongoing remedial activities and future planned actions at the site. These reports are available at the DOE Information Center located at 475 Oak Ridge Turnpike, Oak Ridge, Tennessee (telephone number: 1-865-241-4780).
6	P. 7, Line 16. Does "formerly been cleared for farmland" refer to land usage before or after the Oak Ridge Reservation was established?	ATSDR suspects that the land was used for farmland before the establishment of the ORR, however, a reference could not be found to confirm this. Because a timeframe could not definitively be associated with this phrase, ATSDR deleted it from the document.

	Public Comment	ATSDR's Response
7	Pp. 8–10. The demographics section is little more than a presentation of population numbers. While brief reference is made to numbers of elderly, children, etc., and certain ethnic breakdowns are quantified in Figure 3, no meaningful correlation is made to potential exposure pathways, sensitive populations, etc.	In this evaluation, ATSDR *assumed* exposure to the contaminated media. The location of each detection was not individually evaluated to determine whether anyone was actually being exposed.
8	P. 12. Are there any previous chemical screenings or assessments that can be discussed here?	Section II.G discusses Phase I and Phase II of the Tennessee Department of Health's (TDOH's) Oak Ridge Health Studies, which consisted of a screening-level evaluation of all past releases of hazardous substances and operations at the ORR and included an in-depth dose reconstruction of those chemicals identified as requiring further study. Figure 3 shows the results of the TDOH's screening process for past exposures.
9	P. 13, Figure 4, Table 4, and Appendix C. Figure 4, as well as Table 4, and the two ORRHES briefs on Dose Reconstruction Feasibility and Screening contain lists of the contaminants recommended by ORHASP for dose reconstruction or further study. However, these lists do not completely agree. The brief on dose reconstruction feasibility in Appendix C lists cesium, while the other lists include radionuclides released to the Clinch River. These items may be the same, but are worded differently. The list in the brief on screening agrees with the list on page 4 of Volume 7 of the Dose Reconstruction Reports, which is the summary volume. These lists need to be reconciled.	Figure 4 (now Figure 3) and Table 4 present information for two different evaluations. Figure 4 (now Figure 3) depicts the TDOH's screening process for past exposure. Table 4 shows ATSDR's estimated pica child exposure doses for current exposures compared to acute screening guidelines. The lists of potential contaminants and high priority contaminants in Figure 4 (now Figure 3) and Table 2 in the brief in Appendix C are the same.
10	P. 12 and Appendix C. The text on page 12 mentions the brief in Appendix C on Screening-Level Evaluations of Additional Potential Materials of Concern, identifying that activity as Task 7 of the Dose Reconstruction Project. Vol. 7, the summary volume of the Dose Reconstruction Reports, also summarizes this task. The brief in this PHA states that 25 materials or groups of materials were evaluated under Task 7. Vol. 7 gives the number as 28. Table 2 in the brief on screening lists 24 separate materials evaluated. Can these numbers be reconciled? More importantly, a clarifying statement is needed to explain the relationship between Task 7 of the Dose Reconstruction Project, which dealt with past releases, and the subject of this PHA, which deals with current and future releases. Some clear statement needs to be made about the origin of the subject of this PHA, and whether it has any connection with Task 7 of the Dose Reconstruction Project.	The correct number of materials or groups of materials is 28. ATSDR revised the brief to state that 28 materials or groups of materials were evaluated under Task 7. Table 2 in the brief is a reproduction of Table ES-2 in the Task 7 report. TDOH conducted the Oak Ridge Health Studies to evaluate whether off-site populations have been exposed in the past. Task 7 of the dose reconstruction was a screening-level evaluation of potential chemicals of concern, using data through 1990. This PHA documents ATSDR's screening of environmental data from 1990 to 2003, addresses whether additional chemicals not identified by Task 7 require further evaluation, and discusses the public health implications related to estimated exposures. ATSDR added further clarification to the PHA.

	Public Comment	ATSDR's Response
11	P. 15, line 5. Suggest replacing "driven by exposure" to another phrase that is more descriptive of the PHA process. To some, "driven by exposure" may seem dismissive of the notion that the PHA should be "driven by" community concerns of health problems in their area.	ATSDR deleted the sentence in Section III.A and re-phrased the sentence in Section III.C to read "As discussed earlier, exposure to a contaminant is an important factor in ATSDR's evaluation."
12	P. 16, line 14. Identify and describe the primary data sources used for the PHA.	Section III.C identifies and describes the primary data source (i.e., OREIS) used for this PHA.
13	Pp. 26–36. It is not clear in the text why "comparison values do not exist" for chemicals detected in the biota when they are available for the same chemicals in other media (e.g., arsenic).	Comparison values are calculated concentrations of a substance in a specific medium that are unlikely to cause harmful health effects in exposed people. ATSDR has derived comparison values for soil/sediment, water, and air, but has not derived comparison values for biota.
14	P. 16, line 22. Add further explanation that there may be comparison values for certain contaminants in some media but not in others (e.g., arsenic in water vs. arsenic in fish).	ATSDR added clarification to Section III.B.
15	Pp. 17 and 35 (Figures 5 and 7). An inconsistency in terminology exists between Figures 5 and 7. Figure 5 refers to "health guidelines," while Figure 7 refers to "screening guidelines." If these two terms are meant to be synonyms, then one term should be selected and the other eliminated.	ATSDR revised Figure 5 (now Figure 4) and Figure 8 to be consistent with the use of "screening guidelines" in Figure 7.
16	Pp. 17, 22, 26, 35, 43, and 44. (Figures 5 and 7, Table 3 and Table 5). Another significant inconsistency exists in various places. Figure 5 shows pathway evaluations as the third step, while Figure 7 shows it as the first step.	ATSDR revised Figure 5 (now Figure 4), Figure 7, and Figure 8 to be consistent with each other.

	Public Comment	ATSDR's Response
17	Figure 7 lists chemicals with exposure-doses above cancer/non-cancer screening guidelines, and describes more realistic exposure assumptions used to further evaluate health risks due to such chemicals. Among the more realistic assumptions is consideration of site-specific receptor populations. However, Table 3, which gives exposure-dose parameters, says nothing about site-specific receptor populations in terms of location-related pathway definitions. Then the discussions, beginning on page 26, of the screening and exposure-dose evaluations for individual media, the latter of which require pathways, make no mention of pathways. Finally, on page 43, pathways are mentioned and tabulated in Figure 5, which lists the normal pathways for 16 of the 17 chemicals evaluated, the 17th being lead, which has only a pica pathway. An explicit generic statement about pathways is needed in this report, perhaps near the top of page 26. If it is conservatively assumed that the receptor populations receive their exposures at the locations of the sampling stations at which the highest concentrations were measured, no matter where those sampling stations are located, unless otherwise stated, then this assumption should be explicitly stated. Otherwise, pathways involving locations need to be described.	ATSDR removed the phrase "site-specific receptor population" from Figure 5 (now Figure 4) and Figure 7. To clarify, ATSDR added the following to a text box in Section III.C: "It is important to note that ATSDR is *assuming* exposure to the contaminated media. The location of each detection was not individually evaluated to determine whether anyone was actually being exposed."
18	P. 20 and Table 3. On page 20, the term IR is labeled as "Intake Rate," while in Table 3 the label is "Ingestion Rate." The terminology should be made uniform between the text and the table. (A common cause of this type of problem is trying to do proofreading on the screen instead of with a paper copy. Only with a paper copy can text, tables, figures, and references be viewed simultaneously to ensure consistency.)	ATSDR revised the text to consistently use the term "intake rate."
19	Pp. 21 and A-2. The definition of CSF in the glossary is too vague. Following the text on page 21, the definition of CSF should be expanded to state that it is the cancer risk per 30-year exposure averaged over 70 years.	ATSDR added the following sentence to the definition of cancer slope factor in Appendix A: "The relative potency of carcinogens is calculated by multiplying estimated chronic-exposure doses (defined in this document as a 30-year exposure averaged over 70 years) by EPA's CSFs."
20	Pp. 23–24. Although the OREIS database contains voluminous quantities of environmental sampling data, the data in OREIS came from a variety of sources and were collected for a variety of purposes. Samples were not necessarily analyzed for consistent sets of chemical constituents, nor were data quality parameters (e.g., detection limits, data validation rules, etc.) consistently applied. Section III.C. needs to be expanded to describe the methodology by which OREIS data were assessed for suitability to be used in the PHA and how any shortcomings or inconsistencies in the data were handled.	ATSDR added the following to Section III.C: "ATSDR's database manager scrutinized the data evaluated in this public health assessment to ensure proper quality assurance/quality control. ATSDR did not use any data in this evaluation that were deemed unreliable. For example, surface water data are typically reported in micrograms per liter (µg/L) or milligrams per liter (mg/L). Some surface water data in OREIS were reported in milligrams per kilogram (mg/kg). ATSDR suspected that the media code had been interpreted incorrectly and these data were actually fish data. Since this could not be confirmed, the data were not used in this evaluation."

	Public Comment	ATSDR's Response
21	Pp. 26–36. This section needs maps to show where the sampling data were collected. Where are the "off-site" locations and how are they defined? Discussion of the numbers of chemicals detected is insufficient inasmuch as the absence of any specific chemical detections in an area could be the result of omission from the analytical suite, data quality issues, or both. Any potential gaps in the data coverage need to be identified and discussed.	Appendix D contains maps showing the number of samples collected from and the number of chemicals sampled at each location in each media. ATSDR added references to the maps in Appendix D throughout Section III.D.
22	Appendix D. These figures appear to be the maps needed for Section III.D, although they do not appear to be referenced in the text. These figures need to be discussed in the text with respect to the adequacy of the data coverage for the purposes of the PHA. What is the meaning or significance of the even-numbered figures (D-2 through D-18) each entitled "Number of Chemicals Collected from…"?	ATSDR added references to the maps in Appendix D throughout Section III.D, and revised the title of the even numbered figures to be "Number of Chemicals Sampled at…"
23	Appendix D. The figures in Appendix D only show ranges of numbers of samples collected, and numbers of chemicals detected, at the plotted sampling locations, for given media and location categories. Other informative figures were presented to the PHAWG on January 21, 2003, showing all sampling locations for specific contaminants, and only those locations at which concentrations were found to exceed comparison values. Figures of this latter type would be useful additions to this PHA because they would give information about locations otherwise absent from this report.	The figures in Appendix D are provided to show the robustness of the data evaluated. The figures presented at former Public Health Assessment Work Group (PHAWG) meetings were used to visually demonstrate ATSDR's initial screening process. Only a few (of many potential) examples were selected. ATSDR's public health evaluation was based on average concentrations across multiple locations and was not a location-specific evaluation. ATSDR *assumed* that people were being exposed to the contaminated media. Each detection was not individually evaluated to determine whether anyone was actually being exposed at that location.
24	P. 29 and Figure 7. Benzo(a)pyrene is missing from Figure 7 under chemicals with exposure-doses above cancer/non-cancer screening guidelines, for fish (there were 12 chemicals in this category not 11).	The exposure doses for benzo(a)pyrene in fish were above screening guidelines during the initial screen, but below screening guidelines during the second screen. The chemicals listed under the heading of "Chemicals with Exposure Doses Above Cancer/Noncancer Screening Guidelines" are those that were detected above screening guidelines during the second screen. See the fish discussion in Section III.D for additional explanation.
25	P. 33. The note on page 33 about Figure 7 should be duplicated in the text on page 26, so that the reader can be aware of the opportunity of using the table to follow the text. Then the statement on page 33 can be expanded to explain that the list of chemicals evaluated for public health implications, as shown in Figure 7, is compiled from the list of chemicals exceeding screening guidelines above it, simply by eliminating duplications.	ATSDR added references to Figure 7 throughout Section III.D and revised the final reference to read "The list of chemicals evaluated for public health implications, as shown in Figure 7, is compiled from the list of chemicals exceeding screening guidelines. To eliminate duplication, the chemicals are combined across the different media."
26	P. 37. Again, the reader should be alerted early in Section IV that Figure 7 can be used as a reference for following the discussion of public health implications, because the discussion follows the list of chemicals evaluated, located opposite the step labeled "Contaminants of Concern."	ATSDR added the following sentence to Section IV.A: "See Figure 7 for a list of chemicals evaluated for public health implications."

	Public Comment	ATSDR's Response
27	P. 43, Figure 7, and Tables 15–32. Exposure-doses for all 17 chemicals evaluated, as listed in Figure 7, plus many more, are listed in Tables 15–32. However, in Section IV.C, tables of exposure doses are given for only 9 of the 17 chemicals evaluated. This should be stated on page 43, along with the generic technical basis, described in terms of revised and more realistic calculations, for dismissing the other eight chemicals from the complete final step in the evaluation process.	ATSDR did not dismiss eight chemicals from the final step in the evaluation process. Tables were only included in Section IV.C for those chemicals that had estimated exposure doses that exceeded screening guidelines for more than one media or species. For example, for antimony, only a child eating on-site game was above the noncancer screening guideline. The exposure dose could easily be discussed in the text and did not require a table with only one row of data. Please read Section IV.C for a complete evaluation of all 17 chemicals.
28	P. 68, line 13. A graphic depicting completed exposure pathways would be helpful.	ATSDR added an exposure pathways figure. Please see the new Figure 5 in the final PHA.
29	P. 68, last paragraph. Will the cancer incidence review be completed? Since the cancer review cannot address or imply causal associations, why is it mentioned in this PHA?	The cancer incidence review is now complete and has been included in the final PHA as a community concern in Section VI.I. The final document is available on the Internet at http://www.atsdr.cdc.gov/HAC/oakridge/phact/cancer_oakridge/index.html.
30	P. 70, line 33. The Multiple Chemical Exposures section begins on page 65.	ATSDR corrected the page number reference.
31	P. 14, Figure 4. In the third column heading, add an "e" to the word "rational."	ATSDR made the editorial change.
32	P. 74 and Table 38. Somewhere on page 74 there should be a note explaining that Table 38 contains a list of chemicals detected in Scarboro for which there were no substance-specific screening guidelines, and that therefore guidelines for similar materials were used as surrogates. The title of Table 38 should be modified by inserting the phrase, "substance-specific" after the word, "without," and the next-to-last column heading should begin with the word "Surrogate."	ATSDR moved Table 38 to Appendix B and included a reference to it in Section VI.H. ATSDR changed the title of the table to "Table B-6. Chemicals Detected in Scarboro" and added the word "surrogate" to the column header in all tables in Appendix B.
33	P. A-9. The term "screening guidelines" does not appear in the glossary so it is somewhat hard to keep straight what values are comparison values, what values are screening guidelines, and what values are health effects levels. This definition needs to be added to the glossary, explaining that screening guidelines are calculated exposure-doses, while comparison values are environmental concentrations.	ATSDR added a definition for screening guideline to Appendix A.
34	Appendix B. Each of the five tables includes a column labeled "average concentration." How were these averages determined? Are the average data sets representative of assessing exposures in the areas and media of concern?	Unless otherwise noted, average concentrations in Appendix B were calculated using detected concentrations only and do not take into account nondetected values. To clarify, ATSDR added notes to the tables in Appendix B.
35	I did not review the several data tables throughout the PHA closely, but I assume ATSDR has or will thoroughly check them and make any necessary technical or editorial corrections.	Yes, ATSDR checked the tables for technical and editorial accuracy.

	Public Comment	ATSDR's Response
36	The Citizens' Advisory Panel (CAP) agrees that evidence presented in the report supports the Agency for Toxic Substances and Disease Registry's (ATSDR) conclusion that current and potential future releases of contamination from the Oak Ridge Reservation (ORR) are unlikely to cause any detectable public health effects, acknowledging the limited data regarding dioxins and the presence of cadmium in some vegetables.	Thank you for your comment.
37	Although the document finds inconclusive results regarding potential health effects from eating food contaminated with dioxin and cadmium, it does not clearly define the pathways that these chemicals traveled from sources on the reservation to fish and vegetables, respectively. Are there any other sources of these contaminants that could account for their presence in local food?	Cadmium is a naturally occurring element and dioxins are found in areas considered "uncontaminated" due to atmospheric deposition. ATSDR evaluates potential health effects resulting from exposures, but does not evaluate the sources of these releases.
38	The report makes an effort to be understandable to the lay reader with mixed results. Graphics such as the Figure 5 foldout on page 18 are helpful. However, Table 3 (page 22) should give some idea in lay terms about what quantities the metric fractions represent (for example, compared to a teaspoonful, how much is 0.0005 kg of soil?).	For additional perspective, ATSDR added a text box under Table 3 showing rough equivalents of the intake rates.
39	On Figure 2 (page 5) the purple area (representing parcel ED-1, also known as Horizon Center) is shown as leased land, with reference to outdated (2002) information. This parcel is now in part owned by the Community Reuse Organization of East Tennessee. This should be updated to show the actual land disposition.	Because the map is outdated, ATSDR removed it from the document.
40	Figure 6 shows the ORR Health Effects Subcommittee area of interest, but fails to label the county or counties included in a small zone between Meigs and Loudon.	The area not identified on Figure 6 is part of McMinn County. It was not included on the map because ORRHES does not consider it to be one of the eight counties of interest.
41	ATSDR should review this document to ensure that reference and acronym lists are complete. Some of the acronyms are not properly explained until you get to Appendix A; all should be included in the acronym list.	ATSDR checked the reference and acronym lists.
42	The interested public would not expect to find responses to comments on the Y-12 Uranium Releases PHA as an appendix to this PHA. Appendix E should be included in a final version of the Y-12 Uranium Releases PHA and/or as a separate stand alone document. In addition, all responses to comments should be available on the ATSDR Web site.	ATSDR removed the responses to public comments on the Y-12 uranium releases PHA from Appendix E. Once completed, documents are available on ATSDR's "Oak Ridge Reservation: Public Heath Activities" Web site at http://www.atsdr.cdc.gov/HAC/oakridge/phact/index.html.

APPENDIX F

Responses to Peer Review Comments

ATSDR received the following comments from independent peer reviewers for the *Evaluation of Current (1990 to 2003) and Future Chemical Exposures in the Vicinity of the Oak Ridge Reservation* public health assessment. For comments that questioned the validity of statements made in the document, ATSDR verified or corrected the statements.

	Peer Reviewer Comment	ATSDR's Response
Does the public health assessment adequately describe the nature and extent of contamination currently in the off-site areas in the vicinity of the DOE Oak Ridge Reservation?		
1	Yes. The public health assessment adequately describes the nature and extent of contamination in the off-site areas of the DOE ORR.	Thank you for your comment.
2	Yes. The sections, figures and tables relevant to this question were reviewed. The information presented in these sources was found to be adequate in describing the nature and extent of contamination currently in the off-site areas in the vicinity of the DOE Oak Ridge Reservation. All potential sources of contamination (i.e., soil, sediment, surface water, biota, game and air) were considered.	Thank you for your comment.
3	For the most part, this document demonstrates nicely the nature and extent of contamination currently in "off-site" areas in and around the Oak Ridge Reservation.	Thank you for your comment.
Are the methods and approaches used to screen the chemical data protective of public health?		
4	Yes, the methods used to screen the chemical data are protective of public health. The methods used are generally accepted methods by the regulatory and risk assessment community.	Thank you for your comment.
5	Yes. Section III and other relevant data were reviewed and found to adequately describe the methods and approaches used to screen the chemical data. These methods and approaches are deemed to be protective of public health. The only suggestion I have at this point is to include a definition (perhaps as part of Appendix A) of the term "non-cancer" endpoints that is used throughout the document.	A definition for noncancer was added to the glossary (Appendix A).
6	Overall the general answer to this question is yes. However, this answer is premised on the specificity of chemical exposure and the current knowledge base for the dose-effect relationships between human exposure and the measure effect. Caution should be used not to overstate the impact on the current data inasmuch new information is constantly being reported on the effects of low-dose exposures and effects not seen previously in target organs.	ATSDR agrees that new toxicological information is constantly being reported and ATSDR scientists make every attempt to use the best available toxicity data when determining the public health implications of exposure to environmental chemicals. Most of the estimated exposure doses are several orders of magnitude below currently reported effect levels and, consequently, have a large margin of safety incorporated into them.

	Peer Reviewer Comment	ATSDR's Response
Does the public health assessment adequately evaluate all potential pathways of human exposure in off-site areas near the DOE Oak Ridge Reservation?		
7	Yes, the assessment evaluates all realistic potential pathways of human exposure in off-site areas of the DOE ORR.	Thank you for your comment.
8	Yes. All potential pathways of human exposure in off-site areas near the DOE Oak Ridge Reservation were adequately evaluated and described in the public health assessment document.	Thank you for your comment.
9	This issue appears to have been addressed adequately.	Thank you for your comment.
Are all relevant environmental and toxicological data (i.e., hazard identification, exposure assessment) being appropriately used?		
10	Yes, the data in the assessment are used appropriately.	Thank you for your comment.
11	Yes. All relevant environmental and toxicological data have been appropriately used in this document. Page 65, line 7 states that the NOAEL (0.35 mg/kg/day) used to derive the intermediate-duration MRL is from an animal study and incorporates an uncertainty factor of 300. There is no reference given for the animal study. A large study on toxaphene has been conducted in monkeys and the immunology part of it has been published. I wonder if this study's results were taken into consideration in deriving the MRL. In any case the reference is listed here for your convenience: H. Tryphonas et al. 2001. Effects of toxaphene on the immune system of cynomolgus (*Macaca fascicularis*) monkeys. Food Chem Toxicol 39: 947–958.	Thank you for your comment. The derivation of the minimal risk level (MRL) is described in ATSDR's toxicological profile for toxaphene (1996). The reference animal study is: Chu et al. 1986. Toxicity of toxaphene in the rat and beagle dog. Fundam Appl Toxicol 7:406-418. Thank you for providing the newer study information. ATSDR did not consider the Tryphonas el al. (2001) animal study in the derivation of the intermediate MRL because it was a chronic study and it was published after the August 1996 toxicological profile release date. The lowest-observed-adverse-effect level (LOAEL) in the Tryphonas et al. (2001) study is reported to be 0.4 mg/kg/day, and the no-observed-adverse-effect level (NOAEL) is 0.1 mg/kg/day. The exposure doses that ATSDR estimated (see Table 15) are well below both these effects levels. Therefore, this newer study further supports ATSDR's conclusions that adverse effects are not expected from exposure to toxaphene in the fish evaluated in this PHA.
12	To the extent that the current criteria documents on specific chemicals provide the nature and extent of the adverse effects of the chemical of interest and importance, the current document presents data consistent with these.	Thank you for your comment.
Does the public health assessment accurately and clearly communicate the current and future public health hazards to off-site populations living in the vicinity of the DOE Oak Ridge Reservation?		
13	Yes, the assessment accurately and clearly communicates the current and future hazards to off-site populations.	Thank you for your comment.

	Peer Reviewer Comment	ATSDR's Response
14	Yes. In addition to the information communicated within this report there are several valuable reference sites and contacts of offices listed for those who are interested in obtaining further information.	Thank you for your comment.
15	It depends on which group you are targeting. The lay population may not appreciate some aspects of the presentation. The rationale for choosing a chemical of importance for monitoring is lacking in a number of instances.	ATSDR worked closely with the Oak Ridge Reservation Health Effects Subcommittee (ORRHES) during the screening process. However, some members of the public may still have questions regarding the conclusions and recommendations. ATSDR welcomes comments and questions and will try to address them in a format that best communicates the public health message to the specific audiences. Independent of ATSDR's screening evaluation, chemicals were selected for environmental monitoring based on historic use, detections, and/or potential for release. ATSDR's screening evaluation was not designed to identify chemicals for environmental monitoring; rather, it was conducted to identify chemicals requiring further evaluation to determine whether they are present at levels constituting a health hazard (see Section III and Figure 5—now Figure 4—for ATSDR's screening process).
Are the conclusions and recommendations appropriate in view of the current off-site conditions as described in the public health assessment?		
16	The recommendations may need expansion based on discussions within the report text. That is, on page 43 (lines 1 and 2) a recommendation is made that all children have their blood lead levels tested. This is not repeated on page 80 (Section VIII. Recommendations). Similarly, a recommendation is made on page 53 (lines 9–13) that residents might take alternative measures for vegetable garden construction. This recommendation is not repeated in Section VIII.	Upon further consideration, ATSDR removed the recommendation that all children have their blood lead levels tested because the scenario that prompted the recommendation was highly hypothetical and based on a worst-case scenario. (For more information about routine childhood blood lead testing see the response to comment 21.) Upon re-evaluation, ATSDR realized that a mistake had been made in the calculations for cadmium; when this mistake was corrected, the warning to take alternate measure for vegetable garden construction were no longer needed.
17	Yes. The conclusions and recommendations based on the current off-site conditions and findings as described in the public health assessment document are appropriate.	Thank you for your comment.
18	Overall, the answer is yes.	Thank you for your comment.
Are there any other comments about the public health assessment that you would like to make?		
19	The report was well written.	Thank you for your comment.

	Peer Reviewer Comment	ATSDR's Response
20	I found the legend for Figure 6 (ORRHES) difficult to follow. There seemed to be more colors on the map than there were provided in the legend.	A revised version of Figure 6 is included in the final PHA.
21	On page 43, lines 1 and 2, it is recommended that "all children" have their blood lead levels tested. "ALL" encompasses an undefined area. Perhaps it makes sense to reference the appropriate residential area(s) affected.	Upon further consideration, ATSDR removed the recommendation that all children have their blood lead levels tested because the scenario that prompted the recommendation was highly hypothetical and based on a worst-case scenario. ATSDR clarified the guidance in the text box to be specific to children between the ages of 6 months and 6 years at high risk for having elevated blood lead levels. In response to information about the distribution and prevalence of lead poisoning among U.S. children, the Centers for Disease Control and Prevention (CDC) changed its national blood lead screening recommendations to a state-based approach. In *Screening Young Children for Lead Poisoning: Guidance for State and Local Public Health Officials*, CDC called on state health departments to develop plans to ensure screening of all children at high risk for having elevated blood lead levels.[25]
22	On page 58, line 18, heptachlor epoxide in game is discussed as "not at levels of health concern," but in the footnote (number 16), we learn that heptachlor epoxide was not sampled in game.	ATSDR added the word "on-site" before "game" because the level of heptachlor epoxide detected during the limited sampling was below screening levels. The footnote states that heptachlor epoxide was not sampled in **off-site** game.
23	This document presents nicely historically relevant facts and the nature and importance of the monitoring around Oak Ridge.	Thank you for your comment.

[25] CDC. 1997. Screening young children for lead poisoning: guidance for state and local public health officials. Atlanta, GA: US Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention.