Table 3. Summary of Peak Annual Releases From White Oak Dam for the Eight Key Radionuclides

	Peak Annual Releases (curies)			*Number of Years at 10% of Peak Release or More*
Radionuclide	***Lower Bound***	***Central Estimate***	***Upper Bound***	
Cesium 137	50	200	510	14
Ruthenium 106	1,600	2,100	2,700	5
Strontium 90	68	190	390	18
Cobalt 60	64	85	110	15
Cerium 144	70	94	120	13
Zirconium 95	72	210	440	9
Niobium 95	17	200	520	10
Iodine 131	10	68	190	10

Source: ChemRisk 2000
Annual estimates were based on data in log books, interviews with knowledgeable parties, and laboratory documents.

II.C. Remedial and Regulatory History

As a result of several on-site processes that produced nonradioactive and radioactive wastes, on November 21, 1989, USEPA listed the ORR on the final National Priorities List (NPL) (EUWG 1998; U.S. DOE 2001a; U.S. EPA 2002a). The DOE is performing remediation activities at the reservation under a Federal Facility Agreement (FFA), which is an interagency agreement between the DOE, U.S. EPA, and TDEC. The U.S. EPA and TDEC, along with the public, help DOE select the details for remedial actions at the ORR (U.S. DOE 2003a). These parties work collaboratively to ensure that adequate remediation activities are used, and to ensure that hazardous waste related to previous and current ORR activities is completely studied and appropriate remedial action is taken (U.S. DOE 1996b, 2003a). DOE is conducting its investigations of the ORR under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a program that requires an FFA be established for all NPL sites owned by the federal government (EUWG 1998; U.S. EPA 2002b). In addition, DOE is incorporating response procedures designated by CERCLA, with mandatory actions from the Resource Conservation and Recovery Act (RCRA) (U.S. EPA 2002b). See Figure 5 for a time

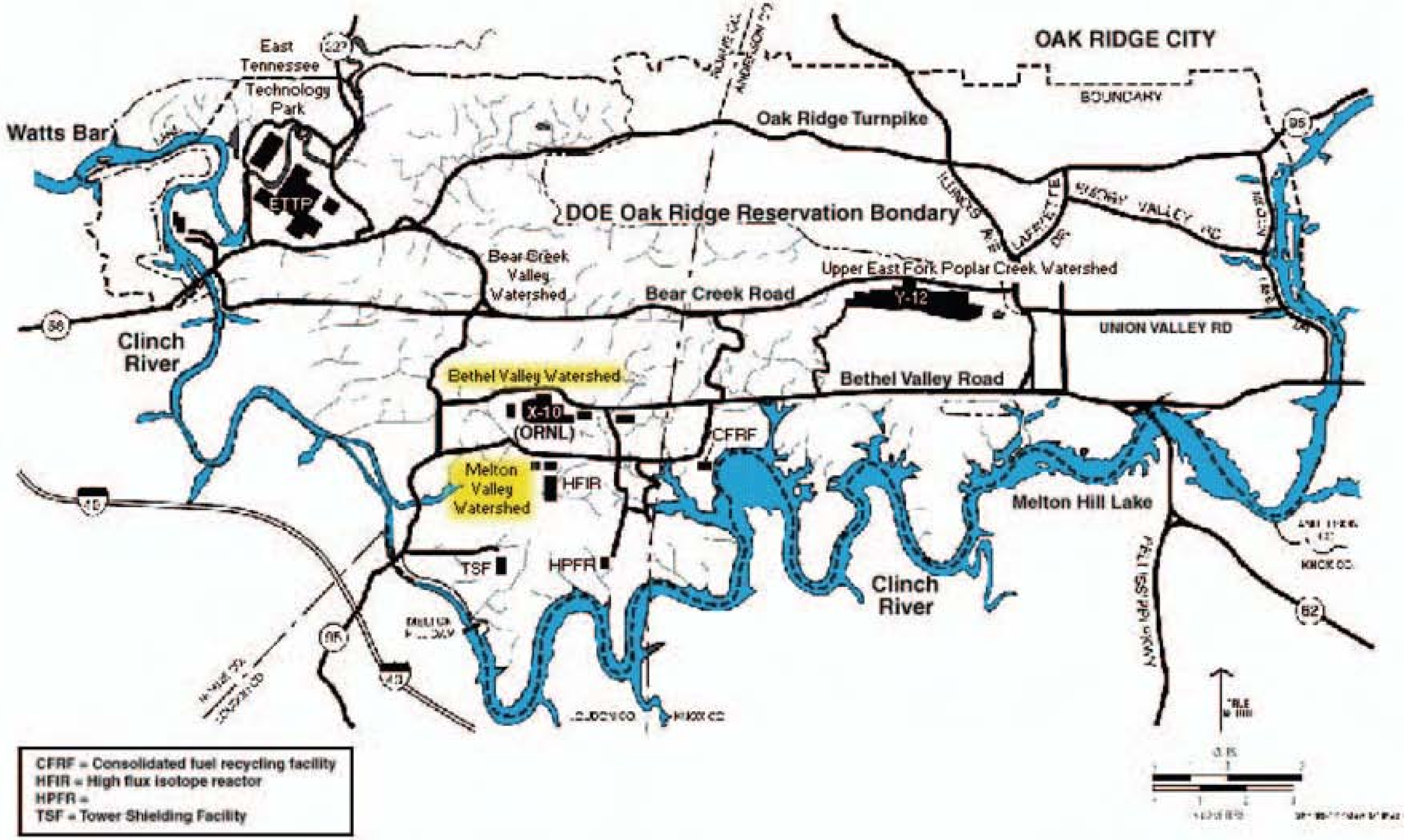
> The Federal Facility Agreement was implemented at the ORR on January 1, 1992. This is a legally binding agreement used to establish schedules, procedures, and documentation for remedial activities at the ORR (EUWG 1998). The Federal Facility Agreement is available online at http://www.bechteljacobs.com/ettp_ffa.shtml

line of major processes, environmental data, and public health activities associated with the X-10 site.

Radioactive waste material, such as Cs 137 and Sr 90, is present in old waste sites at the ORR. These waste sites constitute 5% to 10% of the reservation, but the majority of them were not designed with adequate containment structures. In addition to the improper design, leaching caused by abundant rainfall and high water tables have contributed to the radionuclide contamination of surface water, groundwater, soil, and sediments at the ORR (EUWG 1998). According to DOE, waste sites located in the Melton Valley Watershed "…are the primary contributors to off-site spread of contaminants" from the ORR and White Oak Creek flows through or past these areas (U.S. DOE 2002b).

In 1986, DOE began remedial actions at the ORR under a RCRA permit. Since that time, DOE has started about 50 response activities under the FFA that address waste disposal and contamination issues on the reservation (U.S. EPA 2002a). To facilitate the investigation and remediation of contamination related to the reservation, the contaminated areas on the ORR were separated into five large tracts of land that are typically associated with the major hydrologic watersheds (EUWG 1998). More specifically, the contaminated areas associated with X-10 are located in the Bethel Valley Watershed and the Melton Valley Watershed (U.S. DOE 2001b). Please refer to Figure 9 for the locations of these two watersheds.

Figure 9. Map of the Bethel Valley Watershed and the Melton Valley Watershed



Source: Lockheed Martin Energy Systems, Inc. 1998

II.C.1. Bethel Valley Watershed

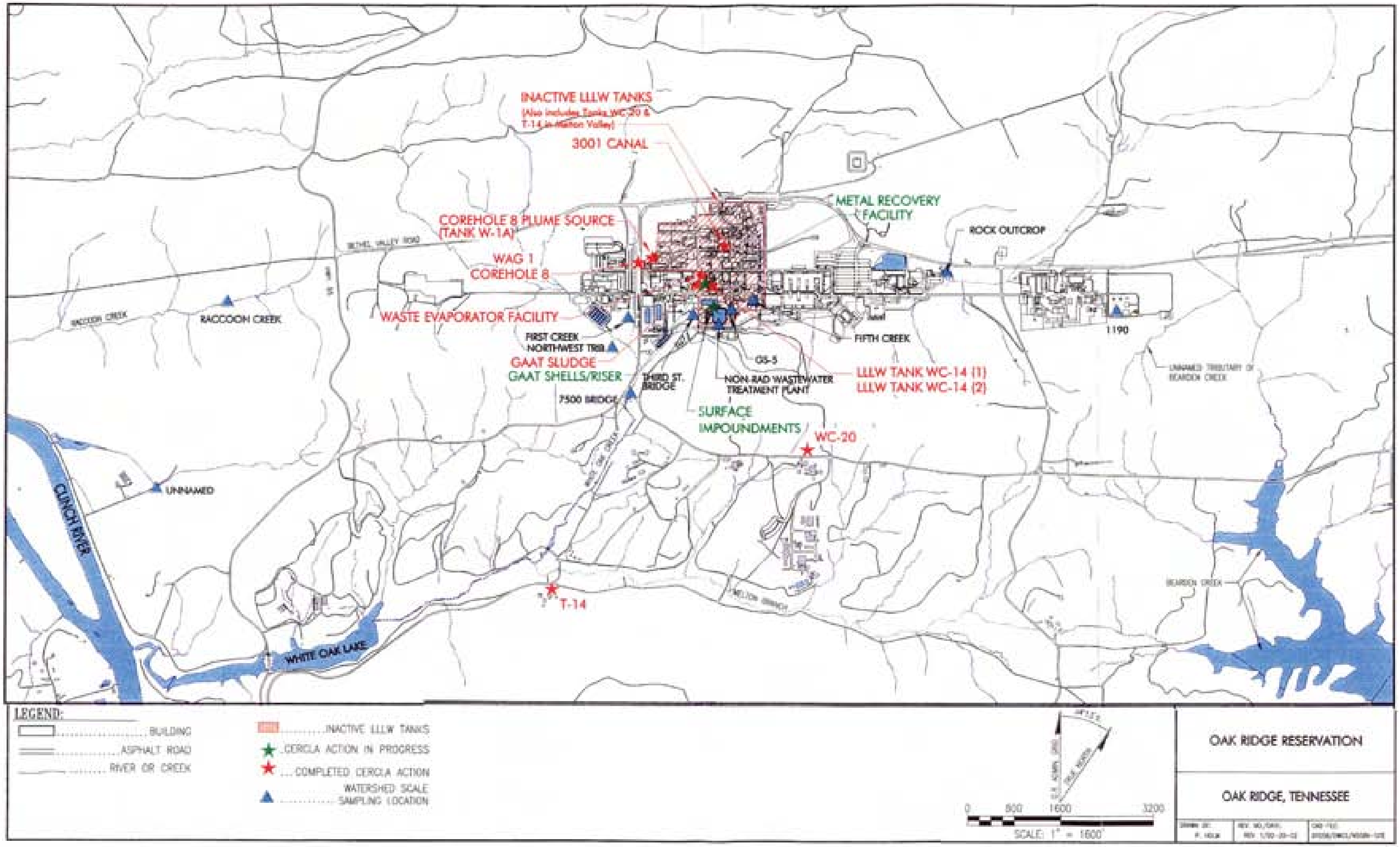
The major operations at X-10 take place within the Bethel Valley Watershed. The main plant, key research facilities, primary administrative offices, as well as various forms of waste sites, are situated in Bethel Valley. Over the past 60 years, X-10 releases have contaminated the Bethel Valley Watershed. Mobile contaminants primarily leave the Bethel Valley Watershed via White Oak Creek. These contaminants travel from the Bethel Valley Watershed to the Melton Valley Watershed, where further contaminants enter White Oak Creek. Then, the contaminants that have been discharged to White Oak Creek are released over White Oak Dam and into the Clinch River (U.S. DOE 2001b).

Many remedial activities have been conducted in Bethel Valley to protect human health and the environment in the present and future. These actions, which comply with federal and state requirements, have removed the most contaminated materials (including source and leaching materials) and reduced the amount of contaminants in Bethel Valley. Main remedial activities conducted in Bethel Valley associated with X-10 operations have included 1) groundwater treatment and extraction at the Corehole 8 Plume, 2) sludge and liquid waste removal at the Gunite and Associated Tanks (GAAT), 3) liquid and solid waste removal and treatment at the inactive liquid low-level waste tanks, and 4) contaminated sediment removal from the surface impoundments operable unit (SAIC 2002, 2004; U.S. DOE 2001c). In addition, in May 2002 a Record of Decision (ROD) was signed to address several interim remedial actions in Bethel Valley. As of fiscal year 2003, a groundwater study had been initiated under the ROD (SAIC 2004). Please see Figure 10 for a map of Bethel Valley that includes these areas. The main remedial activities conducted in Bethel Valley are detailed further in Appendix B.

II.C.2. Melton Valley Watershed

X-10 disposed of its radioactive wastes (liquid and solid) in Melton Valley, and also operated its experimental facilities within this watershed (U.S. DOE 2002a, 2002b). Discharges from Melton Valley's waste areas have produced secondary contamination sources that include sediment, groundwater, and soil contamination. Furthermore, contaminants discharged from Melton Valley travel off the reservation through surface water and flow into the Clinch River (SAIC 2002).

Figure 10. Map of the Major Remedial Activities in Bethel Valley



Source: SAIC 2002

As a result, the waste sites in the Melton Valley Watershed "…are the primary contributors to off-site spread of contaminants" from the ORR (U.S. DOE 2002b).

Many remedial activities, which comply with federal and state requirements, have been conducted in Melton Valley. These actions—undertaken to protect human health and the environment in the present and future—have removed the most contaminated materials and reduced the amount of contaminants in Melton Valley. Main remedial activities related to X-10 operations and the White Oak Creek study area (see Figure 11) have included 1) removing contaminated soil and restricting access to the Cesium Plots Research Facility, 2) building a sediment retention structure at the mouth of White Oak Creek to reduce off-site movement of sediments to the Watts Bar Reservoir and the Clinch River, 3) reducing releases of strontium 90 into White Oak Creek from waste area grouping (WAG) 4 trenches, 4) installing a groundwater treatment unit at WAG 5 to prevent strontium 90 from entering Melton Branch, and 5) injecting radioactive waste and grout below ground and removing LLLW underground storage tanks (USTs) from the Old Hydrofracture Facility (OHF) (SAIC 2002; U.S. DOE 2002c; U.S. EPA 2002a). A Record of Decision was signed in September 2000 to focus on remedial activities that prevent contaminant releases into surface waters and groundwater in Melton Valley (SAIC 2002, 2004). Please see Figure 12 for a map of Melton Valley that includes these areas. The main remedial activities conducted in Melton Valley are further detailed in Appendix B.

II.C.3. Off-Site Locations

This section discusses remedial activities that have been conducted at two off-site locations related to X-10 that are located within the White Oak Creek Public Health Assessment study area: the Clinch River/Poplar Creek Operable Unit (OU) and the Lower Watts Bar Reservoir OU (SAIC 2002). The White Oak Creek study area (see Figure 11) consists of the area along the Clinch River, from the Melton Hill Dam to the Watts Bar Dam. The Lower Watts Bar Reservoir is downstream of the ORR, extending from the confluence of the Clinch and Tennessee Rivers to the Watts Bar Dam (U.S. DOE 1995a). As a result, the Clinch River and the Lower Watts Bar Reservoir have received contaminants related to X-10 operations (Jacobs EM Team 1997b; U.S. DOE 1995a; U.S. DOE 2001a). Please see Figure 1 and Figure 4 for these surface water locations.

Figure 11. Map of the White Oak Creek Study Area

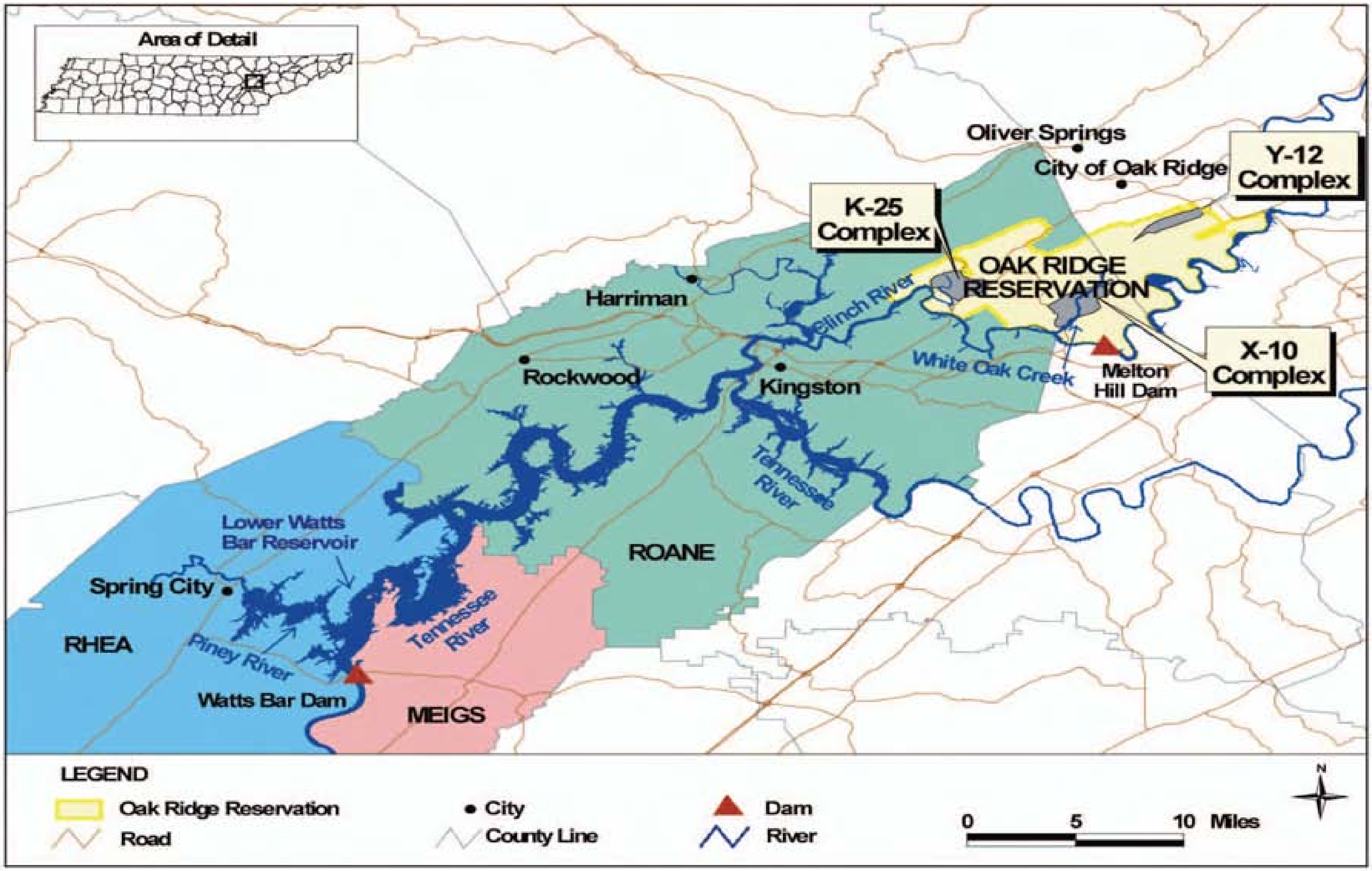
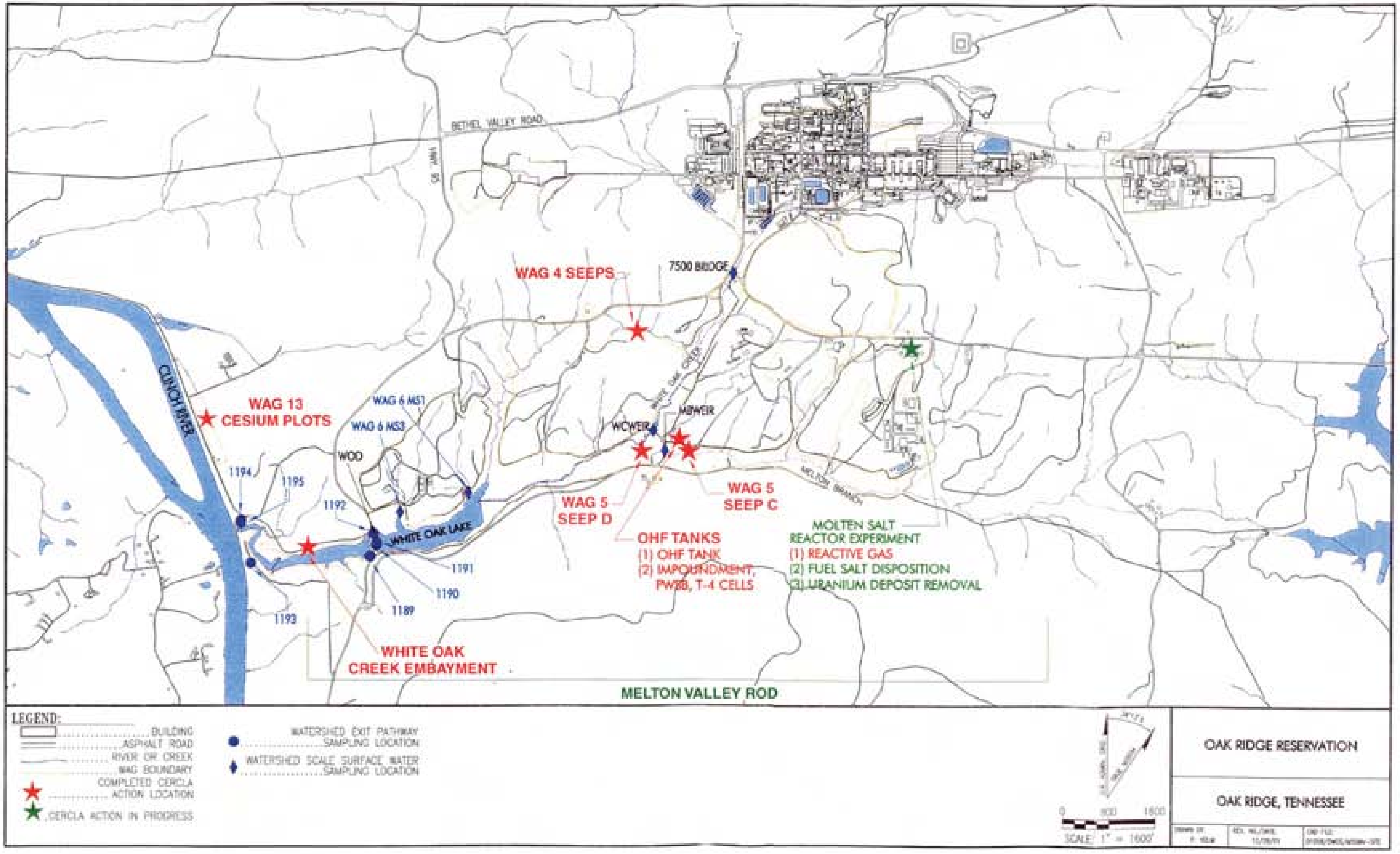


Figure 12. Map of the Major Remedial Activities in Melton Valley



Source: SAIC 2002

Remedial actions at the Clinch River/Poplar Creek OU and the Lower Watts Bar Reservoir OU, which were undertaken to protect human health and the environment in the present and future, comply with federal and state guidelines (Jacobs EM Team 1997b; U.S. DOE 1995a). Remedial activities at these OUs are summarized below.

- *Clinch River/Poplar Creek*. The Clinch River/Poplar Creek OU consists of the biota and sediments in the Melton Hill Reservoir and the Watts Bar Reservoir from CRM 0.0 (where the Tennessee and Clinch Rivers join) to CRM 43.7, which is upstream of Melton Hill Dam. In addition, the OU contains the Poplar Creek embayment from the mouth of Poplar Creek along the Clinch River (at CRM 12.0) to its joining with East Fork Poplar Creek (at Poplar Creek mile [PCM] 5.5). All of the Poplar Creek sections of the OU are within the borders of the ORR (SAIC 2002; U.S. DOE 2001a).

  In 1996, a remedial investigation/feasibility study (RI/FS) was conducted to examine the past and present releases to off-site surface water and to determine if remedial action was necessary (ATSDR et al. 2000). The RI/FS concluded that the Clinch River/Poplar Creek OU presented two main risks by exposure to 1) fish tissue that contained chlordane, mercury, PCBs, and arsenic; and 2) deep sediments in the primary river channel that contained arsenic, mercury, cesium 137, and chromium (Jacobs EM Team 1997b; Jacobs Engineering Group Inc. 1996; SAIC 2002; U.S. DOE 2001a). The largest concentrations of radionuclides that have been detected are buried between 8 and 32 inches into the deep sediments; radionuclide contamination has *not* been detected in the shoreline sediment (Jacobs EM Team 1997b).

  A baseline risk assessment was conducted. It suggested that consumption of certain fish contaminated with PCBs posed the greatest risk to public health. In addition, fish contaminated with chlordane, mercury, and arsenic presented the possible chance of causing health effects. The assessment also determined that the consumption of any type of fish in Poplar Creek posed a health risk, as well as bass from the Clinch River below Melton Hill Dam. Furthermore, the risk assessment determined that contaminants in deep-water sediments would only present a health risk if they were dredged; no exposure pathway currently exists to the deep-water sediments (Jacobs EM Team 1997b).

  In September 1997, DOE issued a Record of Decision for the Clinch River/Poplar Creek OU. EPA and TDEC—supportive agencies for this response action—agree with the remedial actions selected for this OU. The chosen actions, which comply with federal and state requirements, were undertaken to protect human health and the environment in the present and future. The following remedial actions were selected for the OU:

  1. yearly monitoring to assess fluctuations in concentration levels and contaminant dispersion,
  2. advisories on fish consumption,
  3. surveys to gauge the usefulness of the fish advisories, and

4. institutional controls to restrict activities that could unsettle the sediment (Jacobs EM Team 1997b; SAIC 2002; U.S. DOE 2001a; U.S. EPA 2002a).

These institutional controls are developed under an interagency agreement (IAG) established by DOE, EPA, TVA, TDEC, and the U.S. Army Corps of Engineers (USACE) in February 1991. The IAG allows these agencies to work cooperatively through the Watts Bar Interagency Agreement to review permitting and all other activities that could result in disturbing the sediment (for example, building a dock or erecting a pier) (ATSDR 1996; Jacobs EM Team 1997b; U.S. DOE 2003a). Please see page 3-12 of the ROD at http://www.epa.gov/superfund/sites/rods/fulltext/r0497075.pdf for more details. For additional information on institutional controls to prevent sediment-disturbing activities, please see *Rules of the Tennessee Department of Environment and Conservation, Chapter 1200-4-7, Aquatic Resource Alteration Permit Process; Section 26A of the Tennessee Valley Authority Act of 1933; and Section 10 of the Rivers and Harbors Act of 1910 (U.S.A.C.E.)* (Jacobs EM Team 1997b).

> In February 1991, DOE, EPA, TVA, TDEC, and USACE established an interagency agreement. Under this agreement, these agencies collaboratively work through the Watts Bar Interagency Agreement to review permitting and other activities that could possibly disturb sediment, such as erecting a pier or building a dock (ATSDR 1996; Jacobs EM Team 1997b; U.S. DOE 2003a). For more details, see the ROD at http://www.epa.gov/superfund/sites/rods/fulltext/r0497075.pdf.

In February 1998, a Remedial Action Report (RAR) was approved. This report recommended that monitoring be conducted for surface water, fish, sediment, and turtles in the Clinch River/Poplar Creek OU (ATSDR et al. 2000). Since this time, annual surface water sampling, sediment monitoring, and fish and turtle sampling have been conducted at the Clinch River/Poplar Creek OU (SAIC 2002; U.S. DOE 2001a). Institutional controls are also used to examine activities that could result in movement of the sediments, and the Tennessee Wildlife Resources Agency (TWRA) prints fish consumption advisories in its *Tennessee Fish Regulations* (SAIC 2002).

- *Lower Watts Bar Reservoir*. The Lower Watts Bar Reservoir OU stretches from the confluence of the Tennessee River and the Clinch River downstream to the Watts Bar Dam. All surface water and sediment released from the ORR enter the Lower Watts Bar Reservoir OU (SAIC 2002; U.S. DOE 2001a; U.S. DOE 2003c). In 1995, a RI/FS was conducted to assess the level of contamination in the Watts Bar Reservoir, to create a baseline risk analysis based on the contaminant levels, and to determine if remedial action was necessary (ATSDR et al. 2000). The RI/FS revealed that discharges of radioactive, inorganic, and organic pollutants from the ORR have contributed to biota, water, and sediment contamination in the Lower Watts Bar Reservoir (ATSDR et al. 2000; SAIC 2002; U.S. DOE 2001a, 2003b). The baseline risk analysis indicated that standards for environmental and human health would not be reached if deep channel sediments with cesium 137 were dredged and placed in a residential area, and if people consumed moderate to high quantities of specific fish that contained increased levels of PCBs (ATSDR et al. 2000; Environmental Sciences Division et al. 1995).

In September 1995, DOE issued a Record of Decision for the Lower Watts Bar Reservoir OU. EPA and TDEC, which are supportive agencies for this response action, agree with the remedial actions selected for this OU. The chosen actions were undertaken to protect human health and the environment in the present and future, and comply with federal and state requirements. The following contaminants of concern (COCs) were identified at the OU: 1) mercury, arsenic, PCBs, chlordane, and aldrin in fish; 2) mercury, chromium, zinc, and cadmium in dredged sediments and sediments used for growing food products; and 3) manganese through ingestion of surface water (ATSDR et al. 2000; SAIC 2002; U.S. DOE 2001a, 2003b). The largest threat to public health from the Lower Watts Bar Reservoir is related to the consumption of PCB-contaminated fish (SAIC 2002; U.S. DOE 2001a, 2003b). The ROD concluded that if the deep sediments were kept in place, then "…these sediments do not pose a risk to human health because no exposure pathway exists (U.S. DOE 1995a)."

The remedial activities selected for the Lower Watts Bar Reservoir have included using preexisting institutional controls to decrease contact with contaminated sediment, fish consumption advisories printed in the *Tennessee Fish Regulations*, and yearly monitoring of biota, sediment, and surface water (ATSDR et al. 2000; SAIC 2002; U.S. DOE 1995a, 2001a, 2003b; U.S. EPA 2002a). The interagency agreement established by DOE, EPA, TVA, TDEC, and USACE in February 1991 allows these agencies to work cooperatively through the Watts Bar Interagency Agreement to review permitting and all other activities that could result in disturbing the sediment, such as building a dock or erecting a pier (ATSDR 1996; Jacobs EM Team 1997b; U.S. DOE 2003a). According to the interagency agreement, DOE is required to take action if an institutional control is not effective or if a sediment-disturbing activity could cause harm (Jacobs EM Team 1997b; U.S. DOE 2003a). For more details, please see page 3-5 of the Lower Watts Bar Reservoir ROD at http://www.epa.gov/superfund/sites/rods/fulltext/r0495249.pdf and the Clinch River/Poplar Creek OU ROD at http://www.epa.gov/superfund/sites/rods/fulltext/r0497075.pdf. For additional information on institutional controls to prevent sediment-disturbing activities, please see *Rules of the Tennessee Department of Environment and Conservation, Chapter 1200-4-7, Aquatic Resource Alteration Permit Process; Section 26A of the Tennessee Valley Authority Act of 1933; and Section 10 of the Rivers and Harbors Act of 1910 (U.S.A.C.E.)* (Jacobs EM Team 1997b).

II.D. Land Use and Natural Resources

When, the government acquired the ORR in 1942, it reserved a section of the reservation (about 14,000 acres out of the total of approximately 58,575) for housing, businesses, and support services (ChemRisk 1993d; ORNL 2002). In 1959, that section of the ORR was turned into the independently governed city of Oak Ridge. This self-governing area has parks, homes, stores, schools, offices, and industrial areas (ChemRisk 1993d).

The majority of residences in Oak Ridge are located along the northern and eastern borders of the ORR (Bechtel Jacobs Company LLC et al. 1999). Since the 1950s, however, the urban population of Oak Ridge has grown toward the west. As a result of this expansion, the property lines of many homes in the city's western section border the ORR property (Faust 1993). Apart from these urban sections, the areas close to the ORR continue to be mainly rural, as they have historically been (Bechtel Jacobs Company LLC et al. 1999; ChemRisk 1993d). The closest homes to X-10 are located near Jones Island, about 2.5 to 3.0 miles southwest of the main facility (ChemRisk 1993d).

In 2002, the ORR measured 34,235 acres, which includes the three main DOE facilities: Y-12, X-10, and K-25 (ORNL 2002). The majority of the ORR is situated within the city limits of Oak Ridge. These DOE facilities constitute approximately 30% of the reservation; the remaining 70% of the reservation was turned into the National Environmental Research Park in 1980. This park was created so that protected land could be used for environmental education and research, and to show that the development of energy technology could be compatible with a quality environment (EUWG 1998). A large amount of land at the ORR that was formerly cleared for farmland has grown into full forests over the past several decades. Sections of this land contain areas called "deep forest" that include flora and fauna considered ecologically significant, and portions of the reservation are regarded as biologically rich (SAIC 2002).

Today, the entire ORNL site encompasses approximately 26,580 acres. The main operations at the ORNL take place on about 4,250 acres, which was formerly known as the X-10 site. The remaining acres are divided between the Oak Ridge National Environmental Research Park (21,980 acres) and the Solway Bend area that is used for environmental monitoring (350 acres) (ORNL et al. 1999). The X-10 site contains approximately 517 buildings, trailers, and additional facilities, which total over 3.4 million square feet. There are additional facilities related to X-10 operations, but these are situated at the Y-12 plant and at off-site locations. Of the X-10 facilities and those at the other locations, however, 156 are inactive or are expected to be inactive in the future (Bechtel Jacobs Company LLC et al. 1999).

Historically, forestry and agriculture (beef and dairy cattle) have constituted the primary uses of land in the area around the reservation; but these land uses are both declining. For several years, milk produced in the area was bottled for local distribution, whereas beef cattle from the area were sold, slaughtered, and nationally distributed. In addition, tobacco, soybeans, corn, and wheat were the primary crops grown in the area. Also, small game and waterfowl were hunted on a regular basis in the ORR area, but deer were hunted during specific time periods (ChemRisk 1993d). Waterfowl and small game hunting regularly occurs within the ORR area, while deer hunting occurs annually on the ORR (ChemRisk 1993d). During the annual deer hunts, radiological monitoring is conducted on all deer prior to their release to the hunters. Monitoring is conducted to ensure that none of the animals contain quantities of radionuclides that could cause "significant internal exposure" to the consumer (Teasley 1995).

The southern and western boundaries of the ORR are formed by the Clinch River; Poplar Creek and East Fork Poplar Creek drain the ORR to the north and west (Jacobs EM Team 1997b). White Oak Creek, which travels south along the eastern border of the X-10 site, flows into White Oak Lake, over White Oak Dam, and into the White Oak Creek Embayment before meeting the Clinch River at CRM 20.8 (ChemRisk 1993b, 1999a; TDOH 2000; U.S. DOE 2002a). Ultimately, every surface water system on the reservation drains into the Clinch River (ChemRisk 19993b). The Lower Watts Bar Reservoir is situated downstream of the ORR, extending from the confluence of the Clinch and Tennessee Rivers to the Watts Bar Dam (U.S. DOE 1995a). As a result, the Clinch River and the Lower Watts Bar Reservoir have received contaminants associated with X-10 operations (Jacobs EM Team 1997b; U.S. DOE 1995a; U.S. DOE 2001a). Please see Figure 4 for these relative water systems.

The majority of land around the Clinch River and the Lower Watts Bar Reservoir is undeveloped and wooded. Other than activities at the ORR, there is minimal industrial development in these surrounding areas, and there is a fair amount of residential growth. The public has access to the Clinch River and to the Lower Watts Bar Reservoir, which it uses for recreational purposes such as boating, swimming, fishing, water skiing, and shoreline activities (U.S. DOE 1996d, 2001b, 2003b).

Kingston and Spring City both maintain public water supplies in the vicinity of the Oak Ridge Reservation (Figures 13 and 14 show these water intake and city locations, respectively, that are both within the White Oak Creek study area). The Kingston water supply has two water intakes, but only one of the intakes—located upstream on the Tennessee River in Watts Bar Lake at Tennessee River Mile (TRM) 568.4—would potentially be affected by ORR contaminants

(Hutson and Morris 1992; G. Mize, Tennessee Department of Environment and Conservation, Drinking Water Program, personal communication re: Kingston public water supply, 2004). Spring City obtains its water from an intake on the Piney River branch of Watts Bar Lake (Hutson and Morris 1992).

Under the Safe Drinking Water Act, the EPA has since 1974 set health-based standards for substances in drinking water and specified treatments for providing safe drinking water (U.S. EPA 1999). The public water supplies for Kingston and Spring City are continually monitored for these regulated substances, which include 15 inorganic contaminants, 51 synthetic and volatile organic contaminants, and 4 radionuclides. For EPA's monitoring schedules, see http://www.epa.gov/safewater/pws/pdfs/qrg_smonitoringframework.pdf (EPA 2004a).

According to EPA's Safe Drinking Water Information System (SDWIS), the Kingston and Spring City public water supply systems have not had any significant violations (U.S. EPA 2004b). To look up information related to these and other public water supplies, go to EPA's Local Drinking Water Information Web Site at http://www.epa.gov/safewater/dwinfo.htm. In addition, in 1996 TDEC's DOE Oversight Division started to participate in EPA's Environmental Radiation Ambient Monitoring System (ERAMS). Under this program, TDEC collects finished drinking water samples from the Kingston Water Treatment Plant on a quarterly basis and then submits the samples to EPA for radiological analyses (TDEC 2002, 2003a). TDEC has also conducted filter backwash sludge sampling at Spring City because contaminants from the reservation could potentially move downstream into community drinking water supplies (TDEC 2003b). Additional information on TDEC's participation in the ERAMS program is provided in Section II.F.3. of this document. To ask specific questions related to your drinking water, please call 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 800-426-4791 or visit EPA's Safe Drinking Water Web site at http://www.epa.gov/safewater.

II.E. Demographics

The White Oak Creek study area (see Figure 11) consists of the area along the Clinch River, from the Melton Hill Dam to the Watts Bar Dam. Four main cities fall within this area. Three of the cities—Harriman, Kingston, and Rockwood—are located in Roane County and one of the cities—Spring City—is located in Rhea County. Meigs County is also within the study area. Figure 13 provides the current population distribution for the Watts Bar Reservoir and Figure 14 details current demographic information for areas within ½, 1, and 5 miles of the Clinch River and the Lower Watts Bar Reservoir. There are 13,362 people living within ½ mile, 20,573 people living within 1 mile, and 70,700 people living within 5 miles. For children aged 6 and younger, 983 live within ½ mile, 1,621 live within 1 mile, and 5,812 live within 5 miles.

II.E.1. Counties Within the White Oak Creek Study Area

Since 1940, the populations of Meigs County, Rhea County, and Roane County have all grown by over 50% (Bureau of the Census 1993, 2000). Table 4 presents the population for these three counties over a 60-year time period and Figure 15 shows the population distribution for each county over time.

Table 4. Populations of Meigs, Rhea, and Roane Counties From 1940 to 2000

County	*1940*	*1950*	*1960*	*1970*	*1980*	*1990*	*2000*
Meigs County	6,393	6,080	5,160	5,219	7,431	8,033	11,086
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

Source: U.S. Census Bureau 1993, 2000

Figure 13. Population Distribution on the Watts Bar Reservoir

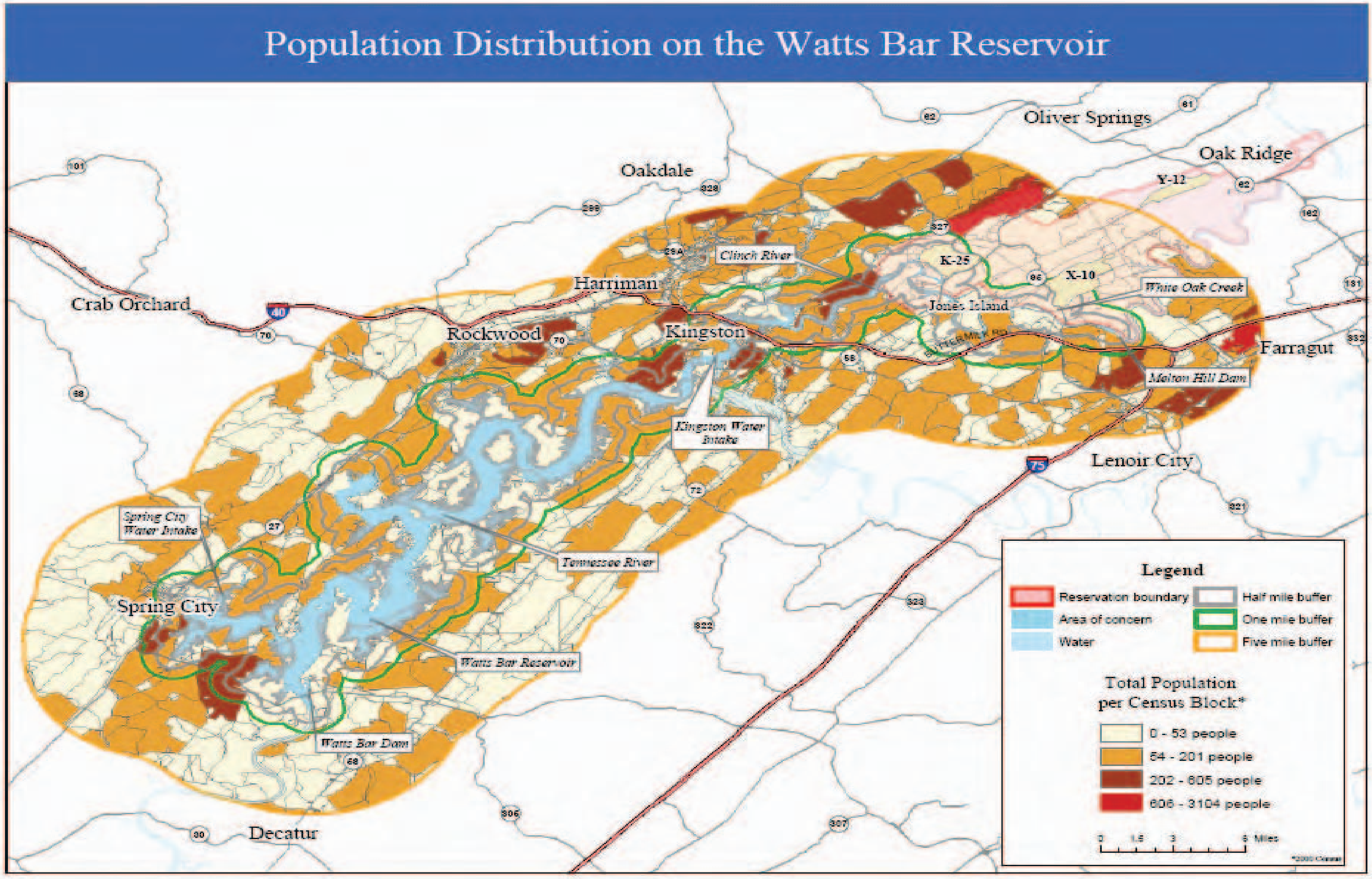


Figure 14. Population Demographics Around the Watts Bar Reservoir

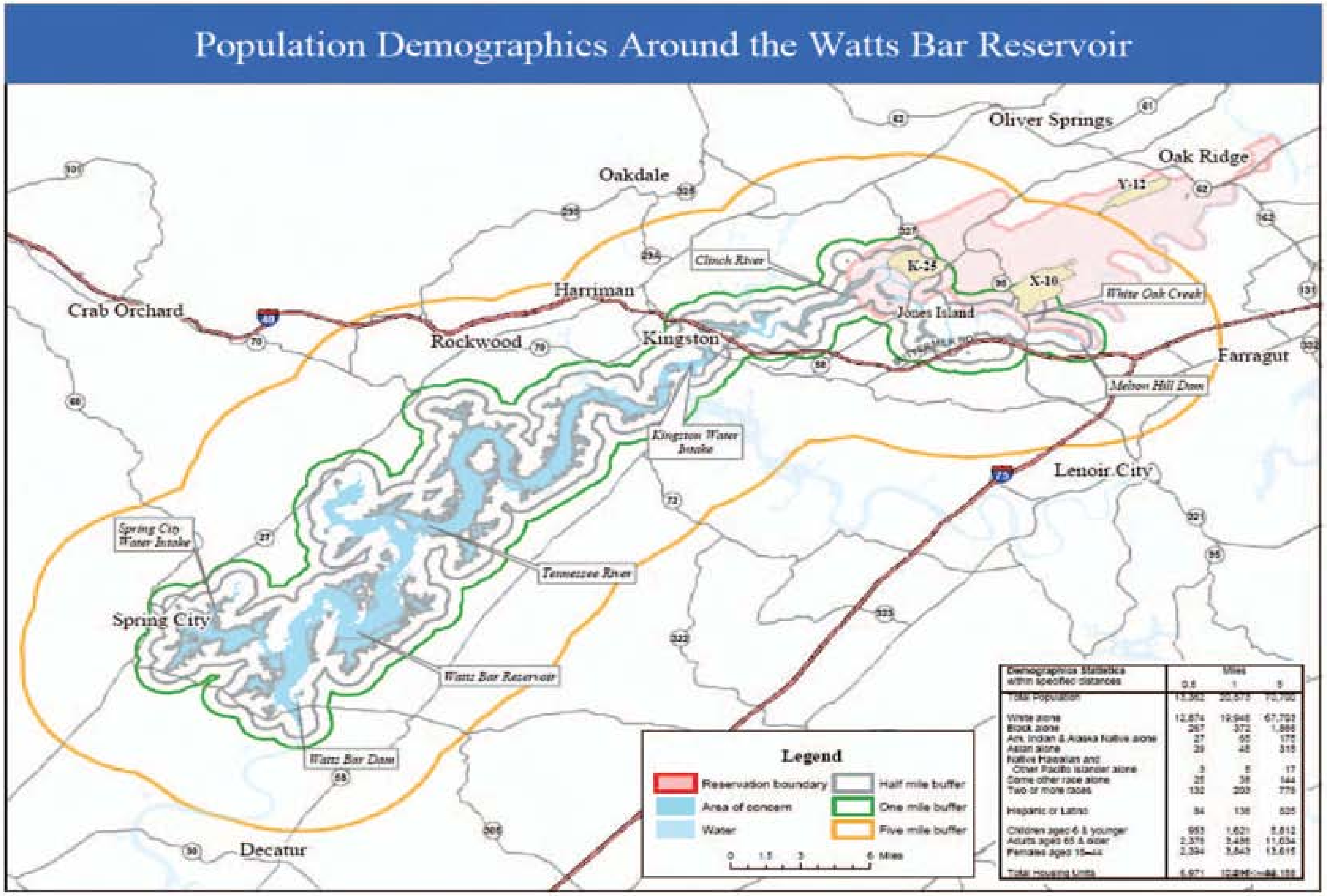
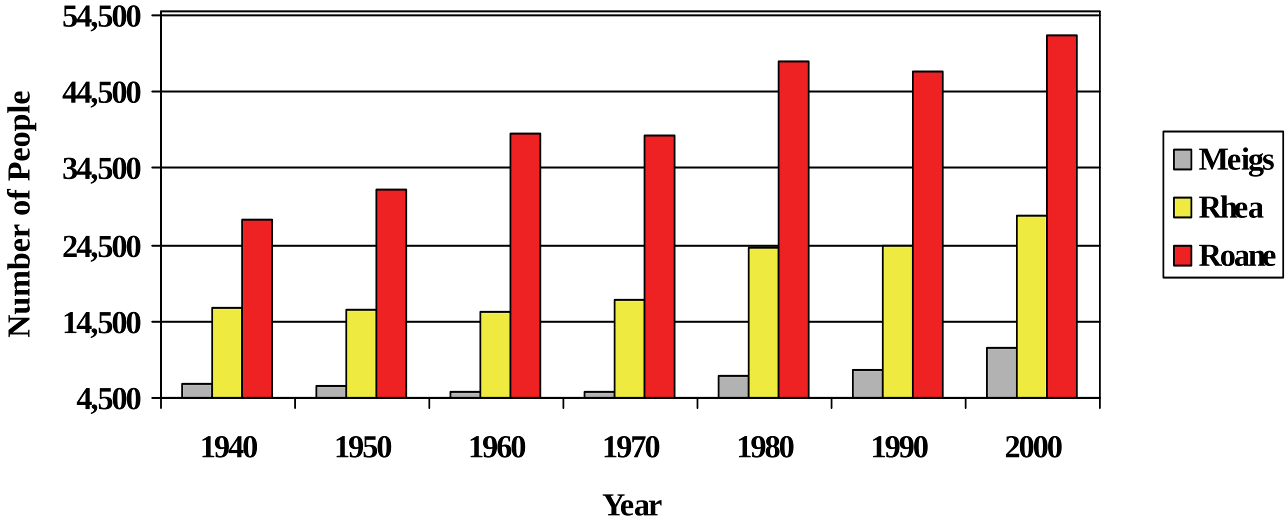


Figure 15. Population Distribution of Meigs, Rhea, and Roane Counties From 1940 to 2000



Source: U.S. Census Bureau 1993, 2000

Meigs County

Although between 1940 and 1960, the population of Meigs County decreased, the population has more than doubled since that time, increasing from 5,160 to 11,086 (114.8%) (see Table 4 and Figure 15). The largest percentage increase in population occurred between 1970 and 1980, when the number of residents grew from 5,219 to 7,431 (42.4%). Since 1940, the population of Meigs County has grown by almost 75% (Bureau of the Census 1993, 2000). As of 2000, the majority of residents worked in the manufacturing industry. The Meigs County population is comprised of 10,826 Caucasians, 138 African-Americans, and 122 persons of other races. Also, the largest percentage of residents is between the ages of 35 and 44, and the median age is 36.7 (Bureau of the Census 2000).

Rhea County

The population of Rhea County declined between 1940 and 1960, but has continued to increase since the 1960s (see Table 4 and Figure 15). The largest increase (40.9%) occurred between 1970 and 1980, when the number of residents increased from 17,202 to 24,235. Over the past 60 years, the population of Rhea County has increased by nearly 75% (Bureau of the Census 1993, 2000). As of 2000, the majority of residents worked in the manufacturing industry. The Rhea

County population consists of 27,097 Caucasians, 580 African-Americans, and 723 persons of other races. In addition, the largest proportion of residents is between the ages of 35 and 44, with a median age of 37.2 (Bureau of the Census 2000).

Roane County

Over this 60-year period, the population of Roane County has grown by 86.8%, as shown in Table 4 (Bureau of the Census 1993, 2000). Slight declines in population occurred between 1960 and 1970, and between 1980 and 1990 (East Tennessee Development District 1995; Bureau of the Census 1993). Meanwhile, the county population increased during the remaining time periods to reach a population of 51,910 in 2000. Figure 15 shows the population distribution of the county over time (East Tennessee Development District 1995; Bureau of the Census 1993, 2000).

The majority of Roane County's 2000 population is Caucasian (49,440); the remaining portion of the population consists of African-American residents (1,409) and persons of other races (1,061) (Bureau of the Census 2000). Since the 1970s, the median age of Roane County residents has increased from 32.1 to 40.7, suggesting that the county has an aging population (East Tennessee Development District 1995; Bureau of the Census 2000). The X-10 site and the K-25 site are both located within Roane County (East Tennessee Development District 1995; Jacobs EM Team 1997a). Primarily because of these two facilities, between 1940 and 1990 manufacturing was the predominant occupation for Roane County residents (East Tennessee Development District 1995; Bureau of the Census 1993).

II.E.2. Cities Within the White Oak Creek Study Area

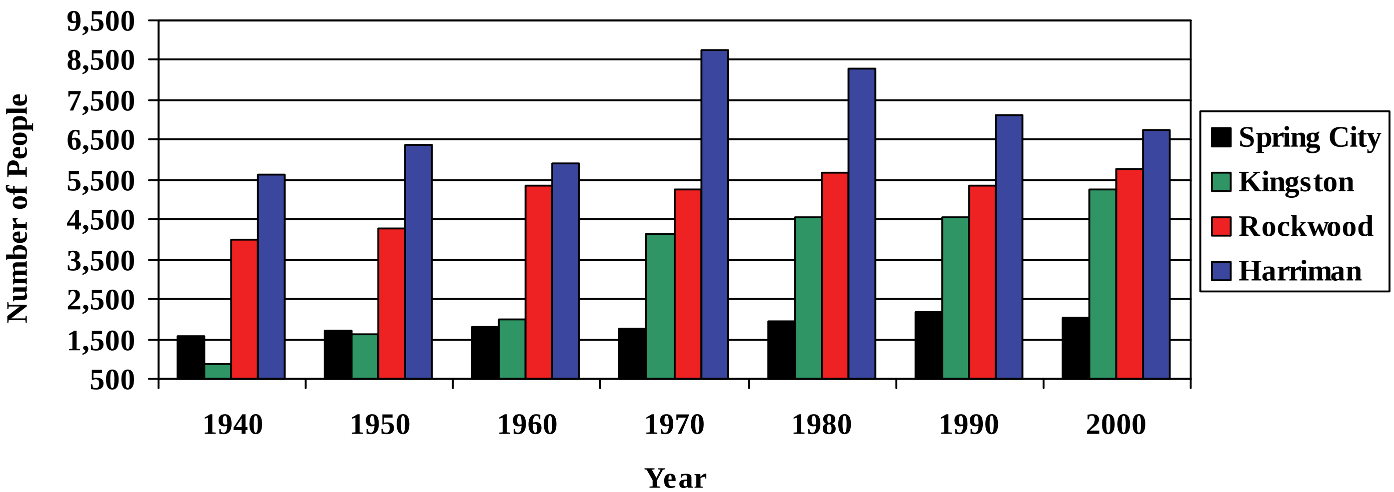
Three cities in the White Oak Creek study area—Kingston, Rockwood, and Harriman—are located in Roane County and Spring City is located in Rhea County. Table 5 shows the populations of these four cities between 1940 and 2000, and Figure 16 shows the population distribution during that time period.

Table 5. Populations of Spring City, Kingston, Rockwood, and Harriman From 1940 to 2000

City	1940	1950	1960	1970	1980	1990	2000
Spring City	1,569	1,725	1,800	1,756	1,951	2,199	2,025
Kingston	880	1,627	2,010	4,142	4,561	4,552	5,264
Rockwood	3,981	4,272	5,345	5,259	5,695	5,348	5,774
Harriman	5,620	6,389	5,931	8,734	8,303	7,119	6,744

Source: Bureau of the Census 1940, 1950, 1960, 1970, 1980, 1993, and 2000

Figure 16. Population Distribution of Spring City, Kingston, Rockwood, and Harriman From 1940 to 2000



Source: Bureau of the Census 1940, 1950, 1960, 1970, 1980, 1993, and 2000

Spring City

Spring City is approximately 49 miles southwest of the X-10 site (see Figure 11) (MapQuest 2003). Between 1940 and 2000, the population of Spring City continually fluctuated, as shown in Table 5. During this time period, the number of residents increased between 1940 and 1960 and between 1970 and 1990. The population declined from 1960 to 1970 and from 1990 to 2000. The largest percentage increase in population was seen between 1980 and 1990, followed by the largest decrease between 1990 and 2000 (Bureau of the Census 1940, 1950, 1960, 1970, 1980, 1993, 2000). As of 2000, the largest percentage (31.6%) of residents worked in the manufacturing industry. The population consists of 1,914 Caucasians, 91 African-Americans, and 20 persons of other races. The highest percentage of the population is between the ages of 35 and 44, and the city's median age is 44.0 (Bureau of the Census 2000).

Kingston

The city of Kingston, which is the seat of Roane County, is located at the confluence of the Clinch River and the Tennessee River (see Figure 11), and it is about 22 miles southwest of the X-10 site (MapQuest 2003). As shown in Table 5, the population of Kingston has grown steadily from 1940 to 2000, except for a 0.2% decrease between 1980 and 1990 (East Tennessee Development District 1995; Bureau of the Census 1993, 2000). In 1969, the city of Kingston had one manufacturing plant; by 1990, 6 of the 35 manufacturing plants in Roane County were in Kingston (East Tennessee Development District 1995). Since 1990, the greatest portion of residents has been employed in the professional services field (East Tennessee Development District 1995; Bureau of the Census 2000). In 2000, the population consisted of 4,935 Caucasians, 187 African-Americans, and 142 persons of other races. The majority of Kingston residents are between the ages of 45 and 54; the median age is 41.6 (Bureau of the Census 2000).

Rockwood

The city of Rockwood is about 33 miles southwest of the X-10 site (see Figure 11) (MapQuest 2003). As Table 5 shows, the population of Rockwood has fluctuated from 1940 to 2000. The city experienced steady growth between 1940 and 2000, except for slight declines that occurred between 1960 and 1970 and between 1980 and 1990 (East Tennessee Development District 1995; Bureau of the Census 1993, 2000). In 1969, 10 out of 29 manufacturing plants in Roane County were in Rockwood; by 1990, Rockwood had 13 out of the 35 manufacturing plants in the county (East Tennessee Development District 1995). The largest percentage of residents is employed in the manufacturing field. As of 2000, the Rockwood population consisted of 5,362 Caucasians, 314 African-Americans, and 98 persons of other races. The median age is 42.0, and the greatest portion of individuals is between the ages of 45 and 54 (Bureau of the Census 2000).

Harriman

The city of Harriman is about 24 miles west of the X-10 site (see Figure 11) (MapQuest 2003). As Table 5 shows, the population of Harriman peaked between 1970 and 1980, and has continued to decline since that time (East Tennessee Development District 1995; Bureau of the

Census 1993, 2000). In 1969, 18 of the 29 manufacturing plants in Roane County were located in the city of Harriman. By 1990, Roane County had 35 manufacturing plants, but the number within Harriman had fallen to 15 (East Tennessee Development District 1995). Still, as of 2000, manufacturing is the leading source of employment for Harriman residents. In 2000, the population consisted of 6,077 Caucasians, 501 African-Americans, and 166 persons of other races. The majority of residents are between the ages of 45 and 54, with the median age of 40.5 (Bureau of the Census 2000). As of 1990, Harriman had more minority residents than any other city in Roane County (East Tennessee Development District 1995).

II.F. Summary of Public Health Activities Pertaining to White Oak Creek Radionuclide Releases

This section describes the public health activities that pertain to radionuclide releases to White Oak Creek from the X-10 site. ATSDR, the TDOH, and other agencies have conducted additional public health activities at the ORR, which are described in Appendix C. Please see Figure 5 for a time line of public health activities related to radionuclide releases from X-10.

II.F.1. ATSDR

Since 1991, 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. While the TDOH conducted the Oak Ridge Health Studies to evaluate whether off-site populations have experienced exposures in the *past*, to prevent duplication of the state's efforts ATSDR's activities focused on *current* and *future* public health issues. The following paragraphs highlight major public health activities conducted by ATSDR that pertain to White Oak Creek radionuclide releases.

Health consultations, exposure investigations, and other scientific evaluations. ATSDR health scientists have addressed current public health issues related to the Watts Bar Reservoir area.

- *Health consultation on the Lower Watts Bar Reservoir, February 1996*. In March 1995, DOE released a proposed plan to address the chemical and radiological contaminants in the Lower Watts Bar Reservoir. DOE's plan called for leaving contaminated sediment in place with the use of institutional controls to prevent disruption of the contaminated sediment (for example, people must apply for and obtain a permit from TVA, the U.S. Army Corps of Engineers (USACE), or TDEC before dredging any sediment in the Lower Watts Bar Reservoir. See Section III.B.3. for more details on the Watts Bar Interagency Agreement and the process to obtain a permit.). Local residents were worried about the contamination in the reservoir and they expressed their concerns about the adequacy of DOE's proposed remedial actions and controls. The residents requested that ATSDR assess the current and future health hazards associated with contaminants left in place in the Lower Watts Bar Reservoir sediment, and as a result, ATSDR conducted a health consultation on the area.

To evaluate the chemical and radiological contaminants in the Lower Watts Bar Reservoir, ATSDR reviewed environmental sampling data from the 1980s and 1990s that had been assembled by DOE, TVA, and various consultants. In addition, ATSDR examined TVA's 1993 and 1994 Annual Radiological Environmental Reports for the Watts Bar nuclear plant. Initially, ATSDR screened the data to determine if any contaminants were present at levels that exceeded health-based comparison values. To determine if current chemical and radiological contaminant levels could potentially affect area residents, ATSDR used both worst-case exposure scenarios and realistic exposure scenarios to estimate the doses for any contaminants that were above the comparison values.

> ATSDR uses a comparison value (CV) as a screening level during the public health assessment process. Substances found in amounts greater than their CVs are further evaluated. If a contaminant exceeds its comparison value, it does not necessarily mean that the contaminant will cause adverse health effects. Comparison values are used to help ATSDR determine which contaminants need to be evaluated more closely.

ATSDR found that only polychlorinated biphenyls (PCBs) in the Lower Watts Bar Reservoir fish presented a public health concern. The agency found that frequent and long-term consumption of reservoir fish could moderately increase a person's chance of cancer, and that reservoir turtles could also contain PCBs at levels of public health concern. (ATSDR et al. 2000).

ATSDR also determined that present contaminant levels in the reservoir sediment and surface water were not of public health concern—the reservoir was safe for recreational activities, such as skiing, swimming, and boating, and the municipal water was safe to drink. Furthermore, ATSDR reviewed the DOE's remedial action plan and concluded the remedial actions were protective of public health. These remedial actions included continuing environmental monitoring; maintaining the fish consumption advisories; and implementing institutional controls to prevent resuspension, removal, disruption, or disposal of contaminated sediment (ATSDR et al. 2000). For more specific details on the findings of ATSDR's health consultation, see Section III.B.3. and Appendix D.

Given its findings, ATSDR made the following recommendations:

1. To minimize exposure to PCBs, the Lower Watts Bar Reservoir fish advisory should remain in effect.

2. ATSDR should work with the state of Tennessee to implement a community health education program on the Lower Watts Bar fish advisory and on the health effects of PCB exposure.

3. The likelihood of health effects from consumption of turtles in the Lower Watts Bar Reservoir should be evaluated. The evaluation should investigate turtle consumption patterns and PCB levels in edible portions of turtles.

4. Surface and subsurface sediments should not be disturbed, removed, or disposed of without careful review by the interagency working group (this working group was previously discussed in Section II.C.3.).

5. Sampling of municipal drinking water at regular intervals should be continued. In addition, if a significant release of contaminants from the ORR is discharged into the Clinch River at any time, DOE should notify the municipal water systems and monitor surface water intakes.

- *Watts Bar Reservoir exposure investigation, March 1998*. Prior to this exposure investigation, studies on the Watts Bar Reservoir and on the Clinch River had reviewed several contaminants, but the only contaminant found to be of current public health concern was PCBs in reservoir fish. These past studies, which include DOE's remedial investigations on the Lower Watts Bar Reservoir (1994) and on the Clinch River/Poplar Creek (1996), as well as ATSDR's 1996 Health Consultation on the Lower Watts Bar Reservoir, based their findings on estimated PCB exposure doses and estimated increases of cancer likelihood after consuming large amounts of fish over extended time periods. Mainly, ATSDR conducted this exposure investigation because of the uncertainties associated with estimating exposure doses and by estimating increases in cancer likelihood from ingestion of reservoir fish and turtles. In addition, these past investigations did not confirm that people were actually being exposed or that they had elevated PCB or mercury levels. Also, a TDOH contractor suggested conducting an extensive, region-wide evaluation to assess the relevant exposures and health effects in counties surrounding the Watts Bar Reservoir (Thapa 1996). ATSDR believed, however, that before any agency conducted extensive investigations it should determine if mercury and PCBs were actually elevated in individuals who consumed large amounts of fish and turtles from the reservoir.

> Exposure investigations are one of the public health approaches that ATSDR used to develop a better characterization of past, present, or possible future human exposure to hazardous substances in the environment. These investigations only evaluate exposures and do not assess whether exposure levels resulted in adverse health effects.

The ATSDR exposure investigation evaluated exposures at one point in time (September 1997). Because, however, serum PCBs levels are an indicator of chronic exposure (greater than 1 year) and mercury blood levels are an indicator of intermediate exposure (15 days to 3 months), the investigation results provide information on both past and present exposure. ATSDR focused its evaluation on individuals who consumed moderate to high amounts of fish and turtles from the Watts Bar Reservoir. Participants were recruited through fishing licenses, newspaper, radio, and television announcements, as well as through posters and flyers placed at various fishing-related locations (e.g., bait shops). ATSDR interviewed more than 550 volunteers; 116 of these individuals had consumed enough fish or turtles to be included in the investigation. A brief summary of this exposure investigation is provided in Appendix D.

The results of this investigation were disseminated to the public through a mailing and in a public forum. ATSDR concluded that the participants' serum PCB levels and blood mercury levels were consistent with those seen in the general population. The three major findings are listed below (ATSDR et al. 2000; ORHASP 1999):

1. The investigation participants' serum PCB levels and blood mercury levels were very similar to levels seen in the general population.

2. Of the 116 people tested, only 5 (4%) had serum PCB levels above 20 micrograms per liter (μg/L) or parts per billion (ppb), the level regarded as elevated for total PCBs. Four of the five participants who exceeded 20 μg/L had levels between 20 and 30 μg/L. One participant had a serum PCB level that measured 103.8 μg/L, which is above the distribution seen in the general population. Follow-up counseling was given to study participants with elevated PCB blood levels. Through this counseling, researchers were able to investigate other potential past exposure routes and to recommend behaviors that could reduce future exposure.

3. One investigation participant had a total blood mercury level above 10 μg/L, which is regarded as elevated. The other participants had mercury blood levels that varied up to 10 μg/L, which would be likely in the general population. Follow-up counseling was also given to this person.

Community and physician education on PCBs in fish, September 1996. As a follow-up to the recommendations in the Lower Watts Bar Reservoir Health Consultation, ATSDR created a program to educate the community and physicians on PCBs in the Watts Bar Reservoir. On September 11, 1996, Daniel Hryhorczuk, MD, MPH, ABMT, from the Great Lakes Center at the University of Illinois at Chicago, presented information on the health risks related to the consumption of PCBs in fish. Dr. Hryhorczuk made his presentation to about 40 area residents at the community health education meeting in Spring City, Tennessee. In addition, on September 12, 1996, an educational meeting for health care providers in the Watts Bar Reservoir area was held at the Methodist Medical Center in Oak Ridge, Tennessee. Furthermore, ATSDR collaborated with local residents, associations, and state officials to create a brochure informing the public about TDEC's fish consumption advisories for the Watts Bar Reservoir (ATSDR et al. 2000).

Coordination with other parties. Since 1992 and continuing to the present, ATSDR has consulted regularly with representatives of other parties involved with the ORR. Specifically, ATSDR has coordinated its efforts with TDOH, TDEC, the National Center for Environmental Health (NCEH), the National Institute for Occupational Safety and Health (NIOSH), the Health Resources Services Administration (HRSA), and DOE. These coordinated efforts led to the establishment of the Public Health Working Group in 1999, and then to the formation of the Oak Ridge Reservation Health Effects Subcommittee (ORRHES). In addition, ATSDR provided some assistance to TDOH in its study of past public health issues (ATSDR et al. 2000).

Oak Ridge Reservation Health Effects Subcommittee. The ORRHES was established in 1999 by ATSDR and Centers for Disease Control and Prevention (CDC) under the authority of the Federal Advisory Committee Act (FACA), 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 consists of people who represent 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 are open to the public, and everyone can attend and present their ideas and opinions. The subcommittee performs the following functions:

- Serves as a citizen advisory group to CDC and to ATSDR and makes recommendations on matters related to public health activities and research at the ORR.
- Gives citizens an opportunity to collaborate with agency staff members and to learn more about the public health assessment process and other public health activities.
- Helps to prioritize the public health issues and community concerns to be 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 are open to all who wish to attend and participate. Figure 17 shows the organizational structure of the ORRHES, and Figure 18 is a chart that shows the process of providing input into public health assessments. For more information on the ORRHES, visit the ORRHES Web site at www.atsdr.cdc.gov/HAC/oakridge (ATSDR et al. 2000).

ATSDR field office. In 2001, ATSDR opened 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. The ATSDR field office is located at 1975 Tulane Avenue, Oak Ridge, Tennessee. ATSDR's field office staff can be contacted by calling 865-220-0295 (ATSDR et al. 2000).

Where can one obtain more information on ATSDR's activities at Oak Ridge?

ATSDR has conducted several additional analyses that are not documented here or in Appendix C, as have other agencies that have been involved with this site. Community members can find more information on ATSDR's past activities by 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 the ATSDR Oak Ridge Field Office, public libraries, and the DOE Information Center in Oak Ridge. For directions to these repositories, please contact the ATSDR Oak Ridge field office at (865) 220-0295.

2. *Visit the ATSDR or ORRHES Web sites.* These Web sites include our past publications, schedules of future events, and other information materials. ATSDR's Web site is at www.atsdr.cdc.gov and the ORRHES Web site is at 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/index.html.

3. *Contact ATSDR directly.* Residents can contact representatives from ATSDR directly by dialing the agency's toll-free number, 1-888-42ATSDR (or 1-888-422-8737).

Figure 17. Organizational Structure for the Oak Ridge Reservation Health Effects Subcommittee

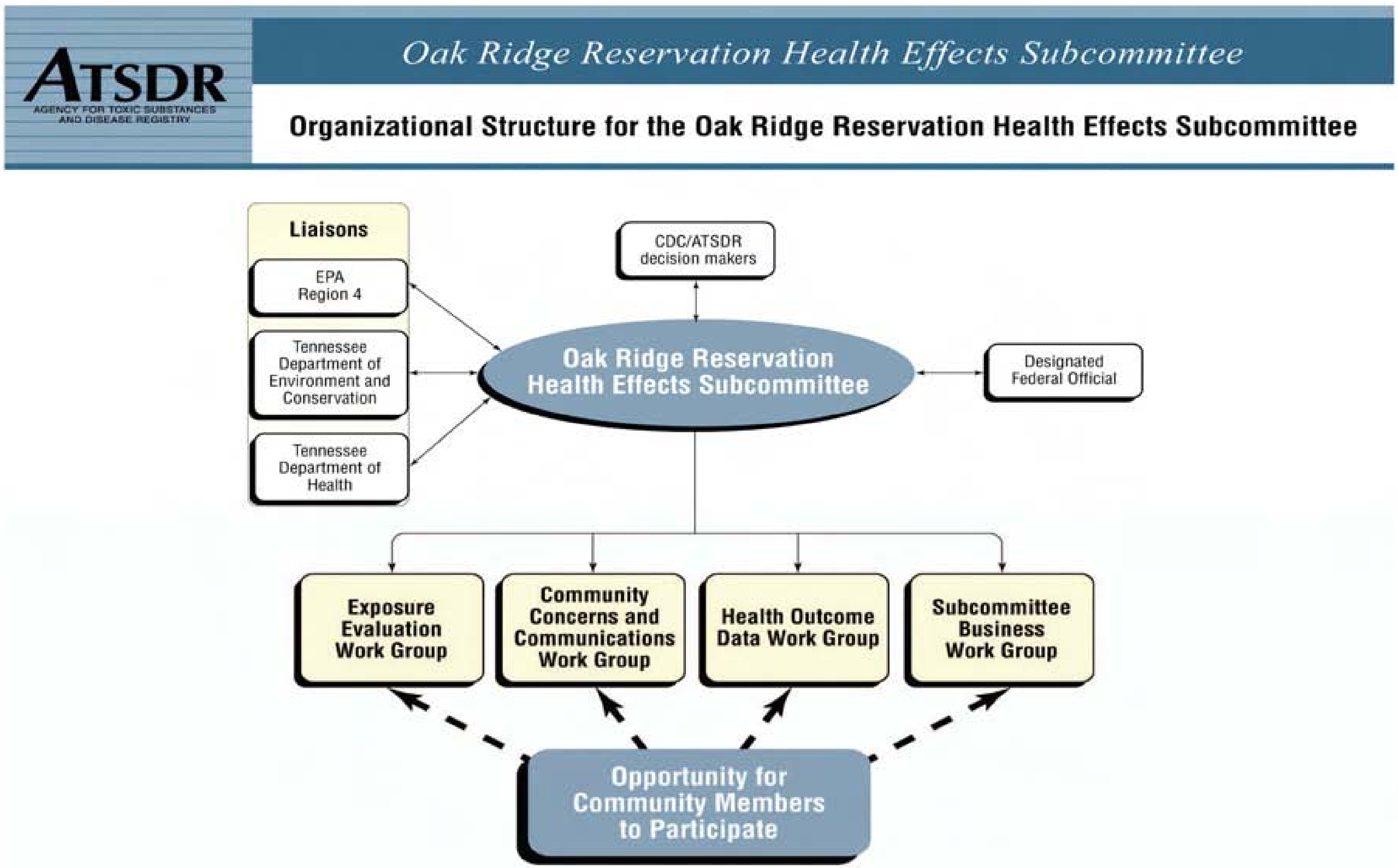


Figure 18. Process Flow Sheet for Providing Input Into the Public Health Assessment Process