Draft for
Public Comment

PUBLIC HEALTH ASSESSMENT
Polychlorinated Biphenyl (PCB) Releases: Oak Ridge Reservation (USDOE)

Oak Ridge, Anderson County, Tennessee
CERCLIS NO. TN1890090003

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Foreword

The Agency for Toxic Substances and Disease Registry (ATSDR) was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The U.S. 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 the exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations; the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When not enough environmental information is available, 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 contacts could result in harmful effects. ATSDR recognizes that children—because of their play activities and growing bodies—can be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to children is considered first when evaluating the health threat to a community. The health impacts to other high-risk groups within the community (such as the elderly, chronically ill, and people engaging in high-risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicological, and epidemiological studies and the data collected in disease registries, to determine the health effects that can 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 these cases, the report will suggest what further public health actions are needed.

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

Because ATSDR is primarily an advisory agency, these reports usually identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. If an urgent health threat exists, however, 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 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, ATSDR encourages you to send them to us.

Letters should be addressed as follows:

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List of Abbreviations

ABMT	American Board of Medical Toxicology
ALS	amyotrophic lateral sclerosis
AOEC	Association of Occupational and Environmental Clinics
ATSDR	Agency for Toxic Substances and Disease Registry
B.A.	Bachelor of Arts
B.S.	Bachelor of Science
BSCP	Background Soil Characterization Project
CD	Cluster of Differentiation (e.g., CD3, CD4, CD8, CD56)
CDC	Centers for Disease Control and Prevention
CEDR	Comprehensive Epidemiologic Data Resource
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	CERCLA Information System
cm	centimeter(s)
COPD	chronic obstructive pulmonary disease
CRM	Clinch River mile
DABT	Diplomate of the American Board of Toxicology
DDT	dichlorodiphenyltrichloroethane
DNA	deoxyribonucleic acid
DOE	U.S. Department of Energy
EFPC	East Fork Poplar Creek
EI	exposure investigation
EMEG	environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
ER^-	estrogen receptor negative
ETTP	East Tennessee Technology Park
FACA	Federal Advisory Committee Act
FAMU	Florida Agriculture and Mechanical University
FFA	Federal Facility Agreement
g	gram(s)
g/day	gram(s) per day
g/ml	gram(s) per milliliter
HazDat	Hazardous Substance Release and Health Effects Database
HRSA	Health Resources Services Administration
Ig	immunoglobulin (e.g., IgA, IgE, IgG, IgM)
kg	kilogram
LNT	linear no-threshold
LOAEL	lowest-observed-adverse-effect level
LOD	limit of detection
M.B.A.	Master of Business Arts
MCP	Microsoft Certified Professional
M.D.	Medical Doctor
mg	milligram(s)
mg/day	milligrams per day
mg/kg	milligrams per kilogram

List of Abbreviations (continued)

mg/kg/day	milligrams per kilogram per day
µg/L	micrograms per liter (= ppb, or parts per billion)
µg/kg	micrograms per kilogram
$\mu g/m^3$	micrograms per cubic meter
MPH	Master of Public Health
MRL	minimal risk level
MS	multiple sclerosis
M.S.	Master of Science
NA	not applicable
NCEH	National Center for Environmental Health
ng/ml	nanograms per milliliter
NHANES	National Health and Nutrition Examination Survey
NIH	National Institute of Health
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no-observed-adverse-effect level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OREIS	Oak Ridge Environmental Information System
ORHASP	Oak Ridge Health Agreement Steering Panel
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORRHES	Oak Ridge Reservation Health Effects Subcommittee
PBPK	physiologically based pharmacokinetic
PCB	polychlorinated biphenyl
PCM	Poplar Creek mile
PHA	public health assessment
PHAP	Public Health Action Plan
Ph.D.	Doctor of Philosophy
ppb	parts per billion
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
R.N.C.	Registered Nurse, Certified
TBG	thyroxin-binding globulin
TDEC	Tennessee Department of Environment and Conservation
TDOH	Tennessee Department of Health
TN	Tennessee
TRM	Tennessee River Mile
TSCA	Toxic Substances Control Act
TSH	thyroid stimulating hormone
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
UF_6	uranium hexafluoride
U.S.	United States
USACE	U.S. Army Core of Engineers

I. Summary

In 1942, the federal government established the Oak Ridge Reservation (ORR) in Anderson and Roane Counties, Tennessee as part of the Manhattan Project to research, develop, and produce special radioactive materials for nuclear weapons. Four facilities were built at that time: the Y-12 plant, the K-25 site, and the S-50 site (now part of the K-25 site) to enrich uranium, and the X-10 site to manufacture and separate plutonium. Since the end of World War II, the role of the ORR (Y-12 plant, K-25 site, and X-10 site) has broadened to include a variety of nuclear research and production projects vital to national security.

During its long history, ORR operations have released polychlorinated biphenyls (PCBs) and generated a variety of other nonradioactive and radioactive wastes that have been released into the environment and are now present in old waste sites. As a result, in 1989 the U.S. Environmental Protection Agency (EPA) added the ORR to the National Priorities List (NPL). The U.S. Department of Energy (DOE) is conducting cleanup activities at the ORR under a Federal Facility Agreement (FFA) with EPA and the Tennessee Department of Environment and Conservation (TDEC). These agencies are working together to investigate and remediate hazardous waste generated from past and present site activities.

Since 1992, the Agency for Toxic Substances and Disease Registry (ATSDR) has responded to requests from and addressed health concerns of community members, civic organizations, and other government agencies. ATSDR is the principal federal public health agency charged with evaluating human health effects of exposure to hazardous substances in the environment. To address these concerns and requests, ATSDR has worked extensively, with input and assistance from the community, to determine whether levels of environmental contamination at and near the ORR present a public health hazard to surrounding communities. In the process ATSDR has identified and evaluated several public health issues and has worked closely with many parties. During the 1990s, ATSDR's activities focused on current public health issues related to Superfund cleanup activities at the site. ATSDR addressed public health issues associated with three off-site areas affected by ORR operations: the East Fork Poplar Creek area, Clinch River/Poplar Creek, and the Lower Watts Bar Reservoir. While ATSDR has evaluated current Superfund issues, the Tennessee Department of Health (TDOH) has conducted the Oak Ridge Health Studies to evaluate whether off-site populations have in the past undergone exposures.

During the Oak Ridge Health Studies, the TDOH conducted extensive reviews and screening analyses of available information. The TDOH identified four hazardous substances that might have been responsible for adverse health effects: PCBs in fish from East Fork Poplar Creek, Clinch River, and Watts Bar Reservoir; mercury released from the Y-12 plant; iodine from X-10 activities; and radionuclides released to White Oak Creek from X-10 activities. In addition to dose reconstruction studies on these four substances, the TDOH conducted additional screening analyses for releases of uranium, radionuclides, and several other toxic substances.

To expand upon the efforts of the TDOH—but not duplicate them—ATSDR scientists conducted a review and a screening analysis of the department's screening level evaluation of past exposure (1944 to 1990) to identify contaminants that require further evaluation. Using this review, ATSDR scientists are conducting Public Health Assessments (PHAs) on the releases of PCBs

from the ORR, uranium releases from Y-12, mercury releases from Y-12, iodine-131 releases from X-10, radionuclides from White Oak Creek, a uranium and fluorides release from K-25, and on other topics, such as the Toxic Substances Control Act (TSCA) incinerator and off-site groundwater.

In addition, ATSDR is screening current (1990 to 2003) environmental data to identify any other chemicals that require further evaluation. In these PHAs, ATSDR scientists evaluate and analyze the data and findings from previous studies and investigations to assess the public health implications of past and current exposure.

This PHA only evaluates PCB releases from the ORR into nearby off-site waterways, including the East Fork Poplar Creek, Clinch River, Tennessee River, and Lower Watts Bar Reservoir. The PHA assesses past and current PCB exposure for people who use or who live along these waterways and addresses the community health concerns and the issues related to PCB contamination in the water, to sediment and nearby soil, and to the aquatic food chain associated with the waterways.

The PCBs released from the ORR originated from the large electrical energy requirements (in transformers and capacitors) necessary the production of uranium and plutonium isotopes at K-25, X-10, and Y-12 and from machining operations (e.g., cutting oils and cooling fluids). During these uses and in later waste disposal, oily PCB fluids spilled on the ground and entered ponds and creeks that flowed into, or were carried by soil suspended in water to, Poplar Creek, East Fork Poplar Creek, Clinch River, and the Watts Bar Reservoir. The TDOH documented detailed information about these historical occurrences.

Using the findings of investigations conducted by various agencies, available environmental data, and the results of previous ATSDR studies, ATSDR closely examined the nature and extent of PCB contamination in the ORR's nearby waterways and evaluated past and current exposure situations. In the initial ATSDR screening evaluation in Section III (Evaluation of Environmental Contamination and Potential Exposure Pathways), ATSDR concluded that the levels of PCB contamination that entered the water, sediment, and soil of East Fork Poplar Creek, Poplar Creek, Clinch River, and Tennessee River, as well as those that reached the downstream Lower Watts Bar Reservoir, are in each case too low to cause observable adverse health effects for the people who used or who continue to use these waterways and associated floodplains for drinking, swimming, farming, and gardening. This conclusion is based on ATSDR's screening evaluation of the TDOH's Oak Ridge Health Studies conclusions and on its own evaluation of data on PCB contamination of environmental media, both biological and nonbiological. This screening evaluation indicates, however, that some people who ate fish or geese from these waterways received higher doses than the ATSDR's screening minimal risk levels (MRLs). Therefore, the health effects of fish and geese consumption are evaluated in more depth in Section IV (Public Health Implications).

Screening Evaluation of Past Exposure (1944–1995)

Using its evaluation of past exposure to PCBs, ATSDR determined that none of the exposure pathways involving intake of PCB-contaminated sediment, airborne PCB contamination, and waterborne PCB contamination are a public health hazard. Nevertheless, ATSDR conducted a more in-depth public health evaluation to determine whether it was safe to eat fish and geese in the past.

ATSDR began the screening evaluation by reviewing Reports of the Oak Ridge Dose Reconstruction (Task 3), *PCBs in the Environment Near the Oak Ridge Reservation, A Reconstruction of Historical Doses and Heath Risks* (ChemRisk 1999a) (referred to as the "Task 3 report"). This conservative (i.e., protective) evaluation, stated the levels of PCBs in the air, water in all the waterways, and sediment in Poplar Creek, Clinch River, and Watts Bar Reservoir are not a public health hazard. For the 13 exposure pathways not eliminated, ATSDR screened PCB concentrations in the East Fork Poplar Creek sediment and soil and the fish from all the waterways separately. For nonbiological media, such as sediment or soil, ATSDR compared the distribution of contamination with protective comparison values developed for children and adults exposed for chronic and intermediate durations. For biological media, such as fish and geese, ATSDR compared distribution of PCB contamination with specially developed ORR-specific comparison values. ATSDR derived these values using consumption data on moderate to high consumers of Watts Bar Reservoir fish and ATSDR's minimal risk level for chronic exposure to PCBs.

ATSDR delineated the fish-consuming groups from the fish consumption information collected during the Watts Bar Exposure Investigation (ATSDR 1998).

- ATSDR found that no source of sediment below any body of water, at any distance from sediment beds in a floodplain, or taken from any depth (deposited at any time) was sufficiently contaminated with PCBs that illness could result from any duration of exposure to adults or children. Thus, all pathways based on direct or indirect intake of PCB-contaminated sediment are eliminated. Therefore, none of the PCB levels in the sediment and soil in any of the evaluated waterways are a public health hazard.
- The PCB levels found in some species of fish exceeded the comparison values for some consumption groups. Therefore, eating fish was retained for further in-depth health effects evaluation.
- The median PCB concentration in Canada geese exceeded the comparison values for moderate and high consumption. Therefore, eating geese was retained for further in-depth health effects evaluation.

Screening Evaluation of Current Exposure (1996–Present)

Using its evaluation of current exposure to PCBs, ATSDR determined that no pathway involving intake of PCB-contaminated sediment, airborne PCB contamination, waterborne PCB contamination, or turtle meat is a public health hazard. ATSDR conducted a more in-depth public health evaluation regarding the safety of fish consumption.

- Sediment sampled in 1996 and later was less contaminated than sediment sampled earlier than that date. PCBs were not detected in most samples, and where PCBs were found, the concentrations were all below ATSDR comparison values. As in the case of earlier samples, ATSDR found no sediment below any body of water or at any distance from sediment beds that was sufficiently contaminated with PCBs that illness could result from any duration of exposure. Therefore, sediment is not a public health concern.
- Waterborne PCB contamination is not a likely source of illness. Given the relative sediment and water solubility of PCBs, the potential maximum PCB concentrations in the water are well below ATSDR's comparison values for drinking water. Further, TDEC's Division of Water Supply regulates drinking water at all public water systems. According to EPA's Safe Drinking Water Information System, the Kingston and Spring City public water supply systems have not had any significant violations. Recreational exposure (e.g., from swimming or water-skiing) is even less likely to cause illness than drinking the water. Therefore, neither surface water nor groundwater is a public health concern.
- The ORR does not currently release PCBs into the air. Besides, the air pathway makes less of a contribution to PCB exposure than sediment or water. ATSDR has shown that sediment and water pathways did not carry sufficient PCB concentrations to be of health concern. Therefore, the air pathways from 1996 onward are similarly of no health concern.
- For the Clinch River, Tennessee River, and the Lower Watts Bar Reservoir, fish fillets had higher PCB levels than whole fish. Concern over eating fish was eliminated for some consumption groups, but not for all. Therefore, eating fish was retained for further in-depth health effects evaluation.
- Turtle meat (muscle) was not sufficiently contaminated with PCBs to be a likely source of PCB-related illness. Therefore, eating turtle meat is not a public health concern. People should, however, avoid eating turtle fat. Discarding the fat, eggs, and all organs—while only saving the meat for eating—can reduce PCB exposure.
- Serum PCB levels of moderate to high consumers of Watts Bar Reservoir fish are slightly lower than national norms for total PCBs.

Public Health Implications of Eating Fish and Geese

ATSDR's review of PCB body burdens nationwide found that people occupationally exposed to PCBs have much greater body burdens than do those who consume PCB-contaminated fish. Fish consumers have greater body burdens than the general population, and the difference between fish consumers and nonconsumers has increased over time. Body burdens of people who ate fish from Watts Bar Reservoir or the Clinch River are below those of people exposed occupationally, above those of nonfish consumers, and within the national norm for those who consume sport fish.

Cancer is an unlikely health outcome from eating PCB-contaminated fish near ORR. Nevertheless, due to the potential for noncancer health effects, prudent public health practice would limit high-quantity consumption of *certain fish species* (see Figure 1). ATSDR has therefore categorized the frequent eating of one or more meals a week, over an extended period of time, of *certain species of fish* (catfish, white bass, hybrid bass [striped bass-white bass], striped bass, and largemouth bass) as a public health hazard. But eating any amount of sunfish species or one fish meal per month of other fish species is not a public health hazard. That said, however, given that exposure to PCBs can cause developmental problems, certain sensitive populations such as pregnant women and children should be particularly careful to avoid eating *certain species of fish* from Poplar Creek, the Clinch River, the Tennessee River, and Lower Watts Bar Reservoir.

Catfish

- Children should eat no more than one fish meal per month from Poplar Creek, the Clinch River, the Tennessee River, and the Lower Watts Bar Reservoir.
- Adults should eat no more than one fish meal per week from Poplar Creek, the Clinch River, the Tennessee River, and the Lower Watts Bar Reservoir.

White Bass, Hybrid Bass (Striped Bass-White Bass), and Striped Bass

- Children should eat no more than one fish meal per month from Poplar Creek, the Clinch River, and the Tennessee River; and no more than one fish meal per week from the Lower Watts Bar Reservoir
- Adults should eat no more than one fish meal per week from Poplar Creek and the Clinch River; and no more than two fish meals per week from the Tennessee River.

Largemouth Bass

- Children should eat no more than one fish meal per week from the Clinch River; and no more than two fish meals per week from the Tennessee River.

Fish is a healthy food that provides many nutritional benefits. Some of the fish from Poplar Creek, the Clinch River, the Tennessee River, and Lower Watts Bar Reservoir can safely be consumed in lower quantities.

- Sunfish species from Poplar Creek, the Clinch River, the Tennessee River, and the Lower Watts Bar Reservoir are safe to eat in any amount.
- Largemouth bass from Poplar Creek and the Lower Watts Bar Reservoir are safe to eat, even in high amounts. From the Clinch River and the Tennessee River largemouth bass can be safely consumed in moderate to low quantities.
- Low quantities of any species of fish—even catfish—are safe to eat.
- Canada geese are safe to eat in any amount.

If community members are concerned and wish to reduce their exposure to PCBs without forfeiting the health benefits gained from eating fish, they can follow these suggestions:

- Eat the less fatty parts of the fish; throw away skin, fat deposits, head, guts, kidneys, and liver.
- Remove the skin and the strip of light-colored fat that remains along the belly flap at the bottom of the fillet as well as any fat that may be present along the sides and the midpoint of the back.
- Grill, broil, or bake fish on a rack to allow fat—and chemicals—to drain away. This helps remove pollutants stored in the fatty parts of the fish. Avoid frying for larger, fatty fish.
- Do not reuse cooking liquids or fat drippings from the fish—these liquids retain PCBs.
- Choose to eat younger (or smaller) fish and those lower on the food chain (e.g., sunfish).

CONCLUSIONS

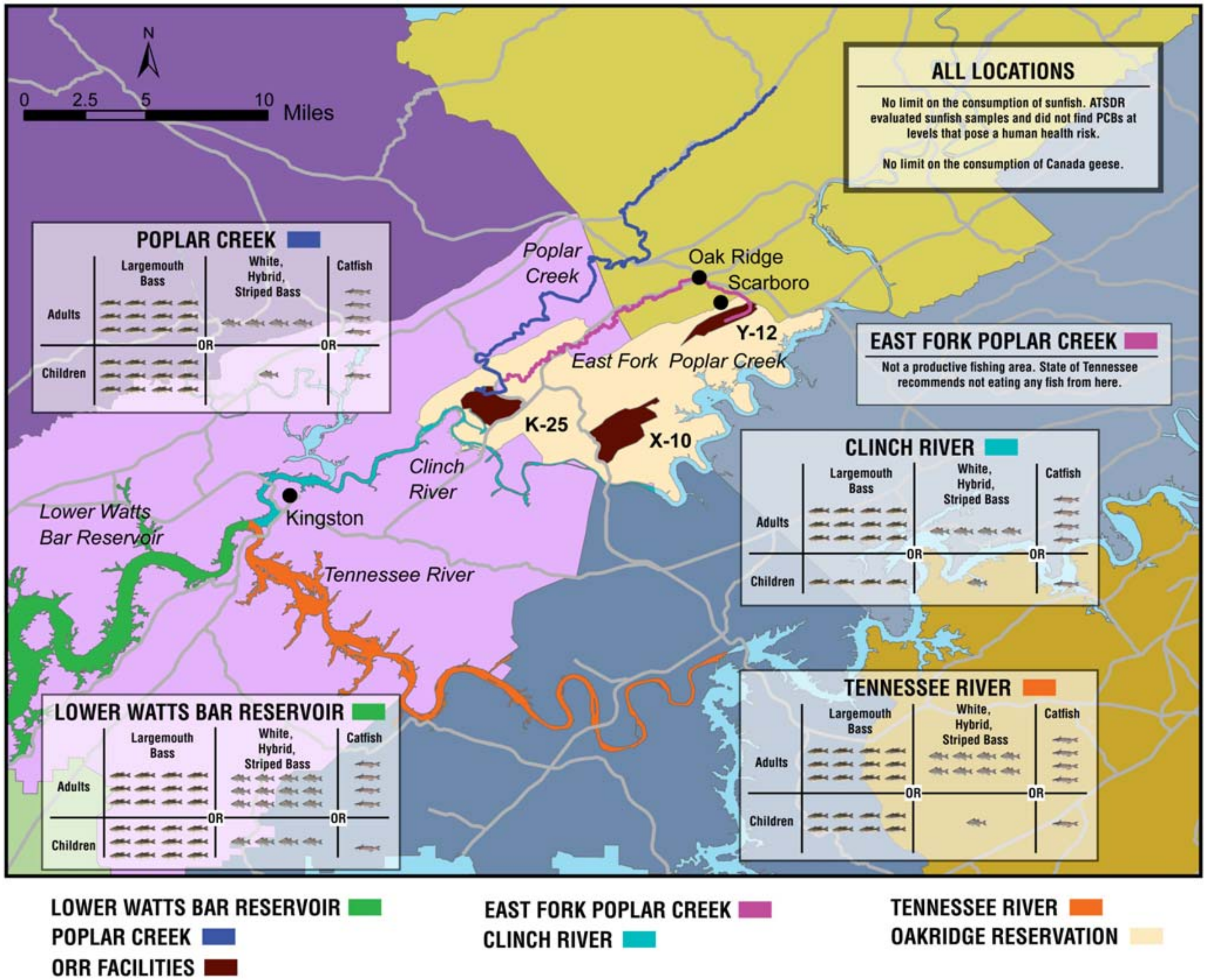
Sunfish species can be safely eaten in any amount.

All fish species can be safely eaten in low amounts from any water body near ORR.

Eating moderate to high amounts of certain species of fish (catfish, white bass, hybrid striped bass, and striped bass) is not recommended. ATSDR recommends that to reduce their exposures, people should follow the fish advisory.

People should avoid eating turtle fat. Discarding the fat, eggs, and all organs—while only saving the meat (muscle) for eating—can reduce exposure to PCB-contaminated fat and tissue.

Figure 1. Maximum Number of Fish Meals That Can Safely Be Eaten per Month



Notes: One adult meal of fish is considered to be 8 ounces (227 grams). Children were assumed to eat one-third as much as adults.
Each fish represents one fish meal per month.

II. Background

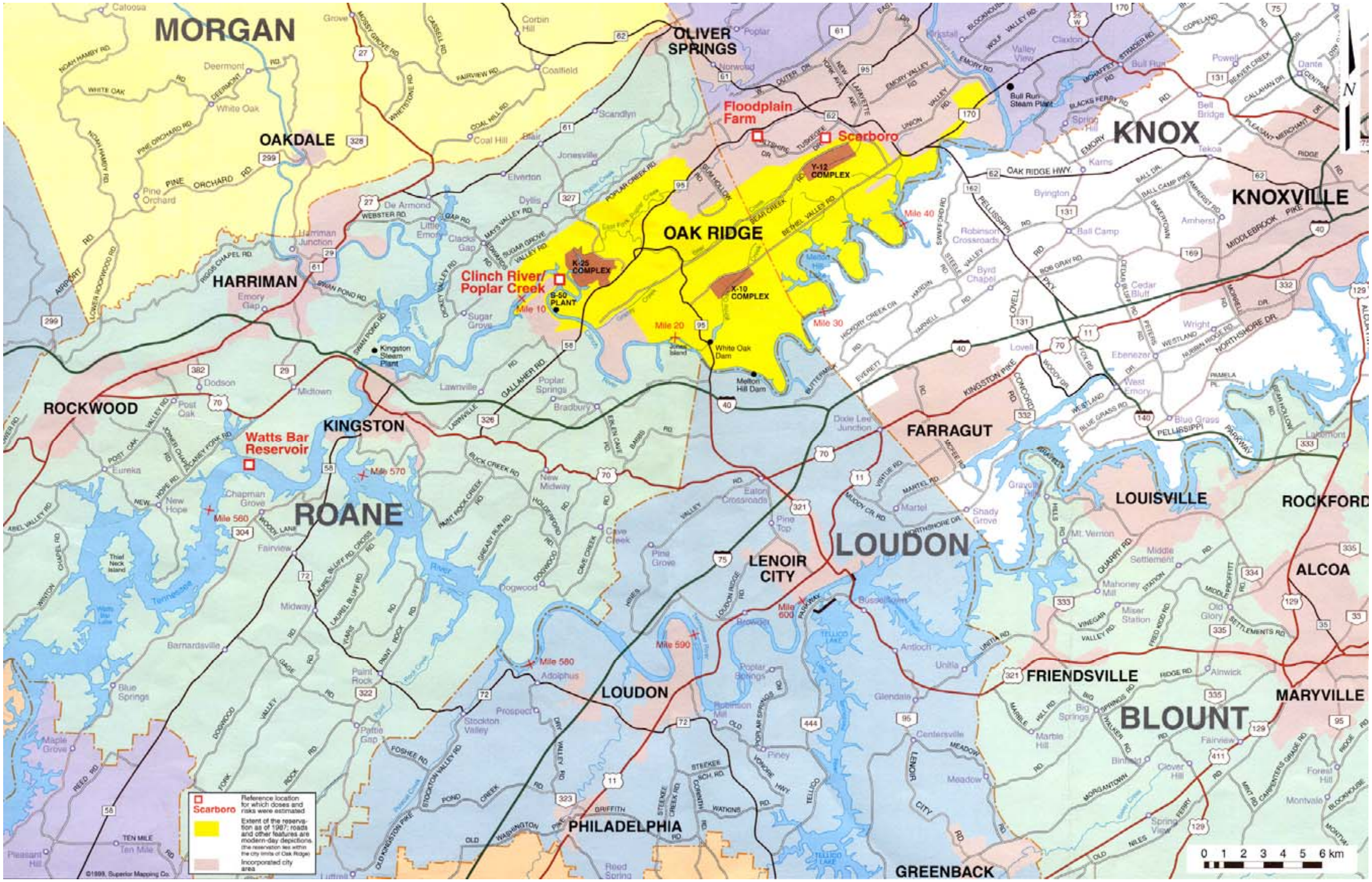
II.A. Site Description

In 1942, shortly after the United States entered World War II, the federal government built the Oak Ridge Reservation (ORR) under the Manhattan Project initiative to manufacture and study nuclear products for nuclear weapons (ChemRisk 1993a; TDOH 2000). The ORR is in the city of Oak Ridge, in eastern Tennessee, about 15 miles west of Knoxville, straddling Roane and Anderson Counties (ChemRisk 1993a; Jacobs Engineering Group Inc 1996; ORNL 2002). The southern and western borders of the ORR are formed by the Clinch River. The city of Oak Ridge forms ORR’s northern and eastern borders (see Figure 2) (EUWG 1998; ORNL 2002).

When the federal government acquired the ORR the reservation occupied 58,575 acres. The federal government has since conveyed away 24,340 of the original 58,575 acres, and the U.S. Department of Energy (DOE) now controls 34,235 acres (Jacobs Engineering Group Inc 1996; ORNL 2002). The rest of the land is managed by other entities (e.g., the city of Oak Ridge and the Tennessee Valley Authority (TVA)) (ORNL 2002). Figure 3 shows the old and new boundaries.

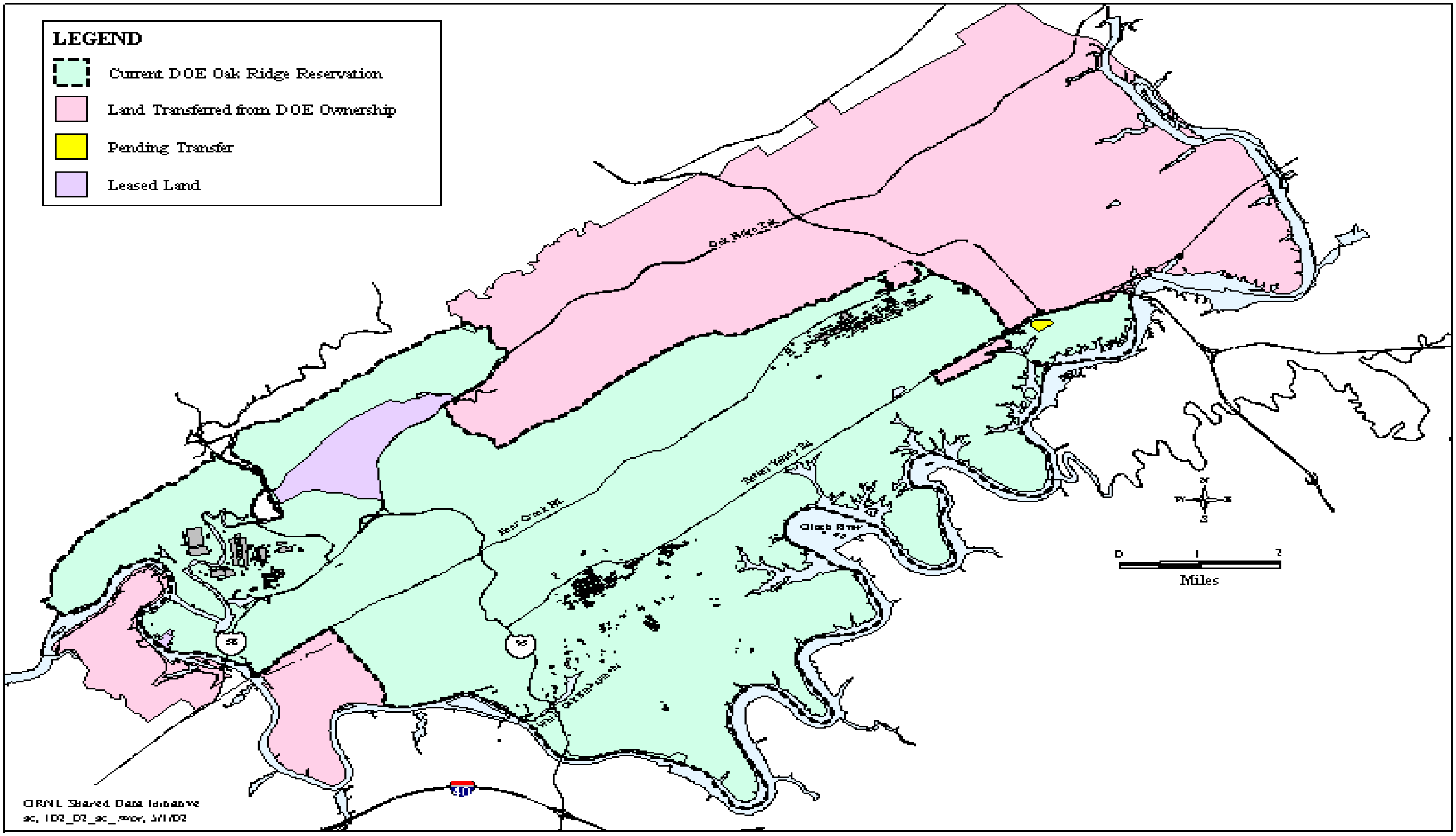
During the Manhattan Project the government constructed four facilities at the ORR. Three sites, the K-25 site (formerly known as the Oak Ridge Gaseous Diffusion Plant and now referred to as the East Tennessee Technology Park [ETTP]), the Y-12 plant (now known as the Y-12 National Security Complex), and the former S-50 site were developed to manufacture enriched uranium (ChemRisk 1993a; Jacobs Engineering Group Inc 1996; TDEC 2002; TDOH 2000). The X-10 site (formerly known as the Clinton Laboratories and now referred to as the Oak Ridge National Laboratory) was developed to manufacture and separate plutonium.

Figure 2. Location of the Oak Ridge Reservation



Source: ChemRisk 1999a

Figure 3. Original and Current ORR Boundaries



Source: ORNL 2002

II.A.1. The K-25 Site (now referred to as the East Tennessee Technology Park)

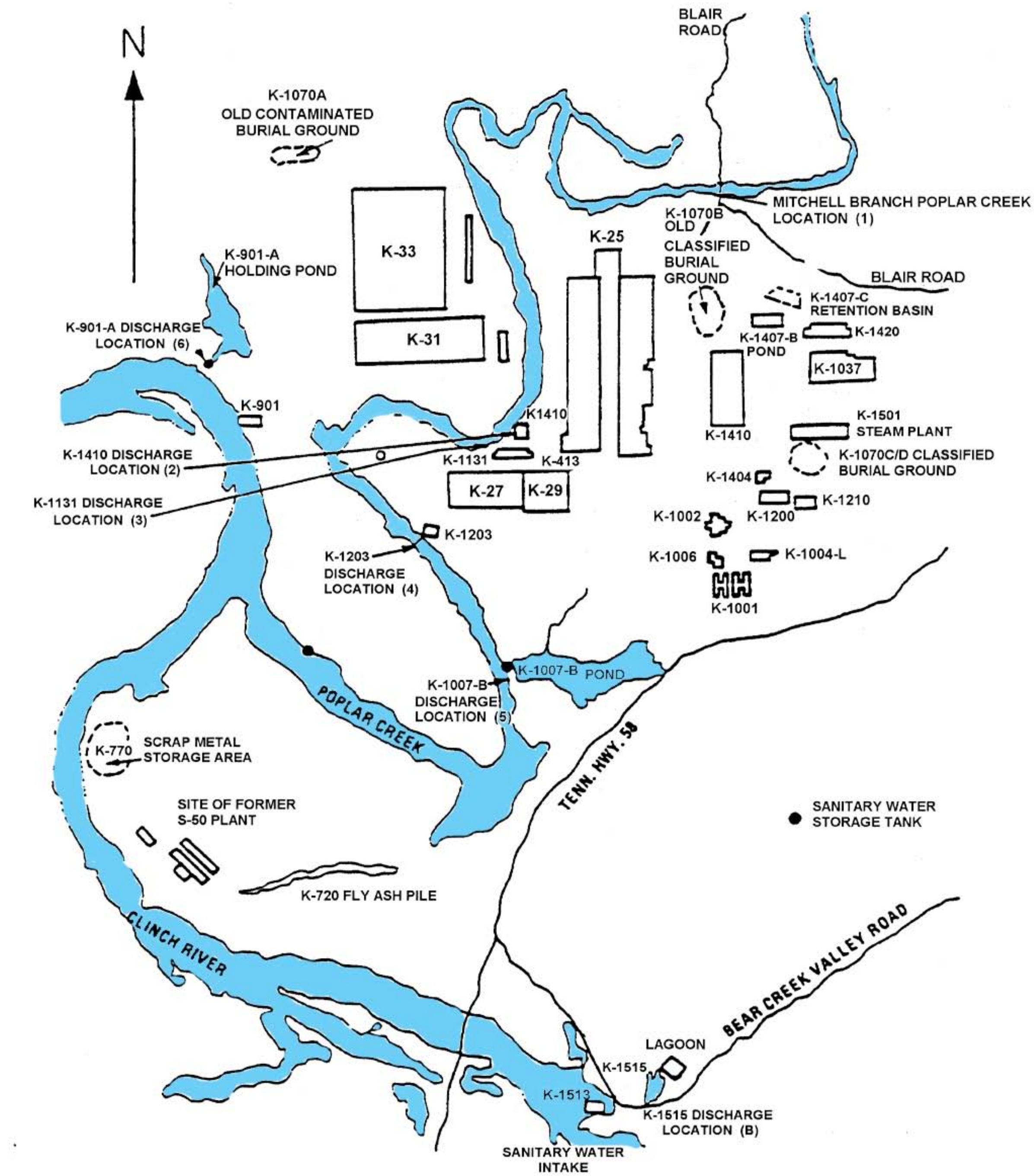
The K-25 site occupies 600 hectares (1,500 acres) within the ORR adjacent to the Clinch River, approximately 21 kilometers (13 miles) west of downtown Oak Ridge, Tennessee (U.S. DOE 1997). The boundaries of the K-25 watershed are Black Oak Ridge on the north, West Pine Ridge on the south, and the Clinch River to the west. The eastern boundary comprises Blair Road, Highway 58, and Highway 95. As shown in Figure 2, downstream of its confluence with East Fork Poplar Creek, Poplar Creek winds through the K-25 area to the Clinch River at the area's southern boundary. The Clinch River then joins the Tennessee River, which flows into Lower Watts Bar Reservoir.

Historically at the K-25 Site uranium isotopes were separated by gaseous diffusion; site activities have now however broadened to include incinerating waste PCBs left over from the electrical system that powered the pumps needed for that gaseous diffusion (ChemRisk 1993a). The site is complex, with multiple facilities and disposal sites (ChemRisk 1993a). Gaseous diffusion alone used five buildings in the northern part of the K-25 site. Thermal separation processes took place in three buildings in southwestern K-25 later used for incineration, warehousing, and beryllium processing. At least 500 other buildings scattered through K-25 housed various support operations. Waste disposal included a sewage treatment plant, a neutralization facility and pits, dilution pits, holding ponds, a retention basin, lagoons, incinerators, drum and other waste storage areas, burn areas, ash piles, burial grounds, and scrap metal dumpsters. Figure 4 shows K-25 area facilities.

II.A.2. The Y-12 Plant (now known as the Y-12 National Security Complex)

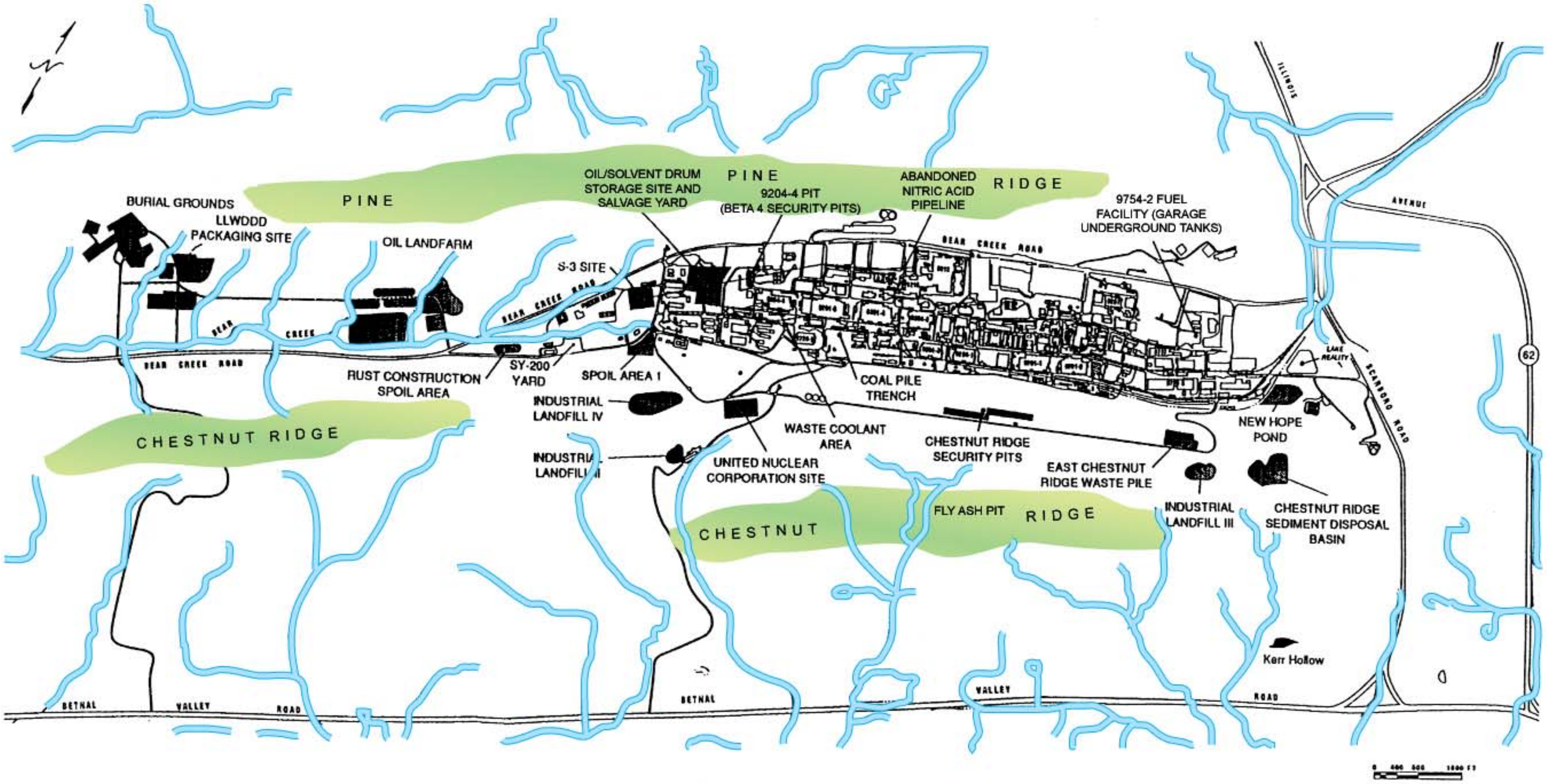
The Y-12 plant is in the eastern end of Bear Creek Valley, about ½ mile from the center of Oak Ridge (ChemRisk 1999c). It is bordered on the south by Chestnut Ridge and on the north by Bear Creek Road and Pine Ridge (ChemRisk 1999a) (see Figure 5). The main Y-12 production area is 0.6 miles wide and 3.2 miles long. The area contains some 240 principal buildings, of which 18 directly processed or stored uranium compounds (ChemRisk 1999c). The 825-acre Y-12 plant is within Oak Ridge corporate limits, 2 miles south of downtown (ChemRisk 1999c; TDOH 2000). Scarboro is less than ½ mile away. Pine Ridge, which rises to about 300 feet above the valley floor, separates Y-12 from most of residential Oak Ridge (TDOH 2000). Bear Creek begins at the west end of Y-12 and flows 8 miles southwest to its confluence with East Fork Poplar Creek (ChemRisk 1999a). The headwaters of East Fork Poplar Creek run through a series of underground pipes extending along the western and southern ends of Y-12. The aboveground part of East Fork Poplar Creek begins along the central portion of the southern boundary of the plant, flows in a northwest direction through a gap in Pine Ridge, and continues through commercially zoned areas in Oak Ridge before meandering west towards its confluence with Poplar Creek (ChemRisk 1999a).

Figure 4. Oak Ridge Gaseous Diffusion Plant Site Map



Source: ChemRisk 1999a

1 **Figure 5. Map of the Y-12 Plant Site**



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3 Source: ChemRisk 1999a

II.A.3. The X-10 Site (now referred to as the Oak Ridge National Laboratory)

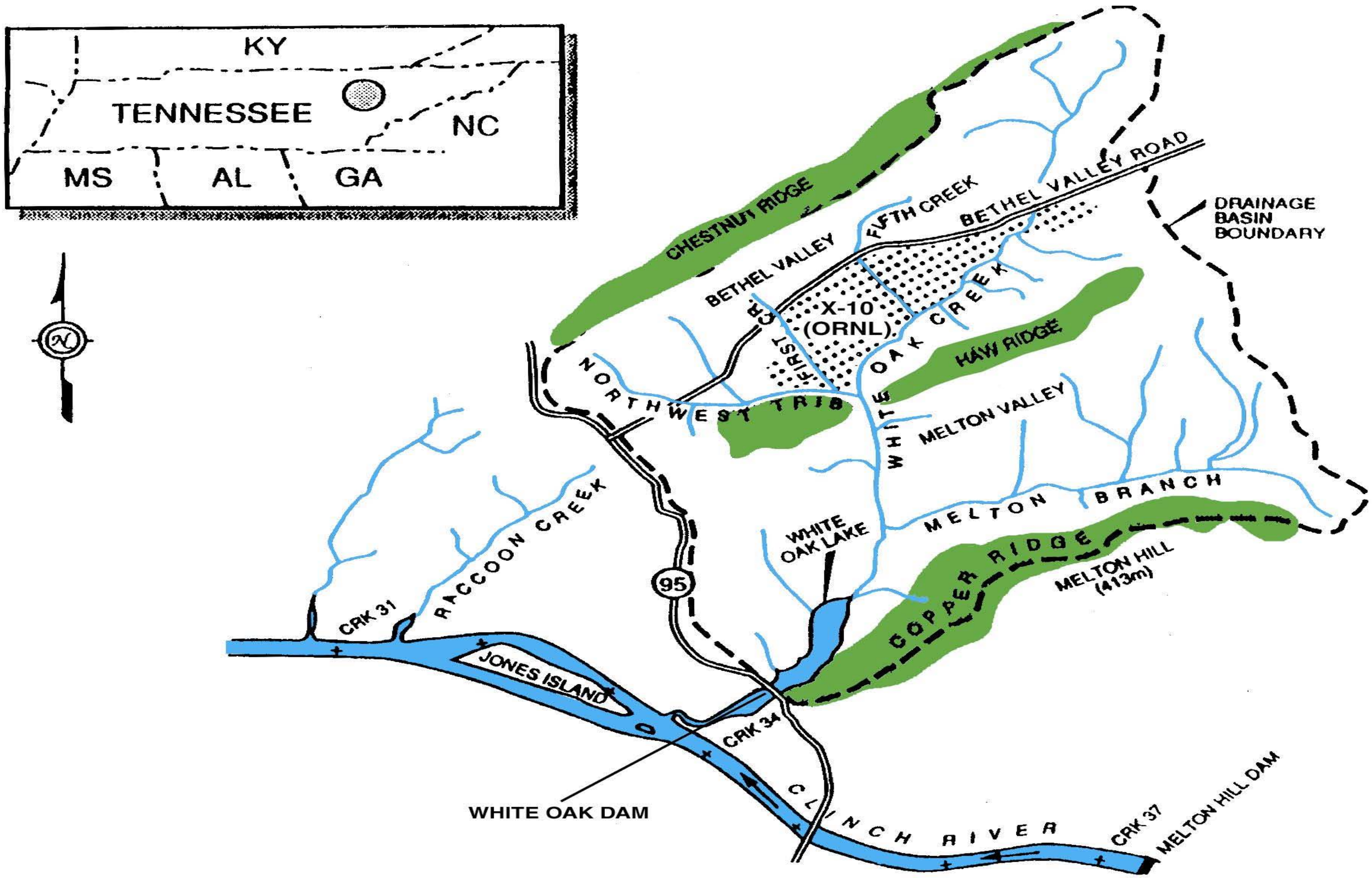
The original X-10 site is part of the Oak Ridge National Laboratory (ORNL), which encompasses 26,580 acres. Operations at the laboratory are on the former X-10 site (4,250 acres) in Roane County (Bechtel Jacobs Company LLC et al. 1999; ORNL et al. 1999; TDEC 2002).

The X-10 site was built in 1943 as a pilot plant to demonstrate chemical techniques of plutonium separation. The separation operations generated radioactive and chemical waste liquids, which a network of underground storage tanks and pipelines carried away and stored. Originally a laboratory wholly dedicated to nuclear technology research and development, X-10 presently includes multidisciplinary efforts in nonnuclear technologies and sciences (ChemRisk 1999a).

X-10 is on the southern border of the ORR. The valley floor is highly developed within the central site area, and the surrounding terrain is wooded. The facility discharges to two small streams on site, First and Fifth Creeks, which in turn discharge to White Oak Creek. White Oak Creek passes south of the developed area, leaves the valley through a gap in Haw Ridge, and then enters Melton Valley. There White Oak Creek flows into White Oak Lake, which was formed by White Oak Lake Dam, built by the TVA in 1943. The dam is 1.7 miles upstream from the confluence of White Oak Creek and the Clinch River. White Oak Creek Embayment lies between White Oak Lake and the Clinch River (ChemRisk 1999a).

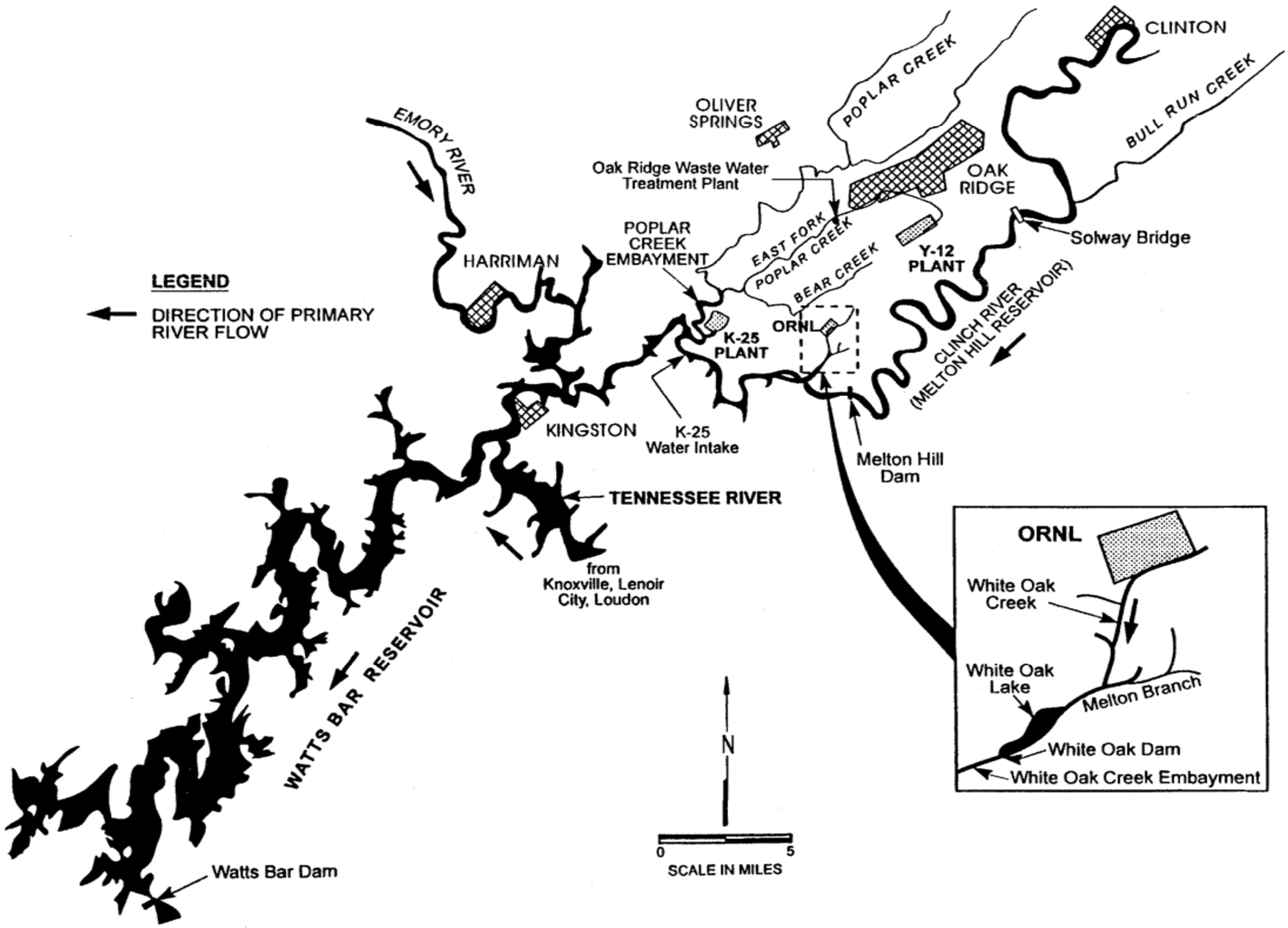
The X-10 site is within two watersheds—Bethel Valley and Melton Valley (ORNL et al. 1999). The main laboratory at X-10 is on Bethel Valley Road, within Bethel Valley (ChemRisk 1999b; ORNL et al. 1999). The site also contains remote facilities and waste storage areas in Melton Valley (ORNL et al. 1999). X-10 is 10 miles southwest of Oak Ridge center and is surrounded by heavily forested ridges that include Chestnut Ridge, Haw Ridge, and Copper Ridge (ChemRisk 1999b; TDOH 2000). White Oak Creek, which begins in Bethel Valley, flows southward along the eastern border of the plant and travels through a gap in Haw Ridge before entering Melton Valley (ChemRisk 1993a, 1999b). From Melton Valley, White Oak Creek joins the Clinch River at Clinch River mile (CRM) 20.8 (ChemRisk 1999b). Public access to the ORR is restricted. Consequently, people do not have access to substances carried down the creek and through the lake and embayment until those substances reach the confluence with the Clinch River. See Figure 6 for a detailed map of the X-10 area and Figure 7 for a detailed map of the surface waters associated with the ORR in general.

Figure 6. Detailed Map of the X-10 Area



Source: ChemRisk 1999b

Figure 7. Surface Waters Associated with the ORR



Source: ChemRisk 1993a

II.B. Operational History

II.B.1. The K-25 Site

The federal government began building the K-25 uranium enrichment facility in 1943, and it was operating by January 1945. The K-25 site used gaseous diffusion to enrich uranium into its U-235 component and then feed this slightly enriched uranium to the uranium enrichment facilities at Y-12 (ChemRisk 1999a). After World War II, Y-12 needed less enriched uranium; as a result, K-25 began providing it elsewhere. By the 1950s, K-25 supplied all enriched uranium used in the United States for commercial and military purposes (ChemRisk 1999a). Between 1945 and 1954, four additional gaseous diffusion process buildings (K-27, K-29, K-31, K-33) were erected, and the K-25 site was renamed the Oak Ridge Gaseous Diffusion Plant (ChemRisk 1993a; ORHASP 1999).

The K-25 site operated as a weapons-grade uranium enrichment facility until 1964 (EUWG 1998). At this time, because the military requirements had been fulfilled, buildings K-25 and K-27 were closed (ChemRisk 1993a). Between 1965 and 1985, when the facility manufactured commercial-grade uranium, the manufacturing process incorporated uranium hexafluoride (UF_6). From the 1960s until 1985, centrifuge enrichment processes took place on the K-25 site (EUWG 1998). Activities at the remaining gaseous diffusion process buildings were discontinued in 1985, and the buildings were officially closed in 1987 (ChemRisk 1993a; ORHASP 1999; U.S. DOE 2003b). At this time, the site name was reverted back to the K-25 site from Oak Ridge Gaseous Diffusion Plant (ORHASP 1999). Currently, K-25 is primarily the headquarters for waste storage treatment and disposal at the ORR (ChemRisk 1999a).

K-25 used PCBs in the gaseous diffusion process of uranium enrichment. The chief use of PCBs at the K-25 site was in electrical transformers and capacitors in the electrical power system for the gaseous diffusion cascades. From 1945 to 1984 these transformers and capacitors held a total estimated volume of 125,000 gallons of PCBs. Between 1989 and 1991 most of these PCBs were incinerated off site. During plant operations, incidental releases might have migrated off site via surface runoff and storm sewer discharge (ChemRisk 1999a).

What Are PCBs?

PCBs are a group of man-made chlorinated organic compounds that contain up to 209 individual chemicals (congeners) with varying abilities to cause harmful effects. No known natural sources of PCBs occur in significant quantities in the environment, although traces of naturally occurring congeners can exist in some microorganisms (Falch et al. 1995). PCBs are oily liquids and solids that range from colorless to light yellow and are tasteless and odorless. As they are difficult to burn, they made good insulators.

PCBs also could have migrated off site from sources other than electrical equipment. For example, although most PCBs in burial grounds, burn areas, holding ponds, switchyards, and outside storage areas would have been contained on site, some might have migrated off site via surface runoff, waste water discharges, and volatilization to air. Reported incidents at K-25 included an explosion and fire in 1951 near the K-31 process area, and two accidental spills at K-25. One spill consisted of 40 to 50 gallons of PCB fluids from a leaking storage drum at K-711 in 1991 to a diked area on site, some of which migrated to the Clinch River via stormwater drains.

The second was a spill of about 2,000 gallons of PCB-contaminated mineral oil from an equipment failure at the K-732 switchyard, which released the oil via a storm drain to Poplar Creek (ChemRisk 1999a).

II.B.2. The Y-12 Plant

Since the early 1940s, large quantities of uranium were processed on the ORR for enrichment into uranium-235, which was used in nuclear weapons components, in commercial nuclear reactors, and in various research and development projects (ChemRisk 1993a). Although the gaseous-diffusion method yields considerable uranium-235, larger amounts of the isotope were produced electromagnetically at Oak Ridge (Coker 1999).

From 1944 to 1947, the Y-12 plant was used to enrich uranium electromagnetically. By 1952, however, the facilities were converted to fabricate nuclear weapon components (ChemRisk 1999c). During the Cold War the government built and operated a column-exchange process (Colex) that used large quantities of mercury as an extraction solvent to enrich the lithium in lithium 6 (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 dismantling and storage of strategic nuclear materials from retired nuclear weapons systems. In October 2000, oversight of the Y-12 plant was changed from the DOE Oak Ridge Operations to the DOE National Nuclear Security Administration. The National Nuclear Security Administration currently uses the Y-12 National Security Complex as the primary storage site for highly enriched uranium.

PCB contamination at Y-12 resulted from several sources, including the electrical systems (i.e., transformers and capacitors), the use of PCB-containing cutting oils, and the Z-oil system for cooling the electromagnetic separation process. PCBs were also used in hydraulic systems throughout Y-12. Once environmental regulations on the use, storage, and disposal of PCB-contaminated equipment went into effect in the 1980s, Y-12 engineers began to identify and remove PCB-containing electrical equipment. Much of the equipment currently in place is original; therefore, recently measured concentrations are similar to historical PCB levels in the transformers and capacitors (ChemRisk 1999a).

Y-12 activities generated thousands of gallons of waste oils. Much of the waste oils from Y-12 contained no PCBs; only mineral oils, water soluble coolants, antifreeze, motor oils, and specialized products. Most PCB-contaminated waste oils generated at Y-12 came from machining of enriched uranium (M-Wing coolant), hydraulic systems, and electrical transformers (ChemRisk 1999a).

Early records suggest, but do not document, that Y-12 liquid wastes generated before 1950 were discarded at burial facilities at X-10. Starting in the early 1950s, Y-12 sent most of its liquid waste to the Bear Creek Disposal Area. The three principal disposal sites at Bear Creek were the S-3 Ponds, the Burial Grounds, and the Oil Landfarm (ChemRisk 1999a).

Oils with high PCBs content were not burned at the Burial Grounds because they were nonflammable. From 1955 to 1961 waste oils with low-level PCBs or non-PCB-bearing fluids were poured over solid waste and burned at Burial Ground A's Burn Pit. In 1961 a burn tank installed in Burial Ground A collected flammable waste oils and coolants; nonflammable liquids were drained into adjacent trenches. Although small amounts of transformer oils and hydraulic fluids (both of which had low PCBs content) might have been burned, significant quantities of PCBs were not burned at Burial Ground A. Oils with high PCB levels came from M-Wing coolants, discarded 2 years after oil burning ended (ChemRisk 1999a).

In the late 1970s two tanks were installed at the Salvage Yard/Solvent Drum Storage Area in the northwest part of the Y-12 area to store 11,000 gallons of PCB-contaminated oils. Any spills were released to the storm drain system (ChemRisk 1999a).

After 1982, waste oils were stored at Y-12 tank farms awaiting incineration at the K-25 TSCA incinerator. The oils were separated by PCB content; waste oils with greater than 5 parts per million (ppm) PCBs were kept separate from those with lower PCB levels. In 1987 this concentration limit was decreased to 2 ppm. Some waste oils below the concentration limits were sent off site for commercial disposal. From 1982 to 1991, 150,000 gallons of PCB-waste oils had accumulated at Y-12. In 1991, when the K-25 incinerator began operations, these oils were sent to the K-25 incinerator and by 1995 most of these oils had been burned (ChemRisk 1999a).

II.B.3. The X-10 Site

The X-10 site was built in 1943 as a "pilot plant" to demonstrate the manufacture and chemical separation of plutonium (ChemRisk 1993a, 1999b; TDOH 2000). After World War II, the facility also engaged in nonweapons-related activities (e.g., physical and chemical division of nuclear products, creation and assessment of nuclear reactors, and manufacture of a range of radionuclides for global use in medicine, industry, and research) (ChemRisk 1993a; Jacobs Engineering Group Inc 1996). In the 1950s and 1960s, X-10 became a worldwide research center for the study of nuclear energy and to investigate physical and life sciences related to nuclear energy. Following the establishment of DOE in the 1970s, research at X-10 was extended to include the study of energy transmission, conservation, and production (UT-Battelle 2003). Today, ORNL receives worldwide recognition as a facility for extensive research and development in several areas of science and technology. In addition, X-10 manufactures numerous radioactive isotopes that have significant uses in medicine and research (TDEC 2002).

The main activities potentially associated with off-site releases of contaminants from X-10 included: 1) production of radioactive lanthanum (1944 to 1956), 2) Thorex processing of short-decay irradiated thorium (approximately 1954 to 1960), 3) graphite reactor operations (1943 to 1963), 4) processing of graphite reactor fuel for plutonium recovery (1943 to 1945), and 5) waterborne and airborne waste disposal (1943 to present). These historical activities at X-10 required equipment such as capacitors, transformers, pumps, and electric motors. Lubricating and cooling oils associated with this equipment probably contained PCBs. The primary use of PCBs at X-10 was in the form of dielectric oils in electrical transformers at concentrations ranging from <5 to 1 million ppm. Because the government had originally planned to run the X-10 site for only 1 year, minimal waste had been expected from the facility's chemical separation processes (ChemRisk 1993a, 1999b; Jacobs Engineering Group Inc 1996). As a result, the intended waste disposal practices proved insufficient for the wastes generated at X-10. Disposal of wastes in the early years was mainly documented for radioactive substances. Therefore, the extent to which radionuclide wastes were separated from organic wastes, such as PCB-contaminated oils, is unknown.

When X-10 began operating in 1943, liquid wastes were put into several underground gunite (i.e., sprayed concrete) tanks located in Bethel Valley. Each gunite tank held 170,000 gallons, but wastes quickly filled them to capacity. To dispose of the liquid wastes, the sludges were kept in the gunite tanks, and the wastes that did not settle were held until enough radioactivity was lost through decay that liquids (combined with diluting water) could be released to White Oak Creek (ChemRisk 1993a, 1999b; Jacobs Engineering Group Inc 1996; ORHASP 1999; U.S. DOE 1997). The creek received this wastewater and stormwater drainage as it flowed through the X-10 facilities, before it emptied into the Clinch River at the site's southern boundary. Some of the waste released into White Oak Creek reached the Clinch River. This waste includes radionuclides. Whether PCBs from discarded transformer oils were mixed in with the radioactive wastes is unclear.

Historically, X-10 wastes were disposed at on-site tanks, in burial grounds, or in surface impoundments. No information was found on the disposal of PCBs at these sites before environmental regulations (ChemRisk 1999a). The lack of information on PCB waste disposal at X-10 probably resulted from of the lack of awareness of the potential hazards associated with PCBs prior to the 1970s. Despite the absence of records about early PCB disposal, most of the contaminant releases to White Oak Creek are associated with former operations at X-10. Since the late 1970s, PCB releases have been handled according to federal regulations and ORR policies. During the 1970s, 1980s, and 1990s, surveys of PCBs in environmental media found low-level contamination in the near and downstream of X-10. Releases from the facility are negligible since the 1970s, but PCBs remain in White Oak Creek Embayment and White Oak Lake. Thus, PCBs were released either before the late 1970s or from ongoing low-level releases. These waterways are, however, on site at the ORR. Public access to the embayment and the lake is restricted. The contaminants from X-10 reach the public when creek water and its suspended sediment flow past the White Oak Creek's confluence with the Clinch River, or when fish from the creek swim into the river.

For more details on operational history and use of PCBs, please see Task 3 of the Reports of the Oak Ridge Dose Reconstruction, *PCBs in the Environment Near the Oak Ridge Reservation, A Reconstruction of Historical Doses and Heath Risks* (ChemRisk 1999a) (referred to as the "Task 3 report") and the *Oak Ridge Health Studies Phase 1 Report: Volume II—Part A—Dose Reconstruction Feasibility Study, Tasks 1 & 2, A Summary of Historical Activities on the Oak Ridge Reservation with Emphasis on Information Concerning Off-Site Emission of Hazardous Material* (ChemRisk 1993a).