APPENDIX B

OAK RIDGE SITE DESCRIPTION

B.1 GENERAL INFORMATION

General Description of Plant Facilities

The Oak Ridge Reservation (ORR) (Figures 1 and 2) contains three major facilities: the Oak Ridge National Laboratory (ORNL) for energy research and development; the Oak Ridge Y-12 Plant (Y-12) for weapons production; and the Oak Ridge Gaseous Diffusion Plant (ORGDP) formerly utilized for enriching uranium. In April 1984 Martin Marietta Energy Systems, Inc. assumed the role of operating contractor for these facilities.

ORNL; located toward the west end of Bethel Valley, is a large, multipurpose research laboratory whose mission is to conduct basic and applied research in areas related to energy.

The Oak Ridge Y-12 Plant, which is located immediately adjacent to the City of Oak Ridge, has five major responsibilities: (1) fabricate nuclear weapons components, (2) process source and special nuclear materials, (3) provide support to the weapons design laboratories, (4) provide support to other installations, and (5) provide support to other government agencies.

Until the summer of 1985, the primary mission of the ORGDP was U-235 enrichment of uranium hexafluoride (UF_6) for eventual use as a fuel in nuclear reactors. The gaseous diffusion process was used to accomplish the isotopic enrichment. In August 1985, the gaseous diffusion process at ORGDP was shut down.

B.2 OAK RIDGE Y-12 PLANT

The Y-12 Plant produces components for the various nuclear weapon system in the nation's defense arsenal. A portion of this effort involves converting U-235 compounds to metal and the appropriate casting, rolling, and machining operations required to produce a finished product.

The Y-12 Plant lies directly south of Oak Ridge, Tennessee. The Y-12 Plant occupies the upper reaches of East Fork Poplar Creek in Bear Creek Valley, which lies between Pine Ridge to the north and Chestnut Ridge to the south. In the Y-12 area, the land surface in Bear Creek Valley has an elevation of 975+/-50 ft, and the tops of Pine and Chestnut Ridges rise to 1200+/-50 ft.

Bear Creek Valley contains a topographic divide that produces a diverging surface water drainage system. Bear Creek flows southwest to Poplar Creek. East Fork Poplar Creek, which drains most of the Y-12 facilities, flows in the opposite direction to the northeast.

Bear Creek Valley is underlain by Cambrian limestones, siltstones and shales referred to as the Conasauga Group. Pine Ridge consists of sandstones and sandy shales of the Rome formation, and Chestnut Ridge is composed of siliceous dolomites of the Knox Group.

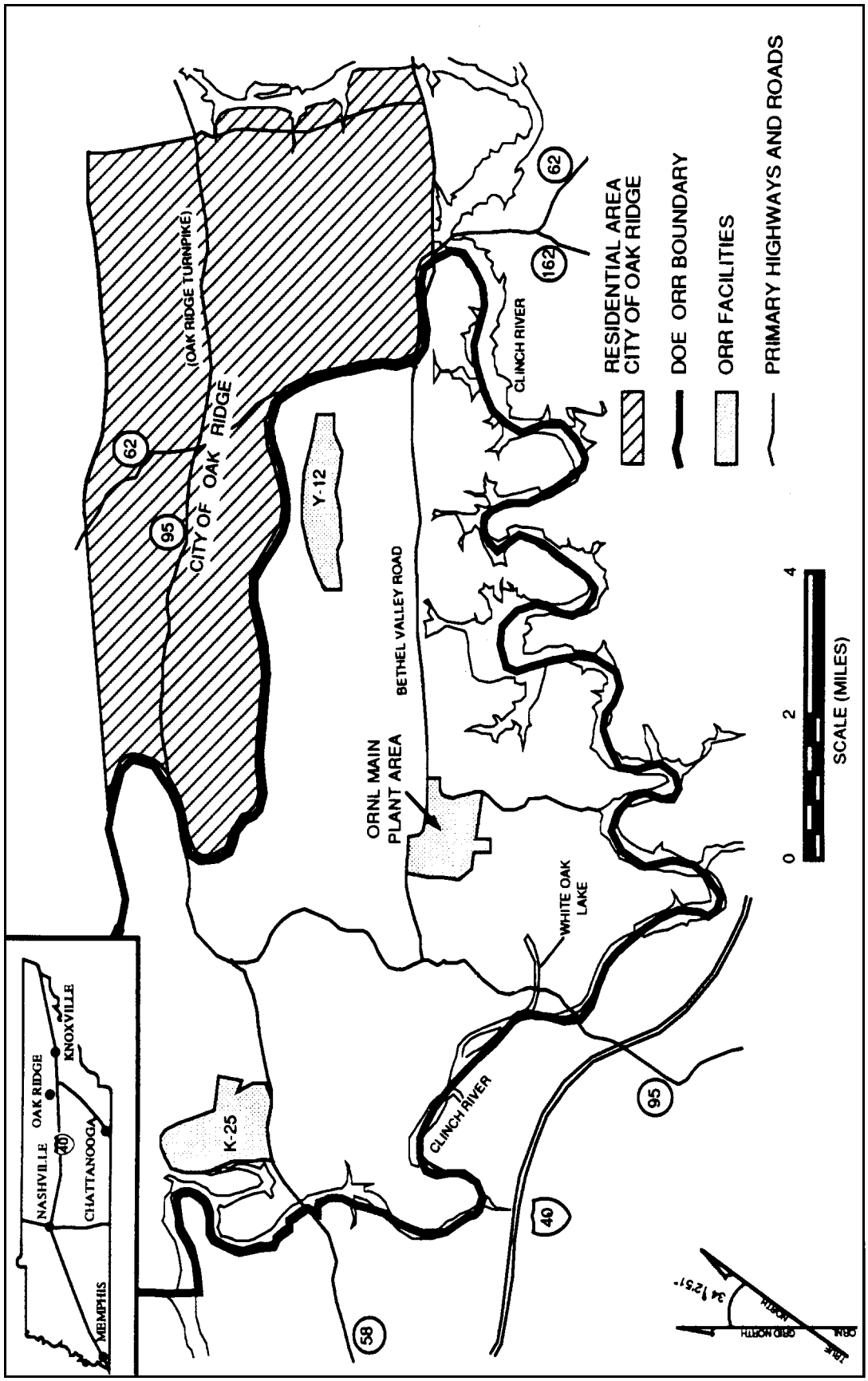

Fig. 1. Map of DOE's Oak Ridge Reservation.

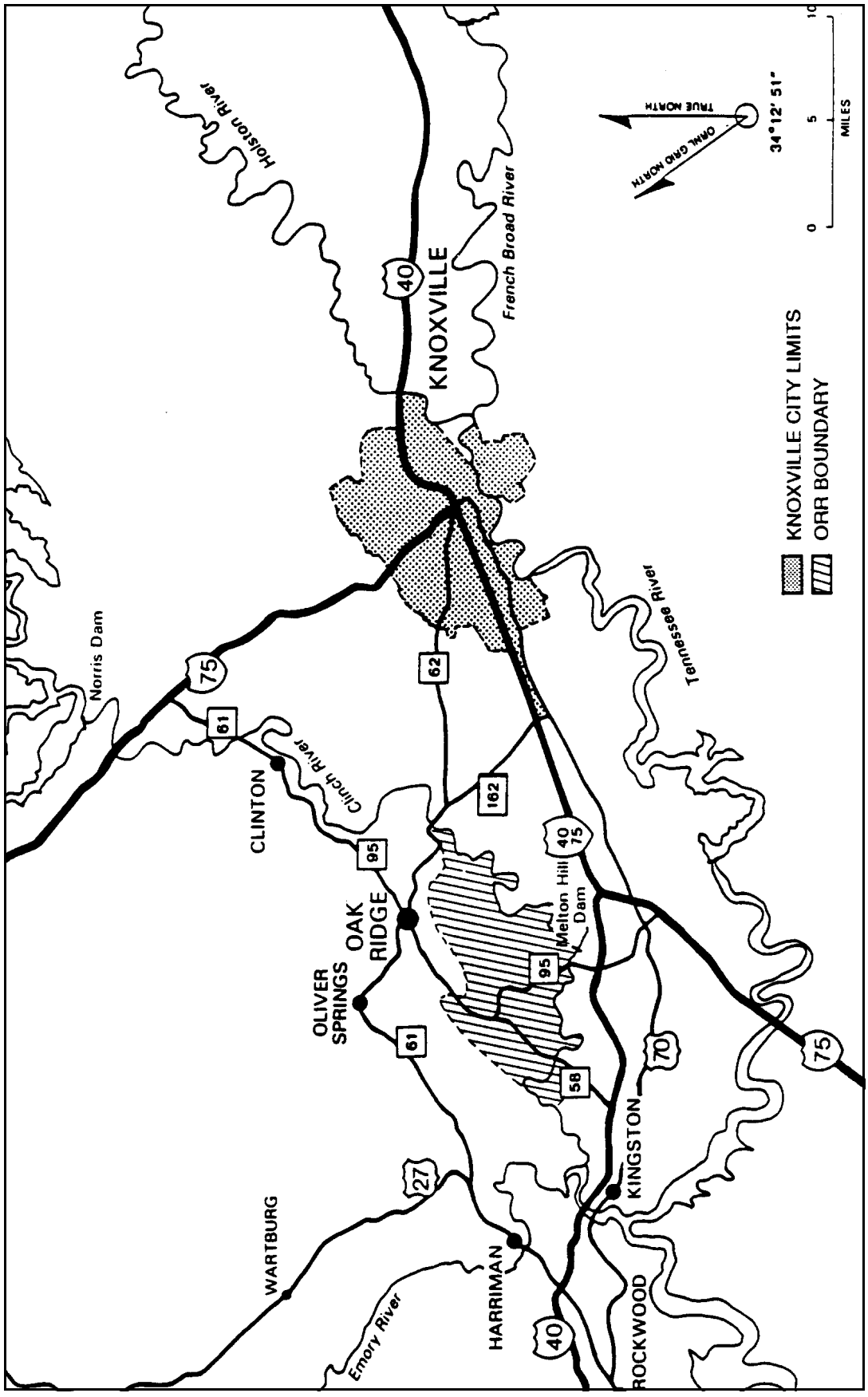

Fig. 2. Map of Oak Ridge, Tennessee, area.

B.3 OAK RIDGE GASEOUS DIFFUSION PLANT (ORGDP)

Although much of ORGDP (also known as K-25) is shut down, some waste streams are being generated and wastes now in storage will require disposal. Waste management activities at ORGDP are increasing. Low-level radioactive waste from other DOE-ORO sites are now being placed in interim storage facilities in the K-25 Building vaults until the final disposition strategy is identified. Also, polychlorinated biphenyl (PCB) contaminated wastes began arriving from other DOE-ORO sites in 1987 for future incineration in the new K-1435 Toxic Substance Control Act (TSCA) incinerator.

As with any large-scale separation process, major support and auxiliary facilities were required. Typical facilities included the feed system and the systems for collecting the product and waste (tails) streams. The uranium hexafluoride (UF_6) feed material was vaporized to the cascade from its containment cylinder in steam-heated autoclaves. The product and tails withdrawal required a condensing system.

Operation of most of the diffusion stages is below atmospheric pressure; therefore, containment leakage to the cascade from the atmosphere, from feed materials, and from internal coolant leaks required a purge cascade for removal of unwanted materials. Trapping facilities employing alumina and sodium fluoride was used extensively.

The recirculating water source for the heat dissipation system was raw water from the Clinch River which was pumped to a clarification facility and treated with lime, soda ash, and organic coagulants (polymers) for removal of calcium, magnesium, and suspended solids. The clarified water was treated with hexavalent chromium, zinc, and phosphate to inhibit corrosion of heat transfer equipment.

Due to high rates of water evaporation in this system, it was necessary to remove or direct a portion of the recirculating water flow through a side stream softener for removal of dissolved solids that concentrate in water. The precipitate for this operation was discharged to a holding pond. A blowdown stream from the recirculating water system was processed through an electrolytic reduction facility where the soluble hexavalent chromium (Cr^{t6}) was reduced to the trivalent state (Cr^{+3}) precipitated, and transferred to the same holding pond.

Support facilities produced solutions that required concentration and recovery with some residual discarded and buried. Laboratory sample residues and obsolete chemical reagents, spent chemicals, and contaminated equipment used in research and development projects, and trapping materials, such as alumina and sodium fluoride, became candidates for discard.

Contaminated classified scrap, material, and equipment discards and classified waste were taken to classified yards and buried.

B.3.1 Historical Releases

B.3.1.1 Radionuclide release summary

From 1946 through 1987, total uranium releases from ORGDP are estimated to be 10,517 kg to the air, 16,699 kg to the surface water, and 33,000 kg to on-site land disposal.

B.3.1.2 Chemical release summary

Numerous chemicals were used at ORGDP each year. Of these, several were released to the atmosphere during normal use due to their volatility. A list of chemicals and the yearly average release for the years between 1979 and 1985 are shown in the following table.

ORGDP Chemical Releases, 1974-1985

Chemical	Annual Average Release
Carbon Tetrachloride	1.8 gal
Chloroform	12.0 lb
Fluorine	91.0 lb
Methylene chloride	692.0 lb
1,1,2-Trichloro-1,2,2-Trifloroethane/acetone	348.0 gal
1,1,2-Trichloro-1,2,2-Trifluoroethane/isopropanol and nitromethane	226.0 lb

B.4 OAK RIDGE NATIONAL LABORATORY (ORNL)

The Oak Ridge National Laboratory (ORNL), also known as the X-10 Site, is located in the southwest portion of the Oak Ridge Reservation on Bethel Valley Road. It comprises approximately 3563 ha, consisting of 445 ha in the central site located in Bethel Valley, of which 222 ha are fenced, and a 3118-ha buffer area containing several satellite facilities. Controlled access to the site is maintained by fences and a 24-hour security patrol.

The principal facilities located at the central site consist of nuclear research reactors, particle accelerators, hot cells, radioisotope production facilities, research facilities in the basic and applied sciences, support operations, and waste management units. Other facilities are located in satellite areas in proximity to the main plant site. These include research reactors; fuel reprocessing facilities; waste treatment, storage and disposal units located in Melton Valley; and the Tower Shielding Facility located on Copper Ridge south of Melton Valley.

B.4.1 Waste Generation

Although early records of ORNL site operations are generally not complete, it has been possible to piece together a fairly accurate summary of the major waste generating programs through the available records and interviews with ORNL staff who worked during most of the operating life of the Laboratory. Based on that information, six programs or activities were found to be responsible for essentially all of the waste generation and on-site disposal. These activities are listed as follows:

- fuel reprocessing,
- isotopes production,
- waste management,

- radioisotope applications,
- reactor developments, and
- multi-program laboratory operations.

Waste streams (both liquid and solid) produced by these programs can be characterized as nonhazardous, chemically hazardous, radioactive, or mixed, i.e., containing both radionuclides and hazardous chemicals. Although ORNL produces a variety of waste streams, the bulk of the hazardous waste is radioactive or mixed. In addition to waste generated on site, a significant quantity of solid, low-level radioactive wastes generated at other sites have been disposed of at ORNL. These were received when ORNL was designated as the Southern Regional Burial Ground from 1955 to 1963 and are contained in Solid Waste Storage Areas (SWSAs) 4 and 5.

B.4.2 Environmental Releases

Treatment, storage and/or disposal of liquid and solid wastes in underground storage tanks, surface impoundments, pits/trenches, landfills, and waste treatment facilities have resulted in environmental releases of radioactive and nonradioactive contaminants. As a result of routine waste management operations, a number of spills and leaks have occurred that have resulted in contaminant releases. The magnitude of contamination from environmental releases is dependent, among other factors, on the nature of the waste and the method of disposal and is currently being determined by the Remedial Action Program (RAP).

As an initial step in identifying areas where past and current waste management activities have resulted in residual contamination or which represent a potential source of continuing environmental release, a complete listing of all known active/inactive waste management areas and contaminated facilities has been prepared. Because of the large number of sites on the list (around 300), ORNL has combined the sites into 20 waste area groupings (WAGs). The WAG concept was developed in order to allow “perimeter monitoring of both groundwater and surface water for each hydrologic entity in a time frame that is much shorter than that required to isolate and define each solid waste management unit (SWMU) individually” (Resource Conservation and Recovery Act [RCRA] Facility Assessment, 1987). Each WAG contains sites within geographically contiguous and/or hydrologically defined areas. Three of the WAGs contain only a single site (WAGs 11, 12 and 20); several contain only two to four discrete units (WAGs 2, 3, 4, 6, 10, 13, 15, and 16); the remainder contain ten or more sites. The main plant area (WAG 1), for example, contains more than 100 sites that include surface impoundments, landfills, tanks, container storage areas, treatment facilities, and leak/spill sites.

Evaluation of historical information and the analytical results from environmental surveys indicates that seven of the WAGs will be further characterized in order to determine the source and magnitude of contaminant release. These characterizations are currently being conducted under the authority of RCRA Section 3004(u) according to conditions established by the RCRA Hazardous and Solid Waste Amendments permit for ORNL’s Hazardous Waste Storage Facility -Building 7652.

As remedial investigations continue, it is expected that additional contaminated sites or potential sources of contaminant releases will be discovered. These will be added to ORNL’s list of SWMU/Comprehensive Environmental Response, Compensation, and Liability Act sites, if appropriate, and according to procedures established in ORNL’s RCRA permit - Permit No. TN 1890090003.

B.5 OAK RIDGE ASSOCIATED UNIVERSITIES

Oak Ridge Associated Universities (ORAU) is a private not-for-profit association of 49 colleges and universities. It is a contractor of the U.S. Department of Energy, conducting research and educational programs in the areas of energy, health, and the environment for DOE, ORAU's member institutions, and other private and government organizations. For administrative purposes, ORAU is being included with ORNL facility description, although the facilities, missions and operating contractors are different.

The accidental irradiation of cattle in New Mexico during the testing of the first atomic bomb in 1945 provided an opportunity to study the long-range biological effects of irradiation on animals. The U.S. Government purchased the cattle and shipped them to Oak Ridge and began a research program to investigate the effects of fallout radiation.

B.5.1 History of Operation

Five potential CERCLA sites at ORAU are considered. Four of these sites are on property previously operated by the University of Tennessee for the Atomic Energy Commission (AEC).

B.5.2 Specific Site Descriptions

B.5.2.1 Animal Disposal Site I

A site closure plan was approved on April 11, 1985, by the Tennessee Department of Health and Environment. Closure has been certified.

The carcass burial ground is located near the intersection of Pumphouse and Bethel Valley Roads and is an area not accessible to the general public.

B.5.2.2 Animal Disposal Site II

This disposal site is located on Freels Bend Road near Bluff road.

Animal Disposal Site II was used until 1970 for disposal of solid household waste such a paper, cardboard, office materials, and glassware. Small laboratory animals (mice and rats) may have been disposed of in small quantities, but there is no record of chemical or hazardous waste disposal in this area.

B.5.2.3 Animal Disposal Site III

This disposal site is located near Bull Bluff Road at Clark Recreation Center.

Animal Disposal Site III was used until 1963 when Melton Hill Reservoir covered the road leading to the site. It was used for burial of farm, husbandry and research animals such as sheep, pigs, cattle and horses. No contaminated animals are known to be buried there. There is no record of the burial of chemicals or hazardous wastes at this site.

B.5.2.4 Large Animal Containment Facility

The Large Animal Facility is located in a collection of buildings known as the Scarboro Facility located at the junction of Bethel Valley Road and State Highway 62.

This facility was used for one set of experiments involving pigs and americium. The experimentation lasted from July 19, 1982 - May 20, 1983. Cleanup, decontamination and monitoring took place from June 6, 1983 - August 18, 1983. Americium (Am-241) contaminated ducts are located in the large animal containment facility The contamination is in the ductwork venting the animal containment rooms up to the first line HEPA filters. The building has been decommissioned.

B.5.2.5 MERT Acid Pit

Near the MERT Division buildings 2714F and 2714G at 248 Laboratory Road lies a concrete pit into which laboratory sinks drained. The pit had an inner lining of brick and was divided into two sections at the bottom. Since the 1940s the pit received drainage from all laboratories in this complex. It is believed that this pit was placed between the sewer and the laboratories to act as a dilution point for acids. It has not been used as an acid pit since 1946, although laboratory drains emptied into it until October 1984. The pit contained approximately two feet of sludge contaminated with heavy metals and radioactive materials.

On October 29-30, 1984, the sludge from the acid pit was removed and placed in 55-gallon drums. The barrels were checked for pH and neutralized when appropriate. The barrels were disposed of as mixed wastes at the Oak Ridge National Laboratory. No cracks or openings were observed in the 8" concrete walls or floor after the sludge removal.

B.6 AREA SURFACE WATERS

The impounded Clinch River (i.e., Melton Hill Reservoir, impounded on the Clinch River in 1963, and the upper portion of Watts Bar Reservoir, impounded on the Tennessee River in 1942) bounds the ORR on the south and west for a distance of approximately 63 km (Fig. 3). This boundary extends from Clinch River Kilometer (CRK) 79 above the Melton Hill Dam (at CRK 37) to CRK 16, approximately 3 km downstream from the mouth of Poplar Creek and near the ORGDP. Contaminants released from the ORR enter the Clinch River primarily downstream from the Melton Hill Dam (at CRK 37) via White Oak Creek (ORNL), Bear Creek and East Fork Poplar Creek (Y-12), and Poplar Creek (ORGDP), and are transported downstream into Watts Bar Reservoir. The transport of contaminants down the Clinch River and their ultimate distribution in Watts Bar Reservoir are influenced by the flow regimes of the Clinch and Tennessee Rivers, which are controlled primarily by hydropower releases and secondarily by major storm-flow events.

Watts Bar Reservoir is located on the Tennessee River below its confluence with the Clinch River, and is the first impoundment on the Tennessee River downstream of the ORR. Watts Bar was impounded just prior to the development of the Oak Ridge facilities and, therefore, retains in its sediments a long-term accumulation (and history) of materials released from the Oak Ridge complex.

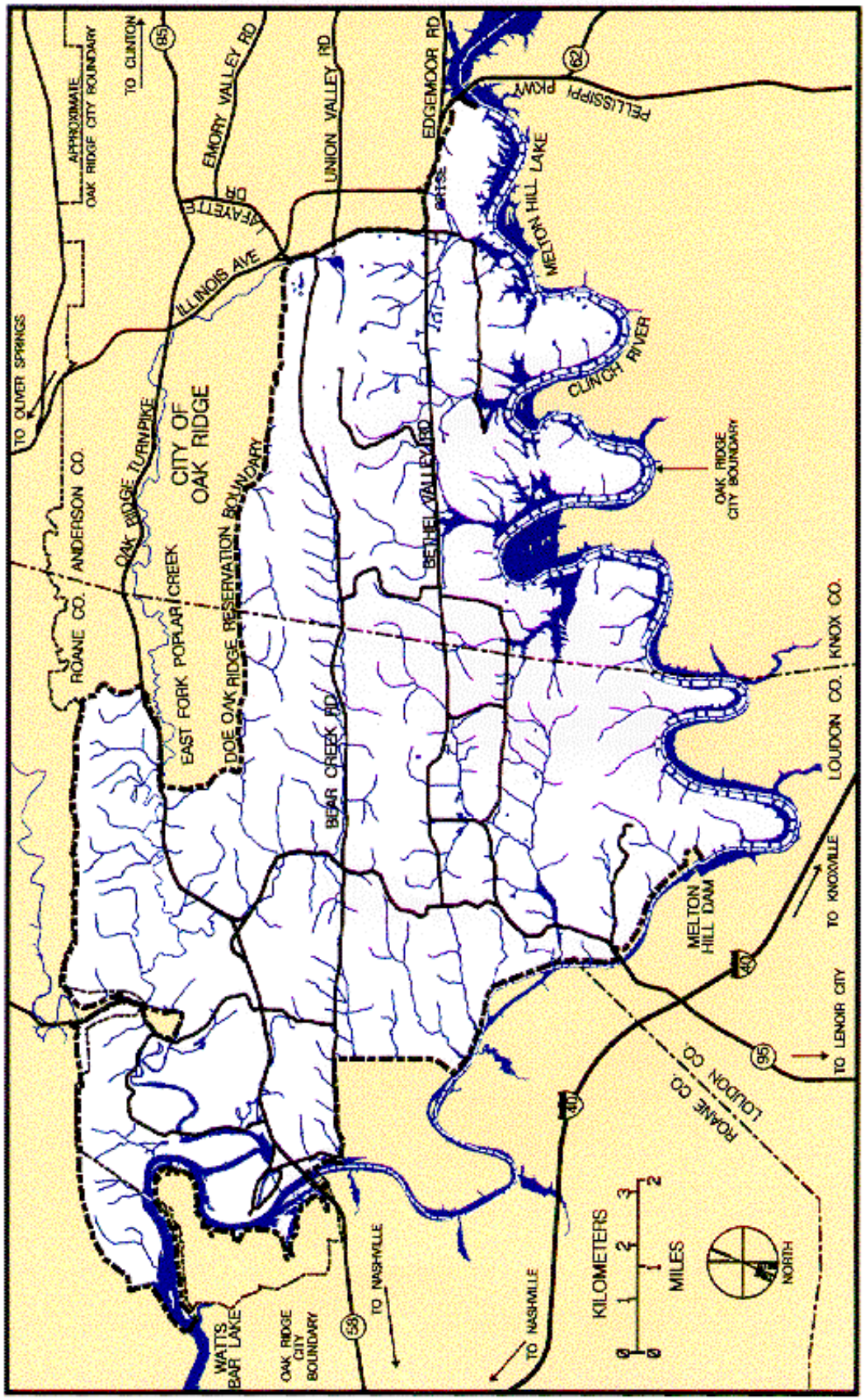

Fig. 3. Area surface waters, showing location of Clinch River and Melton Hill and Watts Bar reservoirs.

B.6.1 Major Streams Draining the ORR

Poplar Creek, with a drainage basin area of 352 km^2, is the only large stream on the ORR, and has three major tributaries (Fig. 4). The main branch (West Fork Poplar Creek) originates off of the ORR in the Cumberland Mountains and drains some areas of strip mining activity. The Creek enters the ORR at Poplar Creek Kilometer (PCK) 9.3 north of the ORGDP and flows through the plant area before entering the Clinch River near CRK 19. East Fork Poplar Creek originates from a spring at the Y-12 Plant, and stream flow was formerly controlled by the New Hope Pond, a 0.2-ha settling basin located 1.6 km below the spring. New Hope Pond closure under RCRA began prior to November 8, 1988. The function formerly served by New Hope Pond is now provided by the new Lake Reality. The Creek flows for approximately 0.9 km below Lake Reality before leaving the boundary of the ORR and entering the populated section of the City of Oak Ridge. After flowing for a distance of approximately 15 km, the stream again enters the ORR and flows another 7.8 km before eventually joining the West Fork at PCK 8.8. The headwaters of the third tributary, Bear Creek, are also located at the Y-12 Plant, although numerous small tributaries originating along the southeast slope of Pine Ridge are located in the upper reaches of the watershed. The stream flows within the ORR for a distance of 11.3 km from the Y-12 Plant to the confluence with East Fork Poplar Creek at EFPCK 2.4.

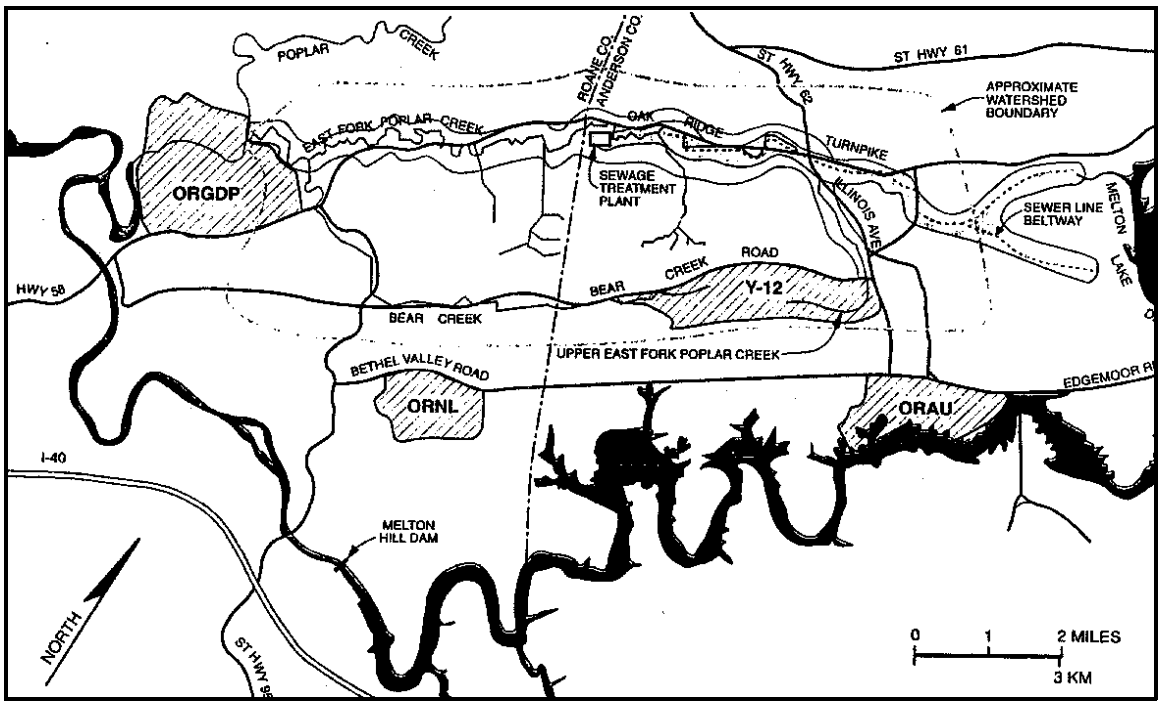

Fig. 4. Poplar Creek and its tributaries.

The White Oak Creek (WOC) watershed (Fig. 5) is located near the southern boundary of the ORR and has a drainage area of 16.9 km. WOC drains the ORNL area and also receives the drainage of Melton Valley through Melton Branch. Three distinct environments can be identified within the WOC watershed: (1) White Oak Lake (WOL), (2) WOC and tributaries above the Lake, and (3) WOC embayment below the Lake. WOL is a shallow impoundment that extends approximately

0.7 km upstream from the dam and has a surface area of about 8 ha. The water level in WOC embayment is controlled by the operation of Melton Hill Dam and Watts Bar Dam. When Watts Bar Reservoir is maintained at or near full pool (approximately April to October) and discharges occur at Melton Hill Dam, the subsequent rise in water level in the Clinch River creates an embayment extending from the mouth of the Creek to the WOL Dam.

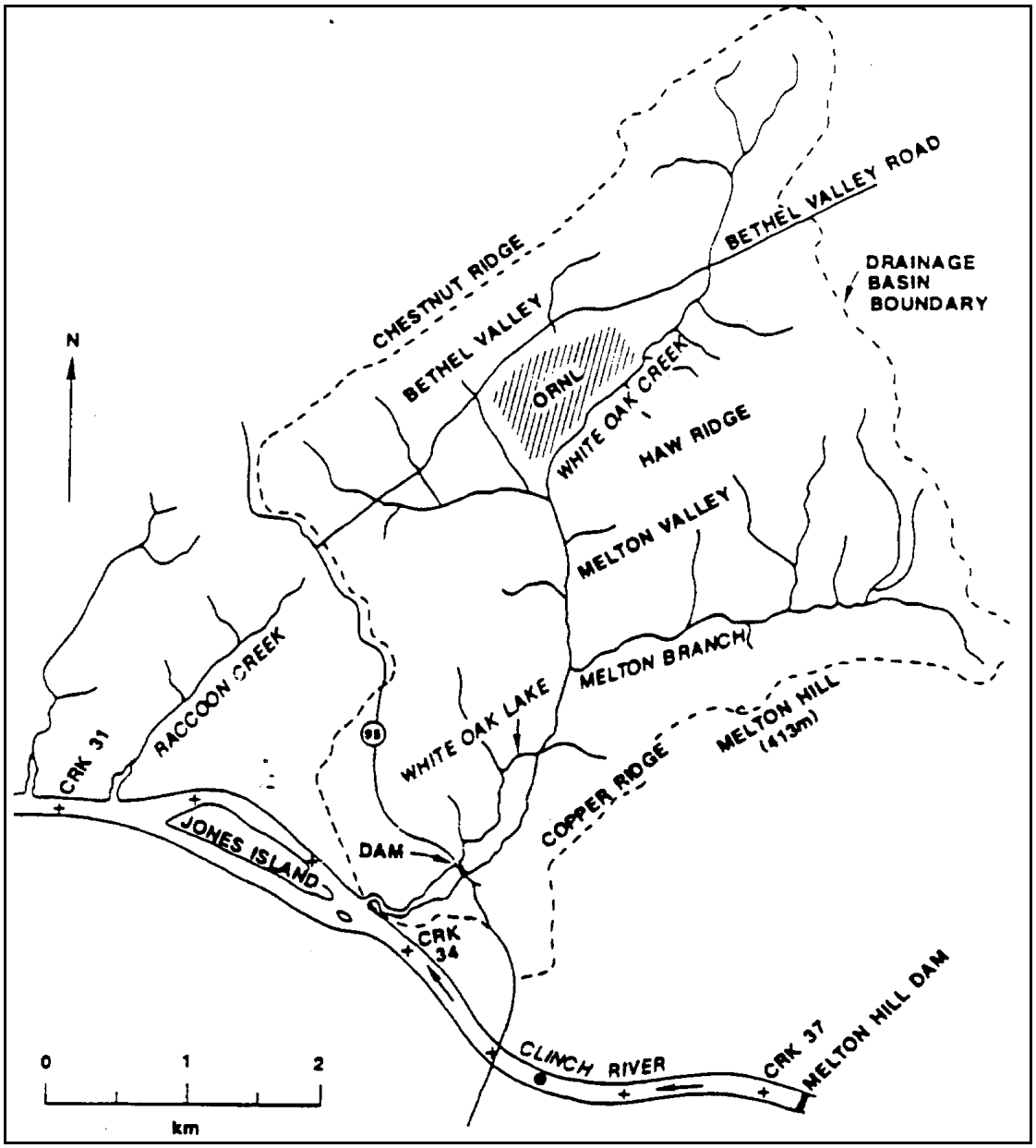

Fig. 5. Map of the White Oak Creek watershed.

B.6.2 The Clinch River

The Clinch River has its headwaters near Tazewell, Virginia, and empties into the Tennessee River at Kingston, Tennessee. The Clinch River watershed comprises 11% of the Tennessee River

watershed. Three dams operated by the TVA control the flow of the Clinch River. The Norris Dam, completed in 1936, is approximately 50 km upstream from the ORR. Norris Reservoir is a water storage, flood control, and hydropower impoundment. The Melton Hill Dam, completed in 1963, controls the flow of the river near the reservation. Its primary function is not flood control but power generation. Watts Bar Dam, completed in 1942, is located on the Tennessee River downstream of the Clinch-Tennessee confluence and affects the flow of the lower reaches of the Clinch.

Peaking power is generated at the Melton Hill Dam, so water flow in the lower Clinch River is pulsed. Pulsation of the flow in the lower Clinch River affects the tributaries on the reservation. During periods of power generation, backflow may occur into Poplar Creek, White Oak Creek and other embayments.

Periods of no flow from the dam have lasted as long as 29 days, and the annual average number of days of no flow per year is 13. During flood conditions, water velocities may be hazardous and may reach 2.1 m/s.

Appreciable deposition of sediments on the bed of the Clinch River begins downstream from CRM 14. The amount of sediment deposition generally increases towards the mouth of the river, with deposition extending laterally over wider and wider parts of the river bed. Upstream from CRM 14, deposition is confined to parts of the channel immediately adjacent to the bank. Sediment deposition patterns are influenced by the effects of water impoundment in Watts Bar Reservoir on sediment transport capacity. The cross-sectional flow area of the reservoir increases in the down stream direction, and as a consequence, the flow velocity and sediment transport capacity of the river decrease.

B.6.3 The Tennessee River

The Tennessee River is one of the most extensively impounded river systems in the world. The TVA water control system consists of 51 dams, including 36 hydropower projects. Nine large multiple purpose reservoirs are located on the mainstem of the Tennessee River between Knoxville, Tennessee and Paducah, Kentucky. These mainstem, multiple purpose reservoirs are used for flood control, hydropower generation, navigation, municipal and industrial water supply, and recreation. Each of these dams has a navigation lock, and together these mainstem reservoirs comprise a 1046-km (650-mile) navigation channel.

Of the nine mainstem impoundments on the Tennessee River, Watts Bar Reservoir is the first reservoir located downstream of the Oak Ridge facilities. The Watts Bar Dam was closed in 1942, just prior to the initiation of plant operations at Oak Ridge. River impoundments are usually efficient sediment and contaminant traps; therefore, much of the contamination released from the Oak Ridge facilities over the pst 45 years can be expected to reside in and/or to be reflected in the Watts Bar Reservoir sediments. recent efforts to determine the extent of contamination of the Watts Bar Reservoir sediments have provided evidence in support of this expectation.

B.6.4 Stream Classification and Water Use

The area in and adjacent to the ORR has no streams classified as scenic rivers or otherwise “sensitive areas.” Waters in the Clinch and Tennessee Rivers are used for water supply, industrial processes, fishing and recreation, irrigation, generation of electric power, and navigation.

Twelve water supplies, serving an estimated population of 200,000 persons within 274 river km (170 river miles) of White Oak Creek, use water potentially influenced by materials released from the ORR. Principal users of the water are the ORGDP and the TVA Kingston Steam Plant on the Clinch River and the communities of Kingston, Soddy Daisy, Falling Water, Waldens Ridge, Chattanooga, and South Pittsburg, Tennessee, on the Tennessee River. Surface water is used by facilities on the ORR as a source of water supply as well as a means for wastewater discharge.

B.6.5 Contaminant Release to the Clinch River

Historical radionuclide releases from the DOE Oak Ridge facilities have been summarized recently (U.S. DOE 1988). Existing data on the estimated annual liquid releases from the ORO include H-3, Co-60, Sr-90, Nb-95, Zr-95, Ru-106, I-131, Cs-137, Ce-144, and transuranics from ORNL; Th-232 and U-238 from the Y-12 Plant; and Tc-99, Np-237, and U-238 from ORGDP. Much less data on releases of metals and organic contaminants exists. However, preliminary screening-level risk analyses based on samples obtained from White Oak Lake and from Off-site areas (Hoffman et al. 1984) indicate a variety of contaminants of potential concern (Table 1).

Data on the annual releases of Co-60, Sr-90, and Cs-137 from ORNL and White Oak Lake (WOL) into the Clinch River are listed in Table 2. Approximately 665 curies (2.5×10^{13} Bq) of Cs-137 have been released from WOL into the Clinch River System. Because most of this release occurred between the years 1954 and 1959, and because the half-life of CS-137 for radioactive decay is 30 years, the total decay-corrected amount of CS-137 discharged as of June 1986 is about 335 curies.

Preliminary results of recent investigations indicate that about 85% of the total release of Cs-137 (decay corrected) from the ORR now resides in the sediments of Watts Bar Reservoir. These data demonstrate that Watts Bar Reservoir is a highly efficient trap for particle-reactive contaminants and strongly suggest that other contaminants of concern (Co-60, Pu-239/-240, Hg, PCBs, PAHs, etc.) are also efficiently retained within the reservoir and accumulated in the reservoir sediments.

Investigations by the Oak Ridge Task Force (Turner et al, 1985) and TVA (1986) have indicated that about 110 metric tons of mercury (Hg) may have been released from the Y-12 Plant between 1950 and 1982. Although as much as 80 metric tons of the released Hg may still reside within the floodplain sediments along Each Fork Poplar Creek, it is estimated that about 0.2 metric tons of Hg may be exported from the Creek each year. Vertical profiles of Hg have been examined in sediment cores collected in off-site areas. These profiles show a strong correlation with the history of Hg releases from the Y-12 Plant and, because the largest releases of Hg from Y-12 were coincidental in time with the largest releases of Cs-137 from ORNL, the sediment profiles of Hg and CS-137 correspond closely. Extrapolation of the mercury concentration data in these cores indicate that between 50 and 300 metric tons of Hg may have accumulated in off-site areas. In addition to mercury (Hg), levels of arsenic, cadmium, chromium, lead, nickel, silver, and zirconium were found to occur at elevated levels relative to background in the tributaries that drain into the Clinch River.

Recently, fish-sampling efforts by TVA and ORNL have revealed elevated PCB concentrations (i.e., in excess of the FDA tolerance limit of 2 ppm) in channel catfish in Melton Hill Reservoir and in the Clinch River below Melton Hill Dam. ORNL investigators reported that gizzard shad collected in the White Oak Creek embayment also contained high PCB levels, averaging 3.0 ppm (range = 1.8 - 4.8 ppm).