NUREG–0498
Supplement No. 1

Final Environmental Statement

related to the operation of
Watts Bar Nuclear Plant,
Units 1 and 2

Draft Report for Comment

Docket Nos. 50–390 and 50–391
Tennessee Valley Authority

U.S. Nuclear Regulatory Commissi

Office of Nuclear Reactor Regulation

November 1994

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

TO: Addressees for NUREG-0498, "Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant, Units 1 and 2," Supplement 1

This supplement documents the NRC staff's most recent review of the environmental issues at the Watts Bar Nuclear Plant. A full scope of environmental topics are examined in this supplement. The NRC staff concludes that there are no significant changes in environmental impacts as a result of changes in plant design, proposed plant operation or changes in the environment.

Please provide any comments you may have on the draft supplement by January 30, 1995. Written comments may be sent to:

Chief, Rules Review and Directives Branch
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Comments may also be delivered between the hours of 7:45 a.m. and 4:45 p.m. on Federal workdays to:

Two White Flint North
11545 Rockville Pike
Rockville, Maryland 20853

Please feel free to contact Scott Flanders at (301) 504-1172.

Sincerely,

William Travers

William D. Travers, Deputy Associate Director
for Advanced Reactors and License Renewal
Office of Nuclear Reactor Regulation

NUREG–0498
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Abstract

The Final Environmental Statement (FES) issued in 1978 represents the Nuclear Regulatory Commission's (NRC's) previous environmental review related to the operation of Watts Bar Nuclear Plant (WBN). The NRC has determined that it is appropriate to re-examine the issues associated with the environmental review before issuance of an operating license. The purpose of this NRC review is to discuss the effects of observed changes in the environment and to evaluate the changes in environmental impacts that have occurred as a result of changes in the WBN Plant design and proposed methods of operations since the last environmental review. A full scope of environmental topics has been evaluated, including regional demography, land and water use, meteorology, terrestrial and aquatic ecology, radiological and non-radiological impacts on humans and the environment, socioeconomic impacts, and environmental justice. The staff concluded that there are no significant changes in the environmental impacts since the NRC 1978 FES-OL from changes in plant design, proposed methods of operations, or changes in the environment. The applicant's preoperational and operational monitoring programs were reviewed and found to be appropriate for establishing baseline conditions and ongoing assessments of environmental impacts.

The staff also conducted an analysis of plant operation with severe accident mitigation design alternatives (SAMDAs) and concluded that none of the SAMDAs, beyond the three procedural changes that the applicant committed to implement, would be cost-beneficial for further mitigating environmental impacts.

Contents

Figures

Tables

Foreword

This Supplement to the Final Environmental Statement (FES) Related to the Operation of Watts Bar Nuclear Plant Units 1 and 2 was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation (the staff). This supplement to the FES was prepared in accordance with the Commission's regulations in Title 10 of the *Code of Federal Regulations*, Part 51 (10 CFR Part 51), which implements the requirements of the National Environmental Policy Act of 1969 (NEPA). The Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plants Units 1 and 2 (NRC 1978 FES-OL) was issued in 1978. This supplement to the NRC 1978 FES-OL was prepared in order to further the interests of the NEPA.

NEPA states, among other things, that it is the continuing responsibility of the Federal government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may

- fulfill the responsibilities of each generation as trustee of the environment for succeeding generations

- ensure for all citizens of the United States of America safe, healthful, productive, and aesthetically and culturally pleasing surroundings

- attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences

- preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice

- achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities

- enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Further, with respect to major Federal actions significantly affecting the quality of the human environment, NEPA calls for the preparation of a statement on

- the environmental impact of the proposed action

- any adverse environmental effects that cannot be avoided should the proposal be implemented

- alternatives to the proposed action

- the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity

- any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

The environmental review presented here discusses the changes (since the NRC 1978 FES-OL) in the environment and changes in the environmental impact in and around the Watts Bar Nuclear Plant as a result of changes to the plant's design and proposed methods of operation. Assessments and evaluations relating to these changes presented in this statement augment and update those described in the NRC 1978 FES-OL.

This supplement updates the NRC 1978 FES-OL by

- evaluating changes in the environment in and around the Watts Bar Nuclear Plant

- evaluating changes in facility operation, and design that could potentially result in environmental impacts of operation (including those that would enhance as well as degrade the environment) different from those projected in the NRC 1978 FES-OL

- reporting the results of relevant new information that has become available since the NRC 1978 FES-OL

- factoring into this supplement new environmental policies and statutes that have a bearing on the licensing action

- reporting the results of the staff's review of the alternative of plant operation with the installation of severe accident mitigation design alternatives (SAMDAs) for the Watts Bar Nuclear Plant.

Definitions

Acanthamoeba	a pathogenic amoeba that is responsible for causing primary amoebic meningoencephalitis. These microorganisms are located in surface water.
Asiatic clam *Corbicula* sp.	a species of clam that was accidentally introduced to North America and inhabits the Tennessee River. The Asiatic clam is considered a nuisance species.
Background radiation	the level of radiation in an area which is produced by sources of radiation (mostly natural) other than the one of specific interest. Examples of such radiation sources are cosmic radiation and radioactive elements in the atmosphere, building materials, the human body, and the crust of the earth.
Benthos	organisms living in and on the bottom of an aquatic ecosystem.
Biofouling	the gradual accumulation of waterborne organisms on the surfaces of engineering structures in water that contributes to corrosion of the structures and to decrease the efficiency of moving parts.
Biomonitoring	monitoring of living organisms.
Blue-green algae	any of a group of photosynthetic microorganisms classified as either plants (division Cyanophyta) or bacteria (division Cyanobacteria) because they possess characteristics of both plants and bacteria.
Byssal threads	a tuft of long tough filaments by which some bivalve molluscs (as mussels) adhere to a surface.
Candidate Species	a species that is being evaluated for listing as endangered or threatened by the U.S. Fish and Wildlife Service
Chickamauga Reservoir	the reservoir behind Chickamauga Dam in the Tennessee River. The section of the river that passes Watts Bar Nuclear Plant is considered to be a part of the Chickamauga Reservoir.
Chlorophyll *a*	one form of the green pigment that is found in plant cells, responsible for photosynthesis.
Cooling tower blowdown	the release of excess water from the cooling towers.

Curie (Ci)	the special unit of activity. Activity is defined as the number of nuclear transformations occurring in a given quantity of material per unit of time. One curie of activity is 37 billion transformations per second.
Daphnid	minute freshwater branchiopod crustaceans with antennae used as locomotor organs, of the genera *Daphnia* or *Ceriodaphnia*.
Decommissioning	removing nuclear facilities safely from service and reducing residual radioactivity to a level that permits release of the property for unrestricted use and termination of the license.
DECON	the decommissioning alternative for a nuclear facility shortly after cessation of operation in which equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits termination of the license.
Diffuser	a system used to discharge cooling tower blowdown, or routine releases from the yard holding pond at the WBN Plant. The diffuser allows for the releases to enter the river in a diffuse manner, rather than have it released as a concentrated release in a narrow area.
Dissolved oxygen levels	a measure of the amount of oxygen that is dissolved in a liquid.
Eastern hellbender	(*Cryptobranchus a. alleganiensis*) a large aquatic, usually gray, salamander.
Effluent	waste material (as in liquid industrial refuse or sewage) discharged into the environment.
Electrofishing	the taking of a fish by a system based on their tendency to respond positively to a source of direct electric current.
Electromagnetic fields (EMF)	a form of non-ionizing radiation produced by the movement of electricity through wires such as in appliances or in power transmission lines.
Endangered species	species of plants or animals that have been deemed by the U.S. Fish and Wildlife service to have such low numbers of individuals that the species is in danger of becoming extinct.

ENTOMB — the decommissioning alternative of a nuclear facility in which radioactive contaminants are encased in a structurally long-lived material, such as concrete. The entombed structure is appropriately maintained and continued surveillance is carried out until the radioactivity decays to a level permitting termination of the license.

Entrainment — drawing in or transport by flow of a fluid.

Exposure — the condition of being made subject to the action of radiation; also, a measure of the ionization produced in air by x-ray or gamma radiation.

Forebay — the section of the reservoir immediately above a dam.

Genetic effects of radiation — effects of radiation that alter the hereditary material and may therefore affect subsequent unexposed generations.

Intake structure — an opening through which fluids enter an enclosure.

Invertebrates — animals without backbones - such as insects, crustaceans, and molluscs.

Ion exchange — in this document, a process for selectively removing a constituent from a waste stream by reversibly transferring ions from a liquid to an insoluble solid (the ion exchange media)

Ionizing radiation — any form of radiation that generates ions in the irradiated material.

Legionella — the bacterium which causes Legionnaire's disease.

Low-level waste (LLW) — all radioactive waste materials that are not high-level or transuranic waste.

Macrophytes — a vascular aquatic plant, large enough to see with the naked eye.

Maximally exposed (offsite) individual	the hypothetical person who would receive the greatest possible radiation dose from a specific release. For atmospheric releases, this individual is assumed to breathe air at the offsite boundary location with the highest airborne concentration and to consume food products raised exclusively in that offsite boundary location receiving the maximum ground deposition of released radioactive material. For liquid releases, this individual is assumed to consume large quantities of river water and fish.
Meteorological tower	a tower containing instruments for obtaining meteorological data such as wind speed, direction, humidity, and temperature.
Molluscicide	a chemical that is toxic to clams and mussels.
Mussel sanctuary	an area designated by the State of Tennessee to be a biological preserve for mussel species.
Naeglaria fowleri	a pathogenic amoeba that is responsible for causing primary amoebic meningoencephalitis. These microorganisms are located in surface water.
Occupational radiation exposure	the radiation exposure to which workers at a nuclear facility are subjected during the course of their work.
Outage	a period of interruption of operation of a power plant.
Outfall	liquid waste discharge point.
pH	a measure of the hydrogen ion concentration of a solution expressed as a negative logarithm of the effective hydrogen-ion concentration in gram equivalents per liter. A pH of 7 is neutral. pH values from 0 to 7 indicate acid conditions; those from 7 to 14 indicate alkaline conditions.
Plankton	the usually microscopic plant and animal life found free-floating in water. The plants are called "phytoplankton." The animals are called "zooplankton."
Poly-chlorinated biphenyl (PCB)	any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine, have industrial applications, and are poisonous environmental pollutants which tend to accumulate in animal tissues.

Population dose — the summation of individual radiation doses received by all those exposed to the radiation source or event being considered (expressed as person-rem). The same as collective dose.

Prefixes — used to designate fractions:
centi = 10^{-2} = 0.01
milli = 10^{-3} = 0.001
micro = 10^{-6} = 0.000001
nano = 10^{-9} = 0.000000001
pico = 10^{-12} = 0.000000000001

Pressurized water reactor (PWR) — a type of nuclear reactor where the water in the primary coolant system remains pressurized. Both Watts Bar Nuclear Plant and Sequoyah Nuclear Plant are PWRs.

Radiation — energy in the form of electromagnetic rays (radiowaves, light, x-rays, gamma rays) or particles (electrons, neutrons, helium nuclei) sent out through space from atoms, molecules, or atomic nuclei as they undergo internal change. It may also result from particle and electromagnetic radiation interactions with matter.

Recruitment — a complex process incorporating adult survival, adult reproduction rate, juvenile survival, and juvenile growth. The net rate of recruitment is the amount by which the population changes in size during one stage or over one interval of time.

Rem — a unit of radiation dose equivalent that is proportional to the risk of biological injury.

Resin — ion exchange media for the purification of contaminated liquids.

Resin liners — cylindrical metal containers used for the ion exchange media (resins and/or zeolites) during purification of contaminated water by ion exchange processes.

Rotenone — a crystalline insecticide that is obtained from the roots of several tropical plants and is commonly used as a fish sampling tool.

Rotifer — microscopic aquatic invertebrate.

SAFSTOR — the decommissioning alternative in which the nuclear facility is placed and maintained in such a condition that it can be safely stored, monitored, and subsequently decontaminated to levels that permit termination of the license.

Sequoyah Nuclear Plant	a TVA owned two-unit nuclear power facility located on the Tennessee River outside of Chattanooga, Tennessee.
Spawn	to produce or deposit eggs, especially aquatic animals.
Stratify	to divide into a series of graded statuses (e.g., temperatures of a lake are generally warmer on top than on bottom).
Tailrace	the section of a river immediately below a dam where the streambed is influenced by the water released from the dam.
Thermophilic	heat loving.
Threatened species	species that have not been listed as "endangered" by the U.S. Fish and Wildlife Service, but that occur in such low numbers of individuals that their numbers could be threatened by outside forces.
Transition zone	the section of the river between the tailrace and the location where the river flow is unmodified by the upstream dam.
Watts Bar Reservoir	the reservoir above Watts Bar Dam.
Watts Bar Nuclear Plant	a TVA owned and operated Nuclear power facility. Specifically the buildings and facilities on Watts Bar Nuclear Plant Site.
Watts Bar Nuclear Site	the area surrounding the Watts Bar Nuclear Plant.
Zebra mussel	Any of three species (*Dreissena polymorpha*, *Mytrilopsis leucophaeta*, and the quagga) of molluscs that were accidentally introduced into the Great Lakes and are spreading to surrounding waterways where they colonize and clog water intake pipes and out compete native mussels for food and space. The zebra mussel is considered a nuisance species.

Abbreviations/Acronyms

ACC	averted cleanup costs
ACGIH	American Conference of Governmental Industrial Hygienists
AEC	Atomic Energy Commission
AFW	auxiliary feedwater
ALARA	as low as is reasonably achievable
ALWRs	advanced light-water reactors
AOE	averted occupational exposure
AOSC	averted onsite costs
APBs	accident progression bins
APE	averted public exposure
ARFs	air return fans
ATWS	anticipated transient without SCRAM
BAE	boric acid evaporators
BCDMH	1-Bromo-3-chloro-5,5-dimethylhydantoin
BEIR	Biological Effects of Ionizing Radiation
BRS	boron recovery system
CCPs	centrifugal charging pump
CCS	component cooling system
CDF	Core Damage Frequency
CDWE	condensate demineralizer waste evaporator (system)
CFR	code of federal regulations
COE	cost of enhancement
CP	construction permit
CPI	Containment Performance Improvement
CSS	containment spray system
CVCS	chemical and volume control system
dBA	decibel (A-scale)
DC	direct current
DCH	direct containment heating
DGH	Dodecylguanidine hydrochloride
DOE	U.S. Department of Energy
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EDTA	ethylene diamine tetra acetic (acid)
EI	Environmental Information
EIS	Environmental Impact Statement
EMF	electromagnetic fields
EPA	U.S. Environmental Protection Agency

ERCW	essential raw cooling water
ESA	Endangered Species Act
ETA	ethanolamine
FES	Final Environmental Statement
FES-OL	Final Environmental Statement - Operating License
FSAR	Final Safety Analysis Report
FWS	U.S. Fish and Wildlife Service
GI	generic issue
HVAC	heating, ventilation, and air conditioning
HPME	high-pressure core melt ejection
HPSI	high-pressure safety injection
ICRP	International Commission on Radiological Protection
IPE	Individual Plant Examination
IRP	Integrated Resource Plan
ISLOCA	inter-system loss-of-coolant accident
KPDS	key plant damage state
KRC	key release category
kV	kilovolts
LPSI	low pressure safety injection
LOCA	loss-of-coolant accident
LVWTP	low-volume waste treatment pond
LWR	light-water reactor
MG	motor generator
MIC	microbiologically induced corrosion
MW	megawatt
NCRP	National Council on Radiation Protection and Measurements
NESC	National Electric Safety Code
NEPA	National Environmental Policy Act
NPDES	National Pollution Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
ODCM	Offsite Dose Calculation Manual
OL	Operating License
PAME	primary amoebic meningoencephalitis
PCB	polychlorinated biphenyl
PRA	probabilistic risk assessment
PORVs	power operated relief valves

PWRs	pressurized water reactors
QA	quality assurance
QC	quality control
radwaste	radioactive waste
RCP	reactor coolant pump
RCS	reactor coolant system
RHR	residual heat removal
RWST	refueling water storage tank
SAMDA	severe accident mitigation design alternative
SER	safety evaluation report
SGTR	steam generator tube rupture
SQN	Sequoyah Nuclear
TEDA	tetraethyldiamine
TLD	thermoluminescent dosimeter
TMI	Three Mile Island
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
WBN	Watts Bar Nuclear

Summary and Conclusions

This Supplemental Environmental Statement was prepared by the U.S. Nuclear Regulatory Commission (NRC), Office of Nuclear Reactor Regulation, hereinafter known as "the staff."

The Tennessee Valley Authority (TVA), hereinafter known as "the applicant," has applied for a facility-operating license for the Watts Bar Nuclear (WBN) Plant. The WBN Plant is a two-unit nuclear power plant located approximately 80 kilometers (50 miles) northeast of Chattanooga at the Watts Bar Site on the Tennessee River in Rhea County, Tennessee. Each of the two identical units employs a four-loop pressurized water reactor nuclear steam supply system furnished by Westinghouse Electric Corporation. Each of the two reactor cores is rated at 3,425 megajoules per second (3,425 megawatts) thermal. The net electrical output is 1,160 megajoules per second (1,160 megawatts) electric (TVA 1994a). Each unit will use one cooling tower that draws makeup water from the Chickamauga Reservoir.

The applicant is planning to complete the WBN Plant, Unit 1, and start generating electric power by mid-1995. The Final Environmental Statement Related to the Operation of Watts Bar Nuclear Plant Units 1 and 2 (NRC 1978 FES-OL) was written in 1978. When the NRC 1978 FES-OL was published, Watts Bar Unit 1 had an expected fuel load date of December 1979; however, the completion date was extended as a result of construction delays. Unit 1 is now close to completion and the applicant expects to load fuel in the spring of 1995 and initiate commercial generation in mid-1995. Unit 2 is approximately 65% complete and is being re-evaluated as part of an Integrated Resource Planning process being conducted by the applicant.

The NRC's regulations in 10 CFR 51.92 require the NRC staff to prepare a supplement to an FES if there are substantial changes in the proposed action that are relevant to environmental concerns or there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. That same regulation permits the staff to prepare a supplement when, in its opinion, preparation of a supplement will further the interests of the National Environmental Policy Act (NEPA). This supplement documents the staff's review pursuant to 10 CFR 51.92. The staff concludes that there are no significant changes in environmental impacts as a result of changes in plant design, procedures or proposed methods of plant operation, or changes in the environment. Therefore, this document has been prepared to supplement the NRC 1978 FES-OL in the interest of furthering NEPA. The purpose of this supplement is to evaluate any changes in the environment and changes in the plant design, procedures, and proposed methods of operation since the previous evaluation of the environment by the staff in 1978.

The non-radiological impacts evaluated in this document can be categorized into impacts on land use, impacts on water use, impacts on the terrestrial environment, impacts on the aquatic environment, and human health and socioeconomic impacts.

The staff's conclusions are based on the evaluation of the changes in environmental impacts, since the NRC 1978 FES-OL, as a result of (1) changes in plant design and procedures, (2) changes in proposed method of plant operations, or (3) changes to the environment. These conclusions are that

- There are no changes in the design of the WBN Plant that result in a significant change in environmental impact.

- Changes in proposed WBN Plant operations have occurred. However, the changes do not result in a significant environmental impact.

- Changes in the population and demographics of the region have occurred since 1978. However, the changes are not significant (Section 2.1) and the changes in employment and in impact funds resulting from startup of Unit 1 will not have a significant socioeconomic impact on the area.

- No additional impacts were determined for land use or water use.

- There are no significant changes in the regional climatology or WBN Site meteorology.

- There are no significant changes in the terrestrial or aquatic environment in the WBN Site vicinity.

- There are no significant changes in the background radiological characteristics in the WBN Site vicinity.

- The applicant's preoperational and operational monitoring programs were reviewed and found appropriate for establishing conditions and ongoing assessments of environmental impacts.

- Based on the data available, it does not appear that any minority or low income communities would be disproportionally affected by plant operations.

- The staff analysis of the alternative of facility operation with the installation of severe accident mitigation design alternatives (SAMDAs) concluded that none of the SAMDAs beyond the three procedural changes that the applicant committed to implement would be cost-beneficial for further mitigating environmental impacts.

1 Introduction

The Watts Bar Nuclear (WBN) Plant is located in Rhea County, Tennessee, approximately 80 kilometers (50 miles) northeast of Chattanooga, Tennessee (Figure 1.1). The WBN Site is a 7.1-square kilometer (1,770-acre) site on the west bank of the Chickamauga Reservoir, and is located on the Tennessee River at Tennessee River Mile (TRM) 528 as measured from the mouth of the river. It is approximately 3.2 kilometers (2 miles) south of the Watts Bar Dam (TRM 529.9) and 1.6 kilometers (1 mile) downstream of the four-unit Watts Bar Steam Plant, also located on the west bank of the reservoir at TRM 529 (Figure 1.2). The Watts Bar Steam Plant is in cold standby and has not operated since 1983.

The WBN Plant is a two-unit facility. The Tennessee Valley Authority (TVA), referred to in this document as "the applicant," designed, built, and proposes to operate the WBN Plant. The facility, administrative and support facilities, and all associated parking are located on Federal property under the control of the applicant. Each of the two identical units employs a four-loop pressurized water reactor nuclear steam supply system furnished by Westinghouse Electric Corporation. Each reactor is rated at 3,425 megajoules per second (3,425 megawatts) thermal. The net electrical output of each unit is 1,160 megajoules per second (1,160 megawatts) electric (TVA 1994a).

1.1 History

On May 14, 1971, the applicant submitted an application requesting the issuance of construction permits for WBN Units 1 and 2. On January 23, 1973, the Atomic Energy Commission (AEC) issued Construction Permits CPPR-91 and CPPR-92 for the two WBN units. These were issued following the AEC staff's environmental review of the proposed plant. The applicant released its final Environmental Impact Statement Construction Permit (EIS-CP) in November 1972 (TVA 1972). In late 1976, the applicant submitted an application including a Final Safety Analysis Report (FSAR) and Environmental Information (EI) requesting the issuance of operating licenses for both Units 1 and 2. These documents were docketed on October 4, 1976 (FSAR), and November 23, 1976 (EI), respectively. Subsequently, the U.S. Nuclear Regulatory Commission (NRC) began the operational safety and environmental reviews. The staff issued the NRC Final Environmental Statement-Operating License (FES-OL) in December 1978 (NRC 1978) to support issuance of operating licenses for the two WBN units. The NRC 1978 FES-OL relied on the applicant's earlier final environmental EIS-CP (TVA 1972) and documented changes in the plant's design and the environment since release of the applicant's 1972 EIS-CP.

About six months before completion of the NRC 1978 FES-OL, Unit 1 was approximately 85% complete, and Unit 2 was approximately 65% complete. Construction delays, however, delayed the completion schedules for both facilities. Unit 1 is currently nearing completion, and the applicant expects to start generating electricity at the unit by mid-1995. The completion of Unit 2 is being reevaluated as part of the applicant's Integrated

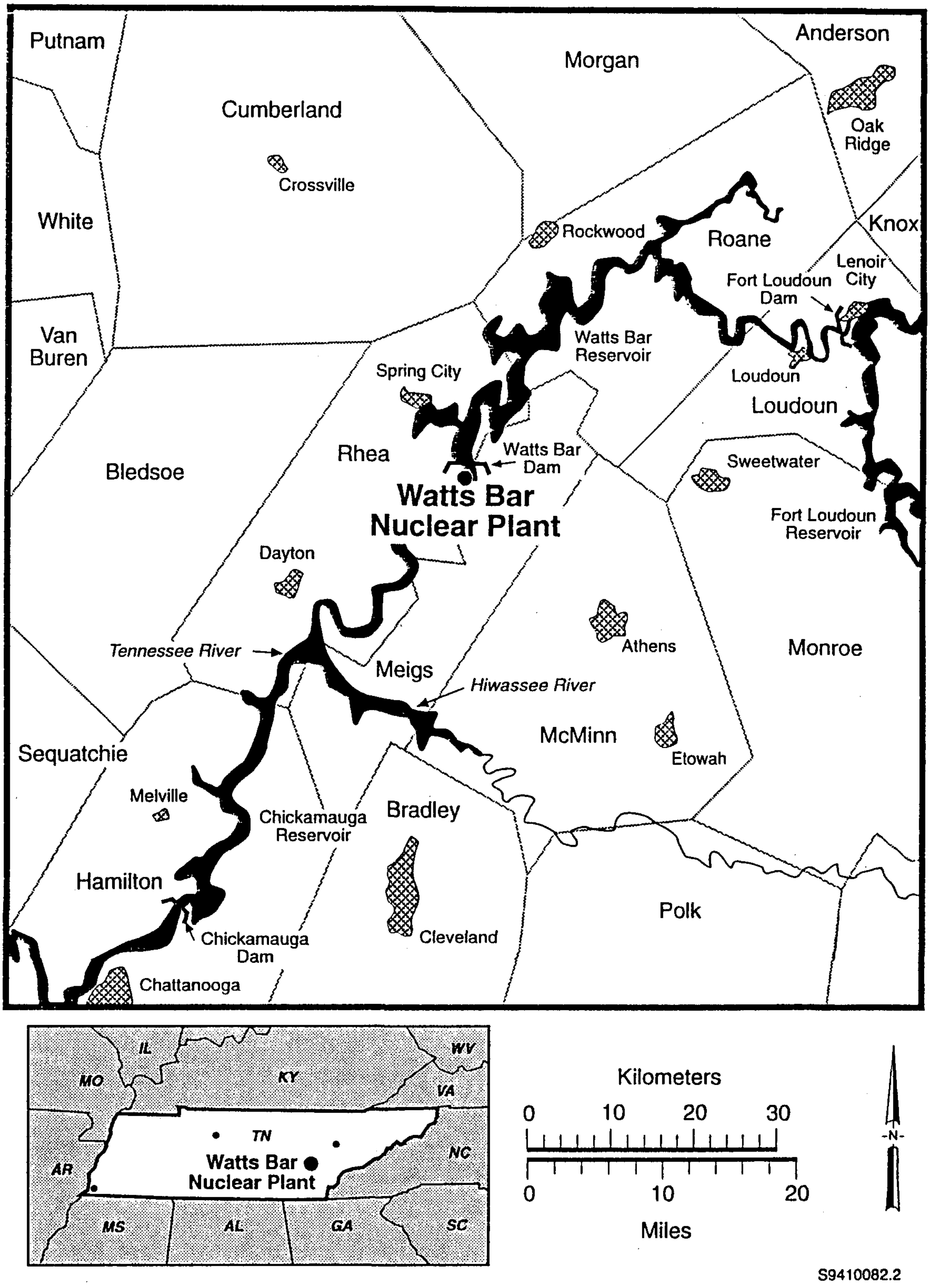

Figure 1.1 Location of the Watts Bar Nuclear Plant

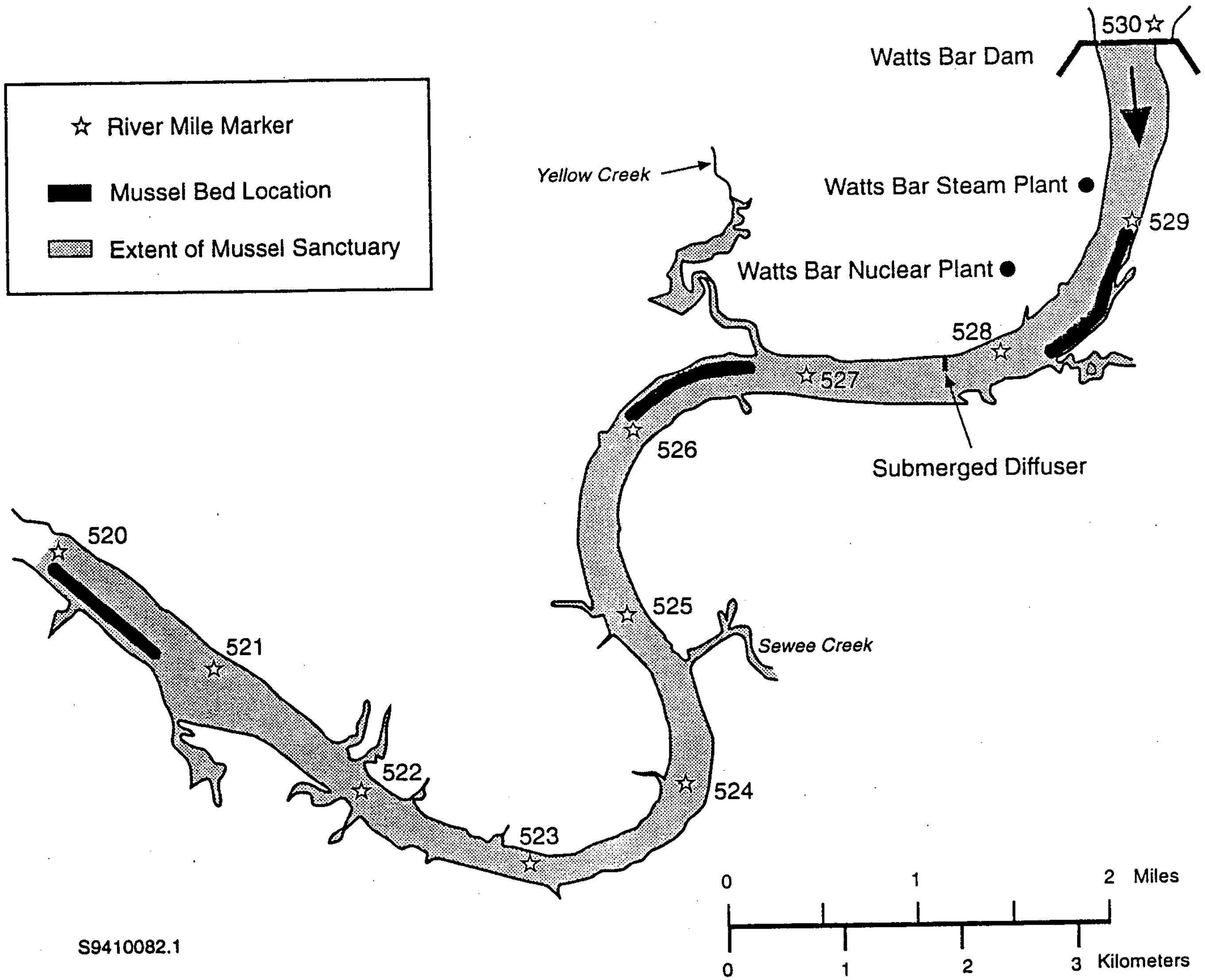

Figure 1.2 Location of the Watts Bar Nuclear Plant and Mussel Sanctuary

Resource Planning process. The 10 CFR 51.92(a) requires the NRC to supplement a final environmental statement if the proposed action has not been taken, and (1) there are substantial changes in the proposed action that are relevant to environmental concerns, or (2) there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. Under 10 CFR 51.92(b), the NRC may prepare a supplement when, in its opinion, preparing one will further the purposes of the National Environmental Policy Act (NEPA). In order to further NEPA, and because of the extended period of time since environmental impacts were last evaluated, the staff decided to prepare a supplement to the NRC 1978 FES-OL. The supplement contains an evaluation of changes to impacts as a result of changes in the environment, plant design, and proposed methods of operation since 1978.

The staff requested that the applicant provide updated environmental information in connection with the anticipated operation of WBN Unit 1 (NRC 1994a). The applicant provided a copy of a report entitled Watts Bar Nuclear Plant, Review of Final Environmental Statement (TVA 1994b). By letter, dated June 21, 1994 (NRC 1994b), the staff asked the applicant to provide additional environmental information to help determine whether the NRC 1978 FES-OL should be supplemented. The applicant responded with their August 5, 1994, submittal (TVA 1994c). Additional information was supplied by the applicant on September 27, 1994 (TVA 1994d), and on November 4, 1994 (TVA 1994e), in response to the staff's requests for additional information.

The staff has reviewed the NRC 1978 FES-OL and the applicant's submittals, has conducted multi-disciplinary environmental site visits and has met with appropriate Federal and State regulatory and resource agencies. This document is a result of the staff's review. It updates the NRC 1978 FES-OL by focusing on each section of that document. For sections in which no changes have occurred, the reader is referred to the NRC 1978 FES-OL. The material in this document follows the same general order used in the 1978 FES-OL, although some modifications have been made. For issues not previously considered, new sections have been added.

1.2 Environmental Approvals and Consultations

The applicant is required to hold certain Federal, State, and local environmental permits, as well as meet relevant Federal and State statutory requirements.

The applicant stated (TVA 1994e) that all required Federal, State, and local permits and approvals necessary for plant operation have been obtained and are being renewed as required by the applicable regulations. The permits include various state air permits, a permit for the use of underground storage tanks, a landfill permit, and an EPA hazardous waste generator permit (TVA 1994e).

In addition, the applicant holds the National Pollution Discharge Elimination System (NPDES) Permit No. TN0020168 from the State of Tennessee (State of Tennessee 1993) for the WBN Plant. The NPDES permit must be renewed every five years. This permit authorizes the discharge of process wastewater involved in, or resulting from, the generation of electric power by thermonuclear fission and associated operations, i.e., steam generator blowdown, cooling tower blowdown, sanitary wastewater, intake screen and strainer back-washes, miscellaneous flows, and storm water runoff from specific outfalls. Permit limits and monitoring requirements are specified in the NPDES permit.

As required by Section 7 of the Federal Endangered Species Act (ESA), the NRC and the applicant have initiated consultation with the U.S. Fish and Wildlife Service (FWS) (TVA 1994d) regarding potential impacts to species listed as threatened or endangered under the ESA. Such consultation is an action separate from preparation of this supplement to the NRC 1978 FES-OL (NRC 1978). Consultation with the FWS is required for all Federal projects with the potential for impacting listed species.

The applicant and the NRC prepared a biological assessment to support consultation and facilitate discussions with the FWS on the WBN Plant (NRC 1994c). This biological assessment described pertinent project components, summarized information about the listed species known to inhabit the vicinity of the WBN Site, and described the potential impacts of the plant's operation on these species. The FWS will provide the NRC with a biological opinion before publishing this supplement as a final report.

1.3 References

10 CFR Part 51. 1994. "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." U.S. Nuclear Regulatory Commission, Washington, D.C.

State of Tennessee. 1993. *State of Tennessee NPDES Permit No. TN0020168: Authorization to Discharge Under the National Pollution Discharge Elimination System.* For Tennessee Valley Authority. Facility located at Watts Bar Nuclear Plant, Units 1 and 2. Issued September 30, 1993. Effective Date - December 1, 1993.

Tennessee Valley Authority (TVA). 1972. *Final Environmental Statement, Watts Bar Nuclear Plant Units 1 and 2.* Tennessee Valley Authority, Office of Health and Environmental Science. November 1972.

Tennessee Valley Authority (TVA). 1994a. *Final Safety Analysis Report, Watts Bar Nuclear Plant.* Amendment 88, August 1994.

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Tennessee Valley Authority (TVA). 1994c. Letter from D. E. Nunn, TVA, to U.S. NRC. August 5, 1994. Subject: Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Request for Additional Information Relating to Final Environmental Statement.

Tennessee Valley Authority (TVA). 1994d. Letter from D. E. Nunn, TVA, to U.S. NRC. September 27, 1994. Subject: Watts Bar Nuclear Plant (WBN) - Response to NRC's Request for Additional Information Related to the Watts Bar Environmental Review.

Tennessee Valley Authority (TVA). 1994e. Letter from D. E. Nunn, TVA, to U.S. NRC. November 4, 1994. Subject: Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Request for Additional Information Related to Environmental Review.

U.S. Nuclear Regulatory Commission (NRC). 1978. *Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2.* NUREG-0498. Docket Nos. 50-390 and 50-391. U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1994a. Letter from U.S. NRC to M. O. Medford, TVA. March 9, 1994. Subject: Final Environmental Statement Update.

U.S. Nuclear Regulatory Commission (NRC). 1994b. Letter from U.S. NRC to M. O. Medford, TVA. June 21, 1994. Subject: Final Environmental Statement Update.

U.S Nuclear Regulatory Commission (NRC). 1994c. Letter from U.S. NRC, to L. A. Barclay, U.S. Fish and Wildlife Service. October 28, 1994. Subject: Watts Bar Nuclear Plant Biological Assessment.

2 The Site

This description of the Watts Bar Nuclear (WBN) Site includes a discussion of the regional demography of the surrounding area in Section 2.1; the water use, including a description of the current water quality conditions in Section 2.2; the current meteorology of the WBN Site in Section 2.3; the terrestrial and aquatic ecology in Section 2.4; the current background dose levels in Section 2.5; the historical and archeological sites in Section 2.6; and the geology and seismology of the WBN Site in Section 2.7.

2.1 Regional Demography

Changes have been noted in the regional demography of the area surrounding the WBN Plant since the time of publication of the NRC 1978 FES-OL (NRC 1978). Changes in both the population and the region's socio-economic characteristics are discussed.

2.1.1 Population Changes

The estimated resident population within 80 kilometers (50 miles) of the WBN Plant has increased by 140,000 since the NRC 1978 FES-OL was completed (Table 2.1). The counties closest to the WBN Site, however, have lagged behind the overall population growth in the State of Tennessee (Table 2.2). Much of the population increase has occurred in the region's urban centers, which are at the far edges of the 80-kilometer (50-mile) region surrounding the plant (Figure 2.1, Table 2.1). Figure 2.2 depicts the applicant's population projection for the area surrounding the plant by the year 2040 (TVA 1994a). Appendix C, Tables C.1 and C.2, provide this information in tabular form. For the effect of population changes on radiological exposure impacts, see Section 5.5.2.

2.1.2 Changes in Regional Socioeconomic Characteristics

Per capita and median household incomes have increased in real terms in the counties closest to the WBN Site, although household and per capita incomes have continued to lag behind the Statewide average (Figure 2.3, Table 2.3). Some of the smaller towns in the WBN Site area have developed strip-mall shopping areas in the last 15 years to expand the variety of retail opportunities available to the residents.[a] The ethnic character of the population has remained fairly constant between the 1980 and 1990 Censuses (Table 2.4).

(a) Site visit to the Spring City and Dayton areas, September 13, 1994.

Table 2.1 Differences Between Estimated Population in 1978 and 1990, by Distance and Direction from the WBN Plant

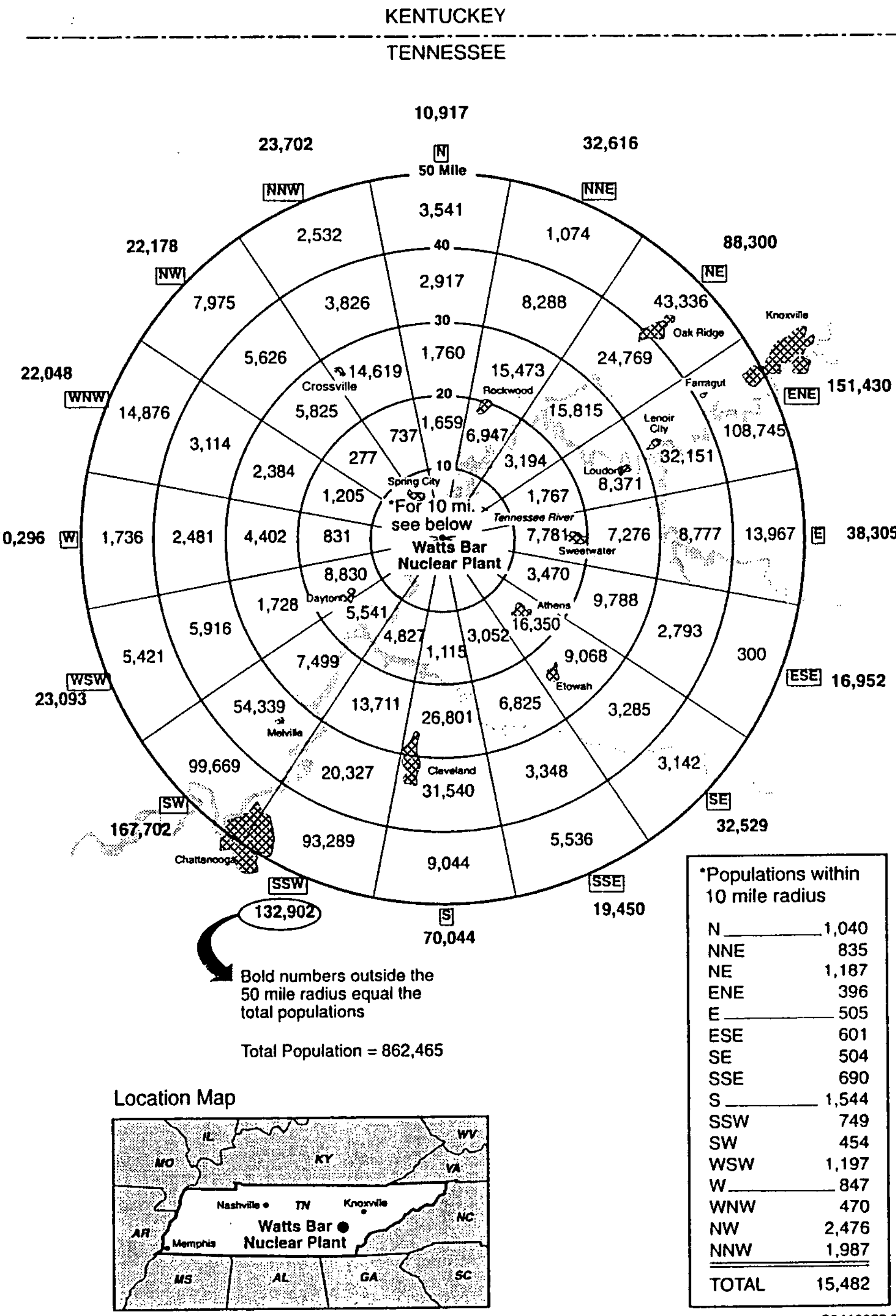
	Distance from WBN Plant kilometers (miles)					
Direction	0-16 km (0-10)	16-32 km (10-20)	32-48 km (20-30)	48-64 km (30-40)	64-82 km (40-50)	Total
N	620	-61	1,445	1,597	361	3,962
NNE	685	-598	-927	1423	189	772
NE	497	1,504	5,170	8,924	131	16,226
ENE	-109	307	26	12,991	27,940	41,155
E	65	931	1,936	3,602	4,837	11,371
ESE	121	755	1,983	-337	180	2,702
SE	99	-1,330	-1,567	1,575	-493	-1,716
SSE	205	292	3,140	473	-924	3,186
S	74	59	11,491	-4,530	4,134	11,228
SSW	333	3,682	6,875	10,767	-5,711	15,946
SW	64	2,971	2,699	33,964	-26,101	13,597
WSW	212	410	803	886	721	3,032
W	312	251	812	1,426	691	3,492
WNW	150	625	-22	454	2,051	3,258
NW	641	-258	4,120	1,966	2,525	8,994
NNW	492	107	3,689	376	-1,298	3,366
Total	4,461	9,647	41,673	75,557	9,233	140,571

Data Sources: 1990 Population: TVA (1994a) 1978 Population: NRC (1978).

Table 2.2 Population Data, Counties Closest to WBN Plant

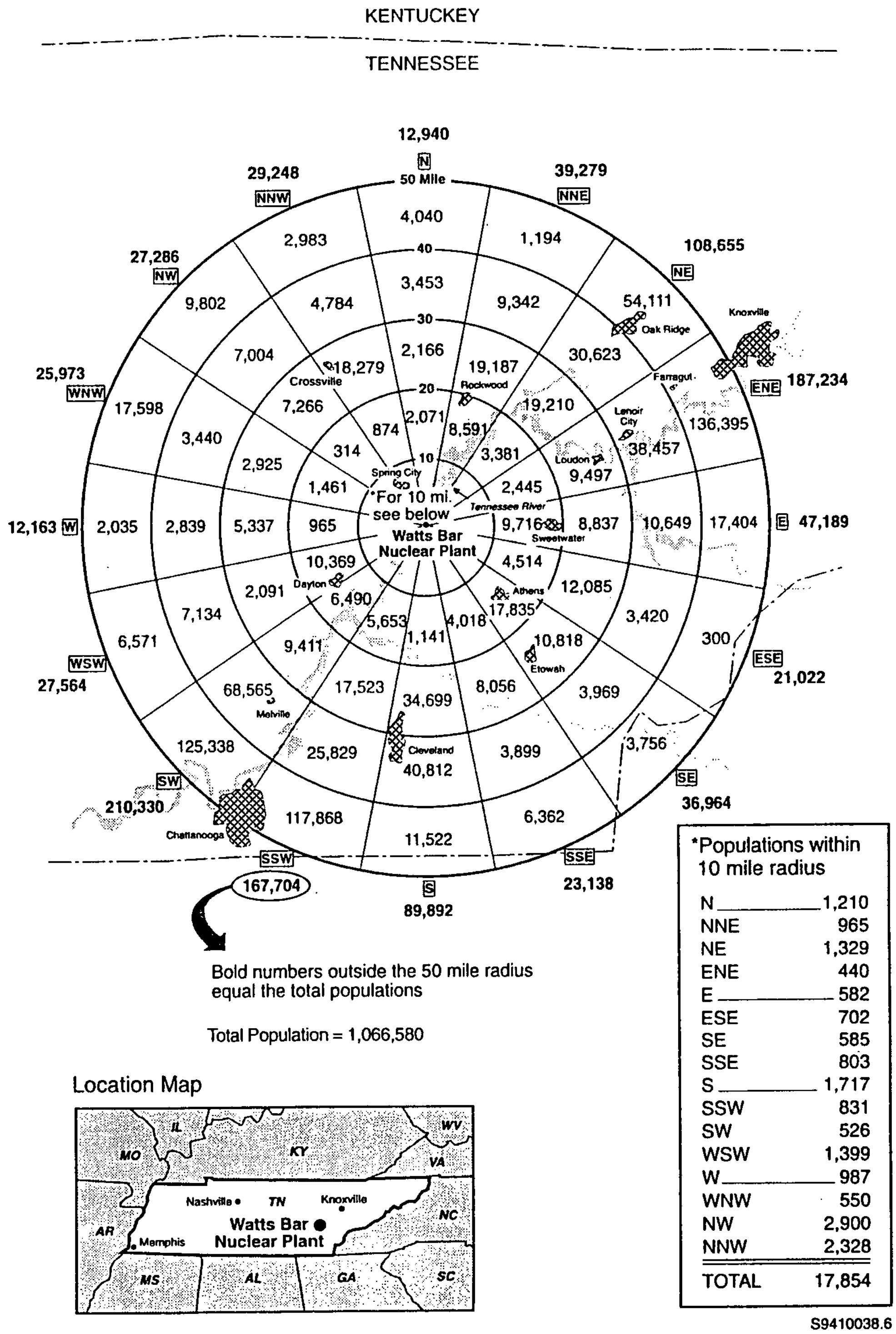
	Population			Population Changes			
	1980	1990	1992	Change, 1980-1990	Change, 1990-1992	% Change, 1980-1990	% Change, 1990-1992
Anderson County	67,346	68,250	70,525	904	2,275	1.34	3.33
Bledsoe County	9,478	9,669	9,779	191	110	2.02	1.14
Blount County	77,770	85,969	90,400	8,199	4,431	10.54	5.15
Bradley County	67,547	73,712	75,934	6,165	2,222	9.13	3.01
Cumberland County	28,676	34,736	36,743	6,060	11,834	21.13	3.52
Hamilton County	287,740	285,536	288,637	-2,204	3,101	-0.77	1.09
Knox County	319,694	335,749	347,583	16,055	11,834	5.02	3.52
Loudon County	28,553	31,255	33,242	2,702	1,987	9.46	6.36
McMinn County	41,878	42,383	43,552	505	1,169	1.21	2.76
Meigs County	7,431	8,033	8,412	602	379	8.10	4.72
Monroe County	28,700	30,541	31,376	1,841	835	6.41	2.73
Morgan County	16,604	17,300	17,714	696	414	4.19	2.39
Polk County	13,602	13,643	13,903	41	260	0.30	1.91
Rhea County	24,235	24,344	25,270	109	926	0.45	3.80
Roane County	48,425	47,227	48,094	-1,198	867	-2.47	1.84
Sequatchie County	8,605	8,863	9,186	258	323	3.00	3.64
Total (16 counties)	1,076,284	1,117,210	1,150,350	40,934	33,140	3.80	2.97
Tennessee	4,591,000	4,877,000	5,024,000	286,000	147,000	6.23	3.01

Data Sources: U.S. Department of Commerce 1983, 1992a, TVA 1994d.



*Populations within 10 mile radius	
N	1,040
NNE	835
NE	1,187
ENE	396
E	505
ESE	601
SE	504
SSE	690
S	1,544
SSW	749
SW	454
WSW	1,197
W	847
WNW	470
NW	2,476
NNW	1,987
TOTAL	15,482

Figure 2.1 Population Surrounding the WBN Plant, 1990 (TVA 1994a)



*Populations within 10 mile radius

N	1,210
NNE	965
NE	1,329
ENE	440
E	582
ESE	702
SE	585
SSE	803
S	1,717
SSW	831
SW	526
WSW	1,399
W	987
WNW	550
NW	2,900
NNW	2,328
TOTAL	17,854

Figure 2.2 Population Surrounding the WBN Plant, 2040 (TVA 1994a)

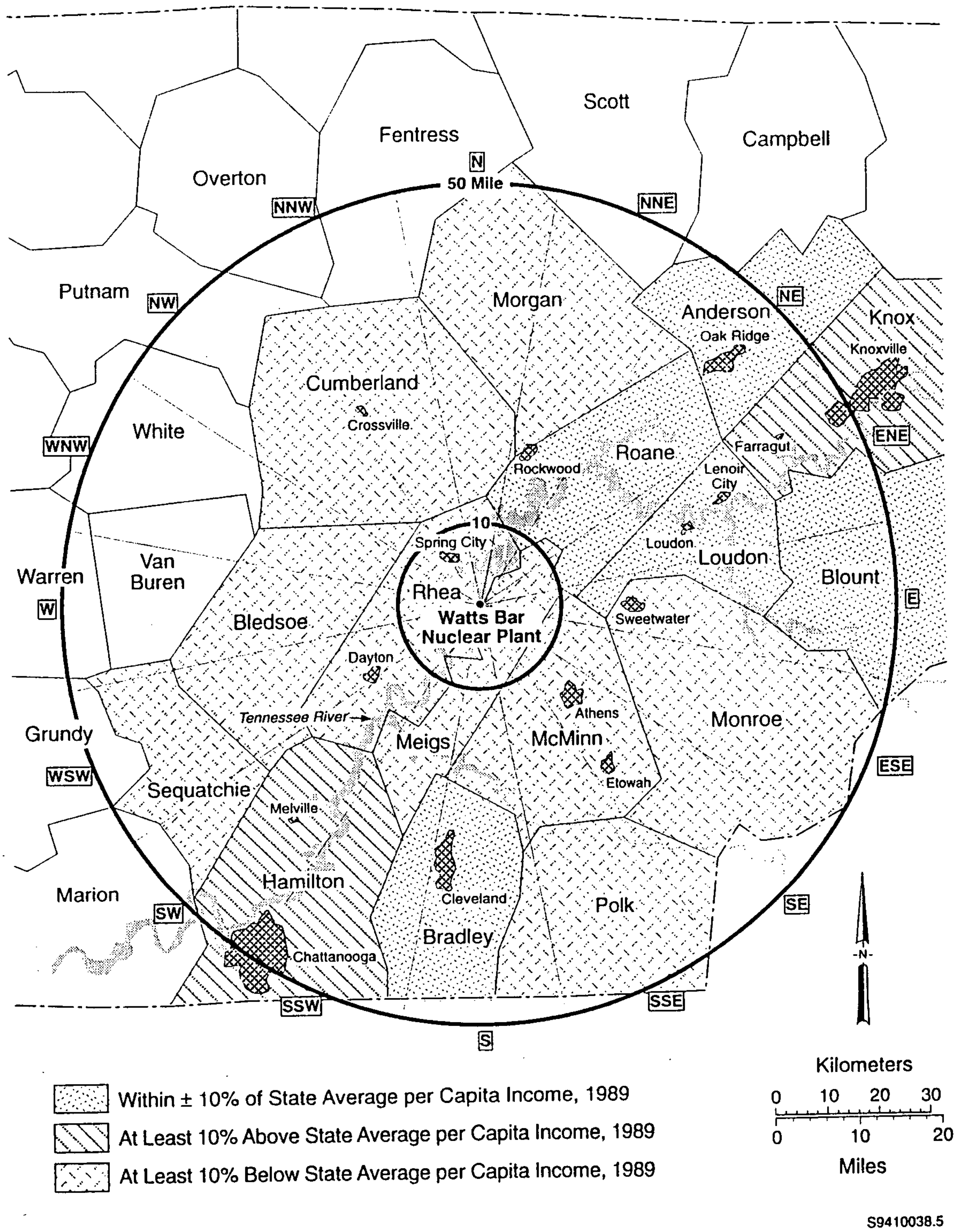


Figure 2.3 Per Capita Personal Income for Counties in the WBN Site Compared with the State of Tennessee Average, 1989. Source: U.S. Department of Commerce 1992b

Table 2.3 Personal Income Data, Counties Closest to WBN Plant Relative to the State of Tennessee, 1980 to 1990

Location	1979 Per Capita Income (1989 dollars)	1989 Per Capita Income (1989 dollars)	1979 Median Household Income (1989 dollars)	1989 Median Household Income (1989 dollars)	Percent of Families Below Poverty Level, 1979	Percent of Families Below Poverty Level, 1989
Anderson County	11,934	13,182	27,478	26,496	11.3	11.5
Bledsoe County	7,677	8,053	18,137	18,250	21.4	16.3
Blount County	11,177	12,674	25,719	25,575	10.4	10
Bradley County	10,176	11,768	25,027	25,678	11	11.3
Cumberland County	8,501	9,782	19,775	20,474	17.8	14.2
Hamilton County	11,761	13,619	26,805	26,523	10.2	10.2
Knox County	11,777	14,007	25,256	26,010	10.8	10.2
Loudon County	10,294	12,006	23,686	24,258	10.3	10.7
McMinn County	9,891	10,508	23,505	21,901	13.9	14.3
Meigs County	9,413	9,237	24,026	20,181	12.3	18.5
Monroe County	8,489	9,080	20,125	19,932	16.2	15.2
Morgan County	8,118	7,722	18,552	19,280	21.6	15.8
Polk County	7,961	9,311	20,639	21,663	16.7	14.2
Rhea County	8,736	9,333	21,387	19,915	15.6	15.8
Roane County	10,736	12,015	25,929	24,210	10.1	12.2
Sequatchie County	7,794	9,377	18,740	19,223	20.5	19.9
Tennessee	10,612	12,255	24,154	24,807	13.1	12.4

Data Sources: U.S. Department of Commerce 1983, 1992b, 1993.

Table 2.4 Minority Population Data, Counties Closest to WBN Plant

	1980		1990	
	Percent Non-White	Percent Hispanic[a]	Percent Non-White	Percent Hispanic[a]
Anderson County	5.04	0.69	5.33	0.56
Bledsoe County	3.66	1.03	4.42	0.39
Blount County	3.53	0.68	4.03	0.43
Bradley County	4.73	0.77	4.86	0.97
Cumberland County	0.29	0.83	0.75	0.36
Hamilton County	20.12	0.73	20.36	0.68
Knox County	9.54	0.65	10.22	0.62
Loudon County	1.80	0.50	1.67	0.27
McMinn County	5.26	0.33	5.42	0.41
Meigs County	1.61	0.16	1.85	0.21
Monroe County	3.28	0.39	3.21	0.40
Morgan County	1.54	0.42	1.98	0.35
Polk County	0.15	0.53	0.53	0.26
Rhea County	3.51	0.66	3.18	0.54
Roane County	3.40	0.75	3.78	0.45
Sequatchie County	0.46	0.65	0.14	0.28
Total (16 counties)	9.73	0.66	9.91	0.58
Tennessee	16.40	0.74	17.00	0.68

Data Sources: U.S. Department of Commerce 1983, 1992a.

(a) Hispanic persons can be of any race.

2.2 Water Use

A description of the regional water use (Section 2.2.1), the changes in the surface water hydrology of the plant (Section 2.2.2), and changes in the water quality (Section 2.2.3) are discussed in this section.

2.2.1 Regional Water Use

The NRC 1978 FES-OL described the downstream users of both public and industrial water supplies within an 80-kilometer (50-mile) radius of the plant; it also detailed the water's travel time and dilution factor. According to information supplied by the applicant, the water-use information given in the NRC 1978 FES-OL is no longer current (TVA 1994b). Additional water users have been identified (Table 2.5). Between the WBN Plant and the Watts Bar Dam the only water user is the Watts Bar Steam Plant. The Watts Bar Steam Plant has not operated since 1983 (TVA 1994c).

2.2.2 Surface Water Hydrology

Changes made in the surface-water hydrology since the NRC 1978 FES-OL include the decision to retain two temporary chemical holding ponds, which are still being used to contain and treat chemicals from the turbine building (TVA 1994c). The chemical holding ponds are currently being used and will continue to be used during plant outages, rather than during routine operation of the plant. The smaller of the two ponds is lined and has a volume of 3800 cubic meters (1 million gallons). The larger pond, which is unlined, has a volume of almost 19,000 cubic meters (5 million gallons). The ponds discharge via Outfall 107 to the large yard holding pond is monitored in accordance with the plant's NPDES permit (State of Tennessee 1993).

A 9,500 cubic meter (2.5 million gallon) evaporation/percolation pond was constructed by the applicant and used for the treatment and disposal of spent trisodium phosphate cleaning wastes, a residual of the pre-operational cleaning of Units 1 and 2 (TVA 1994c). This pond does not discharge by an outfall. It was approved by the State of Tennessee in the NPDES permit (State of Tennessee 1993), and groundwater is being monitored by a well downgradient of the pond (TVA 1990a). Discharges have not impacted and are not expected to impact public water supplies. The pond is no longer being used and the applicant plans to close the pond, push in the berm walls, and cap and revegetate the area. No date has been set for closing the evaporation/percolation pond; the applicant is waiting for State approval to close the pond.

The construction runoff holding pond will remain in service, rather than being leveled and graded as indicated in the NRC 1978 FES-OL. The construction runoff holding pond is currently being used to collect discharge water from an onsite sewage treatment plant; from the heating, ventilating, and air conditioning cooling water system at the WBN Training Center; from fire protection wastewater; and from site storm water runoff. The discharge via Outfall 112 to an unnamed tributary of Yellow Creek is monitored in accordance with the NPDES permit (State of Tennessee 1993).

Table 2.5 Dilution Factors and Travel Times for Downstream Water Users Within an 80-Kilometer (50-Mile) Radius of the WBN Plant (TVA 1994b)

Water Use	Location	Travel Time (days)	Dilution Factor
Watts Bar Nuclear Plant	TRM 528.8R[a]	N/A	N/A
Dayton, TN	TRM 503.8R	1.8	204
Soddy-Daisy Falling Water U.D.	TRM 487.2R Soddy CK 4.0	3.0	272
Sequoyah Nuclear Plant	TRM 483.6R	3.3	282
U.S. Army Volunteer Ammunition Plant	TRM 473.0L[b]	4.0	307
Chickamuaga Dam	TRM 471.0	4.2	[c]
E. I. DuPont Company	TRM 469.9R	4.2	[c]
Tennessee-American Water	TRM 465.3L	4.6	[c]
Rock-Tennessee Mill	TRM 463.5R	4.7	[c]
Dixie Sand and Gravel	TRM 463.2R	4.7	[c]
Chattanooga Missouri Portland Cement	TRM 456.1R	5.2	[c]
Signal Mountain Cement	TRM 454.2R	5.4	[c]
Raccoon Mountain Pump Storage	TRM 444.7L	6.1	[c]
Signal Mountain Cement	TRM 433.3R	6.9	[c]
Nickajack Dam	TRM 424.7	7.5	[c]
South Pittsburgh, TN	TRM 418.0R	8.0	[c]
Bridgeport, AL	TRM 413.6R	8.3	[c]
Widows Creek Steam Plant	TRM 407.7R	8.7	[c]
Mead Corporation	TRM 405.2R	8.9	[c]

(a) Right bank
(b) Left bank
(c) River is assumed to be fully mixed downstream of the Chickamauga Dam; dilution factor equals 448.

The applicant maintains a general storm water permit for industrial sources that contains requirements for erosion and sedimentation controls, including inspections, corrective actions, and annual sampling. The applicant has indicated (TVA 1994c) that it has implemented all requirements for erosion and sedimentation controls.

2.2.3 Water Quality

The staff reviewed the information submitted by the applicant and concludes that it provides an adequate characterization of the environment. In its August 5, 1994 submittal (TVA 1994c), the applicant stated that the information and analyses of water quality in the Tennessee River in the vicinity of the WBN Plant had not significantly changed from that discussed in the NRC 1978 FES-OL. The staff's review of the data supports the applicant's conclusion that there have not been any measurable changes in the water quality for this part of the river.

The NRC 1978 FES-OL characterized the water quality in the Tennessee River in the vicinity of the WBN Plant as "effluent limited." Additional data collected since 1978 supports this designation (TVA 1993). To illustrate current water quality conditions in the vicinity of the WBN Site, the following sections summarize the applicant's 1993 "Summary of Vital Signs and Use Stability Monitoring on Tennessee Valley Reservoirs" (TVA 1993) for the Watts Bar Reservoir. Measurements of water quality conditions were commonly made in the forebay (the section of the reservoir immediately above the dam), the tailrace (the section of the river immediately below the dam), and the transition zone (the section of the river between the tailrace and the location where the river flow is unmodified by the dam). Section 5.2.5 contains a discussion of the impact of water quality changes since the NRC 1978 FES-OL.

Temperature

The NRC 1978 FES-OL did not address the normal range of surface-water temperature in the Tennessee River in the vicinity of the WBN Site. Subsequent monitoring of surface-water temperatures during April-September 1993 ranged from a minimum of 18.3°C (64.9°F) in April to a maximum of 30.2°C (86.4°F) in July in the forebay and from 16.7°C (62°F) to 29.8°C (85.6°F) for the same months at the transition zone. The State of Tennessee's maximum water temperature criteria for the protection of fish and aquatic life is 30.5°C (86.9°F).

Dissolved Oxygen

The NRC 1978 FES-OL included a discussion of dissolved oxygen concentrations in the Tennessee River in the vicinity of the WBN Site. Current values for dissolved oxygen concentrations at the 1.5-meter (4.9-foot) depth ranged from a low of 6.5 milligrams per liter (6.5 parts per million) in September to a high of 12.6 milligrams per liter (12.6 parts per million) in April at the forebay, and from 7.1 milligrams per liter (7.1 parts per million) to 11.3 milligrams per liter (11.3 parts per million) for the same months at the transition zone. At the inflow sampling site on the Tennessee River arm of the Watts Bar Reservoir (i.e., the tailrace of the Fort Loudoun Dam), a minimum dissolved oxygen concentration of 3.9 milligrams per liter (3.9 parts per million) was recorded in September. This low value is related to low oxygen levels in the water released through the dam and high flows, which keep mud from building up on the lake bottom. At the inflow sampling site on the Clinch River arm of Watts Bar Reservoir (i.e., the tailrace of Melton Hill Dam), a minimum dissolved oxygen concentration of 6.3 milligrams per liter (6.3 parts per million) was recorded in March. Tennessee's minimum dissolved oxygen criteria for the protection of fish and aquatic life is 5.0 milligrams per liter (5.0 parts per million), measured at the 1.5-meter (4.9-feet) depth.

Data on temperature and dissolved oxygen show that Watts Bar Reservoir developed a moderate degree of both thermal and oxygen stratification throughout most of the summer of 1993. Data on the dissolved oxygen concentration versus the depth show that a strong gradient also develops in Watts Bar Reservoir, particularly from June through August. At the forebay, near-bottom dissolved oxygen concentrations in the hypolimnion (the lowermost, noncirculating layer of cold water) were less than 2 milligrams per liter (2 parts per million) in June and July. Additionally, the proportion of the hypolimnion with low dissolved oxygen concentrations (i.e., less than 2 milligrams per liter [2 parts per million]) averaged about 13% of the total cross-sectional area, higher than in any other Tennessee River reservoir. The minimum observed dissolved-oxygen concentration in Watts Bar Reservoir in 1993 was 0.6 milligrams per liter (0.6 parts per million) at the bottom of the forebay in July, but dissolved oxygen concentrations were never less than 4 milligrams per liter (4 parts per million) at the transition zone.

pH

The NRC 1978 FES-OL reported a pH-range from 6.8 to 8.5 in the Tennessee River in the vicinity of the WBN Plant. Historically, the pH levels of water in the Watts Bar Reservoir have been higher than other Tennessee River sampling sites. This is due to addition of the cool, well-oxygenated, nitrate-rich, and hard water of the Clinch River, which combines with the Tennessee River (and Watts Bar Reservoir) at TRM 567.9, about 11 kilometers (7 miles) upstream from the transition zone sampling site. In the summer of 1993, pH values ranged from 6.8 to 9.0 throughout Watts Bar Reservoir. During much of the April-September sampling period, near-surface values frequently exceed a pH of 8.5 at both the forebay and transition zone, with dissolved oxygen saturation values commonly exceeding 100%, indicating high rates of photosynthesis. Tennessee's criteria for the protection of fish and aquatic life is a maximum pH of 8.5.

Phosphorus

The NRC 1978 FES-OL reported total phosphorus levels ranging from <0.01 milligrams per liter (<0.01 parts per million) to 0.05 milligrams per liter (0.05 parts per million). The average total phosphorus concentrations observed in Watts Bar Reservoir (0.029 milligrams per liter [0.029 parts per million] at the forebay and 0.035 milligrams per liter [0.035 parts per million] at the transition zone) were among the lowest for the monitoring locations in 1993. In addition, the average dissolved ortho-phosphorus concentrations of 0.007 milligrams per liter (0.007 parts per million) and 0.004 milligrams per liter (0.004 parts per million), respectively, at the forebay and transition zones were also among the lowest observed at any of the Tennessee River Vital Signs Monitoring locations in 1993. Total nitrogen/total phosphorus ratios on Watts Bar Reservoir are higher than on any other Tennessee River reservoir. The low phosphorus concentrations in combination with the relatively high nitrogen concentrations (supplied by both the Clinch and Tennessee River inflows) cause the high total nitrogen/total phosphorus ratios in Watts Bar Reservoir (particularly at the transition zone) and suggest that the productivity of some aquatic vegetation may occasionally be limited by phosphorus.

Chlorophyll *a*

The NRC 1978 FES-OL measured the levels of chlorophyll *a* in the Tennessee River in the vicinity of the WBN Plant. The highest chlorophyll *a* concentrations were measured in August at the forebay (10 micrograms per liter [10 parts per billion]) and in May at the transition zone (11 micrograms per liter [11 parts per billion]). Surface concentrations of chlorophyll *a* in 1993 averaged about 7 micrograms per liter (7 parts per billion) at the forebay and about 8 micrograms per liter (8 parts per billion) at the transition zone.

Sediment

The NRC 1978 FES-OL did not address water that is intermixed with the sediments in the Tennessee River in the vicinity of the WBN Plant. Chemical analysis of sediments in Watts Bar Reservoir forebay in 1993 indicated elevated levels of non-ionized ammonia (240 micrograms per liter [240 parts per billion]) in the water that is intermixed in the sediments. Although the non-ionized form of ammonia (NH_3) is 300 to 400 times more toxic than NH_4^+, fish are more tolerant of its effects in high-pH conditions, such as those found in Watts Bar Reservoir. Traces of chlordane (18 micrograms per liter [18 parts per billion]) and mercury were detected at the transition zone. Mercury levels were slightly elevated 0.72 micrograms per liter (0.72 parts per million), but they were still at a level below sediment-quality guidelines for mercury (i.e., 1.0 micrograms per liter [1.0 parts per million]). The most likely source of this contamination is past operations at Oak Ridge National Laboratory where major environmental cleanup activities are now underway (TVA 1993). Using rotifers and daphnids, toxicological screening of this water found indications of acute toxicity (40% survival for each organism) in the forebay. The forebay sediment water was also found to be toxic to rotifers in 1992. Particle-size analysis showed sediments from the forebay area consisted of nearly 100% silt and clay grain-size particles. Because sediments containing smaller grain-size particles are associated with higher organic content and generally bind larger amounts of trace metals, this may partly explain the high levels of contaminants found in the water located in the forebay sediments.

Fecal Coliform Bacteria

The NRC 1978 FES-OL addressed fecal coliform levels in the Tennessee River in the vicinity of the WBN Site. These levels range from < 10 to 20 bacteria per 100 milliliters (per 3.4 ounces). Fourteen swimming areas in the vicinity of the WBN Plant were tested for fecal coliform bacteria 12 times each in 1993. Four sites had one or more samples exceeding 1,000 bacteria per 100 milliliters (per 3.4 ounces), which is Tennessee's maximum concentration allowable for a single sample. Samples from these swimming areas were collected after a rainfall when bacteria concentrations are generally higher. Only 3 of the 14 swimming areas had very low geometric mean concentrations for all samples (<20 bacteria per 100 milliliters [3.4 ounces]), a lower ratio than in other Tennessee River reservoirs.

Poly-Chlorinated Biphenyls

The NRC 1978 FES-OL did not address poly-chlorinated biphenyls (PCBs). Fish from Watts Bar Reservoir have been under intensive investigation for several years because of PCB contamination. The Tennessee Department of Environment and Conservation has advised the public not to eat certain species of fish from Watts Bar Reservoir and to limit consumption of other species. Four of these species (channel catfish [*Ictalurus punctatus*], sauger [*Stizostedion canadense*], white bass [*Morone chrysops*], and striped bass [*Morone saxitalis*], including striped bass/white bass hybrids) were re-examined in autumn 1992. Average PCB concentrations among sample sites ranged from 0.4 to 1.9 micrograms per liter (0.4 to 1.9 parts per million) for channel catfish (five sites), 1.0 to 1.1 micrograms per liter (1.0 to 1.1 parts per million) for striped bass (two sites), 0.2 to 0.6 micrograms per liter (0.2 to 0.6 parts per million) for sauger (three sites), and the average for white bass at a single location was 0.7 micrograms per liter (0.7 parts per million).

2.3 Meteorology

This section supplements the description of regional and local climatology and meteorology of the WBN Site contained in the NRC 1978 FES-OL using data collected by the National Weather Service and the applicant since 1978. In addition, this section presents the staff evaluation of atmospheric dispersion using 20 years of onsite meteorological data.

2.3.1 Regional Climate

The NRC 1978 FES-OL and the NRC Safety Evaluation Report (SER) (NRC 1982a) for WBN describe the general climate of the Great Tennessee Valley and of the WBN Site. These descriptions are based on records that date from the beginning of the twentieth century for Chattanooga, Knoxville, and other locations. These records provide an adequate representation of regional climatic conditions; additional information is unlikely to show significant changes in climatological parameters such as prevailing wind direction, mean wind speed, or annual precipitation.

Record extreme values for minimum temperature, maximum 24-hour rain and snowfall, and monthly precipitation have been exceeded at Chattanooga since completion of the NRC 1978 FES-OL (TVA 1994c). The applicant concludes (TVA 1994c) that these changes do not affect the environmental impact conclusions in the NRC 1978 FES-OL. The staff concurs that meteorological observations do not show a significant change in the regional or local climates since the preparation of the NRC 1978 FES-OL. Therefore, the staff concludes that the climatological description in the NRC 1978 FES-OL is adequate.

2.3.2 Severe Weather

The applicant states that severe weather statistics for the region related to hail, high winds, thunderstorms, and ice storms are consistent with those presented in the NRC 1978 FES-OL (TVA 1994c). The tornado strike probability stated in the NRC 1978 FES-OL is 0.00076 per year (76 chances in 100,000 of a tornado striking the WBN Site in any given year) with a recurrence interval of 1,300 years. The applicant has updated its estimate of the tornado strike probability and recurrence interval. The applicant's current estimate of tornado strike probability, based on a longer period and a smaller area, is 0.00015 per year (15 chances out of 100,000 of a tornado striking the WBN Site in any given year) with a recurrence interval of 6,755 years (TVA 1994a). The staff independently estimates the tornado strike probability to be about 0.00018 per year (18 chances out of 100,000 of a tornado striking the WBN Site in any given year) with a recurrence interval of about 5,400 years. The staff's estimate is based on the methodology of WASH-1300 (Markee, Beckerly, and Sanders 1974) as implemented in the Tornado Computer Code (Schreck and Sandusky 1982) and tornado data summarized in NUREG/CR-4461 (Ramsdell and Andrews 1986). The applicant's current estimate and the staff's estimate of tornado strike probability are lower than the estimate in the NRC 1978 FES-OL and are not significantly different.

2.3.3 Local Meteorological Conditions

Onsite meteorological data covering the period from January 1974 through December 1993 have been submitted by the applicant (TVA 1994d). Analysis of these data shows that the meteorological conditions at the WBN Site are generally consistent with conditions expected on the basis of the regional climatology. Winds tend to be light and flow up and down the Tennessee River valley. The stable atmospheric conditions that occur at night are accompanied by light winds that are driven by local conditions rather than the up and down valley flow. Neutral atmospheric stability conditions may occur at any time of day and are prevalent during the transition between day and night. During neutral conditions the winds at the plant tend to be aligned with the prevailing valley flow.

Analysis of the data shows that extremely unstable conditions have the highest average wind speeds during the 20-year period of onsite data collection at WBN Site. High wind speeds are expected to be associated with neutral stability conditions. The applicant provided information that shows the highest wind speeds during unstable conditions were associated with winds from the south-southwest (TVA 1994b). South-southwest winds have the highest frequency of occurrence of any wind direction. This information also shows that the frequencies of calm winds and winds in the 0.3 to 0.6 meters per second (0.6 to 1.4 mile per hour) wind speed class during extremely unstable atmospheric conditions (stability classes A and B) are much lower than expected.

Based on the staff's visit to the WBN Site, a review of additional meteorological data provided by the applicant, an examination of an aerial photograph of the plant site, and consideration of the physical processes involved, the staff concludes that the association between the high average wind speeds and extremely unstable atmospheric conditions is probably caused by two factors. The first factor is general overturning of the atmosphere during unstable conditions that prevents wind speeds from decreasing to the lowest speed classes. As a result, there are essentially no occurrences of low wind speed to reduce the average wind speeds for the extremely unstable stability classes.

The second factor is related to the performance of the parameter used to approximate atmospheric stability conditions: temperature difference. The temperature difference parameter performs satisfactorily under homogeneous atmospheric conditions. Under the condition described above, a complex atmospheric vertical structure (multiple boundary layers) sets up and the temperature measurement points reflect significantly different conditions; consequently, the parameter does not perform well.

The shift in stability class is not significant because it occurs under conditions associated with relatively good dispersion and occurs infrequently.

2.3.4 Atmospheric Dispersion

Data from the applicant's meteorological system located at the WBN Site (see Section 6.1.1) have been used to estimate atmospheric dispersion characteristics for the WBN Plant (NRC 1978, 1982a; TVA 1994a). The applicant has submitted meteorological data covering the 20-year period from January 1974 through December 1993 (TVA 1994d). Data summaries for this period show a larger fraction of the calm conditions (wind speeds below the anemometer threshold) and a lower annual average wind speed than seen in data used in the dispersion calculations presented in the NRC 1978 FES-OL and the applicant's FSAR (TVA 1994a).

The staff conducted an independent evaluation of the dispersion conditions using the 20-year meteorological data set and the method described in Regulatory Guide 1.111 (NRC 1977). The evaluation assumed ground-level releases, a building cross-sectional area of 1800 square meters (20,000 square feet) and a terrain adjustment factor of 1.5. Neither deposition nor decay were considered. The results of the dispersion estimates for the exclusion area boundary (1,250 meters [0.77 miles]) and the outer radius of the low population zone (4,828 meters [3 miles]) to the southeast of the plant are shown in Table 2.6. The southeast sector was selected for the analysis because the applicant indicates that it is the sector with maximum normalized concentration values (TVA 1994a). Table 2.6 also compares the staff's dispersion estimates with previously reported values.

The longer period of record for the meteorological data used in the atmospheric dispersion calculations performed by the staff and by the applicant for the FSAR (TVA 1994a) provides more representative estimates of the meteorological conditions than the two-year period of record used in atmospheric dispersion calculations for the NRC SER (NRC 1982a) and the NRC 1978 FES-OL. The results of the staff analysis based on 20 years of record, including the most recent five-year period, are not significantly different from the results of

Table 2.6 Maximum-Sector Normalized Concentration Estimates for the Exclusion Area Boundary and Low Population Zone in the 22.5° Sector Southeast of the WBN Site

		Normalized Concentration, (seconds per cubic meter)			
Boundary	**Period**	**Staff**	**FSAR**	**NRC WBN SER**	**NRC 1978 FES-OL**
Exclusion Area Boundary	annual	1.1×10^{-5}	1.3×10^{-5}	N/A	5.0×10^{-5}
Low Population Zone	annual	1.7×10^{-6}	1.5×10^{-6}	7.8×10^{-7}[(a)]	N/A

(a) Estimated on the basis of the 0-8 hour and 4- to 26-day values using the method described in Regulatory Guide 1.145 (NRC 1982b).

the analysis presented in the applicant's FSAR. On this basis, the staff concludes that the 1974-1988 meteorological data used in the FSAR provide an adequate basis for estimating atmospheric dispersion characteristics for this supplement. The staff further concludes that the dispersion estimates reported in the applicant's FSAR are representative of the WBN Site and are acceptable for use in dose calculations.

2.4 Ecology

An understanding of the ecology of the WBN Site plays an important role in assessing the impact of the WBN Plant on the surrounding environment. Descriptions of the terrestrial ecology and the aquatic ecology in the area surrounding the WBN Plant are given are Sections 2.4.1 and 2.4.2, respectively.

2.4.1 Terrestrial Ecology

The NRC 1978 FES-OL stated that, prior to being acquired by the applicant, the area of the WBN Site was agricultural. The current environment at the station consists primarily of industrial areas surrounded by undisturbed wildlife habitat, with no areas identified as critical habitat for terrestrial species protected under the Federal Endangered Species Act (ESA). Additional data (TVA 1994c) have identified several marshy forested wetlands southwest of the WBN Site. Wetlands are protected by Executive Order 11990, "Protection of Wetlands," 42 FR 26961 (1977).

Approximately 300 kilometers (185 miles) of transmission lines are associated with the WBN Site (TVA 1994d), as shown in Figure 2.4. All lines were in place at the time of the NRC 1978 FES-OL. The rights-of-way cover approximately 14.6 square kilometers (3,621 acres), of which 7.2 square kilometers (1,769 acres) are forested, 6.2 square kilometers (1,534 acres) are agricultural, 1 square kilometer (238 acres) is urban, and the remaining areas are industrial, barren, or over water (TVA 1994d). Forested areas are those

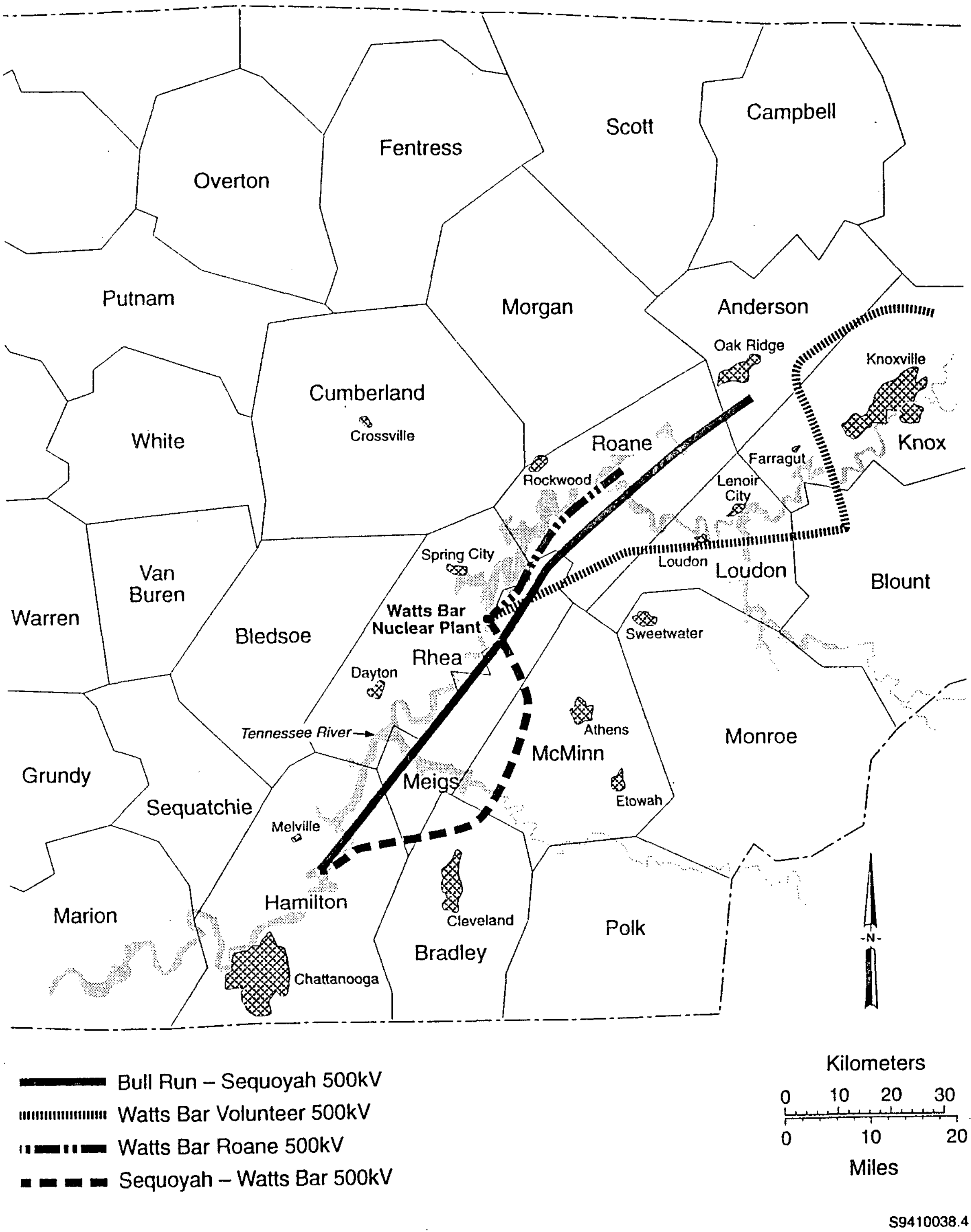


Figure 2.4 Transmission Line Corridors Associated with the WBN Plant

generally found within the Ridge and Valley Province, with an oak-chestnut climax type (TVA 1976). The forested and agricultural regions provide habitat for a variety of game species, including white-tailed deer (*Odocoileus virginiana*), cottontail rabbits (*Sylvilagus floridanus*), and northern bobwhite (*Colinus virginianus*).

The NRC 1978 FES-OL, on the basis of the TVA 1972 EIS-CP (TVA 1972), identified only two Federally designated terrestrial species known to occur at the station area: a spider lily (*Hymenocallis occidentalis*) and the southern bald eagle (*Haliaeetus leucocephalus*).

Prior to enactment of the ESA in 1973, the spider lily was listed by the U.S. Forest Service, Southern Region, in 1972 as a species of concern. This species, however, is not currently listed as an endangered, threatened, or candidate species under the ESA, nor is it currently listed as a species of concern by the State of Tennessee. Therefore, this species is not afforded State or Federal legal protection. Additionally, surveys conducted in 1978 and 1994 (TVA 1994d) failed to locate any individual members of the species on the WBN Site, and the spider lily is not known to exist in the transmission line corridors.

Currently, the bald eagle and the gray bat (*Myotis grisescens*) are the only terrestrial species near the WBN Site listed as endangered by the FWS under the ESA and by the State of Tennessee Department of Environment and Conservation. Bald eagles continue to visit the WBN Site during the winter, foraging for fish and roosting in trees near the reservoirs. In 1994, there was a documented nesting attempt about 6.4 kilometers (4 miles) south-southwest of the plant. Subsequent information (TVA 1994c) indicated that the gray bat uses a cave within 6.4 kilometers (4 miles) of the plant, and forages for insects over the reservoir near the plant.

The State of Tennessee also lists the osprey (*Pandion haliaetus*) as endangered (TVA 1994d). The osprey, which uses the Tennessee River near the WBN Site for foraging was identified as being on or near the Site during a field inspection in September 1994 (TVA 1994d).

The applicant also evaluated the TVA Regional Natural Heritage Project database to determine whether any Federally protected or State-protected species occur within a ten-county area containing the WBN Site and associated transmission line corridors (TVA 1994d). This database contains locality and distribution information about known populations of Federally and State-listed species on a State-wide basis.

The database evaluation identified 15 Federally listed and/or State-listed animal species, and indicated that six of these species are known to occur within 0.8 kilometers (0.5 mile) of the transmission line corridors (Table 2.7). The six species include the bald eagle, osprey, and gray bat already mentioned as being found on or near the WBN Site. It also includes Cooper's hawk (*Accipiter cooperii*), the sharp-shinned hawk (*Accipiter striatus*), and the grasshopper sparrow (*Ammondramus savannarum*).

The database evaluation identified 35 Federally listed and/or State-listed plant species. Of these 35, eleven populations of eight species listed by the State of Tennessee as threatened or endangered are known to occur within 0.8 kilometer (0.5 mile) of the transmission line corridors (Table 2.7). Four of these eight species

Table 2.7 Listed Species on or near the WBN Site Transmission Line Corridors

Common Name	Scientific Name	Listing Status		Location[a]
		Federal	State	
BIRDS				
Bald eagle	*Haliaeetus leucocephalus*	Endangered	Endangered	1,2
Osprey	*Pandion haliaetus*	-	Endangered	1,2
Cooper's hawk	*Accipiter cooperii*	-	Threatened	2
Sharp-shinned hawk	*Accipiter striatus*	-	Threatened	2
Grasshopper sparrow	*Ammodramus savannarum*	-	Threatened	2
MAMMALS				
Gray bat	*Myotis grisescens*	Endangered	Endangered	1,2
PLANTS				
Auriculate false foxglove	*Tomanthera auriculata*	Candidate	Endangered	2
Tall larkspur	*Delphinium exaltatum*	Candidate	Endangered	2
Bugbane	*Cimicifuga rubifolia*	Candidate	Threatened	2
False foxglove	*Aureolaria patula*	Candidate	Threatened	2
Goldenrod	*Solidago ptarmicoides*	-	Endangered	2
Bush honeysuckle	*Diervilla lonicera*	-	Threatened	2
Bush honeysuckle	*Diervilla sessilifolia* var. *rivularis*	-	Threatened	2
Goldenseal	*Hydrastis canadensis*	-	Threatened	2

(a) 1 = on or near WBN Site; 2 = within 0.8 kilometer (0.5 mile) of WBN transmission lines.

(auriculate false foxglove [*Tomanthera auriculata*], tall larkspur [*Delphinium exaltatum*], bugbane [*Cimicifuga rubifolia*], false foxglove [*Aureolaria patula*]) are also designated as Federal candidate-Category 2 species, and are currently being evaluated for protection under the ESA. Five of these eight plant species (false foxglove, bugbane, goldenseal [*Hydrastis canadensis*], and the two species of bush honeysuckle [*Diervilla lonicera, Diervilla sessilifolia* var. *rivularis*]) found near the transmission lines are not expected to occur within the transmission line corridors because these species only occur in forest habitats (TVA 1994d). The other three plant species (auriculate false foxglove, a goldenrod [*Solidago ptarmicoides*], and tall larkspur) are known to occur in naturally barren areas or prairie sites and could colonize the open areas created within the transmission right-of-ways. However, no known populations of these species currently occur within any of the corridors, and the corridors do not cross any of the known population locations. An evaluation of the effects of the WBN Site and transmission line operation on the terrestrial environment is provided in Section 5.3.

2.4.2 Aquatic Ecology

The characteristics of the WBN Site's aquatic environment and biota were previously described in the TVA 1972 EIS-CP (TVA 1972). This information was based on some site-specific data combined with a general knowledge of the Tennessee River tailrace habitats and their associated aquatic biota. Extensive supplemental information, from preoperational monitoring programs, was evaluated in the NRC 1978 FES-OL. Since publication of the NRC FES-OL in 1978, preoperational studies have continued to provide information specific to the WBN Site. These studies are listed in Section 6.1.5 of this report. A preoperational monitoring report, detailing preoperational monitoring efforts and results from 1973-1985, was published in 1986 (TVA 1986). This report, other preoperational reports, and information gathered during the 1994 WBN Site visit, were determined to be acceptable representations of the environment and were used as a basis for the staff's review of the aquatic ecology in the vicinity of the WBN Site. The review indicated that changes had occurred either within various populations or in the staff's knowledge of the populations within the vicinity of the WBN Site. The specific populations include aquatic macrophytes, fish, and the mussel communities. In addition, changes have occurred since 1978 in the listing of threatened and endangered species.

The historical record shows the long-term average release between completion of the Watts Bar Dam in 1942 and 1985 to be approximately 767 cubic meters per second (27,100 cubic feet per second) (TVA 1990b). Higher flows usually occur December through March, although the seasonal pattern varies. Based on the long-term average flow, in one day water moves from the dam (TRM 529.9) past the WBN Site to TRM 515 in the summer and to TRM 508 in the winter for a total of 24 and 35 river kilometers (14.9 and 21.9 river miles), respectively (TVA 1986). Velocities in the upper portion of the Chickamauga Reservoir are highly variable. Travel times are up to 50% faster in the middle of the main channel than in the slower, shallow areas. The combination of high flows, channel bends, and small cross sections found in the upper portion of the Chickamauga Reservoir creates fully-mixed flow condition on the river upstream of the Hiwassee River confluence (Figure 1.1) (TVA 1986).

Plankton

Recent studies indicate that virtually all plankton passing the WBN Site originate in the Watts Bar Reservoir and pass through the turbines at the Watts Bar Dam. There is no reason to suspect that plankton are not uniformly distributed in the water column. Through preoperational monitoring, plankton populations have been shown to vary enormously from day to day near the WBN Site. Sampling surveys during the period between 1973 and 1985 indicate that plankton populations decreased at the WBN Site, due to the swift-flowing nature of the Chickamauga Reservoir. The populations then gradually increased further downstream to levels comparable to those at the Watts Bar Reservoir forebay (TVA 1986).

Blue-green algae is rarely a major component of the phytoplankton population at the WBN Site. In this portion of the river where the water is fast-flowing, phytoplankton growth is limited and their populations generally decrease downstream until the river flow slows and becomes more lake-like at a distance of 40 to 48 kilometers (25 to 30 miles) below the WBN Site.

Aquatic Macrophytes

Introduced exotic aquatic plants in Watts Bar Reservoir have declined from about 2.8 square kilometers (700 acres) in the late 1980s to an estimated 0.04 square kilometers (10 acres) in 1993 (TVA 1993). Eurasian watermilfoil (*Myriophyllum spicatum*) and spinyleaf naiad (*Najas minor*) were the dominant species prior to the recent decline. The populations of both species have fluctuated over the past 25 years, primarily in response to river-flow conditions. One additional species, hydrilla (*Hydrilla verticellata*), was found in the late 1980s, but has not been seen in recent years. The 1986 preoperational monitoring report (TVA 1986) indicated that changes in Watts Bar Reservoir conditions during the 1980s led to the increase of submerged aquatic macrophytes. In 1985, 16% (22 square kilometers or 5,600 acres) of the total reservoir had been colonized, primarily by the Eurasian watermilfoil and the spinyleaf naiad. These species created reservoir-use conflicts, which led to control measures in areas around recreation and public access sites, lakeshore development, and industrial water intakes because of the implication that such dense aquatic weeds deteriorate water quality (by raising temperatures and lowering dissolved oxygen concentrations). Peak macrophyte coverage in Chickamauga Reservoir occurred only in relatively shallow overbank areas relatively far downstream from the WBN Plant. The WBN Site is located in the riverine tailwater area of Chickamauga Reservoir where suitable overbank habitat is rare and macrophyte levels near the plant never reached nuisance levels, even during years of peak coverage.

Fish Community

In 1993, shoreline electrofishing (60 transects) and offshore gill netting (39 net-nights) sampled a total of 5,174 fish representing 50 species (TVA 1993). Three species made up the majority of the overall sample: gizzard shad (*Dorosoma cepedianum*) (37%), bluegill (*Lepomis macrochirus*) (13%), and emerald shiners (*Notropis atherinoides*) (12%). Electrofishing results showed catch rates to be similar in the Clinch River inflow, the Tennessee River inflow, and the forebay but over twice as high at the transition zone. The higher catch rate in the transition zone was attributed mainly to the abundance of emerald shiners and bluegill. Threadfin shad (*Dorosoma petenense*) young-of-the-year catch rates were moderate in all sample zones except the Tennessee River inflow which was considered high. Gill netting catch rates were much the same in all four sample areas.

The NRC 1978 FES-OL discounted the previous belief that the tailrace of the Watts Bar Dam was actually a favorable fish-spawning habitat for several tailrace-spawning species, including sauger (*Stizostedion canadense*), smallmouth bass (*Micropterus dolomieui*), white bass (*Morone chrysops*), and possibly yellow perch (*Perca flavescens*). Targeted studies since that 1978 document have confirmed that the tailwater reach between the WBN Site and the dam is not an area of major spawning activity for these species. Hunter Shoals (TRM 520-522), located 10 to 11 kilometers (6 to 7 miles) below the WBN Site, has been identified as a major spawning area for white bass and as the primary spawning site for sauger in the Chickamauga Reservoir (TVA 1993). Due to declining sauger populations, the Tennessee Wildlife Resources Agency (TWRA) released approximately 191,000 sauger fingerlings into the upper Chickamauga Reservoir in 1990. The apparent success of this effort was seen in 1991 when high numbers of age 1 sauger were captured during annual monitoring efforts in the reservoir (TVA 1991a).

Mussel and Clam Communities

The Tennessee River is home to both introduced and native mussel and clam species. There are three non-native mussel or clam species known to be introduced into the Tennessee River (the Asiatic clam [*Corbicula* sp.], zebra mussel [*Dreissena polymorpha*], and dark falsemussel [*Mytilopsis leucophaeta*]), and there is one non-native species (quagga mussel [*Dreissena* sp.]) with the potential to invade the Tennessee River system.

At the time of publication of the NRC 1978 FES-OL, Asiatic clams were the only nuisance mussel population inhabiting the Tennessee River. These species were accidentally introduced to North America, probably through the discharge of various ships' ballast water into North American waterways. Because they are prolific breeders, they have spread rapidly. The Asiatic clam became prominent in the benthos communities of the river during the 1960s. The Asiatic clam is considered a pest species because its shells obstruct underground pipes, fouling municipal water treatment facilities and other piping systems, including the raw water systems of nuclear generating plants. These species can outcompete many native mussel and clam species, some of which are presently listed as endangered or threatened.

The zebra mussel has recently been introduced to the Tennessee River, but it has not yet been found at the WBN Site (U.S. Army Corps of Engineers 1992). However, this mussel has been found in very small numbers in Watts Bar Reservoir and in the lock at Watts Bar Dam, upstream of the WBN Site. This organism attaches to a wide variety of firm surfaces using tough proteinaceous byssal threads. The larval stage of the zebra mussel and the Asiatic clam differ from that of native mussels in that they do not require a fish host to develop into an adult. Instead, the zebra mussel and Asiatic clam larvae are planktonic and can be drawn into raw-water piping systems of such facilities as water treatment plants, dams, fossil and nuclear generating plants, navigation locks, boat engine cooling systems, and other facilities. As the larvae settle and attach, layers of zebra mussels can build up in critical piping systems. The result is usually partial or total blockage of piping systems; this can cause damage to equipment and facilities and require facility outage time to remove the blockage. Zebra mussels also outcompete native species for food and space.

A zebra mussel look-alike, the dark falsemussel was discovered in three Tennessee River locks in September 1992. This estuarine species is capable of survival, but not of reproduction, in freshwater systems. However, the mussel was found in numbers great enough to consider it a possible biofouler. Another species, the quagga mussel, is known to intermingle with zebra mussel colonies and is expected to reach the Tennessee River and WBN Site within a few years. As yet, the quagga mussel has not been found outside the Great Lakes area; however, there is no reason to doubt its chances of becoming more widespread. The zebra mussel, dark false-mussel, and quagga mussel are all termed "attached biofouling mussels" with the same system-infesting behavioral characteristics; throughout this document they collectively will be referred to as "zebra mussel."

The applicant has implemented mussel-control methods on site, restricting control measures to the facility. The applicant currently uses a non-oxidizing molluscicide, Clam-Trol™ (CT-1), to inhibit infestation by Asiatic clams and plans to use the same method to deal with the potential spread of zebra mussels as discussed in Section 3.4.

Native species of freshwater mussels also inhabit the tailrace of the Watts Bar Dam as described in the NRC 1978 FES-OL. Among changes in the information provided by the 1978 FES-OL are the identification of another concentration of mussels near the WBN Site, the expansion of the freshwater mussel sanctuary, and an increase in the number of mussel species identified at the WBN Site. Refer to Chapter 5 for a discussion of the significance of these changes.

Although no mussel concentrations were reported along the right bank in the vicinity of the blowdown diffuser in 1978, a concentration of mussels or a "mussel bed," has since been documented as existing along the right (descending) shoreline of the river just downstream from the mouth of Yellow Creek and the WBN Plant discharges between TRM's 526 and 527 (TVA 1994c). The approximate location of the mussel bed is shown in Figure 1.2. In 1990, the highest numbers of mussels were found at TRM 528 while the lowest numbers of mussels were found at TRM 526 and the TRM 520 mussel bed location showed intermediate densities. Of the 31 mussel species identified in these two surveys, five species account for approximately 90% of the specimens recorded at these monitoring stations (TVA 1986). The remaining 26 mussel species are often represented by less than 1% of the total specimens examined. Results of these surveys indicate that mussel populations in the Watts Bar tailwater have been in decline since the early 1940's when the Chickamauga and Watts Bar Reservoirs were filled (1940 and 1942). Previous to the impoundments, a total of 64 freshwater mussel species are thought to have occurred near the WBN Site (TVA 1986). In recent years, only 31 mussel species have been recorded in the vicinity of the WBN Site, and only 28 species were reported during the 1988 and 1990 surveys (TVA 1991b). Most of these were adults 30 or more years of age and in poor condition (emaciated soft parts and extreme shell erosion) (TVA 1994e). As stated in a March 1991 preoperational mussel monitoring report (TVA 1991b), no young or juvenile mussels have been found during sampling since monitoring began in 1983. Although the reason for the mussels' lack of recruitment is not known, it is reasonable to assume that impoundment of the river and the resulting modifications to the riverine system are largely responsible (TVA 1986). Continued monitoring in the Chickamauga Reservoir is expected to show a gradual decline in mussel species abundance and diversity (see Section 6.2.5).

In 1965, the State of Tennessee established a freshwater mussel sanctuary in the Chickamauga Reservoir. The sanctuary extended 4.8 kilometers (3 miles) from TRM 529.9 to 526.9. Since 1987, the mussel sanctuary has been extended to TRM 520.0 by the Tennessee Wildlife Resources Agency, creating a total of 16 kilometers (10 river miles) in which the harvesting of mussels is illegal (TVA 1994f). The WBN Plant is situated in the middle of the mussel sanctuary at TRM 528.

Threatened and Endangered Species

The NRC 1978 FES-OL reported the presence of two endangered freshwater mussel species, Federally protected under the Endangered Species Act. They were the pink mucket (*Lampsilis abrupta [= L. orbiculata]*) and the dromedary pearly mussel (*Dromus dromas*), both found in the Tennessee River Chickamauga Reservoir. Since publication of NRC 1978 FES-OL, three additional species have been identified in the Tennessee River and tributary streams near the WBN Site that are granted threatened or endangered status by the U.S. Fish and Wildlife Service (Table 2.8). These include two endangered freshwater mussels, the fanshell (*Cyprogenia stegaria*) and the rough pigtoe (*Pleurobema plenum*), and a fish, the snail darter (*Percina tanasi*). Four additional aquatic species existing on or near the WBN Site are currently listed as Federal candidates (Category 2) and are considered active candidates for Federal protection by the FWS (TVA 1994d) under the ESA. These four species include two mussels, the pyramid pigtoe (*Pleurobema rubrum [=P. pyrimidatum]*) and the Tennessee clubshell (*Pleurobema oviforme*); one fish, the blue sucker (*Cycleptus elongata*); and one amphibian, the Eastern hellbender (*Cryptobranchus a. alleganiensis*).

2.5 Background Radiological Characteristics

Since the staff issued the NRC 1978 FES-OL, the applicant has continued to collect data on the background radiological characteristics in the vicinity of the WBN Site from its preoperational radiological environmental monitoring program. The results of these surveys have been provided in annual reports, the latest of which was issued in April 1994 for calendar year 1993 (TVA 1994f). The only changes in background radiological characteristics noted by the staff were the continued gradual decrease in fallout-radionuclide concentrations (e.g., strontium-90, cesium-137 in soil and milk) and the temporary increase in the short-lived radioiodine (iodine-131) observed following the Russian reactor accident at Chernobyl in the spring of 1986.

An aerial radiological survey of the WBN Site and surrounding area was performed for the NRC in April 1982 (Jobst and Semmler 1982). Figure 2.5 is a map of the radiation intensity (excluding cosmic radiation) from terrestrial sources measured during the aerial survey. The readings were corrected to represent the exposure rates at 1 meter (3.3 feet) above the ground. With one localized exception the observed exposure rates ranged from 0.02 to 0.07 picocoulombs per kilogram per second (3 to 10 microroentgens per hour), which is within the range of typical background radiation levels. The area of highest background exposure rate observed (0.07 to 0.14 picocoulombs per kilogram per second [10 to 20 microroentgens per hour]) was over the coal ash pile located by the Watts Bar Steam Plant, reflecting the concentration of naturally occurring radionuclides in the ash.

Table 2.8 Listed Aquatic Species Occurring on or near the WBN Site

Common Name	Scientific Name	Listing Status: Federal	Listing Status: State	Location[a]
BIVALVES				
Dromedary pearly mussel	*Dromus dromas*	Endangered	Endangered	1
Pink mucket	*Lampsilis abrupta (= L. orbiculata)*	Endangered	Endangered	1
Pyramid pigtoe	*Pleurobema rubrum (= P. pyrimidatum)*	Candidate	----	1
Rough pigtoe	*Pleurobema plenum*	Endangered	Endangered	1
Tennessee clubshell	*Pleurobema oviforme*	Candidate	--	1
Fanshell	*Cyprogenia stegaria*	Endangered	Endangered	1
FISH				
Blue sucker	*Cycleptus elongata*	Candidate	Threatened	1
Snail darter	*Percina tanasi*	Threatened	Threatened	1,2
AMPHIBIANS				
Eastern hellbender	*Cryptobranchus a. alleganiensis*	Candidate	NMGT[b]	2

(a) 1 = in or along mainstream of Tennessee River near WBN Site;
2 = within 0.8 kilometers (0.5 miles) of WBN transmission line.
(b) NMGT = in need of management.

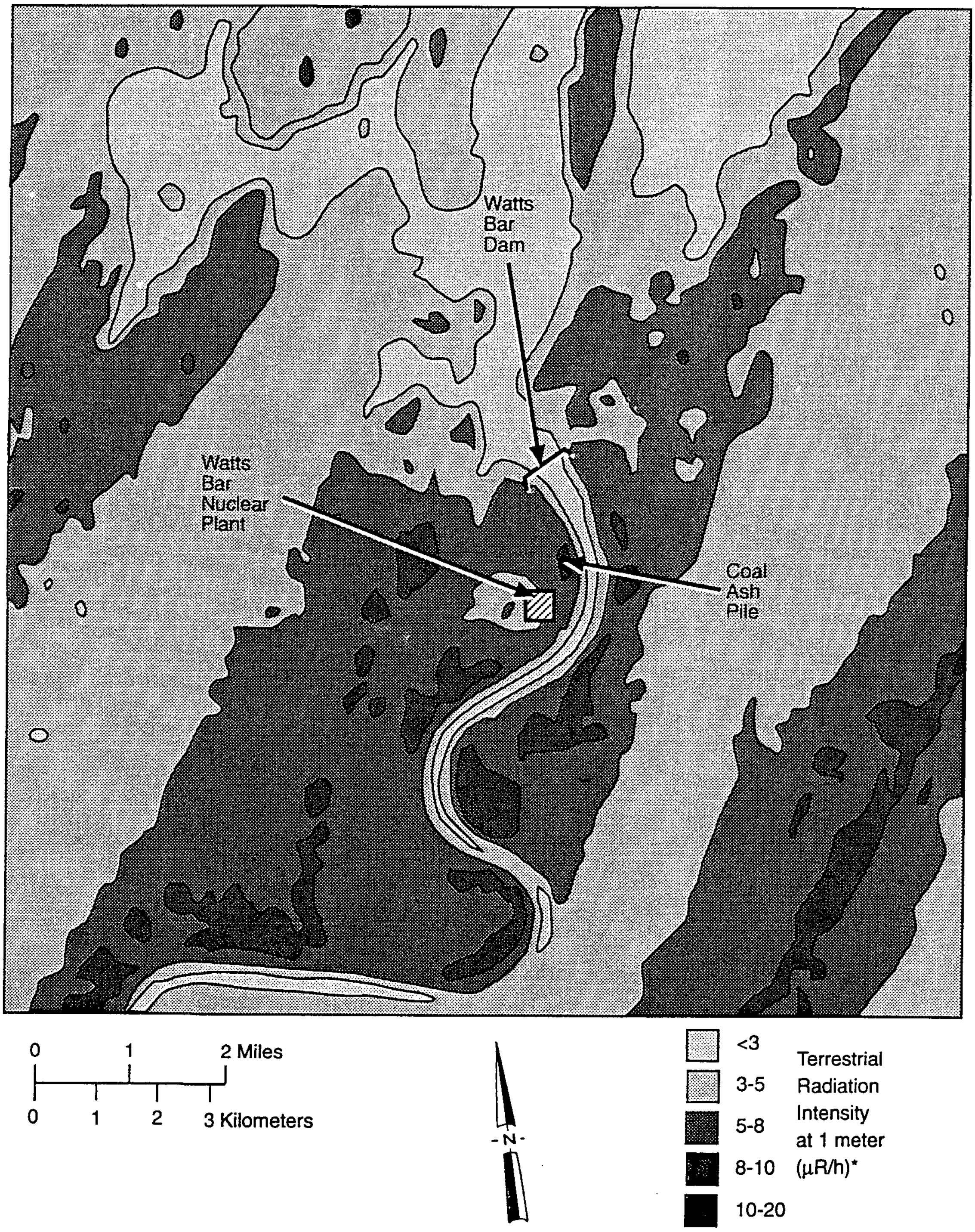


Figure 2.5 Background Exposure Rates from Terrestrial Components in the Vicinity of the WBN Plant (from Jobst and Semmler 1982)

2.6 Historical and Archeological Sites

The NRC 1978 FES-OL did not address historical and archeological sites; however, information on historical and archeological sites was included in the TVA 1972 EIS-CP (TVA 1972). The TVA 1972 EIS-CP stated that two archeological sites existed in the WBN Site and were previously recorded by the Department of Anthropology of the University of Tennessee. However, the TVA 1972 EIS-CP indicated that there were no sites listed in the National Register of Historic Places or known to be under consideration for such listing. The project was also reviewed by the Tennessee Historical Commission, and no specific items of particular historical significance were identified.

These sites consisted of a single Early Mississippian platform mound (Leuty Mound 40RH6) and a group of five Late Woodland period Hamilton mounds (McDonald Site 40RH7). A data recovery excavation was undertaken in 1971 (Schroedl 1978). In addition, two open habitation areas adjacent to the Mississippian platform mound were noted in the 1971 excavations; a data recovery excavation was undertaken and the results were subsequently published (Calabrese 1976). Archeological sites also exist along the reservoir shoreline, downstream from the WBN Site, but they would not be affected by plant operations. Plant operations are not expected to impact any areas along the river where any additional, but still unidentified, sites may exist.

The transmission line corridors associated with the WBN Site were surveyed, and no archeological sites were encountered that were potentially eligible for the National Register of Historic Places; nor were any archeological sites encountered.

No further excavation or construction of the WBN Site and no additional transmission line corridors are planned. Therefore, the staff concludes that operating and maintaining the plant and the transmission line corridors will not adversely affect any potential, currently unknown, archeological sites. Any additional excavation or construction within the WBN Site, or any changes in the perimeter of the WBN Site, would require review by the NRC staff.

2.7 Geology and Seismology

Geology and seismology issues were not addressed in the NRC 1978 FES-OL. These topics were addressed briefly in the TVA 1972 FES-CP (TVA 1972). For a complete summary of the geological and seismological characteristics of the WBN Plant, the staff assessment is provided in Section 2.5 of the Final Safety Analysis Report (FSAR) for the WBN Plant (TVA 1994a). The staff reviewed the information contained in the FSAR and concludes that it is an adequate description of the geological and seismological characteristics of the WBN Site.

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3 The Plant

This chapter updates information in those sections of the NRC 1978 FES-OL (NRC 1978) pertaining to the WBN Plant design and plant operation. The areas of the WBN Plant that are discussed include station and potable water systems in Section 3.1; the diffuser heat dissipation system in Section 3.2; the radioactive waste treatment system in Section 3.3; and the chemical, sanitary, and other waste treatment systems in Section 3.4. The power transmission system is briefly addressed in Section 3.5.

3.1 Plant Water Use

The applicant's plans have not changed significantly from those discussed in the NRC 1978 FES-OL. Steam generator makeup water, service water, and condenser cooling water will still be drawn from the Tennessee River. Maximum station water usage from the Tennessee River for steam generator make up, service water, and condenser cooling water remains at 4 cubic meters per second (143 cubic feet per second), which is 0.7% of the mean river flow past the plant.

Potable water is still being obtained from a groundwater system; however, the groundwater system is now operated by the Watts Bar Utility District, which uses three wells located 4 kilometers (2.5 miles) northwest of the site (TVA 1994a). Two of the wells have a maximum capacity of 2,730 cubic meters (720,000 gallons) per day and a third standby well has a maximum capacity of 545 cubic meters (144,000 gallons) per day. The maximum groundwater consumption for potable water after initial startup is expected to be 1,140 cubic meters (300,000 gallons) per day.

Section 5.2 contains a discussion of the impacts of plant water use changes since the NRC 1978 FES-OL.

3.2 Heat Dissipation Systems

The applicant's design and plan for the operation of the diffuser heat dissipation system have not changed significantly from those discussed in the NRC 1978 FES-OL. The WBN Plant has a closed-mode cooling system with one natural draft cooling tower for each of the two units. The cooling tower is used for heat dissipation via evaporative processes. Maximum evaporation from the cooling tower was given in the NRC 1978 FES-OL as 1.8 cubic meters per second (64 cubic feet per second). The WBN Plant is designed to route blowdown from the cooling towers to either the Tennessee River, through a multi-port diffuser system (Outfall 101), or into the 234,900 cubic-meter (190 acre feet) yard holding pond. A positive interlock is maintained with the Watts Bar Dam so that when the flow rate from the dam is less than 98 cubic meters per second (3,500 cubic feet per second), the two diffuser legs are automatically closed and the blowdown flow is diverted to the yard holding pond. The yard holding pond has an overflow weir on the south side of the pond (Outfall 102) that is used as an alternate discharge when the capacity of the pond is exceeded. The diffuser is located in the Tennessee River at Tennessee River Mile (TRM) 527.9. The overflow weir discharges into the Tennessee River at TRM 527.2.

The multi-port diffuser system discharges the blowdown into the Tennessee River. The diffuser consists of two pipes that branch from a central conduit on the right (facing downstream) bank of the river and then extend perpendicularly to the river flow. Each of the two pipes is controlled by a butterfly valve. The downstream leg is approximately 91 meters (298 feet) long and 1.37 meters (4.5 feet) in diameter. The upstream leg is 139 meters (456 feet) long and 1.07 meters (3.5 feet) in diameter. The maximum discharge through the diffuser system is estimated as 4.9 cubic meters per second (173 cubic feet per second) for both units, a slight increase (approximately 1%) from that reported in the NRC 1978 FES-OL. The NRC 1978 FES-OL gives a thorough description of the diffuser.

3.3 Radioactive Waste Treatment System

The applicant has made a number of changes to the design of the radioactive waste treatment system from that described in the NRC 1978 FES-OL. Neither the boron recovery system, which included boric acid evaporators, nor the condensate demineralizer waste evaporator system will be used to support operation of the WBN Plant. Liquid waste will be processed, as necessary, through a new mobile demineralizer system. The mobile demineralizer will replace the existing atmospheric demineralizer. The mobile demineralizer system will remove most soluble and suspended radioactive materials from the waste stream through filtration, media-activated carbon, and ion-exchange resin. When the resin medium is expended, it will be sluiced to a container for storage and subsequent approved offsite disposal.

Under plant procedures, as indicated in the NRC 1978 FES-OL, radioactive releases may be discharged from the plant through the cooling tower blowdown. An additional release could occur from the discharge of low-level radioactive liquid effluents from the turbine building station sump to the yard holding pond through the low-volume waste treatment pond. Such a release would occur only in the unlikely event of a primary-to-secondary leak, which is not considered a major release pathway. Monitoring of this release path is controlled in accordance with the WBN Offsite Dose Calculation Manual (ODCM) (TVA 1994b). Releases from the liquid-waste processing system will be controlled in compliance with 10 CFR Part 20, Appendix B and 10 CFR Part 50, Appendix I, as described in the FSAR. Releases have been evaluated and are expected to be well within the limits described in 10 CFR Part 20 and 10 CFR Part 50, Appendix I. The nonradioactive characteristics of the liquid waste processing system are controlled by the NPDES permit (Section 3.4). The gaseous radioactive waste treatment system has not changed significantly from that presented in the NRC 1978

FES-OL. Section 11 of the applicant's Final Safety Analysis Report (FSAR) TVA 1994a describes in detail the systems for processing both liquid and gaseous wastes as well as any potential radiological releases involved in such processing (see Section 5.5 for a summary of the radiological releases).

3.4 Chemical, Sanitary, and Other Waste Treatment

Since issuance of the NRC 1978 FES-OL the applicant has instituted a Chemical Traffic Control Program (TVA 1994c) and has changed the planned use of chemicals that may be discharged from the WBN Plant. The NPDES permit (State of Tennessee 1993) regulates all chemical discharges at the WBN Plant. Table 3.1 summarizes the additional chemicals and their resulting chemical end-products (TVA 1994c). Those chemicals that were not included in the NRC 1978 FES-OL are shown in bold in Table 3.1; they are also summarized briefly below.

The NRC 1978 FES-OL indicated that morphaline and hydrazine would be used as additives to the steam generator feedwater. The applicant has indicated (TVA 1994c) that ethanolamine (ETA) and ammonia will be used for pH control, hydrazine will be retained for oxygen scavenging, and boric acid will be used, for controlling crevice chemistry.

The NRC 1978 FES-OL indicated that the WBN Plant would use chlorine to treat raw cooling water for Asiatic clam control. However, the raw-water treatment program has been changed in order to (1) control corrosion in carbon steel metals; (2) control organic fouling, including slime; (3) minimize the effect of microbiologically induced corrosion (MIC); and (4) inhibit the growth of Asiatic clams. To accomplish these tasks, the following chemicals will be used in the manner described:

- A copolymer dispersant (Betz TVA-06™) will be injected on a year-round continuous basis to keep settleable solids in suspension and thereby reduce accumulations of silt and rust. The letter of agreement with the State of Tennessee indicates that the release of copolymer is anticipated to be no more than 0.2 parts per million as active product (TVA 1994d).

- Tetrapotassium pyrophosphate will be injected on a year-round continuous basis to sequester iron from existing corrosion products in raw-water piping and ancillary components. The applicant expects that it will take approximately two years to clean up the piping and components, at which point the dosage will be reduced to a level that is sufficient to maintain a clean system. The letter of agreement with the State of Tennessee indicates that the release of pyrophosphate (listed as "Betz Inhibitor 30K-30656"™) at the diffuser discharge is not expected to exceed 0.2 parts per million as total phosphorus (TVA 1994d).

Table 3.1 Summary of Added Chemicals and Resulting End Product Chemicals (adapted from TVA 1994c)

Item No.	System	Chemical Treatment Source Chemical and Waste Products	Estimated Maximum Annual Use kg	Estimated Maximum Annual Use (lbs)	Waste End Product Chemical	Resulting End Product[a] Average Annual kg	Resulting End Product[a] Average Annual (lbs)
1	Makeup water filter plant	Alum			Al $(OH)_3$[b]	7,500	(16,510)
		$Al_2(SO_4)_3 \bullet 18H_2O$	35,700	(78,800)			
					SO_4^{2-}	13,900	(30,600)
					Settled Solids[b,c]	32,100	(70,800)
2	Makeup water demineralizer	Sulfuric Acid H_2SO_4 (93% solution)	105,000	(231,000)	SO_4^{2-} (Neutral pH)	98,400	(217,000)
		Sodium Hydroxide NaOH (50% solution)	195,000	(431,000)	Na^+ (Neutral pH)	56,200	(124,000)
	Natural Minerals Removed by Demineralizers	Sodium Na^+	4,590	(10,120)	Na^+	4,590	(10,120)
		Chloride Cl^-	8,940	(10,700)	Cl	8,940	(10,700)
		Sulfate SO_4^{2-}	9,870	(21,750)	SO_4^{2-}	8,870	(21,750)
		Total Dissolved Solids	53,300	(117,500)	Dissolved Solids	53,300	(117,500)
3	Secondary Steam System	Sulfuric Acid	268,000	(590,100)	SO_4^{2-} (Neutral pH)	262,000	(578,000)
	Condensate Polishing Demineralizers	Sodium Hydroxide NaOH	161,000	(353,500)	Na^+ (Neutral pH)	92,200	(203,260)
	Ionized Soluble Species Removed by Demineralizers	Carbonates (CO_3^{2-})	11,500[d]	(25,400)[d]	CO_3^{2-}	11,500[d]	(25,400)[d]
		Metallic Salts					
		Ethanolamine	44,000	(97,820)	$EtONH_2^+$	44,000	(97,820)
		Boric Acid	45,000	(100,000)	H_3BO_3	45,000	(100,000)
4	Auxiliary Steam Generators	Ammonia NH_3	1.4	(3)[e]	NH_3	1.4	(3)
		Hydrazine $H_2N_2H_2$	4.5	(10)[f]	NH_3	4.5	(10)

Table 3.1 (continued)

Item No.	System	Chemical Treatment Source Chemical and Waste Products	Estimated Maximum Annual Use kg	Estimated Maximum Annual Use (lbs)	Waste End Product Chemical	Resulting End Product[a] Average Annual kg	Resulting End Product[a] Average Annual (lbs)
5	Condenser Circulating Water Systems	<<Copper (corrosion product only)[h]			Cu	2,800	(6,200)
		<<Nickel (corrosion product only)[h]			Ni	313	(690)
6	Raw Cooling Water[g]	Pyrophosphate	34,100	(75,752)	$H_2PO_4^{1-}$	34,100	(75,752)
		Organic Co-Polymer Dispersant	7,950	(17,673)	N/A	7,950	(17,673)
		Zinc Sulfate	18,200	(40,405)	Zn^{2+}	7,340	(16,312)
					SO_4^{2-}	10,800	(24,092)
		Copper-Trol™	261	(581)	Benzotriazole	261	(581)
		Clam-Trol™	1,390	(3,080)	DGH	69	(154)
					Quat	110	(246)
		Bromo-Chloro-Hydantoin	3,610	(8,024)	HOCl	1,280	(2,808)
					HOBR	2,350	(5,216)
7	Raw Service Water[g]	Pyrophosphate	3,790	(8,417)	$H_2PO_4^{1-}$	3,790	(8,417)
		Organic Co-Polymer Dispersant	883	(1,964)	N/A	883	(1,964)
		Zinc Sulfate	2,020	(4,489)	Zn^{2+}	815	(1,812)
					SO_4^{2-}		
		Copper-Trol™	29	(65)	Benzotriazole	1,200	(2,677)
		Clam-Trol™	154	(342)	DGH	29	(65)
					Quat	8	(17)
		Bromo-Chloro-Hydantoin	401	(891)	HOCl	12	(27)
					HOBR	140	(312)
						260	(579)

Table 3.1 (continued)

Item No.	System	Chemical Treatment Source Chemical and Waste Products	Estimated Maximum Annual Use		Waste End Product Chemical	Resulting End Product[a] Average Annual	
			kg	(lbs)		kg	(lbs)
8	Essential Raw Cooling[g] Water	Pyrophosphate	151,000	(335,581)	$H_2PO_4^{1-}$	151,000	(335,581)
		Organic Co-Polymer Dispersant	35,200	(78,291)	N/A	35,200	(78,291)
		Zinc Sulfate	80,500	(178,994)	Zn^{2+}	32,500	(72,262)
					SO_4^{2-}		
		Copper-Trol™	1,160	(2,574)	Benzotriazole	48,000	(106,728)
		Clam-Trol™	6,140	(13,644)	DGH	1,160	(2,574)
					QUAT	307	(682)
		Bromo-Chloro-Hydantoin	16,000	(35,546)	HOCl	490	(1,091)
					HOBR	5,600	(12,439)
						10,400	(23,107)

[a]Items 1, 2, 4, 5, 6, 7, and 8 are based on 365 days per year operation at rated capacity. Item 3 is based on 292 days per year operation at rated capacity.

[b]Precipitated material that will make up the water treatment sludge on a dry weight basis. Ultimately put in landfill. No discharge.

[c]Estimates based on maximum suspended solids data observed at TRM 529.9.

[d]The quantitites of ionized soluble species continuously removed by the condensate demineralizers are predicated upon a primary to secondary leak rate or a condenser tube leak. These constituents will be discharged in the form of neutral salts of sodium, oxides of iron, or suspended solids. High crud filters will treat the backwash waste prior to discharge.

[e]Ammonia will be added as needed to maintain pH of 9.0 in the system.

[f]Hydrazine will be added as needed as a dissolved oxygen scavenger. Hydrazine is conservatively assumed to decompose to ammonia.

[g]Based on chemical feed rates at maximum cooling water usage and treatment schedule.

[h]Although copper and nickel will not be added to the system, the values shown represent high estimates of corrosion losses. Actual losses are expected to be less.

- Zinc sulphate will be injected on a year-round continuous basis to reduce corrosion rates of carbon-steel piping and components. The letter of agreement with the State of Tennessee (TVA 1994d) indicates that the release of zinc sulfate (Betz TVA-07™) is anticipated to be maintained at 0.2 parts per million zinc.

- Butyl benzotriazole (Copper-Trol™)[1], a corrosion inhibitor, will be injected periodically into the raw-water systems to reduce corrosion rates. Most of the heat exchangers cooled by the raw water systems are constructed with copper or copper-alloy tubes. The primary point of chemical injection will be at the intake pumping station. Dodecylguanidine hydrochloride (DGH) and n-alkyl dimethyl benzyl ammonium chloride (quat) will be injected periodically to eradicate clams and mussels and prevent MIC. These two chemicals are also marketed under the name Clam-Trol™.[a]

- 1-Bromo-3-chloro-5,5-dimethylhydantoin (BCDMH), an oxidizing biocide used to reduce MIC and control Asiatic clams and zebra mussels, will be injected at the intake pumping station approximately four hours each day throughout the year. Samples of river water are collected periodically during clam-spawning season to monitor the concentration of Asiatic clam larvae entering the plant. Twice a year, BCDMH will be injected continuously for at least three weeks after the peak clam-dissemination periods (unless a non-oxidizing biocide is used).

The pyrophosphate, zinc sulfate, and copolymer will be injected into the raw water systems using flow controllers located in the intake pumping station. The BCDMH will also be injected at the intake pumping station. The primary point of chemical injection for Copper-Trol™ and Clam-Trol™ will be the intake pumping station; however, other locations may be used under special circumstances.

The NRC 1978 FES-OL stated that the applicant planned to use potassium chromate for corrosion inhibition in the closed-component cooling-water system; however, as a result of advances in corrosion inhibition, WBN Plant now will use tolytriazole and sodium molybdate for corrosion and pH control. The system remains closed, and no releases to the environment are planned.

Plant components may still be chemically cleaned prior to initial startup and during plant operation to remove corrosion-product buildup. Chemicals to be used during metal cleaning include trisodium phosphate, ethylene diamine tetra acetic (EDTA) acid, hydrochloric acid, and hydrazine. In addition, during startup, hydrazine and ammonia will be used for oxygen scavenging and corrosion inhibition, respectively, in the oil-fired boilers.

Sanitary waste from WBN is treated onsite in an extended aeration plant with four separate units, having a combined treatment capacity of 454 cubic meters (120,000 gallons) per day. The treated effluent is routed to the runoff holding pond before being discharged to the river in accordance with the NPDES permit.

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(1) ™Trademark of Betz Laboratories, Inc., Trevoise, Pennsylvania.

The plant grounds drain into a yard holding pond, which is equipped with skimming capability for removal of debris and oil.

The applicant is removing transformers containing PCB from the site or retrofilling them with mineral oil or silicon fluid. Modifications of the transformers located outside of the plant have been completed. The entire retrofill project is anticipated to be complete by late 1994, at which time there will be no more transformers containing PCBs on site.

Nonradioactive and nonhazardous solid wastes are disposed of in State-approved sanitary landfills or in onsite approved landfills, depending on the waste and type. This includes construction debris and office waste. Hazardous wastes are disposed of or treated at offsite State- or Environmental Protection Agency (EPA)-approved treatment/disposal facilities. Most of the pipe insulation that contained asbestos has been, or will be, removed from the site and replaced with asbestos-free insulation.

3.5 Power Transmission System

No changes have been made to the applicant's proposed operation of the power transmission system as described in the NRC 1978 FES. The Watts Bar-Volunteer transmission line that was described in the NRC 1978 FES-OL was placed into service on July 19, 1981.

The operational maintenance of the transmission line system involves periodic manual and chemical removal of trees and shrubs that threaten line integrity along with preventing erosion through periodic inspections and mitigation. The applicant also manages rights-of-way near waterways and wetlands with special provisions to maintain trees and vegetation cover, both to control erosion and to provide wildlife habitat. The maintenance plan is described by the applicant (TVA 1976, 1992, 1994d).

3.6 References

10 CFR Part 20. 1994. "Standards for Protection Against Radiation." U.S. Nuclear Regulatory Commission, Washington, D.C.

10 CFR Part 50. 1994. "Domestic Licensing of Production and Utilization Facilities." U.S. Nuclear Regulatory Commission, Washington, D.C.

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U.S. Nuclear Regulatory Commission (NRC). 1978. *Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant, Units Nos. 1 and 2*. NUREG-0498. December 1978. Docket Nos. 50-390 and 50-391. U.S. Nuclear Regulatory Commission, Washington, D.C.

4 Environmental Effects of Site Preparation and Plant and Transmission Facilities Construction

The conclusions related to environmental effects of WBN Site preparation and WBN Plant and Transmission facilities construction as given in the NRC 1978 FES-OL (NRC 1978) have not changed. WBN Site preparation and facility construction for Unit 1 has been completed, and no additional impacts are expected. Additional construction of transmission lines is not expected (TVA 1994). Impacts are not expected for facility construction of Unit 2 that are not previously discussed in the NRC 1978 FES-OL.

4.1 References

Tennessee Valley Authority (TVA). 1994. Letter from D. E. Nunn to U.S. NRC. August 5, 1994. Subject: Watts Bar Nuclear Plant (WBN) Units 1 and 2 - Request for Additional Information Relating to Final Environmental Statement.

U.S. Nuclear Regulatory Commission (NRC). 1978. *Final Environmental Statement Related to Operation of Watts Bar Nuclear Plant Units Nos. 1 and 2*. NUREG-0498. Docket Nos. 50-390 and 50-391.

5 Environmental Impact of Watts Bar Nuclear Plant and Transmission Facilities Operations

This chapter discusses the effects on the environment of changes in WBN Plant design and proposed plant operating practices since preparation of the NRC 1978 FES-OL. It also discusses the effects of observed changes in the environment. Sections 5.1 and 5.2 discuss potential changes in impact on land and water use, respectively. Sections 5.3 and 5.4 discuss changes in impact on the terrestrial and aquatic environment, respectively. Changes in radiological and non-radiological health impacts are discussed in Sections 5.5 and 5.6. Section 5.7 discusses changes in socioeconomic impacts. Section 5.8 discusses Environmental Justice.

5.1 Impacts on Land Use

The NRC 1978 FES-OL noted that anticipated land use during operation of the WBN Site will not differ from the present land use, either at the plant or along the transmission lines. The plant and the transmission lines were built as planned, and there are no impacts on land use that were not identified in the NRC's previous analyses. The area around the WBN Site will be maintained as a controlled-access area, which will enhance its function as a wildlife habitat. The staff has concluded that the WBN Site and transmission lines will not adversely effect wetlands identified by the applicant (TVA 1994a).

The applicant's management plan (TVA 1992a) for transmission rights-of-way accommodates existing land uses along the various rights-of-way. Transmission lines crossing privately held lands are managed in accordance with the policies and requests of the land owners. Managing vegetation within the rights-of-way involves clearing, hand-cutting, and applying herbicides, as appropriate to the area and as required by the individual land owners (TVA 1994b). Raptors are not discouraged from utilizing the transmission lines or towers as roosts or nesting sites.

The applicant has made gates, locks, and/or cables available to land owners along the rights-of-way to control off-road vehicular traffic. The staff, by aerial overflight, has examined the rights-of-way and concluded that they are adequately maintained with little or no erosion along the access roads. Erosion is heaviest within portions of the rights-of-way that are privately owned, because of off-road vehicular traffic. The applicant's management plan for maintaining rights-of-ways uses recognized best management practices for the control of vegetation and erosion (TVA 1992a). Right-of-ways near waterways and wetlands are managed with special procedures for maintaining the trees and vegetative cover both to control erosion and to provide wildlife habitat (TVA 1992a).

5.2 Impacts on Water Use

This section describes and evaluates the impacts of design and operation of the WBN Plant on water use, including impacts from thermal discharges, operational chemical wastes, and sanitary wastes. A discussion of the State of Tennessee regulations (State of Tennessee 1993) on discharges into the Tennessee River, including heat, chemicals and other wastes is also included.

5.2.1 Thermal Discharges

The 1993 NPDES permit (State of Tennessee 1993) issued to the applicant by the State of Tennessee specifies limits for the WBN Plant thermal effluent that may be discharged by the WBN Plant into the Tennessee River. The permit also defines instream monitoring and reporting requirements necessary for compliance with the effluent limitations.

In accordance with a previous NPDES permit, the applicant was required to conduct a study to determine an appropriate daily average temperature limit for discharges from Outfall 101 and Outfall 102. This was completed and a report was submitted to the State of Tennessee in December 1993 (TVA 1993a). The report proposed an upper temperature limit of 35°C (95°F) for the diffusers. It also proposed an upper temperature limit for emergency overflows from Outfall 102 of 40°C (104°F). These discharge limits were subsequently incorporated into the WBN NPDES permit (State of Tennessee 1993).

The changes in the thermal discharge limits (adding the new upper temperature limit for the diffuser and emergency outfall discharges) does not result in a change in the environmental impact previously described in the NRC 1978 FES-OL.

5.2.2 Operational Chemical Wastes

Section 3.4 describes the changes and additions that have been made in the chemicals to be discharged from the WBN Plant. Table 3.1 lists the chemicals to be released (TVA 1994a). The concentrations of the chemicals that are released from the facility will be reduced after mixing with the river.

The WBN NPDES permit controls the chemical waste discharges to the Tennessee River. The NPDES permit limits are levels that have been shown to have no deleterious effect on aquatic biota based on sensitivity testing as discussed in Section 5.4. The NPDES permit requires that the applicant conduct a confirmatory biomonitoring study of the discharges (see Section 6.2.4).

The staff concludes that the changes in plant design and operation relating to the chemical discharges do not result in a change in the environmental impact previously described in the NRC 1978 FES-OL.

5.2.3 Sanitary Wastes

The sanitary waste system for the WBN Plant is discussed in Section 3.4 of this report. The sanitary waste will be treated in an onsite extended aeration plant. Effluent is routed to the runoff holding pond and discharged to the Tennessee River. The discharges will be controlled and monitored in accordance with the NPDES permit. The staff's review of the sanitary waste system indicates that there is no change from the conclusions reached in the NRC 1978 FES-OL.

5.2.4 NPDES Permit

The EPA has developed regulations and procedures to implement the provisions in the Clean Water Act that apply to aquatic and water quality aspects of nuclear steam electric generating stations. The Clean Water Act procedures regulate the major features of the NRC-licensed projects that affect the aquatic environment. The NRC Atomic Safety and Licensing Appeal Board held in Yellow Creek (8 NRC 702 [1978]) that the NRC does not have the authority to include any non-radiological license conditions for the protection of the aquatic environment, because the Clean Water Act places full responsibility for such matters with the EPA (in Tennessee, this authority is exercised by the State). Effluent limitations, water quality monitoring and determination of the best available technology for intake structures are developed by the EPA (or in this case the State of Tennessee Division of Water Pollution Control) through the NPDES permit issued for each facility.

The NPDES permit must be renewed every five years. This permit authorizes the discharge of process wastewater associated with the generation of electric power by thermonuclear fission and associated operations, steam generator blowdown, cooling tower blowdown, sanitary wastewater, intake screen and strainer backwash, miscellaneous flows, and storm water runoff from specific outfalls. The most recent permit for the WBN Plant, Units 1 and 2 was issued on September 30, 1993, by the State of Tennessee, Division of Water Pollution Control (State of Tennessee 1993). The permit became effective on December 1, 1993, and expires on September 29, 1998.

5.2.5 Effects on Water Users through Changes in Water Quality

In the NRC 1978 FES-OL the staff concluded that changes in water quality caused by the WBN Plant are unlikely to preclude any of the current or projected uses of the Tennessee River. The conclusion has not changed, despite proposed changes in the discharges discussed in Sections 5.2.1 through 5.2.4 above.

5.2.6 Effects on Surface Water Supply

The applicant's planned water use from the Tennessee River has not changed from that discussed in the NRC 1978 FES-OL. The Chickamauga Reservoir is a multipurpose reservoir operated in accordance with established rules for purposes of navigation, flood control, and hydroelectric power generation. Because the maximum station water usage from the Tennessee River is 0.7% of the mean river flow past the plant, water use at the WBN Plant is unlikely to have a measurable impact on the stream flow through, or the pool elevation of the Chickamauga Reservoir as it is operated. This is consistent with the staff's conclusion in the NRC 1978 FES-OL.

5.2.7 Effects on Groundwater

Groundwater consumption by the WBN Plant is discussed in Section 3.1. The design and operation of the WBN Plant is unlikely to have a measurable impact on the ground water supply. This is consistent with the staff's conclusion in the NRC 1978 FES-OL.

5.2.8 River Recreational Use

The NRC 1978 FES-OL did not address river recreational uses. Recreation near the WBN Plant consists primarily of bank and boat fishing on the Tennessee River. Fishing berms have been developed on both the right and left banks of the river below the Watts Bar Dam (upstream from the WBN Site). A TVA boat ramp on the left bank below the dam (approximately TRM 528) provides access for tailwater boat fishing. Recreational use patterns below Watts Bar Dam are similar to those that occur at other TVA mainstream dams.

Primary impacts on river recreational use near the WBN Site are associated with the operation of the Watts Bar Dam. Power production and flood control practices such as drawdowns can cause inconveniences to boaters and fishermen. By contrast, influences on river recreational use from operation of the WBN Plant will have minimal effect. The staff concludes that operation of the WBN Plant is unlikely to have an adverse impact on recreational use (TVA 1994c).

5.3 Impact on Terrestrial Environment

The impact on the terrestrial environment is discussed in three separate sections: impacts on terrestrial animal species, impacts on plant species, and impacts on endangered species.

5.3.1 Impacts on Terrestrial Animal Species

Impacts to animal species due to operation and maintenance of the WBN Plant and transmission lines could result from habitat changes resulting from maintenance of transmission line corridors, effects of electromagnetic fields (EMF), collisions with transmission lines or cooling towers, and noise from plant operations.

The applicant's transmission line maintenance procedures (TVA 1992a) will ensure that no significant long-term impacts on terrestrial animal species will occur due to maintenance of the transmission line corridors (TVA 1994b).

Numerous studies referenced in NUREG-1437 (NRC 1991) have failed to show significant EMF effects on birds or other animals. Also, since the transmission lines were constructed in the late 1970s, no unusual occurrences of bird collisions with transmission facilities or with WBN Plant structures have been reported. Therefore, these features are unlikely to significantly affect local bird populations.

Expected maximum noise levels from operation of the plant were estimated by the applicant to range between 53 and 63 decibels with intermittent sound levels ranging from 84 to 101 decibels (A-weighted scale) - (TVA 1980). Raptors, including bald eagles and peregrine falcons (*Falco peregrinus*), exposed to noise levels in this range may exhibit alarm response, but numerous observations have identified no adverse effects on foraging, nesting success, or reproduction (FWS 1988).

The staff concludes that activities associated with WBN Plant operations are not likely to result in significant long-term impacts on terrestrial animal species in the surrounding area and this conclusion is consistent with that reached in the NRC 1978 FES-OL.

5.3.2 Impacts on Terrestrial Plant Species

Mechanical clearing and herbicides will be used in accordance with the applicant's management procedures (TVA 1992a) to maintain the transmission line rights-of-way. The impact on terrestrial plant species is expected to be minimal.

The staff concludes, based on the review of the applicant's (TVA 1980) and the staff's site visit in September 1994, that the applicant's program for forage seeding has effectively controlled erosion in the transmission line corridors.

The NRC 1978 FES-OL identified, as a potential environmental concern, the acid mist formed by the mergence of moist air from the Watts Bar cooling towers and combustion gases from the Watts Bar Steam Plant stacks as a potential environmental concern. Based on the applicant's analysis (TVA 1980) and NRC (1991), the staff concludes that the mergence of the WBN Plant cooling tower and Watts Bar Steam Plant plumes will have negligible impact on terrestrial vegetation near the WBN Site.

5.3.3 Impacts on Threatened and Endangered Terrestrial Species

Two species listed as endangered under the Federal ESA by the FWS (Southern bald eagle and the gray bat) and several additional species listed as threatened or endangered by the State of Tennessee Department of Environment and Conservation (as discussed in Section 2.4.1) use the area in the vicinity of WBN Plant and its associated transmission line corridors.

The raptor species listed by the State of Tennessee will likely nest outside the transmission line corridors in larger trees. The grasshopper sparrow will nest in low-growing herbaceous vegetation. The removal of trees and shrubs beneath the power lines is unlikely to have an impact on the nesting activities of any of the above avian species (listed in Table 2.7).

Eight species of plants that are listed by the State of Tennessee as threatened or endangered (including four Federal Candidates) are known to occur within at least 0.8 kilometers (0.5 mile) of the transmission line corridors (Table 2.7). Of these, the tall larkspur, the goldenrod, and the auriculate false foxglove occur in naturally barren areas and prairie habitats, and could exist in the open, cleared habitats found in transmission line corridors. The other five plant species occur in forest habitats and are unlikely to be affected by maintenance and operation of the transmission lines. To date, none of these species are known to occur in the WBN Plant transmission line corridors.

Maintenance activities along transmission corridors associated with the WBN Plant are conducted according to the applicant's procedures. Transmission line segments are reviewed for the presence of Federally protected or candidate species or State-listed species before the work is performed.

A Biological Assessment was submitted, separately by the staff (NRC 1994) and the applicant to the FWS. The Biological Assessment evaluated the potential for plant operation to adversely impact Federally listed endangered or threatened species as discussed in Section 1.2. The staff and the applicant concluded that no radioactive, thermal, or chemical discharge would adversely affect any of the Federally-protected terrestrial species.

5.4 Impacts on Aquatic Environment

The NRC 1978 FES-OL indicated that there were no expected deleterious effects on aquatic biota due to plant operation. Changes since the 1978 publication were discussed in Sections 2.4.2 and 3.4 and their implications are discussed below, along with a current statement of potential aquatic environmental impacts. The potential for impact to aquatic communities from various aspects of the operation of the WBN Plant include entrainment and impingement of aquatic biota, thermal effects and chemical effects. The effect of the operation of the WBN Plant on endangered and threatened species as well as on nuisance species is discussed separately below.

5.4.1 Entrainment and Impingement of Aquatic Biota

The NRC 1978 FES-OL concluded that losses to phytoplankton and zooplankton communities from entrainment in the intake cooling water to be inconsequential. High concentrations of these organisms are found in the Watts Bar Dam forebay and this major source of input would not readily be depleted by plant operations. Nothing has changed to alter this conclusion.

Nothing has changed to alter the conclusion in NRC 1978 FES-OL that the entrainment of larval fish will not result in a significant impact. Larval fish entrainment is expected to occur in approximately the same proportions as that of plankton (TVA 1994c). The staff concluded in the NRC 1978 FES-OL, based on preliminary findings, that the tailwater reach between the WBN Plant and the dam was not a significant spawning area for sauger, thereby decreasing any possibility for larval entrainment at the WBN Plant. This conclusion has been substantiated by additional studies (TVA 1991) designed to locate spawning sites for tailrace-spawning fish species in the WBN Site vicinity, as discussed in Section 2.4.2.

The staff's conclusion that fish impingement will be minimal due to the low intake velocity, 0.12 meters per second (0.4 feet per second) maximum near intake openings, and limited make-up water required by the closed-system cooling system (maximum of 0.7% of the average river flow) has not changed (NRC 1978; TVA 1994a).

5.4.2 Thermal Effects

The thermal characteristics of the discharge have not changed since the NRC 1978 FES-OL. As discussed in Section 5.2.1, specific effluent limitations for thermal effluents discharged by the WBN Plant into the Tennessee River are defined and regulated by the NPDES permit.

5.4.3 Chemical Effects

Section 3.4 describes the changes in the chemical effluents resulting from the raw water treatment program. This program has been revised since the NRC 1978 FES-OL to include the corrosion inhibitors pyrophosphate; zinc sulfate; butyl benzotriazole (Copper-Trol™), a copolymer dispersant; and the biocides/molluscicides BCDMH and Clam-Trol™ (CT-1) (TVA 1992b). A review of the WBN Plant's current chemistry manuals and product fact sheets indicates that the WBN Plant's chemical additions to the raw water system are well below concentrations that cause toxic effects in standard aquatic test organisms such as rainbow trout (*Oncorhynchus mykiss.*), bluegill (*Lepomis macrochirus*), sheepshead minnow (*Cyprinodon variegatus*), fathead minnow (*Pimephales promelas*), daphnids (*Daphnia magna* and *Ceriodaphnia* sp.), grass shrimp (*Paleomonetes pugio*), and American oyster (*Crassostrea virginica)* (Betz Industrial 1993, TVA 1993b, TVA 1994d, TVA 1994e, TVA 1994f).

Although no heavy metals were originally to be added to the plant discharge, zinc sulfate is now being used to reduce corrosion rates of carbon steel piping and components (TVA 1992b). It is added continuously to the raw water system and is subject to the NPDES permit requirements. A year-long study involving monthly effluent toxicity tests confirms that the discharge of zinc and other corrosion inhibitors, in concentrations used at WBN Plant, do not result in toxic effects to aquatic biota (TVA 1992c, 1992d, 1992e, 1993c, 1993d, 1993e, 1993f, 1993g, 1993h, 1993i, 1993j, 1993k). The applicant has committed to taking corrective action if toxic effects are observed as a result of zinc sulfate use, including reevaluation and subsequent alteration of the plant's corrosion-inhibiting methods if proven necessary (TVA 1994a).

To determine safe discharge limits for the molluscicide Clam-Trol™, a series of monthly static renewal tests using fathead minnows and daphnids (*Ceriodaphnia dubia*) was conducted by the applicant over a 12-month period when chemicals were being used at the plant. These tests did not identify any toxicity in undiluted Outfall 101 effluent based on responses of either species. Both are standard NPDES toxicity biomonitoring organisms (NRC 1994; TVA 1994a).

In addition, two studies evaluating the potential impact of the WBN Plant chemical use by the applicant on a representative freshwater mussel, the paper pondshell (*Anodonta imbecilis*), were conducted to compare the sensitivity of juvenile mussels with standard NPDES toxicity-testing organisms.

The first study (Hudson and Barton 1994) was conducted using daphnids and 8 to 10-day-old juvenile paper pondshell mussels. A study was conducted of the organisms' toxic response to chemicals added to Outfall 101 effluent. The chemicals used in the study are those intended to be used by the applicant during plant operation. Daphnid survival during the 48-hour exposure was reduced in treatments containing the chemicals DGH/Quat, active ingredients in a molluscicide (Clam-Trol™ CT-1), currently used at the WBN Plant to control Asiatic clams. No toxic effects were observed in juvenile mussels for any treatment during 9-day tests. A repeat study using DGH/Quat added to the WBN Plant effluent also showed toxicity to daphnids but not to mussels (TVA 1994a).

The second study (EMPE 1994) tested daphnids, fathead minnows, the paper pondshell, another freshwater mussel (*Elliptio arctata*), and a rotifer (*Brachionus calyciflorus*). In this test, these non-target organisms were exposed to effluent with DGH/Quat. The results of this study were similar to those of the first study as daphnids were again the most sensitive species. The most sensitive mussel in this experiment, the paper pondshell, was 15 times less sensitive to the molluscicide than the daphnid when silt was included in the test (silt occurs naturally in the river and is a detoxifying agent for DGH/Quat) (TVA 1994a).

All chemical discharge from the WBN Site is strictly regulated by the NPDES permit. The levels permitted under these regulations are expected to protect aquatic species. Specifically, the NPDES permit prohibits discharges through the diffuser unless water releases from the applicant's upstream Watts Bar Dam exceed 98 cubic meters per second (3,500 cubic feet per second) (see Section 3.2). This system of discharge provides an added means to ensure the protection of aquatic species found near the diffuser.

Toxicity studies, along with current monitoring practices, indicate that undiluted effluent from the WBN Site will not affect mussel species residing in the diffuser mixing zone. Combining this with the detoxifying effects of silt in the river and the large dilution that occurs as discharge mixes with river water results in an increased safety margin, not only for mussel species but fish and other aquatic life as well. Although the sensitivity of endangered and threatened species in the WBN Site reach have not been compared specifically to the sensitivity of daphnids, the existence of an order of magnitude difference in sensitivity of the daphnids compared with the fish and mussel species tested indicates that the whole effluent testing required by the NPDES permit at the WBN Plant (using daphnids as a test organism) should ensure that no impact to aquatic species near or downstream from the WBN Plant discharges will occur (NRC 1994). The applicant has committed to employing a different clam-control method following appropriate effects-testing if ongoing biomonitoring indicates adverse effects on the aquatic life (TVA 1994a).

The staff concludes that the impact to aquatic life from discharges from the WBN Site will be minimal. This conclusion is consistent with that reached in the NRC 1978 FES-OL.

5.4.4 Impacts on Threatened and Endangered Aquatic Species

A Biological Assessment was submitted separately by the staff (NRC 1994) and the applicant to the FWS. The Biological Assessment evaluated the potential for plant operation to adversely impact Federally listed endangered or threatened species, as discussed in Section 1.2. Both the staff and the applicant concluded that no radioactive, thermal, or chemical discharge would adversely affect any of the Federally protected aquatic species. Additionally, threatened/endangered mussel species are further protected by the establishment of the mussel sanctuary.

5.4.5 Nuisance Aquatic Organisms

Potential nuisance aquatic organisms found in the vicinity of the WBN Plant include various aquatic macrophytes, blue-green algae, and molluscs (see Section 2.4.2). The potential for increase in population size of nuisance organisms as a result of plant operation is minimal (TVA 1994g).

As indicated in Section 2.4.2, the WBN Plant is located in the riverine tailwater area of Chickamauga Reservoir where relatively shallow overbank habitat that is suitable for macrophyte growth is rare. Macrophyte levels near the plant have never reached nuisance levels. The Sequoyah Nuclear (SQN) Plant, located in the Chickamauga Reservoir 72 kilometers (45 miles) downstream from the WBN Plant, is in an area of more suitable aquatic macrophyte habitat than exists near the WBN Plant. However, a study (TVA 1993i) failed to show any correlation between operation of the SQN Plant and growth patterns of aquatic macrophytes in Chickamauga Reservoir. Thus, there does not appear to be any basis for expecting WBN Plant operation to affect macrophyte growth in Chickamauga Reservoir (TVA 1994g).

Conditions conducive to the development of nuisance "blooms" of blue-green algae in lakes and reservoirs can be caused by increased temperatures and/or levels of fertility. As indicated in Section 2.4.2, blue-green algae are rarely a major component of the phytoplankton population at the WBN Site. The nutrient and waste heat levels in the WBN Plant discharge are minimal and will not encourage the growth of blue-green algae. Operational monitoring at SQN Plant, where greater amounts of waste heat are discharged into the water, has not shown significant changes. Thus, there is no reason for concluding that increases in the abundance of blue-green algae will occur as a result of the WBN Plant operation (TVA 1994g).

The Asiatic clam occurs throughout Chickamauga Reservoir. Certain water users, including the applicant, have implemented control measures to prevent biofouling by this clam. Another species, the zebra mussel, has recently been introduced into the Tennessee River and is expected to become a greater biofouling threat than the Asiatic clam, as discussed in Section 2.4.2. No features of plant operation are known to increase the growth or reproduction of either population. Thus, increases in these organisms as a result of plant operation are not expected (TVA 1994g).

The staff concludes that the growth of nuisance aquatic organisms will not be significantly increased by operation of the WBN Plant.

5.5 Radiological Impacts

The NRC 1978 FES-OL contained an evaluation of the radiological impacts projected for 30-years of plant operation. Some of the technical bases for the NRC 1978 FES-OL evaluation have changed. Consequently, the staff has reviewed the changes to the environment, proposed operating procedures, and the WBN FSAR (TVA 1994h) to support the conclusions in this section.

Nuclear power reactors in the United States must comply with the regulatory requirements of 10 CFR Part 20, "Standards for Protection Against Radiation." These regulations provide limits on levels of radiation and limits on concentrations of radionuclides in a facility's effluent releases to the air and water (above natural background). License requirements on effluents from nuclear power reactors are specified in 10 CFR 50.36a. Technical specifications are prepared by the applicant to assure that releases of radioactive materials to unrestricted areas during normal operations, including expected operational occurrences, are maintained as low as is reasonably achievable (ALARA). Appendix I to 10 CFR Part 50 provides numerical guidance on dose-design objectives for light-water reactors (LWRs) to meet the ALARA requirement. Applicants must provide reasonable assurance that the following calculated dose-design objectives will be met for each reactor unit in unrestricted areas: 1 picosievert per second (3 millirem per year) to the total body or 3 picosieverts per second (10 millirems per year) to any organ from all pathways of exposure from liquid effluents; 3 picograys per second (10 millirads per year) gamma radiation or 6 picograys per second (20 millirads per year) beta radiation air dose from gaseous effluents near ground level and/or 1.5 picosieverts per second (5 millirems per year) to the total body or 5 picosieverts per second (15 millirems per year) to the skin from gaseous effluents; and 6 picograys per second (15 millirems per year) to any organ from all pathways of exposure from airborne effluents that include the radioiodines, carbon-14, tritium, and the particulates (see Table 5.1).

5.5.1 Changes to the Plant

Changes have been made in the WBN Plant liquid and solid radioactive waste systems but not in the gaseous radwaste systems since the NRC 1978 FES-OL was issued (see Section 3.3). The change in the liquid radioactive waste system design (i.e., the applicant is no longer using evaporators) increases the applicant's postulated liquid release for both units. As a result, the applicant will provide an analysis showing either (1) the annual releases will be less than 0.37 terabecquerels (10 curies) (excluding tritium) or (2) that no cost-beneficial dose reduction measures are available.

In the NRC 1978 FES-OL, it was recognized that specific radioactive waste treatment systems and waste storage and handling systems would be modified or supplemented to take advantage of technological improvements and evolving regulatory requirements. Design of the WBN radioactive waste systems has evolved to reflect the operating experience of the applicant and the nuclear industry.

5.5.2 Summary of Radioactive Effluents and Potential Exposures of Humans

Exposure Pathways

The exposure pathways used in the NRC 1978 FES-OL were more inclusive than those determined to be important in the most recent pathway analysis, in Chapter 11 of the WBN FSAR (TVA 1994h). The Tennessee River is not used for irrigation nor are invertebrates harvested for consumption; consequently, the related pathways are no longer used in the dose calculations. The WBN FSAR (TVA 1994h) analysis also does not consider any dose received from swimming in or boating on the Tennessee River because these doses have been found at SQN Plant to be several orders of magnitude lower than the dose received from shoreline recreation (TVA 1994a). Essentially all of the dose to individuals or the population surrounding the plant is accounted for by direct radiation or inhalation of radionuclides present in atmospheric releases and ingestion of fish and water containing radionuclides from liquid releases. The staff concludes that changes in the exposure pathway analysis do not result in a measurable change in the environmental impact previously described.

Dose Commitments from Radioactive Releases to the Atmosphere

There have been no substantial changes in the described design or planned operation of the gaseous radioactive waste treatment system from those presented in the NRC 1978 FES-OL. Radiation dose commitments to individuals and to the public from routine atmospheric releases from the WBN Plant have been reviewed and recalculated because the NRC analytical models have been revised. The new assessments are summarized in the next two sections.

Table 5.1 Summary of Staff Position - Methods of Evaluating Compliance with Appendix I (adapted from Regulatory Guide 1.109) (NRC 1977)

Type of Dose	Appendix I[a] Design Objectives	RM-50-2 Design Objectives[a]	Point of Dose Evaluation
Liquid Effluents			
Dose to total body from all pathways	1 picosievert/sec per unit (3 millirem/yr per unit)	2 picosievert/sec per site (5 millirem/yr per site)	Location of the highest dose offsite[b]
Dose to any organ from all pathways	3 picosievert/sec per unit (10 millirem/yr per unit)	2 picosievert/sec per site (5 millirem/yr per site)	Location of the highest dose offsite[b]
Non-tritium releases	------	6 kilobecquerels/sec per unit (5 Ci/yr per unit)	------
Gaseous Effluents[c]			
Gamma dose in air	3 picogray/sec per unit (10 millirad/yr per unit)	3 picogray/sec per site (10 millirad/yr per site)	Location of the highest dose offsite[d]
Beta dose in air	6 picogray/sec per unit (20 millirad/yr per unit)	6 picogray/sec per site (20 millirad/yr per site)	Location of the highest dose offsite[d]
Dose to total body of an individual	1.5 picosievert/sec per unit (5 millirem/yr per unit)	1.5 picosievert/sec per site (5 millirem/yr per site)	Location of the highest dose offsite[b]
Dose to skin of an individual	5 picosievert/sec per unit (15 millirem/yr per unit)	5 picosievert/sec per site (15 millirem/yr per site)	Location of the highest dose offsite[b]
Radioiodines and Particulates[e] Released to the Atmosphere			
Dose to any organ from all pathways	5 picosievert/sec per unit (15 millirem/yr per unit)	5 picosievert/sec per site (15 millirem/yr per site)	Location of the highest dose offsite[f]
I-131 releases	------	1.2 kilobecquerels/sec per unit (1 Ci/yr per unit)	------

(a) Evaluated for a maximum individual, as described in Section B of Regulatory Guide 1.109.
(b) Evaluated at a location that is anticipated to be occupied during plant lifetime or evaluated with respect to such potential land and water usage and food pathways as could actually exist during the term of plant operation.
(c) Calculated only for noble gases.
(d) Evaluated at a location that could be occupied during the term of plant operation.
(e) Doses due to carbon-14 and tritium intake from terrestrial food chains are included in this category.
(f) Evaluated at a location where an exposure pathway and dose receptor actually exist at the time of licensing. However, if the applicant determines design objectives with respect to radioactive iodine on the basis of existing conditions and if potential changes in land and water usage and food pathways could result in exposures in excess of the guideline values given above, the applicant should provide reasonable assurance that a monitoring and surveillance program will be performed to determine: (1) the quantities of radioactive iodine actually released to the atmosphere and deposited relative to those estimated in the determination of design objectives; (2) whether changes in land and water usage and food pathways which would result in individual exposures greater than originally estimated have occurred; and (3) the content of radioactive iodine in foods involved in the changes, if and when they occur.

Radiation Dose Commitments to Individuals from Airborne Releases

Table 5.2 compares the estimated annual airborne releases and resulting doses as reanalyzed by the NRC staff and as presented in the WBN FSAR (TVA 1994h), the NRC 1978 FES-OL, and the 1987-1993 average from the SQN Plant's Semi-Annual Radioactive Effluent Reports (TVA 1994a). The current NRC release estimates are different from the earlier NRC estimates because of changes in the analytical models. The design and operation of the WBN, including that of the radioactive waste system, is modeled after the applicant's SQN Plant. Consequently, the type and quantity of radionuclides generated from SQN and WBN Plant operations are expected to be similar. Therefore, the actual SQN Plant airborne release data are relevant for comparison to the expected WBN airborne effluents.

The staff concludes that the WBN Plant is capable of being operated within the 10 CFR Part 50, Appendix I criteria under the NRC-specified conditions, and actual releases and doses are expected to be lower than the criteria.

Radiation Dose Commitments to Populations from Airborne Releases

The NRC 1978 FES-OL estimated the population within 80 kilometers (50 miles) of the WBN Plant for the year 2000 as 1,050,000. The WBN FSAR (TVA 1994h) estimate for the year 2040 is 1,100,000. Hence, the expected 80-kilometer (50-mile) population at the planned expiration of the operating license is not significantly different from that used in the NRC 1978 FES-OL. The estimated annual population doses from the WBN Plant FSAR, the NRC 1978 FES-OL, and recent data from the SQN Plant's Semi-Annual Radioactive Effluent Reports are 180 person-millisieverts (18 person-rem), < 50 person-millisieverts (< 5 person-rem), and < 10 person-millisieverts (< 1 person-rem), respectively. These annual population doses are less than 0.002% of the annual doses from natural radiation sources.

Table 5.2 Comparisons of Annual Airborne Releases and Doses for WBN Plant Two-Unit Operation

	NRC Current Assessment	WBN FSAR (Tables 11.3-9 and 11.3-13)	NRC 1978 FES-OL (Tables 3.4 and 5.9)	SQN Plant (1987-1993 Average)	10 CFR Part 50 Appendix I Guidelines
Noble gas releases	440 TBq (12,000 Ci)	520 TBq (14,000 Ci)	250 TBq (6,800 Ci)	31 TBq (840 Ci)	N/A
Total body dose	0.02 millisievert (2 millirem)	0.05 millisievert (4.8 millirem)	0.01 millisievert (1 millirem)	0.001 millisievert (0.13 millirem)	0.1 millisievert (10 millirem)
Organ dose	0.07 millisievert (7 millirem)	0.22 millisievert (22 millirem)	0.04 millisievert (3.9 millirem)	0.0002 millisievert (0.02 millirem)	0.3 millisievert (30 millirem)

Dose Commitments from Radioactive Liquid Releases to the Hydrosphere

The WBN Plant systems for the control of liquid effluents have changed since the NRC 1978 FES-OL. Although these changes increase the estimated releases and potential doses, analyses by the applicant show that the plant can be operated within the guidelines of 10 CFR Part 50, Appendix I.

The radiation dose commitments to individuals and to the public from postulated routine liquid releases are summarized in the following two sections.

Radiation Dose Commitments to Individuals from Liquid Releases

Table 5.3 compares the estimated annual liquid releases and resulting doses as presented in the WBN FSAR (TVA 1994h), the NRC 1978 FES-OL, and the 1987-1993 average from the SQN Plant's Semi-Annual Radioactive Effluent Reports. The design and operation of the WBN, including that of the radioactive waste system, is modeled after the applicant's SQN Plant. Consequently, the type and quantity of radionuclides generated from SQN and WBN Plant operations are expected to be similar. Therefore, the actual SQN Plant liquid release data are relevant for comparison to the expected WBN liquid effluents. The 1987 to 1993 period was chosen because this was the period in which the SQN Plant operated as the WBN Plant is expected to operate, that is, demineralizers were used and evaporators were not.

Table 5.3 Comparisons of Annual Liquid Releases and Doses from WBN Plant Two-Unit Operation

	NRC Current Assessment[a]	WBN FSAR (Tables 11.2-7 and 11.2-11)	WBN FES (Tables 3.3 and 5.9)	SQN Plant (1987-1993 Average)	10 CFR Part 50 Appendix I Guidelines
Tritium Releases	TBD	200 TBq (5200 Ci)	380 TBq (10,400 Ci)	32 TBq (870 Ci)	N/A
Other Radionuclide Releases	TBD	0.81 TBq (22 Ci)	0.016 TBq (0.44 Ci)	0.018 TBq (0.48 Ci)	N/A
Total Body Dose	TBD	0.011 millisievert (1.1 millirem)	0.001 millisievert (0.1 millirem)	0.0008 millisievert (0.08 millirem)	0.06 millisievert (6 millirem)
Maximum Organ Dose	TBD	0.015 millisievert (1.5 millirem)	0.0019 millisievert (0.19 millirem)	0.001 millisievert (0.1 millirem)	0.2 millisievert (20 millirem)

(a) To be resolved after the applicant provides an analysis showing either (1) the annual releases will be less than 0.37 terabecquerels (10 curies) (excluding tritium) or (2) that no cost-beneficial dose reduction measures are available.

The staff concludes that (1) the WBN FSAR estimates, even though based on conservative assumptions, meet the dose guidelines given in 10 CFR Part 50, Appendix I; and (2) recent SQN Plant operational data for liquid effluents indicate that actual releases and resulting doses to the public will be a fraction of the 10 CFR Part 50, Appendix I guidelines.

Appendix I to 10 CFR Part 50 limits the dose or dose commitment to a member of the public from radioactive materials in liquid effluents. This limitation is met procedurally through sampling of effluent streams and projecting future doses based on these releases. The applicant's Technical Specifications require that the applicant estimate the potential downstream consequences resulting from liquid effluent releases to the environment at least every 31 days according to the methodology provided in the applicant's ODCM (TVA 1994i). If the results of the calculation performed prior to release indicate that the specified acceptance criteria would be exceeded, appropriate actions will be taken to ensure the release is not executed. The evaluation of potential effects from long-term buildup of radioactive material in liquid effluents was also performed by the applicant using design value releases and buildup in river sediment and in aquatic biota. This total dose estimate for aquatic biota, based on conservative release rates, exposure times, and ingestion rates, was 0.04 millisieverts (4 millirems).

The dose to the maximally exposed member of the public will not exceed the 10 CFR Part 50, Appendix I guidelines and so will be no more than about 1% of the dose from natural sources. The final estimates will be provided in the Final SER for the WBN Plant.

Radiation Dose Commitments to Populations from Liquid Releases

The estimated annual population dose from liquid releases was provided in the WBN FSAR (TVA 1994h). In that analysis, doses from ingestion of water, consumption of fish, and shoreline recreation were estimated for exposures to radionuclides routinely released in liquid effluents. No credit was taken for removal of activity from the water through absorption on solids and sedimentation, by deposition in the biomass, or by processing within water treatment systems. The annual population dose from consumption of fish was calculated using the assumption that all of the edible fish harvested from the Tennessee River, within 80 kilometers (50 miles) downstream of the WBN Plant, is consumed by humans. For comparison, the estimated annual population doses from the WBN FSAR (TVA 1994h), the NRC 1978 FES-OL, and the SQN Plant's Semi-Annual Radioactive Effluent Reports are 36 person-millisieverts (3.6 person-rem), < 40 person-millisieverts (< 4 person-rem), and < 10 person-millisieverts (< 1 person-rem), respectively. These annual population doses are less than 0.001% of the annual dose from natural radiation sources.

Direct Radiation from the Facility

The estimated plant-related direct radiation dose rates used in the NRC 1978 FES-OL analysis remained unchanged. The estimates of the radiation dose in the environment as a result of radioactivity contained within the reactor and its components continue to be less than 2 picosieverts per second (5 millirem per year). This can be contrasted with the natural radiation background dose rate (NCRP 1987) estimated to be 100 picosieverts per second (300 millirem per year) (30 picosieverts per second [100 millirem per year] if radon is excluded).

Occupational Radiation Exposure

For the NRC 1978 FES-OL, the occupational dose was estimated as 5 person-sieverts (500 person-rem) per reactor-year (10 person-sieverts [1000 person-rem] for two reactors). Conditions have changed and the currently expected doses are lower, as discussed below. Most of the dose to nuclear plant workers results from external exposure to radiation coming from radioactive materials outside the body rather than from internal exposure from inhaled or ingested radioactive materials. Experience shows that the dose to nuclear plant workers varies from reactor to reactor and from year to year. For environmental-impact purposes, this dose can be projected by using the experience to date with modern pressurized-water reactors (PWRs). Recently licensed 1000-megajoules per second (1000-megawatt) PWRs are operated in accordance with the post-1975 regulatory requirements and guidance that place increased emphasis on maintaining occupational exposure at nuclear power plants ALARA. These requirements and guidance are outlined primarily in 10 CFR Part 20, Standard Review Plan Chapter 12 (NRC 1981), and Regulatory Guide 8.8, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be as Low as Is Reasonably Achievable."

The applicant's proposed implementation of these requirements and guidelines is reviewed by the staff during the licensing process, and the results of that review are reported in the SER. The license is granted only after the review indicates that an acceptable ALARA program can be implemented. In addition, regular reviews of operating plants are performed by the staff to determine whether the ALARA requirements are being met.

Average collective occupational dose per reactor for 373 PWR-years of operation is available for those plants operating between 1989 and part of 1993. The average annual collective dose at PWRs over this period was 2.5 person-sieverts (245 person-rem), with a range of 0.2 to 32 person-sieverts (18 to 3,200 person-rem) (adapted from NRC 1993). The average annual dose per nuclear-plant worker of about 0.008 sieverts (0.8 rem) has not varied significantly during this period. Where collective doses were large, there was a correspondingly large number of workers. The worker dose annual limit, established by 10 CFR Part 20, is 5 centisieverts (5 rems). The average collective dose per reactor for SQN Plant for this period was 3.9 person-sieverts (387 person-rem). SQN Plant's average dose for this period is high because of steam generator repairs in 1990. The collective dose at SQN Plant has been steadily decreasing since 1990. It is expected that the collective dose over the life of the WBN Plant will be about the same as at other PWRs.

5.5.3 Radiological Impact on Animals

The staff agrees with the conclusions made in the NRC 1978 FES-OL regarding radiological impacts on biota other than man. That is, no significant radiological impact is expected on aquatic or terrestrial biota, including endangered species, as a result of the WBN Plant operations.

5.5.4 Storage and Transportation of Radioactive Material

The NRC 1978 FES-OL provides essentially correct descriptions of both wet and dry waste handling and the forms of waste to be generated at the WBN Plant. However, in lieu of solidification, "wet" solid wastes will be transferred to approved high integrity containers and dewatered prior to shipment offsite. As discussed in Section 3.3, waste evaporators will not be utilized; thus, no evaporator bottoms will be generated at the WBN Plant, and as a result, the characteristics of the waste generated at the WBN Plant will change.

Current information indicates that the NRC 1978 FES-OL was conservative in estimating the amount of waste that the WBN Plant will generate annually. The volume of wet waste assumed in the NRC 1978 FES-OL (480 cubic meters [17,000 cubic feet]) is high compared with that currently produced by the SQN Plant (about 16 cubic meters [580 cubic feet] in calendar year 1993) (TVA 1994a) and the average volume produced by a two-unit PWR plant (about 150 cubic meters [5,000 cubic feet]). This difference in waste volumes is partly a result of industry efforts to reduce the amount of waste generated because of the high disposal costs. Another reason for this difference is that most plants do not operate evaporators (and therefore do not generate evaporator bottoms). The annual volume of wet waste from the WBN Plant is expected to be 150 cubic meters (5,000 cubic feet), which is less than the 480 cubic meters (17,000 cubic feet) estimated in the NRC 1978 FES-OL.

The Chem-Nuclear disposal facility near Barnwell, South Carolina, is currently used by the applicant for the disposal of low-level radwaste from its other facilities. The Barnwell facility is scheduled to close at the end of 1995. Shipments made from the WBN Plant before 1996 will go to the Barnwell facility. The replacement facility for Barnwell will be located in Wake County, North Carolina. Although the original start date for the North Carolina facility was early 1996, the current schedule for that facility calls for it to open sometime after mid-1997. This may require the WBN Plant to store low-level radwaste onsite for more than a year. To accommodate this anticipated delay, the applicant is evaluating the location and cost of an onsite storage facility to handle up to four years of WBN-generated waste.

Based on the annual volume of low-level radwaste generated by SQN Plant, the NRC staff expects that the following volumes of waste will be generated and stored prior to ultimate shipment for disposal (Table 5.4).

Based on SQN Plant experience, shifting from onsite compaction of dry waste to offsite incineration results in less volume of low-level waste for ultimate disposal. However, the volume of waste generated at the WBN Plant will remain the same as without offsite compaction or incineration (see Section 3.3). While the onsite compaction method originally planned for the WBN Plant would be expected to result in a volume reduction factor of 3, incineration of waste can produce a volume reduction factor of about 100 (28 cubic meters [1000 cubic feet] of incinerable waste results in 0.3 cubic meters [10 cubic feet] of ash for disposal). Similarly, offsite super-compaction (at higher compaction pressure) of non-incinerable waste (such as metals) will result in a volume reduction of 5 to 8. Overall, a volume reduction of about 14 has been obtained for the combined dry waste types at the SQN Plant.

Table 5.4 Annual Waste Generation and Storage for WBN Plant Two-Unit Operation

	Volume Generated		Volume to be Stored		
Waste Type	Cubic Meters	(Cubic Feet)	Cubic Meters	(Cubic Feet)	Number of Containers
Ion-exchange Resin/Filters	150	(5000)	150	(5000)	5
Dry Active Waste	570	(20,000)	40	(1,400)	11
Irradiated Components	< 3	(<100)	< 3	(<100)	In fuel pool

Therefore, instead of using onsite compaction, with a waste volume of about 190 cubic meters (6,700 cubic feet) being transported about 720 kilometers (450 miles) to the disposal facility, the original 570 cubic meters (20,000 cubic feet) will be shipped only 80 kilometers (50 miles) from the WBN Site to the waste processor in Oak Ridge, Tennessee. There it will be processed (incinerated and/or compacted) to about 40 cubic meters (1,400 cubic feet), then either transported about 720 kilometers (450 miles) to the disposal facility or returned the 80 kilometers (50 miles) to the WBN Site for storage until a licensed waste disposal site is available. The number in either case is smaller than that estimated in the NRC 1978 FES-OL and does not increase the number of measurable transportation impacts such as increases in traffic accidents. The shipping distance for unprocessed waste is reduced by an order of magnitude and fewer shipments will be required from the processor to the disposal facility (an 80% reduction). This will also reduce the already low levels of radiation exposure to the public during the transportation of the waste for disposal.

As noted above, based on SQN Plant experience, the NRC staff expects the following volumes of waste to be shipped from the WBN Plant on an annual basis once a licensed facility is available (Table 5.5).

If offsite disposal is available, resin/filter waste is planned to be shipped directly to the disposal facility not long after sufficient volume has been accumulated in onsite storage tanks. Dry waste will be sent to the offsite waste processor for volume reduction by incineration, super-compaction, and other methods. Waste processing by an offsite vendor will reduce the waste volume; however, the radionuclide content is expected to remain unchanged. Based on operating experience at the SQN Plant, the NRC staff estimates that the total annual resin activity will be about 80 terabecquerels (2000 curies) and dry waste will contain about 6 terabecquerels (150 curies). Most of the activity will be cobalt-58, chromium-51, iron-55, cobalt-60, niobium-95, nickel-63, zirconium-95, cesium-134, cesium-137, and manganese-54. As noted above, the applicant is evaluating the placement of an onsite storage facility if onsite storage is required.

Table 5.5 Annual Volumes of Waste Shipped for WBN Plant Two-Unit Operation

Waste Type	Volume Shipped Cubic Meters	(Cubic Feet)	Frequency Shipment Per Year
Ion-exchange Resin/Filters	150	(5000)	4 to 6
Dry Active Waste (to offsite processor)	570	(20,000)	< 20[a]
Dry Active Waste (from offsite processor)	40	(1,400)	< 35[b]
Irradiated Components	< 3	(< 100)	< 1[b]

(a) Shipped in 6.6-meter (20-foot) sea-vans at 30 cubic meters (1,040 cubic feet) each. Shipments could decrease by half if 13-meter (40-foot) containers are used.

(b) Shipped by the waste processor with other generators' waste in multi-container shipments averaging 1.2 cubic meters (40 cubic feet) per shipment. If all waste in the shipment were the WBN Plant's, the entire annual volume would require only 1 or 2 shipments.

Ultimately, resin waste from the mobile waste demineralizer will be sent to a licensed disposal facility for disposal. In the interim, the mobile demineralizer will be used to remove radioactive ions from water in the plant using ion-exchange resin and other media. The spent resin will be collected in a storage tank in the Radwaste Packaging area. When sufficient volume of resin is collected, the resin will be sluiced to a high integrity container inside an NRC-licensed shipping cask located in the Railroad Bay. The resin will be dewatered inside these containers to meet disposal site criteria. No other processing of the resin is planned. The two principal sources of ion-exchange resin are the chemical and volume control system and the mobile demineralizer.

The mobile demineralizer will be located in the Radwaste Packaging area. Shielding and distance will be used to reduce the potential for radiation exposure to operators and others who might be in the area. Experience with similar equipment at other nuclear plants has shown that radiation exposure to operators is low and well within that expected from similar plant radwaste management systems. Resin shipping casks will be constructed of steel or steel-lead to provide shielding during packaging of the material and transport to the disposal facility or storage facility. Dose rates will be within Department of Transportation limits, and calculated doses to the public will be a small percentage of natural background. The annual doses to the public will be smaller than those given in the NRC 1978 FES-OL since the volume of waste produced and the number of shipments made will be smaller than previously anticipated.

The NRC 1978 FES-OL assumed that the applicant would ship spent fuel offsite for disposal and that shipments would comply with applicable transportation guidelines issued by NRC and/or the U.S. Department of Transportation. The plans for the WBN Plant spent fuel disposal remain the same. The applicant contemplates storing spent fuel onsite until the U.S. Department of Energy (DOE) completes construction of permanent disposal facilities in accordance with the Nuclear Waste Policy Act of 1982. If necessary, the applicant will provide additional storage capacity onsite until DOE begins accepting spent fuel. There are several methods available for expanding onsite storage capacity including higher density spent fuel storage racks, fuel rod consolidation, and dry storage outside the Auxiliary Building. The applicant will conduct an appropriate environmental review prior to selecting one of these alternatives.

Occupational radiation doses during storage, monitoring, and retrieval of the waste are expected to be a small percentage of the total dose to workers who handle and work around radioactive materials each day. Occupational doses will be minimized by the use of shielding, distance, and reduced stay time around the material.

The estimated doses from the transportation of fuel and waste are unchanged from the NRC 1978 FES-OL. Table S-4 of 10 CFR 51.52 (upon which the impact estimates are based) has been revised but the changes do not alter the conclusion that the impact from transportation is small.

5.5.5 Health Effects of Radiation Doses from Effluents

As discussed in previous paragraphs of Section 5.5, the doses are expected to be small, below the NRC dose criteria. The health effects from these doses will be small, as discussed in the paragraphs below.

The staff used somatic (cancer) and genetic risk estimators that are based on widely accepted scientific information to estimate potential health effects from both occupational radiation exposures and those to offsite populations as a result of the WBN Plant operation. Specifically, the staff's estimates are based on information compiled by the National Academy of Science's Committee on the Biological Effects of Ionizing Radiation, BEIR (BEIR 1990) and Publication 60 of the International Commission on Radiological Protection (ICRP 1991). The estimates of the risks to workers and the general public are based on conservative assumptions (that is, the estimates are probably higher than the actual number). The risk estimators from Table 3 of ICRP 60 were used to estimate health effects from fatal cancers or severe heredity effects per 100 person-sieverts (per million person-rem).

The risk of potentially fatal cancers in the exposed work force population is estimated by multiplying the plant-worker-population dose by the somatic risk estimator (or 4 fatal cancers per 100 person-sievert [400 fatal cancers per million person-rem]). The risk of severe hereditary effects attributable to exposure of the work force is a risk borne by the progeny of the workers, but is considered separately in ICRP 60, with a severe hereditary effect estimate of less than 1 effect per 100 person-sievert (80 effects per million person-rem) (compared to 1.3 effects per 100 person-sievert [130 effects per million person-rem] for the general population. The risk is lower for workers because a smaller fraction of their doses will be received by people young enough to be expected to contribute progeny.

Accurate measurements of radiation and radioactive contaminants can be made with a very high sensitivity so that much smaller amounts of radionuclides can be detected than can be associated with any possible observable health effects. Furthermore, the effects of radiation on living systems have for decades been subject to intensive investigation and consideration by individual scientists as well as by select committees that are constituted to objectively and independently assess radiation dose effects. Although, as in the case of chemical contaminants, there is debate about the exact extent of the effects of very low levels of radiation that result from nuclear power plant effluents, conservative estimates of deleterious effects are well established and amenable to standard methods of risk analysis. Thus, the risks to the maximally exposed member of the public or to the total population outside the boundaries can be estimated. These fatal cancer and severe hereditary effect risk estimates are provided in Table 5.6.

The risk to the maximally exposed member of the public is estimated by multiplying the fatal cancer risk estimator 5 per 100 person-sieverts (500 per million person-rem) by the estimated dose to the total body (as shown in Table 5.6). This calculation results in a risk of potential premature death from cancer to this individual from exposure to radioactive effluents (gaseous or liquid) of approximately 3 chances in 1 million. These risks are small in comparison to cancer incidence from causes unrelated to WBN Plant operation; viz., 200,000 chances in 1 million (American Cancer Society 1994).

Table 5.6 Potential Fatal Cancers and Severe Hereditary Effects in Selected Population Groups from One Year of WBN Plant Two-Unit Operation[(a)]

Exposed Population	Dose Commitment	Estimated Fatal Cancers	Estimated Severe Hereditary Effects
WBN Occupational Work-Force	10 person-sievert (1000 person-rem[(b)])	0.4	0.08
Maximally Exposed Individual[(c)]	0.06 millisievert (0.006 rem)	0.000003	N/A
Offsite Population[(d)]	0.22 person-sievert (22 person-rem)	0.01	0.003

(a) Impacts assume year 2040 population.
(b) Average person-rem dose for operating nuclear power plants (the NRC 1978 FES-OL, Section 5.5.1, Occupational Radiation Exposure, p. 5-15).
(c) A hypothetical individual receiving the Appendix I criteria dose.
(d) General population (1.1 million) within 80 kilometers (50 miles) of the WBN Plant in year 2040 using the population doses from FSAR as amended.

The risk of death from cancer resulting from exposure to radioactive effluents from the WBN Plant to an average individual living within 80 kilometers (50 miles) of the facility is much less than the risk to the maximally exposed individual. The staff calculates the probability of a single cancer death attributable to WBN Plant operation in the population within 80 kilometers (50 miles) of the WBN Site is approximately 1 in 100. The statistically expected value is zero deaths.

The significance of this risk can be illustrated by comparing it to the total projected incidence of cancer deaths in the population living within 80 kilometers (50 miles) of the WBN Plant. Multiplying the estimated population within 80 kilometers (50 miles) of the WBN Plant assumed for the year 2040 (1.1 million people) by the incidence of eventual actual cancer fatalities of about 20% implies that about 220,000 cancer deaths not attributable to the WBN Plant are expected.

To estimate these risks to the population living within 80 kilometers (50 miles) of the WBN Site, the ICRP 60 (ICRP 1991) factor of approximately 1 severe hereditary effort per 110 person-sieverts (130 severe hereditary effects per million person-rem) is multiplied by the dose from exposure to radioactivity attributable to WBN effluents (i.e., 0.22 person-sieverts [22 person-rem]). The staff estimates the probability of a single severe genetic disorder occurring across all future generations of the exposed population is 3 in 1000.

In the preceding analysis, the risk of potential genetic disorders from WBN Plant operations is small compared with the risk of actual genetic ill health in the population from natural causes. Multiplying the estimated population within 80 kilometers (50 miles) of the plant (about 1.1 million persons in the year 2040) by the incidence of multifactorial traits (BEIR 1990) of genetic ill health (about 12%), it is estimated that about 0.13 million genetic abnormalities are expected in the population from causes unrelated to WBN Plant operations.

5.5.6 Impacts of the Uranium Fuel Cycle

The impacts of the uranium fuel cycle considered in the NRC 1978 FES-OL were based on 30 years of plant operation with annual refueling. The applicant's current plans include 40 years of operation and refueling every 18 months. The net result of these changes is a slight reduction in fuel usage. The staff estimates this reduction in uranium use to be between 10 and 15%.

The current assessment of the environmental impacts of the uranium fuel cycle is summarized in Table S-3 of 10 CFR 51.51. The staff concludes that the doses and potential health effects will be small compared to the effects of natural radiation sources.

5.6 Non-Radiological Human Health Impacts

Non-radiological health effects that are considered include electromagnetic fields (EMF) and shock hazards from transmission lines, airborne pathogenic organisms, noise, and air quality. EMF and shock hazards were discussed in the NRC 1978 FES-OL.

5.6.1 Electromagnetic Fields and Shock Hazards from Transmissions Lines

Section 3.5 discusses the WBN power transmission system. Two human health issues related to transmission lines are shock hazard and exposure to electric and magnetic fields (also known as electromagnetic fields). Electromagnetic fields (EMFs) are a form of non-ionizing radiation. EMF are produced by the movement of electrical charges through wires, such as those in household appliances and in the transmission lines associated with power plants. A number of research studies (both epidemiological and laboratory-related) have been performed to determine whether EMF exposure adversely affects human health. Numerous uncertainties surround the information obtained from these studies. Some studies suggest a statistical association between 60-hertz EMF and specific types of cancer; however, no cause-and-effect relationship has been established between EMF exposure and cancer or other disease (EPA 1992a, 1992b). Consequently, there is no defined hazardous level for EMF. EMF levels are known to decrease with distance from the source. EMF exposure to persons in the vicinity of elevated power transmission lines is reduced to lower levels than the EMF exposure inside the home produced by appliances and electrical wiring (NRC 1991).

Shock hazards are produced mainly through direct contact with conductors and have effects ranging from a mild tingling sensation to death (NRC 1991). The transmission line towers associated with the WBN Plant are designed to preclude direct public access to the conductors. However, secondary shock currents are produced when persons contact capacitively charged objects (such as vehicles parked near a transmission line) or magnetically linked metallic structures (such as fences near a transmission line). Shock intensity depends on the strength of the electric field, the size and location of the object, and the ground insulation. Design criteria that limit hazards from steady state currents are based on the National Electrical Safety Code (NESC), which requires that transmission lines are designed to limit the short-circuit current to ground produced from the largest anticipated vehicle to less than 5 milliamperes (NRC 1991). The applicant's design ensures that the transmission lines exceed the requirement given in the NESC (TVA 1994b). The staff concludes that the impact of shock hazards and EMF exposure will be minimal as a result of operation of the WBN Plant.

5.6.2 Airborne Pathogenic Microorganisms

Some thermophilic microorganisms associated with cooling towers and thermal discharges can have deleterious impacts on human health. These microorganisms include the enteric pathogens *Salmonella* sp. and *Shigella* sp. as well as *Pseudomonas aeruginosa* and thermophilic fungi. Methods of testing for these microorganisms are known and their presence in aquatic environments is often controllable. Other microorganisms normally present in surface water, but not as easily detected or controlled, include the bacteria *Legionella* (which causes Legionnaire's disease) and the amoebae of the genera *Naeglaria* and *Acanthamoeba*, which cause a rare but very serious human infection, primary aerobic meningoencephalitis (PAME) (NRC 1991).

Legionella has been found to be present in the aerosols in the vicinity of condensers or cooling tower basins when they were in the process of being cleaned. Two reported cases of *Naeglaria* sp. related infections associated with the cleaning of cooling towers have been reported (NRC 1991). For this reason, utilities that identify microorganisms in the cooling tower that are responsible for PAME often require respiratory protection for workers in the vicinity of the cooling towers and condensers.

The potential health effects from *Naeglaria fowleri* at sites such as the WBN Site, located on rivers with average flow rates less than 2830 cubic meters per second (100,000 cubic feet per second), are a public health concern (NRC 1991). These microorganisms occur in surface water where the risk of infection is always present. Increases in average water temperature due to weather or climatic conditions, or from the discharge of heat, may cause an increase in the levels of the microorganisms. Information obtained by the applicant in discussions with the Center for Disease Control in Atlanta indicated that, in order to contract primary amoebic meningoencephalitis from *Naeglaria fowleri*, large doses of cyst-contaminated water entering the nasal mucosa area are required. A few cases have been reported in swimmers from Texas and the Carolinas during the past few years; these were not associated with aerosol cysts from power plant cooling towers (TVA 1994g). The Tennessee Department of Health was not aware of any cases for which either *Legionella* or *Naegleria* were associated with cooling towers in Tennessee (TVA 1994b). The staff concludes that the operation of the WBN Plant is not likely to result in adverse effects to human health as a result of the presence of these microorganisms.

5.6.3 Noise Levels

The principal sources of noise from plant operations are the natural draft cooling towers, the transformers and the loudspeakers. Occasional noise sources include auxiliary equipment such as pumps and building ventilation fans. The applicant has estimated operational sound levels (TVA 1980) by using published values for noise emission from large cooling towers and the applicant's own sound survey data on noise emission from 500 kV transformers. Sound levels at three locations near the site boundary 900 meters (3000 feet) to 1,800 meters (6,000 feet) from the transformers and cooling towers were between 53 and 63 decibels. Intermittent sound levels range from 84 to 103 decibels (A-weighted scale) from air-blast circuit breakers breaking under an electrical load, and from sound generated during steam venting (TVA 1980).

There are no Federal regulations for levels of noise for public exposures. However, the levels estimated by the applicant are well below the Threshold Limit values set by the American Conference of Governmental Industrial Hygienists (ACGIH) for workers (ACGIH 1994). These levels represent conditions that nearly all workers may be repeatedly exposed to without adverse effect on their ability to hear and understand normal speech.

The threshold limit level for a 24-hour duration is 80 decibels, the level for sounds lasting around a minute is 113 decibels (A-weighted scale). Thus, the staff concludes that these noise levels are unlikely to cause a detrimental effect on public health.

5.6.4 Air Quality

Non-radioactive discharges to the air are controlled by Federal, State, and local statutes, regulations and ordinances. .The applicant has stated that all permits and approvals necessary for plant operation have been obtained and are being reviewed as required by the applicable agencies. The applicant has also stated that periodic inspections of its facilities are conducted by Federal and State environmental agencies to verify that they are being operated in accordance with applicable requirements (TVA 1994a).

The operational impact of two oil-fired boilers used to provide building heat and startup steam was specifically addressed in the TVA 1972 EIS-CP (TVA 1972). The calculated concentrations of particulates, oxides of sulfur and nitrogen, carbon monoxide, and hydrocarbon from potential releases at the WBN Plant were two or more orders of magnitude below applicable standards. The applicant has indicated that emissions from these boilers "...will be controlled as necessary to meet applicable regulatory requirements, and resulting impacts are expected to be insignificant." (TVA 1994c)

The applicant has estimated that there will be about 0.003 cubic meters per second (0.1 cubic feet per second) of drift from each tower and concluded that the effects of the drift will not be significant (TVA 1972). There have been no changes in the design or planned operation of the cooling towers (TVA 1994a). Therefore, the conclusions in the NRC 1978 FES-OL have not changed.

5.7 Socioeconomic Impacts

The NRC 1978 FES-OL projected that the onsite workforce at commercial operation of both units would be fewer than 200 and concluded that no significant impacts would occur. Current projections indicate that total onsite employment at commercial operation of the WBN Plant Unit 1 in the summer of 1995 will total about 1,800, including 450 personnel associated with Unit 2. Total employment at the site including operating and construction personnel was approximately 4,000 in mid-1994, down from 4,900 in December, 1992 (TVA 1994g). The level of operations employment, while significantly larger than originally expected, is significantly less than current employment. If the employment level were to shrink to 1,800 at the beginning of operations, a loss of 2,200 additional jobs, it is most likely that any socioeconomic impacts would arise from the downturn rather than from the remaining employees (who are already onsite). However, socioeconomic impacts are still not expected for a variety of reasons discussed below.

Total WBN Site employment during the early period of operation of WBN Plant, Unit 1 will depend on resolving the status of Unit 2, where there is currently no construction activity. According to the applicant, Unit 2 is about 65% complete; Construction Permit CPPR-92 expires in 1999. The schedule for the completion of Unit 2 will be resolved as part of the applicant's 1995 Integrated Resource Plan. Until then, there is no basis for projecting the magnitude or timing of the future onsite construction workforce. Because the impacts are likely to be greatest if Unit 2 construction activity either is not restarted or is restarted with considerable delay, it is assumed that 2,200 additional jobs (3,100 total jobs relative to December 1992) will be lost immediately upon completion of Unit 1. If Unit 2 construction activity is restarted, however, fewer jobs would be lost.

Socioeconomic impacts of large-scale employment changes primarily occur when such changes are concentrated in a handful of communities. However, the construction employees have been spread thinly among a group of over 50 communities within a radius of 80 to 100 kilometers (50 to 60 miles) of the WBN Site. In 1990, the population of this area was over 1,000,000 people, with a labor force of 550,000 (TVA 1994g). While some outmigration may be expected, the dynamics of the large labor market in the region and the extended period over which layoffs will occur make it likely that those workers who choose to stay will be able to find employment. The wide dispersal of employees reduces the likelihood of impact in any particular community's labor pool, housing market, or utility system revenues as a result of finishing Unit 1. While no current information is available on the current geographic distribution of the WBN Plant employees, the applicant believes that the current distribution is still similar to that during the peak of construction during the mid-1980s, shown in Table C.3. This is the latest available data on residences of the WBN Plant workforce.

In accordance with this distribution of employees, the applicant implemented a socioeconomic impact mitigation program early in the construction period. The NRC 1978 FES-OL described the initial stages of the program, which began in 1973 and continued until 1984. During that program, the applicant provided $1,600,000 directly to local governments of the two nearest counties, Meigs and Rhea, to assist in the provision of services and facilities. Law enforcement and educational areas received the largest amounts of assistance at $698,000 and $675,000, respectively. The remaining $237,000 was distributed among a number of other functional areas such as fire protection, solid waste, and health recruitment (TVA 1994a). The public service capacities built up during the construction period still remain in place and will not be adversely affected.

Under Section 13 of the TVA Act, the applicant has made tax-equivalent payments to the State of Tennessee, determined 50% by book value of the applicant's property and 50% by value of the applicant's power sales in the state (TVA 1994g). Tennessee redistributes 35% of its payments to local governments by two different mathematical formulas. For the counties, shares are based on relative population, total acreage in the county (42.8%), and the applicant's acres in the county (14.4%). City payments are based on population. These tax-equivalent payments are expected to continue after operation of the WBN Plant Unit 1 begins. The state also currently pays an allocated share (3%) of its payment in excess of the base amount ($55,000,000) to cities and counties impacted by the applicant's major construction activities. For example, in FY 1992, eight designated counties and 34 cities within these counties located in the WBN Site geographic area shared a portion of these impact funds, shown in the third column of Table C.4. The maximum amount that a county and its incorporated cities can receive is 10% of the total impact funds. The Tennessee impact funds are more than 1% of the total funds available for only a handful of these local governments, shown by an asterisk in the last column of

Table C.4. Immediate loss of these funds might have been a short-term concern for these few communities; however, an amendment to Tennessee law provides for a three-year phase-out period for the impact funds following the completion of construction, leaving time for the governments to adjust.

Finally, the area has a great deal of experience accommodating large changes in employment at the WBN Plant. One potential problem associated with downturns in employment at the end of construction is that some people will leave the area in search of employment elsewhere. This could put temporary downward pressure on local real estate values, assessed valuation, and tax base. However, contacts in the local real estate community suggest that the story is more complex. Currently, the housing market in the area is a "seller's market" with houses moving off the market at about 95% of the asking price and within the initial term of the sales contract (TVA 1994g). This view is also supported by recent history. Local realtors report that larger (temporary) job losses associated with the shutdown of construction in 1990 did not result in serious softening of real estate prices. Information supplied by local realtors suggests that market prices probably declined 2 to 5%, about the current rate of annual increase. In 1990 the market was supported by the movement of new manufacturing jobs into the general area of the WBN Plant. At the present time, connection of the Dayton area to Chattanooga has improved dramatically with the opening of a four-lane highway link. The consequent suburbanization of Chattanooga into the Dayton area offers similar support for housing prices in the WBN Site region.[a]

5.8 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations"; 59 FR 7629 (1994) directs Federal agencies in the Executive Branch to consider environmental justice so that their programs and activities will not have "disproportionately high and adverse human health or environmental effects...on minority populations and low income populations...." The NRC, although an independent agency, indicated its willingness to comply with the Executive Order and to participate with an Interagency Working Group in developing guidelines to implement it. Those guidelines are still being developed and, therefore, are not available for use in the preparation of this supplement.

Although the siting decision on the WBN Plant was made over 20 years ago, and the TVA 1972 EIS-CP and the NRC 1978 FES-OL do not explicitly address environmental justice, the NRC staff, in preparing this supplement, reviewed the WBN regional[b] characteristics to identify the proportions of low income or minority populations that could be potentially affected by plant operations. The data reviewed by the staff indicate that the WBN Plant is located in a predominately non-minority, low income area.

(a) Informal interviews with local realtors, Dayton, Tennessee, September 13, 1994.

(b) The WBN region is the region within a 80 kilometer (50 mile) radius of the WBN site (See Figures 2.1, 2.2, 2.3).

Table C.5 provides (1) the per capita income and median household income averages for the counties within the WBN region, (2) per capita income and median household income as a percent of the Tennessee State average, and (3) the percent of persons below poverty level as a percent of the Tennessee State average. The WBN region is a relatively poor section of the State, with per capita and median household income both below the State average. The counties to the northeast of the plant (Roane, Knox, and Anderson) and to the South (Hamilton and Bradley) generally have incomes above the Tennessee average (See Figure 2.1 and 2.2 for county location). The counties in which the WBN site is located, Rhea and Meigs, generally have incomes from slightly below the State average to more than 20% below the State average.

Table C.6 breaks down, based on the 1990 Census, the minority population within the WBN region by race and ethnicity, and county. The minority populations in the WBN region mostly reside in Hamilton, Bradley and Knox counties, well away from the WBN Plant. The minority population in Rhea and Meigs (the counties in which the WBN Site is located) are relatively small, approximately 2 percent, and 4 percent of the county population, respectively.

Section 2 of this supplement provides a description of the current environmental conditions and describes the changes since the 1978 FES-OL; Section 5 discusses any change in environmental impacts from those previously disclosed (in the TVA 1972 EIS-CP and the NRC 1978 FES-OL). The human health and socioeconomic environmental impacts to the low income populations located closest to the site are the same as those discussed in Sections 5.2 (impact on water use), 5.5 (radiological health effects), 5.6 (non-radiological health effects), and 5.7 (socioeconomic).

The environmental impacts from plant operations decrease as you get further away from the WBN Site. Thus, the staff concludes that the low income population located close to the WBN Site has the potential to receive a greater environmental impact than other groups. However, in the NRC 1978 FES-OL, the NRC concluded that it is possible to operate the station with only minimal environmental impacts. Based on the staff's evaluation of changes in plant design, proposed plant operation and the environment, the staff has determined that there is no significant change in environmental impacts that would alter the conclusion reached in the NRC 1978 FES-OL. Therefore, the impacts on the low income population located close to the WBN Site are minimal, notwithstanding the fact that those impacts will be greater than those populations located further away.

5.9 References

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6 Environmental Monitoring Program

Changes in the preoperational and operational monitoring programs have been evaluated. The preoperational monitoring programs are discussed in Section 6.1 and the operational monitoring studies are discussed in Section 6.2.

6.1 Preoperational Monitoring Program

Preoperational monitoring studies include meteorology, water quality, groundwater, aquatic ecology, terrestrial ecology, and radiological studies were initiated in stages beginning in December 1976.

6.1.1 Preoperational Onsite Meteorological Program

Collection of onsite meteorological data began in 1971 with installation of a temporary 40-meter (130-foot) instrumented tower. A permanent 91-meter (300-foot) instrumented tower and environmental data station began operation in May of 1973 at a location approximately 760 meters (2500 feet) south-southwest of the Unit 1 Reactor Building (TVA 1994a). Meteorological instrumentation in the permanent system initially included wind direction and speed at 10 meters (33 feet) and 93 meters (305 feet); temperature at 1 meter (3 feet), 10 meters (33 feet), 46 meters (150 feet), and 91 meters (300 feet); and dewpoint, solar radiation, atmospheric pressure, and rainfall at 1 meter (3 feet). Several changes were made to the instrumentation between September 1976 and April 1981. These changes led to the current system which includes wind and temperature sensors at 10 meters (33 feet), 46 meters (150 feet), and 91 meters (300 feet); dewpoint at 10 meters (33 feet); and solar radiation and rainfall at 1 meter (3 feet). The current system is described in the NRC Safety Evaluation Report (NRC 1982) and in detail in the applicant's FSAR (TVA 1994b).

The onsite meteorological data collection program appears to conform to the guidance in Regulatory Guide 1.23 (USAEC 1972). Data recovery rates for wind direction, wind speed, and temperature difference exceed 95% for each parameter and 93% for the parameters combined. The staff considers these data recovery rates, which exceed the minimum data recovery rate criterion in Regulatory Guide 1.23, to be acceptable.

6.1.2 Preoperational Water Quality Studies

Preoperational water quality studies were described in the NRC 1978 FES-OL (NRC 1978), and the results are presented in the preoperational monitoring report (TVA 1986). An additional study (discussed in Section 5.2.1) of the thermal effluent releases was also conducted (TVA 1993a).

6.1.3 Preoperational Groundwater Studies

Preoperational groundwater studies were described in the NRC 1978 FES. An additional study was performed to analyze the impacts of the evaporation/percolation pond, (described Section 2.2.2) (TVA 1990a).

6.1.4 Preoperational Aquatic Biological Monitoring

Preoperational aquatic biological monitoring was described in the NRC 1978 FES-OL. Additional baseline monitoring was performed from 1982 through 1985, and a number of special studies focusing on specific issues were performed from 1983 through 1994 (TVA 1994a, 1994c, 1993c, 1991a, 1991b, 1990b, 1989, 1986). These monitoring efforts are summarized below in Tables 6.1 and 6.2 (TVA 1994a); related information for Sequoyah Nuclear (SQN) Plant are included.

Table 6.1 Summary of WBN Plant Baseline Preoperational Aquatic Monitoring Programs (1972-1993)

Study	Type of Sampling	Years Conducted
Adult Fish	Rotenone, electrofishing, gill-nets, hoop-nets	1970-1993
		1976-1979, 1982-1985
Larval Fish	Trawling	1976-1979, 1982-1985
Benthos	Dredges, artificial substrates, Hess Samples	1973-1977, 1982-1985
Zooplankton	Plankton nets	1973-1977, 1982-1985
Phytoplankton	Plankton nets	1973-1977, 1982-1985
Periphyton	Artificial substrates	1973-1977, 1982-1985
Chlorophyll	Artificial substrates	1973-1977, 1982-1985
Primary Productivity	N/A	1973-1977, 1982-1985
Autotrophic Index	N/A	1973-1977, 1982-1985

Table 6.2 Summary of WBN Plant/SQN Plant Special Aquatic Monitoring Program

Study	Type of Sampling	Years Conducted
Mussels	Diver	1983-1992 (biennial)
Sauger populations	Electrofishing, gillnetting larval sampling	1986-1991 1987
White crappie	Larval netting, light traps, electrofishing, trapnetting	1986-1989 1987-1989
White bass population	Electrofishing, tagging, larval sampling	1990-1992 1990-1991
Channel Catfish	Literature review	1990-1992
Dissolved Oxygen	Direct measurements	1987-1989

6.1.5 Preoperational Terrestrial Monitoring

The NRC 1978 FES-OL proposed a monitoring program consisting of an aerial survey using color infrared and/or multispectral or multiband photography to be compared with similar surveys performed during plant operation. These aerial surveys were meant to detect changes in local vegetation that could result from the mergence of the WBN Plant cooling tower drift and the Watts Bar Steam Plant stack plume. This monitoring program was never implemented because WBN Plant and the Watts Bar Steam Plant never operated at the same time. In addition, subsequent analyses (TVA 1979 and NRC 1991) indicate that the effects of the mergence of these plumes would be negligible.

6.1.6 Preoperational Radiological Monitoring

Only minor changes to the preoperational radiological environmental monitoring program have been made since the NRC 1978 FES-OL. In 1984 some of the atmospheric monitoring stations were relocated to provide better local (site boundary and perimeter) and remote coverage based on meteorological data. In addition, the air sample collection systems were modified to provide for simultaneous collection of air particulates and radioiodine. The atmospheric monitoring network includes local, perimeter, and remote monitors. In 1993, five thermoluminescent dosimeter (TLD) stations were added to the program in the area between 3 kilometers (2 miles) and 6 kilometers (4 miles) from the plant and in June 1993 a new dairy farm [6.6 kilometers (4.1 miles) east-southeast of the plant] was added to the program, doubling the respective coverages within 8 kilometers (5 miles) of the plant.

The staff reviewed the preoperational radiological monitoring program as described in the 1993 annual report (TVA 1994d) and the ODCM (TVA 1994e).

In March 1984, two local monitors (located within or near the plant boundary) were added, for a total of four local monitors. Prior to March 1984, there were six perimeter monitors, at which time two were deactivated and the equipment was used to establish two additional local monitors. One remote monitoring station was discontinued and the equipment was used to establish another remote station in Alloway, 23.8 kilometers (14.9 miles) north-northwest of the plant.

Changes made in 1984 to the air particulate and charcoal filter systems included the installation of cone-shaped filter holders, located on the outside of the monitoring stations, that were protected from rain by a metal overhang housing the gum paper fallout tray. These systems were modified at seven of the ten monitoring stations, incorporating 4.8-centimeter (1-7/8-inch) diameter glass fiber filters for collection of air particulates and 5.7-centimeter (2-1/4-inch) diameter, 2.5-centimeter (1-inch) thick tetraethyldiamine (TEDA)-impregnated charcoal for collection of radioiodine.

The staff considers these changes to the preoperational radiological environmental monitoring program to be acceptable. In addition to the applicant's environmental monitoring program, the NRC maintains a TLD monitoring program surrounding the WBN Plant in conjunction with the State of Tennessee.

6.2 Operational Monitoring Program

The operational monitoring programs are continuations of the preoperational monitoring programs discussed in Section 6.1. The operational monitoring programs will begin when the WBN Unit 1 Plant begins operation. The operational programs include meteorological monitoring, water quality monitoring, groundwater monitoring, chemical effluent monitoring, aquatic biological monitoring, terrestrial monitoring, and radiological monitoring.

6.2.1 Operational Onsite Meteorological Program

The applicant will continue the preoperational meteorological program during operation of the plant (TVA 1994a). The staff conducted a review of the applicant's onsite meteorological system in September 1994. Variations in atmospheric conditions that lead to stability class disparities in the vicinity of the meteorological tower were assessed in Section 2.3.3. There does not appear to be an alternate location in the vicinity of the plant where more representative conditions could be measured. The instrumentation and data collection appear to be consistent with the guidelines set forth in Regulatory Guide 1.23 (USAEC 1972). The staff concludes that the tower is located in an appropriate position relative to the plant and surrounding topographic features to provide meteorological data that are generally representative of the conditions in the vicinity of the plant.

6.2.2 Operational Water Quality Monitoring

The operational water quality monitoring program, described in the NRC 1978 FES-OL, has changed as a result of changes to the NPDES permit issued by the State of Tennessee (State of Tennessee 1993).

The NPDES permit specifies water quality monitoring at the outfalls. The NPDES permit also requires that thermal plume modeling and temperature modeling be conducted.

6.2.3 Operational Groundwater Monitoring

The groundwater monitoring program has not changed from that described in the NRC 1978 FES-OL. Samples will be obtained from two wells tapping into the Conasauga Shale Aquifer. One well will be downgradient and one upgradient of the plant. The samples will be taken monthly as specified in the NRC 1978 FES-OL. The staff continues to find the operational groundwater monitoring program acceptable.

6.2.4 Operational Chemical Effluents Monitoring

The operational chemical effluent monitoring program described in the NRC 1978 FES-OL has changed as a result of changes to the NPDES permit issued by the State of Tennessee (State of Tennessee 1993). The NPDES permit requires that the applicant conduct chronic toxicity testing on daphnids and fathead minnows with effluents from Outfalls 101, 102, and 112.

6.2.5 Operational Aquatic Biological Monitoring

In light of the additional information accumulated in preoperational monitoring efforts since publication of the NRC 1978 FES-OL, revisions to the 1978 operational monitoring plan were made. The operational monitoring plan revision was submitted to the State of Tennessee in a letter dated September 8, 1993 (TVA 1993b). Subsequently, this plan was approved by the State and incorporated as a requirement into the WBN Plant NPDES permit (State of Tennessee 1993). The elements of the current Operational Aquatic Biological Monitoring Plan (TVA 1994a) are described below. Monitoring will commence when Unit 1 becomes operational.

Fish Impingement

During the period from December through May, the number of fish impinged on the intake screens on the Tennessee River in a 24-hour period will be determined once each week. From June through November, the number of fish impinged will be determined once every two weeks. Appropriate modifications will be made in the sampling program as dictated by the results.

Larval Fish Entrainment Sampling

Samples will be collected biweekly March through August at five stations along a transect perpendicular to flow at TRM 528, adjacent to the intake. Samples will also be collected in the WBN Plant cooling water intake channel.

WBN Plant Vicinity Creel Survey

The catch rate, average weight, and percent composition of each species harvested will be estimated by collecting angler harvest data three days each week in the river reach between Watts Bar Dam (TRM 529.9) and Yellow Creek (TRM 526.8). The surveys will be conducted by the applicant. They will be designed to provide a comparison with preoperational data and to assess the tailwater in terms of fisherman success and satisfaction. The surveys' purpose is to document any effects of plant operation on the sport fishery below Watts Bar Dam. It will also provide an indication of sportfish attraction to the WBN Plant intake and discharge areas.

Reservoir-Wide Creel Survey

The Wildlife Resources Agency will conduct surveys during five randomly selected days each week. Total catch, fishing pressure, and success for Chickamauga Reservoir will be estimated by counting and interviewing fishermen.

Cove Rotenone Sampling

Five coves in Chickamauga Reservoir will be sampled every other year to document long-term trends in the stock and species composition of reservoir fish. The cove rotenone sampling will add to a long-term database on reservoir fish populations that is a part of both the WBN Plant and Sequoyah Nuclear Plant operational monitoring.

Water Quality

Water quality sampling in support of the aquatic biological monitoring program will be performed six times between March and August during appropriate flow and operational conditions at four locations in the vicinity of the WBN Plant. Three of the surveys will evaluate selected trace metal concentrations in the water, along with the general water quality and biological support parameters evaluated in all the surveys.

Plankton

Sampling for chlorophyll *a*, as an indication of phytoplankton biomass, will be conducted six times per year at four stations, one upstream of the WBN Plant and three downstream.

Benthic Macroinvertebrates

Sampling for benthic macroinvertebrates will be conducted using Hess samplers at five stations between TRM 521.0 and 528.8 during summer and fall quarters.

Mussel Surveys

All endangered and threatened mussel species populations will continue to be closely monitored to ensure that no measurable impacts are taking place. The applicant has committed to taking the necessary corrective steps to amend the situation should such an impact occur (TVA 1994a).

Biennial surveys by divers in the tailwater mussel sanctuary will be continued. Additionally, quadrat samples will be taken to document mussel reproductive success. Following operation of WBN Plant Unit 2, an assessment and evaluation of bioaccumulation of selected trace metals by molluscs will be implemented and will continue for a minimum of three years after commercial operation.

6.2.6 Operational Terrestrial Monitoring

The NRC 1978 FES-OL identified three operational terrestrial monitoring programs: effects of cooling tower drift and plume interactions, effects of bird collisions with the cooling tower, and maintenance of transmission lines. Based on subsequent analyses (TVA 1979 and NRC 1991), the staff concludes that monitoring for plume interactions is no longer necessary. The staff concludes that further monitoring of cooling tower bird collisions is not necessary because there have been no recorded serious episodes of bird collisions with cooling towers.

The applicant has committed to survey transmission line corridors for the presence of Federally protected or candidate species before maintenance activities are conducted (NRC 1994).

6.2.7 Operational Radiological Monitoring

The preoperational radiological environmental monitoring program will be continued once the WBN Plant becomes operational; a full description of the program is contained in the Offsite Dose Calculation Manual (TVA 1994e). The TLD direct radiation monitoring network program, maintained by the NRC, will continue to provide independent measurement of the ambient radiation levels around the WBN site.

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7 Accident Analysis

7.1 Realistic Accident Analysis

The staff reviewed the realistic accident analysis in the NRC 1978 FES-OL (NRC 1978). With the exception of a change in the population projection between 2020 and 2030, the technical bases and assumptions have not changed. Resin use in the waste handling process was not considered in the NRC 1978 FES-OL. The applicant performed an assessment of an accident involving the failure of the spent fuel resin storage tank and of the transfer resins in the Railroad Bay. In this analysis, a bounding calculation (WBNTSR-017 "Offsite Dose Due to the Failure of the Spent Resin Storage Tank") was performed for spill of the resins from the WBN Plant spent resin storage tank. The limiting calculation assumed the tank (8.5 cubic meters [300 cubic feet]) was full and that the resin spill would result in an immediate release of all noble gases contained in the tank to the outside environment. The offsite dose was projected to be less than 500 mrem (1.4 millirem under the 30-day low population zone criteria and 2.8 millirem under the 2-hr exclusion area bounding criteria). The mobile demineralizer system resin storage tank has only a 5.7 cubic meter (200 cubic feet) capacity; consequently, the spent resin storage tank accident assessment bounds all other accidents involving spent resins.

7.2 Severe Accident Mitigation Design Alternatives (SAMDAs)

7.2.1 Introduction

The NRC considers the alternative of plant operation with the installation of Severe Accident Mitigation Design Alternatives (SAMDAs) in the environmental impact review that is performed as part of every operating license application. The purpose of this consideration is to ensure that plant design changes with the potential for improving severe accident safety performance are identified and evaluated.

The applicant submitted an initial assessment of SAMDAs for WBN Plant, Unit 1, on June 5, 1993 (TVA 1993). This assessment was based on the original Individual Plant Examination (IPE) for the WBN Plant (September 1, 1992), which reported an annual total Core Damage Frequency (CDF) for the WBN Plant of 3.3E-4 per year. Based on this assessment, the applicant concluded that none of the candidate SAMDAs considered were cost effective for the WBN Plant.

The applicant subsequently revised the IPE in order to reflect plant design changes, procedure upgrades, and training enhancements. The revised IPE (TVA 1994) reported a total mean CDF of 8.0E-5 per year, which is about a factor of 4 smaller than the CDF reported in the original IPE submittal. (The staff's evaluation of the revised WBN Plant IPE is described in an IPE evaluation report dated September 29, 1994 [NRC 1994]) The applicant also updated the WBN Plant SAMDA analysis to reflect the results of the revised IPE, and to include evaluation of additional, plant-specific design improvements identified through the IPE. The revised SAMDA analysis, entitled "Watts Bar Nuclear Plant Unit 1 Value Impact Analysis of Potential Plant Improvements," was submitted to NRC on June 30, 1994 (TVA 1994b). As a result of the revised analysis, two of the additional, plant-specific design improvements were determined by the applicant to be risk and cost beneficial. The applicant committed to incorporate these improvements (procedure changes) in the WBN Plant operating procedures before initial criticality.

Based on a review of the revised SAMDA submittal, NRC issued requests for additional information to the applicant on September 2, 20, and 27, 1994, and October 17, 1994 (NRC 1994b, 1994c, 1994d, 1994e). After discussions with NRC, the applicant decided to re-baseline the IPE in order to take credit for the two procedure changes committed to in the June 30, 1994 submittal (TVA 1994b), plus one additional procedure change that was also identified but not committed to in the previous IPE and SAMDA analyses. The procedure changes involve (1) stopping one train of containment spray in order to delay the need to switch over to recirculation, (2) cross-tying the 500kV power at Unit 2 to the 161kV power system at Unit 1, and (3) using a spare 6800V to 480V transformer to supply the 480V shutdown boards. The assumptions and bases for rebaselining of Value Impact Analysis are listed in Tables 1 through 3 of the Executive Summary of Revision 1 of SAMDA. The applicant has now committed to implement each of these changes.

A submittal describing the results of the rebaselining and providing updated risk reduction estimates for the remaining SAMDAs was provided to NRC on October 7, 1994 (TVA 1994c). The rebaselined analysis, referred to here as the "final" SAMDA submittal, reduces the CDF still further to 5.8E-5 per year. The total risk estimated for the WBN Plant in the final analysis is 211 person-rem over the 40-year plant life.

The staff's assessment of SAMDAs for the WBN Plant is presented below. This assessment is based largely on the review of the applicant's final evaluation of potential design improvements. The staff review was performed by NRC staff and their contractors, Scientech, Inc. and Sanford Cohen & Associates.

7.2.2 Estimate of Risk for Watts Bar Nuclear Plant

TVA Risk Estimates

The applicant did not perform a plant-specific risk assessment of offsite consequences (Level 3 probabalistic risk assessment [PRA]) for the WBN Plant. Instead, the applicant made extensive use of the Sequoyah NUREG-1150 (NRC 1990a) analysis in order to generate the risk profile for the WBN Plant. Specifically, the WBN Plant PRA Level 2 results, taken from the WBN Plant IPE submittal, were mapped into SQN Plant Level 3 accident progression bins and release categories. The SQN Plant consequence results were then scaled to compensate for differences in population and weather between the SQN and WBN Sites.

The various TVA SAMDA submittals and the corresponding reported values for CDF and total offsite risk are summarized in Table 7.1. In the original SAMDA analysis (TVA 1993), the applicant estimated the total offsite risk to the population within 80 kilometers (50 miles) of the WBN Site to be about 2300 person-rem

Table 7.1 Summary of WBN Plant IPE and SAMDA Submittals

History	Date	CDF	Total Offsite Risk (Person-rem)
Original SAMDA, based on original IPE	6/5/93	3.3E-4	2,300
Revised SAMDA, based on updated IPE	6/30/94	8.0E-5	200
Final SAMDA, based on procedural modifications & population adjustment	10/7/94	5.8E-5	211

over the 40-year plant life. This was based on direct use of SQN Site characteristics (meteorology, population data, and evacuation modeling) and consequence analysis results. In the revised SAMDA submittal (TVA 1994b), the applicant estimated the total offsite risk to be about 200 person-rem over the 40-year plant life. The factor of ten reduction in risk that distinguishes the original from the revised SAMDA stems from both a reduction in CDF and a scaling of the SQN Site consequence results to compensate for differences in population and weather between the SQN and WBN Sites (an approximate factor of 4 reduction).

In the final SAMDA submittal (TVA 1994c), the applicant estimated the total offsite risk to be about 5.28 person-rem per year, or 211 person-rem over the plant life. In addition to rebaselining the CDF to reflect the three procedural changes mentioned earlier, the applicant increased the risk (and risk reduction) estimates by approximately 34% to reflect the expected growth in the number of persons living within 80 kilometers (50 miles) of the WBN Site over the 40-year license. The population change increased the total estimated risk for WBN Plant, but was partly compensated for by the reduction in CDF afforded by the procedural fixes.

The breakdown of the population dose by initiating event is provided in Table 7.2. The breakdown of the population dose in terms of the containment failure modes and NUREG-1150 (NRC 1990a) accident progression bins (APBs) into which the WBN Plant Level 2 results were mapped is provided in Table 7.3. The bulk of the risk is attributed to containment bypass events, such as steam generator tube rupture (SGTR), and events which lead to early containment failure.

Review of TVA's Risk Estimates

The applicant's estimate of offsite risk at the WBN Plant is based on four major elements of analysis, specifically:

- the Level 1 and 2 PRA for the WBN Plant that form the basis for the May 2, 1994 (revised) IPE submittal (TVA 1994a)

Table 7.2 Initiating Event Contribution to Population Dose

Initiating Event	Risk Contribution	
	Person-Rem	**Percent of Total**
SGTR	89	42
Loss of Offsite Power	40	19
Simple Transients	13	6
Loss of Shutdown Board	13	6
Flood in ERCW Pump Rooms	10	5
Other LOCAs	13	6
Non-isolable LOCAs	6	3
Other	27	13
Total	211	100

Table 7.3 Accident Progression Bin Contribution to Population Dose

Accident Progression Bin	Risk Contribution	
	Person-Rem	**Percent of Total**
Bypass (APB 7)	122	58
Early CF (APB 1-4, 9)	49	23
Late CF (APB 5)	38	18
Basemat Failure (APB 6)	2	1
Total	211	100

- the rebaselining of the IPE results to incorporate credit for three additional procedure modifications discussed previously
- the extension of the Level 2 IPE to a Level 3 assessment
- the updating of the population in the vicinity of the WBN Plant.

In order to provide a basis for concluding on the acceptability of the applicant's risk estimates, the staff has reviewed each of these analyses/processes, as summarized below.

The staff's review of the WBN Plant IPE is described in an evaluation report dated September 29, 1994 (NRC 1994a). That review included evaluation of the methodology, models, data, and assumptions used to estimate CDF and characterize containment performance and source term releases. In the IPE evaluation report, the staff concluded that the applicant's analysis met the intent of Generic Letter 88-20, that is, the IPE properly assessed and depicted core damage, severe accident progression, and containment response, together with the contributions from initiators and the failure of front-line safety and support systems. A further review of the Level 2 PRA performed as part of the SAMDA evaluation also supports this finding. Accordingly, the staff concludes that results of the revised IPE provides an acceptable platform for assessing the risk reduction potential of SAMDAs.

An extensive evaluation of the rebaselining of the IPE results to incorporate the three procedural modifications previously discussed was not performed as part of the present review. However, the staff notes that the applicant used the same methodology as in the IPE submittal, and that the rebaselined CDF and risk estimates are consistent with independent PRA assessments performed for similar plants. Furthermore, because the principal role of the rebaselined IPE results is to screen potential SAMDAs, precise CDF and risk estimates are not critical to the analysis. It is therefore concluded that the results of the rebaselined IPE analysis are adequate for purposes of meeting the SAMDA evaluation requirement.

The staff has reviewed the process used by the applicant to extend the Level 2 IPE to a Level 3 assessment. This process was carried out in two steps: (1) converting the WBN Plant release categories into the release categories or APBs used in the NUREG-1150 (NRC 1990d) study for SQN Site, and (2) scaling the weather and population distribution factors to account for the differences in the two sites.

The accident sequences from the WBN Plant IPE were first mapped into key plant damage states (KPDSs) using an applicant-developed spread sheet. The KPDSs were transformed into key release categories (KRCs) using the containment matrix developed during the updated IPE. The KRCs were then transformed into the SQN APBs using another applicant-developed spread sheet. In the applicant's analysis, 42 WBN Plant release categories were mapped into the 10 APBs used in the SQN Plant analysis. As an example, five release categories with common characteristics were mapped into APB #4, i.e., a vessel breach with vessel failure pressure at less than 200 pounds per square inch and containment failure occurring at vessel failure or soon afterward. The mapping process is documented in detailed spread sheets provided in the applicant's revised SAMDA submittal (TVA 1994a). Based on a review of the information provided in these spread sheets, the staff concludes that the conversion of the WBN Plant release categories into the SQN Plant APBs appears to have been performed properly, and is therefore acceptable.

The frequencies of the APBs were transformed into population dose by using population dose conversion factors calculated for SQN Plant and by scaling this value to account for population and weather differences between the SQN and WBN Sites. The scaling results in a factor of 4 reduction in the risk estimates. That is, given the same accident source terms at the WBN and the SQN Sites, the consequences for the WBN Site would be one fourth the consequences at SQN Plant for each release category and therefore for the overall risk (in person-rem). This would be the case despite the fact that the total population within an 80-kilometer (50-mile) radius surrounding the WBN Site is greater than the total population surrounding SQN Site (based on 1980 census data). The factor of 4 arises from the differences in the distribution of population and the differences in the atmospheric dispersion factors between sites. The key "distribution" difference is that, within a 32 kilometers (20-mile) radius (the area that would be most affected by a release from the containment) the population surrounding the WBN Site is less than one fourth the population surrounding SQN. This is primarily because the WBN Site is farther away from the Chattanooga metropolitan area than SQN. Although uncertainties exist in this scaling factor, the significance of these uncertainties is not large relative to other uncertainties and assumptions considered in this evaluation. The staff concludes that the scaling process is sound and that the value used (factor of 4) is appropriate.

The risk (and risk reduction) values reported in the June 30, 1994 SAMDA submittal (TVA 1994b) were based on the population in the vicinity of the WBN Site in 1980. The applicant's rebaselined estimates of risk reflect an upward adjustment from the prior analyses to account for the time-averaged population that would be expected over the life of the plant, specifically, between the years 1995 and 2035. This results in a 34% increase in risk. Recognizing the uncertainty in projecting the population and distribution of the population within the 80-kilometer (50-mile) region, the staff based its estimates of offsite risk on the projected population at the end of plant life rather than the average population over the 40-year period. This is equivalent to a 41% increase in population and offsite risk from the 1980 values.

In conclusion, the staff considers the methodology used by the applicant to estimate the offsite risk for the WBN Plant to provide an appropriate and sound basis from which to proceed with an assessment of risk reduction potential for candidate SAMDAs. The staff has based its assessment of offsite risk on the rebaselined values reported by the applicant, but has increased these values slightly (by about 6%) to account for a higher population at the end of plant life. It is important to note that although the WBN Plant IPE and risk estimation techniques may include some conservatisms, the values for CDF, risk, and the various risk contributors are best-estimate rather than conservative values. Typically, the 95th percentile values for person-rem risk would be about a factor of four higher than these "mean" values. The overall impact of uncertainties is discussed below.

7.2.3 Potential Design Improvements

Process for Identifying Potential Design Improvements

The applicant identified a set of potential SAMDAs for the WBN Plant through a systematic assessment of the key contributors to risk at the plant, and means by which this risk could be further reduced. The process for identifying design improvements included three major steps:

- review and characterization of residual risk at WBN Plant based on the IPE and Level 3 extension

- identification of potential design improvements from the plant-specific assessments

- identification of additional design improvements from generic studies and SAMDA analyses for other plants, including Comanche Peak and Limerick.

A determination was made of what drives the risk at the WBN Plant, in terms of initiating events, dependencies in safety systems or support systems, and containment failure characteristics. These characterizations focused attention on what improvements would have the greatest impact.

Plant-specific design enhancements were identified through a systematic process that included screening each sequence and top event from the Level 1 and Level 2 WBN Plant IPE analysis for potential improvements, and conducting importance analyses using the WBN Plant model and spreadsheets that were generated using the RISKMAN code. Generic design improvements were identified through a systematic process that included review and assessment of potential candidates assessed as part of (1) previous SAMDA reviews for other LWRs, such as Limerick; (2) the NRC Containment Performance Improvement (CPI) program; (3) Generic Letter 88-20; Supplement 2 (NRC 1990b), and (4) previous IPEs for plants having the same containment design (i.e., ice condenser) as the WBN Plant.

Screening criteria were developed and applied, as described in Section 3 of the applicant's Value Impact Analysis report (TVA 1994b). Those enhancements that passed the screening (i.e, that were classified as having a "high" risk reduction potential) were selected for further cost/benefit analysis. Based on this screening process, 26 SAMDAs were selected by the applicant for further analysis. Of these 26, three have been selected for implementation. The complete set of enhancements considered for the WBN Plant is described in Appendix B of the applicant's Value Impact report (TVA 1994b), along with the assessment/ classification of potential risk significance. The SAMDAs selected for further analysis and a summary of the corresponding Value/Impact results are listed in Table 7.4, and described below.

Design Improvements Evaluated in Detail by TVA

A brief summary of the 26 improvements evaluated quantitatively by the applicant and the anticipated benefits of each is provided below. The numbers in parentheses correspond to the design alternative number in the applicant's submittal.

Table 7.4 Summary of Value/Impact Study Results

Design Improvement	TVA Estimates			Staff Estimates		
	Cost ($$10^6$)	Averted Risk[a] (Person-rem)	$/Person-rem	Cost-AOSC[b] ($$10^6$)	Averted Risk[c] (Person-rem)	$/Person-rem
I. Improve Availability of ECCS Recirculation						
1. Procedure change to stop one train of sprays	d/	d/	d/	d/	d/	d/
2. Install containment spray throttle valves	0.20	1.1	180,000	0.13	4.1	32,000
3. Redesign to delay containment spray actuation	0.41	1.1	370,000	0.33	4.1	83,000
4. Install automatic high pressure recirculation	2.1	<1.1	1,900,000	2.0	4.1	500,000
II. Improve Availability of AC Power						
1. Procedure change to cross-tie 500kV and 161kV AC power	d/	d/	d/	d/	d/	d/
2. Accelerate availability of fifth diesel generator	0.43	4.9	89,000	0.41	6.0	68,000
III. Improve Ability to Cope with Loss of AC Power and SBO						
1. Procedure change to utilize existing spare 6900V/480V transformers	d/	d/	d/	d/	d/	d/
4. Install accumulators for turbine-driven AFW pump flow control valves	0.32	22	15,000	0.13	31	**4,500**
5. Provide DC load shed analysis and procedure	0.11	14	8,200	0.057	17	**3,500**
6. Provide portable battery charger	0.11	14	7,700	0.050	17	**3,100**
7. Install AC-independent coolant injection system	3.5	90	39,000	2.4	140	18,000
IV. Improve Ability to Cope with Loss of RCP Seal Cooling						
1. Install improved RCP seals[e]	0.16	8.5	19,000	0.018	15	**1,600**
1a. Install independent RCP seal cooling system (with new EDG)[f]	3.5	9.5	370,000	3.3	17	200,000
2. Install independent RCP seal cooling system (without new EDG)	2.4	11	220,000	2.2	19	120,000
3. Modify charging pump cooling from CCS to ERCW	0.30	19	16,000	0.031	30	**1,300**

Table 7.4 (contd)

Design Improvement	TVA Estimates			Staff Estimates		
	Cost ($\$10^6$)	Averted Risk[a] (Person-rem)	\$/Person-rem	Cost-AOSC[b] ($\$10^6$)	Averted Risk[c] (Person-rem)	\$/Person-rem
V. Improve Containment Performance						
1. Install deliberate ignition system	6.1	19	320,000	6.1	20	310,000
2. Install reactor cavity flooding system	8.8	90	98,000	8.8	95	93,000
3. Install filtered containment venting system	20	90	220,000	20	95	210,000
4. Install core retention device	45	61	720,000	45	65	680,000
5. Install containment inerting system	11	19	580,000	11	20	550,000
6. Install additional containment bypass instrumentation	2.3	0.9	2,700,000	2.3	0.9	2,500,000
7. Install reactor depressurization system	4.6	19	240,000	4.6	21	220,000
8. Install independent containment spray system	5.8	61	94,000	5.8	65	89,000
9. Install AC-independent Air Return Fan power supplies	1.0	19	53,000	1.0	20	50,000
VI. Miscellaneous						
1. Install MG set trip breakers in control room	0.14	2.8	52,000	0.054	6.4	9,000
2. Improve procedures for temporary HVAC during loss of room cooling	0.025	0.4	65,000	0.015	0.8	19,000

(a) Based on a 40-year plant life and projected average population over plant life. Does not include averted occupational exposure.
(b) Includes averted onsite costs, in accordance with NUREG/BR-0058.
(c) The sum of averted offsite risk and averted occupational exposure. Based on a 40-year plant life and projected population at end of plant life
(d) Design improvement will be implemented and is credited in the risk reduction estimates.
(e) Identified as Option III.2 and Option IV.1 in TVA analysis.
(f) Identified as Option III.3 in TVA analysis.

Category I - Improve Availability of ECCS Recirculation

This category of enhancements is intended to reduce the likelihood of failure of Emergency Core Cooling System (ECCS) in the recirculation mode, which is one of the dominant contributors to CDF for the WBN Plant. The applicant already has committed to implement a procedural enhancement to secure one train of sprays in events in which two trains of spray are not needed, such as small loss-of-coolant accidents (LOCAs) (Design Improvement I.1). This would improve the availability of ECCS recirculation by delaying the time of switch-over to recirculation, thereby reducing the potential for related human errors.

- Install Containment Spray Throttle Valves (I.2) - install additional valves in the containment spray system to allow throttling of spray flow, and provide procedures to support their use. This would provide additional time for operator recovery actions and further reduction in the susceptibility of the plant to ECCS recirculation failures.

- Redesign to Delay Containment Spray Actuation (I.3) - redesign the containment spray actuation system to delay (or eliminate unnecessary) system actuation in small LOCA events. This would extend the time to refueling waste storage tank (RWST) depletion and provide additional time to cool down without ECCS recirculation.

- Install Automatic High Pressure Recirculation (I.4) - automate the alignment of ECCS recirculation to the high-pressure charging and safety injection pumps to eliminate human errors made during manual realignment.

Category II - Improve Availability of AC Power

Loss of offsite power is a sizeable contributor to core damage and population dose. This category of enhancements is intended to improve the availability of AC power by providing access to alternate, diverse AC power sources. The applicant already has committed to implement a procedure to cross-tie the Unit 2 500kV grid to the 161kV power system at Unit 1 (Design Improvement II.1).

- Accelerate Availability of Fifth Emergency Diesel Generator (EDG) (II.2) - provide a fifth EDG as a backup to the two Unit 1 EDGs, and the two Unit 2 EDGs that will be transferred to Unit 1 with the licensing of Unit 1. This would increase the availability of AC power, further reducing the frequency of station blackout.

Category III - Improve Ability to Cope with Loss of AC Power & Station Blackout

The following are options for improving the WBN Plant's ability to cope with an extended loss of offsite power or station blackout. The applicant already has committed to implement a procedure to use spare 6900V to 480V transformers to supply shutdown boards (Design Improvement III.1).

- Install Accumulators for Turbine-Driven auxiliary feedwater (AFW) Pump Flow Control Valves (III.4) - provide control air accumulators for the turbine-driven AFW flow control valves, the motor-driven AFW pressure control valves, and the steam generator pressurizer power operated relief valves (PORVs). This would eliminate the need for local manual action to align nitrogen bottles for control air during loss of offsite power.

- Provide DC Load Shed Analysis & Procedure (III.5) - Provide detailed engineering analyses and procedures to extend battery life by shedding additional DC loads under station blackout conditions (in addition to the loads that would be shed under the existing load shed procedure). This would allow operation of the turbine-driven AFW pump for a longer period of time and would facilitate restoration of offsite power after 4 hours by extending availability of breaker control power.

- Provide Portable Battery Charger (III.6) - provide a portable, diesel-driven battery charger to ensure that DC power would remain available under station blackout conditions. This would allow operation of the turbine-driven AFW pump for a longer period of time and would facilitate restoration of offsite power after 4 hours by ensuring availability of breaker control power.

- Install AC Independent Coolant Injection System (III.7) - install an AC-independent coolant injection system capable of providing feed and bleed cooling of the reactor coolant system (RCS) under station blackout conditions.

Category IV - Improve Ability to Cope with Loss of RCP Seal Cooling

This category of enhancements includes items that would either improve reactor coolant pump (RCP) seal performance under loss of RCP seal cooling or prevent failure of the seals entirely.

- Install Improved RCP Seals (III.2 and IV.1) - install replacement RCP O-ring seals constructed of improved materials. The replacement seals would be capable of withstanding higher temperatures and would have a higher likelihood of remaining intact under loss of seal cooling conditions.

- Install Independent RCP Seal Cooling System (with new EDG) (III.3) - install a non-safety grade, manually actuated seal injection pump that is independently cooled (non-component cooling system [CCS]/essential raw cooling water [ERCW]) and independently powered (from a separate, small EDG). This would reduce the frequency of RCP seal LOCA in scenarios where the normal means of seal cooling (centrifugal charging pumps [CCPs]) has failed or is unavailable, including both station blackout and non-station blackout events.

- Install Independent RCP Seal Cooling System (without new EDG) (IV.2) - install a non-safety grade manually actuated seal injection pump that is independently cooled (non-CCS/ERCW), but powered from the existing emergency bus. This would reduce the frequency of RCP seal LOCA in scenarios where the normal means of seal cooling (CCS/ERCW) has failed or is unavailable, but would not be effective in station blackout events.

- Modify Charging Pump Cooling from CCS to ERCW (IV.3) - add a cross-connect to permit cooling CVCS Pump B with ERCW in the event that CCS is lost. (CCP A already has the capability to be cooled by ERCW; this enhancement involves providing ERCW cooling capability for the CCP B.) This would improve the ability to prevent RCP seal LOCAs in sequences involving loss of CSS.

Category V - Improve Containment Performance

These design changes would improve the ability of the containment to withstand the challenges associated with late hydrogen burn, late overpressurization, basemat melt-through, and containment bypass.

- Install Deliberate Ignition System (V.1) - provide an AC- and DC-independent system to promote ignition of combustible gases generated within the containment during severe accident scenarios. This would reduce the likelihood of containment failure from hydrogen combustion events during station blackout, when the existing hydrogen igniter system would be unavailable.

- Install Reactor Cavity Flooding System (V.2) - provide the capability to flood the reactor cavity of containment. This would reduce the possibility of direct contact of molten core debris with the containment liner, and could potentially mitigate the effects of direct containment heating and corium-concrete interactions.

- Install Filtered Containment Vent System (V.3) - provide the capability to vent the containment through a vent path routed to an external filter. This would reduce the frequency and offsite consequences of late containment over-pressure failures.

- Install Core Retention Device (V.4) - provide a core debris control device to prevent the direct impingement of core debris onto the primary containment steel shell during a high-pressure core melt ejection (HPME) event. The device would prevent the molten core material from contacting the containment shell by providing a barrier between the seal table and the containment shell in the seal table room. This enhancement would reduce the likelihood of containment failure resulting from HPME.

- Install Containment Inerting System (V.5) - install a containment inerting system to provide an inert containment atmosphere during power operation. This would reduce the threat to containment integrity from flammable gases, by preventing the combustion of hydrogen and carbon monoxide produced during core damage scenarios.

- Install Additional Containment Bypass Instrumentation (V.6) - install additional pressure-monitoring instrumentation between the first two isolation valves on the low-pressure injection lines, residual heat removal (RHR) suction lines, and high-pressure injection lines. The additional instrumentation would improve the ability to detect valve leakage or open valves, and would decrease the frequency of Inter-Systems Loss of Coolant Accident (ISLOCA).

- Install Reactor Depressurization System (V.7) - provide the capability to rapidly depressurize the reactor coolant system and allow injection from low-pressure systems. This would reduce the threat of direct containment heating (DCH) and induced failures of steam generator tubes in high pressure core melt sequences.

- Install Independent Containment Spray System (V.8) - provide an independent containment spray system to cool core debris and provide containment heat removal. This would prevent over-temperature and long-term overpressure by steam, and thus reduce the likelihood of containment failure.

- Install AC Independent Air Return Fan Power Supplies (V.9) - provide independent power supplies to the air return fans (ARFs) to preserve ARF functions for accident scenarios in which normal operation is not possible, e.g., during station blackout. Continued ARF operation would maximize the pressure-suppression capabilities of the ice condenser and prevent the accumulation of detonable concentration of hydrogen in the containment.

Category VI - Miscellaneous Enhancements

- Install Motor Generator (MG) Set Trip Breakers in Control Room (VI.1) - provide trip breakers for the MG sets in the WBN Plant control room. In the current design, an anticipated transient without scram (ATWS) would require an immediate action outside the control room to trip the MG sets. This enhancement would simplify that action and decrease the risk of an ATWS event.

- Improve Procedures for Temporary Heating Ventilation and Air-Conditioning (HVAC) During Loss of Room Cooling (VI.2) - develop procedures for providing temporary means of room cooling in the event of loss of room cooling, such as would occur in station blackout sequences. This would delay overheating and failure of ECCS, electrical, and other key support equipment that require room cooling to ensure component availability.

Staff Evaluation of Potential Design Improvements

The staff has reviewed the set of potential design improvements identified by the applicant in Appendix B to the applicant's Value Impact analysis (TVA 1994b), and find it to be comprehensive. The set includes the major improvements identified as part of the NRC CPI program, the accident management strategies identified by NRC in Generic Letter 88-20, Supplement 2 (NRC 1990b), and the NRC review of SAMDAs for Comanche Peak and Limerick (NRC 1989a, 1989b) that would be applicable to the WBN Plant. The set also includes potential design improvements oriented towards reducing the core damage frequency and risk from major contributors specific to the WBN Plant.

The set of design improvements selected by the applicant for detailed evaluation also appears to be reasonable. The improvements considered include a filtered containment vent, and flooded rubble bed core retention device, which are two improvements specifically called out in NUREG-0660 for evaluation as part of Three Mile Island (TMI) Item II.B.8.

The staff notes that the set of design improvements evaluated in detail by the applicant is not all-inclusive, in that (1) less expensive design improvements can be postulated that provide the same level of risk reduction potential afforded by several of the design options, and (2) the set does not include improvements to address the major contributor to risk at the WBN Plant, specifically steam generator tube rupture (SGTR). In this regard the staff requested further justification for not including several design improvements, including

- enhancements to reduce the risk from SGTR events, such as (1) improved instrumentation for responding to SGTR events, (2) improved depressurization capabilities or procedures to terminate releases in unisolatable SGTR events, and (3) additional systems to scrub fission product releases or to route these releases back to the containment

- provision of alternate power to the existing igniters from an existing onsite power source rather than the more elaborate system considered by the applicant

- use of manual RCS depressurization using existing plant hardware rather than the dedicated system considered by the applicant

- use of the fire water system as a backup to either the containment spray system, or systems that provide injection pump cooling

- use of a hydrostatic test pump as a backup for RCP seal injection/cooling.

In response to the staff's request, the applicant provided additional justification as to why these potential enhancements would not be cost effective for the WBN Plant, and were therefore not considered further. Key points raised by the applicant in their responses were that

- It would be difficult to further reduce risk from SGTR events since the dominant SGTR sequences involve failures caused by human actions, and human error rates assumed for these actions are already low (about 1E-4). Furthermore, the SGTR-related improvements identified would entail significant modifications or analyses, and would far exceed the value of the risk associated with SGTR events.

- Hydrogen combustion related failures of containment account for less than 10% of the total risk at the WBN Plant, due in large part to the existing AC-powered hydrogen ignition system. Since the majority of the remaining loss of offsite power risk is due to long-term (i.e., battery depletion) type station blackout events, the value of using existing station batteries to supply backup power to the igniters would not generally be effective. The cost of other alternate power supplies would also not be justified because of the low remaining level of risk.

- Based on thermal-hydraulic analyses performed for the applicant, the existing PORVs and head vents do not have sufficient capacity to effectively depressurize the RCS. Although manual depressurization may moderate the pressure in the RCS and thus post-failure containment loads, the applicant indicates that pressures sufficient to allow low pressure injection to discharge or to prevent debris dispersal from the reactor would not be reached, and that manual depressurization may preclude thermally-induced creep-rupture of the hot leg, which is more desirable. Thus, manual actions to depressurize were not considered further.

- The benefit of using the fire water system as a backup for either containment spray or injection pump cooling would be very limited because all of the WBN Plant high-pressure fire pumps are AC-powered and therefore would not be available in station blackout events.

- Although a hydrostatic pump is available, the complications that would be involved in making the proper connections in the allotted time reduce the effectiveness of this option and preclude this from being simply a "procedural" modification.

The staff has reviewed the applicant's rationale for not considering these design options for further analysis and finds it to be reasonable.

The staff concludes that the applicant has used a systematic and comprehensive process for identifying potential design improvements for the WBN Plant, and that the set of potential design improvements identified and evaluated by the applicant is reasonably comprehensive and therefore acceptable.

7.2.4 Risk Reduction Potential of Design Improvements

TVA Evaluation

Those design enhancements that passed the preliminary screening process were further defined by the applicant in terms of specific hardware or procedural enhancements that would be involved, such that quantitative estimates of risk reduction potential and costs could be developed.

The general process used by the applicant to determine the risk reduction potential for each enhancement involved determining the approximate effect that the design change would have on the related event tree top events, reflecting that impact by modifying the associated spread sheets, and calculating a new value of CDF and total risk. A plant damage state spread sheet was used to total the plant damage states resulting from the various sequences and to transfer the frequencies to the Level 2 portion of the PRA. A Level 2 spreadsheet was used to translate the plant damage state frequency to radiological release category frequencies. A release category spreadsheet was used to translate the release category frequencies into accident progression bin frequencies. Based on the updated accident progression bin frequencies, the new dose to the public and the difference from the base case was calculated.

The applicant's basis for estimating the risk reduction for each design improvement is provided in Section 4 of the applicant's Value Impact analysis (TVA 1994b) and is summarized in Table 7.5. The corresponding risk reduction estimates are provided in Table 7.4 (Summary of Value/Impact Study Results). The staff's review of the applicant's risk reduction estimates is provided in the section below.

Staff Evaluation

The staff has reviewed the applicant's bases for estimating averted risk for the various design improvements. In reviewing the applicant's analysis, one significant deviation from the NRC's guidance for estimating the benefit of potential design changes was noted. Specifically, the applicant has estimated the benefit of each enhancement only in terms of the averted offsite risk. The applicant's analysis did not consider averted occupational exposures or averted onsite property damage in evaluating the cost-effectiveness of proposed enhancements that reduce core damage frequency.

With regard to estimating averted offsite risk, the staff notes that the applicant has used considerable judgement in assessing the impact of each design change on the WBN Plant risk profile, and that the rationale and assumptions on which the risk reduction estimates are based (summarized in Table 7.5) are reasonable and generally conservative. The staff has based its estimates of averted offsite risk for the various SAMDAs on the applicant's rebaselined risk reduction estimates, but has increased these values slightly (by about 6%) to account for a higher population at the end of plant life.

With regard to design improvements that reduce core damage frequency, the staff has estimated the averted occupational exposures (and averted onsite property damage) and included this risk reduction in the staff estimates of averted risk for the relevant SAMDAs. The basis for these estimates is described in Section 7.2.5. The staff estimates for averted risk, which reflect a sum of averted offsite and onsite risk, are presented in Table 7.4 for each of the candidate design improvements. These risk reduction estimates are used as the basis for the staff's cost/benefit comparison described in Section 7.2.6.

Table 7.5 Summary of TVA's Assessment of Risk Reduction for Candidate Design Improvements

Potential TVA Design Modification	TVA's Basis for Estimating Risk Reduction
I.1 Procedure change to stop one train of sprays	Reduce operator error rates for recovery of failed valves
II.1 Procedure change to facilitate cross-tie of 500 kV and 161 kV AC power	Increase probability of recovering offsite power
III.1 Procedure change to use existing spare 6900/480 V transformers	Reduce the frequency of failure of the 480 V shutdown boards associated with unavailability during transformer maintenance
I. Improve Availability of ECCS Recirculation	
I.2 Install containment spray throttle valves	Reduce operator error rates for recovery of failed valves
I.3 Redesign to delay containment spray actuation	Reduce operator error rates for recovery of failed valves
I.4 Install automatic high pressure recirculation	Use risk reduction benefit associated with Enhancement I.1
II. Improve Availability of AC Power	
II.2 Complete fifth emergency diesel generator	Ensure all four 6.9-kV shutdown boards are supported by an operable EDG, even when one is in maintenance.
III. Improve Capability to Cope with Loss of AC Power and Station Blackout	
III.2 Install improved RCP seals	Reduce the probability of RCP seal failure by a factor of four. Increase the likelihood of recovery of offsite power by a factor of 10 to reflect the additional time available to recover power before a seal LOCA
III.3 Install independent RCP seal cooling system (with new EDG)	Increase the likelihood of recovery of offsite power to reflect the additional time available to recover offsite power given a seal LOCA was avoided
III.4 Install accumulators for turbine-driven AFW pump flow control valves	Eliminate dependence of AFW pump flow control valves on the essential control air system, and reduce the operator error rate for SBO conditions
III.5 Provide DC load shed analysis & procedure	Extend battery life indefinitely, and ensure availability of breaker control power
III.6 Provide portable battery charger	Extend battery life indefinitely, and ensure availability of breaker control power
III.7 Install AC-independent coolant injection system	Similar to Item III.5, except that core uncovery would occur in 8 hours due to the loss of primary system inventory as a result of RCP seal LOCA

Table 7.5 (contd)

Potential TVA Design Modification	TVA's Basis for Estimating Risk Reduction
IV. Improve Capability to Cope with Loss of RCP Seal Cooling	
IV.1 Install improved RCP seals	Same as Enhancement III.2
IV.2 Install independent RCP seal cooling system (w/o new EDG)	Similar to Item III.3, except this applies only to non-SBO seal LOCAs. Add an operator action to initiate
IV.3 Modify charging pump cooling from CCS to ERCW	Eliminate all core damage sequences involving loss of CCS cooling
V. Improve Containment Performance	
V.1 Install deliberate ignition system	Eliminate all containment failures due to hydrogen burns
V.2 Install reactor cavity flooding system	Eliminate containment failures that result from direct contact of melt, CCI, and DCH
V.3 Install filtered containment vent system	Eliminate containment failures that result from direct contact of melt, CCI, and DCH
V.4 Install core retention device	Eliminate all containment failures except those associated with bypass events (APB #7) and containment failures that occur with the reactor vessel intact (APB #1 and #2
V.5 Install containment inerting system	Eliminate all containment failures due to hydrogen burns
V.6 Install additional containment bypass instrumentation	Reduce the frequency of ISLOCA scenarios by a factor of two
V.7 Install reactor depressurization system	Eliminate all containment failures associated with reactor vessel breach at high RCS pressure (APB #3)
V.8 Install independent containment spray system	Eliminate all containment failures except those associated with bypass events (APB #7) and containment failures that occur with the reactor vessel intact (APB #1 and #2)
V.9 Install AC-independent air return fan power supplies	Eliminate all containment failures due to hydrogen burns
VI. Miscellaneous Enhancements	
VI.1 Install MG set trip breakers in control room (ATWS)	Eliminate all failures to trip the reactor
VI.2 Improve procedures to provide temporary HVAC during loss of room cooling	Requantify assuming room cooling not needed for equipment operability

7.2.5 Cost Impacts of Candidate Design Improvements

Applicant Evaluation

The applicant's method for determining costs for each potential design improvement is documented in Section 3.2.1 of the June 30, 1994 Value Impact submittal (TVA 1994b). The applicant developed cost estimates for each implementation option from either a site-specific engineering estimate or, for the major modifications, from industry and/or NRC cost data. The site-specific estimates consider four major cost categories (engineering, material, construction, and equipment maintenance) with subcategories (e.g., development of training modules, bulk commodities, trade labor) defined by the requirements of the proposed enhancement. For certain design improvements, the applicant also cites a more detailed analysis of similar scope prepared for the Sequoyah plant as evidence that its cost estimate is biased low.

In the original Value Impact study submitted on June 30, 1994 (TVA 1994b), the applicant failed to discount recurring costs for two design improvements. However, the cost estimates reported for these design options in the final SAMDA submittal (TVA 1994c) were revised to include appropriate discounting. The applicant's cost estimates are reported in Table 7.4, based on the final SAMDA submittal (TVA 1994c).

Staff Evaluation

The staff has reviewed the bases for the applicant's cost estimates. For certain improvements, the staff also compared TVA's cost estimates with estimates developed elsewhere for similar improvements, even though the bases for some of these cost estimates were different. The staff considered the cost estimates developed as part of the evaluation of design improvements for Limerick and Comanche Peak (NUREG-0974 [NRC 1989a] and NUREG-0775 [NRC 1989b], respectively) and for the evolutionary advanced light-water reactors (ALWRs).

Except for the few exceptions noted below, the applicant's cost estimates are judged to reflect valid bases and assumptions, and their accuracy is considered sufficient to provide a reasonable and appropriate basis for the SAMDA analyses, given the uncertainties surrounding the underlying cost estimates and the level of precision necessary given the greater uncertainty inherent on the benefit side, with which these costs were compared. The exceptions involve

- use of fully burdened labor rates in estimating the costs of the proposed enhancements

- apparent over-estimates of the costs associated with two specific design improvements.

The staff has based its estimates of the costs of the various candidate improvements on the applicant's cost estimates, with consideration of these concerns, as discussed below.

Use of fully burdened labor rates is appropriate when the work will be performed by contractor rather than the applicant's personnel. However, where the applicant's personnel are expected to perform specific functions (notably engineering, quality assurance (QA)/quality control (QC), and training functions), the costs incurred by the applicant will likely only be the marginal labor costs. For most of the enhancements evaluated by the applicant, re-estimation of the costs to reflect the applicant's marginal labor costs would not make a significant difference in the overall evaluation, and therefore was not considered further in the staff's assessment. However, as discussed below, use of alternative cost assumptions could impact the overall evaluation for three SAMDAs, specifically, Install Improved RCP Seals (Enhancements III.2 and IV.1), Modify Charging Pump Cooling from CCS to ERCW (Enhancement IV.3), and Provide DC Load Shed Analysis and Procedures (Enhancement III.5).

Install Improved RCP Seals (Enhancement III.2 and IV.1)

The applicant's estimate for installing improved RCP seals is $162,800, based on an estimate of $2,800 for the engineering approval and $160,000 for the replacement seal cartridges. No construction or maintenance costs are attributed to the enhancement by the applicant, as its estimate assumes that the improved RCP seals would be installed and/or replaced as part of routine seal re-builds during future outages.

The applicant did not clearly state if this enhancement is to be accomplished prior to plant startup or during future outages. If the enhancement is to be accomplished prior to plant startup, then the estimate appears to be low in that it does not include the labor costs that would be incurred in installing the improved seals. Normally, labor costs for installation are roughly equal to material costs; an estimate of about $320,000 would seem appropriate to use for this enhancement if the change is to be made prior to plant startup.

On the other hand, if the enhancement is to be implemented during future outages, then the attribution of the total costs of the improved seals ($40,000 per cartridge) to the enhancement is high. If the change is to be made only after the existing seals have reached the end of their service life, the cost should only be the minor engineering costs for change approval plus the delta cost of the improved seals. Assuming the $40,000 per cartridge provided by the applicant is the total cost per cartridge, an estimate of $18,800 to $34,800 (10 - 20% surcharge for the improved seals) for this enhancement at a future date would seem reasonable. Estimated benefits would need to be adjusted to reflect remaining plant life to accurately evaluate the cost/benefit for implementing this enhancement at a future date.

The staff has based its assessment of this design option on the cost estimates provided by the applicant, but has considered the impact of potentially lower installation costs in reaching conclusions on improvements in this area.

Modify Charging Pump Cooling from CCS to ERCW (Enhancement IV.3)

The applicant's estimate to modify the charging pump cooling configuration to allow cooling by ERCW is $295,200. This estimate is derived from an engineering analysis that considers the need to evaluate the current design for the intended application, the physical changes to piping systems and new hardware that will be required, and the need to develop procedures and provide additional training for operators.

While the applicant's estimate provides few details of the labor hours and costs assumed in costing this enhancement, its estimate of $295,200 seems reasonable considering the scope of the analyses and physical modifications that need to be performed. However, it is not clear from the applicant's SAMDA analysis (TVA 1994b) why contractor engineering support (estimated by the applicant at $159,000 or more than one-half of the total costs) is needed to perform this analysis. If in-house staff are used, the real cost of the enhancement may only be the marginal labor costs.

The staff has based its assessment of this design option on the cost estimates provided by the applicant, but has considered the impact of potentially lower installation costs in reaching conclusions on improvements in this area.

Provide DC Load Shed Analysis and Procedures (Enhancement III.5)

The applicant's estimate of the costs to provide DC load shed analysis and procedures is $113,200. This enhancement would involve performing an engineering analysis that considers the need to revise the station blackout coping analysis and associated procedures and providing additional training for operators and licensing support.

While the applicant's estimate provides few details of the labor hours and costs assumed in costing this enhancement, its estimate of $113,200 seems reasonable considering the scope of the analyses that need to be performed. However, it is not clear from the applicant's SAMDA analysis (TVA 1994b) why contractor support (estimated by the applicant at $75,000 or two-thirds of the total costs) is needed to perform this analysis. If in-house staff are used, the real cost of the enhancement may only be the marginal labor costs.

The staff has based its assessment of this design option on the cost estimates provided by the applicant, but has considered the impact of potentially lower installation costs in concluding on the need for any improvements in this area.

In addition to the concerns related to use of fully burdened labor rates in estimating the costs of the proposed enhancements, the costs associated with two specific design improvements may be over-estimated in the applicant's analysis, specifically with regards to the Install Additional Containment Bypass Instrumentation (Enhancement V.6) improvement and the Install MG Set Trip Breakers in Control Room (Enhancement VI.2) improvement. The impact is discussed below.

Install Additional Containment Bypass Instrumentation (Enhancement V.6)

The applicant's estimate of the cost to install additional containment bypass instrumentation is $2.3 million. This value was taken from the estimate made by Texas Utilities for a similar enhancement at Comanche Peak. The Comanche Peak estimate of $2 million (in 1989 dollars) includes $100,000 for equipment, material, and subcontracts; $1.3 million for installation; $300,000 for engineering and QA; and $300,000 for "Owner's Support Cost."

With no details given to support the Comanche Peak estimate, it is difficult to evaluate its reasonableness. Given the relatively modest scope of the enhancement (installing pressure sensors on the low pressure safety injection (LPSI), RHR suction, and high pressure safety injection (HPSI) lines) the estimated costs (particularly for installation) may be considerably lower. However, the cost/benefit ratio for this design change is several orders of magnitude greater than the $1,000 per person-rem screening criterion, as discussed in Section 7.2.6. Thus, this option would not be cost beneficial even if the costs were significantly lower.

Install MG Set Trip Breakers in Control Room (Enhancement VI.2)

The applicant's estimate of the cost to install MG set trip breakers in the WBN Plant Control Room is $142,500. This estimate is based on an engineering estimate that provides $34,400 for engineering, $11,700 for materials, $71,200 for construction, and $25,200 for procedure changes and training.

Given the relatively minor scope of this enhancement, the applicant's estimates of the necessary engineering support and construction labor appear high. Engineering is estimated to require 615 hours, which is significantly higher than the estimates for Enhancements III-2 (50 hours), III-4 (410 hours), and III-6 (300 hours). Construction, which the applicant states involves three 150 meters (500 feet) cabling runs, an additional relay panel, and mounting several relays, is estimated to require 2,327 hours of trade labor. Although these estimates may be high, the cost/benefit ratio for this design change is over an order of magnitude greater than the $1,000 per person-rem screening criterion, as discussed in Section 7.2.6. Thus, this option would not be cost beneficial even if the costs were substantially lower.

A final note concerns the applicant's cost estimates for completing the fifth emergency diesel generator (Enhancement II.2). In its October 7, 1994 revision to the SAMDA analysis (TVA 1994c), the applicant makes it clear that the issue for this enhancement is whether or not to provide a fifth emergency diesel generator, rather than when such a generator would be available as implied in their June 30, 1994 submittal (TVA 1994b). On that basis, the revised cost estimate provided by the applicant in their final SAMDA submittal is judged to be reasonable and appropriate.

7.2.6 Cost-Benefit Comparison

Applicant Evaluation

Once the costs and benefits of the candidate enhancements were developed, the applicant calculated the cost/benefit ratio for each enhancement by dividing the dollar cost of the enhancement by the estimated offsite dose averted. The applicant's estimates of the cost per person-rem averted for the various design and procedural improvements are presented in Table 7.4. These values are based on the applicant's estimates of averted offsite risk and, for design changes that reduce core damage frequency, do not reflect the impact of averted onsite risk and averted onsite costs.

Consistent with current NRC practice (NRC 1983), the applicant used a screening criterion of $1,000 per person-rem averted to identify whether any of the design improvements could be cost-effective. On this basis, none of the remaining 23 enhancements (beyond the three procedure improvements already committed to by the applicant) are judged by the applicant to be cost-effective.

This conclusion is premised on the WBN Plant PRA model, which incorporates credit for three procedural modifications which, in an earlier SAMDA assessment, showed "cost per person-rem averted" in the range of $600 to $5,000. Thus cost-effective modifications have already been made, in part motivated by the SAMDA process.

Of the 23 potential enhancements, the applicant estimates that 2 have cost/benefit ratios between $1,000 and $10,000 per person-rem, 10 have cost/benefit ratios between $10,000 and $100,000 per person-rem, and the remaining 11 have cost/benefit ratios greater than $100,000 per person-rem. The applicant does not anticipate the implementation of any of these remaining SAMDAs.

Staff Evaluation

As noted previously, the applicant estimated the benefit of each enhancement only in terms of the averted public (offsite) dose, and did not consider averted onsite costs (AOSC) or averted occupational exposures (on-site risk) in evaluating the cost effectiveness of the proposed enhancements. Accordingly, the staff developed estimates of the cost-effectiveness of the SAMDAs; these estimates were developed in terms of both dollars per person-rem and value/impact ratios.

The dollars per person-rem estimates reflect net costs and are calculated as

$$\text{Dollars per Person-Rem} = \text{COE} - \text{AOSC} / \text{APE} + \text{AOE}$$

where COE = Cost of Enhancement ($)
AOSC = Averted Onsite Costs ($)
APE = Averted Public Exposure (person-rem)
AOE = Averted Occupational Exposure (person-rem).

The value/impact (V/I) estimates also reflect net costs and are calculated as

$$V/I = \$APE + \$AOE + AOSC / COE$$

where COE and AOSC are as defined above and

\$APE = Monetized Value of Averted Public Exposure ($)
\$AOE = Monetized Value of Averted Occupational Exposures ($).

In both the dollars per person-rem and value/impact calculations, future costs have been discounted at 7%. In calculating the value/impact ratios, averted exposures are monetized using a value of $1,000 per person-rem, with no discounting of future exposures.

The calculated value/impact ratios and dollars per person-rem estimates for each of the proposed enhancements accounting for averted offsite costs and averted onsite property damage and occupational exposure are presented below. In computing these ratios, the estimated change in core damage frequency and the estimated cost for the enhancement are taken directly from the applicant's final SAMDA submittal (TVA 1994c). The averted offsite risk estimates are also based on the applicant's estimates with a slight adjustment to account for the population at the end of plant life.

The estimates of averted occupational exposure (AOE) are calculated as

AOE = Annual core-damage frequency reduction
x occupational exposure per core-damage event
x number of years of plant life remaining.

The estimates of averted occupational exposure are based on the best estimate of 21,000 person-rem per event given in NUREG/BR-0184 and assume 40 years of plant life remaining. The lower and upper bounds provided in NUREG/BR-0184 are 0 and 41,000 person-rem per event.

The estimates of AOSC include cleanup and power replacement costs. Averted cleanup costs (ACC) are calculated as:

ACC = annual core-damage frequency reduction
x present value of cleanup costs per core-damage event
x discount factor accounting for plant life remaining.

The estimated cleanup cost for severe accidents is given as 1.5 billion dollars in NUREG/BR-0184. This cost is the sum of equal annual costs over a 10-year cleanup period. At a 7% discount rate, the present value of this stream of costs is $1.1 billion. A discount factor of 13.33 accounts for the 40-year lifetime of the plant, yielding an integrated cleanup cost of 14 billion dollars.

The estimated integrated cost of replacement power is $6.2 billion. This value is taken from the individual plant calculations performed to derive the estimates of long-term replacement power presented in NUREG/CR-6080 (NRC 1993).

Summing the integrated cleanup cost of $14 billion and the integrated power replacement cost of 6.2 billion dollars yields an "at risk value" of $20 billion for onsite costs. This "at risk value" of $20 billion, multiplied by the estimated change in core damage frequency for a given enhancement, yields the expected AOSC for each enhancement.

The resulting staff cost/benefit ratio values are reported in Table 7.4. Consistent with the results of the applicant's assessment, the NRC staff assessment indicates that none of the design or procedural improvements fall below the $1,000 per person-rem criterion. However, several of the candidates (the 5 improvements indicated in bold in Table 7.4) fall within a factor of 5 of the $1,000 per person-rem criterion. Additional cost/benefit elements are provided in Table 7.6 for these five SAMDAs. The fourth and fifth columns show

Table 7.6 Value/Impact Ratios for Selected Design Improvements

	Design Improvement	Cost[a] ($)	AOSC[b] ($)	Averted Risk (Person-Rem): Offsite	Averted Risk (Person-Rem): Onsite	Value/Impact Ratio: AOSC as a Cost Offset[c] ($/person-rem)	Value/Impact Ratio: AOSC as a Benefit[d] (Dimensionless)
III.4	Install accumulators for AFW pump flow control valves	325,000	184,000	23	8	4500	0.66
III.5	Provide DC load shed analysis and procedure	113,000	55,000	15	2	3500	0.63
III.6	Provide portable battery charger	107,000	55,000	15	2	3100	0.67
IV.1	Install improved RCP seals	163,000	139,000	9	6	1600	0.95
IV.3	Modify charging pump cooling from CCS to ERCW	295,000	255,000	20	10	1300	0.96

(a) Values reported by TVA. Values do not include Averted Onsite Costs (AOSC)
(b) Staff values for Watts Bar based on: AOSC = [$2.02E10] x [Δ CDF/y]
(c) Current practice: $/Person-Rem = [Cost - AOSC] / [Averted Risk]
(d) Proposed practice: V/I = [(Averted Risk) x ($1000/person-rem) + AOSC] / [Cost]

the staff's estimates of averted offsite (public) and onsite (occupational) risk. The last two columns show the impact of treating AOSC either as a cost offset, as in the current staff approach, or as a benefit, as in a proposed staff approach that is currently under consideration. In the latter case, value/impact ratios of 1 or greater would be judged cost beneficial. None of the SAMDAs have a value/impact greater than 1.

A more detailed assessment for the five SAMDAs was performed, recognizing the uncertainties inherent in the cost/benefit analysis and the screening nature of the assessment. This assessment was based on both probabilistic and deterministic considerations and is summarized below.

Install Accumulators for Turbine Driven AFW Pump Flow Control Valves and Steam Generator PORVs (Enhancement III.4)

This proposed design alternative involves installing control air accumulators for the turbine-driven AFW flow control valves, the motor-driven AFW pressure control valves, and the steam generator PORVs. This would eliminate the need for local manual action to align nitrogen bottles for control air during loss of offsite power. The applicant estimated that a total of about 22 person-rem or 10% of the risk at the WBN Plant would be eliminated through this modification.

The staff has considered the benefits provided by backup accumulators for these air-operated valves and concludes that such an improvement is not justified at the WBN Plant. For a complete loss of AC power and for certain Appendix R fire scenarios, air to the flow control valves for the turbine driven AFW pump could be lost. Operator action outside the control room is acceptable under these conditions. The operator actions required at the WBN Plant involve manually isolating the compressed air from the control valves and then aligning nitrogen bottles to supply motive force for the valves. All of these actions are via locally operated manual valves. Such operator actions are not uncommon for coping with complete station black-out and certain fire scenarios at many of the existing nuclear plants. The staff considers reliance on these manual actions adequate for meeting the station blackout rule and the fire protection requirements and, therefore, acceptable. Accordingly, modifications to install backup accumulators are not needed at the WBN Plant.

Provide DC Load Shed Analysis & Procedure (Enhancement III.5)

This proposed design alternative involves performing a detailed, time-dependent analysis of all DC loads and developing a detailed load shed procedure to eliminate all loads that could possibly be shed. Additional sequencing of systems (on and off) to provide additional reductions in battery loads would be considered. the applicant estimated that a total of about 14 person-rem or 7% of the risk at the WBN Plant would be eliminated through this modification, based on the assumption that improved load shed procedures would extend the life of the station batteries indefinitely.

As noted in Section 7.2.5, the cost of this design improvement may be significantly less than estimated by the applicant if the work is performed by the applicant's staff rather than by a contractor. Regardless, the

NRC staff does not believe that significant risk reduction can be achieved through this improvement since the applicant has already committed to implement a load shed procedure in order to comply with the station blackout rule. The staff approved the applicant's station blackout coping analyses for the WBN Plant. The staff found that the DC power system will have adequate capacity for station blackout duration of 4 hours by shedding non-essential loads (the applicant identified the loads that will be shed after 30 minutes during an station blackout event). The staff stated that the applicant should make sure that the loads that are needed for coping with station blackout and that are needed by the operators for monitoring important parameters are not shed. As part of the coping analysis, the extension of battery duty cycle (battery capacity available beyond 4 hours) by shedding additional non-required loads was reviewed by the licensee and determined to be ineffective. The staff agrees with that assessment based on the following considerations: (1) few additional loads can be shed, (2) more elaborate load shed procedures may unnecessarily burden operators to shed additional loads individually, and (3) the ability to cope with station blackouts lasting significantly longer than 4 hours would be limited by long term availability of condensate inventory, a compressed air system, a HVAC system, containment isolation, and reactor inventory.

The staff concludes that this improvement is not warranted because of the practical limitations on the effectiveness of this improvement, combined with the relatively small estimated risk reduction both in absolute terms and as a fraction of the total risk.

Provide Portable Battery Charger (Enhancement III.6)

This proposed design alternative involves providing a portable, diesel-driven battery charger to ensure that DC power would remain available under station blackout conditions. This would allow operation of the turbine-driven AFW pump for a longer period of time and would facilitate restoration of offsite power after 4 hours by ensuring availability of breaker control power. The applicant estimated that a total of about 14 person-rem would be eliminated through this modification, based on the assumption that a portable battery charger would extend the life of the station batteries indefinitely.

The staff agrees that a portable, diesel-driven battery charger will assure the availability of DC power for a longer period of time. However, for the same reasons as cited above, batteries alone do not assure the ability to cope with a station blackout of longer duration. The continued availability of condensate inventory, compressed air, HVAC, containment isolation, and reactor inventory would also need to be ensured. The staff concludes that this improvement is not warranted because of the practical limitations on the effectiveness of this design improvement and the relatively small estimated risk reduction.

Install Improved RCP Seals (Enhancement III.2)

This proposed design alternative involves replacement of the current RCP O-ring seals with seals constructed of improved materials. The replacement seals would be capable of withstanding higher temperatures and would have a higher likelihood of remaining intact under loss of seal cooling conditions.

The applicant estimated that about 9 person-rem or 4% of the total risk would be eliminated through this modification, based on the assumption that installation of improved seals would reduce seal LOCA frequency by a factor of 4.

The staff believes that improved RCP seals would not be as effective in reducing the frequency of seal LOCA as represented in the applicant's assessment. A recent study, NUREG/CR-5167 (NRC 1991), explored the benefits of improved seal materials. This study found that while improved elastomers will extend the time to seal failure and thereby increase the probability of cooling recovery, improved elastomers in the secondary seals would have little or no effect on the probability of primary seal failure by the "popping open" mode under loss of cooling conditions. "Popping open" failures are primarily induced by two-phase flow instabilities in the seals and are not directly related to secondary seal materials. Based on information developed in the study, the probability of core uncovery due to seal failure would be reduced by less than a factor of two using the improved seals.

NRC Generic Issue 23 (GI-23) addresses concerns related to RCP seal LOCA. The results of that study have indicated that currently operating PWR provide adequate protection to the public health and safety without additional requirements. A proposed rule addressing loss of integrity of RCP seals is being considered for public comment and is intended to be viewed as a safety enhancement. The staff proposed rule is performance-based and would allow licensees to demonstrate that no further actions are needed to address RCP seal vulnerabilities on the basis that the risk of core damage attributable to such vulnerabilities is sufficiently low. The staff anticipates that licensees would evaluate potential corrective or mitigative actions to reduce the frequency of seal failure if the estimated mean value of CDF from seal LOCA falls in the range E-5 to E-4, and that licensees would implement corrective or mitigative actions if the mean value is estimated to be greater than E-4. The frequency of RCP seal failure due to loss of seal cooling at the WBN Plant is about 1E-5 (16% of the total CDF). Thus, the WBN Plant falls in the range where licensees would be expected to consider appropriate corrective or mitigative actions, but is below the level at which we would expect licensee implementation of corrective or mitigative actions.

On the basis of the estimated frequency of core damage due to seal LOCA, combined with the relatively small estimated risk reduction associated with this improvement, the staff concludes that imposition of licensee actions to address the RCP seal issue are not justified for further mitigating environmental concerns. The staff notes that the WBN Plant will be undergoing a more detailed evaluation of RCP seal integrity when the final resolution of GI-23 is implemented, and that, as a result of that activity, the staff's position can change.

Modify Charging Pump Cooling from CCS to ERCW (Enhancement IV.4)

This proposed design alternative involves adding a cross-connect to permit cooling CVCS Pump B with ERCW in the event that CCS is lost. Centrifugal charging Pump A (CCP A) already has the capability to be cooled by ERCW; this enhancement involves providing ERCW cooling capability for the CCP B. This would improve the ability to prevent RCP seal LOCAs in sequences involving loss of containment spray system (CSS). The applicant estimated that about 19 person-rem or 9% of the total risk would be eliminated through this modification.

The applicant's risk reduction estimate for this design improvement is considered reasonable. (The aforementioned concern related to seals "popping open" is not relevant to this design improvement, since two-phase flow would not occur in sequences in which this design option is successfully implemented.) However, as noted in Section 7.2.5, if the work is performed by the applicant's staff rather than by a contractor, the cost of the design improvement may be considerably less than estimated by the applicant. This would render the improvement cost beneficial in accordance with the NRC Value Impact Analysis guidelines.

The staff notes that this design improvement has a relatively low cost and favorable impact on core damage frequency and risk. According to the applicant's estimates, total core damage frequency would be reduced by about 20% (to 4.5E-5 per year), and offsite risk would be reduced by about 10%. However, NRC will not require further action by the applicant to address this issue prior to the resolution of GI-23. The staff expects that the WBN Plant would undergo a more detailed evaluation of RCP seal integrity when the final resolution of GI-23 is implemented, and that this modification as well as other improvements would be further evaluated as part of that activity.

In summary, the staff concludes that none of the five design improvements discussed above warrant implementation for the WBN Plant. With one possible exception, none of the design improvements would be cost beneficial based on the staff's cost benefit analysis. The one exception involves the modification of the charging pump cooling piping configuration to reduce support system dependencies and is expected to be further evaluated by the licensee as part of the resolution of the generic issue concerning integrity of reactor coolant pump seals. Furthermore, the largest risk reduction estimated for any of the five improvements is about 20 person-rem or approximately 10% of the total risk at the WBN Plant. Thus, even if these design changes could be shown cost beneficial on the basis of lower installation costs, risk at the WBN Plant would not be significantly impacted through implementation of any of the design improvements.

All of the remaining SAMDAs have a cost/benefit ratio of about an order of magnitude or more greater than the $1,000 per person-rem criterion, and were not evaluated further. The factor of 10 is considered to provide ample margin to cover uncertainties in risk and cost estimates, given that, in general, estimates for these factors were conservatively evaluated.

7.2.7 Conclusions

The applicant has completed a comprehensive, systematic effort to identify and evaluate potential plant enhancements to mitigate the consequences of severe accidents at the WBN Plant. As a result of this assessment, the applicant identified and committed to implement three enhancements to the WBN Plant operating procedures. These procedure changes involve (1) stopping one train of containment spray in order to delay the need to switch over to recirculation, (2) cross-tying the 500kV power at Unit 2 to the 161kV power system at Unit 1, and (3) using a spare 6800V to 480V transformer to supply the 480 V shutdown boards. The applicant has concluded that no additional design enhancements are cost-effective for the WBN Plant, i.e., there are no candidate improvements with a cost/benefit ratio below the $1,000 per person-rem screening criterion.

Based on its review of SAMDAs for the WBN Plant, the staff estimated the cost/benefit ratio for five candidate SAMDAs to be within a factor of 5 of the $1,000 per person-rem criterion. Recognizing uncertainties and issues inherent in the determination of the averted risk values and cost estimating methodology, a more detailed assessment for the five SAMDAs was performed based on both probabilistic and deterministic considerations.

The staff concludes that none of the five design improvements warrant implementation for the WBN Plant for the purpose of further mitigating severe accidents. One of the design changes related to RCP seal integrity has a low cost and favorable impact on core damage frequency and risk. However, the frequency of core damage due to seal LOCA at the WBN Plant is less than the value where licensee implementation of corrective or mitigative actions is clearly justified. Furthermore, the largest risk reduction estimated for any of the five improvements is about 20 person-rem or approximately 10% of the total risk at the WBN Plant. Thus, even if these design changes could be shown cost beneficial on the basis of lower installation costs, risk at the WBN Plant would not be significantly reduced through implementation of any of the design improvements.

All of the remaining SAMDAs have a cost/benefit ratio of about an order of magnitude or more greater than the $1,000 per person-rem criterion, and were not evaluated further. The factor of 10 is considered to provide ample margin to cover uncertainties in risk and cost estimates given that, in general, estimates for these factors were conservatively evaluated.

The staff has considered the robustness of this conclusion relative to critical assumptions in the analysis, specifically, the impact of uncertainties in the averted offsite risk estimates, and the use of alternative cost/benefit screening criterion. The staff concludes that the findings of the analysis would be unchanged even considering these factors.

7.3 References

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Tennessee Valley Authority (TVA). 1994a. Letter from W. J. Museler, TVA, to U.S. NRC. May 2, 1994. Subject: Watts Bar Nuclear Plant (WBN) Unit 1 and Common - Generic Letter 88-20 - Individual Plant Examination (IPE) - Update of Level 1 and 2 Analysis.

Tennessee Valley Authority (TVA). 1994b. Letter from D. E. Nunn, TVA, to U.S. NRC. June 30, 1994. Subject: Watts Bar Nuclear Plant (WBN) Unit 1 and 2 - Severe Accident Mitigation Design Alternatives (SAMDAs) Evaluation from Updated Individual Plant Evaluation (IPE).

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U.S. Nuclear Regulatory Commission (NRC). 1994b. Letter from U.S. NRC, to O. D. Kingsley, Jr., TVA. September 2, 1994. Subject: Watts Bar Nuclear Plant - Severe Accident Mitigation Design Alternatives.

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U.S. Nuclear Regulatory Commission (NRC). 1994d. Letter from U.S. NRC., to O. D. Kingsley, Jr., TVA. September 27, 1994. Subject: Watts Bar Nuclear Plant - Severe Mitigation Design Alternatives.

U.S. Nuclear Regulatory Commission (NRC). 1994e. Letter from U.S. NRC., to O. D. Kingsley, Jr., TVA. October 17, 1994. Subject: Watts Bar Nuclear Plant - Severe Mitigation Design Alternatives.

8 Consequences of Proposed Actions

Possible consequences of the actions proposed have been evaluated with respect to changes in WBN Plant operation, design, and the environment. Unavoidable adverse effects are discussed in Section 8.1, short-term uses and long-term productivity issues are discussed in Section 8.2, resource commitments are discussed in Section 8.3, and decommissioning and land use are discussed in Section 8.4.

8.1 Unavoidable Adverse Effects

The staff has assessed the environmental, physical, social, and economic impacts attributed to the operation and maintenance of the WBN Plant. Site preparation was completed prior to 1978. Since the major portion of construction of the facility is also complete, and the remaining construction of Unit 2 can be accomplished with minimal effect on the environment, the construction effects discussed in the NRC 1978 FES-OL (NRC 1978) are no longer pertinent. The staff has not identified any additional adverse effects that will be caused by the operation or maintenance of the WBN Plant.

8.2 Short-term Uses and Long-term Productivity

The staff has evaluated the short-term uses and long-term productivity of the WBN Site and has determined that there are no changes since the issuance of the NRC 1978 FES-OL. The presence of the WBN Plant in Rhea County, Tennessee, will continue to influence the future use of other land in its immediate environs as well as the continued removal of county land from agricultural use as the result of any increased industrialization.

8.3 Irreversible and Irretrievable Commitments of Resources

The staff has evaluated the commitment of resources in the NRC 1978 FES-OL and concludes that there are no changes except for the continuing escalation of costs, which have increased the dollar values of materials used for fueling the station.

As discussed in the NRC 1978 FES-OL, uranium is the principal natural resource irretrievably consumed in facility operation. Other materials consumed, for practical purposes, are fuel-cladding materials, reactor control elements, other replaceable reactor core components, chemicals used in water treatment, ion-exchange resins, and minor quantities of materials used in maintenance and operation. Except for the isotopes uranium-235 and uranium-238, the consumed resource materials have wide-spread usage; therefore, their use in the proposed operation is reasonable with respect to needs in other industries. The principal use of the uranium isotopes is for production of useful energy.

8.4 Decommissioning

Information provided in Section 8.4, "Decommissioning and Land Use," of the NRC 1978 FES-OL has been superceded as a result of a rule on decommissioning (10 CFR 50.75 and 10 CFR 50.82), which became effective on July 27, 1988 (NRC 1988). These regulations set forth technical and financial criteria for decommissioning licensed nuclear facilities. These regulations address decommissioning, planning needs, timing, funding methods, and environmental review requirements.

The Commission's rule on decommissioning specifically addresses three decommissioning alternatives: DECON, SAFSTOR, and ENTOMB.

DECON is the decommissioning alternative in which equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits termination of the license.

SAFSTOR is the decommissioning alternative in which the nuclear facility is placed and maintained in a condition that allows the safe storage of radioactive components of the nuclear plant and subsequent decontamination to levels that permit termination of the license. Benefits include a reduction in occupational exposure and possibly in waste volume.

ENTOMB is the decommissioning alternative in which radioactive contaminants are encased in a structurally long-lived material, such as concrete. The entombed structure is appropriately maintained and continued surveillance is carried out until the radioactivity decays to a level permitting termination of the license.

The decommissioning rule also indicates that continuing authority to possess a reactor in a decommissioned status is governed by the provisions of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." Requirements for limits on both occupational and offsite exposure related to decommissioning activities are contained in 10 CFR Part 20, "Standards for Protection Against Radiation."

The decommissioning rule requires that license holders of commercial nuclear power reactors submit a plan to ensure that funds will be available to decommission the facility. The decommissioning funding plan addresses the financial aspects of decommissioning. Financial assurance is guaranteed by prepayment, an external sinking fund (into which deposits are made periodically), or surety, insurance, or other method. Prepayment may be in the form of deposits of cash or liquid assets, sufficient to pay decommissioning cost, into an account segregated from the licensee's assets and outside the licensee's administrative control. It may also be in the form of a trust, escrow account, government fund, certificate of deposit, or deposit of government securities. An external sinking fund is established and maintained by setting funds aside periodically in an account segregated from licensee assets and outside the licensee's administrative control, in which the total amount of funds would be sufficient to pay decommissioning costs. An external sinking fund may also be in the form of a trust, escrow account, government fund, certificate of deposit, or deposit of government securities. The surety or insurance method would guarantee that decommissioning costs will be paid should the licensee default. A surety method may be in the form of a surety bond, letter of credit, or line of credit. Any surety or insurance method used to provide financial assurance for decommissioning must meet specific conditions; for example, it must be payable to a trust established for decommissioning costs and it must remain in effect until the license has been terminated.

The decommissioning rule requires that a preliminary decommissioning plan containing a site-specific cost estimate for decommissioning and an up-to-date assessment of the major technical factors that could affect planning for decommissioning be submitted at or about five years before the projected end of operation. In addition, the decommissioning rule requires that an application to decommission a facility be submitted within two years following the decision by the licensee to permanently cease operations. The application for the termination of the license must be accompanied or preceded by a proposed decommissioning plan. The rule requires that the proposed decommissioning plan include (1) the choice of the alternative for decommissioning with a description of the activities involved; (2) a description of controls and limits on procedures and equipment to protect occupational and public health and safety; (3) a description of the planned final radiation survey; (4) an updated cost estimate, a comparison of that estimate with the then current funds set aside for decommissioning, and a plan for assuring the availability of adequate funds for completion of decommissioning; and (5) a description of technical specifications, quality assurance provisions, and physical security plan provisions in place during decommissioning.

With its application for a license amendment to authorize decommissioning, 10 CFR 51.53 requires the licensee to submit a document entitled, "Supplement to Applicant's Environmental Report - Post Operating License Stage." This document would update the "Applicant's Environmental Report - Operating License Stage" to select any new information or significant environmental change associated with the proposed decommissioning activities.

8.5 References

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9 Index

Appendix A

Reserved for Comments on the Draft Supplement Environmental Impact Statement

Appendix B

Contributors to the Supplement

Appendix B

Contributors to the Supplement

The overall responsibility for the preparation of this supplement was assigned to the Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission (NRC). The statement was prepared by members of the Office of Nuclear Reactor Regulation with assistance from other NRC organizations, the Pacific Northwest Laboratory, Scientech, Inc., and Sanford Cohen & Assoc.

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(a) Pacific Northwest Laboratory is operated for the U.S. Department of Energy by the Battelle Memorial Institute.

Appendix C

Socioeconomics

Appendix C

Socioeconomics

This appendix provides additional population and socioeconomic data in the Watts Bar region. Included are (1) population distribution around the WBN Plant for 1990 and projected for 2040 (Tables C.1 and C.2), (2) the residential distribution of the WBN Plant workforce in the mid-1980s (Table C.3), (3) the distribution of tax-equivalent payments to local entities in the WBN Site vicinity by the applicant and State of Tennessee (Table C.4), and (4) data on the income, poverty status, race, and ethnicity of the population around the WBN Plant (Tables C.5 and C.6).

Table C.1 Year 1990 Population Distribution in the Watts Bar Region

Direction	Distance from WBN Plant (kilometers) [miles] (0-16) [0-10]	(16-32) [10-20]	(32-48) [20-30]	(48-64) [30-40]	(64-82) [40-50]	Total
N	1,040	1,659	1,760	2,917	3,541	10,917
NNE	835	6,947	15,473	8,288	1,074	32,616
NE	1,187	3,194	15,815	24,769	43,336	88,300
ENE	396	1,767	8,371	32,151	108,745	151,430
E	505	7,781	7,276	8,777	13,967	38,305
ESE	601	3,470	9,788	2,793	300	16,952
SE	504	16,530	9,068	3,285	3,142	32,529
SSE	690	3,052	6,825	3,348	5,536	19,450
S	1,544	1,115	26,801	31,540	9,044	70,044
SSW	749	4,827	13,711	20,327	93,289	132,902
SW	454	5,541	7,499	54,539	99,669	167,702
WSW	1,197	8,830	1,728	5,916	5,421	23,093
W	847	831	4,402	2,481	1,736	10,296
WNW	470	1,205	2,384	3,114	14,876	22,048
NW	2,476	277	5,825	5,626	7,975	22,178
NNW	1,987	737	14,619	3,826	2,532	23,702
Total	15,482	67,763	151,343	213,695	414,182	862,465

Data source: Tennessee Valley Authority, Watts Bar Final Safety Analysis Report.

Table C.2 Year 2040 Population Distribution in the Watts Bar Region

Direction	Distance from WBN Plant (kilometers) [miles] (0-16) [0-10]	(16-32) [10-20]	(32-48) [20-30]	(48-64) [30-40]	(64-82) [40-50]	Total
N	1,210	2,071	2,166	3,453	4,040	12,940
NNE	965	8,591	19,187	9,342	1,194	39,279
NE	1,329	3,381	19,210	30,623	54,111	108,655
ENE	440	2,445	9,497	38,457	136,395	187,234
E	582	9,716	8,837	10,649	17,404	47,189
ESE	702	4,514	12,085	3,420	300	21,022
SE	585	17,835	10,818	3,969	3,756	36,964
SSE	803	4,018	8,056	3,899	6,362	23,138
S	1,717	1,141	34,699	40,812	11,522	89,892
SSW	831	5,653	17,523	25,829	117,868	167,704
SW	526	6,490	9,411	68,565	125,338	210,330
WSW	1,399	10,369	2,091	7,134	6,571	27,564
W	987	965	5,337	2,839	2,035	12,163
WNW	550	1,461	2,925	3,440	17,598	25,973
NW	2,900	314	7,266	7,004	9,802	27,286
NNW	2,328	874	18,279	4,784	2,983	29,248
Total	17,854	79,840	187,386	264,220	517,279	1,066,580

Data source: Tennessee Valley Authority, Watts Bar Final Safety Analysis Report.

Table C.3 Residential Distribution of WBN Plant Workforce

Local Entity	Responding Employees 7/30/82	Responding Employees 4/30/84	Percent of Total Responses 7/30/82	Percent of Total Responses 4/30/84
Crossville	67	78	2.60%	2.96%
Athens	145	143	5.62%	5.43%
Chattanooga	164	152	6.36%	5.77%
Cleveland	125	99	4.85%	3.76%
Dayton	139	149	5.39%	5.65%
Decatur	151	128	5.85%	4.86%
Englewood	23	21	0.89%	0.80%
Etowah	26	28	1.01%	1.06%
Evensville	35	39	1.36%	1.48%
Grandview	13	19	0.50%	0.72%
Graysville	23	24	0.89%	0.91%
Harriman	93	93	3.61%	3.53%
Hixson	70	84	2.71%	3.19%
Kingston	103	110	3.99%	4.17%
Lenoir City	54	48	2.09%	1.82%
Madisonville	44	43	1.71%	1.63%
Niota	19	20	0.74%	0.76%
Oliver Springs	10	15	0.39%	0.57%
Philadelphia	N/A	9	0.00%	0.34%
Riceville	20	18	0.78%	0.68%
Rockville	N/A	50	0.00%	1.90%
Rockwood	100	62	3.88%	2.35%
Soddy Daisy	56	79	2.17%	3.00%
Spring City	316	333	12.25%	12.64%
Sweetwater	47	64	1.82%	2.43%
Ten Mile	112	107	4.34%	4.06%
Knoxville	121	141	4.69%	5.35%

Table C.3. (contd)

Local Entity	Responding Employees 7/30/82	Responding Employees 4/30/84	Percent of Total Responses 7/30/82	Percent of Total Responses 4/30/84
Oak Ridge	11	8	0.43%	0.30%
Benton	12	10	0.47%	0.38%
Birchwood	5	6	0.19%	0.23%
Coppermill	6	N/A	0.23%	0.00%
Dunlap	9	10	0.35%	0.38%
East Ridge	8	7	0.31%	0.27%
Harrison	26	23	1.01%	0.87%
Lake City	6	6	0.23%	0.23%
Loudon	19	14	0.74%	0.53%
Oakdale	8	7	0.31%	0.27%
Oliver Springs	10	6	0.39%	0.23%
Ooltewah	11	18	0.43%	0.68%
Pikeville	14	17	0.54%	0.65%
Powell	10	12	0.39%	0.46%
Salt Creek	18	20	0.70%	0.76%
Tellico Plains	26	22	1.01%	0.83%
Vonore	8	8	0.31%	0.30%
Clinton	15	15	0.58%	0.57%
Maryville	17	18	0.66%	0.68%
Other	264	252	10.24%	9.56%
Total	2579	2635	100.00%	100.00%

Data source: Tennessee Valley Authority, Watts Bar Nuclear Plant Construction and Operation Employee Survey Results and Mitigation Summary, July 30, 1982, and April 30, 1984.

Table C.4 Tax-Equivalent Payments to Designated Counties and Cities in the WBN Site Vicinity Fiscal Year 1992

	Importance of TVA Impact Funds to Local Entities Near WBN Plant, Fiscal Year 1992						
Local Entity	Redistributed from State	State Allocated Impact Funds	Direct from TVA	Total from TVA	Total Revenue from All Sources	TVA Percent of Total	TVA Impact Percent of Total
Bradley Co.	$362,521	$201,486	$30,181	$594,188	$59,403,000	1.00%	0.34%
Charleston	$3,312	$1,785		$5,097	$280,000	1.82%	0.64%
Cleveland	$155,311	$83,287		$238,598	$83,108,000	0.29%	0.10%
Hamilton Co.	$1,308,715	$164,835	$24,839	$1,498,389	$211,994,000	0.71%	0.08%
Chattanooga	$816,351	$88,016		$904,367	$534,789,000	0.17%	0.02%
Collegedale	$25,604	$2,914		$28,518	$4,324,000	0.66%	0.07%
East Ridge	$107,028	$12,181		$119,209	$7,439,000	1.60%	0.16%
Lakesite	$4,159	$473		$4,632	$118,000	3.93%	0.40%
Lookout Mtn.	$9,642	$1,097		$10,739	$2,061,000	0.52%	0.05%
Red Bank	$62,499	$7,113		$69,612	$3,411,000	2.04%	0.21%
Ridgeside	$2,029	$231		$2,260	$173,000	1.31%	0.13%
Signal Mtn.	$35,678	$4,061		$39,739	$4,189,000	0.95%	0.10%
Soddy-Daisy	$41,795	$4,757		$46,552	$2,085,000	2.23%	0.23%
Walden	$7,725	$879		$8,604	$451,000	1.91%	0.19%
Loudon Co.	$542,186	$210,540	$21,256	$773,982	$22,380,000	3.46%	0.94%
Greenback	$3,292	$4,372		$7,664	$125,000	6.13%	*3.50%
Lenoir City	$32,703	$41,407		$74,110	$67,292,000	0.11%	0.06%
Loudon	$23,693	$27,120		$50,813	$26,140,000	0.19%	0.10%
Philadelphia	$2,348	$3,119		$5,467	$53,000	10.32%	*5.88%
McMinn Co.	$360,385	$198,153	$39,266	$597,804	$48,938,000	1.22%	0.40%
Athens	$61,477	$56,534		$118,011	$46,840,000	0.25%	0.12%
Calhoun	$2,800	$2,581		$5,381	$275,000	1.96%	0.94%
Englewood	$9,362	$7,532		$16,894	$829,000	2.04%	0.91%

Table C.4 (contd)

Importance of TVA Impact Funds to Local Entities Near WBN Plant, Fiscal Year 1992

Local Entity	Redistributed from State	State Allocated Impact Funds	Direct from TVA	Total from TVA	Total Revenue from All Sources	TVA Percent of Total	TVA Impact Percent of Total
Etowah	$19,350	$17,836		$37,186	$14,104,000	0.26%	0.13%
Niota	$5,699	$3,923		$9,622	$466,000	2.06%	0.84%
Meigs Co.	$296,027	$245,042	$3,713	$544,782	$7,770,000	7.01%	*3.15%
Decatur	$6,903	$41,516		$48,419	$783,000	6.18%	*5.30%
Monroe Co.	$666,232	$217,765	$29,543	$913,540	$22,119,000	4.13%	0.98%
Madisonville	$15,384	$21,626		$37,010	$2,698,000	1.37%	0.80%
Sweetwater	$26,173	$36,122		$62,295	$16,969,000	0.37%	0.21%
Tellico Plains	$4,395	$6,125		$10,520	$762,000	1.38%	0.80%
Vonore	$3,500	$4,920		$8,420	$217,000	3.88%	*2.27%
Rhea Co.	$466,358	$206,067	$6,349	$678,774	$32,800,000	2.07%	0.63%
Dayton	$32,594	$50,137		$82,731	$16,648,000	0.50%	0.30%
Graysville	$3,292	$11,741		$15,033	$275,000	5.47%	*4.27%
Spring City	$12,524	$18,614		$31,138	$1,617,000	1.93%	*1.15%
Roane Co.	$675,233	$199,218	$20,787	$895,238	$45,164,000	1.98%	0.44%
Harriman	$39,107	$30,030		$69,137	$41,083,000	0.17%	0.07%
Kingston	$25,908	$19,202		$45,110	$2,919,000	1.55%	0.66%
Oak Ridge	$141,804	$10,575		$152,379	$62,970,000	0.24%	0.02%
Oliver Springs	$17,413	$4,130		$21,543	$1,660,000	1.30%	0.25%
Rockwood	$27,126	$23,403		$50,529	$21,674,000	0.23%	0.11%
Total	$6,465,637	$2,292,465	$175,934	$8,934,036	$1,419,395,000	0.63%	0.16%

Data source: TVA Response to Question 32, Tax Equivalent Payments to Designated Entities, Fiscal year 1992, NRC Docket 50-390 and 50-391, September 27, 1994.

Table C.5 Income and Poverty Status Around the WBN Plant, 1989

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
Tennessee	12255	24807	15.7	100%	100%	100%
Anderson County	13182	26496	14.3	108%	107%	91%
Clinton Div.	12963	26549	15.7	106%	107%	100%
Clinton Town (pt)	13691	24597	17.9	112%	99%	114%
Oak Ridge City (pt)	27541	67732	1.8	225%	273%	11%
Clinton S. Div.	11765	27413	13.2	96%	111%	84%
Clinton Town (pt)	11470	23056	7	94%	93%	45%
Oak Ridge City (pt)	N/A	N/A	N/A	N/A	N/A	N/A
Lake City E. Div.	8640	19144	21.2	71%	77%	135%
Lake City Town (pt)	7671	13686	31.5	63%	55%	201%
Lake City W. Div.	6411	17746	27.7	52%	72%	176%
New River Div.	5195	9708	33.3	42%	39%	212%
Norris Div.	11338	26256	14.6	93%	106%	93%
Norris City	15325	31406	8.8	125%	127%	56%
Oak Ridge Div.	16860	30589	10.3	138%	123%	66%
Oak Ridge City (pt)	16860	30589	10.3	138%	123%	66%
Walden Ridge Div.	9593	22099	18.4	78%	89%	117%
Oliver Springs (pt)	10179	22933	14	83%	92%	89%
Bledsoe County	8053	18250	19.2	66%	74%	122%
Cumberland Plateau Div.	6705	19936	20.4	55%	80%	130%
Sequatchie Valley Div.	9141	17881	18.3	75%	72%	117%
Pikeville Town	9065	15217	26.6	74%	61%	169%
Walden Ridge Div.	7740	17721	19.7	63%	71%	125%
Blount County	12674	25575	12.4	103%	103%	79%

Table C.5 (contd)

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
Binfield Div.	11903	27045	14.4	97%	109%	92%
Friendsville Div.	15690	29407	10.3	128%	119%	66%
Friendsville City	12070	30000	7.9	98%	121%	50%
Maryville City (pt)	44429	127308	N/A	363%	513%	N/A
Lanier Div.	12116	28091	8.7	99%	113%	55%
Maryville-Alcoa Div.	12766	25016	12.9	104%	101%	82%
Alcoa City	12876	22398	14	105%	90%	89%
Eagleton Village CDP	11593	23363	11.2	95%	94%	71%
Maryville City (pt)	13397	25206	13.9	109%	102%	89%
Rockford City (pt)	11817	28036	10.1	96%	113%	64%
Townsend Div.	9482	21128	14	77%	85%	89%
Townsend City	10428	16625	15.6	85%	67%	99%
Wildwood Div.	12000	28870	10.8	98%	116%	69%
Seymoor CDP	13534	32989	8.4	110%	133%	54%
Bradley County	11768	25678	13.8	96%	104%	88%
Charleston Div.	12566	32360	9.5	103%	130%	61%
Charleston City	11225	24500	19.1	92%	99%	122%
Cleveland City (pt)	14518	38914	8.4	118%	157%	54%
Cleveland Div.	11040	21743	19.1	90%	88%	122%
Cleveland City (pt)	11554	20951	19.6	94%	84%	125%
East Cleveland CDP	7407	11932	35.2	60%	48%	224%
South Cleveland CDP	10246	27338	13	84%	110%	83%
Wildwood Lake CDP (pt)	10659	28229	12.5	87%	114%	80%

Table C.5 (contd)

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
South Bradley Div.	12330	28256	7.7	101%	114%	49%
Cleveland City (pt)	11975	23958	N/A	98%	97%	N/A
South Cleveland CDP(pt)	11731	24883	5.3	96%	100%	34%
Wildwood Lake CDP (pt)	10527	28187	6.8	86%	114%	43%
Southeast Bradley Div.	11090	26599	9.5	90%	107%	61%
Wildwood Lake CDP (pt)	12007	25272	14.9	98%	102%	95%
West Bradley Div.	12848	29163	9.7	105%	118%	62%
Cleveland City (pt)	16704	31250	8.3	136%	126%	53%
Hopewell CDP	13582	30244	9.8	111%	122%	62%
Cumberland County	9782	20474	18.1	80%	83%	115%
Crab Orchard Div.	7601	17543	19.9	62%	71%	127%
Crab Orchard City (pt)	7117	14022	28.5	58%	57%	182%
Crossville Div.	9744	19247	20.3	80%	78%	129%
Crab Orchard City (pt)	N/A	N/A	N/A	N/A	N/A	N/A
Crossville City	8895	16081	28.6	73%	65%	182%
Crossville North Div.	11832	24215	11.4	97%	98%	73%
Fairfield Glade CDP	17323	29031	3.3	141%	117%	21%
Lantana Div.	9758	21560	16.4	80%	87%	104%
Maryland- Pleasant Hill Div.	8123	18824	22.1	66%	76%	141%
Pleasant Hill Town	10907	19667	15.5	89%	79%	99%
Hamilton County	13619	26523	13.1	111%	107%	83%
Chattanooga Div.	13082	24599	15.7	107%	99%	100%
Chattanooga City (pt)	12345	22040	18.5	101%	89%	118%
Collegedale (pt)	17875	60250	N/A	146%	243%	N/A
East Brainerd CDP (pt)	17511	48072	3.5	143%	194%	22%
East Ridge City (pt)	15676	33859	8.7	128%	136%	55%

Table C.5 (contd)

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
Harrison CDP	14819	35606	3.6	121%	144%	23%
Middle Valley CDP (pt)	15063	48864	3.1	123%	197%	20%
Ooltewah CDP (pt)	15924	30582	10.2	130%	123%	65%
Red Bank City	13662	25015	9.9	111%	101%	63%
Ridgeside City	36476	57036	4.8	298%	230%	31%
Signal Mountain Town (pt)	N/A	N/A	N/A	N/A	N/A	N/A
Soddy-Daisy City (pt)	9384	21312	15.3	77%	86%	97%
Walden town (pt)	35280	75000	N/A	288%	302%	N/A
East Ridge Div.	13788	26258	7.5	113%	106%	48%
East Ridge City (pt)	13788	26258	7.5	113%	106%	48%
Lookout Mountain Div.	19604	30991	8.3	160%	125%	53%
Chattanooga City (pt)	11949	26196	10	98%	106%	64%
Lookout Mountain Town (pt)	41079	64266	3.1	335%	259%	20%
Middle Valley Div.	14403	41151	3.8	118%	166%	24%
Chattanooga City (pt)	11648	23750	N/A	95%	96%	N/A
Middle Valley CDP (pt)	13513	39123	3.9	110%	158%	25%
Soddy Daisy City (pt)	11145	25729	23.6	91%	104%	150%
Ooltewah Div.	13373	30324	8.6	109%	122%	55%
Collegedale City (pt)	10432	27964	8.1	85%	113%	52%
Ooltewah CDP (pt)	9612	18259	16.4	78%	74%	104%
Sale Creek Div.	11893	28423	11.8	97%	115%	75%
Soddy-Daisy City (pt)	10749	26000	8	88%	105%	51%
Signal Mountain Div.	20719	44164	4.1	169%	178%	26%
Fairmount CDP	15482	34635	6.5	126%	140%	41%
Signal Mountain Town (pt)	23893	49821	1.1	195%	201%	7%
Walden Town (pt)	26980	50955	4.4	220%	205%	28%

Table C.5 (contd)

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
Snow Hill Div.	13119	32330	9.9	107%	130%	63%
Soddy-Daisy Div.	11602	27494	12.9	95%	111%	82%
Lakeside City	14735	42000	8.3	120%	169%	53%
Soddy-Daisy City (pt)	10814	21875	16.7	88%	88%	106%
Knox County	14007	26010	14.1	114%	105%	90%
Concord Div.	21844	54410	3.3	178%	219%	21%
Farragut Town (pt)	22560	61486	1.8	184%	248%	11%
Knoxville City (pt)	3904	18750	N/A	32%	76%	N/A
Carryton Div.	11007	25991	11	90%	105%	70%
Gibbs Div.	11386	30527	10.6	93%	123%	68%
Halls Div.	12586	30521	8.5	103%	123%	54%
Halls CDP	14109	32864	6.2	115%	132%	39%
Hardin Valley Div.	14915	32752	9.9	122%	132%	63%
Farragut Town (pt)	12534	32153	3.4	102%	130%	22%
Karns CDP (pt)	17749	31840	1.3	145%	128%	8%
Knoxville City (pt)	N/A	N/A	N/A	N/A	N/A	N/A
Karns Div.	15567	37005	4.3	127%	149%	27%
Karns CDP (pt)	12462	35185	1.3	102%	142%	8%
Knoxville City (pt)	5796	26250	N/A	47%	106%	N/A
Knoxville Div.	13684	23924	16.2	112%	96%	103%
Knoxville City (pt)	12113	19920	20.8	99%	80%	132%
Powell Div.	13081	26262	8.7	107%	106%	55%
Powell CDP	13985	31113	7.2	114%	125%	46%
Skaggston Div.	8708	20587	17.1	71%	83%	109%
Mascot CDP	7881	19097	19.1	64%	77%	122%
Loudon County	12006	24258	13.6	98%	98%	87%

Table C.5 (contd)

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
Greenback Div.	13003	23983	10.9	106%	97%	69%
Greenback City	11366	21364	12.8	93%	86%	82%
Lenoir City Div.	12068	24413	13.9	98%	98%	89%
Farragut Town (pt)	4667	13750	N/A	38%	55%	N/A
Lenoir City (pt).	9345	18014	21.2	76%	73%	135%
Loudon Town (pt)	N/A	N/A	N/A	N/A	N/A	N/A
Loudon Div.	11878	23768	14.2	97%	96%	90%
Loudon Town (pt)	10140	19460	18.1	83%	78%	115%
Philadelphia Div.	10467	25281	13.2	85%	102%	84%
Philadelphia City	9809	18375	20.8	80%	74%	132%
McMinn County	10508	21901	17.2	86%	88%	110%
Athens Div.	10726	21951	18.5	88%	88%	118%
Athens City	10286	19259	23.3	84%	78%	148%
Nioata City	11226	21797	12.5	92%	88%	80%
Sweetwater City (pt)	N/A	N/A	N/A	N/A	N/A	N/A
Calhoun-Riceville Div.	11296	27598	13.6	92%	111%	87%
Calhoun Town	10298	24750	4.4	84%	100%	28%
Englewood Div.	8692	17905	18.8	71%	72%	120%
Englewood Town	7843	14722	23.3	64%	59%	148%
Eltowah Div.	10248	21134	15.5	84%	85%	99%
Eltowah City	9853	18703	20	80%	75%	127%
Meigs County	9237	20181	22.3	75%	81%	142%
Big Springs-East View Div.	7991	19071	26.3	65%	77%	168%
Decatur Div.	9971	21935	19.6	81%	88%	125%
Decatur Town	9330	21312	23.3	76%	86%	148%

Table C.5 (contd)

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
Ten Mile Div.	9571	19375	21.5	78%	78%	137%
Monroe County	9088	19932	17.8	74%	80%	113%
Madisonville Div.	9146	20226	17.8	75%	82%	113%
Madisonville Town	9911	19314	15.1	81%	78%	96%
Sweetwater Div.	10001	20397	16.4	82%	82%	104%
Sweetwater City (pt)	10061	19865	16.2	82%	80%	103%
Tellico Plains Div.	7727	18106	21	63%	73%	134%
Tellico Plains Town	7141	14904	24.4	58%	60%	155%
Venore Div.	8974	20788	15.3	73%	84%	97%
Venore Town	8484	16354	21.5	69%	66%	137%
Morgan County	7722	19280	20.2	63%	78%	129%
Coalfield Div.	7950	20769	19.2	65%	84%	122%
Oliver Springs Town (pt)	5796	8523	51.7	47%	34%	329%
Lancing Div.	6951	14797	25.3	57%	60%	161%
Oakdale Div.	8176	22068	15.7	67%	89%	100%
Harriman City (pt)	N/A	N/A	N/A	N/A	N/A	N/A
Oaksdale Town	8137	17500	16.5	66%	71%	105%
Sunbright Div.	6722	16884	24.6	55%	68%	157%
Wartburg Div.	8175	17461	19.2	67%	70%	122%
Wartburg City	8601	14395	26.1	70%	58%	166%
Polk County	9311	21663	18.3	76%	87%	117%
Benton Div.	9753	22245	17.1	80%	90%	109%
Benton Town	8423	17500	30	69%	71%	191%

Table C.5 (contd)

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
Ducktown Div.	8800	18937	18.2	72%	76%	116%
Copperhill City	11411	17266	15.5	93%	70%	99%
Ducktown City	8432	13295	21.1	69%	54%	134%
Parksville Div.	10793	25308	14.6	88%	102%	93%
Turtletown Div.	6124	16348	28.9	50%	66%	184%
Rhea County	9333	19915	19	76%	80%	121%
Dayton Div.	9005	19489	20.4	73%	79%	130%
Dayton City	8946	18355	20.8	73%	74%	132%
Graysville Town	8394	20673	21.9	68%	83%	139%
Spring City Div.	9990	20529	16	82%	83%	102%
Spring City Town (pt)	9412	19757	21.1	77%	80%	134%
Roane County	12015	24210	16	98%	98%	102%
Barnard Div.	11911	25424	13.3	97%	102%	85%
Harriman Div.	10029	20253	20.3	82%	82%	129%
Harriman City (pt)	8772	16077	27	72%	65%	172%
Kingston Div.	13691	28905	11.9	112%	117%	76%
Kingston City	13196	26958	13	108%	109%	83%
Oak Ridge City (pt)	N/A	N/A	N/A	N/A	N/A	N/A
Oak Ridge Div.	15085	34558	11.1	123%	139%	71%
Oak Ridge City (pt)	24922	63046	1.9	203%	254%	12%
Oliver Springs Town (pt)	9972	12905	29.3	81%	52%	187%
Rockwood Div.	10637	20681	19.4	87%	83%	124%
Harriman City (pt)	15520	28750	N/A	127%	116%	N/A
Rockwood City	9654	17024	23.5	79%	69%	150%
Sequatchie County	9377	19223	22.9	77%	77%	146%

Table C.5 (contd)

Location	Per Capita Income (1989 dollars)	Median Household Income	Percent of Households Below Poverty Level, 1989	Per Capita Income as Percent of State Average	Median Household Income as Percent of State Average	Percent of Persons Below Poverty Level as A Percent of State Average
Center Point Div.	10290	23996	14.9	84%	97%	95%
Dunlap Div.	9053	17797	25.9	74%	72%	165%
Dunlap City	8928	17920	24.3	73%	72%	155%

Data source: 1990 Census of Population, Summary Social, Economic, and Housing Characteristics (Tennessee).

Table C.6 Population Distribution by Race and Ethnicity Around the WBN Plant (Counties and Places Over 1,000 People) 1990

Location	Total	White	Black	American Indian, Eskimo, Aleut	Asian or Pacific Islander	Other	Hispanic Origin
Anderson County	68,250	64,615	2,763	243	547	82	381
Clinton	8,972	8,629	289	40	6	8	50
Oak Ridge	27,310	24,409	2,180	97	562	62	266
Lake City	2,166	2,141	3	7	13	2	16
Norris	1,303	1,301	0	0	0	2	12
Oliver Springs	3,433	3,295	114	14	8	2	9
Bledsoe County	9,669	9,242	375	42	3	7	38
Pikeville	1,771	1,683	76	10	0	2	3
Blount County	85,969	82,503	2,783	195	409	79	368
Maryville	19,208	18,340	603	40	204	21	102
Alcoa	6,400	5,053	1,307	5	24	11	35
Eagleton Village	5,169	5,099	35	21	11	3	16
Rockwood	5,348	4,990	334	8	11	5	16
Seymoor	7,026	6,930	24	12	38	22	44
Bradley County	73,712	70,132	2,900	200	232	248	712
Cleveland	30,354	27,790	2,177	81	143	163	436
East Cleveland	1,249	1,216	26	7	0	0	24
South Cleveland	5,372	5,277	58	15	10	12	33
Hopewell	3,569	2,508	46	4	4	7	20
Cumberland County	34,736	34,475	42	137	49	33	124
Crossville	6,930	6,868	2	31	19	10	25
Fairfield Glade	3,209	2,194	11	2	2	0	3

Table C.6 (contd)

Location	Total	White	Black	American Indian, Eskimo, Aleut	Asian or Pacific Islander	Other	Hispanic Origin
Hamilton County	285,536	227,413	54,477	585	2,479	582	1,946
Chattanooga	152,466	99,057	51,338	329	1,478	264	974
East Brainerd	11,594	10,788	665	20	93	28	86
East Ridge	21,101	20,686	112	52	240	11	96
Harrison	7,191	6,796	293	35	42	25	58
Middle Valley	12,255	12,002	90	15	137	11	59
Red Bank	12,322	11,464	673	18	108	59	137
Soddy-Daisy	8,240	8,145	64	9	17	5	24
Walden	1,523	1,514	0	2	7	0	6
Lookout Mountain	1,901	1,831	51	4	14	1	5
Collegedale	5,048	4,612	171	10	121	134	246
Ooltewah	4,903	4,372	473	20	30	8	44
Fairmount	1,578	1,569	1	1	5	2	10
Signal Mountain	7,034	6,977	17	1	34	5	36
Knox County	335,749	301,421	29,603	797	3,327	601	2,067
Farragut	12,793	12,242	181	18	322	30	115
Halls	6,450	6,405	14	10	19	2	18
Karns	1,454	1,445	0	5	4	4	10
Knoxville	165,121	136,604	26,053	399	1,725	340	1,099
Powell	7,534	7,374	100	15	31	14	27
Mascot	2,138	2,069	52	9	1	7	7
Loudon County	31,255	30,732	400	52	50	21	83
Lenoir City	6,147	6,086	25	27	7	2	20
Loudon	4,026	3,872	142	2	8	2	10

Table C.6 (contd)

Location	Total	White	Black	American Indian, Eskimo, Aleut	Asian or Pacific Islander	Other	Hispanic Origin
McMinn County	42,383	40,085	2,051	96	121	30	174
Athens	12,054	10,825	1,136	18	61	14	60
Sweetwater	5,066	4,621	403	7	26	9	15
Englewood	1,611	1,605	0	2	4	0	10
Etowah	3,815	3,635	142	18	16	4	18
Meigs County	8,033	7,884	118	28	2	1	17
Decatur	1,361	1,346	13	2	0	0	2
Monroe County	30,541	29,561	833	48	71	28	123
Madisonville	3,033	2,854	161	5	7	6	13
Morgan County	17,300	16,957	265	46	25	7	60
Harriman	7,119	6,507	574	15	13	10	27
Polk County	13,643	13,571	0	25	42	5	36
Rhea County	24,344	23,571	581	62	53	77	132
Dayton	5,671	5,269	350	10	23	19	23
Graysville	1,301	1,272	1	11	5	12	23
Spring City	2,199	2,037	145	7	5	5	15
Roane County	45,227	45,444	1,456	95	191	41	212
Kingston	4,552	4,316	194	5	27	10	26
Sequatchie County	8,863	8,851	2	4	5	1	25
Dunlap	3,731	3,724	2	2	2	1	15

Data sources: 1990 Census of Population, General Population Characteristics (Tennessee).

NRC FORM 335 (2-89) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

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NUREG-0498, Supp. 1

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Draft Report for comment

3. DATE REPORT PUBLISHED

MONTH	YEAR
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5. AUTHOR(S)

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Washington, DC 20555-0001

9. SPONSORING ORGANIZATION – NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

Same as 8 above

10. SUPPLEMENTARY NOTES

Docket Nos. 50-390 and 50-391

11. ABSTRACT (200 words or less)

The Final Environmental Statement (FES) issued in 1978 represents the Nuclear Regulatory Commission's (NRC's) previous environmental review related to the operation of Watts Bar Nuclear Plant (WBN). The purpose of this NRC review is to discuss the effects of observed changes in environment and to evaluate the changes in environmental impacts that have occurred as a result of changes in the WBN Plant design and proposed methods of operations since the last environmental review. A full scope of environmental topics has been evaluated, including regional demography, land and water use, meteorology, terrestrial and aquatic ecology, radiological and non-radiological impacts on humans and the environment, socioeconomic impacts, and environmental justice. The staff concluded that there are no significant changes in the environmental impacts since the NRC 1978 FES—OL from changes in plant design, proposed methods of operation, or changes in the environment. The applicant's preoperational and operational monitoring programs were reviewed and found to be appropriate for establishing baseline conditions and ongoing assessments of environmental impacts. The staff also conducted an analysis of plant operation with severe accident mitigation design alternatives (SAMDAs) and concluded that none of the SAMDAs, beyond the three procedural changes that the applicant committed to implement, would be cost-beneficial for further mitigating environmental impacts.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)

Watts Bar Nuclear Plant
Supplemental Environmental Statement

13. AVAILABILITY STATEMENT

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14. SECURITY CLASSIFICATION

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30-390

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FOR IMMEDIATE RELEASE
(Thursday, April 27, 1995)

NRC STAFF ISSUES FINAL SUPPLEMENT TO ENVIRONMENTAL STATEMENT ON WATTS BAR

The Nuclear Regulatory Commission has issued a final supplement to an environmental impact statement it first issued in 1978 related to proposed operation of Tennessee Valley Authority's two Watts Bar nuclear power plants near Spring City, Tennessee.

The two units have not yet been licensed for operation. Unit 1 was nearly complete in 1985 but a number of deficiencies were identified by employees and confirmed in NRC inspections. Corrective measures are still underway. TVA has decided not to complete Unit 2 on its own.

Each of the pressurized water reactors is designed to produce about 1,160 megawatts of electrical power.

Because of the extended period of time since the previous review and some changes in the Watts Bar plant design and proposed methods of operation, the NRC staff issued for public comment, in December last year, a draft supplement that evaluated the environmental impacts that have occurred. The environmental topics evaluated included regional demography, land and water use, meteorology, terrestrial and aquatic ecology, radiological and non-radiological impacts on humans and the environment, socioeconomic impacts and environmental justice.

After consideration of the public comments, the staff has concluded that there are no significant environmental impacts associated with the changes in plant design and proposed methods of operation. The staff's conclusion is not a final licensing action.

Copies of the final supplement to the environmental impact statement will be available for public inspection at the NRC Public Document Room, 2120 L Street, NW, Washington, DC 20555 and the Chattanooga-Hamilton County Library, 1001 Broad Street, Chattanooga, Tennessee. Copies may be purchased from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082 in about two weeks.

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