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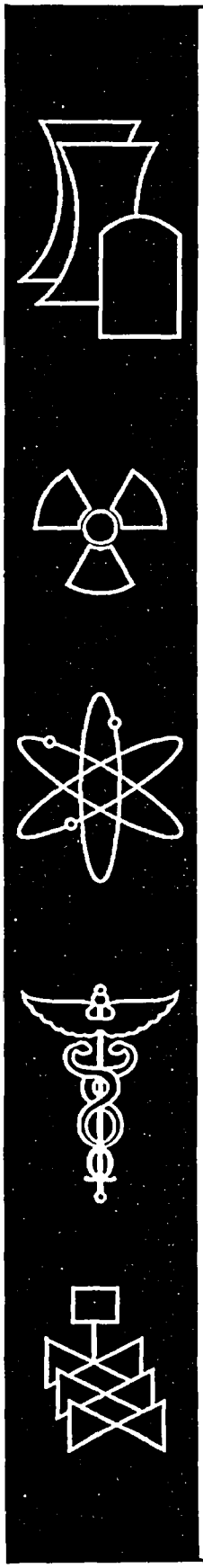

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 21

Regarding
Browns Ferry Nuclear Plant, Units 1, 2, and 3

Final Report

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, DC 20555-0001

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NUREG-1437
Supplement 21

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 21

Regarding Browns Ferry Nuclear Plant, Units 1, 2, and 3

Final Report

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Division of Regulatory Improvement Programs
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Abstract

The U.S. Nuclear Regulatory Commission (NRC or Commission) considered the environmental impacts of renewing nuclear power plant operating licenses (OLs) for a 20-year period in its *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2, and codified the results in Title 10 of the Code of Federal Regulations (CFR) Part 51. In the GEIS (and its Addendum 1), the staff identified 92 environmental issues and reached generic conclusions related to environmental impacts for 69 of these issues that apply to all plants or to plants with specific design or site characteristics. Additional plant-specific review is required for the remaining 23 issues. These plant-specific reviews are to be included in a supplement to the GEIS.

This supplemental environmental impact statement (SEIS) has been prepared in response to an application submitted to NRC by the Tennessee Valley Authority (TVA) to renew the OLs for Browns Ferry Nuclear Plant, Units 1, 2, and 3 (BFN) for an additional 20 years under 10 CFR Part 54. The SEIS includes the NRC staff's analysis that considers and weighs the environmental impacts of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures available for reducing or avoiding adverse impacts. It also includes the staff's recommendation regarding the proposed action.

Regarding the 69 issues for which the GEIS reached generic conclusions, neither TVA nor the staff has identified information that is both new and significant for any issue that applies to BFN. In addition, the staff determined that information provided during the scoping process did not call into question the conclusions in the GEIS. Therefore, the staff concludes that the impacts of renewing the BFN OLs will not be greater than impacts identified for these issues in the GEIS. For each of these issues, the staff's conclusion in the GEIS is that the impact is of SMALL[(a)] significance (except for collective offsite radiological impacts from the fuel cycle and high-level waste and spent fuel, which were not assigned a single significance level).

Regarding the remaining 23 issues, those that apply to BFN are addressed in this SEIS. For each applicable issue, the staff concludes that the significance of the potential environmental impacts of renewal of the OLs is SMALL. The staff also concludes that additional mitigation measures are not likely to be sufficiently beneficial as to be warranted. The staff determined that information provided during the scoping process did not identify any new issue that has a significant environmental impact.

The NRC staff recommends that the Commission determine that the adverse environmental impacts of license renewal for BFN are not so great that preserving the option of license

(a) Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

renewal for energy-planning decisionmakers would be unreasonable. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the Environmental Report submitted by TVA; (3) consultation and discussions with Federal, State, and local agencies; (4) the staff's own independent review; and (5) the staff's consideration of public comments.

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Executive Summary

By letter dated December 31, 2003, the Tennessee Valley Authority (TVA) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating licenses (OLs) for Browns Ferry Nuclear Plant, Units 1, 2, and 3 (BFN) for an additional 20-year period. If the OLs are renewed, State regulatory agencies and TVA will ultimately decide whether the plant will continue to operate based on factors such as the need for power or other matters within the State's jurisdiction or the purview of the owners. If the OLs are not renewed, then the plant must be shut down at or before the expiration dates of the current OLs, which are December 20, 2013, for Unit 1, June 28, 2014, for Unit 2, and July 2, 2016, for Unit 3.

The NRC has issued regulations implementing Section 102 of the National Environmental Policy Act of 1969 (NEPA) (42 USC 4321) in Title 10 of the Code of Federal Regulations (CFR) Part 51. Section 102 of NEPA directs that an environmental impact statement (EIS) is required for major Federal actions that significantly affect the quality of the human environment. In 10 CFR 51.20(b)(2), the Commission requires preparation of an EIS or a supplement to an EIS for renewal of a reactor OL. In addition, 10 CFR 51.95(c) states that the EIS prepared at the OL renewal stage will be a supplement to the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2.[a]

Upon acceptance of the TVA application, the NRC began the environmental review process described in 10 CFR Part 51 by publishing a Notice of Intent to prepare an EIS and conduct scoping. The staff visited the BFN site in March 2004 and held public scoping meetings on April 1, 2004, in Athens, Alabama. In the preparation of this supplemental environmental impact statement (SEIS) for BFN, the staff reviewed the TVA Environmental Report and compared it to the GEIS, consulted with other agencies, conducted an independent review of the issues following the guidance set forth in NUREG-1555, Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*, and considered the public comments received during the scoping process. The public comments received during the scoping process that were considered to be within the scope of the environmental review are provided in Appendix A, Part 1, of this SEIS.

The staff held two public meetings in Athens, Alabama, on January 25, 2005 to describe the results of the NRC environmental review, answer questions, and provide members of the public with information to assist them in formulating comments on this SEIS. When the comment period ended, the staff considered and dispositioned all of the comments received. These comments are addressed in Appendix A, Part 2, of this SEIS.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

TVA, a Federal corporation wholly owned by the U.S. Government, is a Federal Agency and subject to the requirements of NEPA. In compliance with NEPA, TVA prepared an SEIS to provide the public and TVA decisionmakers with an assessment of the environmental impacts of extending the operating life of the BFN nuclear units. This NRC SEIS draws upon the content of the TVA SEIS, but was prepared by NRC staff independently.

This SEIS includes the NRC staff's analysis that considers and weighs the environmental effects of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures for reducing or avoiding adverse effects. It also includes the staff's recommendations regarding the proposed action.

The Commission has adopted the following statement of purpose and need for license renewal from the GEIS:

> The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and, where authorized, Federal (other than NRC) decisionmakers.

The goal of the staff's environmental review, as defined in 10 CFR 51.95(c)(4) and the GEIS, is to determine

> ... whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

Both the statement of purpose and need and the evaluation criterion implicitly acknowledge that there are factors, in addition to license renewal, that will ultimately determine whether an existing nuclear power plant continues to operate beyond the period of the current OL.

NRC regulations at 10 CFR 51.95(c)(2) contain the following statement regarding the content of SEISs prepared at the license renewal stage:

> The supplemental environmental impact statement for license renewal is not required to include discussion of need for power or the economic costs and economic benefits of the proposed action or of alternatives to the proposed action except insofar as such benefits and costs are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation. In addition, the supplemental environmental impact statement prepared at the license renewal stage need not discuss other issues not related to the environmental effects of the proposed action and the

alternatives, or any aspect of the storage of spent fuel for the facility within the scope of the generic determination in § 51.23(a) ["Temporary storage of spent fuel after cessation of reactor operation–generic determination of no significant environmental impact"] and in accordance with § 51.23(b).

The GEIS contains the results of a systematic evaluation of the consequences of renewing an OL and operating a nuclear power plant for an additional 20 years. It evaluates 92 environmental issues using the NRC's three-level standard of significance – SMALL, MODERATE, or LARGE – developed using the Council on Environmental Quality guidelines. The following definitions of the three significance levels are set forth in footnotes to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B:

SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

For 69 of the 92 issues considered in the GEIS, the analysis in the GEIS reached the following conclusions:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are not likely to be sufficiently beneficial to warrant implementation.

These 69 issues were identified in the GEIS as Category 1 issues. In the absence of new and significant information, the staff relied on conclusions as amplified by supporting information in the GEIS for issues designated as Category 1 in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B.

Of the 23 issues that do not meet the criteria set forth above, 21 are classified as Category 2 issues requiring analysis in a plant-specific supplement to the GEIS. The remaining two issues, environmental justice and chronic effects of electromagnetic fields, were not categorized. Environmental justice was not evaluated on a generic basis and must be addressed in a plant-specific supplement to the GEIS. Information on the chronic effects of electromagnetic fields was not conclusive at the time the GEIS was prepared.

This SEIS documents the staff's consideration of all 92 environmental issues identified in the GEIS. The staff considered the environmental impacts associated with alternatives to license renewal and compared the environmental impacts of license renewal and the alternatives. The alternatives to license renewal that were considered include the no-action alternative (not renewing the BFN OLs) and alternative methods of power generation. Based on projections made by the U.S. Department of Energy's Energy Information Administration, gas- and coal-fired generation appear to be the most likely power-generation alternatives if the power from BFN is replaced. These alternatives as well as coal gasification and a replacement nuclear plant are evaluated.

TVA and the staff established independent processes for identifying and evaluating the significance of any new information on the environmental impacts of license renewal. Neither TVA nor the staff identified information that is both new and significant related to Category 1 issues that would call the conclusions in the GEIS into question. Similarly, neither the scoping process nor the staff identified any new issue applicable to BFN that has a significant environmental impact.

In July 2004, TVA submitted extended power uprate (EPU) applications to increase the licensed power levels of each of the three BFN units to 3952 megawatts-thermal (MW[t]), or 120 percent of the originally licensed power levels, for a total power level of 11,856 MW(t). If approved, the EPUs would take effect during the existing license term. NRC will evaluate the potential environmental impacts of an EPU in a separate Environmental Assessment. Therefore, the impacts associated with the increase in thermal power level from the currently licensed value to the EPU value is not evaluated in this SEIS. However, the staff performed its evaluation of impacts for the license renewal term in this SEIS assuming all three units are operating at 120 percent of the original licensed power level.

The staff determined that there is a potential, at the higher power levels, that BFN may no longer be within the envelope of impacts defined by the GEIS for some Category 1 issues. If the potential impacts are beyond the defined envelope, then the generic conclusions concerning these Category 1 issues may no longer be valid. The staff examined each of the 54 Category 1 issues applicable to BFN and determined that the level of impact for 34 of the Category 1 issues could be influenced by the thermal power level of the reactors. The staff further evaluated each of the 34 issues to determine if increasing the unit power level above the

levels considered in the GEIS would affect the generic conclusions. After evaluating all 34 issues the staff determined that the generic conclusions reached in the GEIS are still valid and none of the GEIS conclusions were changed based on the staff's analysis. Therefore, the proposed EPU does not constitute new and significant information and the staff could continue to rely upon the conclusions of the GEIS for all Category 1 issues applicable to BFN.

TVA's license renewal application presents an analysis of the Category 2 issues plus environmental justice and chronic effects from electromagnetic fields. The staff reviewed the TVA analysis for each issue and conducted an independent review of each issue. Three Category 2 issues are not applicable because they are related to plant design features or site characteristics not found at BFN. Four Category 2 issues are not discussed in this SEIS because they are specifically related to refurbishment. TVA has stated that its evaluation of structures and components, as required by 10 CFR 54.21, did not identify any major plant refurbishment activities or modifications as necessary to support the continued operation of BFN for the license renewal term. In addition, any replacement of components or additional inspection activities are within the bounds of normal plant operation, and are not expected to affect the environment beyond the bounds of the plant operations evaluated in TVA's 1972 Final Environmental Statement Related to Operation of BFN.

Fourteen Category 2 issues related to operational impacts and postulated accidents during the license renewal term, as well as environmental justice and chronic effects of electromagnetic fields, are discussed in detail in this SEIS. Five of the Category 2 issues and environmental justice apply to both refurbishment and operation during the license renewal term and are only discussed in this SEIS in relation to operation during the license renewal term. For all 14 Category 2 issues and environmental justice, the staff concludes that the potential environmental effects are of SMALL significance in the context of the standards set forth in the GEIS. In addition, the staff determined that appropriate Federal health agencies have not reached a consensus on the existence of chronic adverse effects from electromagnetic fields. Therefore, no further evaluation of this issue is required. For severe accident mitigation alternatives (SAMAs), the staff concludes that a reasonable, comprehensive effort was made to identify and evaluate SAMAs. Based on its review of the SAMAs for BFN, and the plant improvements already made, the staff concludes that none of the candidate SAMAs are cost-beneficial.

Mitigation measures were considered for each Category 2 issue. Current measures to mitigate the environmental impacts of plant operation were found to be adequate, and no additional mitigation measures were deemed sufficiently beneficial to be warranted.

If the BFN OLs are not renewed and Units 1, 2, and 3 cease operation on or before the expiration of their current licenses, then the adverse impacts of likely alternatives will not be

smaller than those associated with continued operation of BFN. The impacts may, in fact, be greater in some areas.

Unit 1 has not operated since 1985, and TVA is currently engaged in activities necessary to return it to service. Almost all of the activities associated with this effort are confined to existing onsite structures, and little new construction is necessary. Impacts arising from these activities are outside the scope of the license renewal review. Any impacts associated with this effort would be bounded by the EIS prepared by TVA when the plant was originally licensed.

The NRC staff recommends that the Commission determine that the adverse environmental impacts of license renewal for BFN are not so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the Environmental Report submitted by TVA; (3) consultation and discussions with other Federal, State, and local agencies; (4) the staff's own independent review; and (5) the staff's consideration of public comments.

Abbreviations/Acronyms

°	degree
µCi	microcurie(s)
µCi/ml	microcuries per milliliter
µGy	microgray(s)
µm	micrometer(s)
µSv	microsieverts
ac	acre(s)
ABWR	Advanced Boiling Water Reactor
ACC	averted cleanup and decontamination costs
ADAMS	Agencywide Document Access and Management System
ADCNR	Alabama Department of Conservation and Natural Resources
ADEM	Alabama Department of Environmental Management
ADPH	Alabama Department of Public Health
ADS	automatic depressurization system
ADWFF	Alabama Division of Wildlife and Freshwater Fisheries
AEA	Atomic Energy Act of 1954
ALARA	As Low As Reasonably Achievable
ANHP	Alabama Natural Heritage Program
AOC	averted offsite property damage costs
AOE	averted occupational exposure
AOSC	averted onsite costs
APE	averted public exposure
ATWS	anticipated transient without scram
BA	Biological Assessment
BETX	benzene, ethylbenzene, toluene and xylene isomers
BFN	Browns Ferry Nuclear Power Plant, Units 1, 2, and 3
BLEU	blended low-enriched uranium
BMP	best management practices
Bq	becquerel(s)
Btu	British thermal unit(s)
BWR	boiling water reactor
BWROG	Boiling Water Reactor Owners Group
C	Celsius
CAIR	Clean Air Interstate Rule
CCDP	conditional core damage probability
CCW	condenser circulating water
CDF	core damage frequency
CEQ	Council on Environmental Quality

CFR	Code of Federal Regulations
cfs	cubic feet per second
Ci	curie(s)
cm	centimeter(s)
COE	cost of enhancement
COPC	chemicals of potential concern
CPI	containment performance improvement
CRD	control rod drive
CS	core spray
CVCS	chemical and volume control system
DBA	design-basis accident
DC	direct current
DDT	dichlorodiphenyltrichloroethane
DMR	Discharge Monitoring Report
DOE	U.S. Department of Energy
DPR	demonstration power reactor
DSM	demand-side management
EECW	emergency equipment cooling water
ECCS	emergency core cooling system
EIA	Energy Information Administration (of DOE)
EIS	environmental impact statement
ELF-EMF	extremely low frequency-electromagnetic field
EOP	Emergency Operating Procedure
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EPU	extended power uprate
EQ	equipment qualification
ER	Environmental Report
ESRP	Environmental Standard Review Plan, NUREG-1555, Supplement 1, Operating License Renewal
F	Fahrenheit
FAA	Federal Aviation Administration
FIVE	fire-induced vulnerability evaluation
FR	Federal Register
fps	feet per second
FPS	fire protection system
FSAR	Final Safety Analysis Report
ft	foot/feet

FWPCA	Federal Water Pollution Control Act of 1972 (also known as the Clean Water Act of 1977)
FWS	U.S. Fish and Wildlife Service
g	gravitational acceleration
gal	gallon
GDC	general design criteria
GEIS	Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437
gpm	gallons per minute
ha	hectare(s)
HVAC	heating ventilation air conditioning
HCLPF	high confidence low probability of failure
HHSI	high head safety injection
HLW	high-level radioactive waste
HPCI	high-pressure coolant injection
hr	hour(s)
Hz	Hertz
in.	inch(es)
IPE	Individual plant examination
IPEEE	individual plant examination of external events
ISFSI	independent spent fuel storage installation
ISLOCA	interfacing systems loss-of-coolant accident
kg	kilogram(s)
km	kilometer(s)
KPDS	key plant damage states
kV	kilovolt(s)
kV/m	kilovolt per meter
kWh	kilowatt hour(s)
L	liter(s)
lb	pound
LERF	large early release frequency
LLNL	Lawrence Livermore National Laboratory
LLW	low level waste
LNG	liquefied natural gas
LOCA	loss of coolant accident
LOOP	loss of offsite power

LWR	light-water reactor
m	meter(s)
mg	milligrams
m/s	meter(s) per second
m^3/d	cubic meters per day
m^3/s	cubic meter(s) per second
mA	milliampere(s)
MAAP	Modular Accident Analysis Program
MACCS2	MELCOR Accident Consequence Code System 2
mi	mile(s)
min	minutes
MGD	millions of gallons per day
mGy	milligray(s)
mL	milliliter(s)
MMNS	Mississippi Museum of Natural Science
MNHP	Mississippi Natural Heritage Program
mph	miles per hour
mrad	millirad(s)
mrem	millirem(s)
mSv	millisievert(s)
MT	metric ton(s) (or tonne[s])
MTU	metric ton(s)-uranium
MW	megawatt(s)
MWd/MTU	megawatt-days per metric ton of uranium
MWh	megawatt hours
MW(e)	megawatt(s)-electric
MW(t)	megawatt(s)-thermal
MWh	megawatt hour(s)
NA	not applicable
NAS	National Academy of Sciences
NCI	National Cancer Institute
NCWRC	North Carolina Wildlife Resources Commission
NEPA	National Environmental Policy Act of 1969
NESC	National Electric Safety Code
ng/J	nanogram per joule
NHPA	National Historic Preservation Act
NIEHS	National Institute of Environmental Health Sciences
NO_x	nitrogen oxide(s)
NPDES	National Pollutant Discharge Elimination System

NRC	U.S. Nuclear Regulatory Commission
NWPPC	Northwest Power Planning Council
ODCM	Offsite Dose Calculation Manual
OL	operating license
OLTP	original licensed thermal power
PAR	passive autocatalytic recombiners
PARS	publicly available records
PDS	plant damage state
PM_{10}	particulate matter, 10 microns or less in diameter
ppt	parts per thousand
PRA	Probabilistic Risk Assessment
PSA	Probabilistic Safety Assessment
PSD	prevention of significant deterioration
PSW	plant service water
PWR	pressurized water reactor
RAB	reactor auxiliary building
RAI	request for additional information
RBCCW	reactor building closed cooling water
RCIC	reactor core isolation cooling
RCP	reactor coolant pump
RCRA	Resource Conservation and Recovery Act
RCS	reactor coolant system
rem	roentogen equivalent man
REM	radiological environmental monitoring
REMP	radiological environmental monitoring program
RHR	residual heat removal
RHRSW	residual heat removal service water (system)
rms	root mean square
RPC	replacement power cost
RWST	refueling water storage tank
ry	reactor year
s	second(s)
SAG	Severe Accident Guideline
SAMA	Severe Accident Mitigation Alternative
SAMG	Severe Accident Management Guideline
SAR	Safety Analysis Report
SBO	station blackout

SCR	selective catalytic reduction
SEIS	Supplemental Environmental Impact Statement
SER	Safety Evaluation Report
SGTR	steam generator tube rupture
SHPO	State Historic Preservation Officer
SLC	standing liquid control
SMZ	steamside management zone
SO_2	sulfur dioxide
SO_x	sulfur oxide(s)
SRV	safety relief valve
SSC	systems, structures, and components
Sv	sievert(s)
SW	service water
TBq	terrabecquerel
TRM	Tennessee River Mile
TVA	Tennessee Valley Authority
UDB	urban development boundary
UFSAR	Updated Final Safety Analysis Report
U.S.	United States
USC	United States Code
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USFWS	United States Fish and Wildlife Service
yd	yard
yr	year

1.0 Introduction

Under the U.S. Nuclear Regulatory Commission's (NRC's) environmental protection regulations in Title 10 of the Code of Federal Regulations (CFR) Part 51, which implement the National Environmental Policy Act of 1969 (NEPA), renewal of a nuclear power plant operating license (OL) requires the preparation of an environmental impact statement (EIS). In preparing the EIS, the NRC staff is required first to issue the statement in draft form for public comment, and then issue a final statement after considering public comments on the draft. To support the preparation of the EIS, the staff has prepared a *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999).[a] The GEIS is intended to (1) provide an understanding of the types and severity of environmental impacts that may occur as a result of license renewal of nuclear power plants under 10 CFR Part 54, (2) identify and assess the impacts that are expected to be generic to license renewal, and (3) support 10 CFR Part 51 to define the number and scope of issues that need to be addressed by the applicants in plant-by-plant license renewal proceedings. Use of the GEIS guides the preparation of complete plant-specific information in support of the OL renewal process.

The Tennessee Valley Authority (TVA) operates Browns Ferry Nuclear Plant, Units 1, 2, and 3 (BFN) in northern Alabama under OLs DPR-33, DPR-52, and DPR-68, respectively, which were issued by the NRC. These OLs will expire in December 2013 for Unit 1, June 2014 for Unit 2, and July 2016 for Unit 3. On December 31, 2003, TVA submitted an application to NRC to renew the OLs for BFN for an additional 20 years under 10 CFR Part 54 (TVA 2003a). TVA is a *licensee* for the purposes of its current OLs and an *applicant* for the renewal of the OLs. Pursuant to 10 CFR 54.23 and 51.53(c), TVA submitted an Environmental Report (ER) (TVA 2003b) in which it analyzed the environmental impacts associated with the proposed license renewal action, considered alternatives to the proposed action, and evaluated mitigation measures for reducing adverse environmental effects.

TVA, a Federal corporation wholly owned by the U.S. Government, is a Federal agency and subject to the requirements of NEPA. In compliance with NEPA, TVA prepared a supplemental EIS (SEIS) to provide the public and TVA decisionmakers with an assessment of the environmental impacts of extending the operating life of the BFN nuclear units (TVA 2002). This NRC SEIS draws upon the content of the TVA SEIS, but was prepared by NRC staff independently.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

This SEIS is the plant-specific supplement to the GEIS for the TVA license renewal application. This supplement relies, in part, on the findings of the GEIS. The staff is preparing a separate safety evaluation report in accordance with 10 CFR Part 54.

1.1 Report Contents

The following sections of this introduction (1) describe the background for the preparation of this SEIS, including the development of the GEIS and the process used by the staff to assess the environmental impacts associated with license renewal; (2) describe the proposed Federal action to renew the BFN OLs; (3) discuss the purpose and need for the proposed action; and (4) present the status of TVA's compliance with environmental quality standards and requirements that have been imposed by Federal, State, regional, and local agencies that are responsible for environmental protection.

The ensuing chapters of this SEIS closely parallel the contents and organization of the GEIS. Chapter 2 describes the site, power plant, and interactions of the plant with the environment. Chapters 3 and 4, respectively, discuss the potential environmental impacts of plant refurbishment and plant operation during the license renewal term. Chapter 5 contains an evaluation of potential environmental impacts of plant accidents and includes consideration of severe accident mitigation alternatives. Chapter 6 discusses the uranium fuel cycle and solid waste management. Chapter 7 discusses decommissioning, and Chapter 8 discusses alternatives to license renewal. Finally, Chapter 9 summarizes the findings of the preceding chapters and draws conclusions about the adverse impacts that cannot be avoided, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and the irreversible or irretrievable commitment of resources. Chapter 9 also presents the staff's recommendation with respect to the proposed license renewal action.

Additional information is included in the appendixes. Appendix A contains public comments related to the environmental review for license renewal and staff responses to those comments. Appendixes B through G, respectively, list the following:

- the preparers of the supplement
- the chronology of NRC staff's environmental review correspondence related to this SEIS
- the organizations contacted during the development of this SEIS
- TVA's compliance status in Table E-1 (this appendix also contains copies of consultation correspondence prepared and sent during the evaluation process)

- GEIS environmental issues that are not applicable to BFN
- severe accident mitigation alternatives.

1.2 Background

Use of the GEIS, which examines the possible environmental impacts that could occur as a result of renewing individual nuclear power plant OLs under 10 CFR Part 54 and the established license renewal evaluation process, supports the thorough evaluation of the impacts of renewal of OLs.

1.2.1 Generic Environmental Impact Statement

NRC initiated a generic assessment of the environmental impacts associated with the license renewal term to improve the efficiency of the license renewal process by documenting the assessment results and codifying the results in the Commission's regulations. This assessment is provided in the GEIS, which serves as the principal reference for all nuclear power plant license renewal EISs.

The GEIS documents the results of the systematic approach that was taken to evaluate the environmental consequences of renewing the licenses of individual nuclear power plants and operating them for an additional 20 years. For each potential environmental issue, the GEIS (1) describes the activity that affects the environment, (2) identifies the population or resource that is affected, (3) assesses the nature and magnitude of the impact on the affected population or resource, (4) characterizes the significance of the effect for both beneficial and adverse effects, (5) determines whether the results of the analysis apply to all plants, and (6) considers whether additional mitigation measures would be warranted for impacts that would have the same significance level for all plants.

NRC's standard of significance for impacts was established using the Council on Environmental Quality (CEQ) terminology for "significantly" (40 CFR 1508.27, which requires consideration of both "context" and "intensity"). Using the CEQ terminology, NRC established three significance levels – SMALL, MODERATE, or LARGE. The definitions of the three significance levels are set forth in the footnotes to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, as follows:

> SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
>
> MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.

LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

The GEIS assigns a significance level to each environmental issue, assuming that ongoing mitigation measures would continue.

The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required in this SEIS unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria of Category 1, and therefore, additional plant-specific review for these issues is required.

In the GEIS, the staff assessed 92 environmental issues and determined that 69 qualified as Category 1 issues, 21 qualified as Category 2 issues, and 2 issues, environmental justice and chronic effects of electromagnetic fields, were not categorized. Environmental justice was not evaluated on a generic basis and must be addressed in a plant-specific supplement to the GEIS. Information on the chronic effects of electromagnetic fields was not conclusive at the time the GEIS was prepared.

Of the 92 issues, 11 are related only to refurbishment, 6 are related only to decommissioning, 67 apply only to operation during the license renewal term, and 8 apply to both refurbishment and operation during the renewal term. A summary of the findings for all 92 issues in the GEIS is codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B.

1.2.2 License Renewal Evaluation Process

An applicant seeking to renew its OLs is required to submit an ER as part of its application. The license renewal evaluation process involves careful review of the applicant's ER and assurance that all new and potentially significant information not already addressed in or available during the GEIS evaluation is identified, reviewed, and assessed to verify the environmental impacts of the proposed license renewal.

In accordance with 10 CFR 51.53(c)(2) and (3), the ER submitted by the applicant must

- provide an analysis of the Category 2 issues in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B in accordance with 10 CFR 51.53(c)(3)(ii)
- discuss actions to mitigate any adverse impacts associated with the proposed action and environmental impacts of alternatives to the proposed action.

In accordance with 10 CFR 51.53(c)(2), the ER does not need to

- consider the economic benefits and costs of the proposed action and alternatives to the proposed action except insofar as such benefits and costs are either (1) essential for making a determination regarding the inclusion of an alternative in the range of alternatives considered, or (2) relevant to mitigation
- consider the need for power and other issues not related to the environmental effects of the proposed action and the alternatives
- discuss any aspect of the storage of spent fuel within the scope of the generic determination in 10 CFR 51.23(a) in accordance with 10 CFR 51.23(b)
- contain an analysis of any Category 1 issue unless there is significant new information on a specific issue – this is pursuant to 10 CFR 51.53(c)(3)(i) and (iv).

New and significant information is (1) information that identifies a significant environmental issue not covered in the GEIS and codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, or (2) information that was not considered in the analyses summarized in the GEIS and that leads to an impact finding that is different from the finding presented in the GEIS and codified in 10 CFR Part 51.

TVA, as a Federal agency, met its obligations under NEPA by preparing its own SEIS for BFN license renewal (TVA 2002). In preparing to submit its application to renew the BFN OLs, TVA

used its own SEIS as part of a process to ensure that information not addressed in or available during the GEIS evaluation regarding the environmental impacts of license renewal for BFN would be properly reviewed before submitting the ER, and to ensure that such new and potentially significant information related to renewal of the licenses for Units 1, 2, and 3 would be identified, reviewed, and assessed during the period of the NRC review. TVA reviewed the Category 1 issues that appear in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, to verify that the conclusions of the GEIS remained valid with respect to BFN. This review was performed by personnel from TVA who were familiar with NEPA issues and the scientific disciplines involved in the preparation of a license renewal ER.

The NRC staff also has a process for identifying new and significant information. That process is described in detail in NUREG-1555, Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal*, (NRC 2000). The search for new information includes (1) review of an applicant's ER and the process for discovering and evaluating the significance of new information; (2) review of records of public comments; (3) review of environmental quality standards and regulations; (4) coordination with Federal, State, and local environmental protection and resource agencies; and (5) review of the technical literature. New information discovered by the staff is evaluated for significance using the criteria set forth in the GEIS. For Category 1 issues where new and significant information is identified, reconsideration of the conclusions for those issues is limited in scope to the assessment of the relevant new and significant information; the scope of the assessment does not include other facets of the issue that are not affected by the new information.

Chapters 3 through 7 discuss the environmental issues considered in the GEIS that are applicable to BFN. At the beginning of the discussion of each set of issues, there is a table that identifies the issues to be addressed and lists the sections in the GEIS where the issue is discussed. Category 1 and Category 2 issues are listed in separate tables. For Category 1 issues for which there is no new and significant information, the table is followed by a set of short paragraphs that state the GEIS conclusion codified in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, followed by the staff's analysis and conclusion. For Category 2 issues, in addition to the list of GEIS sections where the issue is discussed, the tables list the subparagraph of 10 CFR 51.53(c)(3)(ii) that describes the analysis required and the SEIS sections where the analysis is presented. The SEIS sections that discuss the Category 2 issues are presented immediately following the table.

Section 4.7 addresses potential new and significant information. In July 2004, TVA submitted extended power uprate (EPU) applications (TVA 2004a, b) to increase the licensed power levels of each of the three units to 3952 megawatts-thermal (MW[t]), or 120 percent of the originally licensed power levels, for a total station power level of 11,856 MW(t). The staff determined that there is a potential, at the uprated power level, that BFN may no longer be within the envelope of impacts defined by the GEIS, as amended, for some Category 1 issues.

To address this concern, the staff examined each of the 54 Category 1 issues applicable to BFN and determined that 34 of the Category 1 issues could be influenced by the thermal power level of the reactors. The staff then evaluated each of the 34 issues to determine if increasing the unit power level above the levels considered during the development of the GEIS would affect the specific generic conclusions. After evaluating all 34 issues the staff determined that the generic conclusions reached in the GEIS are still valid and none of the GEIS conclusions were changed based on the staff's analysis. Therefore, the proposed EPU does not constitute new and significant information and the staff could continue to rely upon the conclusions of the GEIS for all Category 1 issues applicable to BFN.

NRC prepares an independent analysis of the environmental impacts of license renewal and compares these impacts to the environmental impacts of alternatives. Evaluation of the TVA license renewal application began with publication of a notice of acceptance for docketing and opportunity for a hearing in the *Federal Register* (69 FR 11460) on March 10, 2004. The staff published a notice of intent to prepare an EIS and conduct scoping (69 FR 11462) on March 10, 2004. Two public scoping meetings were held on April 1, 2004, in Athens, Alabama. Comments received during the scoping period were summarized in the *Environmental Scoping Summary Report – Browns Ferry Nuclear Plant, Units 1, 2, and 3, Limestone County, Alabama* (NRC 2004) dated July 2004. Comments applicable to this environmental review are presented in Part 1 of Appendix A.

The staff followed the review guidance contained in NUREG-1555, Supplement 1, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal* (NRC 2000). The staff and its contractors visited the BFN site on March 30 and 31, 2004, to gather information and to become familiar with the site and its environs. The staff also reviewed the comments received during scoping, and consulted with Federal, State, regional, and local agencies. A list of the organizations consulted is provided in Appendix D. Other documents related to BFN were reviewed and are referenced.

This SEIS presents the staff's analysis that considers and weighs the environmental effects of the proposed renewal of the OLs for BFN, the environmental impacts of alternatives to license renewal, and mitigation measures available for avoiding adverse environmental effects. Chapter 9, "Summary and Conclusions," provides the NRC staff's recommendation to the Commission on whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable.

On December 10, 2004, the NRC published the Notice of Availability of the draft SEIS (69 FR 71855). A 75-day comment period began on the date of publication of the U.S. Environmental Protection Agency Notice of Filing of the draft SEIS to allow members of the public to comment on the results of the NRC staff's review. During this comment period, two

public meetings were held in Athens, Alabama, on January 25, 2005. During these meetings, the staff described the results of the NRC environmental review, answered questions, and provided members of the public with information to assist them in formulating their comments. The comment period ended on March 2, 2005. Comments made during the 75-day comment period, including those made at the two public meetings, are presented in Part II of Appendix A of this final SEIS. The NRC responses to these comments are also provided.

1.3 The Proposed Federal Action

The proposed Federal action is renewal of the OLs for BFN. BFN is located in northern Alabama on the north shore of Wheeler Reservoir, an impoundment of the Tennessee River. The BFN site is approximately 16 km (10 mi) south of Athens, Alabama; 16 km (10 mi) northwest of Decatur, Alabama; and 48 km (30 mi) west of Huntsville, Alabama. The plant has three General Electric-designed boiling water reactors. Unit 1 is currently licensed at its original power level of 3293 MW(t) and has a net power output of 1065 megawatts-electric (MW[e]). Units 2 and 3 were granted a license amendment during 1998 that raised their authorized thermal power levels by 5 percent to 3458 MW(t), and each unit currently has a net power output of 1118 MW(e). Plant cooling is normally provided by a once-through cooling system that draws water from the Tennessee River. The plant also has mechanical draft cooling towers that are used when needed to provide additional heat dissipation before the cooling water is returned to the river. With all three units operating, enough electricity would be produced to supply the needs of nearly two million homes. The current OL for Unit 1 expires on December 20, 2013; the license for Unit 2 expires on June 28, 2014; and the license for Unit 3 expires on July 2, 2016. By letter dated December 31, 2003, TVA submitted an application to the NRC (TVA 2003a) to renew these OLs for an additional 20 years of operation (i.e., until December 20, 2033, June 28, 2034, and July 2, 2036, for Units 1, 2, and 3, respectively).

All three of the BFN units were shut down in 1985 to review the TVA nuclear power program and to correct significant weaknesses (TVA 2003b). Unit 2 was returned to service in 1991, and Unit 3 was returned to service in 1995. In 2002, TVA began the process of returning Unit 1 to service, with operation expected to resume in 2007. Almost all the activities associated with this effort are confined to existing onsite structures and little new construction is necessary. No licensing action by NRC is required for the restart of Unit 1, and many of the activities that could have had some environmental impact have already been completed. TVA considered these impacts in a separate SEIS (TVA 2002). Therefore, the effects of Unit 1 restart are outside the scope of license renewal and are not considered in this SEIS, although the potential effects of continued operation of Unit 1 are considered in this analysis.

In July 2004, TVA submitted EPU applications (TVA 2004a, b) to increase the licensed power levels of each of the three units to 3952 MW(t), or 120 percent of the originally licensed power

levels, for a total station power level of 11,856 MW(t). NRC will evaluate the potential environmental impacts of an EPU in a separate Environmental Assessment. Therefore, the impacts associated with the increase in thermal power level from the currently licensed value to the EPU value is not evaluated in this SEIS. However, the staff performed its evaluation of impacts for the license renewal term in this SEIS assuming all three units are operating at 120 percent of the original licensed power level.

This SEIS was prepared to evaluate the potential environmental impacts of operating the BFN units at 120 percent of their originally licensed power levels for an additional 20 years beyond the current license terms for each unit.

1.4 The Purpose and Need for the Proposed Action

Although a licensee must have a renewed license to operate a reactor beyond the term of the existing OL, the possession of that license is just one of a number of conditions that must be met for the licensee to continue plant operation during the term of the renewed license. Once an OL is renewed, State regulatory agencies and the owners of the plant will ultimately decide whether the plant will continue to operate based on factors such as the need for power or other matters within the State's jurisdiction or the purview of the owners.

Thus, for license renewal reviews, the NRC has adopted the following definition of purpose and need (GEIS Section 1.3):

> The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and where authorized, Federal (other than NRC) decisionmakers.

This definition of purpose and need reflects the Commission's recognition that, unless there are findings in the safety review required by the Atomic Energy Act of 1954 or findings in the NEPA environmental analysis that would lead the NRC to reject a license renewal application, the NRC does not have a role in the energy-planning decisions of State regulators and utility officials as to whether a particular nuclear power plant should continue to operate. From the perspective of the licensee and the State regulatory authority, the purpose of renewing an OL is to maintain the availability of the nuclear plant to meet system energy requirements beyond the current term of the plant's license.

1.5 Compliance and Consultations

TVA is required to hold certain Federal, State, and local environmental permits, as well as meet relevant Federal and State statutory requirements. In its ER, TVA provided a list of the authorizations from Federal, State, and local authorities for current operations as well as environmental approvals and consultations associated with BFN license renewal. Authorizations and consultations relevant to the proposed OL renewal action are included in Appendix E.

The staff has reviewed the list and consulted with the appropriate Federal, State, and local agencies to identify any compliance or permit issues or significant environmental issues of concern to the reviewing agencies. These agencies did not identify any new and significant environmental issues. The ER states that TVA is in compliance with applicable environmental standards and requirements for BFN. The staff has not identified any environmental issues that are both new and significant.

1.6 References

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 54. Code of Federal Regulations, Title 10, *Energy,* Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

40 CFR Part 1508. Code of Federal Regulations, Title 40, *Protection of Environment,* Part 1508, "Terminology and Index."

69 FR 11460. March 10, 2004. "Notice of Acceptance for Docketing of the Application and Notice of Opportunity for a Hearing Regarding Renewal of License Nos. DPR-33, DPR-52 and DPR-68 for an Additional Twenty-Year Period." *Federal Register,* U.S. Nuclear Regulatory Commission.

69 FR 11462. March 10, 2004. "Notice of Intent to Prepare an Environmental Impact Statement and Conduct Scoping Process." *Federal Register,* U.S. Nuclear Regulatory Commission.

69 FR 71855. December 10, 2004. "Notice of Availability of Draft Supplement 21 to the Generic Environmental Impact Statement and Public Meeting for the License Renewal of Browns Ferry Nuclear Plant, Units 1, 2, and 3." *Federal Register,* U.S. Nuclear Regulatory Commission.

Atomic Energy Act of 1954. 42 USC 2011, et seq.

National Environmental Policy Act of 1969 (NEPA). 42 USC 4321, et seq.

Tennessee Valley Authority (TVA). 2002. *Final Supplemental Environmental Impact Statement for Operating License Renewal of the Browns Ferry Nuclear Plant in Athens, Alabama.* Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 2003a. *Application for Renewed Operating Licenses, Browns Ferry Units 1, 2, and 3.* Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 2003b. *Applicant's Environmental Report – Operating License Renewal Stage, Browns Ferry Units 1, 2, and 3.* Knoxville, Tennessee.

Tennessee Valley Authority (TVA). 2004a. *Tennessee Valley Authority Browns Ferry Nuclear Plant (BFN), Unit 1, Proposed Technical Specifications (TS) Change TS-431 – Request for License Amendment for Extended Power Uprate Operation, Browns Ferry Unit 1 Extended Power Uprate Environmental Report.* Tennessee Valley Authority, Decatur, Alabama.

Tennessee Valley Authority (TVA). 2004b. *Tennessee Valley Authority Browns Ferry Nuclear Plant (BFN), Units 2 and 3, Proposed Technical Specifications (TS) Change TS-418 – Request for License Amendment for Extended Power Uprate Operation, Browns Ferry Units 2 and 3 Extended Power Uprate Environmental Report.* Tennessee Valley Authority, Decatur, Alabama.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants.* NUREG-1437, Volumes 1 and 2, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants Main Report,* "Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants, Final Report." NUREG-1437, Volume 1, Addendum 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2000. *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal.* NUREG-1555, Supplement 1, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 2004. *Environmental Scoping Summary Report – Browns Ferry Nuclear Plant, Units 1, 2, and 3, Limestone County, Alabama.* Washington, D.C.

2.0 Description of Nuclear Power Plant and Site and Plant Interaction with the Environment

The Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 (BFN) site is located on the north shore of Wheeler Reservoir in Limestone County, Alabama, at Tennessee River Mile (TRM) 294. The plant consists of three boiling water reactors (BWRs) that produce steam, which passes through a turbine to generate electricity. In addition to the nuclear units, the major features of the site are intake and discharge canals, switchyards, a training center, an employee physical fitness center, a materials storage and procurement complex, and structures from a former aquatic research laboratory. The plant and its environment are described in Section 2.1, and the interaction of the plant with the environment is presented in Section 2.2.

2.1 Plant and Site Description and Proposed Plant Operation During the License Renewal Term

BFN is located on approximately 340 ha (840 ac) of Federally owned land that is under the custody of the Tennessee Valley Authority (TVA). TVA is a corporate agency and instrumentality of the United States, as described in the TVA Environmental Report (ER) (TVA 2003a). The site is approximately 48 km (30 mi) west of Huntsville, Alabama; 16 km (10 mi) northwest of Decatur, Alabama; and 16 km (10 mi) southwest of Athens, Alabama. Figures 2-1 and 2-2 show the location of BFN and features within an 80-km and 10-km (50-mi and 6-mi) radius of the site.

Land in the vicinity of BFN is used primarily for agriculture. Population densities are low, with no population centers of significance within 16 km (10 mi) of the plant. The site is surrounded to the north and east by rural countryside. It includes open pasture lands, scattered farmsteads, few residents, and little industry within several miles. The terrain is gently rolling with open views to higher elevations to the north. The south and west side of the plant site abuts Wheeler Reservoir, which is a wide expanse of open river used for a variety of recreational purposes. The reservoir in the vicinity of the plant site is moderately used by recreational boaters and fishermen. There are no homes within the foreground viewing distance to the north and east. However, adjacent to the plant site several developments have partial views of the site – a small residential development is sited to the northwest and another across Wheeler Reservoir to the southwest, and the Mallard Creek public use area is directly across the reservoir. A berm, graded during the initial construction of the plant site and containing approximately 2.5 million m^3 (3.3 million yd^3) of earth excavated to make cooling water channels, lies adjacent to the cooling tower complex and blocks views of the northern and eastern plant areas. Two wildlife management areas – Swan Creek State Wildlife Management

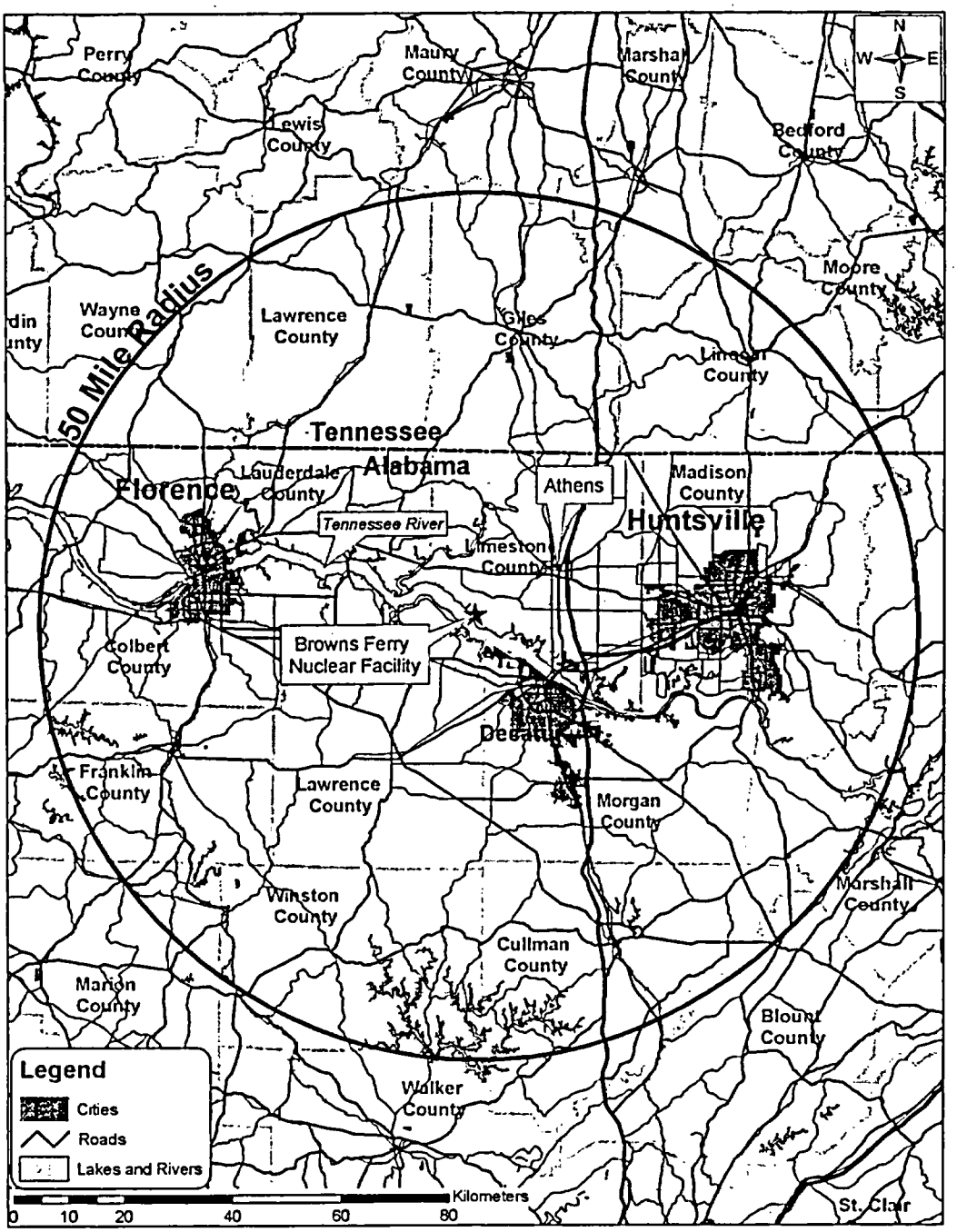

Figure 2-1. Location of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3, 80-km (50-mi) Region

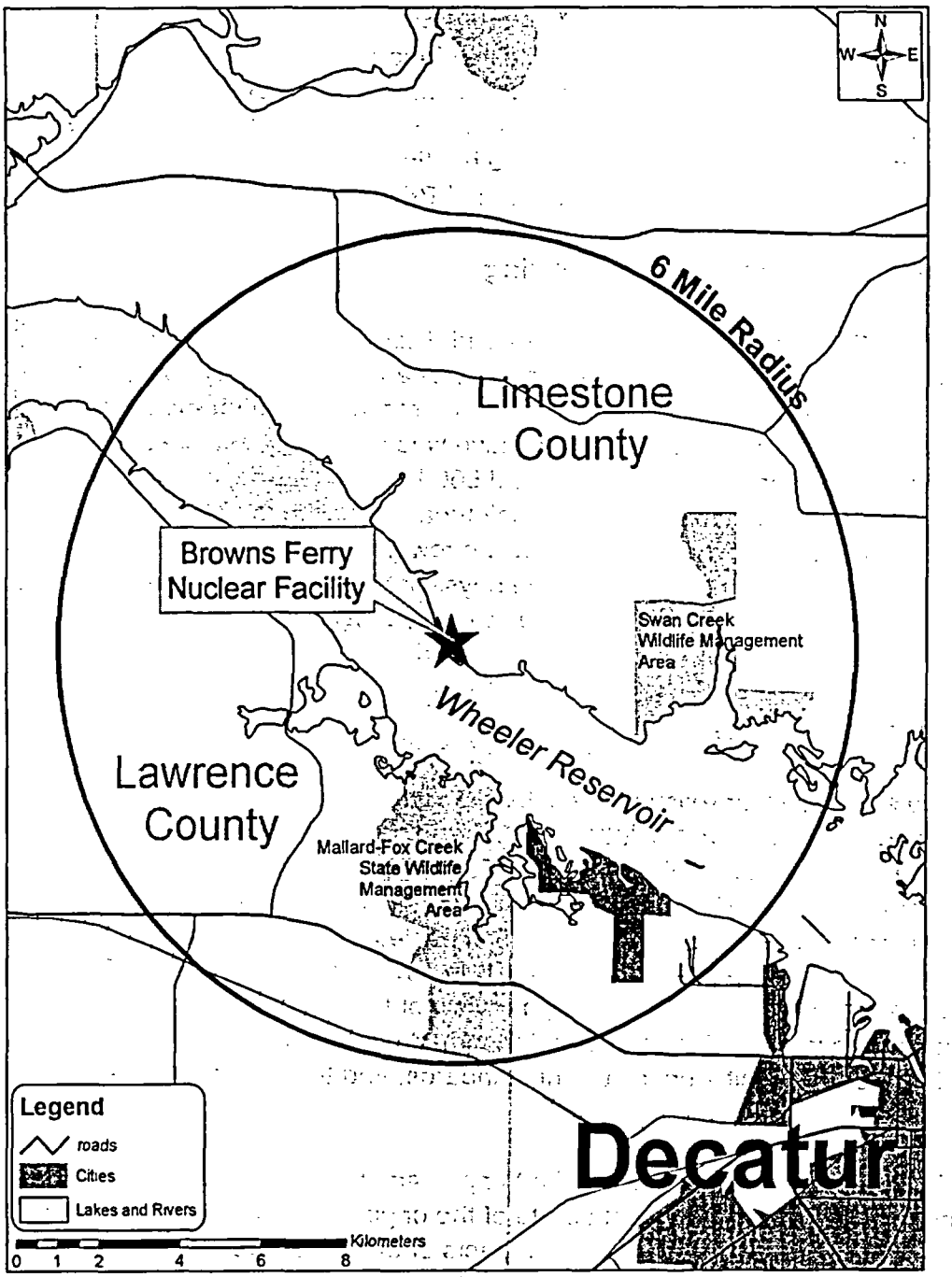

Figure 2-2. Location of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3, 10-km (6-mi) Region

Area and Mallard-Fox Creek State Wildlife Management Area – are within 5 km (3 mi) of the BFN site (TVA 2003a). The Swan Creek Wildlife Management Area includes 1232 ha (3045 ac), and 2357 ha (5825 ac) of water surrounded by numerous industrial facilities. The Mallard-Fox Creek State Wildlife Management Area encompasses approximately 593 ha (1483 ac), and is primarily used for small game hunting. The Round Island Recreation Area is located approximately 5.6 km (3.5 mi) upstream of BFN.

2.1.1 External Appearance and Setting

The three-unit BFN plant, including the intake and discharge canals, is enclosed by a security fence. Primary access to the plant area is by way of an access road through a security gate. The plant has the following principal physical structures in the central site area: reactor containment building, turbine building, radioactive waste building, service building, intake pumping station, transformer yard, 161-kV and 500-kV switchyards, off-gas stack, sewage treatment facilities, and administration and maintenance buildings. The hot and cold water discharge channels and mechanical draft cooling towers are located northwest of the central site area, while the training center, employee physical fitness center, materials storage and procurement complex, and structures from a former aquatic research laboratory are located to the east of the central site area.

2.1.2 Reactor Systems

BFN has two active nuclear reactor units (Units 2 and 3) and one inactive unit (Unit 1) as shown in Figure 2-3. Each unit includes a BWR and a steam-driven turbine generator manufactured by General Electric Company. Each unit originally was licensed for an output of 3293 megawatts-thermal (MW[t]), with a design net electric rating of 1065 megawatts-electric (MW[e]). Major construction on BFN, TVA's first nuclear power plant, began in 1967. Commercial operation began in 1974 for Unit 1, in 1975 for Unit 2, and in 1977 for Unit 3. All three units were shut down in 1985 during a review of the TVA nuclear power program. Unit 2 returned to service in May 1991, and Unit 3 resumed operation in November 1995. Work began in 2002 to bring Unit 1 up to current standards, and the reactor is currently scheduled to restart in 2007.

In 1998, BFN completed an Integrated Plant Improvement Project for Units 2 and 3. Among the improvements made was a 5-percent uprate of the original licensed thermal power (OLTP) for both units from 3293 to 3458 MW(t). The impacts of this action were evaluated in an Environmental Assessment. The U.S. Nuclear Regulatory Commission (NRC) issued the Environmental Assessment and Finding of No Significant Impact related to the October 1, 1997, application for a 5-percent power uprate on August 26, 1998 (NRC 1998). An amendment to

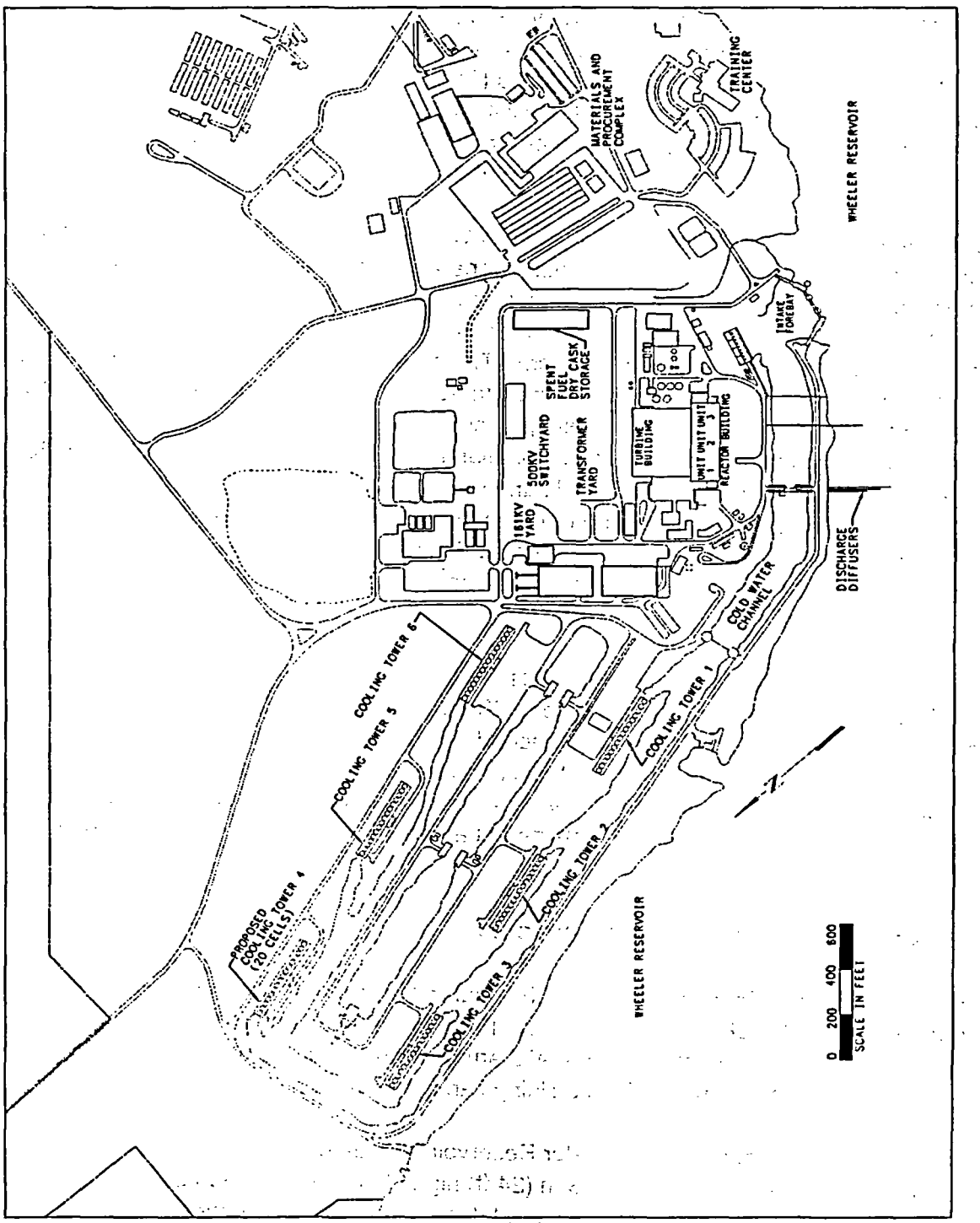

Figure 2-3. Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Site Features

the BFN operating license (OL) was approved by NRC for the 5-percent uprate on September 8, 1998. In June 2004, TVA submitted applications for extended power uprates (EPUs) to 120 percent of OLTP at each of the three BFN units (TVA 2004a, b). These applications, if approved by the staff, will take effect during the existing license term. The impacts evaluated in this supplemental environmental impact statement (SEIS) include those from operation of all three of the BFN reactor units, each at 120 percent of the OLTP.

The nuclear steam supply system at BFN is typical of General Electric BWRs. Each nuclear system includes a single-cycle, forced-circulation, General Electric BWR that produces steam for direct use in a steam turbine. The design employs a pressure suppression primary containment that houses the reactor vessel, the reactor coolant recirculating loops, and other branch connections of the reactor primary system. The pressure suppression system consists of a drywell, a pressure suppression chamber that stores a large volume of water, connecting vents between the drywell and the pressure suppression chamber, isolation valves, containment cooling systems, and other service equipment. Cooling systems are provided to remove heat from the reactor core, the drywell, and the water in the pressure suppression chamber, thus providing continuous cooling of the primary containment under accident conditions. Appropriate isolation valves are actuated during this period to ensure confinement of radioactive material, which might otherwise be released from the reactor containment during the course of an accident.

The secondary containment substructure consists of poured-in-place, reinforced concrete exterior walls that extend up to the refueling floor. The refueling room floor is also constructed of reinforced, poured-in-place concrete. The secondary containment structure completely encloses the primary containment dry wells, fuel storage and handling facilities, and essentially all of the core standby cooling systems for the three units. During normal operation and when isolated, the secondary containment is maintained at a negative pressure relative to the building exterior.

2.1.3 Cooling and Auxiliary Water Systems

Wheeler Reservoir on the Tennessee River is the source for cooling water and most of the auxiliary water systems for BFN (see Figure 2-3). Potable water is supplied by the City of Athens Utilities Water Department in Athens, Alabama. Groundwater is not used at the site. Figure 2-3 shows the general layout of the buildings and structures at the site.

The intake forebay is separated from Wheeler Reservoir by a gate structure with three bays that are each 12 m (40 ft) wide by about 7.3 m (24 ft) high (TVA 1972). Each bay includes a 6-m (20-ft)-high gate that can be raised or lowered depending on the operational requirements of the plant. The flow velocity through the openings varies depending on the gate position.

When the gates are in their full open position and the plant is operated in either the open or helper modes, the average flow velocity through the openings is about 0.2 m/s (0.6 fps) for the operation of one unit, 0.34 m/s (1.1 fps) for the operation of two units, and 0.52 m/s (1.7 fps) for the operation of all three units (TVA 2003a). These flow velocities are based on an intake flow per unit of about 46,300 L/s (734,000 gpm), which is 46.3 m^3/s (1635 cfs).

The intake pumping station includes 18 bays (i.e., six bays per reactor unit), each with a traveling screen. Each bay has a net opening size of about 2.6 m by 6 m (8.66 ft by 20 ft). The maximum average flow velocity through each bay is about 0.49 m/s (1.6 fps) and is independent of the reservoir surface elevation. The maximum average velocity through a clean screen with net openings of 0.95 cm by 0.95 cm (3/8 in. by 3/8 in.) is about 0.64 m/s (2.1 fps) (TVA 2003a). Flow velocities through the intake pump station bays and traveling screens are independent of the number of units in operation and the reservoir elevation.

The BFN units are normally cooled by pumping water from Wheeler Reservoir into the turbine generator condensers and discharging it back to the reservoir via three large submerged diffuser pipes that are perforated to maximize uniform mixing into the flow stream. These pipes range in diameter from 5.2 m to 6.2 m (17 ft to 20.5 ft). The flow exits each discharge pipe through 7800 5-cm (2-in.) ports (TVA 2003b). This straight-through flow path is known as "open cycle" or "open mode" operation. As originally designed, the maximum thermal discharge from the once-through cooling water system is directed into the Wheeler Reservoir, with a temperature increase across the intake and discharge of 13.9°C (25°F) (TVA 1972). The flow exits the diffusers and mixes with the reservoir flow. At the edge of the discharge mixing zone, the water temperature is required to be less than 5.6°C (10°F) above ambient (ADEM 2003).

Through various gates, some of this cooling water can also be directed through cooling towers to reduce its temperature as necessary to comply with environmental regulations. This flow path is known as the "helper mode."

The capacity also exists to recycle cooling water from the cooling towers directly back to the intake structure without being discharged to the reservoir. This flow path, known as the "closed mode" of operation, has not been used since the restart of Units 2 and 3 because of difficulties in achieving temperature limits in summer months and problems with equipment reliability. TVA does not anticipate using this mode in the future, and no procedures for operating in this mode currently exist.

In recent years, only Units 2 and 3 have been operated, but because of a combination of system upgrades and improved flow calibrations, the measured total per-unit condenser circulating water (CCW) flow rate in open mode (with three CCW water pumps per unit) has increased. The condenser tubes were replaced with stainless steel tubing that have a larger internal diameter and lower flow resistance. This modification increased flow through the

condenser by approximately 6 percent. TVA estimates total intake for three-unit operation in open mode to be 139 m^3/s (4907 cfs) or 12,000 m^3/d (3171 million gallons per day [MGD]) (TVA 2003a).

Because of various system limitations, BFN cannot pass all the CCW through the cooling towers when operating in the helper mode. The fraction of cooling water that cannot be passed through the cooling towers is routed directly to the river. Almost all of the cooling water that passes through the cooling towers is returned to the river, but a small amount is lost to the atmosphere during operation. If cooling tower capacity is increased during the license renewal term, this consumptive use could increase proportionately. The cooling towers are only operated when necessary to meet thermal discharge temperature limits specified in the National Pollutant Discharge Elimination System (NPDES) permit issued by the Alabama Department of Environmental Management (ADEM), typically a few weeks during the hottest part of the summer (typically July and August).

For the last 6 years, during which Units 2 and 3 have both been in service, the greatest amount of time cooling tower operation has been required has been about 8 percent of a year (TVA 2003a). Increased thermal power proposed for Units 2 and 3 will result in an additional increase of approximately 2.2°C (4°F) in the circulating water temperature leaving the main condenser (for each operating unit) (Hopping 2004). This increase in water discharge temperature would result in increased use of the cooling towers during summer periods to maintain compliance with discharge limitations. No changes to the plant intake system or to the individual unit intake flow rates are expected to be required as a result of the Unit 2 and 3 EPU project, and operations will continue to meet regulatory limits established in the existing NPDES permit.

Simulations with the near-field hydrothermal model were conducted for the period 1985 through 2002, excluding 2 years (1989 and 1990) for which no river ambient temperature data are available (TVA 2003a). Model results showed that, with Units 2 and 3 operating at 120 percent power, on average the cooling towers will be used approximately 5.3 percent of the time, and derating will be required approximately 0.10 percent of the time (i.e., 6.2 days over the 16-year simulation period). On average, with all three units at 120 percent power, use of the cooling towers will increase to approximately 7.2 percent of the time and derating will increase to approximately 0.29 percent of the time (i.e., 17 days over the 16-year simulation).

The residual heat removal service water (RHRSW) system consists of four pairs of pumps located on the intake structure for pumping raw river water to the heat exchangers in the RHRSW system and four additional pumps for supplying water to the emergency equipment cooling water (EECW) system. The EECW system distributes cooling water supplied by the RHRSW system to essential equipment during normal and accident conditions.

In June 2004, TVA submitted applications for EPUs for the three BFN units (TVA 2004a, b). TVA has stated (TVA 2002a) that "no changes are expected to be required to the plant intake system or to the individual unit intake flow rates as a result of the EPU project." TVA also indicated that existing thermal discharge limits would be met by increased use of the helper towers, and if necessary, derating one or more units. The EPU Environmental Report for BFN, Unit 1 stated that an additional sixth cooling tower, consisting of 20 cells would be built. This sixth cooling tower would be associated only with returning Unit 1 to service (TVA 2004a).

2.1.4 Radioactive Waste Management Systems and Effluent Control Systems

BFN uses various radioactive waste management systems to collect and process the liquid, gaseous, and solid wastes produced during reactor operations. These systems reduce the quantities of radioactive liquid, gaseous, and solid effluents released to the environment. The waste disposal systems meet the design objectives of Title 10 of the Code of Federal Regulations (CFR) Part 50, Appendix I (*Numerical Guide for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As is Reasonably Achievable" for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents*), and controls the release of radioactive material to within the limits specified in the Offsite Dose Calculation Manual (ODCM) and NPDES permits. The methods employed for the controlled release of those contaminants depend primarily on the physical state of material (i.e., solid, liquid, or gaseous) (TVA 2004c).

The liquid and solid wastes from BFN are routed to a common radioactive waste building for collection, treatment, sampling, and disposal. Packaged solid wastes and reusable radioactive material may be temporarily stored in the onsite radioactive waste storage facility or in approved outside storage locations. Gaseous wastes are processed and routed to a common tall stack for release to the atmosphere. The liquid and gaseous radioactive waste systems are designed to reduce the activity in the liquid and gaseous wastes such that the concentrations in routine discharges are below the applicable regulatory limits. The liquid and gaseous effluents are continuously monitored, and the discharge is stopped if the effluent concentrations exceed predetermined levels.

Radioactive fission products build up within the fuel as a consequence of the fission process. These fission products are contained in the sealed fuel rods, but small quantities may escape from the fuel rods into the reactor coolant. Neutron activation of components in the primary coolant system also results in release of radioactive material into the coolant. Non-fuel solid wastes result from treating and separating radionuclides from gaseous and liquid effluents and from removing contaminated material from various reactor areas. Solid wastes also consist of reactor components, equipment, and tools removed from service, as well as contaminated protective clothing, paper, rags, and other trash generated from plant operations, design modifi-

cations, and routine maintenance activities. Solid wastes may be shipped to a waste processor for volume reduction before disposal, or they may be sent directly to a licensed burial site. Spent resins and filters are stored or packaged for shipment to an offsite processing or disposal facility.

Spent fuel consists of fuel rods that have exhausted a certain percentage of their fissile fuel material; they are periodically removed from the reactor core for disposal. Units 2 and 3 currently operate on a 24-month refueling cycle per unit, with each unit refueling in alternate years. Spent fuel is stored onsite in the spent fuel pool. TVA is constructing an independent spent fuel storage installation (ISFSI) for storage of spent fuel in dry storage casks.

The ODCM for BFN (TVA 2004c) is subject to NRC inspection and describes the methods and parameters used for calculating offsite doses resulting from radioactive gaseous and liquid effluents. It is also used for calculating gaseous and liquid effluent monitoring alarm/trip setpoints for release of effluents from BFN. Operational limits for releasing liquid and gaseous effluents are specified to ensure compliance with NRC regulations.

In June 2004, TVA submitted a request for a license amendment for a power uprate at BFN Units 2 and 3 from 3458 MW(t) to 3952 MW(t) (TVA 2004b). Also, TVA plans to return Unit 1 to commercial operation and increase the power level from 3293 MW(t) to 3952 MW(t) (TVA 2004a). The net result of these plans is that TVA intends to operate all three units at the combined total power level of 11,856 MW(t) during the license renewal term. TVA has estimated that operation at the combined total power level of 11,856 MW(t) could increase the amount of radioactive material released in liquid and gaseous effluents and solid radioactive wastes by as much as a factor of 1.8 over the current operation.

2.1.4.1 Liquid Waste Processing Systems and Effluent Controls

The function of the liquid radioactive waste control system is to collect, treat, store, and dispose of all radioactive liquid wastes. Liquid waste is collected in sumps and drain tanks at various locations throughout the plant and is then transferred to the appropriate collection tanks in the Radwaste Building for treatment, storage, and disposal. Waste to be discharged from the system is processed on a batch basis, with each batch being processed by such method or methods appropriate for the quality and quantity of materials determined to be present. Processed liquid waste may be returned to the condensate system for reuse within the plant, or it may be discharged to the environment through the circulating water discharge canal. The liquid waste in the discharge canal is diluted with condenser effluent circulating water to achieve permissible radionuclide concentrations at the site boundary.

Batches of low-conductivity liquid waste are processed through a filter and a waste demineralizer. Demineralizer effluent is sent to a waste sample tank. Depending on the conductivity and level of radioactivity, the liquid may then be discharged to the circulating water discharge canal or the cooling tower blowdown line, transferred to condensate storage tanks, or returned for further processing through the demineralizer.

High-conductivity liquids are processed through a filter and are collected in a floor drain sample tank. If the concentration after dilution is within the applicable limits, the filtered liquid may be discharged.

An alternate method of processing low- and high-conductivity liquid is the use of vendor-supplied, portable equipment that can be interconnected to the permanent radioactive waste system. Depending on effluent quality and plant needs, the liquid can either be transferred to the waste sample tank or the floor drain sample tank. Processing from the waste sample tank or floor drain sample tank is identical to that described above.

All systems are protected against overflow and other unplanned releases by appropriate alarms and shutdown devices. The ODCM prescribes the alarm/trip setpoints for the liquid effluent radiation monitors (TVA 2004c).

During the years 1999 through 2003, the volume of liquid effluents from Units 2 and 3 ranged from 0 to 4.9 million L (0 to 1.3 million gal) per year, including a total of 79 batch releases (TVA 2000, 2001, 2002b, 2003c, 2004c). During 3 of those 5 years, there were no batch releases because liquids were processed and returned to the condensate system for reuse within the plant. The total radioactivity released in liquid effluents during that time was 6.3×10^{11} Bq (17 Ci). The largest annual release during this period was 4.1×10^{11} Bq (11 Ci), which occurred in 1999. Section 2.2.7 describes the hypothetical doses to a maximally exposed individual as a result of those releases.

These liquid radiological effluent releases are typical of the annual releases for operation of BFN, Units 2 and 3 without the power uprates. As discussed earlier, operation at the combined total power level of 11,856 MW(t) during the license renewal term could increase liquid effluent releases by as much as a factor of 1.8 over these typical values.

2.1.4.2 Gaseous Waste Processing Systems and Effluent Controls

Radioactive gaseous effluents include low concentrations of fission-product noble gases (such as krypton and xenon), halogens (mainly iodines), tritium in the form of water vapor, and particulate material containing both fission products and activated corrosion products. The gaseous radioactive waste system is designed to collect and process potentially radioactive effluents prior to discharge through the elevated main plant stack. The system receives

gaseous discharges from each main condenser air ejector, startup vacuum pump, condensate drain tank vent, and steam packing exhauster. Gases from each main condenser air ejector are passed through a preheater, catalytic recombiner, condenser, moisture separator, and dehumidification coil. The gases then enter a decay pipe that provides a retention time of approximately 6 hours, during which nitrogen-16 and oxygen-19 decay to negligible levels. The gases are then passed through a cooler condenser, moisture separator, reheater, prefilter, six charcoal beds, and an afterfilter before they are mixed with dilution air and exhausted to the main stack. The charcoal beds provide about 9.7 hours of retention time for krypton isotopes and 7.3 days of retention time for xenon isotopes. Gases from the gland seals and startup vacuum pumps are held for approximately 1.75 minutes, to allow for decay of nitrogen-16 and oxygen-19, and then are passed directly to the stack for release.

The ODCM prescribes alarm/trip setpoints for the gaseous effluent radiation monitors (TVA 2004c). The actual gaseous effluents for the period from 1999 to 2003 averaged about 6.7×10^{13} Bq (1800 Ci)/yr, with a maximum of 1.8×10^{14} Bq (4900 Ci) in 2003 (TVA 2000, 2001, 2002b, 2003c, 2004c). Section 2.2.7 describes hypothetical doses to a maximally exposed individual as a result of these releases.

These gaseous radiological effluent releases are typical of the annual releases for operation of Units 2 and 3 without the power uprates. As discussed earlier, operation at the combined total power level of 11,856 MW(t) during the license renewal term could increase gaseous effluent releases by as much as a factor of 1.8 over these typical values.

2.1.4.3 Solid Waste Processing

Solid waste from routine operations at Units 2 and 3 consists of spent (dewatered) resin, solidified resin, filters, sludge, evaporator bottoms, dry compressible waste, irradiated components (control rods, etc.), and other non-compressible waste. The solid radioactive waste system consists of systems and components that are used to process and package wet and dry solid wastes so that the waste is suitable for transport and disposal. The system is not used for spent fuel storage and shipment.

Solid waste is typically stored onsite for a period of time to allow for decay of short-lived radionuclides. Solid waste from equipment originating in the nuclear system is stored in the fuel storage pool to allow for radioactive decay before it is prepared for reprocessing or offsite storage. Examples of the waste include components such as activated control rods and in-core instrumentation.

Methods used for processing and packaging solid radioactive waste depend primarily on the waste characteristics. Process solid wastes, such as spent demineralizer resins and filter materials, are collected and dewatered to meet burial site and 10 CFR 61.56 requirements.

These wastes are either temporarily stored onsite in concrete storage modules or shipped directly for burial offsite in a licensed disposal facility. High-integrity containers are used to package waste when the waste classification requires that it meet stability requirements. High-integrity containers used for disposal of this waste are certified for acceptance at the disposal facility to which the waste is shipped.

Dry active waste from operation and maintenance activities is collected throughout the radiologically controlled areas of the facility. Dry active waste such as paper, rags, or used clothing is either placed into containers for storage or shipped directly to a waste processor for volume reduction and subsequent transport to an offsite licensed disposal facility. Most dry active waste has relatively low radionuclide content and may be handled manually. Dry active waste that does not meet the criteria for processing by the offsite processor may be packaged for direct shipment to a disposal facility. Where practical, selected items may be decontaminated onsite for reuse or release. Dry active waste is monitored during packaging to ensure applicable controls are maintained.

Disposal and transportation of solid radioactive waste are performed in accordance with the applicable requirements of 10 CFR Parts 61 and 71, respectively. During the period from 1999 to 2002, generation rates for radioactive solid wastes from routine operation and maintenance activities at Units 2 and 3 ranged from 514 to 654 m^3 (18,200 to 23,100 ft^3)/yr (Pierce 2004). During the period from 1999 to 2002, Units 2 and 3 made 133 shipments of solid radioactive waste with a total activity of 3.0×10^{13} Bq (820 Ci) (TVA 2000, 2001, 2002b, 2003c).

These quantities of solid radioactive waste are typical for operation of BFN, Units 2 and 3 without the power uprates. As discussed earlier, operation at the combined total power level of 11,856 MW(t) during the license renewal term could increase the quantities of solid radioactive waste by as much as a factor of 1.8 over these typical values.

2.1.5 Nonradioactive Waste Systems

The principal nonradioactive effluents from BFN consist of hazardous (chemical), lubrication oil, construction, and sanitary wastes. As is the case with any large industrial facility, BFN generates a variety of wastes that are classified as hazardous under the Resource Conservation and Recovery Act (RCRA). Such wastes include paint-related materials, spent solvents used for cleaning and degreasing, and universal wastes such as batteries, fluorescent light tubes, etc. TVA operates a Hazardous Waste Storage Facility in Muscle Shoals, Alabama, that holds a RCRA Part B permit for temporary storage of hazardous waste. The Hazardous Waste Storage Facility serves as a central collection point for TVA-generated hazardous wastes, and maintains contracts with facilities used to process and dispose of the waste. All hazardous waste generated at BFN is shipped to the Hazardous Waste Storage Facility for consolidation, storage, and transfer to licensed facilities for treatment and disposal. BFN

recycles paint solvents (primarily methyl ethyl ketone) using an onsite still. Universal wastes are collected and shipped to recycling firms. Hazardous waste generation rates for BFN average approximately 1540 kg (3400 lbs) per calendar year. Although it is not a hazardous waste as defined in the RCRA regulations, used oil also is generated at BFN as a result of maintenance activities on plant equipment. All used oil is collected, stored onsite, and shipped to an approved recycling center for energy recovery.

Following restart of Unit 1, hazardous waste generation rates during routine operation of all three units are expected to fall within the normal year-to-year variation currently experienced with two-unit operations. Existing waste management systems are capable of handling the hazardous wastes anticipated from operation of all three units at the uprated power level throughout the license renewal term.

General plant trash such as paper, metals, garbage, and other items collected as part of routine plant operation activities is managed through a TVA system-wide contract with a licensed waste disposal company. This waste material is collected and transported to a State-licensed regional landfill. Generation rates for this type of material are currently approximately 45 MT (50 tons) per month. BFN has an active recycling program to segregate and recycle scrap metal, cardboard, paper, batteries, and aluminum cans at approved State and local recycling facilities (TVA 2003a).

Once Unit 1 is operational, the amount of trash generated would be similar to that of the other operating units, and the overall amount generated would increase slightly (approximately 12.5 percent) from the current level because of the incremental increase in permanent plant staff necessary to operate three units. The existing contractor is capable of handling the increased waste volumes anticipated. Landfill capacity and projections for availability of landfill space in Alabama indicate that sufficient space to accommodate this material from BFN should be available for the duration of the license renewal term (TVA 2003a).

For construction and demolition debris associated with ongoing site activities, such as modifications and additions to facilities, BFN operates a State-permitted construction/demolition landfill within the confines of the BFN site. This landfill is permitted to accept non-hazardous, non-radioactive solid wastes at an average volume of 4.5 MT (5 tons) per day from the BFN site. Materials permitted for disposal include scrap lumber, bricks, sandblast grit, crushed metal drums, glass, wiring, non-asbestos insulation, roofing materials, building siding, scrap metal, concrete with reinforcing steel, and similar construction and demolition wastes. The landfill occupies approximately 3.1 ha (7.7 ac). The generation rate for this type of material over the past 2 years was approximately 0.036 MT (0.04 tons) per day (TVA 2003a).

Once Unit 1 resumes operation, the amount of construction/demolition waste generated as a result of the three-unit operation would not be expected to increase substantially over the rates experienced for two-unit operations.

2.1.6 Plant Operation and Maintenance

The BFN maintenance and modification program supports operation of the nuclear power plant and ensures that equipment, systems, and structures are maintained and modified in accordance with applicable requirements and at a quality level required for them to perform their intended functions as specified in the original design, material specifications, and inspection requirements. Additionally, the following guidance from the Institute of Nuclear Power Operations has been incorporated into the maintenance and modification program as appropriate:

- Inspections are performed by qualified individuals in nuclear assurance or other TVA nuclear organizations where necessary to ensure quality.
- Inspections are performed by individuals other than those who performed or directly supervised the activity being inspected. Inspection results are documented and maintained as records.
- The inspection program provides assurance that plant quality-related items and activities within the scope of the Nuclear Quality Assurance Plan conform to predetermined quality requirements called for in specifications, procedures, and drawings.
- The inspection program includes quality control inspections, nondestructive examinations, line verifications, and special inspections.

TVA Nuclear Standard Programs and Processes address procedural requirements for material receipt and inspection, the American Society of Mechanical Engineers Section XI in-service inspection program, special nuclear material control, and nuclear fuel management (TVA 2003a).

2.1.7 Power Transmission System

BFN is connected into the TVA system network by seven 500-kilovolt (kV) lines via the 500-kV switchyard (Figure 2-4). One line is to the Madison substation, two lines are to the Trinity substation, one line each are to the West Point, Maury, and Union substations, and one line is to the Limestone 500-kV substation (TVA 2003a). In addition, there are two 161-kV lines, one to the Athens substation and one to the Trinity substation. All lines occupy portions of four

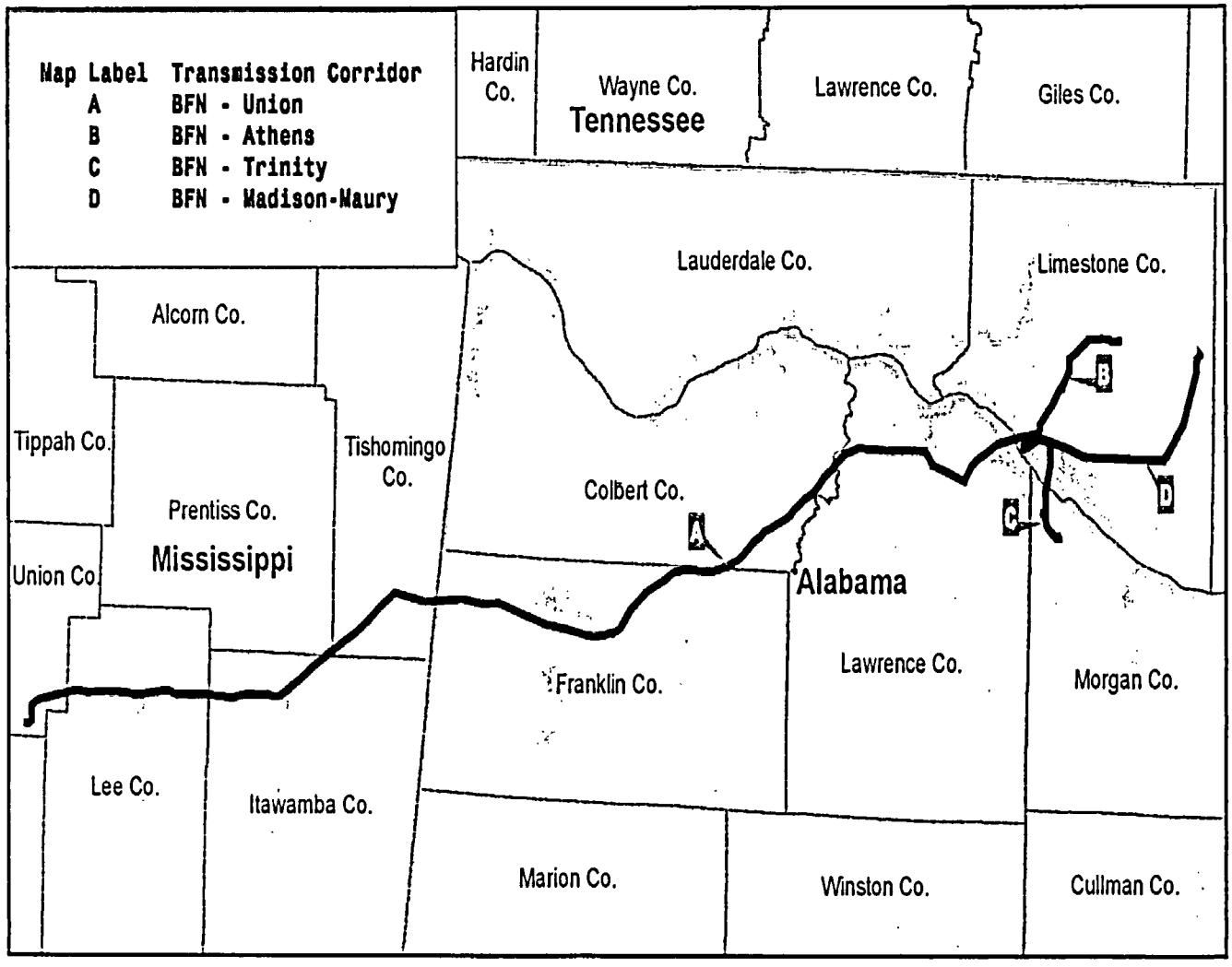

Figure 2-4. Map of Transmission Line Rights-of-Way for Browns Ferry Nuclear Power Plant, Units 1, 2, and 3

transmission line rights-of-way, one to the Maury substation, one to the Trinity substation, one to the Athens substation, and one to the Union, Mississippi, substation (Figure 2-4, Table 2-1). There are portions of other transmission lines within these rights-of-way that were not constructed specifically to connect BFN to the TVA power system. However, for the sake of simplicity and a comprehensive analysis, all the rights-of-way are included in the assessment.

Table 2-1. Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Transmission Line Rights-of-Way

Right-of Way	Line	kV	Year Completed	Length	
				km	mi
BFN to Trinity	BFN-Trinity	500	1968	17.8	11.1
	BFN-Trico	500	1996		
	Trinity-BFN	161	1968		
BFN-Maury	BFN-Madison	500	1968	37.2	23.1
	BFN-West Point	500	1968		
	BFN-Maury	500	1968		
	BFN-Limestone	500	1995		
BFN-Athens	BFN-Athens	161	1968	23.1	14.3
BFN to Union	BFN-Union	500	1980	176.8	109.9

Maintenance of the transmission line rights-of-way is the responsibility of the TVA Transmission and Power Supply – Transmission Operations and Maintenance organization (TVA 2003a). Maintenance activities include vegetation management, pole replacement, installation of lightning arresters and counterpoise, and equipment upgrades. Regular maintenance activities are conducted on a 3- to 5-year cycle. Detailed discussion on transmission line maintenance activities is found in Section 4.2. All activities are reviewed by specialists in the TVA Regional Natural Heritage and Cultural Resources Program. The TVA program maintains a detailed Geographic Information System database of natural and cultural resources along the entire TVA distribution system. The database includes daily updates of Federally and State-listed species habitat and occurrence records (TVA 2003a). Maintenance activities that have the potential to impact sensitive resources are carefully planned and implemented to minimize disturbance.

2.2 Plant Interaction with the Environment

Sections 2.2.1 through 2.2.8 provide general descriptions of the environment near BFN as background information. They also provide detailed descriptions where needed to support the

analysis of potential environmental impacts of refurbishment and operation during the license renewal term, as discussed in Chapters 3 and 4. Section 2.2.9 describes the historic and archaeological resources in the area, and Section 2.2.10 describes possible impacts associated with other Federal project activities.

2.2.1 Land Use

BFN is located on the north shore of Wheeler Reservoir in an unincorporated portion of Limestone County, Alabama. Limestone County does not have land-use zoning applicable to unincorporated portions of the county. Wheeler Reservoir is formed by Wheeler Dam, which is owned and operated by TVA and is approximately 32 km (20 mi) downriver from BFN. The reservoir is 119 km (74 mi) long (TVA 2003a).

BFN is approximately 48 km (30 mi) west of Huntsville, Alabama; 16 km (10 mi) northwest of Decatur, Alabama; and 16 km (10 mi) southwest of Athens, Alabama. The site is a 340-ha (840-ac) tract just south of U.S. Highway 72 and is directly accessible from County Road 25 (Nuclear Plant Road). County Road 25 intersects U.S. Highway 72 approximately 10 km (6 mi) north of the site; it also intersects U.S. Highway 31 approximately 14 km (9 mi) east of the site.

The Swan Creek State Wildlife and Mallard-Fox Creek State Wildlife Management Areas are within 5 km (3 mi) of the plant site. The Swan Creek Wildlife Management Area includes 1232 ha (3045 ac) of land and 2357 ha (5825 ac) of water surrounded by numerous industrial facilities (TVA 2003a). The Mallard-Fox Creek State Wildlife Management Area encompasses approximately 593 ha (1483 ac), and is primarily used for waterfowl and small game hunting (TVA 2005).

2.2.2 Water Use

At the BFN site, the Tennessee River flows from southeast to northwest; and the average width of Wheeler Reservoir ranges from 1.6 to 2.4 km (1 to 1.5 mi). Wheeler Reservoir extends from Guntersville Dam at TRM 349 downstream to Wheeler Dam at TRM 274.9. The drainage area upstream of Wheeler Dam is 76,640 km^2 (29,590 mi^2). The reservoir was created in 1936 as one of the first major dam projects on the Tennessee River for flood control, power generation, and navigation. Wheeler Reservoir has a normal summer pool elevation of 169.5 m (556 ft) above mean sea level and a minimum water elevation of 168 m (550 ft). The lake usually reaches its summer pool elevation by mid-April. Fall drawdown, in anticipation of winter rains, usually begins around August 1. At summer pool elevation, the reservoir has an area of 27,140 ha (67,070 ac), a volume of 1290 million m^3 (1.05 million ac-ft), a mean depth of 4.8 m (15.7 ft), and a hydraulic residence time of 10.7 days (TVA 2002a).

The most recent total BFN intake flow reported to ADEM in the monthly Discharge Monitoring Report (December 2003) and to the Alabama Department of Economic and Community Affairs in the Annual Certificate of Use Report is 8 million m^3/d (2114 MGD), which is approximately 46.3 m^3/s (734,000 gpm) per unit. With the resumption of Unit 1 operations, the total intake flow would be approximately 12 million m^3/d (3171 MGD) or 139 m^3/s (4907 cfs), which represents an increase over the previous high reported flow (10.8 million m^3/d or 2855 million gpm) of 11 percent.

TVA is pursuing EPUs, which would increase the total combined power level to 11,856 MW(t) with no further increase in intake flows. The additional heat would be routed through the diffusers for discharge. TVA has modeled the mixing zone and believes BFN can continue to meet current ADEM regulatory limits of the NPDES permit by employing various mitigating measures such as derating and use of the cooling tower helper mode of operation.

BFN cannot put all of the CCW through the cooling towers when operating in the helper mode because of various system limitations. TVA reports the maximum practical throughput for the six cooling towers as 105.5 m^3/s (3725 cfs) (TVA 2004a). Remaining CCW flow bypasses the cooling towers and is routed directly to the river. Almost all the cooling tower flow is also returned to the river, but there is a small amount lost into the air during operation due to evaporation and "drift." These consumptive losses would not exceed 2.3 percent of the total cooling tower flow, even under worst-case conditions. TVA estimates a loss of 1.5 m^3/s (54 cfs) at 105 percent and 1.8 m^3/s (62 cfs) at 120 percent OLTP for Units 2 and 3 (Hopping 2004). TVA stated (TVA 2004a) that "...restart of Unit 1 will require construction of a sixth cooling tower..."; therefore, the consumptive use of cooling water would increase. TVA estimates a loss of 2.0 m^3/s (71 cfs) at 105 percent OTLP and 2.3 m^3/s (82 cfs) at 120 percent OLTP for all three units (Hopping 2004). The cooling towers are only operated when necessary to meet thermal discharge temperature limits specified in the NPDES permit, typically a few weeks during the hottest part of the summer (usually during July and August).

Although most of the intake water is used for condenser cooling, a small amount (approximately 3 percent) of it is used for other plant uses such as emergency equipment cooling water, residual heat removal, raw cooling water, fire protection, and raw service water systems (TVA 2003a). Almost all of this water is ultimately returned to the river, either directly or indirectly through leakage drains. The only consumption of this water at the site would be from a negligible and unquantifiable amount of evaporation when the water is exposed to air.

BFN also consumes a relatively small amount of river water for use in making highly purified or "demineralized" water for various uses in the plant that require high-grade water. On average, this consumptive rate is approximately 5.7 million L/month (1.5 million gal/month) in the summer, which is somewhat higher than the winter consumption because of running the turbine

building air wash system to keep equipment operating temperatures down. This consumptive rate is equivalent to 2.2 L/s (0.077 cfs) (TVA 2003a).

Using an unsteady flow model of Wheeler Reservoir, the measured releases from Guntersville Dam and Wheeler Dam were used to compute the hourly flow in Wheeler Reservoir at BFN (TVA 1977a). TVA analyzed these data to obtain a time series of the daily average flow for the period 1976 to 2002. For this period, the following statistical properties have been identified for the flow at BFN: the average daily flow was 1320 m^3/s (46,606 cfs), ranging from 10,700 m^3/s (378,742 cfs) to 75 m^3/s (2638 cfs), and the 7Q10 (the lowest average flow for seven consecutive days with a 10-year recurrence) is 250 m^3/s (8700 cfs) (TVA 2003a). Therefore, the total intake water flow of 139 m^3/s (4907 cfs) can encompass a significant fraction of the daily average river flow past the plant.

Target minimum flows currently used for TVA river operations were established by an environmental impact statement in 2004 (TVA 2004f). The target minimum daily average flows in the Tennessee River at BFN are 280 m^3/s (10,000 cfs) for July through September, 310 m^3/s (11,000 cfs) for December through March, and 200 m^3/s (7000 cfs) otherwise.

Based on the information given above, the Tennessee River average annual flow at BFN for the period 1976 to 2002 equates to 4.16×10^{10} m^3/yr (1.47×10^{12} ft^3/yr). This is less than the 9×10^{10} m^3/yr (3.15×10^{12} ft^3/yr) criterion stated by NRC in 10 CFR 51.53(c)(3)(ii)(A) as the value beneath which "an assessment of the impact of the proposed action on the flow of the river and related impacts on in-stream and riparian ecological communities must be provided."

The critical time for approaching the maximum river water temperature limits specified in the BFN NPDES permit, and therefore requiring the use of cooling towers or plant derates, is July and August. Based on the time series data from 1976 to 2002, the average flow in Wheeler Reservoir at BFN was 964 m^3/s (34,028 cfs) during July and August (TVA 2003a). During these same months and same period, the minimum daily average flow observed at BFN was 80 m^3/s (2815 cfs), occurring on July 1, 1987. For comparison, the 7Q10 low-flow value given in the rationale for the BFN NPDES permit is 250 m^3/s (8700 cfs) (ADEM 2003). The daily average flow exceeded the 7Q10 low-flow value 98.6 percent of the time in July and 98.8 percent of the time in August.

The Athens Utilities Water Department supplies potable water to BFN. Potable water consumption at the site is partly a function of the number of people working at the site. Besides drinking fountains and bathrooms, potable water is also used for fire protection, supplied to a 1.9-million-L (500,000-gal) fire protection water bladder tank, and for various clean water uses, such as window and building wash water and pressurized spray water for equipment cleaning.

Some flow is lost to occasional leaks. BFN typically uses 15,000 to more than 30,000 m^3 per month (4 to 8 million gal per month) of potable water (TVA 2003a).

There is no groundwater use at BFN.

2.2.3 Water Quality

Pursuant to the Federal Water Pollution Control Act Amendments of 1972 (FWPCA), the water quality of the plant effluents is regulated through the NPDES, and ADEM is delegated to issue NPDES permits In Alabama. The current permit (AL0022080) was issued December 29, 2000, and is due to expire January 31, 2006. The NPDES permit specifies the discharge standards and monitoring requirements for each discharge. This permit specifies effluent limits for pH, total residual chlorine, oil, grease, biological oxygen demand, fecal coliform, total suspended solids, temperature, naphthalene, and BETX (i.e., benzene, ethyl benzene, toluene, and xylene isomers). Any new regulations promulgated by the U.S. Environmental Protection Agency (EPA) or the State of Alabama would be reflected in future permits.

Compliance with the NPDES process, other provisions of the FWPCA (e.g., Sections 316 (a), 316 (b), 401, 404), and other regulatory requirements is expected to adequately control potential chemical effluent effects. In general, under these regulatory programs, TVA treats waste water effluents, collects and properly disposes of potential contaminants, and undertakes pollution prevention activities that comply with regulatory requirements and minimize the risk of adverse environmental impacts. The NPDES permit contains temperature limits based on a 316(a) demonstration that EPA approved in June 1977. The NPDES permit can be re-opened and modified in the event ADEM determines, through biological and/or water quality monitoring, that more stringent limitations and/or monitoring requirements are necessary to ensure the protection and propagation of aquatic life in the Tennessee River.

BFN has recently experienced sanitary waste violations (total coliform and total suspended solids) because of the increased number of workers at BFN for the Unit 1 restart activity. ADEM has treated these as minor violations, resulting in warning notices and no fines. Upon further review, ADEM revised the maximum allowed values for Outfall DSN13a for total suspended solids up from 45 to 135 mg/L and for fecal coliform up from 400 to 2000 organisms/100 mL to address this issue in the NPDES permit modification effective October 31, 2003. Aerators designed to stabilize fecal coliform below the NPDES permit limits were installed and began operation in December 2003. Subsequent to aerator installation, no NPDES violations were reported for calendar year 2004.

Effluent discharges from plant systems such as yard drains, station sumps, and sanitary waste water would not be expected to change significantly through the license renewal term.

Considering that the plant waste water lagoons and sedimentation ponds possess clay and Hypalon liners, respectively, no impacts to groundwater resources are anticipated. The changes in pond/lagoon discharges to the river would remain within the bounding conditions established in the NPDES.

2.2.4 Air Quality

The climate at the BFN site varies between continental in the fall to maritime in the summer. During the winter and spring seasons, the climate is variable between the two classifications. The climate at Huntsville, Alabama, which is well documented, is generally considered representative of the BFN site.[a] Climatological records for Huntsville indicate that precipitation is fairly evenly distributed among all months, but the winter and spring seasons are wetter than the fall and summer. Normal monthly precipitation ranges from 17 cm (6.7 in.) in March to 8.4 cm (3.3 in.) in August. Normal daily maximum temperatures for Huntsville range from 9.4°C (48.9°F) in January to a high of slightly more than 32°C (89°F) in July. Normal minimum temperatures range from almost -0.6°C (31°F) in January to almost 21°C (70°F) in July. During the period from 1968 to 2002, the highest recorded temperature at Huntsville was 40°C (104°F), which occurred in July, while the lowest recorded temperature was -24°C (-11°F), which occurred in January. The temperatures generally drop below 0°C (32°F) about 63 days annually.

Thunderstorms are reported about 57 days annually in the Huntsville area. Although thunderstorms occur in all months of the year, most occur during the months of May, June, July, and August. Thunderstorms can have windstorms and sometimes hail associated with them, and in some cases produce tornadoes. The highest reported wind speed at Huntsville during the period from 1968 to 2002 was 28.2 m/s (63 mph) from the north-northeast direction. During the period from January 1, 1950, to December 31, 2003, 50 days of hail events were reported in Limestone County. The largest reported hailstones were 9.5 cm (3.75 in.), which fell on the City of Athens, Alabama, on May 18, 1995 (NOAA 2004). During the same time period, 24 tornados were reported in Limestone County. The most violent storm occurred on April 3, 1974, when 11 deaths were reported and 80 people were injured. The most property damage occurred during a tornado on May 18, 1995, when property damage amounting to $5 million was reported along with one death and 55 injuries (NOAA 2004).

The National Severe Storms Laboratory in Kansas City, Missouri, calculated the tornado return probability for the BFN site based on tornado occurrences within a 56-km (30-nautical-mi)

(a) Climatological data for Huntsville is available at http://www.ncdc.noaa.gov/ol/climate/climatedata.html.

radius during the period from 1950 to 1986. Based on 48 tornado occurrences having path size estimates during that 37-year period, the return probability for the site is 6.979×10^{-4} with a mean return interval of 1433 years.

The wind energy resource in northern Alabama is limited. The annual average wind power density in Alabama is almost exclusively Class 1 on a scale of 1 through 7 (Elliott et al. 1987). Areas suitable for wind turbine applications have a rating of 3 or higher. The only areas that meet this criterion are ridge tops in northeastern Alabama where the Appalachian foothills begin, along the exposed Gulf Coast shoreline of Alabama, and in the Mobile Bay area during the winter and spring seasons.

The BFN site is located within the Tennessee River Valley-Cumberland Mountains Interstate Air Quality Control Region (40 CFR 81.72). Presently, this region is considered in attainment for all criteria pollutants (40 CFR 81.301). The EPA is in the process of promulgating new, more restrictive standards for ozone and particulate matter. For ozone, the current 1-hour ozone standard will be replaced by an 8-hour standard. Once these new standards are implemented, several counties that are part of the control region may not be in compliance.

The Sipsey Wilderness area is the only area in Alabama designated in 40 CFR 81.401 as a mandatory Class 1 Federal area in which visibility is an important value. The wilderness area is located about 45 km (28 mi) southwest of the BFN site. All other Class 1 areas located in Tennessee or Mississippi are greater than 80 km (50 mi) from BFN.

Diesel-power auxiliary (emergency) generators, auxiliary boilers, and other small sources such as fuel storage facilities emit various non-radiological pollutants. Emissions from these sources are regulated by ADEM under a Synthetic Minor Operating Permit (ADEM Administrative Code 335-3-15-02-10). This permit remains in effect until the existing administrative code is amended. The terms of that permit require the site to track actual emissions. The most recent report (for 2003) indicated that a total of 35.3 MT (38.9 tons) of pollutants were discharged to the atmosphere from these sources (TVA 2004d). For the period from 1998 to 2003, annual emissions have varied between 27.2 and 40.8 MT (30 and 45 tons).

2.2.5 Aquatic Resources

The aquatic resources in the vicinity of the BFN site are associated primarily with the Wheeler Reservoir portion of the Tennessee River. Wheeler Reservoir is the source and receiving body for the BFN cooling system. The BFN site has about 3772 m (12,375 ft) of Wheeler Reservoir frontage (TVA 2003a). Other nearby aquatic habitats include the following tributaries to Wheeler Reservoir: Paint Rock and Flint Rivers in the upper reach; Indian, Cotaco, and Flint Creeks in the middle reach; and Limestone, Piney, Swan, Fox, Mallard, Spring, First, and

Second Creeks and the Elk River in the lower section. Elk River is the largest of these tributaries, and flows into Wheeler Reservoir about 16 km (10 mi) downstream of BFN. Guntersville Reservoir is located upstream of Wheeler Reservoir, while Wilson Reservoir is located downstream from Wheeler Reservoir.

The seven transmission lines associated with BFN cross a number of streams ranging in size from small intermittent streams to the Tennessee River. Rivers and larger streams crossed by or near the transmission lines include Limestone, Piney, Round Island, Swan, Big Nance, Town, Spring, Cedar, Little Bear, and Bear Creeks in Alabama, and Bear, Little Brown, Donivan, Twentymile, Mantachie, Mud, and Bridge Creeks and the Tennessee-Tombigbee Waterway in Mississippi.

TVA began its Vital Signs Monitoring Program in 1990 to systematically monitor key physical, chemical, and biological indicators (i.e., dissolved oxygen, chlorophyll, sediments, benthic macroinvertebrates, and fish) to evaluate the ecological conditions of its reservoirs and to target detailed assessment studies if significant problems are found (Dycus 1998). Monitoring is conducted in the inflow area (generally riverine in nature), transition zone (mid-reservoir area), and forebay area (generally lacustrine or lake-like in nature). The Vital Signs Monitoring Program transition zone sampling station for Wheeler Reservoir is located at TRM 295.9, a short distance upstream of BFN (TVA 2003a). The ecological health rating for a sample site can range from a minimum of 4.5 (all indicators poor) to 22.5 (all indicators excellent). The overall health evaluation for a reservoir is determined by summing the ratings from all sites and dividing by the maximum possible combined rating for the sites, expressed as a percentage. This approach provides a potential range of scores from 20 to 100 percent and applies to all reservoirs regardless of the number of indicators or sample sites. The percent scoring range is then divided into categories representing good (greater than 72 percent), fair (52 to 72 percent), and poor (less than 52 percent) ecological health conditions for run-of-the-river reservoirs (the cut off between a poor and fair rating for tributary and storage reservoirs is 57 percent rather than 52 percent) (Dycus 1998). Between 1991 and 2003, the ecological health scores for Wheeler Reservoir ranged from a low of 61 (fair) in 1999 to a high of 76 (good) in 1997, with a 1993 to 1997 average of 73 (good) (Dycus 1998). Ecological health scores in 2001 and 2003 were 65 and 72, respectively, indicating a continuing fair rating in recent years (TVA 2004e).

A total of 63 fish species plus hybrid sunfish, hybrid striped bass x white bass (*Morone saxatilis* x *M. chrysops*), and hybrid walleye x sauger (*Stizostedion vitreum* x *S. canadense*) were collected from 1995 through 2002 in the vicinity of BFN (TVA 2002a, 2003a). A total of 72 fish species were collected in impingement samples between 1974 and 1977 (TVA 1978). Important commercial fish species that occur in Wheeler Reservoir include blue catfish (*Ictalurus furcatus*), channel catfish (*I. punctatus*), flathead catfish (*Pylodictis olivaris*), bigmouth buffalo (*Ictiobus cyprinellus*), smallmouth buffalo (*I. bubalus*), and common carp (*Cyprinus carpio*). Gizzard shad (*Dorosoma cepedianum*) and threadfin shad (*D. petenense*) are the

dominant forage species in Wheeler Reservoir (TVA 2003a). Threadfin shad has been the dominant species numerically in Wheeler Reservoir since 1990 (Baxter and Buchanan 1998).

Game fish species include largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), spotted bass (*M. punctulatus*), black crappie (*Pomoxis nigromaculatus*), white crappie (*P. annularis*), bluegill (*Lepomis macrochirus*), longear sunfish (*L. megalotis*), redear sunfish (*L. microlophus*), sauger, striped bass, hybrid striped bass, yellow bass (*Morone mississippiensis*), and yellow perch (*Perca flavescens*). Largemouth bass is the species most often sought by sport fishermen, followed by crappie. Bluegill are the most numerous game fish in Wheeler Reservoir (Baxter and Buchanan 1998). The sport fishery is supplemented by stockings of striped bass, hybrid striped bass, largemouth bass, and channel catfish.

The Vital Signs Monitoring Reservoir Fish Assemblage Index metric scores are based primarily on fish community structure and function, but also consider percentage of sample represented by omnivores and insectivores, overall number of fish collected, and the occurrence of fish with anomalies (e.g., diseases, lesions, parasites, and deformities). The Reservoir Fish Assemblage Index scores from 1993 to 2002 have equated to a rating of fair upstream of BFN (TRM 295.9) and good downstream of BFN at TRM 277. Monitoring done at TRM 292.5 just downstream of BFN from 2000 through 2002 have equated to a rating of good (Baxter and Gardner 2003). There are no health advisories against the consumption of fish from Wheeler Reservoir. However, there are advisories against consuming bigmouth and smallmouth buffalo from two tributaries of upper Wheeler Reservoir (Indian Creek and Huntsville Spring Branch from Redstone Arsenal to the Tennessee River) because of DDT contamination (ADPH 2002, 2003).

The Sport Fishing Index was developed to quantify sport fishing quality for individual sport fish species. The Sport Fishing Index uses information from population sampling (e.g., catch per unit effort from electrofishing and gill netting) and creel results (e.g., angler success) to describe the quality of the resident fishery. Parameters measured include the length and weight of fish in various categories (e.g., preferred-size fish, memorable-size fish, and trophy-size fish). The Sport Fishing Index can range from 20 (very poor) to 60 (excellent) (Hickman 2000). The 2002 scores for Wheeler Reservoir and the TVA system-wide average (given in parentheses) were bluegill, 26 (29); channel catfish, 28 (26); hybrid striped bass, 44 (40); largemouth bass 34 (33); sauger, 42 (30); smallmouth bass, 36 (35); and spotted bass, 42 (35) (TVA 2002c). While the sport fishery in Wheeler Reservoir cannot be considered excellent

clam (*Corbicula fluminea*), and zebra mussel (*Dreissena polymorpha*). The Asiatic clam and zebra mussel are the most problematic of these species because of their impacts on power plants and city water supplies, as well as to their potential ecological impacts (TVA 2004f). The grass carp has been introduced into TVA reservoirs to control heavy infestations of aquatic vegetation. The introduced grass carp are sterile, and the population can be maintained at desired levels by adjusting stocking rates. Grass carp have been collected infrequently in gill net and electroshock samples at TRM 295.9 (TVA 2002a). Other non-native species such as the striped bass, hybrid striped bass, and yellow perch have become popular game species in the Wheeler Reservoir (Baxter and Buchanan 1998).

The phytoplankton community of Wheeler Reservoir is diverse. As many as 27 Chrysophyta (yellow-green or yellow-brown algae), 52 Chlorophyta (green algae), and 17 Cyanophyta (blue-green algae) taxa have been documented (TVA 1977b). The zooplankton assemblage is also diverse, with 32 cladoceran, 24 copepod, and 47 rotifer taxa having been reported (TVA 1977b). The non-native cladoceran *Daphnia lumholtzi* has been documented throughout the Tennessee River system (Baker 2001), and is therefore expected to occur in Wheeler Reservoir (TVA 2003a). It may eventually become a dominant zooplankton species in the southern United States (CARS 2004).

During 2002, there were an estimated 1820 ha (4500 ac) of aquatic plant coverage in Wheeler Reservoir. Between 1976 and 2002, this coverage has varied from a low of 8 ha (20 ac) (1976 to 1978) representing a trace percentage of the reservoir to a high of 3983 ha (9843 ac) (in 1988) or about 14 percent of the reservoir (TVA 2004f). The aquatic plants that commonly occur in Wheeler Reservoir include the invasive exotic Eurasian watermilfoil (*Myriophyllum spicatum*), hydrilla (*Hydrilla verticillata*), spinyleaf naiad (*Najas minor*), the invasive native coontail (*Ceratophyllum demersum*), and southern naiad (*N. guadalupensis*). Most of these plants occur in the broad, shallow overbank habitat upstream of BFN between TRM 296 and 305 (TVA 2002a). Eurasian watermilfoil, hydrilla, and spinyleaf naiad are submersed aquatic plants that can be severely problematic to reservoir use. Although the submersed aquatic southern naiad and the free-floating coontail are generally considered beneficial species, they can occasionally reach nuisance levels (TVA 2004f).

The overbank areas support communities of Asiatic clams, fingernail clams, burrowing mayflies, aquatic worms, and chironomids, while cobble and bedrock areas (found mainly in the old channel) support Asiatic clams, bryozoans, sponges, caddisflies, snails, and some leeches (TVA 2002a). The Vital Signs Monitoring Program transition station at TRM 295.5 had benthic community scores of excellent in 1994, good in 1995, and excellent in both 1997 and 1999 (Dycus and Baker 2000). Benthic macroinvertebrate monitoring was initiated in 2000 in support of the BFN thermal variance monitoring. The benthic community was rated excellent at TRM 295.9 (upstream of the BFN diffusers) in 2000 and good in 2001 and 2002. At TRM 291.7 (downstream of the BFN diffusers) the rating was excellent in 2001 and good in 2002 (Baxter

and Gardner 2003). The average mean density of benthic macroinvertebrates collected upstream (TRM 295.9) and downstream (TRM 291.7) of BFN in November 2002 were 473 and 445/m^2 (5091 and 4790/ft^2), respectively (Baxter and Gardner 2003). In comparison, downstream reaches of Wheeler Reservoir at TRM 277 and Elk River had average ratings of poor between 1994 and 2002, while the upstream reach of Wheeler Reservoir at TRM 347 had an average rating of good over this time period (Baxter and Gardner 2003).

Historically, 39 mussel species occurred in Wheeler Reservoir. Thirty-one of these species were considered riverine (i.e., those that evolved in free-flowing reaches), with 19 of these species now considered non-reproducing riverine species within Wheeler Reservoir (Ahlstedt and McDonough 1992). In 1982, 12 mussel species were collected during a survey for the proposed barge facility at BFN (Pryor 1982), and 11 species were collected across the river during a survey for a proposed barge terminal for the Mallard-Fox Creek Development Project (Carroll 1982). The washboard (*Megalonaias nervosa*) was the most common species collected during both surveys. It is currently the predominant species that is commercially harvested (TVA 2003a). The Ohio pigtoe (*Pleurobema cordatum*) was previously the most valuable commercial species, but its numbers have decreased as a result of habitat alterations caused by impoundment (Ahlstedt and McDonough 1992). None of the species collected were Federally or State protected.

In 1991, 24 species of mussels were collected from Wheeler Reservoir, with six species represented by weathered, empty shells (Ahlstedt and McDonough 1992). The 24 species included all species previously collected near BFN in the two 1982 collections by Pryor (1982) and Carroll (1982). It was estimated that 460 million mussels or 2.33 mussels/m^2 (0.22 mussels/ft^2) occurred in the reservoir in 1991 (Ahlstedt and McDonough 1992). The most common species (and estimated number within Wheeler Reservoir) collected in 1991 were the elephant-ear (*Elliptio crassidens,* 116 million), washboard (88 million), pink heelsplitter (*Potamilus alatus,* 56 million), and threehorn wartyback (*Obliquaria reflexa,* 44 million) (Ahlstedt and McDonough 1992). In addition to the habitat alteration resulting from reservoir creation, over-harvesting and periods of drought (e.g., from 1983 to 1988) may have affected reproduction and/or survival of most thick-shelled mussel species in Wheeler Reservoir (Ahlstedt and McDonough 1992). Water-quality impairments and loss of necessary fish hosts have also contributed to the decline of mussel populations. The biodiversity of mussel communities in the mainstem Tennessee River reservoirs is anticipated to continue the long-term downward trend in terms of abundance and diversity (TVA 2004f).

In 1998, 17 mussel species were collected on the east channel of Wheeler Reservoir near Hobbs Island, more than 64 river kilometers (40 river miles) upstream of BFN, between TRMs 336.4 and 335.5. The two most common mussel species were the elephant-ear and the Ohio pigtoe. Two Federally endangered species were also collected: one specimen of the rough pigtoe (*Pleurobema plenum*) and 16 specimens of the pink mucket (*Lampsilis abrupta*)

(Yokely 1998). In 1999, 16 native mussel species were collected in the vicinity of BFN: 14 species at TRM 298 upstream of BFN and 12 species at TRM 292 downstream of BFN. None of these were Federally listed species (TVA 2003a). Eleven commercial mussel species have been reported near BFN from TRM 305 to TRM 275 (Ahlstedt and McDonough 1992).

Two areas of Wheeler Reservoir are designated as State-protected mussel sanctuaries where commercial mussel fishing is not permitted. One sanctuary extends from Guntersville Dam (TRM 349) downstream to the mouth of Shoal Creek (TRM 347); the second extends from the upstream end of Hobbs Island (TRM 337) downstream to Whitesburg Bridge (TRM 333) (TVA 2003). In the reservoir overbanks, mussels are generally spread over large areas and are not concentrated in mussel beds (TVA 2003a).

The Asiatic clam was first reported in Alabama in 1962, and is now widespread throughout the state (Foster et al. 2000). It inhabits lakes and streams of all sizes and occurs in silt, mud, sand, or gravel substrates (Cummings and Mayer 1992). The major impact caused by the Asiatic clam is biofouling, particularly of power plant and industrial water systems. It also modifies benthic substrates and competes with native species (Foster et al. 2000). The Asiatic clam is consumed by a number of fish, birds, and mammals. Its population density and distribution can be affected by excessively high or low temperatures, salinity, drying, low pH, silt, low dissolved oxygen, and diseases and parasites. The Asiatic clam can often dominate the benthic community, occurring at densities of thousands per square meter (Foster et al. 2000).

Between 1969 and 1976, densities of the Asiatic clam between TRM 307.5 and TRM 278 ranged from 103 to 167 clams/m^2 (9.6 to 15.5 clams/ft^2) (TVA 1977b). The Asiatic clam competes with native mussels for food, nutrients, and space. Dense populations of the Asiatic clam may ingest large numbers of unionid sperm, glochidia, and newly metamorphosed juveniles. They may also completely cover sediments; therefore, dense populations may reduce suitable habitat space for juvenile native mussels. Periodic Asiatic clam die-offs may produce enough ammonia and consume enough oxygen to kill native mussels (Butler 2002).

The zebra mussel had established populations in the Tennessee River by 1992 and had been reported in Alabama by 1994 (Benson 2004). It has continued to spread throughout the river system. Zebra mussel densities in the Tennessee River have remained low, but are now abundant enough below Wilson Dam that they can be measured quantitatively (Butler 2002). The zebra mussel inhabits lakes and streams of all sizes, attaching to rocks, freshwater mussels, or almost any other hard surface (Cummings and Mayer 1992). Their increase causes a decline among many native mussels, as it can out-compete native species for oxygen and food and is so prolific that it can smother native mussel beds (GSMFC 2003).

The raw water intake for BFN is treated biannually with a molluscide to control biofouling by zebra mussels and Asiatic clams. Also, biweekly raw water samples are analyzed from April through October for zebra mussel veligers as an early warning for potential biofouling (TVA 2002a). Data from these samples indicate that zebra mussel reproduction near BFN remains at a low level and that the zebra mussel should not pose a threat to plant operations in the immediate future (TVA 2003a). However, the primary means of keeping the condenser tubes clear of Asiatic clams is the use of a system that uses small sponge rubber balls that are continuously recirculated through the condenser tubes (TVA 1972).

There are 38 Federally listed aquatic species (including three candidate species) whose distribution includes, or has historically included, the Wheeler Reservoir portion of the Tennessee River or its tributaries, or other streams, rivers, or caves within the counties of Alabama and Mississippi through which the BFN transmission line rights-of-way pass (Table 2-2). One of the BFN transmission lines crosses designated critical habitat for one Federally protected species of freshwater mussel. All but nine of the Federally protected 38 species would not currently be expected to occur within Wheeler Reservoir or the streams crossed by the transmission line rights-of-way associated with BFN for the following reasons: (1) the species are presumed to be extinct, (2) the species are presumed to be extirpated in the region, (3) there are no recent records for the species in the region, (4) there are no collection records for the species from pertinent locations, and/or (5) project areas of concern do not have appropriate habitat for the species (e.g., County records are for streams or caves that are not crossed by the BFN transmission lines). Additional information on these 29 Federally listed species is provided in the Biological Assessment in Appendix E.

Table 2-2. Federally and State-Listed Aquatic Species Potentially Occurring in Colbert, Franklin, Lawrence, Limestone, or Morgan Counties, Alabama and/or Itawamba, Lee, Tishomingo, or Union Counties, Mississippi

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
Aquatic Snails					
Athearnia anthonyi	Anthony's riversnail	E	P	--	Large rivers and lower reaches of large creeks on cobble/boulder substrates near riffles
Campeloma decampi	slender campeloma	E	P	--	Large creeks in soft sediments (sand or mud) or detritus
Lithasia lima	warty rocksnail	--	NOST	--	Rocky riffles of low gradient large-sized rivers or moderate gradient medium-sized rivers

Table 2-2. (contd)

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
Lithasia verrucosa	varicose rocksnail	--	NOST	--	Rocky shoals and riffles in moderate currents of medium to large rivers at depths up to 1 m (3 ft)
Pyrgulopsis pachyta	armored snail (armored marstonia)	E	P	--	Shallow, still water along the edge of pools on tree roots and detritus of creeks
			Mussels		
Cumberlandia monodonta	spectaclecase	C	P	--	Large rivers with swiftly flowing water, among boulders in patches of sand, cobble, or gravel in areas where current is reduced
Cyclonaias tuberculata	purple wartyback	--	--	S1	Medium or large rivers in gravel or mixed sand and gravel
Cyprogenia stegaria	fanshell	E	P	--	Medium to large rivers
Dromus dromas	dromedary pearlymussel	E	P	--	Sand and gravel substrates in ruffles and shoals of medium to large rivers
Ellipsaria lineolata	butterfly	--	NOST	S3	Large rivers in sand or gravel
Elliptio arca	Alabama spike	--	--	S3	Shoreline of rivers in sand, sand and gravel, or rock substrates
Epioblasma brevidens	Cumberlandian combshell	E	P	S1	Coarse sand to mixtures of gravel, cobble and boulder-sized rocks in medium to large rivers; tends to occur at depths <1m (3 ft)
Epioblasma capsaeformis	oyster mussel	E	P	--	Usually in small- to medium-sized rivers in the substrates of coarse sand to boulder substrates and moderate to swift currents
Epioblasma florentina florentina	yellow-blossom pearlymussel	E	P	--	Riffle and shoal areas of small- to medium-sized streams
Epioblasma florentina walkeri	tan riffleshell	E	X	--	Headwaters, riffles, and shoals in sand and gravel substrates

Table 2-2. (contd)

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
Epioblasma penita	southern combshell	E	--	S1	Riffles or shoals of medium-sized rivers with sandy gravel to gravel-cobble substrates in moderate to swift current
Epioblasma torulosa torulosa	tubercled blossom	E	P	--	Sandy gravel substrates in riffles and shoals in rapid currents of medium to large rivers
Epioblasma triquetra	snuffbox	--	--	S1	Medium to large rivers in clear, gravel riffles
Epioblasma turgidula	turgid blossom pearlymussel	E	P	--	Sand and gravel substrates of shallow, fast-flowing streams
Fusconaia barnesiana	Tennessee pigtoe	--	NOST	S1	Cracks in bedrock to mixtures of coarse sand, gravel, cobble and boulders in riffle and shoal areas with moderate to swift currents of medium to large rivers; seldom in depths >1m (3 ft)
Fusconaia cor	shiny pigtoe	E	P	--	Shoals and riffles in clear streams with moderate to fast current
Fusconaia cuneolus	fine-rayed pigtoe	E	P	--	Firm cobble and gravel substrates of clear, high gradient streams
Hemistena lata	cracking pearlymussel	E	P	--	Sand, gravel and cobble substrates in swift currents or mud and sand in slower currents of medium to large rivers
Lampsilis abrupta	pink mucket	E	P	--	Larger rivers in gravel or sand
Lampsilis cardium	plain pocketbook	--	--	S3S4	Small creeks to large rivers in mud, sand or gravel
Lampsilis ovata	pocketbook	--	NOST	--	Large rivers in coarse sand or gravel
Lampsilis perovalis	orangenacre mucket	T	--	S1	Medium and large rivers in gravel/cobble or gravel/coarse sand substrates
Lampsilis virescens	Alabama lampmussel	E	P	--	Sand and gravel substrates in shoal areas of medium to large rivers

Table 2-2. (contd)

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
Lemiox rimosus	birdwing pearlymussel	E	NOST	--	Riffle areas with sand and gravel substrates in moderate to fast currents of creeks to medium-sized rivers
Lexingtonia dolabelloides	slabside pearlymussel	C	P	S1	Moderate to high gradient riffles in medium to large rivers
Ligumia recta	black sandshell	--	--	S2	Gravel-cobble and possibly coarse sand substrates in shoals in medium to large rivers
Medionidus conradicus	Cumberland moccasinshell	--	NOST	--	Sand and gravel substrates or in cracks or under rocks in creeks to medium-sized rivers
Obovaria jacksoniana	southern hickorynut	--	--	S2	Medium-sized gravel substrates in river areas of low to moderate currents
Obovaria retusa	ring pink	E	P	--	Gravel and sand bars of large rivers
Obovaria unicolor	Alabama hickorynut	--	--	S3	Sand/gravel substrates in river areas of moderate current
Plethobasus cicatricosus	white wartyback pearlymussel	E	P	--	Gravel substrates of large rivers
Plethobasus cooperianus	orangefoot pimpleback	E	P	--	Sand, gravel and cobble substrates in riffles and shoals in deep water and steady current of large rivers
Pleurobema clava	clubshell	E	P	--	Medium to large rivers in gravel or mixed gravel and sand
Pleurobema curtum	black clubshell	E	--	SH	Sandy gravel to gravel-cobble substrates in riffles and shoals with moderate to fast currents in medium to large rivers
Pleurobema decisum	southern clubshell	E	--	S1S2	Sand and gravel substrates of medium to large rivers

Table 2-2. (contd)

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
Pleurobema oviforme	Tennessee clubshell	--	NOST	--	Sand and gravel substrates (occasionally mud or cracks between bedrock slabs) in vicinity of riffles and shoals of medium to large rivers
Pleurobema perovatum	ovate clubshell	E	--	S1	Moderate gradient pools and riffles of medium to large rivers
Pleurobema plenum	rough pigtoe	E	P	--	Medium to large rivers in sand or gravel
Pleurobema taitianum	heavy pigtoe	E	--	SH	Riffles and shoals on sandy gravel to gravel-cobble substrates in areas of moderate to fast currents of medium to large rivers
Potamilus alatus	pink heelsplitter	--	--	S2	Medium to large rivers in mud or mixed mud, sand and gravel
Potamilus ohiensis	pink papershell	--	NOST	--	Medium to large rivers in silt, mud or sand
Ptychobranchus fasciolaris	kidneyshell	--	NOST	S1	Rivers with coarse sand and gravel substrates
Ptychobranchus subtentum	fluted kidneyshell	C	NOST	--	Small to medium rivers in areas with swift current or riffles; larger rivers in shoal areas
Quadrula intermedia	Cumberland monkeyface	E	P	--	Sand and gravel substrates in shallow riffle and shoal areas of headwater streams to bigger rivers at depths to 0.6 m (2 ft)
Quadrula metanevra	monkeyface	--	NOST	SH	Gravel or mixed sand and gravel substrates in medium to large rivers
Quadrula rumphiana	ridged mapleleaf	--	--	S2	Medium-sized rivers in sand/gravel substrates in moderately silty waters of moderate gradient
Strophitus subvexus	southern creekmussel	--	--	S2	Small to large creeks in sand or sandy mud substrates in areas of low to no current

Table 2-2. (contd)

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
Toxolasma cylindrellus	pale lilliput	E	P	--	Firm rubble, gravel, and sand substrates in shallow riffles and shoals of clean, fast-flowing streams
Toxolasma lividus	purple lilliput	--	NOST	--	Small to medium-sized rivers in mud, sand and gravel substrates
Truncilla truncata	deertoe	--	--	S3	Medium to large rivers in mud, sand or gravel substrates
Villosa taeniata	painted creekshell	--	NOST	--	Smaller streams in sand/gravel substrates
Villosa trabalis	Cumberland bean	E	NOST	--	Sand, gravel, and cobble substrates in waters of moderate to swift currents and depths <1m (3 ft) in medium to large rivers
Villosa vanuxemensis	mountain creeksheel	--	NOST	--	Smaller streams in sand/gravel substrates
	Crayfish and Shrimp				
Palaemonias alabamae	Alabama cave shrimp	E	S1	--	Silt-bottom pools in caves
Cambarus jonesi	Alabama cave crayfish	--	NOST	--	Subterranean pools
Cambarus veitchorum	White Spring Cave crayfish	--	NOST	--	Subterranean pools
Hobbseus petilus	Tombigbee riverlet crayfish	--	--	S2	Slow to moderately flowing small, shallow streams in sand/gravel substrates
Procambarus ablusus	crayfish	--	--	S3	Streams
Procambarus pecki	phantom cave crayfish	--	NOST	--	Subterranean pools with silty bottoms

Table 2-2. (contd)

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
			Fishes		
Clinostomus funduloides	rosyside dace	--	--	S2	Rocky flowing pools of headwaters, creeks and small rivers
Cottus carolinae	banded sculpin	--	--	S1	Gravel and rubble riffles of headwaters, creeks and small rivers; springs and their effluents
Crystallaria asprella	crystal darter	--	--	S1	Clean sand and gravel runs of small to medium rivers
Cyprinella callistia	Alabama shiner	--	--	S2	Gravel- and rubble-bottomed pools and runs of creeks and small to medium rivers
Cyprinella monacha	spotfin chub	E	P	--	Rocky riffles and runs of clean small to medium riffles
Cyprinella spiloptera	spotfin shiner	--	--	S2	Sand and gravel runs and pools of creeks and small, medium and sometimes large rivers
Cyprinella whipplei	steelcolor shiner	--	--	S3	Rocky and sandy runs and, less often, pools of creeks and small to medium rivers
Elassoma alabamae	spring pygmy sunfish	--	P	--	Spring systems
Etheostoma blennioides	greenside darter	--	--	SH	Rocky riffles of creeks and small to medium rivers; shores of large lakes
Etheostoma boschungi	slackwater darter	T	P	--	Gravel-bottomed pools and runs of creeks and small rivers
Etheostoma douglasi	Tuskaloosa darter	--	NOST	--	Fast rocky riffles of creeks and small to medium rivers
Etheostoma flabellare	fantail darter	--	--	S2	Rocky riffles of creeks and small to medium rivers
Etheostoma kennicotti	stripetail darter	--	--	S2	Rocky pools of headwaters, creeks and small rivers
Etheostoma nigripinne	blackfin darter	--	--	S2	Rocky pools and adjacent riffles of headwaters, creeks and small rivers

Table 2-2. (contd)

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
Etheostoma rufilineatum	redline darter	--	--	S2	Clear, fast rocky riffles of creeks and small to medium rivers
Etheostoma tuscumbia	Tuscumbia darter	--	P	--	Springs and spring runs
Etheostoma wapiti	boulder darter	E	P	--	Fast, rocky riffles of small to medium rivers
Etheostoma zonistium	bandfin darter	--	--	S2	Sand- and gravel-bottomed pools of headwaters, creeks and small rivers
Ichthyomyzon castaneus	chestnut lamprey	--	--	S3	Lakes and streams
Ictiobus niger	black buffalo	--	--	S3	Pools and backwaters of small to large rivers, impoundments and lakes
Lythrurus ardens	rosefin shiner	--	--	S2	Rocky pools and runs of clear, fairly fast headwaters, creeks and small rivers
Moxostoma duquesnei	black redhorse	--	--	S1	Sand- to rock-bottomed pools and runs of creeks and small to medium rivers; impoundments
Moxostoma macrolepidotum	shorthead redhorse	--	--	S1	Rocky pools, runs and riffles in small to large rivers; lakes
Notropis boops	bigeye shiner	--	--	S1	Flowing, usually clear and rocky, pools of creeks and small to medium rivers
Notropis rubellus	rosyface shiner	--	--	S1	Rocky runs and flowing pools of small to medium rivers
Noturus exilis	slender madtom	--	--	S1	Rocky riffles, runs and flowing pools of clear creeks and small rivers; rarely along wave-swept margins of large impoundments
Noturus munitus	frecklebelly madtom	--	--	S2	Rocky riffles and runs of medium to large rivers, often near vegetation
Percina evides	gilt darter	--	--	S1	Rocky riffles of small to medium riffles

Table 2-2. (contd)

Scientific Name	Common Name	Status[a]			Habitat
		Federal	AL	MS	
Percina lenticula	freckled darter	--	--	S2	Fast, deep rocky riffles of small to medium rivers
Percina phoxocephala	slenderhead darter	--	--	S1	Gravel runs and riffles of creeks and small to medium rivers
Phenacobius mirabilis	suckermouth minnow	--	--	S1	Gravel and rubble riffles and runs of creeks and small to medium, sometimes large, rivers.
Phoxinus erythrogaster	southern redbelly dace	--	--	S2	Rocky, usually spring-fed pools of headwaters and creeks
Polyodon spathula	paddlefish	--	NOST	S3	Slow-moving water of large rivers
Rhinichthys atratulus	blacknose dace	--	--	S1	Rocky pools of headwaters and creeks
Typhlichthys subterraneus	southern cavefish	--	P	--	Subterranean waters
		Amphibians			
Cryptobranchus alleganiensis alleganiensis	eastern hellbender	--	P	S1	Rocky, clear creeks and rivers with large shelter rocks
Gyrinophilus palleucus	Tennessee cave salamander	--	P	--	Clean, permanent streams and pools of limestone caves

(a) C = candidate; E = endangered; NOST (State ranking developed by Alabama National Heritage Program) = considered rare or sensitive, but has no official status; P = protected; S1 = critically imperiled; S2 = imperiled; S3 = rare or uncommon; S4 = widespread, abundant and apparently secure; SH = of historical occurrence; T = threatened, X = extirpated; -- = not listed.

Sources: ADCNR 2003; Cummings and Mayer 1992; FWS 1990a, 2000a, b, 2004a,b; Johnson and Wehrle 2004; MMNS 2002; MNHP 2002; NatureServe 2004; NCWRC 2004; Page and Burr 1991; TVA 2003a.

The following discussion first addresses the nine Federally listed species that are known to presently occur in Wheeler Reservoir or one or more of the streams crossed by the transmission line rights-of-way associated with BFN. However, no Federally protected aquatic species have been collected, or are currently known to occur, in the immediate vicinity of the BFN site based on TVA's Vital Signs Monitoring Program data and Regional Natural Heritage Programs database (Baxter and Gardner 2003). Following the discussion of the Federally listed aquatic species is a discussion of the aquatic species that are only State-listed for Alabama or Mississippi.

- **Federally Listed Species**

Anthony's riversnail (*Athearnia anthonyi*) is Federally listed as endangered (FWS 1994). It was known to occur in Alabama, Georgia, and Tennessee (FWS 2004c). It has been extirpated from most of its historic range because of pollution, siltation, and habitat modification or destruction. Many populations were lost when the Tennessee River and the lower reaches of its tributaries were impounded (FWS 1994). Only two populations of Anthony's riversnail are known to survive. The largest of these occurs in the Tennessee River in Jackson County, Alabama, and Marion County, Tennessee, a short distance downstream of Nickajack Dam. This population also extends a short distance into the lower sections of the Sequatchie River, Marion County, Tennessee. The other surviving population is restricted to a relatively short reach of lower Limestone Creek, Limestone County, Alabama (FWS 1997a). Limestone Creek is crossed three times by a BFN transmission line and is closely paralleled by the transmission line along two stream segments. However, the BFN transmission line does not cross or parallel the lower section of Limestone Creek where the snail is known to occur. Anthony's riversnail inhabits large rivers and the lower reaches of larger creeks, and occurs on cobble/boulder substrates in the vicinity of riffles. However, it does not always occur in strongly flowing sections (NatureServe 2004). At the two sites in Limestone Creek where Anthony's riversnail occurs, its density ranges up to several hundred individuals per square meter. However, Limestone Creek has been severely impacted in the past by heavy siltation and probably other sources of pollution (e.g., pesticide spraying and mining effluents). A single catastrophic pollution event could potentially destroy all populations of the snail in the creek (FWS 1994; NatureServe 2004). A recovery plan for the Anthony's riversnail has been prepared (FWS 1997a).

The slender campeloma (*Campeloma decampi*) is Federally listed as endangered (FWS 2000b). It is known to exist in only several isolated populations along Limestone, Piney, and Round Island Creeks in northern Alabama (NatureServe 2004). All three creeks are crossed by BFN transmission lines. The slender campeloma typically burrows in soft sediments or detritus. Impacts to the slender campeloma include siltation and other pollutants from poor land-use practices and waste discharges (FWS 2000b).

The armored snail (or armored marstonia) (*Pyrgulopsis pachyta*) is Federally listed as endangered (FWS 2000b). It is known to occur in Alabama from several isolated sites in Limestone and Piney Creeks near Mooresville, Alabama (NatureServe 2004). Piney Creek was formerly a tributary of Limestone Creek before the construction of Wheeler Reservoir (NatureServe 2004). Both creeks are crossed by a BFN transmission line; however, these crossings occur several miles upstream from Mooresville. The armored snail is found in shallow, still water along the edge of pools on tree roots and detritus. It probably also occurs on mud substrates (NatureServe 2004). Impacts to the armored snail include siltation and other pollutants from poor land-use practices and waste discharges (FWS 2000b).

The spectaclecase (*Cumberlandia monodonta*) is a candidate for Federal listing. Its historic range includes Alabama, Arkansas, Iowa, Indiana, Illinois, Kentucky, Missouri, Nebraska, Ohio, Tennessee, Virginia, and Wisconsin (FWS 2004a). It has been largely reduced to a relatively few disjunct sites. The spectaclecase at some of the sites may no longer be capable of reproduction due to loss of fish hosts or due to adverse environmental conditions (e.g., hypolimnetic releases from reservoirs) (NatureServe 2004). In Alabama, the spectaclecase is known in Limestone and Morgan Counties. The spectaclecase is usually found in areas with a strong current. In medium-size rivers, it prefers coarse substrates such as cobble, gravel, or cracks in bedrock. In large rivers, substrates used are typically finer and include sand or mud. It may be associated with shoals, bars, and islands (NatureServe 2004). The spectaclecase is often found in small clusters of the same-aged individuals. Other than burrowing deeper into the substrate, adults are essentially sessile (NatureServe 2004). Fish hosts for the spectaclecase are unknown (Schulz and Marbain 1998). Live specimens of the spectaclecase have been collected in the main stem of the Tennessee River in Colbert, Lauderdale, Limestone, and Morgan Counties as recently as 2000. Recent collections in the mainstream of the Tennessee River have been made in the tailwaters downstream of dams. Relic specimens (i.e., present only as weathered shells) were collected in the Elk River, Limestone County, Alabama in 1998 and 1974 (Butler 2002).

The Cumberlandian combshell (*Epioblasma brevidens*) is Federally listed as endangered, within its entire range (FWS 1997b), except where proposed for establishment as a nonessential experimental population in the free-flowing reach of the Tennessee River from the base of Wilson Dam downstream to the backwaters of Pickwick Reservoir (about 19 km [12 mi]) and the lower 8 km (5 mi) of all tributaries to this reach in Colbert and Lauderdale Counties, Alabama (FWS 2001). A draft recovery plan has been prepared for the species (FWS 2003). It is known to occur in Alabama, Kentucky, Tennessee and Virginia (FWS 2004d). The Cumberlandian combshell is now restricted to populations in limited areas of five drainages, and some of these may no longer be reproducing. The species was eliminated from much of its historic range by impoundments. Existing populations are in decline because of pollution (especially from mining activities), impoundments, and siltation (FWS 1997b). It was last collected from Muscle Shoals (the area now incorporated within the upper reaches of Pickwick Reservoir through Wilson Reservoir and into Wheeler Reservoir) in 1925 (Garner 1997). The Cumberlandian combshell is typically associated with riffle and shoal areas in medium and large rivers in substrates of coarse sand to cobble. It has been apparently eliminated from the mainstems of the Tennessee and Cumberland Rivers (FWS 2004e). In Alabama, moribund specimens were found in the late 1990s in Bear Creek, a tributary of the Tennessee River (NatureServe 2004). Fish hosts for the Cumberlandian combshell include darters and sculpins (Schulz and Marbain 1998). Critical habitat has been designated for the species within the Tennessee and Cumberland River Basins, including a portion of Bear Creek that flows through Colbert County, Alabama, and Tishomingo County, Mississippi (FWS 2004e). One of the BFN

transmission lines crosses Bear Creek in Tishomingo County, Mississippi, within the reach of designated critical habitat.

The pink mucket (*Lampsilis abrupta*) is Federally listed as endangered (FWS 1976). It is known to occur in Alabama, Arkansas, Illinois, Indiana, Kentucky, Louisiana, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia (FWS 2004f). It seems to be surviving and reproducing in sections of river that have been altered by impoundments. However, its range has diminished (e.g., extirpated from Ohio, Pennsylvania, and Illinois) (NatureServe 2004). Within Alabama, the pink mucket occurs in Colbert, Lauderdale, Limestone, Madison, Marshall, and Morgan Counties (NatureServe 2004). Suitable hosts for the glochidia of the pink mucket include freshwater drum (*Aplodinotus grunniens*), largemouth bass, smallmouth bass, spotted bass, sauger, and walleye (Fuller 1974; Barnhart et al. 1997). The pink mucket inhabits areas of large rivers with swift currents, at depths ranging from 0.5 to 8.0 m (1.6 to 26.2 ft) and a mixed sand/gravel/cobble substrate (Barclay 2004). Therefore, it is unlikely that the pink mucket exists in Wheeler Reservoir in the areas near or downstream from BFN. They are generally collected in the tailwater areas downstream from the Tennessee River drainage dams (Barclay 2004). Sixteen individual pink muckets were collected near Hobbs Island (more than 64 km [40 mi] upstream of BFN) in 1998 (Yokely 1998). Past and ongoing threats to the pink mucket include habitat loss and modification from dams and dredging, water-quality degradation, and commercial overharvesting (NatureServe 2004). The zebra mussel would also pose a threat to the pink mucket in areas where they co-exist.

The slabside pearlymussel (*Lexingtonia dolabelloides*) is a candidate for Federal listing. Its historic range includes Alabama, Kentucky, Tennessee, and Virginia (FWS 2004b). Most surviving individuals are restricted to two or three populations, and the long-term viability of all extant occurrences is questionable (NatureServe 2004). It historically occurred in the Cumberland River, although it is now extirpated from the entire Cumberland River system. The slabside pearlymussel was more prevalent in the Tennessee River system. Historically, it was fairly common from Muscle Shoals (the area now incorporated within the upper reaches of Pickwick Reservoir through Wilson Reservoir and into Wheeler Reservoir) to the Tennessee River headwater tributaries in Virginia and the Duck River drainage. It was last collected from Muscle Shoals in 1963 (Garner 1997). Remaining populations occur in a number of tributary streams of the Tennessee River system, but not in the main stem of the river (NatureServe 2004). Bear Creek is the only one of these streams that is crossed by a BFN transmission line. Fish hosts for the slabside pearlymussel include the smallmouth bass and, possibly, various minnow species (Schulz and Marbain 1998). Threats to the species include channel alterations, impoundments, siltation, pollution, commercial clamming, and gravel and coal mining (NatureServe 2004). It is generally found in areas of moderate to swift current velocities with substrates ranging from coarse sand to heterogeneous assemblages for larger-sized particles (NatureServe 2004).

The rough pigtoe (*Pleurobema plenum*) is Federally listed as endangered (FWS 1976). It is known to occur in Alabama, Indiana, Kentucky, Pennsylvania, Tennessee, and Virginia (FWS 2004g), and it has a wide, but very fragmented, distribution that includes Colbert, Lauderdale, Limestone, and Morgan Counties in Alabama. Within the Tennessee River, the rough pigtoe is currently present in an undetermined number of miles downstream of Pickwick, Wilson, and Guntersville Dams (NatureServe 2004). The rough pigtoe occurs in medium to large rivers in sand, gravel, and cobble substrates in shoals, although it is occasionally found on flats and muddy sand (NatureServe 2004). It does not occur in the impounded sections of rivers (FWIE 1996). Therefore, it is unlikely that the rough pigtoe exists in Wheeler Reservoir in the areas near or downstream from BFN. One individual was collected near Hobbs Island (more than 64 km [40 mi] upstream of BFN) in 1998 (Yokely 1998). Possible host fish for the rough pigtoe are bluegill and rosefin shiner (*Lythrurus ardens*) (Schulz and Marbain 1998). The long-term viability of most populations is in jeopardy, particularly for those in large rivers where zebra mussels are established (NatureServe 2004). Threats to the rough pigtoe include impoundments, channelization, dredging, industrial and residential discharges, siltation, herbicide and fertilizer runoff, zebra mussels, loss of glochidial hosts, and natural predators (NatureServe 2004).

The slackwater darter (*Etheostoma boschungi*) is Federally listed as threatened (FWS 1977a). Critical habitat was also designated for the species (FWS 1977a, b). It is known to occur in Alabama and Tennessee (FWS 2004h). The slackwater darter occupies the following five tributaries of the Tennessee River: Buffalo River and upper Shoal Creek in Lawrence County, Tennessee; the Flint River in Madison County, Alabama; Swan Creek in Limestone County, Alabama; and Cypress Creek in Lauderdale County, Alabama (NatureServe 2004). Swan Creek is crossed by one of the BFN transmission lines. Critical habitat for the slackwater darter includes many of the permanent and intermittent streams that are tributaries to Cypress Creek in Lauderdale County, Alabama, and Wayne County, Tennessee (FWS 1977b). None of these streams are located near BFN transmission lines. The slackwater darter typically occurs in gravel-bottomed pools and sluggish areas of creeks and small rivers that are not more than 12 m (39 ft) wide and 2 m (6.6 ft) deep. They often inhabit slow waters beneath undercut banks or accumulations of leaf litter or detritus. Spawning occurs in very shallow (5 to 10 cm [2 to 4 in.]) clear, flowing seepage water characterized by the presence of rushes and sedges in fields and open woods. Threats to the species include habitat loss and degradation. The heavy use of groundwater dries seepage areas used for spawning (NatureServe 2004).

The Alabama cave shrimp (*Palaemonias alabamae*) is Federally listed as endangered (FWS 1988). It is known only from two caves in Madison County, Alabama (NatureServe 2004). Habitat for the cave shrimp is silt-bottom pools in caves (FWS 1990b). Degradation of habitat and groundwater contamination are the major threats to this species (FWS 1990b).

- **State-Listed Species**

In addition to the 31 Federally listed mussel species, an additional 22 mussel species are State-listed within one or more of the counties of concern in Alabama and Mississippi (Table 2-2). As for the Federally listed mussel species, the State-listed species have been primarily impacted by impoundments. Some of the species listed for Mississippi have also been affected by habitat modifications created by the Tennessee-Tombigbee Waterway. The mussel species have also been variously impacted by water-quality degradation (e.g., siltation and chemical contamination). Continued declines in some of these species could be expected in the future, which may lead to their becoming Federally listed species. Several of the species may be listed in one state or the other due to natural constraints in distribution (e.g., a mussel species may be primarily associated with either the Mobile River or the Tennessee River system). For example, the pink heelsplitter is considered imperiled in Mississippi, but is considered a commercial species in Alabama (Ahlstedt and McDonough 1992).

Three Alabama-listed troglobitic crayfish (Alabama cave crayfish [*Cambarus jonesi*], White Spring Cave crayfish [*C. veitchorum*], and phantom cave crayfish [*Procambarus pecki*]) occur in the project area. The Alabama cave crayfish is endemic to Alabama. It is known to occur in caves between Florence and Guntersville, Alabama (NatureServe 2004). The White Spring Cave crayfish is endemic to White Spring Cave in Limestone County, Alabama. It has a very small population size and a low reproductive potential (NatureServe 2004). The phantom cave crayfish is known from only three cave locations in Colbert, Lauderdale, and Morgan Counties, Alabama (NatureServe 2004). Degradation of habitat and groundwater contamination are the major threats to these species (NatureServe 2004).

Two Mississippi-listed crayfish species occur within several of the counties of concern. The Tombigbee riverlet crayfish (*Hobbseus petilus*) is considered imperiled in Itawamba and Lee Counties, while the crayfish *Procambarus ablusus* is considered rare or uncommon in Tishomingo County (MMNS 2002). The imperiled status of the Tombigbee riverlet crayfish results from its restricted range and potential habitat impacts related to the Tennessee-Tombigbee Waterway. There are no existing threats to *P. ablusus* (NatureServe 2004). Its status in Mississippi is based more on Tishomingo County being at the edge of the species range. The species is considered to be apparently secure within Tennessee (NatureServe 2004).

The spring pygmy sunfish (*Elassoma alabamae*) is known in several spring systems in Alabama. Its status has improved as a result of introductions and discoveries of additional populations (NatureServe 2004). It is currently known to occur in Limestone County, Alabama, in the Beaverdam Moss Spring complex (most of Moss Spring and its spring run to Beaverdam Creek, the areas within Beaverdam Swamp, and Lowe's Ditch) and in the Pryor Springs system. It was extirpated from Cave Spring in Lauderdale County, Alabama, because of habitat

inundation by Pickwick Reservoir (NatureServe 2004). In Beaverdam Creek, the range of the spring pygmy sunfish extends downstream to the impounded section of Wheeler Reservoir (Floyd 1999). The species has been negatively impacted by impoundments and water-quality degradation from poor land-use practices (e.g., crop-dusting, vegetation control, and agricultural practices). They are also vulnerable to wetland alterations and chemical spills (NatureServe 2004). The spring pygmy sunfish occurs in areas of clear water with fine sand or mud substrates and abundant and thickly matted vegetation along the shoreline. It apparently uses different spring and swamp microhabitats at different times of the year (NatureServe 2004). Spawning occurs in March and April. Adults spawn at one year of age and die within a few days to months after spawning. The eggs are attached to aquatic vegetation above the substrate (NatureServe 2004).

The Tuskaloosa darter (*Etheostoma douglasi*) has a small range, but occurs in a number of areas in the upper Black Warrior system (Locust Fork and Sipsey Fork systems) in Alabama. It is moderately threatened by timber practices and coal mining, siltation, and proposed reservoirs on Locust Fork (NatureServe 2004). A portion of the Sipsey Fork system occurs in the southern portion of Lawrence County that is not crossed by the BFN transmission lines.

Fewer than 15 populations of the Tuscumbia darter (*Etheostoma tuscumbia*) are known to occur in springs and spring runs along the Tennessee River in Alabama. It is extirpated from Tennessee (NatureServe 2004). Threats to the Tuscumbia darter include changes in the water table, siltation, predation, and loss of aquatic vegetation (NatureServe 2004). Structures such as low dams that are larger than 1.2- to 1.5-m (4- to 5-ft) high pose a barrier to dispersal. Warm summer temperatures in waters surrounding springs are also believed to preclude dispersal (NatureServe 2004). It feeds on invertebrates such as amphipods, snails, and midge larvae with reduced feeding in winter (NatureServe 2004).

The paddlefish (*Polyodon spathula*) is widespread in rivers in the eastern and central United States. While populations are faring well in some areas, they are declining or of unknown trend over much of the range. Threats to the species include habitat alteration (e.g., dams and impoundments), pollution, siltation, and overharvesting. States stock paddlefish to compensate for destruction or unavailability of spawning habitat (NatureServe 2004). While notable increases in paddlefish have been documented in portions of the Tennessee, Cumberland, and Arkansas Rivers, they have all but disappeared from the Tennessee River in Alabama (NatureServe 2004).

The southern cavefish (*Typhlichthys subterraneus*) has a discontinuous range in subterranean waters of Alabama, Arkansas, Georgia, Indiana, Kentucky, Missouri, and Tennessee. The species is apparently stable, but individual populations are vulnerable to habitat alteration and pollution of groundwater (NatureServe 2004).

In addition to the fish species already discussed, 27 other fish species (10 minnows, 10 darters, three suckers, two madtoms, one sculpin, and one lamprey) are listed as species of special concern within one or more of the Mississippi counties within which BFN transmission line rights-of-way occur (Table 2-2). However, no fish species are listed for Lee County, and only the spotfin shiner (*Cyprinella spiloptera*) and steelcolor shiner (*C. whipplei*) are listed for Union County. Both species, plus the other 25 fish species, occur in Itawamba and/or Tishomingo Counties where they occur in the Tennessee and/or the Tennessee-Tombigbee Waterway systems. The frecklebelly madtom (*Noturus munitus*) has a discontinuous distribution (Page and Burr 1991), and within the Tennessee drainage is only known from an upper tributary above Wheeler Reservoir. Twenty-five of the fish species are at the edge of their natural distribution and are more common elsewhere. Water pollution, sedimentation, or habitat loss, modification, or fragmentation could have a localized impact on some of these species. Similarly, siltation, pollution, or habitat fragmentation (e.g., between adult habitat and spawning streams) account for the rare or uncommon status of the chestnut lamprey (*Ichthyomyzon castaneus*) within Itawamba County, Mississippi.

The eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*) ranges widely within the central interior portion of the eastern United States (NatureServe 2004). Northern Alabama and extreme northeastern Mississippi are at the southeastern edge of the eastern hellbender's range (NYSDEC 2003). Within Alabama, the eastern hellbender occurs in Colbert, Franklin, Lauderdale, Limestone, Madison, Marshall, and Morgan Counties (NatureServe 2004). It has been collected in Bear Creek in Tishomingo County in Mississippi and the Tennessee River, and may also occur in Cedar Creek in Mississippi (Mayasich et al. 2003). While the species is apparently secure, populations have declined or been eliminated in many areas due to impoundments, sedimentation, water pollution, overharvesting, and heavy recreational use of habitat (NatureServe 2004). Degradation of habitat is the principal threat to the eastern hellbender. As it primarily "breathes" through its skin, the eastern hellbender requires cool, well-oxygenated, flowing water (NatureServe 2004). The hellbender inhabits rocky, clear creeks and rivers that usually have large rock shelters. They tend to avoid temperatures greater than 20°C (68°F). Males prepare nests beneath large flat rocks or submerged logs, and attend to the eggs. Crayfish are the primary prey, but they also eat other invertebrates and fishes (often scavenged) (NatureServe 2004).

The Tennessee cave salamander (*Gyrinophilus palleucus*) has a small range in Alabama, Tennessee, and Georgia. Threats to the species include flooding of caves because of dams, pollution, siltation, mining, and dumping (NatureServe 2004).

2.2.6 Terrestrial Resources

BFN is located within the Highland Rim section of the Interior Low Plateau Physiographic Province on the north shore of Wheeler Reservoir in Limestone County, Alabama. Botanically, the project site occurs within the Mississippian Plateau section of the Western Mesophytic Forest Region (EPA 2004). In this region of northern Alabama, native forest communities generally consist of mixed oak forests of varying composition in relation to topography and soils. Historically, upland forests in the project area were characterized by mixtures of southern red oak (*Quercus falcata*), black oak (*Q. velutina*), post oak (*Q. stellata*), and white oak (*Q. alba*) with dogwood (*Cornus florida*) commonly present in the understory. The clearing of forested lands for agriculture has converted many of these forest communities to early successional habitats, allowing representative native plant communities to become replaced by introduced plant species.

The BFN site is a 340-ha (840-ac) tract situated in an area where the land is used primarily for agriculture. The countryside includes open pasture lands, scattered farmsteads, few residents, and little industry within several miles. The south and west side of the plant site abuts Wheeler Reservoir. The shoreline is approximately 3772 m (12,375 ft) with 58 percent stabilized with riprap; the remaining 42 percent of the shoreline of the site is partially eroded and is composed of mixed upland forest vegetation. The stabilized shoreline is adjacent to BFN and is primarily vegetated by young (approximately 4- to 5-year-old) black willow (*Salix nigra*), common hackberry (*Celtis occidentalis*), sumac (*Rhus* spp.), and exotic species such as Chinese privet (*Ligustrum sinense*), Japanese honeysuckle (*Lonicera japonica*), and trumpet creeper (*Campsis radicans*). The remainder of the shoreline is just west of the facility and is a young mixed upland forest scattered with a few large specimens (approximately more than 80 years old) of oak and loblolly pine (*Pinus taeda*). Young plants associated with the upland forest include black locust (*Robinia pseudoacacia*), sweetgum (*Liquidambar styraciflua*), sassafras (*Sassafras albidum*), cottonwood (*Populus* spp.), elm (*Ulmus* spp.), common hackberry, and black cherry (*Prunus serotina*). Common understory vegetation in the forested area includes Chinese privet, spleenwort (*Asplenium* spp.), Virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicodendron radicans*).

Invasive exotic plant species are an issue in the area. TVA has identified 19 high priority invasive plant species in the area (TVA 2003a) with a special emphasis on Chinese privet, Japanese honeysuckle, Japanese knotweed (*Polygonum cuspidatum*), and Nepal grass (*Microstegium vimineum*). There are approximately 10 ha (25 ac) and 5 ha (12 ac) of National Wetlands Inventory and U.S. Army Corps of Engineers-classified wetlands, respectively, occurring within the BFN site. This includes forested wetlands, emergent (marsh) wetlands, and scrub-shrub/emergent wetlands (based on 1980s aerial photography). The wetland ecological communities identified on the BFN site are dominated by plant species that are

common in the region. These include black willow, buttonbush *(Cephalanthus occidentalis)*, sedges *(Carex lupulina, C. vulpinoidea, Rhyncospora corniculata)*, rushes (*Juncus* spp.), water hemlock *(Conium maculatum)*, and smartweeds *(Polygonum* spp.). These wetlands occur in areas that have been previously disturbed by clearing and agriculture, and parts that are currently maintained by periodic mowing. These types of wetlands are on land that was previously used or is currently being used for agriculture. The dominant vegetation species occurring within them are common in the region.

The vegetation communities described above are not unusual for the area and provide no uncommon forms of wildlife habitat. Animal species commonly associated with upland communities include white-tailed deer (*Odocoileus virginianus*), cottontail rabbit (*Syvilagus floridanus*), Virginia opossum (*Didelphis virginiana*), hispid cotton rat (*Sigmodon hispidus*), song sparrow (*Melospiza melodia*), eastern bluebird (*Sialia sialis*), northern mockingbird (*Mimus polyglottus*), turkey vulture (*Cathartes aura*), tufted titmouse (*Baeolophus bicolor*), American toad (*Bufo americanus*), spring peeper (*Pseudacis crucifer*), black racer (*Coluber constrictor constrictor*), and eastern box turtle (*Terrapene carolina*) (TVA 2003a). Riparian communities can support a unique assemblage of wildlife including muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), raccoon *(Procyon lotor)*, wood duck (*Aix sponsa*), belted kingfisher (*Ceryle alcyon*), barred owl (*Strix varia*), American woodcock (*Scolopax minor*), Carolina wren (*Thryothorus ludovicianus*), prothonotary warbler (*Protonotaria citrea*), eastern phoebe (*Sayornis phoebe*), bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans*), eastern newt (*Notophthalmus viridescens*), southern two-lined salamander (*Eurycea cirrigera*), common snapping turtle (*Chelydra serpentina serpentina*), and northern water snake (*Nerodia sipedon*) (TVA 2003a). Some waterholes along Wheeler Reservoir are used by American alligators (*Alligator mississippiensis*) in the winter. Invasive terrestrial animals that are expected to occur in the project vicinity include European starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), and rock dove (*Columba livia*).

Two wildlife management areas – Swan Creek State Wildlife Management Area and Mallard-Fox Creek State Wildlife Management Area – are within 5 km (3 mi) of the BFN site (TVA 2003a). The Swan Creek Wildlife Management Area includes 1232 ha (3045 ac) of land and 2357 ha (5825 ac) of water surrounded by numerous industrial facilities. The Mallard-Fox Creek State Wildlife Management Area encompasses approximately 593 ha (1483 ac), and is primarily used for small game hunting. The Round Island Recreation Area is located approximately 5.6 km (3.5 mi) upstream of BFN. The BFN-to-Maury, Alabama, transmission line right-of-way crosses the Duck River State Wildlife Management Area, the Duck River Unit 1 Proposed Designated Critical Habitat, and Elk River and Richland Creek, both of which are listed on the Nationwide Rivers Inventory. The BFN-to-Union, Mississippi, transmission line right-of-way crosses the John Bell Williams State Wildlife Management Area, the Natchez Trace National Parkway, the Tennessee-Tombigbee Waterway, and the Foxtrap Creek Ravine Potential National Natural Landmark.

Terrestrial species listed by the FWS that have the potential to occur in the vicinity of the BFN site or along the transmission line rights-of-way are presented in Table 2-3. State-listed species (excluding Federally listed species) that have the potential to occur in the vicinity of the BFN site or along the transmission line rights-of-way are presented in Table 2-4 for Alabama (ANHP 2003) and Table 2-5 for Mississippi (MMNS 2002). A review of the TVA Regional Natural Heritage database indicates that no Federally or State-listed species of animals or plants have been reported from areas within 5 km (3 mi) of the BFN (TVA 2003a). BFN transmission line

Table 2-3. Federally Listed Terrestrial Species Reported from Counties Associated with the Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Site and Its Transmission Line Rights-of-Way

Scientific Name	Common Name	Federal Status[a]
Birds		
Haliaeetus leucocephalus	bald eagle	T
Picoides borealis	red-cockaded woodpecker	E
Mammals		
Myotis grisescens	gray bat	E
Myotis sodalis	Indiana bat	E
Plants		
Apios priceana	Price's potato bean	T
Asplenium scolopendrium var. *americanum*	American hart's-tongue fern	T
Dalea foliosa	leafy prairie clover	E
Helianthus eggertii	Eggert's sunflower	T
Leavenworthia crassa	fleshy-fruited gladecress	C
Lesquerella lyrata	lyrate bladder-pod	T
Xyris tennesseensis	Tennessee yellow-eyed grass	E

(a) E = endangered, T = Threatened, C = Candidate, (FWS 2004a).

Table 2-4. Alabama State-Listed Terrestrial Species Reported from the Vicinity of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 and Associated Transmission Line Rights-of-Way

Scientific Name	Common Name	State Status[a]
Insects		
Batrisodes jonesi	beetle	NOST
Batrisodes specus	beetle	NOST
Batrisodes tumoris	beetle	NOST
Batrisodes valentinei	beetle	NOST
Pseudanophthalmus distinguens	ground beetle	NOST
Pseudanophthalmus fluviatilis	cave beetle	NOST
Pseudanophthalmus lodingi	ground beetle	NOST
Pseudosinella hirsuta	springtail	NOST
Pseudosinella spinosa	cave springtail	NOST
Rhadine caudata	ground beetle	NOST
Arachnids		
Nesticus jonesi	cave spring cave spider	P
Amphibians		
Aneides aeneus	green salamander	P
Reptiles		
Eumeces authracinus pluvialis	southern coal skink	NOST
Lampropeltis triangulum syspila	red milk snake	NOST
Birds		
Accipiter cooperii	Cooper's hawk	P
Thryomanes bewickii bewickii	Bewick's wren	P
Mammals		
Corynorhinus rafinesquii	eastern big-eared bat	P
Myotis austroriparium	southeastern bat	P
Myotis septentrionalis	northern long-eared bat	NOST
Plants		
Acorus calamus	sweetflag	NOST
Aplectrum hyemale	puttyroot	NOST
Asplenium ruta-muraria	wall-rue spleenwort	NOST
Astragalus tennesseensis	Tennessee milk-vetch	NOST
Boykinia aconitifolia	brook saxifrage	NOST

Table 2-4. (contd)

Scientific Name	Common Name	State Status[a]
Bryoxiphium norvegicum	sword moss	NOST
Cotinus obovatus	American smoke-tree	NOST
Cuscuta harperi	Harper's dodder	NOST
Cypripedium candidum	white lady-slipper	NOST
Cystopteris tennesseensis	Tennessee bladderfern	NOST
Dalea gattingeri	Gattinger prairie-clover	NOST
Delphinium alabamicum	Alabama larkspur	NOST
Delphinium exaltatum	tall larkspur	NOST
Dicentra cucullaria	Dutchman's breeches	NOST
Dodecatheon frenchii	French's shootingstar	NOST
Elodea canadensis	waterweed	NOST
Enemion biternatum	false rue-anemone	NOST
Equisetum arevense	common horsetail	NOST
Eriogonum longifolium var. *harperi*	Harper's umbrella-plant	NOST
Erythronium albidum	white trout-lily	NOST
Frasera caroliniensis	American columbo	NOST
Huperzia lucidula	shining clubmoss	NOST
Huperzia porophila	rock clubmoss	NOST
Hydrastis canadensis	goldenseal	NOST
Hymenophyllum tayloriae	gorge filmy fern	NOST
Isoetes butleri	Butler's quillwort	NOST
Jamesianthus alabamensis	Alabama warbonnet	NOST
Leavenworthia alabamica	Alabama glade-cress	NOST
Leavenworthia uniflora	Michaux leavenworthia	NOST
Lesquerella densipila	Duck River bladderpod	NOST
Linum sulcatum var. *harperi*	Harper's grooved-yellow flax	NOST
Listera australis	southern twayblade	NOST
Mirabilis albida	pale umbrella-wort	NOST
Monotropsis odorata var. *odorata*	sweet pinesap	NOST
Neobeckia aquatica	lake-cress	NOST
Neviusia alabamensis	Alabama snow-wreath	NOST
Onosmodium molle ssp. *molle*	soft false gromwell	NOST
Ophioglossum engelmannii	limestone adder's tongue	NOST
Oxalis grandis	great yellow wood-sorrel	NOST

Table 2-4. (contd)

Scientific Name	Common Name	State Status[a]
Pachysandra procumbens	Allegheny-spurge	NOST
Pediomelum subacaule	tuberous scurfpea	NOST
Phlox pulchra	Wherry's phlox	NOST
Plantago cordata	heartleaved plantain	NOST
Platanthera lacera	ragged fringed orchid	NOST
Schoenolirion croceum	sunnybell	NOST
Selaginella arenicola ssp. *riddellii*	spikemoss	NOST
Selaginella rupestris	spikemoss	NOST
Sida elliottii	Elliot sida	NOST
Silene rotundifolia	roundleaf catchfly	NOST
Silphium brachiatum	Cumberland rosinweed	NOST
Spiranthes magnicamporum	Great Plains ladies'-tresses	NOST
Stewartia ovata	mountain camellia	NOST
Talinum calcaricum	limestone fameflower	NOST
Talinum mengesii	fameflower	NOST
Thalictrum debile	southern meadow-rue	NOST
Thalictrum mirabile	little mountain meadow-rue	NOST
Trichomanes petersii	dwarf filmy-fern	NOST
Trichostomum crispulum	moss	NOST
Trillium flexipes	nodding trillium	NOST
Trillium pusillum var. 1	interior least trillium	NOST
Trillium recurvatum	prairie trillium	NOST
Trillium sessile	sessile trillium	NOST
Triosteum angustifolium	horse-gentian	NOST
Viola egglestonii	Eggleston's violet	NOST

(a) Status rankings developed by Alabama Natural Heritage Program. P = protected, NOST = no official status, but species are tracked by the Alabama Natural Heritage Program due to rarity in the state (ADCNR 2003).

Table 2-5. Mississippi State-Listed Terrestrial Species Reported from the Vicinity of the Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 and Associated Transmission Line Rights-of-Way

Scientific Name	Common Name	State Status[a]
Amphibians		
Aneides aeneus	green salamander	S1
Eurycea lucifuga	cave salamander	S1
Gyrinophilus porphyriticus	spring salamander	S1
Hemidactylium scutatum	four-toed salamander	S1
Pseudacris brachyphona	mountain chorus frog	S3
Pseudotriton ruber	red salamander	S3
Reptiles		
Lampropeltis calligaster rhombomaculata	mole kingsnake	S2
Lampropeltis getula nigra	black kingsnake	S3
Regina septemvittata	queen snake	S3
Insects		
Ellipsaria lineaolata	butterfly	S3
Birds		
Accipiter striatus	sharp-shinned hawk	S1
Aimophila aestivalis	Bachman's sparrow	S3
Petrochelidon pyrrhonota	cliff swallow	S3
Mammals		
Myotis septendrionalis	northern myotis	S3
Peromyscus ploionotus	oldfield mouse	S2S3
Plants		
Anemone quinquefolia	wood anemone	S1S2
Antennaria solitaria	single-headed pussytoes	S3
Aplectrum hyemale	puttyroot	S1
Aquilegia canadensis	wild columbine	S1S2
Arabis canadensis	sicklepod	S2S3
Asarum canadense	Canada wild-ginger	S2S3
Asplenium pinnatifidum	lobed spleenwort	S1
Asplenium resiliens	black-stem spleenwort	S1
Asplenium rhizophyllum	walking-fern spleenwort	S1S2
Asplenium trichomanes	maidenhair spleenwort	S1
Astragalus canadensis	rattle-vetch	S2

Table 2-5. (contd)

Scientific Name	Common Name	State Status[a]
Aster ericoides	white heath aster	S2
Athyrium thelypterioides	silvery spleenwort	S2S3
Cacalia muehlenbergii	great Indian-plantain	S1
Callirhoe triangulata	clustered poppy-mallow	S1S2
Camassia scilloides	wild hyacinth	S2S3
Carex jamesii	Nebraska sedge	S1S2
Carex oligocarpa	eastern few-fruit sedge	S1
Carex picta	painted sedge	S2S3
Carex prasina	drooping sedge	S1
Carex seorsa	separated sedge	S1S2
Carex stricta	uptight sedge	S2
Carex virescens	ribbed sedge	S1
Carya laciniosa	big shellbark hickory	S2S3
Carya leiodermis	swamp hickory	S2S3
Cheilanthes lanosa	hairy lipfern	S2
Chelone glabra	white turtlehead	S3
Chelone lyonii	pink turtlehead	S1
Chelone obliqua	red turtlehead	SH
Chimaphila maculata	spotted wintergreen	S2
Cimifuga racemosa	black bugbane	S1S2
Cladrastis kentukea	yellowwood	S2
Clematis beadlei	vase-vine leather-flower	S1
Coreopsis auriculata	lobed tickseed	S2S3
Cypripedium pubescens	yellow lady's-slipper	SU
Decodon verticillatus	hairy swamp loosestrife	S2S3
Delphinium tricorne	dwarf larkspur	S2
Dentaria diphylla	pepper-root	S1S2
Dentaria heterophylla	slender toothwort	S2S3
Dicentra cucullaria	Dutchman's breeches	S1
Dirca palustris	eastern leatherwood	S2
Dodecatheon meadia	shooting star	S2
Erythronium albidum	white dog's tooth violet	S2
Erythronium americanum	yellow dog's tooth violet	S1S2
Erythronium rostratum	beaked dog's tooth violet	S1S2
Euonymus atropurpureus	burning bush	S2S3
Fraxinus quadrangulata	blue ash	S2
Gynmocladus dioicus	Kentucky coffee-tree	S2
Heuchera villosa var. *macrorhiza*	giant alumroot	S1

Table 2-5. (contd)

Scientific Name	Common Name	State Status[a]
Hexalectris spicata	crested coralroot	S2
Hexastylis shuttleworthii	large-flowered heartleaf	S1
Hybanthus concolor	green violet	S2
Hydrophyllum appendiculatum	appendaged waterleaf	S1
Hydrophyllum macrophyllum	large-leaf waterleaf	S1
Ilex montana	mountain holly	S3
Isoetes engelmannii	Appalachian quillwort	S1S2
Juglans cinerea	white walnut	S2
Lesquerella gracilis	spreading bladder-pod	S2
Ligusticum canadense	nondo lovage	S1S2
Luzula acuminata	hairy woodrush	S3
Melanthium virginicum	Virginia bunchflower	S2S3
Mertensia virginica	Virginia bluebells	S1S2
Muhlenbergia tenuiflora	slender muhly	S1S2
Nemastylis geminiflora	prairie-iris	S2
Neviusia alabamensis	Alabama snow-wreath	S1
Osmorhiza longistylis	smoother sweet-cicely	S3
Pachysandra procumbens	Allegheny-spurge	S3
Panax quinquefolius	American ginseng	S3
Pellaea atropurpurea	purple-stem cliff-brake	S1S2
Penstemon tenuiflorus	narrow flowered beard tongue	S2S3
Perideridia americana	eastern eulophus	S1S2
Phacelia bipinnatifida	fernleaf phacelia	S1
Philadelphus hirsutus	hairy mock-orange	S1
Pinus virginiana	Virginia pine	S2
Platanthera cristata	crested fringed orchid	S3
Platanthera integrilabia	white fringeless orchid	S1
Platanthera lacera	ragged fringed orchid	S1S2
Platanthera peramoena	purple fringeless orchid	S2S3
Polemonium reptans	Jacob's ladder	S2S3
Rhamnus lanceolata	lance-leaved buckthorn	S2
Rhododendron arborescens	smooth azalea	S1
Sabatia campestris	prairie pink	S2S3
Salvia urticifolia	nettle-leaf sage	S2S3
Sedum ternatum	wood stonecrop	S2
Solidago flaccidifolia	Appalachian goldenrod	S1S2
Solidago sphacelata	false goldenrod	S1S2
Spiraea tomentosa	hardhack spiraea	SH

Table 2-5. (contd)

Scientific Name	Common Name	State Status[a]
Spiranthes ovalis	lesser ladies-tresses	S2S3
Staphylea trifolia	American bladdernut	S3
Stellaria pubera	giant chickweed	S2S3
Stewartia ovata	mountain camellia	S1
Swertia caroliniensis	American colombo	S2S3
Tiarella cordifolia	heart-leaved foam-flower	S2
Tomanthera auriculata	earleaf false-foxglove	S1
Tradescantia ernestiana	Palmer's spiderwort	S1
Trautvetteria caroliniensis	Carolina tassel-rue	S1
Trichomanes boschianum	bristle-fern	S1
Trillium flexipes	drooping trillium	S1
Triosteum angustifolium	narrow-leaf fever root	S3
Triphora trianthophora	three birds orchid	S2S3
Viola pubescens var. *eriocarpon*	smooth yellow violet	S1S2

(a) Status rankings developed by the Natural Heritage Inventory; S1 = critically imperiled because of extreme rarity; S2 = Imperiled because of rarity; S3 = rare or uncommon; SH = historically extant; SU = status uncertain (MMNS 2002; MNHP 2002).

rights-of-way pass through Limestone, Morgan, Lawrence, Colbert, and Franklin Counties in Alabama and Tishomingo, Itawamba, Lee, and Union Counties in Mississippi.[a] Eleven Federally listed terrestrial species have been reported from these counties. There are 89 species listed for the State of Alabama and 116 species listed for Mississippi.[a]

The threatened bald eagle (*Haliaeetus leucocephalus*) has been reported in Franklin County, Alabama, and Itawamba and Tishomingo Counties, Mississippi. Bald eagles prefer habitat along coastlines, lakes, rivers, and other water bodies that provide their primary food source (i.e., fish and waterfowl) (NatureServe 2004). Eagles generally nest in tall trees or cliff faces near water and away from human disturbance. Bald eagles are known in the area around BFN, but there are no known nests within 5 km (3 mi) of the site. BFN transmission line rights-of-way are likely to be within foraging areas for this species.

The endangered red-cockaded woodpecker (*Picoides borealis*) has been reported in Lawrence County, Alabama. Red-cockaded woodpeckers inhabit older open pine forests, (generally at least 80 to 120 years old) (FWS 2004d). Hardwood forests or pine forests with a hardwood

(a) Prentiss County, Mississippi is not included. Species are accounted for in adjacent counties.

understory are usually avoided. There is no woodpecker habitat within 5 km (3 mi) of the BFN site, and it is unlikely that there is any suitable habitat along the BFN transmission line rights-of-way.

Gray bats (*Myotis grisescens*) are listed by the FWS as endangered and have been found in Colbert, Franklin, Lawrence, Limestone, and Morgan Counties, Alabama, and Tishomingo County, Mississippi. Gray bats are colonial and are restricted to cave or cave-like habitats (FWS 2004d). Gray bats roost and females form maternity colonies in caves located along rivers and reservoirs over which they feed. In the winter, gray bats congregate and hibernate in a limited number of caves across the southeast (FWS 2004d, i). Roosting and foraging habitat for gray bats is very limited on the BFN site. Water sources for the bats include lagoons, sedimentation ponds, and drainage canals. Although no suitable habitats for these species occur on the BFN site, gray bats likely forage along the Tennessee River, adjacent to the site. BFN transmission line rights-of-way are also likely to be within foraging areas for this species.

The endangered Indiana bat (*Myotis sodalis*) has been reported from Colbert, Lawrence, Limestone, and Morgan Counties, Alabama and Tishomingo County, Mississippi. Indiana bats are highly colonial and hibernate in caves during winter months but can be found in hollow trees and under loose tree bark during the summer, where they form small maternity colonies (FWS 2004d). Indiana bats forage for insects primarily in riparian and upland forests. Roosting and foraging habitat for Indiana bats is very limited on the BFN site. Water sources for the bats include lagoons, sedimentation ponds, drainage canals, and forested habitats are primarily small woodlots of poor quality. BFN transmission line rights-of-way are also likely to be within foraging areas for this species.

Price's potato bean (*Apios priceana*) is listed as threatened by the FWS and has been found in Lee County, Mississippi. This species is found in open mixed hardwood forests often on floodplains in or near riparian areas (NatureServe 2004). Although thought to be somewhat dependent on disturbances that maintain an early succession environment, it is also reported to be sensitive to some management activities such as logging, cattle grazing, and highway right-of-way maintenance. No populations of Price's potato bean are known to exist within 5 km (3 mi) of the BFN site, but suitable habitat could be found along the BFN transmission line rights-of-way.

American hart's-tongue fern (*Asplenium scolopendrium* var. *americanum*) is listed as threatened by the FWS and is known to occur in Morgan County, Alabama (FWS 2004d). In Alabama, this fern is found only around the openings to limestone caves and sinkholes. No populations have been recorded within 5 km (3 mi) of the BFN site; no suitable habitat has been found along the BFN transmission line rights-of-way.

Leafy prairie clover (*Dalea foliosa*) is listed as endangered by the FWS and is known to occur in Franklin, Lawrence, and Morgan Counties, Alabama (FWS 2004d). This species is found in association with cedar glades in northern Alabama and central Tennessee. No populations of leafy prairie clover are known to occur from within 5 km (3 mi) of the BFN site, and no suitable habitat could be found along the BFN transmission line rights-of-way.

Eggert's sunflower (*Helianthus eggertii*) is listed as threatened by the FWS and has been found in Colbert, Franklin, Lawrence, Limestone, and Morgan Counties, Alabama. This species is found in barren habitats within the Interior Plateau Ecoregion of Kentucky, Tennessee, and Alabama (NatureServe 2004). No populations are recorded within 5 km (3 mi) of the BFN site. Populations may occur along the BFN transmission line rights-of-way because the species is reported to respond favorably to management activities such as burning and mowing (NatureServe 2004).

Fleshy-fruited gladecress (*Leavenworthia crassa*) is a candidate species that has been found in Lawrence and Morgan Counties, Alabama. Reportedly endemic to Lawrence and Morgan Counties, this species inhabits limestone glades and has been identified in only six sites (NatureServe 2004). No populations have been recorded within 5 km (3 mi) of the BFN site, but suitable habitat could be found along the BFN transmission line rights-of-way.

The threatened lyrate bladder-pod (*Lesquerella lyrata*) has been reported in Colbert, Franklin, and Lawrence Counties, Alabama. The species in known in only two populations in Franklin and Colbert Counties (FWS 2004d). The plant is an annual in the mustard family and is found in disturbed glade habitats. No populations exist within 5 km (3 mi) of the BFN site, but suitable habitat could be found along the BFN transmission line rights-of-way.

The endangered Tennessee yellow-eyed grass (*Xyris tennesseensis*) is found in Franklin County, Alabama. This species is found in moist-to-wet, limestone-derived soils in open or lightly wooded sites (FWS 2004d). No populations are known to exist within 5 km (3 mi) of the BFN site, but suitable habitat could be found along the BFN transmission line rights-of-way.

2.2.7 Radiological Impacts

TVA has conducted a radiological environmental monitoring program (REMP) in the vicinity of BFN since 1968. Through this program, radiological impacts to workers, the public, and the environment are monitored, documented, and compared to the appropriate standards. The objectives of the REMP are described below:

- Provide representative measurements of radiation and radioactive materials in the exposure pathways and of the radionuclides that have the highest potential for radiation exposures to members of the public.
- Supplement the radiological effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways.

Results of measurements of radiological releases and environmental monitoring are summarized in annual reports (TVA 2004c, g). The limits for all radiological releases are specified in the Browns Ferry ODCM, and these limits are designed to meet Federal standards and requirements (TVA 2004c). The REMP includes monitoring of the aquatic environment (fish and shoreline sediment), the atmospheric environment (airborne radioiodine, gross beta, and gamma), the terrestrial environment (crops, soil, milk), and direct radiation (TVA 2004g).

Review of historical data on releases and the resultant dose calculations indicated that the doses to maximally exposed individuals in the vicinity of the BFN site were a small fraction of the limits specified in EPA's environmental radiation standards 40 CFR Part 190 as required by 10 CFR 20.1301(d). Dose estimates are calculated for a hypothetical maximally exposed individual, based on monitored liquid and gaseous effluent release data, onsite meteorological data, local river flow data, and appropriate pathways identified in the ODCM (TVA 2004c).

The dose from all pathways during the period from 1999 to 2003 to a maximally exposed individual was less than 0.0035 mSv (0.35 mrem)/yr to the whole body or any organ other than the thyroid. To calculate the dose to the maximally exposed individual, the calculated doses from the liquid and gaseous effluent exposure pathways are summed. For the liquid effluent pathway the whole body dose was calculated to be less than 0.0013 mSv (0.13 mrem) per year. The liquid exposure pathways included drinking water, fish ingestion, and direct radiation from shoreline sediment during recreation such as boating. For the gaseous effluent pathways, the whole body dose was calculated to be less than 0.0022 mSv (0.22 mrem) per year; the gaseous exposure pathways included inhalation, ingestion of milk and crops, and direct radiation from the airborne radioactive material. The thyroid dose from all pathways was less than 0.0096 mSv (0.96 mrem)/yr (TVA 2000, 2001, 2002b, 2003c, 2004c).

These doses are typical of the annual dose for operation of BFN, Units 2 and 3 without the power uprates. As discussed earlier, operation at the combined total power level of 11,856 MW(t) during the license renewal term could increase doses by as much as a factor of 1.8 over these typical values. Historically, doses to members of the public from BFN are well below NRC and EPA limits and would continue to be well below NRC and EPA limits during operation at the combined total power level of 11,856 MW(t) during the license renewal term.

2.2.8 Socioeconomic Factors

The staff reviewed the TVA ER and information obtained from several county, city, and economic development staff during a site visit to Limestone and Morgan counties in the spring 2004. The following information describes the economy, population, and communities near BFN.

2.2.8.1 Housing

BFN employs approximately 1000 people on a full-time basis, with an additional 2475 contract employees who are primarily working on the restart of Unit 1 (TVA 2004h). About 300 contract employees who are not affiliated with the restart of Unit 1 support the non-outage operations at Units 2 and 3. Approximately 26 percent of these employees (both plant and contract) live in Lauderdale County, while an additional 21 percent live in Limestone County, 16 percent live in Madison County, and 14 percent live in Morgan County, with the remainder living in other locations (see Table 2-6). Although the employee residences are widely dispersed, the socioeconomic analysis primarily focuses on Lauderdale, Limestone, Madison, and Morgan Counties, because more than 75 percent of the BFN employees live in these counties, and Limestone County is where BFN is located (TVA 2004h).

There are presently more than 2000 temporary workers onsite who are working on the restart of Unit 1. In addition, the units are on a schedule to refuel in alternate years. During refueling, the number of employees increases by as many as 900 temporary workers for a period of 30 to 40 days. Most of the temporary employees appear to primarily reside in surrounding counties and commute to the plant rather than make use of temporary rental housing available in Limestone County (TVA 2003a). Local real estate agents in Athens also confirmed this trend despite the recent increase in employment at the plant, resulting from Unit 1 restart activities. The local real estate market has remained relatively unaffected and rental rates have not significantly increased.[a]

(a) Personal communication (discussion) with L. McBay and L. Smith, Century 21 Realtors, Athens, Alabama (March 31, 2004).

Table 2-6. Residence by County for Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Tennessee Valley Authority and Contract Employees

County	Tennessee Valley Authority Employees		Contract Employees		Total (Employees and Contractors)	
Colbert	71	6.9%	261	10.5%	332	9.5%
Cullman	4	0.4%	13	0.5%	17	0.5%
Franklin	13	1.3%	68	2.7%	81	2.3%
Giles, TN	5	0.5%	4	0.2%	9	0.3%
Jackson	11	1.1%	32	1.3%	43	1.2%
Lauderdale	306	29.6%	617	24.9%	923	26.3%
Lawrence, AL	18	1.8%	94	3.8%	112	3.2%
Lawrence, TN	21	2.0%	60	2.4%	81	2.3%
Limestone	251	24.3%	496	20.0%	747	21.3%
Madison	137	13.2%	419	16.9%	556	15.8%
Marshall, AL	8	0.8%	13	0.5%	21	0.6%
Morgan	172	16.6%	312	12.6%	484	13.8%
Wayne	0	0.0%	23	0.9%	23	0.7%
Other	18	1.7%	63	2.5%	81	2.3%
Total	1035		2475		3510	

Source: TVA 2004h.

Table 2-7 provides the number of housing units and housing unit vacancies for Lauderdale, Limestone, Madison, and Morgan counties for 1990 and 2000. Limestone County, where BFN is located, had 26,897 housing units in 2000, with a vacancy rate around 8 percent. Lauderdale County, in which the greatest number of TVA plant and contract employees reside, had 40,424 housing units and a vacancy rate of just over 10 percent. Madison and Morgan Counties, both of which have a larger population base and a relatively more diverse employment market, had vacancy rates in 2000 of 9 and 8 percent, respectively (USCB 2000). These counties are not subject to restrictive growth control measures that limit housing development (TVA 2003a).

Table 2-8 contains data on population, estimated population, and annual population growth rates for Lauderdale, Limestone, Madison, and Morgan Counties. All counties experienced positive population growth in the 1990s, with Limestone County's rate of increase exceeding 20 percent (TVA 2003a).

Table 2-7. Total Occupied and Vacant (Available) Housing Units by County, 1990 and 2000

	1990	2000	% Increase
		LAUDERDALE COUNTY	
Housing Units	33,522	40,424	21%
Occupied Units	30,905	36,088	17%
Vacant Units	2,617	4,336	66%
		LIMESTONE COUNTY	
Housing Units	21,455	26,897	25%
Occupied Units	19,685	24,688	25%
Vacant Units	1,770	2,209	25%
		MADISON COUNTY	
Housing Units	97,855	120,288	23%
Occupied Units	91,208	109,955	21%
Vacant Units	6,647	10,333	55%
		MORGAN COUNTY	
Housing Units	40,419	47,388	17%
Occupied Units	37,799	43,602	15%
Vacant Units	2,620	3,786	45%

Sources: U.S. Census Bureau (USCB) 2000, 1990.

Table 2-8. Population Growth in Lauderdale, Limestone, Madison and Morgan Counties, Alabama – 1980 to 2025

	Lauderdale County		Limestone County		Madison County		Morgan County	
	Population	% Change	Population	% Change	Population	% Change	Population	% Change
1980	80,546	--	46,005	--	196,966	--	90,231	--
1990	79,661	(-1.1)	54,135	17.7	238,912	21.3	100,043	10.9
2000	87,966	10.4	65,676	21.3	276,700	15.8	111,064	11.0
2015	98,015*	11.4	81,747*	24.5	324,153*	17.1	124,358*	12.0
2025	103,176*	5.3	90,865*	11.2	349,713*	7.9	131,112*	5.4

-- = No data available.
* population estimated
Sources: TVA 2003a.

2.2.8.2 Public Services

Public services include water supply, education, and transportation.

- **Water Supply**

The City of Athens Water Services and the Limestone County Water Authority are the primary sources of potable water in Limestone County. The City of Athens Water Services draws water from the Elk River and currently has a Safe Yield from the River of 21.3 x 10^4 m^3/day (56 MGD) (TVA 2004i). Limestone County Water Authority draws water from the Elk River and four wells. Both of these water systems operate with excess capacity, and currently meet water demands for Unit 1 restart activities and normal BFN operations. As shown in Table 2-9, the average total daily water demand on the City of Athens system is about 2.5 x 10^4 m^3/day (6.5 MGD), which is less than half the permitted capacity of 5.1 x 10^4 m^3/day (13.5 MGD). Athens City Water Services has plans to upgrade its intake structure to accommodate an increased intake rate of 6.8 x 10^4 m^3/day (18 MGD) to ensure supply reliability. This system upgrade is scheduled for implementation during 2004. BFN typically uses 500 to 1000 m^3/day (0.13 to 0.26 MGD).

Table 2-9. Public Water Supply Systems in Limestone County, Alabama

Water System	Source	Permitted Capacity m^3/d (MGD)	Average Daily Demand m^3/d (MGD)	Peak Demand Per Day m^3/d (MGD)	Area Served
City of Athens Water Services	Elk River and wells	5.1 x 10^4 (13.5)	2.5 x 10^4 (6.5)	4.1 x 10^4 (10.7)	City of Athens/ Limestone County
Limestone County Water Authority	Elk River and wells	3.0 x 10^4 (8)	2.4 x 10^5 (6.25)	2.6 x 10^4 (6.75)	Limestone County

Source: TVA 2003a, 2004i

- **Transportation**

The BFN site is approximately 16 km (10 mi) southwest of Athens in northern Alabama in Limestone County and is located just south of U.S. Highway 72, which runs from South Pittsburg, Tennessee, west to Memphis, Tennessee. The site is directly accessible from County Road 25 (Shaw Road), which intersects U.S. Highway 72 approximately 10 km (6 mi) north of the site. County Road 25 (Nuclear Plant Road) also intersects U.S. Highway 31 approximately 14 km (9 mi) east of the site. U.S. Highway 31 intersects U.S. Highway 72 northeast of the site. Browns Ferry Road to County Road 25 just east of the site provides a more direct route to the site from Athens. U.S. Highways 72 and 31 are both high-quality,

four-lane roads with adequate lane widths, alignments, turning lanes, and speed limits of 80 km/hr (50 mph) through Athens and increasing away from the city.

County Road 25 and Browns Ferry Road are medium-quality, two-lane roads with level alignment, some passing zones, and a speed limit of 72 km/hr (45 mph). There is direct accessibility to BFN off County Road 25. The large diamond intersection at one entrance allows for smooth turning movements into and out of the BFN site. Another access road into the plant commonly used by contractors uses a traffic light at the intersection with Nuclear Plant Road. BFN, which is the primary traffic generator in the vicinity of the site, currently averages a daily site non-outage population of approximately 3600 persons; of this total, 1300 is for the total Unit 2 and 3 operating workforce, and 2300 is for Unit 1 recovery. The operational population currently peaks at approximately 2200 persons during outages, which occur every 24 months (per unit) for approximately 2 months. Current truck deliveries are minimal (less than 10 per week) and include hydrogen delivery trucks, Calgon™ water chemistry trucks, and occasional diesel fuel deliveries during peak months. Rural residences located along the county roads that provide access to the site are also sources of traffic in the area (TVA 2003a).

Figure 2-5 shows a map of the local road network for the area. The latest available (1998) average daily traffic counts in proximity to the site indicate approximately 13,440 vehicles per day on U.S. Highway 72 north of the site and 16,260 vehicles per day on U.S. Highway 31 south of U.S. Highway 72. There are no available traffic counts on the county roads; however, TVA estimates approximately 1600 vehicles per day on Shaw Road, Browns Ferry Road, and Nuclear Plant Road.

BFN does not have direct rail service; however, a railway spur track with an unloading area is located off the CSX (Louisville and Nashville Railroad) mainline that runs north and south in Tanner, Alabama, approximately 13 km (8 mi) east of BFN. TVA leased this small parcel of land from CSX and used it for offloading during construction of BFN; however, TVA has not used the spur and unloading area for offloading and transporting materials to the plant since then. After offloading, heavy items were transported on heavy trucks via a "hardened" pathway to the site. This pathway included shallow fords through creek beds along the way. At the site, a short railroad spur runs into the turbine building for transport into the plant (TVA 2003a). The railroad spur track and unloading area may be used for future removal of dry cask spent fuel storage canisters from the site. There are no plans to use it for Unit 1 restart activities or regular plant operations.

Traffic on the Tennessee River near BFN includes both commercial and recreational vessels. The river channels and the locks at Guntersville Lock and Dam and at Wheeler Dam are more than adequate for handling river traffic. Both Guntersville Lock and Wheeler Lock are operating below their utilization capacity (TVA 2003a).

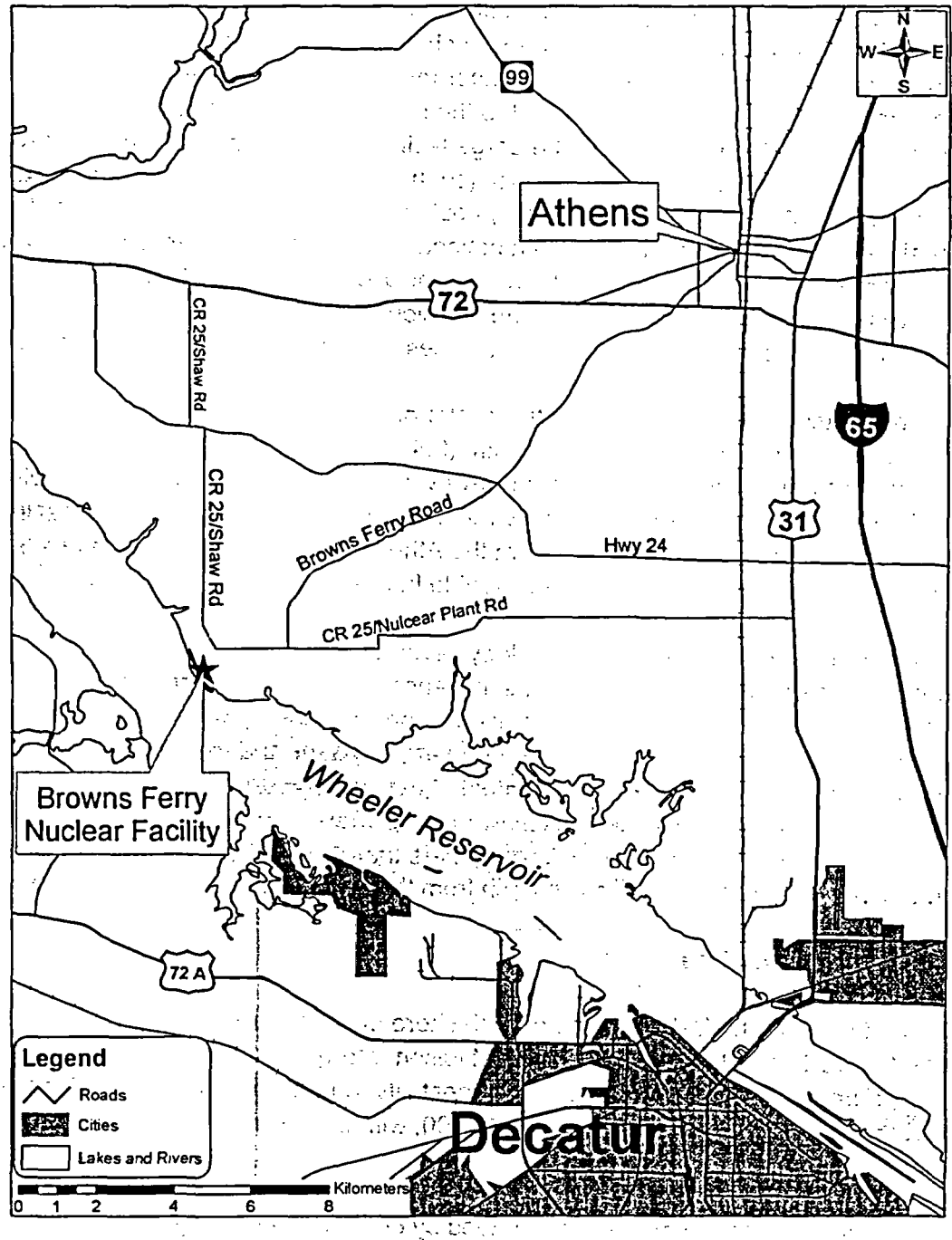

Figure 2-5. Local Road Network for Browns Ferry Nuclear Power Plant, Units 1, 2, and 3

BFN has a qualified barge facility near the northwest corner of the site. Currently it consists of barge tie points and a wide ramp going down into the water. The ramp was used during initial plant construction to transport very heavy loads such as reactor vessels. The barge facility is currently used several times per year, but a temporary crane has to be brought in to unload the barge each time. The roadbed from the plant to the barge facility is "hardened" for heavy loads. Future work is contemplated to upgrade the barge facility by stabilizing the riverbank and installing anchoring cells and a permanent dock (so that the facility will no longer require use of a temporary crane). An upgraded barge facility could eventually be used to facilitate transport of spent fuel canisters offsite for disposal in a national repository. The barge facility would likely be used for some heavy items during Unit 1 restart; however, its use for this purpose and the proposed facility upgrade is independent of the decision to restart Unit 1. Appropriate environmental analyses would be done if TVA decides to propose upgrading the barge facility.

Three pipelines pass within 8 km (5 mi) of the center of the BFN plant site. One pipeline that carries xylene runs north and south about 3.9 km (2.4 mi) east of the plant. The other two pipelines carry natural gas in a common right-of-way about 6.1 km (3.8 mi) south-southwest of the plant. The natural gas pipelines generally run east-west. The only pipeline crossing the BFN site boundary is a potable water line from the Athens Water District. There are no plans to install or connect to any pipelines in the foreseeable future.

BFN is connected to the TVA system network by seven 500-kV lines: one line to Madison substation; two lines to Trinity substation; one line each to the West Point, Maury, and Union substations; and one line to Limestone substation. Normal station power is from the unit station service transformers connected between the generator breaker and main transformer of each unit. Startup power is from the TVA 500-kV system network through the 500-kV to 20.7-kV main and 20.7 kV to 4.16-kV unit station service transformers. Auxiliary power is available through the two common station service transformers that are fed from two 161-kV lines supplying the 161-kV switchyard, one line each from the Athens and Trinity substations.

2.2.8.3 Offsite Land Use

BFN is located in northern Alabama on the north shore of Wheeler Reservoir in an unincorporated portion of Limestone County. Madison, Morgan, Lawrence, and Lauderdale Counties also are in the vicinity of BFN. The largest city in Limestone County is Athens, and the population in the county is approximately 67,000, with approximately 19,000 residing in Athens.

BFN is located in an agricultural area, surrounded by cropland principally planted with cotton. Limestone County is ranked first in Alabama for the most cotton grown. About 89,000 ha (220,000 ac) or 66.8 percent of the total acreage in Limestone County is used for agriculture (TVA 2003a). In addition, there are approximately 31,930 ha (78,900 ac) of forested land in the

county, constituting approximately 23.9 percent of total county acreage. The majority of the forested land is located in the northern two-thirds of the county. Trends show that the amount of forested land has been declining since the early 1960s (TVA 2003a). The amount of land devoted to agriculture has been gradually increasing.

Only about 2 percent of Limestone County is urban development; however, the current trend in population growth will likely result in more land becoming urbanized (TVA 2003a). Population in Limestone County has been gradually increasing because of increased employment opportunities in the county as well as in nearby Huntsville and Decatur. It is expected that the majority of residential growth will occur around Athens and in the Elkmont Village area (TVA 2003a). Development of commercial property is rapidly occurring in the area of the intersection of U.S. Highway 72 and Interstate 65 and along the U.S. Highway 72 corridor to Huntsville.

2.2.8.4 Visual Aesthetics and Noise

- **Visual Aesthetics**

BFN is situated in an area where the land is used primarily for agriculture. Population densities are low, with no population centers of significance within 16 km (10 mi) of the plant. The site is surrounded to the north and east by rural countryside. It includes open pasture lands, scattered farmsteads, few residents, and little industry within several miles. The terrain is gently rolling with open views to higher elevations to the north. The south and west sides of the plant abut Wheeler Reservoir, which is a wide expanse of open river used for an array of recreational purposes. The reservoir in the vicinity of BFN is moderately used by recreational boaters and fishermen (TVA 2003a).

There are no homes within foreground viewing distance to the north and east. Adjacent to the site however, is a small residential development located to the northwest. Another residential development is located across Wheeler Reservoir to the southwest, and the Mallard Creek public use area is directly across the reservoir. These developments have at least partial views of the plant site. A berm, graded during the initial construction of the plant and containing approximately 2.5 million m^3 (3.3 million yd^3) of earth excavated to make cooling water channels, lies adjacent to the cooling tower complex and blocks views of the northern and eastern plant area (TVA 2003a).

Two wildlife management areas – Swan Creek State Wildlife Management Area and Mallard-Fox Creek State Wildlife Management Area – are within 5 km (3 mi) of the BFN site (TVA 2003a). The Swan Creek Wildlife Management Area includes 1232 ha (3045 ac) of land and 2357 ha (5825 ac) of water surrounded by numerous industrial facilities. The Mallard-Fox

Creek State Wildlife Management Area encompasses approximately 593 ha (1483 ac), and is primarily used for waterfowl and small game hunting. The Round Island Recreation Area is located approximately 5.6 km (3.5 mi) upstream of BFN (TVA 2003a).

- **Noise**

Several communities near BFN are exposed to noise from plant operations. The two areas considered to be most susceptible are the Paradise Shores and the Lakeview communities. Paradise Shores is located downstream and adjacent to the BFN site, while Lakeview is located across the river and about 2591 m (8500 ft) from the center of the cooling tower area (TVA 2002a). Upstream and adjacent to the site are two new subdivisions of waterfront homes, Pointe Westmoreland and Lookingbill. Given the distance and buildings and terrain features between BFN and its cooling tower area, Pointe Westmoreland and Lookingbill are not considered to be sensitive to the current noise environment. Given the growth that has occurred around BFN since it first became operational, the initial background noise estimates for both the Paradise Shores and Lakeview communities were not considered representative of present-day conditions.

In June 2001, TVA conducted a new background noise survey (TVA 2002a). For the Paradise Shores community, the 15-hour daytime (7:00 a.m. to 10:00 p.m.) average noise value was 45.7 decibels, while the nighttime (10:00 p.m. to 7:00 a.m.) average was 43.1 decibels. Similar data for the Lakeview community for the same time periods was 44.1 and 38.7 decibels. The predominant noise sources were traffic, lawn mowers, home air-conditioners, and children's activities. At night, insects, frogs, air-conditioners, and traffic were the dominating noises (TVA 2002a). Lakeview has posted traffic restrictions that reduced traffic, thus reducing the recorded background noise values.

In July 2001, a daytime noise survey was conducted while the three cooling towers closest to Paradise Shores were operating. Measurements taken at the same locations used for the background noise survey indicated a total noise level of 45.8 decibels, while the calculated total noise level value for this location was 46.4 decibels, based on noise measurements taken from another location closer to the cooling towers. If the other two operating cooling towers were used, the estimated background noise level would increase by less than 1 decibel. For six cooling towers (assumes the replacement and operation of the sixth cooling tower), the additional total noise level would be 1 to 2 decibels greater than the levels measured during the July 2001 survey. On the day of the testing, noise from the existing five operating cooling towers was not detected in the Lakeview community.

for acceptable noise level for residential areas before noise reduction measures would be considered (TVA 2002a). While the measured noise levels obtained both for the background and during operation of the five cooling towers were discrete measurements, that information can be used to calculate the average annual day/night level. TVA estimated these values to be 50 decibels for Paradise Shores and 46 decibels for Lakeview (TVA 2002a). Therefore, the current estimated noise levels for both communities is below the recommended EPA level. However, this does not preclude the potential for annoyance and complaints from some members of either the Paradise Shores or Lakeview communities because of disturbances of communication, relaxation, and concentration.

2.2.8.5 Demography

- **Resident Population Within 80 km (50 mi)**

Population within 80 km (50 mi) of BFN was estimated (TVA 2003a). An estimated 164,936 people live within 32 km (20 mi) of BFN, and 872,478 live within 80 km (50 mi) (TVA 2003a). The largest population centers within a portion of the 16-km (10-mi) radius are Athens (located in Limestone County with a population 18,967) and Decatur (located in Morgan County with a population of 53,929) (USCB 2000).

Between 1990 and 2000, the population of Lauderdale County grew by 10 percent, Limestone County population grew by 21 percent, Madison County grew by 16 percent, and Morgan County grew by 11 percent. All the population growth of these counties, which surround the plant, were equal to or greater than the growth of the State of Alabama between these same years (10 percent). As a group, these four counties have been growing faster than the State of Alabama. Projections indicate that the growth rate in all four of these counties will exceed 10 percent between 2000 and 2015. The fastest growth, however, is limited to Limestone and Madison counties, which constitute the Huntsville metropolitan area (TVA 2003a).

- **Workforce**

The economy of Limestone County is more closely linked to BFN activities then are the economies of Lauderdale, Madison, and Morgan Counties, because TVA is one of the largest sources of employment for Limestone County residents and contributes a greater share to the county's revenue relative to the share contributed by other neighboring counties.

The largest single employer in Limestone County is Delphi Saginaw Steering Systems, which has approximately 2600 employees. The next largest employers include TVA and the County Board of Education, each of which employs approximately 1200 people throughout the year.

Other major employers in the county include Target Distribution (retail distribution), Federal Mogul Sealing Systems (production of automotive gaskets), Steelcase, Inc., (production of office furniture), and ConAgra Poultry (poultry processing) (Athens-Limestone Chamber of Commerce 2004).

The number of jobs in Limestone County has more than doubled since 1970, reaching a total of 32,068 jobs in 2001 (Table 2-10). The 2001 level is 17.9 percent higher than the 1990 level. During this same time period, the population grew by 23.6 percent, suggesting that Limestone County has become more of a bedroom community to Huntsville as its growth has continued to spread toward the west. With the exception of Colbert and Lawrence Counties, the employment market for the surrounding counties listed in Table 2-10 has been strong during the past three decades relative to State and U.S. growth rates. Based on TVA forecasts of employment for the TVA Power Service Area, employment in Limestone County is expected to be around 41,000 in 2015 and about 53,000 in 2035, which is a 1.5 percent growth per year for the next 30 years (TVA 2003a). Limestone County is more dependent on manufacturing, government, and farm employment than other neighboring counties, as is presented in Table 2-11. The region around BFN has an industrial distribution similar to that of the state as a whole, although it is slightly more dependent on manufacturing. The state, as well as the region surrounding BFN, is more dependent on manufacturing and less on trade and service employment than is the nation as a whole.

Table 2-10. Number of Jobs by County in the Vicinity of Browns Ferry Nuclear Power Plant, Units 1, 2, and 3

County	1970	1980	1990	2001	Average % Change 1970-2001	% Change, 1990-2001
Colbert	25,045	29,775	28,594	28,292	0.4%	(-1.1%)
Lauderdale	20,518	29,126	36,579	43,171	3.6%	18.0%
Lawrence	7,289	8,905	11,445	11,766	2.0%	2.8
Limestone	14,056	18,300	27,188	32,068	4.1%	17.9%
Madison	93,110	108,507	165,710	194,841	3.5%	17.6%
Morgan	34,144	42,699	54,151	64,473	2.9%	19.1%
Alabama (x 1000)	1,413	1,736	2,062	2,410	2.3%	16.9%
United States (x 1000)	91,282	114,231	139,427	167,536	2.7%	20.2%

Source: TVA 2003a

Table 2-11. Major Employment Sectors in Counties Surrounding Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 and in Alabama – 2001

Employment Sector	Colbert	Lauderdale	Lawrence	Limestone	Madison	Morgan	Alabama
Trade and Services	12,391	21,197	4,165	13,180	103,266	28,626	1,151,833
Manufacturing	4,272	6,087	1,883	6,381	27,278	13,797	334,947
Agriculture	849	2,159	1,953	2,149	3,117	1,612	84,339
Government	5,885	7,382	1,753	5,836	37,604	7,930	383,141
Other	4,895	6,346	2,012	4,522	23,576	12,508	455,433
Total Jobs	**28,292**	**43,171**	**11,766**	**32,068**	**194,841**	**64,473**	**2,409,693**
Unemployment (Rate)	2,082 (8.2%)	3,260 (8.0%)	1,115 (6.6%)	1,299 (4.1%)	4,880 (3.4%)	3,083 (5.4%)	112,004 (5.3%)

Source: TVA 2003a; U.S. Bureau of Labor Statistics (BLS 2004)

- **Transient Populations**

There appears to be very little seasonal fluctuation in local populations around BFN caused by transient populations moving through the area. Because migratory workers travel and can spend a significant amount of time in an area without being actual residents, they may be unavailable for census takers to count. If this occurs, these workers would be "under-represented" in U.S. Census Bureau (USCB) population counts. Although migrant workers are commonly found in rural agriculturally productive areas and a significant portion of Limestone County is made up of agricultural land, the farming in this area is less labor-intensive than other regions because of the types of crops that are raised (primarily cotton and soy beans) and the lack of irrigation requirements. There appear to be no significant concentrations of migrant workers in areas surrounding BFN (TVA 2003a).[a]

- **Taxes**

Property taxes are used to fund schools, police and fire protection, road maintenance, and other municipal services. Property taxes may be levied by counties, cities, towns, villages, school districts, and special districts. BFN is located in Limestone County, which generates most of its tax revenues through *ad valorem* taxes, which are taxes levied on the value of real

(a) Personal Communication (discussion) with M. Jordan and A. Stover, Community Development Department, Decatur, Alabama (March 31, 2004).

estate. The commercial and industrial sectors generate relatively more of the tax revenues in Limestone County than the residential sector.[a]

Although TVA is a nonprofit entity, which is not subject to conventional state and local taxation, it makes payments in lieu of taxes to states in which its power operations are carried on and in which it has acquired properties previously subject to State and local taxation in accordance with federal law, Section 13 of the TVA Act, 16 U.S.C. §831l. Under Section 13, TVA pays 5 percent of its gross power revenues to such states and counties (TVA 2004h).

TVA makes tax-equivalent payments to eight states, including Alabama. The State of Alabama then allocates its tax-equivalent payments from TVA in accordance with Title 40 "Revenue and Taxation," Chapter 28 "Distribution of Payments Made In Lieu of Taxes," Sections 40-28-1 through 40-28-4. Alabama distributes 75 percent of the TVA tax-equivalent payments to the 16 TVA-served counties based on a formula from TVA's book value of power property and sales in each of these counties. These counties then share a portion of their payment with cities, the school systems, hospitals, etc., within their boundaries. The remainder of the tax-equivalent payments are either retained for the State's general fund or are distributed to counties not served by TVA. During FY 2003, the State of Alabama allocated $15 million to the general fund, $58 million to TVA-served counties, and nearly $4 million to counties not served by TVA (TVA 2004h).

TVA tax-equivalent payments that are distributed to Limestone County, the City of Athens, and school districts within Limestone County are included in Table 2-12. Because of the series of tax payment formulas and distribution policies, the total amount of the TVA tax-equivalent payment listed in the third column of Table 2-12 is not solely attributable to the existence and operation of BFN. The TVA allocation paid to Limestone County is however largely attributed to TVA's fixed assets. An estimated portion of the tax-equivalent payment to the local jurisdictions that could reasonably be attributed to the existence and operation of BFN in Limestone County is provided in Table 2-12, Column 5.

In fiscal year 2003, Limestone County received just over $4.5 million from the State as redistribution of TVA's tax-equivalent payment. Approximately $2 million of this payment to Limestone County could be attributed to the presence of BFN in the county. Tax-equivalent payments for BFN that were retained by Limestone County average about 8 percent of the total

(a) Personal Communication (discussion) with M. Cole, D. Seibert, T. Hill, P. Ball, E. Ezzell, Limestone County Commission (March 31, 2004).

Table 2-12. Limestone County Distribution of Tax-Equivalent Payments Made by Tennessee Valley Authority in Fiscal Year 2003

Fund	Total Fund Revenue ($)	Tax Equivalent Payment by TVA ($)	% of Total Revenues	Estimated TVA Payment Attributable to BFN[a] ($)	% of Total Revenue
Limestone County General Fund	6,372,000	1,110,276	17%	488,521	8%
Limestone Hospital Fund	1,471,000	221,955	15%	97,660	7%
Limestone Public Buildings, Roads and Bridges	1,850,000	443,536	24%	195,156	11%
City of Athens (less utilities)	17,073,000	884,817	5%	389,320	2%
Athens City School District	23,946,000	545,406	2%	239,979	1%
Limestone County School District	49,547,000	1,157,867	2%	509,462	1%
Other (e.g., libraries and other towns)	NA	166,361	NA	73,199	NA

(a) It is estimated that 44 percent of the TVA tax-equivalent payment is attributable to BFN; thus, all distributions were adjusted proportionately to estimate the BFN portion.
NA = Not Available
Source: LCC 2004; NCES 2004; and TVA 2004h, i.

revenue taken in by the county (excluding funding that passes directly through to school districts, towns, and cities). The distribution of these payments to various county funds (e.g., general fund, building fund, hospital), school districts, and local municipalities is included in Table 2-12. BFN accounted for a smaller proportion of the City of Athens' total revenue (only 2.0 percent) and even less for the local school districts (one percent) during this same period. Although Morgan County also relies on the significant tax-equivalent payments from TVA (approximately $10 million, $2 million of which is retained by the county) (MCC 2004), the amount directly attributable to BFN operations and asset value is far less than the share contributed to Limestone County revenues (TVA 2004h).

2.2.9 Historic and Archaeological Resources

The area around BFN is rich in prehistoric and historic resources. Recent literature provided adequate background information for the area. Consequently, only a brief summary is provided here. Prehistoric and historic period overviews for Alabama are provided by U.S. National Park Service (NPS 2004), Hudson (1999), and Walthall (1980).

2.2.9.1 Prehistoric Period

Archaeological research has indicated that prehistoric Native American occupation of the region around BFN occurred from the Paleo-Indian period (about 10,000 to 8000 B.C.) to the Mississippian period (about A.D. 900 to 1500). Archaeological periods are based on changing settlement and land-use patterns and artifact styles. In Alabama, prehistoric chronology is divided into five broad time periods: Paleo-Indian, Archaic, Gulf Formational, Woodland, and Mississippian.

The prehistoric periods were marked by initial reliance on big game hunting for subsistence, followed by increased use of smaller game animals and plant foods in the Archaic period, more sedentary villages, and an increased reliance on cultivated crops. Through the Mississippian period, the Native American population occupied larger base camps in the river valleys, with subsistence based on agriculture, hunting and gathering, and intergroup trade. The late prehistoric period is primarily identified by the introduction of European trade goods.

2.2.9.2 Native American Historic Period

Prior to the early 18th Century, most of Alabama was home to Native Americans belonging to a southeastern alliance known as the Creek Confederacy. Today's Creek Nation, also known as the Muskogee, were the major tribe in that alliance. The Confederacy consisted of separate and independent tribes that gradually became, over a long period of time, a single political organization. Throughout most of its history, however, the Confederacy was a dynamic institution, constantly changing in size as tribes, for whatever reason, entered or left the alliance.

At the time of historic European contact, the ancestors of the modern Creek Indians lived in a number of small distinct Mississippian-related societies in Alabama and Georgia. The dominant group, sharing a common language or dialects, was the Muskogee. The Muskogee consisted of 12 bands including the Kasihta, Coweta, Coossa, Abihka, Wakokai, Eufaula, Hilibi, Atasi, Kolomi, Tukabahchee, Pakana, and Okchai. The bands situated to the north along the Coosa, Tallapoosa, and Alabama Rivers became known as the Upper Creek, while those along the Chattahoochee and Flint Rivers collectively became known as the Lower Creek.

In the early 1800s, a population of Creek Indians and other groups (such as the Yamassee) were still present in Alabama. However, in 1830 the U.S. Congress passed the Indian Removal Act. Within a couple of years from this date, virtually the entire expanse of Alabama was devoid of Indian settlements.

2.2.9.3 Euro-American Historic Period

The Alabama territory was first explored by the Spanish in 1540. Their immediate objective was to create settlements along the Gulf of Mexico. Entering Pensacola Bay, they failed to establish a permanent settlement, but explored parts of Alabama. The first settlement was built in 1720 in the Mobile area by the French under the command of Baptiste le Moyne Bienville, who was a colonizer and the governor of Louisiana for France. The Alabama territory was later ceded to Great Britain in 1763 after the French and Indian Wars.

After the American Revolution in 1783, the Alabama territory came under the possession of the United States. The defeat of the Creek Indians by Andrew Jackson in 1814 spurred settlement and Alabama became a territory in 1817. Alabama was admitted to the Union in 1819. Late in 1819, the Missouri Territory embraced all of the Louisiana Purchase and the question was raised as to the legal status of slavery in Missouri and the rest of the territory west of the Mississippi. This debate led to the beginning of the Civil War. Alabama was one of several southern states that seceded from the Union on January 11, 1861. The Confederate government was organized at Montgomery on February 4, 1861. After the Civil War in 1868, Alabama was readmitted to the Union. Both World Wars stimulated industrialization and crop diversification in the State of Alabama.

TVA began major construction on BFN in 1967. Unit 1 began commercial operation in August 1974, Unit 2 in 1975, and Unit 3 in 1977. BFN was TVA's first nuclear power plant.

2.2.9.4 Historic and Archaeological Resources at BFN

Much of the BFN site has been disturbed by construction of the nuclear power plant facilities and related infrastructure, including roads, parking lots, and the cooling towers. Some previous disturbance has also occurred along the transmission line rights-of-way. However, there are a few small areas on the site that remain undeveloped. Intact archaeological sites may be present within these undeveloped areas.

The final environmental impact statement for the construction of BFN (TVA 1972) listed one site on the National Register of Historic Places, which is the TVA Wilson Dam located 31 km (19 mi) downstream from BFN. Prior to construction, TVA relocated the Cox Cemetery, an action which involved moving more than 50 graves. Complete records of the grave relocation activities were filed with the Alabama Historical Commission.

TVA has an extensive cultural resource program that works to protect historic resources, as required by Federal law. Staff is responsible for the identification, evaluation, and protection of cultural resources on TVA lands and land affected by TVA actions (TVA 2004j). The majority of

undisturbed land at BFN was surveyed in 2001 as part of the review for license renewal. The survey identified two historic properties. The first property identified was a prehistoric archaeological site (1Li535) with an Early-to-Middle Woodland period occupation. The site is considered potentially eligible for listing in the National Register of Historic Places (TVA 2002a). The second historic property identified was the Cox Cemetery. This cemetery was relocated during the initial construction of BFN. No historic structures were identified during the historic structures survey.

Cultural resources location information is protected by the Archaeological Resources Protection Act of 1979 and by 36 CFR Part 800. Therefore, no maps, photos, or figures of historic properties are provided in this SEIS.

2.2.10 Related Federal Project Activities and Consultations

The staff reviewed the possibility that activities of other Federal agencies might impact the renewal of the OLs for BFN. Any such activities could result in cumulative environmental impacts and the possible need for a Federal agency to become a cooperating agency for preparation of this SEIS (10 CFR 51.10(b)(2)).

TVA, a Federal corporation wholly owned by the U.S. Government, is a Federal agency subject to the requirements of the National Environmental Policy Act of 1969 (NEPA). In compliance with NEPA, TVA prepared an SEIS to provide the public and TVA decisionmakers with an assessment of the environmental impacts of extending the operating life of the BFN nuclear units (TVA 2002a). This NRC SEIS draws upon the content of the TVA SEIS, but was prepared by NRC staff independently.

BFN is located on the north bank of Wheeler Reservoir on the Tennessee River. The reservoir is created by Wheeler Dam, which is approximately 32 km (20 mi) downriver from the plant. Wheeler Dam was constructed and is operated by TVA for flood control, power generation, and navigation.

The Mallard Creek Recreation Area is located directly across the Tennessee River from BFN. This is a TVA developed and operated area. It includes developed areas for camping, picnicking, swimming, and boat launching. Approximately 5.6 km (3.5 mi) upstream of the plant is Round Island Recreation Area, also developed and operated by TVA. It also features facilities for camping, swimming, picnicking, and boat launching. The reservoir in the vicinity of the plant site is moderately used by recreational boaters and fishermen. Wheeler National Wildlife Refuge, operated by FWS, is located upstream from BFN. It is one of the southern-most wintering areas for ducks and geese in the southeastern United States.

After reviewing the Federal activities in the vicinity of the BFN site, the staff determined that there were no Federal project activities that would make it desirable for another Federal agency to become a cooperating agency for preparation of the SEIS.

NRC is required under Section 102(C) of NEPA to consult with and obtain the comments of any Federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved in the subject matter of the SEIS. During the course of preparing this SEIS, NRC consulted with TVA, FWS, and the National Marine Fisheries Service (NOAA Fisheries). Consultation correspondence with these agencies is included in Appendix E.

2.3 References

10 CFR Part 20. Code of Federal Regulations, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 61. Code of Federal Regulations, Title 10, *Energy*, Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste."

10 CFR Part 71. Code of Federal Regulations, Title 10, *Energy*, Part 71, "Packaging and Transportation of Radioactive Material."

36 CFR Part 800. Code of Federal Regulations, Title 36, *Parks, Forest, and Public Property*, Part 800, "Protection of Historic Properties."

40 CFR Part 81. Code of Federal Regulations, Title 40, *Protection of the Environment*, Part 81, "Designations of Areas for Air Quality Planning Purposes."

40 CFR Part 190. Code of Federal Regulations, Title 40, *Protection of the Environment*, Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

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3.0 Environmental Impacts of Refurbishment

Environmental issues associated with refurbishment activities are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999).[a] The GEIS includes a determination of whether the analysis of the environmental issues could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required in this supplemental environmental impact statement unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1 and therefore, additional plant-specific review of these issues is required.

License renewal actions may require refurbishment activities for the extended plant life. These actions may have an impact on the environment that requires evaluation, depending on the type of action and the plant-specific design. Environmental issues associated with refurbishment that were determined to be Category 1 issues are listed in Table 3-1.

Environmental issues related to refurbishment considered in the GEIS for which these conclusions could not be reached for all plants or for specific classes of plants are Category 2 issues. These are listed in Table 3-2.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

Table 3-1. Category 1 Issues for Refurbishment Evaluation

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
SURFACE-WATER QUALITY, HYDROLOGY, AND USE (FOR ALL PLANTS)	
Impacts of refurbishment on surface-water quality	3.4.1
Impacts of refurbishment on surface-water use	3.4.1
AQUATIC ECOLOGY (FOR ALL PLANTS)	
Refurbishment	3.5
GROUNDWATER USE AND QUALITY	
Impacts of refurbishment on groundwater use and quality	3.4.2
LAND USE	
Onsite land use	3.2
HUMAN HEALTH	
Radiation exposures to the public during refurbishment	3.8.1
Occupational radiation exposures during refurbishment	3.8.2
SOCIOECONOMICS	
Public services: public safety, social services, and tourism and recreation	3.7.4; 3.7.4.3; 3.7.4.4; 3.7.4.6
Aesthetic impacts (refurbishment)	3.7.8

The potential environmental effects of refurbishment actions would be identified, and the analysis would be summarized within this section, if such actions were planned. The Tennessee Valley Authority (TVA) indicated that it has performed an evaluation of structures and components pursuant to Title 10 of the Code of Federal Regulations (CFR) 54.21 to identify activities that are necessary to continue operation of Browns Ferry Nuclear Plant, Units 1, 2, and 3 during the requested 20-year period of extended operation. These activities include replacement of certain components as well as new inspection activities and are described in the Environmental Report (TVA 2003).

However, TVA stated that the replacement of these components and the additional inspection activities are within the bounds of normal plant component replacement and inspections (TVA 2003). Therefore, they are not expected to affect the environment outside the bounds of plant operations as evaluated in TVA's final environmental statement (TVA 1972). In addition, TVA's evaluation of structures and components as required by 10 CFR 54.21 did not identify any major plant refurbishment activities or modifications necessary to support the continued

Table 3-2. Category 2 Issues for Refurbishment Evaluation

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53 (c)(3)(ii) Subparagraph
TERRESTRIAL RESOURCES		
Refurbishment impacts	3.6	E
THREATENED OR ENDANGERED SPECIES (FOR ALL PLANTS)		
Threatened or endangered species	3.9	E
AIR QUALITY		
Air quality during refurbishment (nonattainment and maintenance areas)	3.3	F
SOCIOECONOMICS		
Housing impacts	3.7.2	I
Public services: public utilities	3.7.4.5	I
Public services: education (refurbishment)	3.7.4.1	I
Offsite land use (refurbishment)	3.7.5	I
Public services, transportation	3.7.4.2	J
Historic and archaeological resources	3.7.7	K
ENVIRONMENTAL JUSTICE		
Environmental justice	Not addressed[a]	Not addressed[a]

(a) Guidance related to environmental justice was not in place at the time the GEIS and the associated revision to 10 CFR Part 51 were prepared. If an applicant plans to undertake refurbishment activities for license renewal, environmental justice must be addressed in the applicant's Environmental Report and the staff's environmental impact statement.

operation of Browns Ferry Nuclear Plant, Units 1, 2, and 3 beyond the end of the existing operating licenses. Therefore, refurbishment is not considered in this supplemental environmental impact statement.

TVA is in the process of restarting Browns Ferry Nuclear Plant, Unit 1, and used the term "refurbishment" within the Environmental Report (TVA 2003) when discussing some of the impacts of restart. The staff determined that all of the activities associated with the restart of Unit 1 can be, and are being, conducted within the scope of the existing operating license as

reviewed previously (TVA 1972, 2002). Therefore, these activities are not considered refurbishment for the purposes of license renewal and are not being evaluated within the scope of the license renewal application.

3.1 References

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 54. Code of Federal Regulations, Title 10, *Energy*, Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

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4.0 Environmental Impacts of Operation

Environmental issues associated with operation of a nuclear power plant during the license renewal term are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996, 1999).[a] The GEIS includes a determination of whether the analysis of the environmental issues could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristics.

(2) A single significance level (i.e., SMALL, MODERATE, OR LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and therefore, additional plant-specific review of these issues is required.

This chapter addresses the issues related to operation during the license renewal term that are listed in Table B-1 of Title 10 of the Code of Federal Regulations (CFR) Part 51, Subpart A, Appendix B, and are applicable to the Browns Ferry Nuclear Plant, Units 1, 2, and 3 (BFN). Section 4.1 addresses issues applicable to the BFN cooling system. Section 4.2 addresses issues related to transmission lines and onsite land use. Section 4.3 addresses the radiological impacts of normal operation, and Section 4.4 addresses issues related to the socioeconomic impacts of normal operation during the license renewal term. Section 4.5 addresses issues related to groundwater use and quality, while Section 4.6 discusses the impacts of license renewal-term operations on threatened and endangered species. Section 4.7 addresses potential new information that was raised during the scoping period, and Section 4.8 discusses

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

cumulative impacts. The results of the evaluation of environmental issues related to operation during the license renewal term are summarized in Section 4.9. Finally, Section 4.10 lists the references for Chapter 4. Category 1 and Category 2 issues that are not applicable because they are related to plant design features or site characteristics not found at BFN are listed in Appendix F.

4.1 Cooling System

Resumption of three-unit operation after restart of Unit 1 will require upgrading the cooling tower system by constructing a 20-cell cooling tower on the foundation of the original cooling tower number four, and increasing the water intake flow rates by approximately 11 percent above those of past three-unit operation (TVA 2003b). The facility would be operated to ensure that the maximum discharge water temperature and the temperature increase between the intake and discharge points remain within approved regulatory limits. Use of cooling towers would increase and, on rare occasions when the cooling towers are unable to meet thermal limits, the facility would be derated to remain in compliance. Although significant impacts are not anticipated, Tennessee Valley Authority (TVA) will also confirm expected levels of impingement and entrainment resulting from increased intake water flow rates by monitoring during current two-unit operation and following resumption of three-unit operations (TVA 2003b).

Category 1 issues in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, that are applicable to cooling system operation for BFN during the license renewal term, are listed in Table 4-1 (NRC 1996). TVA stated in its Environmental Report (ER) that no new information existed for the issues that would invalidate the GEIS conclusions (TVA 2003b). Additionally, the staff has not identified any new and significant information during its independent review of the ER (TVA 2003b), the staff's site visit, the scoping process, or its evaluation of other available information, such as operation at a combined total power level of 11,856 megawatts-thermal (MW[t]). Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of the issues, the staff concluded in the GEIS that the impacts are SMALL, and additional plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

Table 4-1. Category 1 Issues Applicable to the Operation of the Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Cooling System During the License Renewal Term

ISSUE 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
SURFACE WATER QUALITY, HYDROLOGY, AND USE (FOR ALL PLANTS)	
Altered current patterns at intake and discharge structures	4.2.1.2.1; 4.3.2.2; 4.4.2
Altered thermal stratification of lakes	4.2.1.2.3; 4.4.4.2
Temperature effects on sediment transport capacity	4.2.1.2.3; 4.4.2.2
Scouring caused by discharged cooling water	4.2.1.2.3; 4.4.2.2
Eutrophication	4.2.1.2.3; 4.4.2.2
Discharge of chlorine or other biocides	4.2.1.2.4; 4.4.2.2
Discharge of sanitary wastes and minor chemical spills	4.2.1.2.4; 4.4.2.2
Discharge of other metals in wastewater	4.2.1.2.4; 4.3.2.2; 4.4.2.2
Water use conflicts (plants with once-through cooling systems)	4.2.1.3
AQUATIC ECOLOGY (FOR ALL PLANTS)	
Accumulation of contaminants in sediments or biota	4.2.1.2.4; 4.3.3; 4.4.3; 4.4.2.2
Entrainment of phytoplankton and zooplankton	4.2.2.1.1; 4.3.3; 4.4.3
Cold shock	4.2.2.1.5; 4.3.3; 4.4.3
Thermal plume barrier to migrating fish	4.2.2.1.6; 4.4.3
Distribution of aquatic organisms	4.2.2.1.6; 4.4.3
Premature emergence of aquatic insects	4.2.2.1.7; 4.4.3
Gas supersaturation (gas bubble disease)	4.2.2.1.8; 4.4.3
Low dissolved oxygen in the discharge	4.2.2.1.9; 4.3.3; 4.4.3
Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses	4.2.2.1.10; 4.4.3
Stimulation of nuisance organisms	4.2.2.1.11; 4.4.3

Table 4-1. (contd)

ISSUE 10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections
Terrestrial Resources	
Cooling tower impacts on crops and ornamental vegetation	4.3.4
Cooling tower impacts on native plants	4.3.5.1
Bird collisions with cooling towers	4.3.5.2
Human Health	
Microbiological organisms (occupational health)	4.3.6
Noise	4.3.7

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, for each of these issues follows:

- Altered current patterns at intake and discharge structures. Based on information in the GEIS, the Commission found that

  > Altered current patterns have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of altered current patterns during the license renewal term beyond those discussed in the GEIS.

- Altered thermal stratification of lakes. Based on information in the GEIS, the Commission found that

  > These effects have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of altered thermal stratification of lakes beyond those discussed in the GEIS.

- Temperature effects on sediment transport capacity. Based on information in the GEIS, the Commission found that

  > These effects have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of temperature on sediment transport capacity during the license renewal term beyond those discussed in the GEIS.

- Scouring caused by discharged cooling water. Based on information in the GEIS, the Commission found that

  > Scouring has not been found to be a problem at most operating nuclear power plants and has caused only localized effects at a few plants. It is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of scouring during the license renewal term beyond those discussed in the GEIS.

- Eutrophication. Based on information in the GEIS, the Commission found that

  > Eutrophication has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of eutrophication during the license renewal term beyond those discussed in the GEIS.

- Discharge of chlorine or other biocides. Based on information in the GEIS, the Commission found that

  > Effects are not a concern among regulatory and resource agencies and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, its evaluation of other available information, such as the National Pollutant Discharge Elimination System (NPDES) permit for BFN, Discharge Monitoring Reports (DMRs), discussion with the NPDES compliance office, and operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of discharge of chlorine or other biocides during the license renewal term beyond those discussed in the GEIS.

- Discharge of sanitary wastes and minor chemical spills. Based on information in the GEIS, the Commission found that

  > Effects are readily controlled through NPDES permit and periodic modifications, and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as the NPDES permit for BFN, DMRs, discussion with the NPDES compliance office, and operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of discharges of sanitary wastes and minor chemical spills during the license renewal term beyond those discussed in the GEIS.

- Discharge of other metals in wastewater. Based on information in the GEIS, the Commission found that

  > These discharges have not been found to be a problem at operating nuclear power plants with cooling-tower-based heat dissipation systems and have been satisfactorily mitigated at other plants. They are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as the NPDES permit for BFN, DMRs, discussion with the NPDES compliance office, and operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of discharges of other metals in waste water during the license renewal term beyond those discussed in the GEIS.

- Water-use conflicts (plants with once-through cooling systems). Based on information in the GEIS, the Commission found that

  > These conflicts have not been found to be a problem at operating nuclear power plants with once-through heat dissipation systems.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no water-use conflicts during the license renewal term beyond those discussed in the GEIS.

- Accumulation of contaminants in sediments or biota. Based on information in the GEIS, the Commission found that

  > Accumulation of contaminants has been a concern at a few nuclear power plants but has been satisfactorily mitigated by replacing copper alloy condenser tubes with those of another metal. It is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of accumulation of contaminants in sediments or biota during the license renewal term beyond those discussed in the GEIS.

- Entrainment of phytoplankton and zooplankton. Based on information in the GEIS, the Commission found that

  > Entrainment of phytoplankton and zooplankton has not been found to be a problem at operating nuclear power plants and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, review of monitoring programs, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of entrainment of phytoplankton and zooplankton during the license renewal term beyond those discussed in the GEIS.

- Cold shock. Based on information in the GEIS, the Commission found that

  > Cold shock has been satisfactorily mitigated at operating nuclear plants with once-through cooling systems, has not endangered fish populations or been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds, and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of cold shock during the license renewal term beyond those discussed in the GEIS.

- Thermal plume barrier to migrating fish. Based on information in the GEIS, the Commission found that

  > Thermal plumes have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of thermal plumes to migrating fish during the license renewal term beyond those discussed in the GEIS.

- Distribution of aquatic organisms. Based on information in the GEIS, the Commission found that

  > Thermal discharge may have localized effects but is not expected to effect the larger geographical distribution of aquatic organisms.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, its review of monitoring programs, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts on the distribution of aquatic organisms during the license renewal term beyond those discussed in the GEIS.

- Premature emergence of aquatic insects. Based on information in the GEIS, the Commission found that

  > Premature emergence has been found to be a localized effect at some operating nuclear power plants but has not been a problem and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of premature emergence during the license renewal term beyond those discussed in the GEIS.

- Gas supersaturation (gas bubble disease). Based on information in the GEIS, the Commission found that

  > Gas supersaturation was a concern at a small number of operating nuclear power plants with once-through cooling systems but has been satisfactorily mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of gas supersaturation during the license renewal term beyond those discussed in the GEIS.

- Low dissolved oxygen in the discharge. Based on information in the GEIS, the Commission found that

  > Low dissolved oxygen has been a concern at one nuclear power plant with a once-through cooling system but has been effectively mitigated. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, its review of monitoring programs, or its evaluation of other available information, such as operation at a combined total power level of

11,856 MW(t). Therefore, the staff concludes that there are no impacts of low dissolved oxygen during the license renewal term beyond those discussed in the GEIS.

- Losses from predation, parasitism, and disease among organisms exposed to sublethal stresses. Based on information in the GEIS, the Commission found that

  > These types of losses have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of losses from predation, parasitism, and disease among organisms exposed to sublethal stresses during the license renewal term beyond those discussed in the GEIS.

- Stimulation of nuisance organisms. Based on information in the GEIS, the Commission found that

  > Stimulation of nuisance organisms has been satisfactorily mitigated at the single nuclear power plant with a once-through cooling system where previously it was a problem. It has not been found to be a problem at operating nuclear power plants with cooling towers or cooling ponds and is not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of stimulation of nuisance organisms during the license renewal term beyond those discussed in the GEIS.

- Cooling tower impacts on crops and ornamental vegetation. Based on information in the GEIS, the Commission found that

  > Impacts from salt drift, icing, fogging, or increased humidity associated with cooling tower operation have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available

information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no cooling tower impacts on crops and ornamental vegetation during the license renewal term beyond those discussed in the GEIS.

- Cooling tower impacts on native plants. Based on information in the GEIS, the Commission found that

  > Impacts from salt drift, icing, fogging, or increased humidity associated with cooling tower operation have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no cooling tower impacts on native plants during the license renewal term beyond those discussed in the GEIS.

- Bird collisions with cooling towers. Based on information in the GEIS, the Commission found that

  > These collisions have not been found to be a problem at operating nuclear power plants and are not expected to be a problem during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of bird collisions with cooling towers during the license renewal term beyond those discussed in the GEIS.

- Microbiological organisms (occupational health). Based on information in the GEIS, the Commission found that

  > Occupational health impacts are expected to be controlled by continued application of accepted industrial hygiene practices to minimize worker exposures.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the

staff concludes that there are no impacts of microbiological organisms on occupational health during the license renewal term beyond those discussed in the GEIS.

- Noise. Based on information in the GEIS, the Commission found that

> Noise has not been found to be a problem at operating plants and is not expected to be a problem at any plant during the license renewal term.

The staff has not identified any new and significant information during its independent review of the TVA ER, the scoping process, the staff's site visit, or its evaluation of other available information, such as operation at a combined total power level of 11,856 MW(t). Therefore, the staff concludes that there are no impacts of noise during the license renewal term beyond those discussed in the GEIS.

The Category 2 issues related to cooling system operation during the license renewal term that are applicable to BFN Units 1, 2, and 3 are listed in Table 4-2 and discussed in Sections 4.1.1, through 4.1.5.

Table 4-2. Category 2 Issues Applicable to the Operation of the Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 Cooling System During the License Renewal Term

ISSUE 10 CFR Part 51, Subpart A, Appendix B, Table B	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
WATER USE			
Water use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river with low flow)	4.3.2.1; 4.4.2.1	B	4.1.1
AQUATIC ECOLOGY (FOR PLANTS WITH ONCE-THROUGH AND COOLING POND HEAT-DISSIPATION SYSTEMS)			
Entrainment of fish and shellfish in early life stages	4.2.2.1.2; 4.4.3	B	4.1.2
Impingement of fish and shellfish	4.2.2.1.3; 4.3.3; 4.4.3	B	4.1.3
Heat shock	4.2.2.1.4; 4.4.3	B	4.1.4
HUMAN HEALTH			
Microbiological organisms (public health)(plants using lakes or canals, or cooling towers or cooling ponds that discharge into a small river)	4.3.6	G	4.1.5

4.1.1 Water-Use Conflicts (Makeup Water from a Small River)

The Tennessee River average annual flow at BFN for 1976 through 2002 was 4.16×10^{10} m^3/yr (1.47×10^{12} ft^3/yr). This annual flow is less than the 9×10^{10} m^3/yr (3.15×10^{12} ft^3/yr) criterion stated by the U.S. Nuclear Regulatory Commission (NRC) in 10 CFR 51.53(c)(3)(ii)(A) as the value below which "an assessment of the impact of the proposed action on the flow of the river and related impacts on instream and riparian ecological communities must be provided" (NRC 1996).

NRC made water use and water availability issues a Category 2 issue because two factors may cause them to become important for some nuclear power plants that use cooling towers (NRC 1996). First, the relatively small rates of cooling water withdrawal and discharge allows some power plants with cooling towers to be located on small bodies of water that are susceptible to droughts or competing water uses. Second, closed-cycle cooling systems evaporate cooling water, and this consumptive water loss may represent a substantial proportion of the flow in small rivers. Loss of a substantial portion of flow from a small stream as a result of evaporative losses from a cooling tower will reduce the amount of habitat for fish and aquatic invertebrates. Off-stream water uses, such as power plant consumption, must be regulated to ensure that important in-stream uses, such as habitat for aquatic organisms, boating, sport fishing, and waste assimilation, are not compromised.

BFN normally operates in open mode using once-through cooling. Modeling predicts that, on average, BFN will operate in the open mode 93 percent of the time (TVA 2003b). Cooling towers are not used during open mode operations and consumptive water use is reduced.

For three units operating at a combined total power level of 11,856 MW(t), modeling shows the cooling towers would only be used on average 7 percent of the time in what is called "helper mode" (TVA 2003b). During these times, the total BFN intake water flow for three-unit operation of 12 million m^3/d (3171 MGD) or 139 m^3/s (4907 cfs) can be a significant fraction of the river flow past the plant (the lowest average flow for severe consecutive days with a 10-year recurrence [7Q10] of 250 m^3/s [8700 cfs] in the NPDES permit rationale). However, even when operating in helper mode, consumptive water use is negligible and is expected to remain so throughout the license renewal term.

As discussed more fully in Section 2.2.2, cooling tower consumptive water loss from evaporation and drift is not expected to exceed 2.3 m^3/s (82 cfs) (Hopping 2004), which is less than one percent of the 7Q10, even under worst-case conditions (three-unit operation at 120 original licensed thermal power [OLTP] with unfavorable meteorology). For a two-unit operation cooling tower use is even less frequent with modeling predicting tower use, on average, only 5 percent of the time (TVA 2003b).

Consumptive and off-stream water use has not resulted in significant use conflicts because of the large volume of reservoir water available, the high river flow rate, and the return of most of the water withdrawn (TVA 2003b). Regulatory control of withdrawal rates and NPDES permit limits for return water quality also mitigate potential conflicts. Potential trade-offs can occur with in-stream water uses (e.g., in-stream use conflicts among aquatic life, waste assimilation, navigation, power generation, flood control, and lake levels). These potential conflicts are addressed by historic operating procedures, legal requirements, and regulatory procedures.

The staff independently reviewed the TVA ER and visited the site. The staff determined that water-use conflicts would be SMALL, and further mitigation measures are not warranted.

4.1.2 Entrainment of Fish and Shellfish in Early Life Stages

For power plants with once-through cooling systems, entrainment of fish and shellfish in early life stages into cooling water systems is considered a Category 2 issue, requiring a site-specific assessment before license renewal. To perform this evaluation, the staff reviewed the TVA ER and other TVA environmentally related documents, visited the BFN site, and reviewed the applicant's State of Alabama NPDES Permit AL0022080, which was issued on December 29, 2000, became effective on February 1, 2001, and will remain in force until January 31, 2006 (ADEM 2000).

Section 316(b) of the Federal Water Pollution Control Act of 1972 (FWPCA) (also referred to as the Clean Water Act) requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts. Entrainment of fish and shellfish into the cooling water system is a potential adverse environmental impact that can be minimized by use of the best available technology.

On July 9, 2004, the U.S. Environmental Protection Agency (EPA) published a final rule in the *Federal Register* (69 FR 41575) (EPA 2004) addressing cooling water intake structures at existing power plants where flow levels exceed a minimum threshold value of 190,000 m^3/d (50 MGD). The rule is Phase II in EPA's development of 316(b) regulations that establish national requirements applicable to the location, design, construction, and capacity of cooling water intake structures at existing facilities that exceed the threshold value for water withdrawals. The national requirements, which are implemented through NPDES permits, minimize the adverse environmental impacts associated with the continued use of the intake systems. Licensees are required to demonstrate compliance with the Phase II performance standards at the time of renewal of their NPDES permit. Licensees may be required as part of the NPDES renewal to alter the intake structure, redesign the cooling system, modify station operation, or take other mitigative measures as a result of this regulation. The new

performance standards are designed to significantly reduce entrainment losses due to plant operation. Any required site-specific mitigation would result in less impact from entrainment during the license renewal term.

For all three units operating at a combined total power level of 11,856 MW(t), the total BFN intake water flow would be 139 m^3/s (2.2 million gpm), which can be a significant fraction of the river flow past the plant, especially during the lowest average flow for 7 consecutive days that can have a recurrence of 10 years (7Q10 low-flow value), of 246 m^3/s (3.9 million gpm) (Section 2.2.2). This intake flow represents an 11 percent increase over the original 100 percent power level of 124.9 m^3/s (1.98 million gpm) (Buchanan 1980).

The critical time of year for approaching the maximum river water temperature limits specified in the BFN NPDES Permit (ADEM 2000), and therefore requiring the use of cooling towers or plant derates, is July and August. The average flow in Wheeler Reservoir at BFN during these months is 965 m^3/s (15.3 million gpm) during July and August (TVA 2003b). During these same months the daily average flow exceeds the 7Q10 low-flow value 98.6 percent of the time in July and 98.8 percent of the time in August.

Characterization of the ichthyoplankton of Wheeler Reservoir was initiated prior to startup of BFN, and continued during the initial years of operations (1974 through 1979). From 80 to 98 percent of the larval fish populations were composed of clupeids (e.g., threadfin shad [*Dorosoma petenense*] and gizzard shad [*D. cepedianum*]). Fish larvae entrainment during the initial 6 years of operation ranged from 1.0 to 9.0 percent of the total number of larval fish in the reservoir passing by the plant (Table 4-3). During this same period, the mean hydraulic entrainment (portion of the river flow passing through the plant) varied from 3.0 to 13.3 percent (TVA 1978a; Buchanan 1980). During all years, percent entrainment of larval fish was less than hydraulic entrainment (Table 4-3). In addition to shad, other fish comprising greater than

Table 4-3. Calculated Entrainment of Fish Eggs and Larvae at Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 – 1974 to 1979

Year	Fish Egg Entrainment Percent (Number)	Larval Fish Entrainment Percent (Number)	Percent Mean Hydraulic Entrainment
1974	13.3 (459 million)	1.0 (125 million)	3.0
1975	1.3 (50 million)	3.3 (770 million)	4.4
1976	3.8 (143 million)	6.3 (1.3 billion)	8.4
1977	2.7 (149 million)	9.0 (3.7 billion)	12.0
1978	3.6 (50 million)	5.4 (2.92 billion)	13.3
1979	8.1 (188 million)	4.5 (1.34 billion)	9.0

Sources: Buchanan 1980; TVA 1978a.

1 percent of the total number of entrained larvae included suckers, minnows, freshwater drum (*Aplodinotus grunniens*), and white and yellow basses (*Morone chrysops* and *M. mississippiensis*) (TVA 1978a). The three fish families with the highest estimated entrainment (i.e., percent loss of larvae passing BFN) during three-unit operation at BFN in 1977 were Clupeidae (12.1 percent), Catostomidae (4.5 percent), and Sciaenidae (6.1 percent) (TVA 2002).

Taxa that exhibited increases in larval entrainment percentage over the period of study (1974 through 1977, which coincided with an increase from one- to three-unit operation) included those known to be widely distributed in the water column and essentially planktonic (e.g., Clupeidae, Moronidae, Cyprinidae, and Percidae). Those not exhibiting this trend included fishes that have nest-inhabiting or parental-care characteristics in early life (e.g., Ictaluridae and Centrarchidae) and are thus unlikely to be as planktonic or uniformly distributed in the water column (TVA 1978a). Fish entrainment was generally lower than hydraulic entrainment (the amount of river flow that passes through the plant) because fish larvae are not truly planktonic except at very early stages (TVA 1978a).

Fish egg entrainment during the initial 6 years of operation ranged from 1.3 to 13.3 percent of the total number of eggs in the reservoir passing by the plant. During 1974, the percent egg entrainment was much higher than hydraulic entrainment. During 1979, the percent egg entrainment was similar to hydraulic entrainment, and from 1975 through 1978, percent egg entrainment was much lower than hydraulic entrainment (Table 4-3). The only two commonly occurring species in Wheeler Reservoir that have buoyant or semibuoyant eggs are freshwater drum and mooneye (*Hiodon tergisus*), although the skipjack herring (*Alosa chrysochloris*) may also have buoyant eggs (TVA 1972). It was speculated that conditions were favorable in 1974 for spawning freshwater drum to be attracted to or near the plant intake resulting in the release of large numbers of eggs into the cooling water source (TVA 1978a). A similar speculation accounts for the large percentage of catfish larvae that were entrained in 1975 (TVA 1978a).

Under the original operating mode of 100 percent power, entrained organisms were subject to a 13.9°C (25°F) temperature rise (TVA 2003b). Under 120 percent power this increase in temperature could be as high as 15.9°C (28.7°F) (Hopping 2004). Total duration of cooling system passage is estimated at 7 to 11 minutes, with 5 to 9 minutes spent in heated waters (TVA 2003b). When discharge temperatures do not exceed 37.8°C (100°F), some entrainment survival would be expected (LaJeone and Monzingo 2000). Under a very conservative scenario, total mortality of all entrained ichthyoplankton occurs. Three-unit operation at 120 percent power would increase intake flow rates by approximately 11 percent (TVA 2003b). Therefore, the amount of entrainment would be expected to increase, but the percent increase would be expected to be lower than the hydraulic entrainment increase.

Flow studies conducted at BFN have indicated that most of the water hydraulically entrained by the plant comes from the right side of the main river channel. This pelagic area contains

significantly lower densities of drifting fish larvae than found in the overbank areas. Higher densities of fish eggs (mostly freshwater drum) are transported in the channel portion of the river, but entrainment of freshwater drum eggs and larvae have not resulted in noticeable decreases in abundance of this species, nor is it expected under return to three-unit operation at increased operational rates (TVA 2003b). There are no specific or unique spawning or nursery areas or migration routes for any fish species located upstream of BFN that would make eggs or larvae of these species unusually susceptible to entrainment (TVA 2003b). No obvious declines in these fish species have been noticed based on collection of adults in Wheeler Reservoir (TVA 2003b). Because ichthyoplankton in Wheeler Reservoir are produced upstream and downstream of BFN, it was concluded that entrainment would not add significantly to expected natural mortality of fish eggs and larvae in the reservoir (Buchanan 1980).

The staff reviewed the available information in the TVA ER (TVA 2003b) and in other BFN documents related to the FWPCA 316(b) permitting process. Based on the results of past entrainment studies and the operating history of the BFN intake structure, the staff concludes that the potential impacts of entrainment of fish and shellfish in the early life stages into the cooling water intake system are SMALL, and it is not likely that further mitigation will be warranted. Nevertheless, TVA will evaluate levels of entrainment by monitoring under current two-unit operation and following the return of three-unit operation. Analysis of current and future entrainment data collected at BFN will use modeling techniques designed to extrapolate from the lost production of eggs and larvae of forage species (e.g., clupeids) to more effectively assess overall potential entrainment impacts (TVA 2003b). TVA's Vital Signs Monitoring Program would also continue to assess aquatic communities in Wheeler Reservoir. If it is determined that increased entrainment is resulting in unacceptable environmental impacts, TVA would assess technologies, operational measures, and restoration measures that could be undertaken to remedy the impacts, and institute appropriate mitigation measures in consultation with appropriate Federal and State of Alabama agencies (TVA 2003b).

4.1.3 Impingement of Fish and Shellfish

For plants with once-through cooling systems, impingement of fish and shellfish on debris screens of cooling water system intakes is considered a Category 2 issue, which requires a site-specific assessment before license renewal. To perform this evaluation, the staff reviewed the TVA ER and other TVA environmentally related documents, visited the BFN site, and reviewed TVA's State of Alabama NPDES Permit AL0022080, issued on December 29, 2000, which became effective on February 1, 2001, and will remain in force until January 31, 2006 (ADEM 2000).

Section 316(b) of the FWPCA requires the location, design, construction, and capacity of cooling-water intake structures to reflect the best technology available for minimizing adverse environmental impacts. Impingement of fish and shellfish on the debris screens of the cooling water intake system is a potential adverse environmental impact that can be minimized by use of the best available technology.

On July 9, 2004, EPA published a final rule in the *Federal Register* (69 FR 41575) (EPA 2004) addressing cooling water intake structures at existing power plants whose flow levels exceed a minimum threshold value of 190,000 m^3/d (50 MGD). The rule is Phase II in EPA's development of 316(b) regulations that establish national requirements applicable to the location, design, construction, and capacity of cooling water intake structures at existing facilities that exceed the threshold value for water withdrawals. The national requirements, which are implemented through NPDES permits, minimize the adverse environmental impacts associated with the continued use of the intake systems. Licensees are required to demonstrate compliance with the Phase II performance standards at the time of renewal of their NPDES permit. Licensees may be required as part of the NPDES renewal to alter the intake structure, redesign the cooling system, modify station operation, or take other mitigative measures as a result of this regulation. The new performance standards are designed to significantly reduce impingement losses due to plant operation. Any required site-specific mitigation would result in less impact from impingement during the license renewal term.

During the initial years of plant operation (1974 through 1977), 72 species of fish were collected in impingement samples (TVA 1978a). Four species comprised 95.8 percent of the impinged fish: threadfin shad (76.5 percent), gizzard shad (12.3 percent), freshwater drum (4.3 percent), and skipjack herring (2.7 percent). Each of the remaining 68 species comprised less than 1.0 percent of the total fish impinged; many less than 0.01 percent. Forty-two of the species were impinged at rates estimated to be one fish or less per day (TVA 1978a). Juvenile fish occurred more often than adults in impingement samples. This is attributed to (1) the greater relative abundance of these age classes, (2) juvenile fish of some species may concentrate in the shoreline areas, and (3) juveniles are weaker swimmers than adults (TVA 1978a).

Table 4-4 provides the impingement information for the most prevalent species during initial years of BFN operation (1974 to 1977). Overall, there was a positive relationship between the level of plant operation and impingement. However, for several species (e.g., spotted sucker [*Minytrema melanops*], silver chub [*Macrhybopsis storeriana*], white crappie [*Pomoxis annularis*], and sauger [*Stizostedion canadense*]) impingement levels may have reflected year class variation of the species within the reservoir rather than the level of plant operation (TVA 1978a). Nuclear generating stations are typically operated as baseload facilities and daily changes in the operational mode are minimal. Also, there is usually only a minor variation in

Table 4-4. Calculated Total Number and Percent of Total Impingement for the Most Prevalent Fish Species Impinged at Browns Ferry Nuclear Power Plant, Units 1, 2, and 3 – 1974 to 1977

Common Name (Scientific Name)	March 1974 - March 1975	March 1975 - March 1976	Sept 1976 - Aug 1977
skipjack herring (*Alosa chrysochloris*)	220,964 (4.2 %)	98,751 (3.7 %)	110,487 (1.7 %)
gizzard shad (*Dorosoma cepedianum*)	188,300[a] (3.5 %)	343,312 (12.8 %)	1,353,913 (20.3 %)
threadfin shad (*Dorosoma petenense*)	4,552,208[a] (86.5 %)	1,909,492 (71.0 %)	4,635,290 (69.5 %)
channel catfish (*Ictalurus punctatus*)	21,716 (0.4 %)	11,435 (0.4 %)	24,719 (0.4 %)
white bass (*Morone chrysops*)	14,126 (0.3 %)	13,408 (0.5 %)	50,681 (0.8 %)
yellow bass (*Morone mississippiensis*)	14,453 (0.3 %)	29,936 (1.1 %)	67,005 (1.0 %)
green sunfish (*Lepomis cyanellus*)	10,154 (0.2 %)	3115 (0.1 %)	39,210 (0.6 %)
bluegill (*Lepomis macrochirus*)	17,556 (0.3 %)	9423 (0.4 %)	84,977 (1.3 %)
redear sunfish (*Lepomis microlophus*)	7910 (0.2 %)	2561 (0.1 %)	27,625 (0.4 %)
freshwater drum (*Aplodinotus grunniens*)	179,501 3.4 %)	233,902 (8.7 %)	215,783 (3.2 %)
Total number impinged (Number of species impinged)	5,263,546 (51 species)	2,688,498 (52 species)	6,673,488 (61 species)

(a) The 48,937 individuals identified as only *Dorosoma* spp. were proportionally split between gizzard and threadfin shad.
Source: TVA 1978a.

cooling water use between years as long as all units are operating at normal levels. Therefore, when there are dramatic fluctuations in impingement collections from week to week or from year to year, they generally reflect prevailing conditions in the river and changes in the fish community (Bowzer and Lippincott 2000).

The number of fish impinged between 1974 and 1977 were compared to the estimated standing stock of fish within Wheeler Reservoir (TVA 1978a). For the species listed in Table 4-4, the percent standing stock impinged between September 1976 and August 1977 were skipjack herring, 5.39 percent; gizzard shad, 0.40 percent; threadfin shad, 0.66 percent; channel catfish