ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

OAK RIDGE RESERVATION (USDOE)
WHITE OAK CREEK RADIONUCLIDE RELEASES
OAK RIDGE, ANDERSON COUNTY, TENNESSEE
EPA FACILITY ID: TN1890090003
APRIL 25, 2005

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

Comment Period Ends:

JUNE 23, 2005

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has previously been provided to EPA and the affected state in an initial release, as required by CERCLA section 104 (i) (6) (H) for their information and review. Where necessary, it has been revised in response to comments or additional relevant information provided by them to ATSDR. This revised document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Please address comments regarding this report to:

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Prepared by:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

Foreword

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

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

Exposure

As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects

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

ATSDR uses existing scientific information, which can include the results of medical, toxicologic, and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is

not available. When it touches on cases in which this is so, this report suggests what further public health actions are needed.

Conclusions

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

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

Community

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

Comments

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

Attention: Chief, Program Evaluation, Records, and Information Services Branch
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Atlanta, GA 30333

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Acronyms

ALARA	as low as reasonably achievable
ALI	annual limits on intake
ALS	amyotrophic lateral sclerosis
AOEC	Association of Occupational and Environmental Clinics
ATSDR	Agency for Toxic Substances and Disease Registry
Bq	becquerel
BSCP	Background Soil Characterization Project
CDC	Centers for Disease Control and Prevention
Ce 144	cerium 144
CED	committed effective dose
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFRF	consolidated fuel recycling facility
Ci	curie
cm	centimeter
Co 60	cobalt 60
COC	contaminant of concern
COPD	chronic obstructive pulmonary disease
CRM	Clinch River mile
Cs 137	cesium 137
D&D	decontaminating and decommissioning
DCF	dose conversion factor
DDREF	dose and dose rate effectiveness factor
DOE	U.S. Department of Energy
EDE	effective dose equivalent
EE/CA	Engineering Evaluation/Cost Analysis
EEWG	Exposure Evaluation Work Group
EFPC	East Fork Poplar Creek
EPA	U.S. Environmental Protection Agency
ERAMS	Environmental Radiation Ambient Monitoring System
ETTP	East Tennessee Technology Park
FACA	Federal Advisory Committee Act
FAMU	Florida Agriculture and Mechanical University
FDA	Food and Drug Administration
FFA	Federal Facility Agreement
FFAB	Federal Facilities Assessment Branch
GAAT	gunite and associated tanks
GAO	General Accounting Office
Gy	gray
H3	tritium
HF	hydrofracture facility
HFIR	high flux isotope reactor
Hg	mercury
HRE	homogeneous reactor experiment
HRSA	Health Resources Services Administration

Acronyms (continued)

IAG	interagency agreement
ICRP	International Commission on Radiological Protection
IHP	intermediate holding pond
IROD	Interim Record of Decision
I 131	iodine 131
ISV	in situ vitrification
IWMF	interim waste management facility
LEFPC	Lower East Fork Poplar Creek
LET	Linear Energy Transfer
LLLW	liquid low-level waste
LNT	linear no-threshold
LWBR	Lower Watts Bar Reservoir
MCL	maximum contaminant level
MEPAS	Multimedia Environmental Pollutant Assessment System
MeV	million electron volts
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mGy	milligray
mrem	millirem
μCi/mL	microcuries per milliliter
μg/L	micrograms per liter
μR/hr	microroentgen per hour
MRL	minimal risk level
MS	multiple sclerosis
MSRE	molten salt reactor experiment
mSv	millisievert
MVST	Melton Valley storage tanks
Nb 95	niobium 95
NCEH	National Center for Environmental Health
NCRP	National Council on Radiation Protection and Measurements
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHF	new hydrofracture facility
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no observed adverse effect level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	U.S. Nuclear Regulatory Commission
OHF	Old Hydrofracture Facility
OREIS	Oak Ridge Environmental Information System
ORGDP	Oak Ridge Gaseous Diffusion Plant
ORHASP	Oak Ridge Health Agreement Steering Panel
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORRHES	Oak Ridge Reservation Health Effects Subcommittee
OSWER	Office of Solid Waste and Emergency Response

Acronyms (continued)

OU	operable unit
P&A	plugging and abandonment
PAG	FDA protective action guide
PCB	polychlorinated biphenyl
pCi	picocurie
pCi/L	picocurie per liter
PCM	Poplar Creek mile
PDF	portable document format
PHAP	Public Health Action Plan
PHAWG	Public Health Assessment Work Group
ppb	parts per billion
ppm	parts per million
PWSB	process waste sludge basin
PWTP	Process Waste Treatment Plant
rad	radiation absorbed dose
RaLa	radioactive lanthanum
RAR	Remedial Action Report
RCRA	Resource Conservation and Recovery Act
RER	remediation effectiveness report
RfC	reference concentration
RfD	reference dose
Rh	rhodium
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
Ru 106	ruthenium 106
SDWA	Safe Drinking Water Act
SDWIS	Safe Drinking Water Information System
SNF	spent nuclear fuel
SRS	sediment retention structure
Sr 90	strontium 90
Sv	sievert
SWSA	solid waste storage area
TDEC	Tennessee Department of Environment and Conservation
TDOH	Tennessee Department of Health
TRM	Tennessee River Mile
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TSF	tower shielding facility
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
U 233	uranium 233
USACE	U.S. Army Corps of Engineers
WAC	waste acceptance criteria
WAG	waste area grouping
WBRIWG	Watts Bar Reservoir Interagency Work Group

Acronyms (continued)

WIPP	waste isolation pilot plant
WOC	White Oak Creek
WOCE	White Oak Creek Embayment
W_R	radiation weighting factor
W_T	tissue weighting factor
Zr 95	zirconium 95

I. Summary

ORR Background

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

Over the years, ORR operations have generated a variety of radioactive and nonradioactive wastes. A portion of these remain in old waste sites, and some pollutants have been released into the environment. Consequently, in 1989, the ORR was added to the U.S. Environmental Protection Agency's (EPA's) National Priorities List (NPL). Under a Federal Facility Agreement (FFA) with EPA and the Tennessee Department of Environment and Conservation (TDEC), the U.S. Department of Energy (DOE) is conducting cleanup activities at the ORR. These agencies are working together to investigate and to take remedial action on hazardous waste generated from both past and present site activities.

ATSDR's Involvement and Other Health Activities at ORR

The Agency for Toxic Substances and Disease Registry (ATSDR) is the principal federal public health agency charged with evaluating human health effects of exposure to hazardous substances in the environment. Since 1991 ATSDR has responded to requests and addressed health concerns of community members, civic organizations, and other government agencies in the affected areas of the ORR by working extensively to determine whether levels of environmental contamination in off-site areas present a public health hazard to surrounding communities. During this time, ATSDR has identified and evaluated several public health issues and has worked closely with many parties. While the Tennessee Department of Health (TDOH) conducted the Oak Ridge Health Studies to evaluate whether off-site populations have been exposed in the *past*, ATSDR's activities focused on *current* public health issues related to Superfund cleanup activities at the

site. Prior to this public health assessment, ATSDR addressed current public health issues related to off-site areas, including the East Fork Poplar Creek area and the Watts Bar Reservoir area.

During Phase I and Phase II of the Oak Ridge Health Studies, the TDOH conducted extensive reviews and screening analyses of the available information and identified four hazardous substances related to past ORR operations that could have been responsible for adverse health effects: radioactive iodine, mercury, polychlorinated biphenyls (PCBs), and radionuclides from White Oak Creek. In addition to the 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 on TDOH efforts—but not duplicate them—ATSDR scientists conducted a review and a screening analysis of the department's Phase I and Phase II screening-level evaluation of past exposure (1944–1990) to identify contaminants of concern for further evaluation. Using this review, ATSDR scientists are conducting public health assessments on X-10 iodine 131 releases, Y-12 mercury releases, K-25 uranium and fluoride releases, PCB releases from X-10, Y-12, and K-25, and other topics such as the Toxic Substances Control Act (TSCA) incinerator and off-site groundwater. In spring 2004 ATSDR completed a public health assessment on Y-12 uranium releases and in this public health assessment evaluates radionuclides from White Oak Creek. In conducting these public health assessments, ATSDR scientists are evaluating and analyzing the data and findings from previous studies and investigations to assess the public health implications of past, current, and future exposures.

ATSDR's Evaluation of Exposure to Radionuclide Releases From X-10

As stated, this public health assessment evaluates the releases of radionuclides to the Clinch River (and the Lower Watts Bar Reservoir, or LWBR) from the ORR via White Oak Creek, assesses past, current, and future exposure to radionuclide releases for people who use or live along the Clinch River (and within the White Oak Creek study area; that is, the area along the Clinch River from the Melton Hill Dam to the Watts Bar Dam), and addresses the community health concerns and issues associated with the radionuclide releases from White Oak Creek. This document does not address the release of other contaminants of concern such as mercury, radioactive iodine, PCBs, uranium from the K-25 facility, and fluorides, nor does it address

exposures to those contaminants. ATSDR will evaluate these contaminants and other topics in separate public health assessments.

Most of the radioactive contamination in White Oak Creek came from ORR's X-10 facility (formerly Clinton Laboratories and now known as the Oak Ridge National Laboratory [ORNL]). The entire ORNL site encompasses approximately 26,580 acres. The main operations at the laboratory take place on about 4,250 acres—the original X-10 site. The ORNL site is located in two valleys: Bethel Valley and Melton Valley. In 1943, the X-10 site was built as a "pilot plant" to demonstrate plutonium production and separation. The government had planned to run the X-10 site for 1 year, but this time frame was made indefinite as operations at the facility were broadened. Over time, operations at X-10 grew to include nuclear fission product separation, nuclear reactor safety and development, and radionuclide production for worldwide use in the medical, industrial, and research fields. Today, the ORNL site is globally recognized as a research and development laboratory.

White Oak Creek travels south along the X-10 border, flows through or past several contaminated sources in Melton Valley (e.g., solid waste storage areas), and ultimately empties into White Oak Lake. The government had anticipated using this man-made lake as a "settling basin" for radionuclides released from the X-10 site. Some of the contaminants, however, did not settle in White Oak Lake. Instead, they flowed over White Oak Dam into the White Oak Creek Embayment, and then entered the Clinch River. The ORR-related surface water and sediment that traveled through the Clinch River eventually flowed into the LWBR. The LWBR, which is located downstream of the ORR, extends from the confluence of the Clinch River and the Tennessee River to the Watts Bar Dam. Between 1944 and 1991, approximately 200,000 curies of radioactive waste were discharged from X-10 into the Clinch River via White Oak Creek.

ATSDR concluded that past, current, and future exposures to radionuclides released from White Oak Creek to the Clinch River/Lower Watts Bar Reservoir are not a public health hazard. People who used or lived along the Clinch River or Lower Watts Bar Reservoir in the past, or who currently do so or will in the future, might have or might yet come in contact with X-10 radionuclides that entered the Clinch River or Lower Watts Bar Reservoir via White Oak Creek. However, ATSDR's evaluation of data and exposure situations for users of these waterways indicates that the levels of radionuclides in the sediment, surface water, and biota are—and have been in the past—too low to cause observable health effects.

Past Exposure (1944–1991)

ATSDR evaluated past exposure to radionuclides released from the X-10 site via White Oak Creek. ATSDR's evaluation showed that the estimated external and internal radiation doses from off-site exposure to radionuclides released to the Clinch River from the X-10 site via White Oak Creek in the past were not expected to have caused harmful health effects. Therefore, ATSDR concluded that past off-site exposure to radionuclides that traveled from X-10 to the Clinch River via White Oak Creek was not a public health hazard.

To evaluate past exposure to radionuclide releases from the X-10 site via White Oak Creek, ATSDR primarily relied on data generated during Task 4 of the TDOH's Reports of the Oak Ridge Dose Reconstruction: Radionuclide Releases to the Clinch River from White Oak Creek on the Oak Ridge Reservation—an Assessment of Historical Quantities Released, Off-Site Radiation Doses, and Health Risks (referred to as the "Task 4 report"). The Task 4 team conducted a screening process that allowed the team to estimate the dose and subsequent risk (to individuals and to target organs) associated with exposure to 24 radionuclides in Clinch River sediment, surface water, and biota. The team assumed that individuals would have been exposed between 1944 and 1991—a period of up to 48 years—and that exposure to radionuclides would have occurred during recreational activities or from the consumption of water, milk, fish, local meats, or local crops. Because of conservative parameters used by the Task 4 team, the calculated risk and true exposure would not be underestimated for people who actually lived in the community.

Through its screening process, the Task 4 team concluded that 16 out of 24 radionuclides released from White Oak Creek to the Clinch River did not need further evaluation because the estimated screening indices were below the minimal level of concern. The Task 4 team further studied the following radionuclides: cobalt 60 (Co 60), strontium 90 (Sr 90), niobium 95 (Nb 95), ruthenium 106 (Ru 106), zirconium 95 (Zr 95), iodine 131 (I 131), cesium (Cs 137), and cerium 144 (Ce 144). In addition, the team was able to eliminate from further analysis the swimming and irrigation pathways (or ingestion of locally grown crops). The pathways requiring additional evaluation included drinking water, fish consumption, external radiation from contaminants in shoreline sediments, and ingestion of milk and meat from cattle that grazed near the river.

For this public health assessment, ATSDR used the Task 4 report results to re-evaluate past radionuclide exposures. ATSDR also used the report to estimate doses to community members who consumed local livestock or milk, or who used the Clinch River downstream from the mouth of White Oak Creek for recreation or for drinking water. These estimated doses for past radionuclide exposures to community members varied by critical organ, by pathway of exposure, and by gender.

ATSDR's evaluation indicated that people who ate fish from the Clinch River received the highest estimated doses of radiation. Doses from fish consumption exceeded dose estimates for all exposure pathways by at least a factor of 7. Primarily, the dose depended on how often people ate fish and on the area of the Clinch River where the fish were collected. The highest cumulative organ doses (1944–1991) were for individuals who consumed fish frequently (1 to 2.5 fish meals per week) and caught their fish near Jones Island, close to the mouth of White Oak Creek. The estimated organ doses for people consuming fish from the Jones Island area of the Clinch River were higher than doses received by people walking along the shore and ingesting water, milk, meat, and fish caught from locations downstream of Jones Island.

The Task 4 authors predicted that from any of the exposure pathways, human bone surface received the highest radiation dose. The higher doses to the bone reflect the additional contribution from Sr 90. Still, the maximum annual dose of radiation to the whole body received by people who lived on or used the Clinch River and Lower Watts Bar Reservoir (4 mrem per year) is well below (25 times less than) the 100-mrem per year dose recommended for the public by ATSDR, by the International Commission on Radiological Protection (ICRP), by the U.S. Nuclear Regulatory Commission (NRC), and by the National Council on Radiation Protection and Measurements (NCRP). Furthermore, the estimated annual whole-body dose of 4 mrem is about 2% of the 360 mrem that the average U.S. citizen receives each year from background radiation (i.e., levels typically found in the environment and sources from human activities and products, such as medical x-rays). The maximum dose to the whole body over a lifetime (estimated committed effective dose of 278 mrem over 70 years) from all water and sediment exposure pathways is well below (18 times less than) ATSDR's radiogenic cancer comparison value of 5,000 mrem over 70 years. Doses below this value are not expected to result in observable health effects. Radiation lifetime doses to critical organs (e.g., bone, lower large

intestine, red bone marrow, breast, and skin) are also less than ATSDR's comparison values. ATSDR also conducted a separate analysis of possible exposures to radionuclides for Happy Valley residents who relied on the K-25 water intake along the Clinch River for their drinking water. ATSDR's estimated annual whole-body dose of 14 mrem from drinking water at Happy Valley in the past is at least 7 times lower than 1) ATSDR's MRL of 100 mrem/year, 2) the ICRP, 3) NRC, and 4) the NCRP recommendation of 100 mrem/year maximum dose for members of the public. Therefore, people who lived along or used the Clinch River and Lower Watts Bar Reservoir and who in the past were exposed to levels of radionuclides from White Oak Creek were exposed at levels that are not considered a public health hazard.

Current and Future Exposure (1988–Present and Future)

ATSDR evaluated current and future exposure to radionuclides released from the X-10 site to the Clinch River and the LWBR via White Oak Creek. ATSDR evaluated current exposure to radionuclides via consumption of surface water, dermal contact with surface water and sediment, and consumption of fish and game. After a review of environmental data collected in and around the Clinch River and LWBR areas, the annual environmental monitoring, and the institutional controls intended to prevent disruption of sediment, ATSDR has determined that exposure to the current levels of radionuclides in the surface water, sediment, fish, and game are not expected to cause any harmful health effects in the present and future. Therefore, ATSDR concluded that current and future off-site exposure to radionuclides in the Clinch River and the LWBR via White Oak Creek is not a public health hazard.

In its evaluation of current exposures and doses related to releases from White Oak Creek, ATSDR used, for data from 1989 to the present, the Oak Ridge Environmental Information System (OREIS). ATSDR also obtained 1989–1994 data from ATSDR's 1996 health consultation entitled *Health Consultation for U.S. DOE Oak Ridge Reservation: Lower Watts Bar Reservoir Operable Unit. Oak Ridge, Anderson County, Tennessee. Atlanta, Georgia: U.S. Department of Health and Human Services. February 1996.* ATSDR prepared the 1996 health consultation to respond to community members' concerns about possible exposures to contaminants left in place in LWBR sediment. As part of this process, ATSDR evaluated potential hazards from exposure to either undisturbed or dredged LWBR contaminated sediment and reviewed institutional controls intended to prevent disruption of the contaminated sediment

as outlined by the 1991 Watts Bar Interagency Agreement. ATSDR evaluated *current* exposures to radionuclides via consumption of surface water, dermal contact with surface water and sediment (i.e., shoreline and dredged channel sediment), and consumption of fish and game. ATSDR based its evaluation of *future* exposures on current doses and exposures related to releases from White Oak Creek, data on current contaminant levels in the LWBR and the Clinch River, and institutional controls now in place to monitor contaminants in the LWBR and in the Clinch River.

The cities of Kingston and Spring City draw drinking water from the Tennessee River system. TDEC's Division of Water Supply regulates drinking water at all public water systems in Tennessee under EPA's Safe Drinking Water Act. As a requirement of this program, TDEC ensures that all public water systems in the state meet safe drinking water standards for a variety chemical contaminants and radionuclides. TDEC's monitoring of the Kingston and Spring City public water supplies indicates that the drinking water consistently meets safe drinking water standards. Using these results, ATSDR considers this water safe for consumption and for other household uses.

Lower Watts Bar Reservoir (1988–Present and Future)

ATSDR approximated committed effective doses—that is, doses to the whole body that occur over a lifetime—for either adults or children exposed to radionuclides by walking on shoreline sediment, swimming in or ingesting surface water, or eating fish from LWBR. In deriving exposure doses for LWBR, ATSDR scientists used worst-case hypothetical exposure scenarios with conservative (i.e., protective) assumptions that produce doses much higher (i.e., overestimate exposure) than the levels to which people are actually exposed. ATSDR's estimated doses vary by potential pathway of exposure to radionuclides, ranging from 0.18 mrem from incidental ingestion of surface water while swimming in the Clinch River over a period of 70 years to 1,400 mrem from walking on and handling contaminated sediments dredged from the LWBR deep river channels over a period of 70 years. Nonetheless, ATSDR's conservatively derived, committed effective dose to the whole body for all pathways combined is less than 1,900 mrem—2.5 times below ATSDR's radiogenic CV of 5,000 mrem. ATSDR derived the *radiogenic comparison value* of 5,000 mrem over 70 years after reviewing the peer-reviewed literature and other documents developed to review the health effects of ionizing radiation. Doses

below this value are not expected to result in observable health effects. Furthermore, the estimated annual whole-body dose is less than 30 mrem, which is below (3 times less than) the dose of 100 mrem per year recommended for the public by ATSDR, ICRP, NCRP, and NRC. Therefore, ATSDR considers that the current exposures associated with the detected level of radionuclides in sediment, surface water, game, and fish of the LWBR pose no threat to public health.

Clinch River (1989–Present and Future)

ATSDR's estimated, committed effective dose to the whole body for all pathways along the Clinch River combined is less than 240 mrem—more than 20 times below ATSDR's radiogenic CV of 5,000 mrem. The estimated annual whole-body dose is less than 3.4 mrem—about 30 times below ATSDR's screening comparison value and about 30 times below ICRP's, NCRP's, and NRC's recommended value for the public of 100 mrem/year. The current radiation doses from exposure to radionuclides along the Clinch River varied by organ. ATSDR's estimates show that the *bone* receives the highest total committed equivalent dose over an average (70-year) lifetime of exposure to radionuclides detected along the Clinch River. Ingestion of geese muscle or liver (230 mrem) and fish (114 mrem) were associated with the highest contributions to the bone. Much lower doses were associated with ingestion of Clinch River water (2.8 mrem) and external exposures from walking on sediment (13 mrem) and swimming (1.2 mrem) in the study area. That said, however, the dose estimate to the bone is less than 5 mrem over 70 years—at least 78,000 times lower than the doses of 390,000 to 620,000 mrem associated with bone cancers in radium dial workers. Therefore, ATSDR considers that current exposures to detected levels of radionuclides in sediment, surface water, fish, geese, and turtles of the Clinch River pose no threat to public health.

Given its evaluation, ATSDR concludes that the levels of radionuclides released from White Oak Creek to the Clinch River and to the LWBR would not reasonably result in harmful health effects for either adults or children who have used or who might continue to use the waterways for recreation, food, or drinking water. **ATSDR therefore concludes that past, current, and future uses of these watersheds do not pose a health hazard**.

II. Background

II.A. Site Description

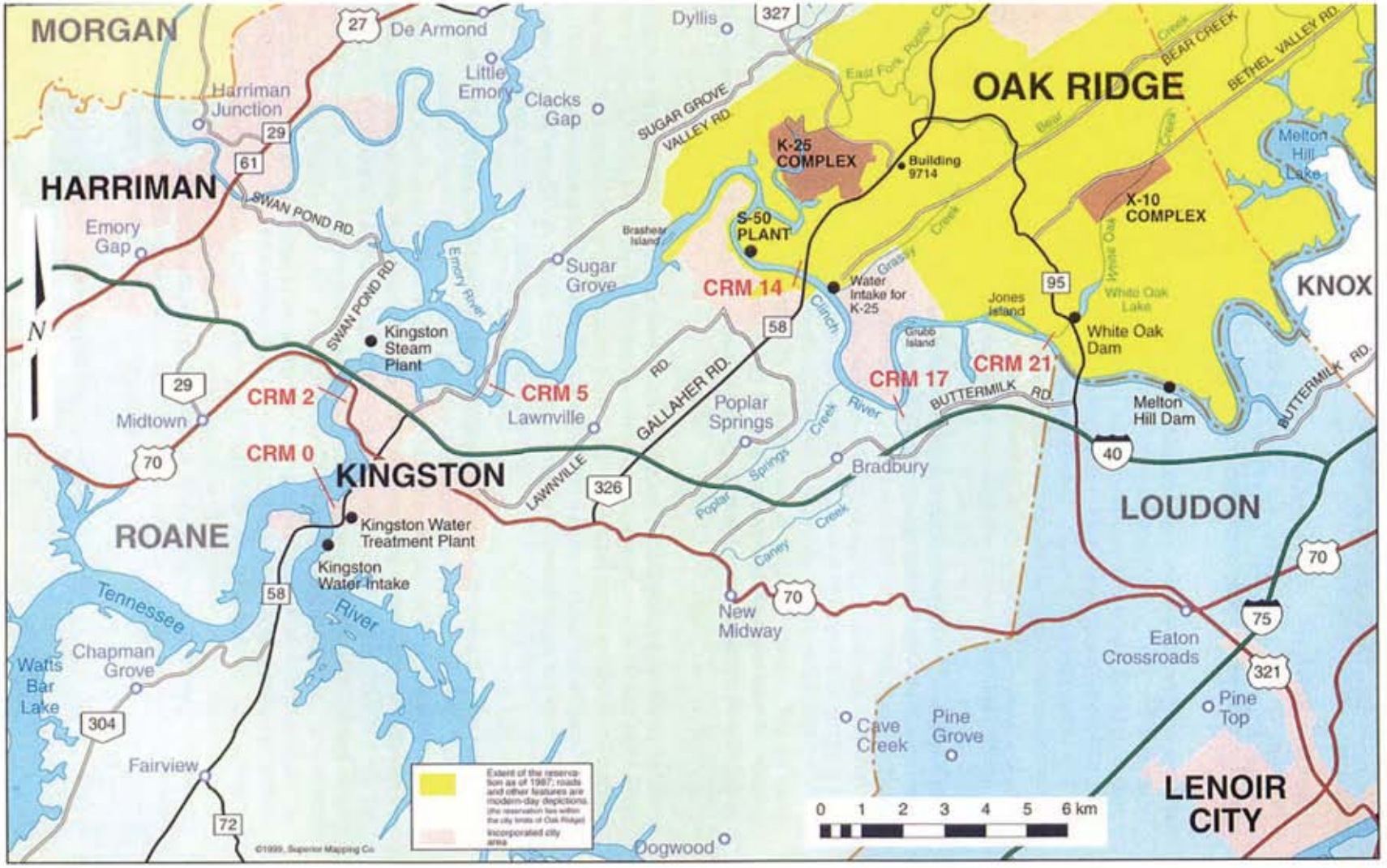
In 1942, during World War II, the U.S. government, under the Manhattan Project initiative, developed the Oak Ridge Reservation (ORR) to produce and study nuclear material needed to make nuclear weapons (ChemRisk 1993b; ORHASP 1999; TDOH 2000). The ORR is located in eastern Tennessee, in the city of Oak Ridge, approximately 15 miles west of Knoxville, and is situated in both Roane and Anderson Counties (ChemRisk 1993b; Jacobs Engineering Group Inc. 1996; ORNL 2002). The southern and western borders of the ORR are formed by the Clinch River, and most of the reservation lies within the Oak Ridge city limits (EUWG 1998). The ORR plants are isolated from the city's populated areas. Figure 1 shows the location of the ORR.

When in 1942 the federal government acquired the ORR, the reservation consisted of 58,575 acres (91.5 square miles). Since that time the federal government has transferred 24,340 (38.0 square miles) of the original 58,575 acres to other parties (e.g., City of Oak Ridge, Tennessee Valley Authority [TVA]), with the U.S. Department of Energy (DOE) maintaining control of the remaining 34,235 acres (53.5 square miles) (Jacobs Engineering Group Inc. 1996; ORNL 2002). Please see Figure 2 for the original and current ORR boundaries.

Under the Manhattan Project, the government constructed four facilities at the ORR. The X-10 site (formerly known as the Clinton Laboratories and now part of what is referred to as the Oak Ridge National Laboratory [ORNL]) was built to produce and separate plutonium. The K-25 site (formerly known as the Oak Ridge Gaseous Diffusion Plant [ORGDP] 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 (now part of the ETTP) were developed to manufacture enriched uranium (ChemRisk 1993b; Jacobs Engineering Group Inc. 1996; TDEC 2002; TDOH 2000).[1]

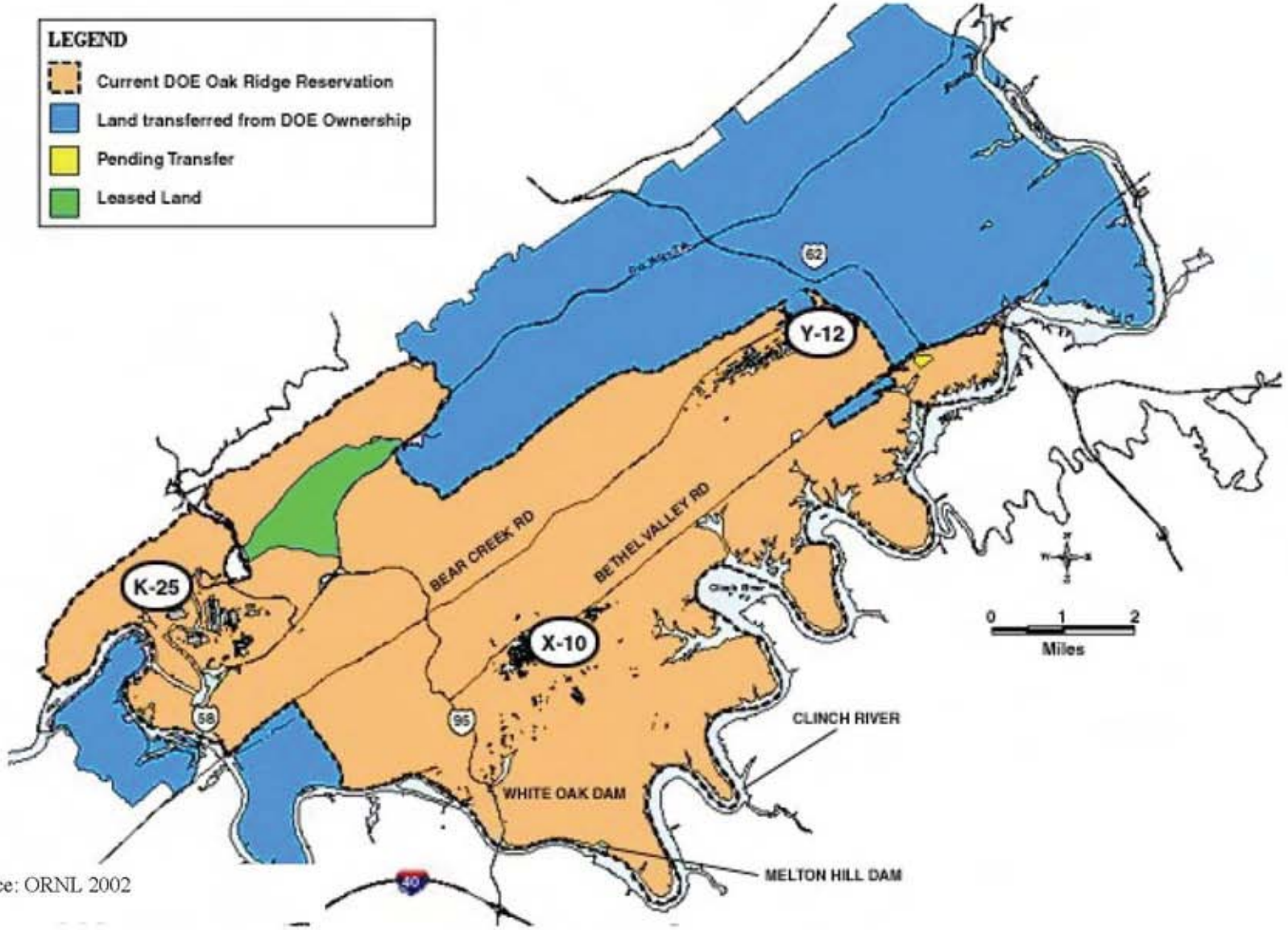
[1] Since this health assessment focuses on radionuclide releases from X-10 to the Clinch River via White Oak Creek, the other main facilities on the ORR are not discussed in detail.

Figure 1. Location of the Oak Ridge Reservation



Source: ChemRisk 1999a

Figure 2. Original and Current ORR Boundaries



Source: ORNL 2002

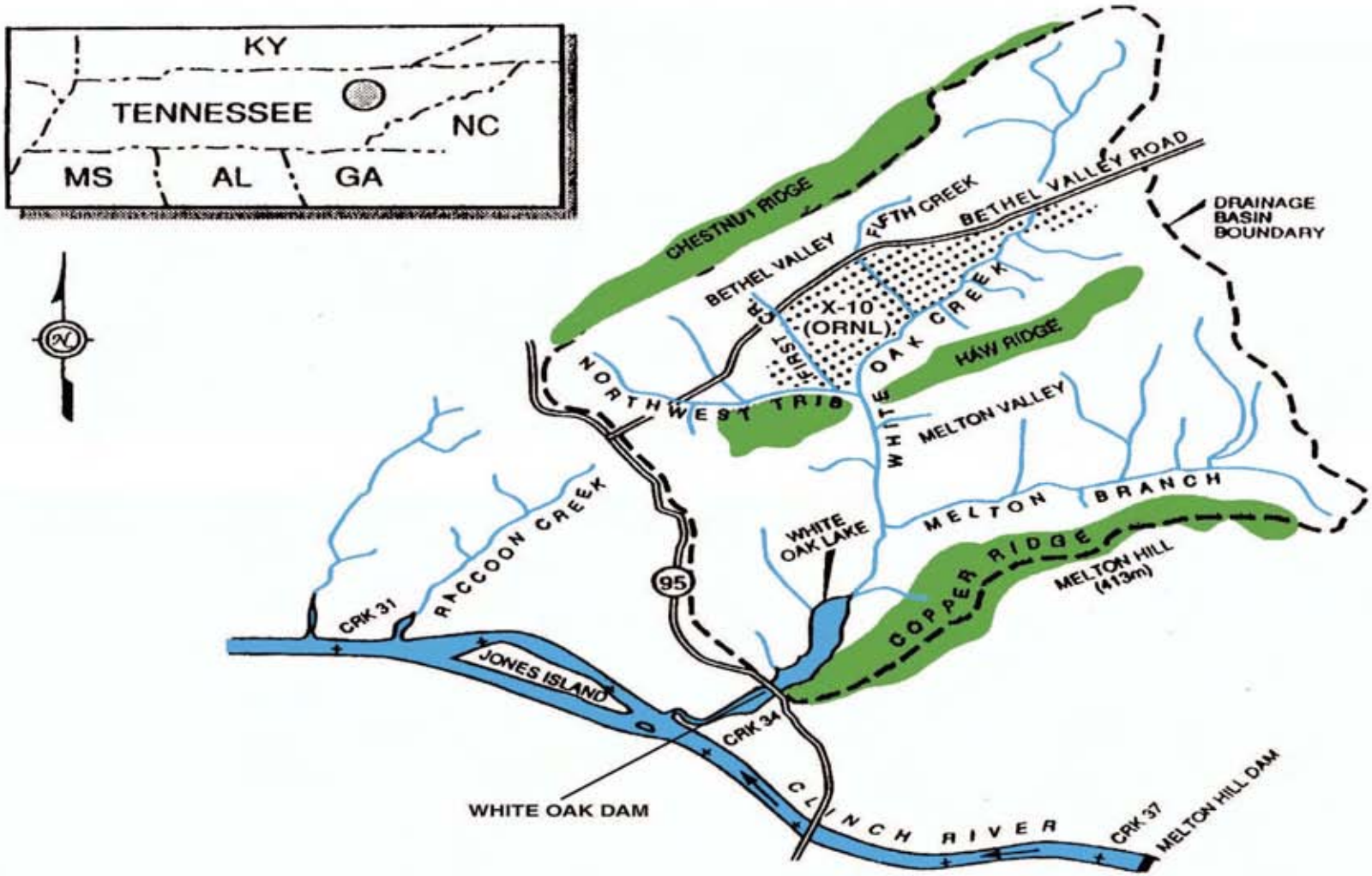
X-10 is now known as the Oak Ridge National Laboratory (ORNL). The entire ORNL site encompasses approximately 26,580 acres and is located in Roane County. The main operations at the laboratory take place on about 4,250 acres—the original X-10 site (Bechtel Jacobs Company LLC et al. 1999; ORNL et al. 1999; TDEC 2002).

The X-10 site is about 10 miles southwest of the city center of Oak Ridge, and is surrounded by heavily forested ridges including Chestnut Ridge, Haw Ridge, and Copper Ridge (ChemRisk 1999a; TDOH 2000). The X-10 site is situated within two watersheds: Bethel Valley and Melton Valley (ORNL et al. 1999). Please see Figure 3 for the location of X-10 in relation to Bethel Valley and Melton Valley. The main laboratory at X-10 is located along Bethel Valley Road, within Bethel Valley (ChemRisk 1999a; ORNL et al. 1999). The X-10 site also contains remote facilities and waste storage areas in Melton Valley (Oak Ridge National Laboratory et al. 1999). White Oak Creek, which begins in Bethel Valley, flows in a southerly direction along the eastern border of the plant and travels through a gap in Haw Ridge before entering Melton Valley (ChemRisk 1993b, 1999a). From Melton Valley, White Oak Creek joins the Clinch River at Clinch River mile (CRM) 20.8 below Melton Hill Dam (ChemRisk 1999a). See Figure 4 for the location of White Oak Creek and the relationship between X-10, White Oak Creek, White Oak Dam, the Clinch River, and the Watts Bar Reservoir.

Before 1963, the Clinch River close to CRM 20.8 was characteristic of a riverine system. Near the mouth of Grassy Creek, at about CRM 14, the Clinch River "becomes wider, the flow decreases, and Watts Bar Reservoir has a greater influence on the water conditions" (G Blaylock, personal communication with ATSDR concerning ATSDR's written comments on the technical reviews of the Oak Ridge Health Studies, Oak Ridge Dose Reconstruction Task 4 Report; 2004).

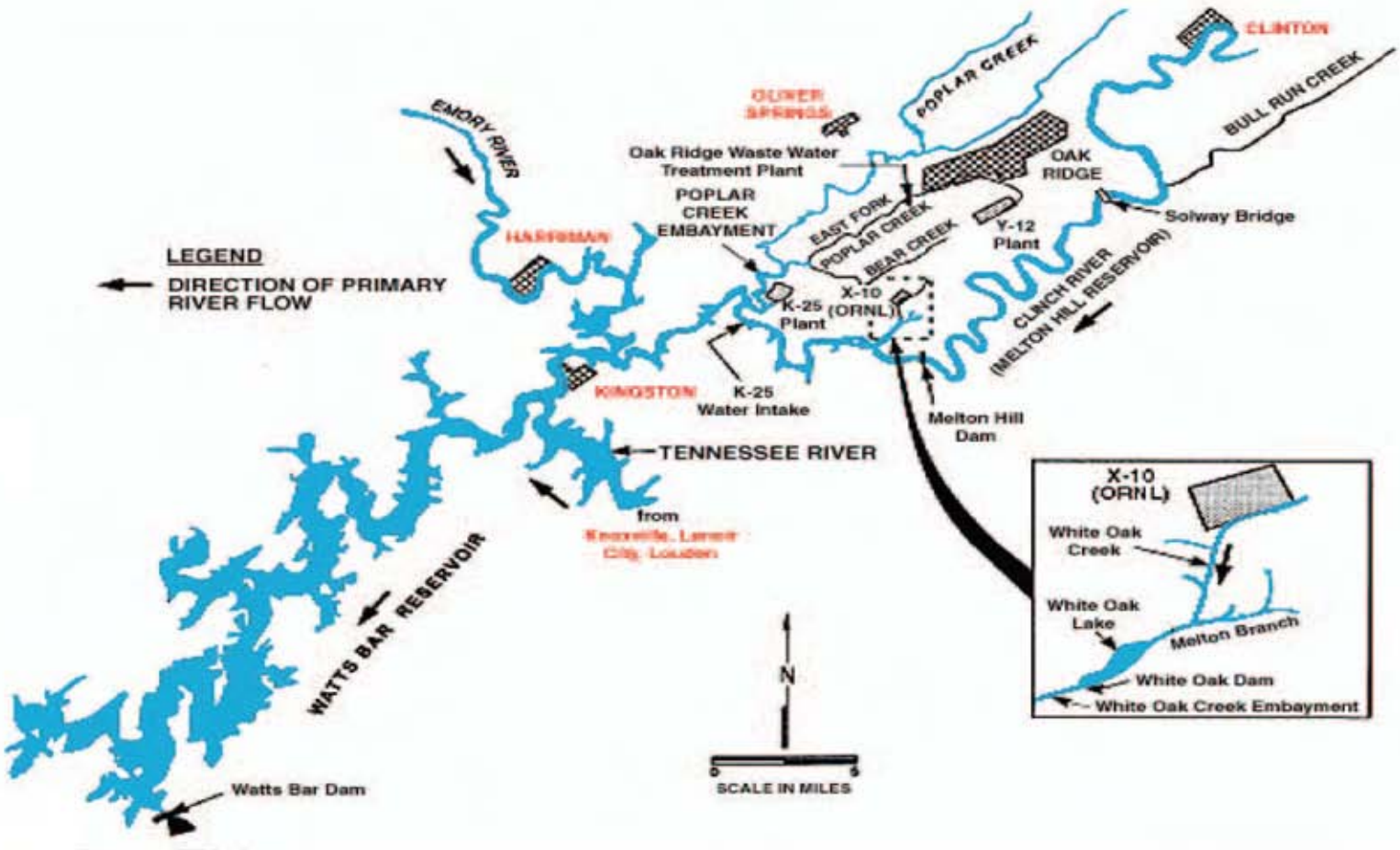
After the construction of the Melton Hill Dam was completed in 1963, the flow of the Clinch River changed. In the morning and evening, Melton Hill Dam releases water when power demands are being met. During remaining times of the day, flow past the mouth of White Oak Creek is extremely minimal. The volume of water released on a daily basis during peak periods is about the same as the quantity of releases prior to Melton Hill Dam's construction, although during peak operations the flow past the mouth of White Oak Creek is significantly higher.

Figure 3. Location of X-10 in Relation to Bethel Valley and Melton Valley



Source: ChemRisk 1999a

Figure 4. Location of White Oak Creek and the Relationship Between X-10, White Oak Lake, White Oak Dam, the Clinch River, and the Watts Bar Reservoir



Source: ChemRisk 1993b